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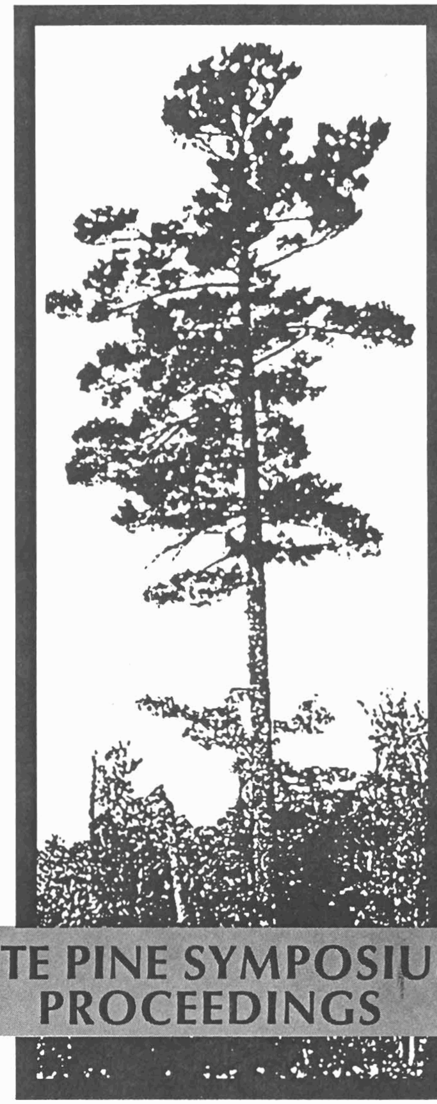

WHITE PINE SYMPOSIUM PROCEEDINGS

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POSTER SESSION ABSTRACTS

THE ROLE OF THE FOREST IN NORTH AMERICAN SOCIETY

Michael Williams[1]

ABSTRACT. Reciprocal relationships can exist between people and their environment. In North America the human perception of the role of the forest in society has changed through time. Each phase has affected the use of the forest and consequently the "management" response. Five major phases since the beginning of European settlement and into the twenty-first century are identified and discussed.

INTRODUCTION

The forest is one of the major resources of the North American continent. Consequently it has played an important and central role in economic, social and cultural life. In Zimmerman's (1951:7) words resources are "an abstraction" or "neutral stuff" until humans perceive a use for them, and the forest is no exception. While it is the hands of people that fashion and use resources, what is actually done or not done depends very much on what is in their minds. Society's perceptions and attitudes are crucial to resource exploitation and they create a management response.

It is the nature and human meaning of the forest, its perceived use, and the consequent management perspective as these have changed through time that form the framework for this talk.[2] What follows is a broad-brush, chronologically-structured view of major shifts in perceptions and responses, which are represented diagrammatically in Figure 1. In highlighting the onset of these shifts in emphasis one should be aware that in the real world events do not fall into neat categories or time-slots. Many are overlapping and interdigitating so that previous emphases do not disappear but simply become less dominant than succeeding ones. Precise dates are difficult to assign.

BEFORE 1800: THE FOREST AS A NEGATIVE RESOURCE

The extent of the forest was immense. Well-formed "commercial" forest covered about 45 percent of the coterminus United States and 70 percent of Alaska, and probably as much as 43 percent of Canada. Beyond that was a fringe of non-commercial, low-productivity forest, useful for local supplies for construction and fuelwood, shelter for game and the conservation of water supplies. In total they may have accounted for another 15-20 percent of the land surface area.

The forest as obstacle

In both countries the forested lands, particularly the deciduous forests, were in the East, where many sophisticated native American tribes lived. It was also the scene of the earliest European impact. Consequently the earliest experiences of Americans and Canadians were forest experiences. Generally speaking early settlers perceived the forest as an obstacle. It was repugnant, forbidding and repulsive. It was the abode of wild animals, hostile people, and characterized by a terrifying eeriness.

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[2]Except for specific quotations and ideas, most of this paper is based on M. Williams 1989. Americans and their Forests, New York, Cambridge University Press.

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Symbolically it represented the dark, sinister - even evil - side of existence where people degenerated into savagery. Physically it impeded agriculture and threatened survival. It was something the Puritan New Englanders took seriously for they passionately believed that social order and the Christian concept of morality stopped on the edge of the clearing. The only value of a forest was when it was felled. The attitude is summed up well by Alexis de Tocqueville many years later when he described pioneer life in Michigan. The pioneer

> living in the wilds...only prizes the works of man. He will gladly send you off to see a road, a bridge, or a fine village. But that one should appreciate great trees and the beauties of solitude, that possibility completely passes him by.

Generally, settlers were "insensible to the wonders of inanimate nature and they may be said not to perceive the mighty forests that surround them till they fall beneath the hatchet. Their eyes are fixed on another sight.... peopling solitudes and subduing nature" (Tocqueville, 1831: II: 74; 1838: 329). The struggle to make the land something better than it was was encapsulated in the idea of progress, and by implication it was morally good.

Exploring the resource

Despite their negative perception of the forest, settlers were well aware that the forest was their most valuable resource. It provided them with the wood which was the raw material that was central to their life and livelihood. Unlike western Europe from where most most of them had come, North America had enormous forests. Wood was abundant, it was ubiquitous, and consequently it was used prodigally. It entered into every aspect of life, quite literally from cradle to coffin, and for about 300 years between 1600 and 1900, it formed an essential element in human needs that is difficult to understand from statistics, and impossible to express in figures. When James Hall (1836: 100-101) said "Well may ours be called a wooden country; not merely from the extent of its forests but because in common use wood has been substituted for a number of most necessary and common articles - such as stone, iron, and even leather", he was thinking of the multifarious human needs in the life and livelihood of the people that were supplied by wood. Quite simply, pioneer life in North America revolved around wood - its removal, consumption, and fabrication.

Because the forest was so common, and because it was regarded as an obstacle to progress, it was not valued highly. Standing timber was waste material that "lumbered the landscape", was useless and cumbersome and had little value. Indeed, bare land was worth more than land with trees. And yet in the process of exploring the potential and using the raw material, settlers were indelibly altering the forest and creating a new resource of agricultural land. No one bothered to comment about that change. "Man gets used to everything", wrote de Tocqueville (1831: 329),

> [He] fells the forests and drains the marshes...The wilds become villages, and the villages towns. The American, the daily witness of such wonders, does not see anything astonishing in all this. This incredible destruction, this even more surprising growth, seem to him the usual progress of things in the world. He gets accustomed to it as the unalterable order of nature.

Thus, one could say that the "management" response to the perception of the forest as obstacle was to get rid of it and create new farm land (probably as much as 113 million acres in the USA alone before 1850). Land settlement, coupled with a high degree of self-sufficiency, was the aim.

After about 1830 two events occurred that altered the perception of the abundance of timber. Farmers had reached the open prairie lands where there was no timber for fencing, construction or fuel. In addition the large and growing cities on the Eastern Seaboard began to experience fuel wood shortages, especially in particularly cold winters. In both locales prices rose as a response to scarcity and the taken-for-granted resource began to be valued more highly.

1800 -1900: THE FOREST AS POSITIVE RESOURCE

Raw material source

The perception of the forest as a source of useful products went from strength to strength after the opening decades of the nineteenth century as the predominantly self-sufficient, rural, agricultural - even peasant - economy was transformed into a highly commercial urban, industrialized one. With lumbering, clearing and the other domestic and industrial impacts, the original cover of the coterminus USA was reduced from roughly 822-850 to 470 million acres by 1920. Thus about 303 million acres of forest had gone into the creation of new agricultural lands. There are no comparable figures for Canada, but the likelihood is that total destruction was far less, if only because of a smaller population, and because about 80 percent of the Canadian forest is boreal and beyond the designs of the agricultural clearers.

But timber was more than new land. As a measure of its importance in American life we know that from 1850 to 1920 the value of products of the lumber industry constantly outstripped all other forms of manufacturing, except meat packing, iron and steel, and flour and gristmills. It was the second ranking industry in 1850 and 1870, third in 1860 and 1910, fourth in 1880 and 1900, and fifth in 1890. It sunk to ninth only in 1920 when modern, manufacturing and valued-added products, such as automobiles and petroleum refining, shifted the ranking permanently.

But these rankings do not convey the true value or importance of wood in the economy. A whole technology based in wood existed in America and Canada from earliest times to possibly 1940, as did a whole "society pervasively conditioned by wood" (Hindle 1975:3), so that wood and wood products, as Hall observed correctly, entered into every walk of life. To the lumber industry rankings of value should be added the products of the wood planers, the packing-box manufacturers, the coopers, the tanners, the carriage-makers, the house builders, the ship builders and furniture makers whose products rose to be at least as valuable, if not more so, than the products of the sawmills. The vast majority of buildings were made of logs or planks, and wood was an essential element even in those made of brick and stone. Wood was the principal material of the transportation system being essential in the majority of ships, river boats and barges carriages, and railcars, bridges, and railroad ties, in plank and corduroy roads and even in road surface blocks and canal locks. In rural areas it was the principal fencing material until the latter 1890s.

Wood was the fuel for over two-thirds of households in both countries until as late as 1880 and for a quarter of households as late as 1920. It made the steam that drove the engines of the railroads and steamers and factories well into the 1880s, and it continued the make the charcoal for a surprisingly large quantity of pig iron smelted, the last charcoal iron automobile engine block being made by Ford in Dearborn in about 1940.

Wood was also the source of many important chemicals such as potash, an early industrial alkali, and naval stores which included pitch, tar and turpentine, all essential ingredients in maritime transport. The bark was a source of tannin for the leather industry, and the sugar maple produced a sweetener.

While much of this resource destruction/exploitation was still being managed by individual farmers as they cleared their blocks, the latter half of the nineteenth century saw the rise of a new form of management response that was highly commercial and is best described as industrial capitalism or industrial exploitation. It was characterized by a thorough and ruthless exploitation of land and labour, and it went hand-in-hand with an innovative and dynamic use of new machines, new methods of transport, and new systems of business organization. Everything in the lumber industry grew larger, faster, more complex and yet more specialized in the quest for greater production and profits. An energetic minority of lumbermen existed who had a clear view of the short-run profit that could be made from rapid and exploitative cutting, a view that could be transferred into action without the restriction of any regulatory agency. In addition, there was very little popular condemnation of the destruction because the public at large demanded abundant and cheap timber.

Although most North Americans thought that the forest and its timber were limitless, there were indications by the later decades of the nineteenth century that timber was scarce and getting dearer. The prospect of an impending "timber famine", actively promoted by Gifford Pinchot and his associates at the turn of the century, was instrumental in galvanizing public and popular awareness of the potentially finite nature of forest resources.

The response in the lumber industry was to combat deficiencies by better communications to bring timber from untouched forests further afield, i.e., the South and then the Pacific Northwest and British Columbia, and the installation of mass-production methods to keep down costs. But by the latter years of the century there was a realization that some form of silviculture was desirable, that is to say, the management of the existing forest to maximize yield. The public response was to bring into being a large and skilled body of professional foresters trained to manage the new state, provincial, and federal forest lands.

An Engine of Growth

Although it was rarely articulated or perceived as such, in retrospect we can appreciate the role of wood in promoting the rapid industrialization of the United States. There is a convincing case to be made that the abundance of wood and the land created by clearing were the starting points for many important economic, social and technological changes. Brooke Hindle (1975) hints at this when he says that it was during America's "wonderful Wooden Age" that the country began the "assent to industrial primacy and to the highest standard of living in the world." American development has been greatly influenced by resources, and of those resources wood constituted a visible, abundant, easily worked and easily exploited raw material and fuel, quite unlike minerals which were underground, and needed much more complex machinery and organization for their exploitation. Wood was an inexhaustible resource of unprecedented magnitude.

The example of how countries today in the less developed tropical world regard their forest resource as a means for achieving economic growth and break-through, even in a fossil fuel age, should be borne in mind as it underlines the importance of this versatile resource.

Aesthetic appreciation

Paralleling the utilitarian appreciation of the forest as a positive resource was a shift in aesthetic appreciation. Rather than regarding the forest as repugnant, some people began to find that nature's "roughness" and "rawness", untouched by the improving and ordering hand of humans, had a picturesque quality about it. Others went further and began to think that wild nature was sublime, and that wild scenes, be they mountains, forests, or snowy northern expanses, could bring pleasure and exalt, just as easily as comfortable, well-ordered landscapes of cleared and made land.

Far from producing degeneracy and immorality, some people felt that life in the forest actually produced civilized thoughts and a morally improved person. The evolution of the simple and the solitary, and the preference for the rural over the urban became stronger so that the "little nooks of still water" were preferable to the "rapid stream of migration, improvement, and change" which swirled past (Irving, 1820: 63-4). It culminated in the Romantic movement that viewed nature as teacher.

This shift in attitudes was reinforced by patriotic ideas, in the sense that if North America had endless forest and Europe did not, then that was something to be proud of. Chateaubriand (1828: 98) touched on this feeling when he said, "There is nothing old in America excepting the woods.....they are certainly the equivalent for monuments and ancestors." This was accompanied by a surge of poetry, and particularly landscape painting of the Hudson River School of painters who during the 1830s and 1840s revelled in depicting the American wilderness and scenery. These sentiments came later in Canada.

Finally, from the mid-nineteenth century onwards, the appreciation of the forest took yet another positive turn with the writings of Emerson and particularly of Thoreau. They both expounded the transcendentalist philosophy that the experience of nature in general, but of forests in particular, produced a higher awareness and sense of reality than did one's immediate surroundings which were materialist. Thus, over the century there was a dramatic reversal of values, and the human meaning of the forest changed from having negative to positive values.

These ideas culminated in a management response on the part of governments to protect the forests because they were a part of the national heritage as well as a part of the national economy. Federal forests were created in catchments and other forest areas not only to ensure a supply of timber, but also to provide areas of recreational, scenic and aesthetic value, and later even to preserve areas of "wilderness". After about 1890 protection as a goal was supplemented by a growing commitment to conserve and actively manage the forest by whatever science available. Thus, by the 1890s the appreciation of the forest and other wild places had passed from being the concern of a small and articulate group of writers, artists, poets and politicians to becoming national cults. For many North Americans, who were now urban dwellers, the primitive conditions of nature no longer impinged on their lives and were no longer to be feared. Wild landscapes were sought out actively, and they could be seen in comparative comfort as vacationeer. In the popular imagination they were now imbued with attributes all of which were good.

1900-1940: THE FOREST AS ENVIRONMENTAL RESOURCE

Concern over the growing scarcity of timber was followed by another worry: What was the clearing doing to the land itself? As one vegetation cover was replaced by another - usually cropland - but often by weeds or other trees, the visual and protective content of the land changed, and not always for the good. Soils were changed, runoff, hydrology, wildlife and a multitude of other ecological characteristics were altered. The forest seemed crucial in the stability of other elements of the land; it was a sort of environmental glue.

Particularly articulate in this regard was George Perkins Marsh, (1864) who emphasised the destructive powers of everyday human activities which upset the "harmonies of nature." He suggested that wise management could mitigate some of these problems. The quite novel idea that Nature was an organic Whole and that forests influenced other facets of the environment had far-reaching effects. For example, settlers wanted to plant trees to increase rainfall, irrigators wanted to plant trees to control floods, and everywhere those concerned with erosion wanted positive forest policies in order to regulate other environmental reactions.

The management aims of most of the lumber barons of the nineteenth century had not considered the land they left behind. Investment was limited and transitory, and profits were garnered quickly. The resource was "mined" with no thought of permanence and long-term management. Lumber firms simply moved out of the depleted regions to cut new stands further afield. Land was only important in as much as it grew timber; "stumpage" was worth owning but land was not. Increasingly, people were critical of the devastation wrought by this mass-production, large-scale lumbering, particularly in the forests surrounding the Great Lakes and then later in the South, which left worthless cutovers. In this exploitation, financial risks had been lessened by rapid cutting followed by the speedy disposal of the cutover stumpland as farmland. But the normal sequence of forest to farmland failed in the marginal farming conditions of the Northern forests. The resulting unwanted tax delinquent and tax reverted lands, and discussion on how the local tax base could be protected, dominated thinking about the forests during the first years of this century. Eventually, by the 1930s the realization dawned in both countries that the sensible and sustainable use of the land would be achieved best by maintaining long-term production of wood and not of food from these areas.

Running parallel to these concerns about the aftermath of lumbering was the greater public emphasis on the importance of the totality of the forest resource - its rivers, lakes, old settlements and wildlife, as well as its trees; in other words, its ecology. Slowly people were becoming aware of the potential of forests as areas of recreation, relaxation and repose. The lakes and rivers were no longer thought of simply as a means of transporting timber but integral features of the beauty of the forested environment which could be a focus for recreation in the form of fishing, canoeing and homesites. The shift from a purely intellectual appreciation to a practical, participatory appreciation owed much to the fishing and hunting lobby which took a lead in pressing state, provincial and federal authorities to put reverted lands into public ownership. Their mass membership gave their views some clout. For example, by 1950, 17.9 million acres in Minnesota, Michigan, and Wisconsin had reverted to states or counties. In Canada most (95 percent) of the forest land was never taken out of public (Crown) ownership (Burgar 1983, Barlowe 1983).

An important factor in the new awareness of the forest was the widespread diffusion of automobiles which increased accessibility. Seasonal vacationing from the large urban centres of the Midwest and southern Ontario had always existed in the Great Lakes area, but this was now supplemented and sometimes replaced by weekend vacationing, a social trend which was widespread and ran through all sections of the population. The cut-overs were on the way to becoming the patrimony of the people as public ownership meant ease and cheapness of access, all of which encouraged the mass-participation of ever-affluent societies.

With the passing of the lumber barons the management gap was filled by the public forest managers created under the newly formed federal and state agencies. Their managerial response had to become more multi-functional than productivity alone. Increasingly forestry departments had to have economists, ecologists, and fish and wildlife experts, and they had to engage in the complex zoning of different uses of the forest. But in the final analysis they still regarded timber production and the protection of the forest stand as their main aim. This was achieved, primarily and initially, through efficient fire control, and later by restoring the resource through reforestation, while, incidentally, stabilizing the environmental system. In the United States the New Deal era and the conservation activities of the Civilian Conservation Corps were notable in this respect. The aim was to increase the productivity of the forest by eliminating waste and engaging in a more scientific approach to forest management. Although few people realized it at the time, while these active managerial policies were being pursued, the forest was being enhanced in its extent and density by the natural, passive regeneration of trees on old farmland, tens of millions of acres of which were being abandoned in the eastern part of the continent.

1950 -1990: THE FOREST AS ENVIRONMENTAL AMENITY

After World War II the perception of the forest resource had polarized into two competing and ultimately conflicting strands. On the one hand the lumber industry, both public and private, threw off its inter-war uncertainty and started investing again for continuous and increased wood production, as North American entered a long boom. One the other hand, the public had become permanently and intimately involved in the natural environment, and every facet of the forest resource has been regarded highly positively. One is consumptive; the other non-consumptive. Both demanded intensive use, and conflict was, and is, probably inevitable.

The aim of long-term forest production requires investment in a continuous flow of timber products in order to achieve industry and community stability. This desirable objective is probably best attained by concentrating on commercially valuable species and even-age management and not being unduly concerned about wildlife, recreational and environmental amenities. This objective is in direct conflict with the changing values of the public which views the forest as an amenity good, so that it has pressed for even more extensive wilderness and recreation areas which have constantly impinged on commercial forest areas and cutting practices. Additionally, a new phenomena began to emerge. The forest, like other wilderness areas, be they the semi-deserts of the Southwest or the inaccessible Rockies, has become a desirable place to live. This striking reversal of values has not been based on a return to nature and the simple life in the Thoreau sense, but a desire to purchase and live in the previously less well developed areas of the continent with (and largely because of) the availability of all the conveniences of modern living. Purchase has not been such a feature in Ontario. Nonetheless, in both countries there has been a locally significant migration of people to forested areas. These people are not interested in wood production but in amenity values such as clean air, clean water, and open space. The involvement and familiarity of people with the forest engenders a sense that in some way they "own" it (which they do in places) and should protect it (Hays 1983). Diversity rather than uniformity is favoured, and the ecological mixture of plants, trees, animals, insects and birds has become treasured. Consequently, even-age and single species stands, and uniform cutting are anathema to such people.

Thus, the latest phase in the perception of the forest is one a conflict between forest as raw material source and forest as experience. The new popular and egalitarian appeal of the forests and involvement of people with its ecosystems have set new standards for late twentieth century forest managers that may be difficult to reconcile. Not all is negative, however. As Hays points out there have been some positive results in that timber management teams have had to diversify and become resource management teams, and that the public have become more involved in management decisions through public hearings and the like. Also many forest areas have become multiple-zoned and -used. But these issues are intimately bound up with wider issues of development versus non-development, insiders versus outsiders, and what are seen as interfering urban busybodies versus rural pioneers.

FOREST OF THE FUTURE

It is, of course, impossible to predict the perception of the forest in the future, but we can be assured that its role in North American life will not diminish, and that in fact it will increase. More and more will be demanded out of less and less, and forest productivity, already high on the list of management priorities, will loom even larger. In the USA it is predicted that the population will rise from 241 million in 1986 to 333 million by 2040, and that it will have at least one-and-a-half times more disposable personal income (USDA, Forest Service, 1990). Between the same two dates, the consumption of lumber is expected to rise from 56.8 billion to 69.4 billion board feet and paper and board consumption will leap astronomically from 81.7 to 173 million tons. At the same time the area of commercial forest will fall from 483.2 to 462.2 million acres as more land is covered by houses, transport routes and industry, or moved permanently into reserved areas. A similar forward predicting Renewable Resource Assessment is not available for Canada.

The disposal income statistic is, perhaps, the most striking as it will mean an even great public participation and interest in wildlands. Environmental causes will rise in importance, the spotted owl/Douglas-fir dispute being perhaps only the tip of a much larger iceberg of habitat preservation, anti-genetic research, anti-commercial harvesting, and the like, that could rip a great hole in the Titanic of increased production. Economic development will clash increasingly with environmental amenity. An increasingly urbanized society will perceive little connection between forests and the source of the raw material that provides the timber and paper products that are essential to life. The challenge to forest managers will be to juggle and reconcile these new perceptions of the meaning of the forest in American society, and to ensure that the processes used in planning and in formulating management policies are accessible to all people interested and affected by decisions and actions (Skok and Buckman 1983). Past responses have been slow and sometimes even resistant; future responses will have to be more rapid and flexible.

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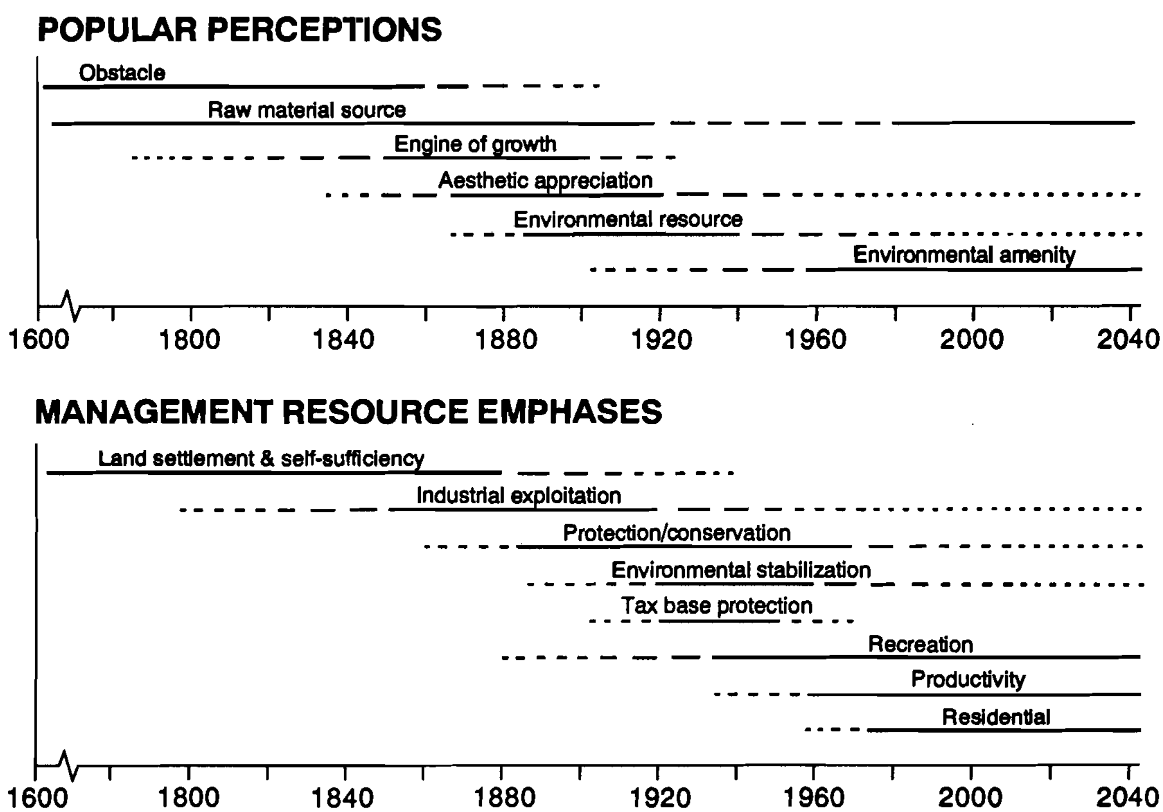

Figure 1. Main phases of popular perceptions of the forest and management response emphases.

ECOLOGICAL CHARACTERISTICS OF WHITE PINE

Forest Stearns[1]

ABSTRACT. White pine, a relatively long-lived, versatile, and genetically variable species, is well adapted to many sites in the Lake States and Ontario. Adequate seed production and ability to become established in the open as well as under a variety of canopy conditions permit it to recover from disturbance forming pure or mixed stands. A degree of shade tolerance and rapid growth after the first 8 or 10 years encourage the success of white pine. Resistance of older stems to fire and wind augment its long term survival. Once far more abundant and the "kingpin" of the early timber industry, white pine can and should play a major role in future Lake States forests.

INTRODUCTION

Common and local (colloquial) names applied to a plant often tell us much about the plant's characteristics. Names for white pine such as cork pine, old field pine, mast pine, and soft pine suggest certain biological characteristics. Knowledge of the biology of an organism is essential to an understanding of its response to stress, site conditions, and management. Such knowledge involves physiology and morphology as well as the role of genetic variation. The success of any species under the varying conditions found in nature depends upon its ability to adapt to a variety of environmental situations. For tree species, this implies conditions that vary over periods of years rather than days or months. Critical periods in the life of trees include seed formation, germination, and early establishment. Other characteristics, especially light, water, and nutrient requirements, as well as form and structure of the root and stem, affect survival and growth. This paper will summarize briefly the biological and ecological characteristics of white pine as well as the relationships between white pine and its associates in northern forests with particular reference to Ontario and the Lake States.

GENETICS, TAXONOMY, AND MORPHOLOGY

Eastern white pine (*Pinus strobus* L.) is a member of a worldwide group of five needled pines in the genus Pinus. White pine and its associates belong to a group known as the soft or white pines as compared to the two and three needled species that are classed as hard or pitch pines. Of the eight species of soft pines that occur in the United States white pine is the only one found in the eastern forests (Sargent 1933). It's closest relatives are western white pine (*P. monticola* Dougl.) and sugar pine (*P. lambertiana* Dougl.) and all three differ from other soft pines in such characters as cone shape and needle length (Mirov 1967).

White pine, like most eastern American pines, has no described varieties in Canada or the United States. One named variety, *P. strobus* var. *chiapensis*, is found in the mountains of Guatemala and southern Mexico (Wendell and Smith 1990). Provenance studies, including a range-wide USDA test of 31 provenances planted at 15 locations, indicate that eastern white pine is a highly variable species (Abubaker and Zsuffa 1990).

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Differences have demonstrated in both morphological and physiological characteristics including seed and germination characteristics, timing of bud set and bud break, foliage color, needle length, height and diameter growth, as well as resistance to damage from ozone, sulphur dioxide, white pine weevil and blister rust (King and Nienstaedt 1969, Wright 1970, Abubaker and Zsuffa 1990, Genys 1990). Greenhouse grown seedlings similarly demonstrated ecotypic variation in breaking of dormancy in response to day length, height growth, seed dormancy, and cold hardiness (Mergen 1963).

The broad geographic range of *P. strobus* demonstrates its adaptability. It occurs from Newfoundland and the Maritimes across Canada to southeastern Manitoba, through the northern United States from Minnesota to New England and southward to northern Georgia. In the midwest scattered outliers, usually associated with sandstone outcrops, are found in southeastern Iowa, southwestern Wisconsin, northern Illinois, and western Indiana.

Compared to most of the associated species, white pine is relatively long lived. Upper limits range from 380 to 426 and even 634 years. The average maximum age is probably well over 500 years (Graham 1941, Stearns 1950, Wells, Thompson and Fons 1983).

White pine occurs on soils that vary from young relatively acid soils of course texture to much older soils that are often fine-textured with well developed profiles. Climate throughout the range tends to be cool and humid although subject to major variations in both temperature and precipitation. In the southern part of its range white pine tends to be found in protected valleys and along streams. Mean July temperatures range from 18 to 25 C (65 to 74 F) while precipitation increases southward (from about 510 mm (20 in) in Minnesota to 2030 mm (80 in) in Georgia. In the Lake States about half of the total moisture comes during the warm season (Wendel and Smith 1990). Moisture surpluses are common in all seasons but extended droughts may occur. Established trees generally can survive even on dry sites where roots may penetrate deeply. The growing season over the range of white pine varies from 90 to 180 days (Wendel and Smith 1990).

Sargent (1933) describes white pine as follows:

> "A tree, while young with slender horizontal or slightly ascending branches in regular whorls usually of five branches; at maturity often 100', occasionally 220' high, with a tall straight stem 3'-4' or rarely 6' in diameter, when crowded in the forest with short branches forming a narrow head, or rising above its forest companions with long lateral branches sweeping upward in graceful curves, the upper branches ascending and forming a broad open irregular head..."

Many trees in the old growth forests reached 46 m (150 ft) in height and 102 cm (40 in) in diameter (Wendel and Smith 1990). When growing in well-stocked pure or mixed stands white pine gradually becomes a clean-boled. If open-grown, low branches may remain for the life of the tree producing a stocky stem of large diameter in a relatively few years. When older trees lose a portion of their crown from wind breakage, branches below the break respond and a bushy upper crown often develops. Both diameter and height growth may vary greatly depending upon age, light, and moisture conditions.

The root system of white pine normally consists of several (3-5) large roots that spread outward from the base of the trunk. These roots branch resulting in a widespread system of support. In soils that are deep and coarse in texture "sinker" roots often develop from the laterals and grow directly downward (Wendel and Smith 1990). Usually mature trees are adequately anchored although when the soil is saturated (e.g. during the 1938 hurricane in New England) windthrow may be common. The fine root system begins to develop during the first year. Smaller lateral roots develop from the area below the root collar producing a much branched network of absorbing roots (Fowells 1965). The structure of the root system varies with soil depth, presence of clay lenses or clay pans, drainage, and soil texture. In poorly drained or thin soils white pine will be shallow-rooted.

Root grafting is frequent beginning early in life (5-15 years of age) and often several trees are interconnected (Bormann and Graham 1959). The amount of grafting depends on several factors including stand density, age, and presence of other tree species. In an older stand, more vigorous trees may support suppressed ones by transfer of photosynthate. Cut stumps and their roots that form part of the grafted network have been shown to remain alive and to translocate water and minerals to the live stems. These extensive root networks may serve to provide additional stability for trees growing in shallow soils and may function to restrict invasion by other species as a stand opens up. Borman and Graham (1959) also suggest that during periods of drought trees in riparian areas may provide water to nearby stems and under stress and that mineral nutrients may be moved between trees. However, transport of water and minerals is much less probable than is movement of assimilates (Loehle and Jones 1990).

NUTRIENT AND MOISTURE REQUIREMENTS

White pine is capable of growth under a wide range of soil and moisture conditions but is most successful on well drained sandy or sandy loam soils in the Lake States and Ontario. It is also successful on less well drained sands such as swampy podzols or glei soils. It grows well on finer textured soils such as loams and silt loams but competition from hardwood species often inhibits establishment or early growth. In the more southern and eastern portion of its range it appears to be generally, but not always, favored by loamy and less well drained soils; there it is more likely to be found on north facing slopes, in valleys or along streams (Wendel and Smith 1990, Wilde 1933). Moisture supply is closely related to nature of the soil. The fact that white pine favors well drained sandy sites suggests its ability to utilize relatively low levels of soil moisture. White pine does not grow on the very dry infertile soils where jack pine and pin oak dominate the vegetation (Kotar et al. 1988). However, in association with red pine, white pine often invades the better jack pine-pin oak sites (Brown and Curtis 1952).

Small root development is most extensive in soils with fine texture, good structure and an intermediate moisture equivalent. A good base exchange capacity with an ample supply of exchangeable bases and nitrogen as well as organic matter results in greater density of these roots (Fowells 1965). In northern Wisconsin, white pine appears in the successional sequence in all habitat types, save for the two driest and most nutrient poor. All types save the driest also have the potential for producing large, high quality trees, although competition on the richer mesic sites is often severe (Kotar et al. 1988). White pine, as is the case with most forest trees, is usually host to one or more species of mycorrhizal fungi. This association may greatly expand the absorptive surface of the roots and may be partially responsible for the ability of the tree to grow in soils low in nutrients (Slankis 1957, Mirov 1967). White pine can utilize moderate to high levels of mineral nutrients to good advantage but low levels do not appear to severely limit growth. Growth and yield data from a variety of sources also suggest that moisture is not directly limiting at high levels as long as the substrate is partially oxygenated nor at low levels, especially after the tree becomes established and subsoil moisture is available. Presumably this versatility results from increased efficiency of extraction of both water and nutrients by a well developed root system and its mycorrhizal associates (Slankis 1957). A mycorrhizal association is less likely to develop in wet soils.

LIGHT REQUIREMENT

White pine is usually classes as intermediate in shade tolerance, similar to red and white oak and red maple. Likewise, it is less tolerant of shade than yellow birch, hemlock, or sugar maple but more tolerant than red pine, aspen, and white birch (Kotar et al. 1988). Shade tolerance in white pine changes with age. The young seedling may survive and develop with as little as 20 percent of full sunlight (Wendel and Smith 1990). As the growing sapling is shaded and suppressed by its associates, physiologic changes will gradually occur that influence height and diameter growth. Formation of secondary xylem may be depressed until growth rings may not be formed at the base. Height growth continues, often at least half as fast as a tree in full sun. Phloem continues to be produced and to function providing for primary root growth. "...as suppression proceeds, the plant invests a higher and higher proportion of its decreasing energy supply in primary growth or in all tissues that require annual renewal thus prolonging its survival" (Bormann 1965). In mixed stands, when the crown of a white pine emerges above the canopy both diameter and height growth proceed at a good rate.

The partial shade tolerance shown by white pine enables it to enter and survive in aspen and birch stands and to gradually dominate those stands as those shorter lived species disappear. In dense pine stands there is considerable mortality of suppressed trees particularly if root grafting is limited. The ability of white pine to grow in response to increased light declines with age. In general, pines less than 30 years old with at least one-third of their height in live crown will respond well, but response declines rapidly with increasing age and decreasing crown length (Folwells 1965). The young seedling grows slowly for the first few years and so many succumb to competition from its herbaceous and woody associates. Most terminal growth occurs between late May and the first of July. Bud break occurs well after it does in associated hardwoods. Stem elongation is rapid. New needles become functional after the leaves of the broadleafed associates are fully expanded.

REPRODUCTION, SEED FORMATION, AND SEEDLING ESTABLISHMENT

Female strobili may be produced by trees ten years old or less and begin to appear in early May. Trees that have reached 20 feet in height may bear appreciable numbers of female strobili but in the early years male strobili are rare. Trees up to one to two feet in diameter may remain predominately female. Pollination occurs in early June, fertilization 13 months later and the seed and cones mature in August and September of that year. Female strobili are produced in most years but male strobili do not occur every year (Folwells 1965). Good seed crops are produced on the average of every 3 to 5 years. The white pine cone beetle, a cone worm, and squirrels sometimes cause seed losses. Seed production increases with age at least until 90-100 years and dominant trees are the best producers. Female strobili are borne in the upper crown and male strobili in the lower crown, usually preventing self pollination (Folwells 1965). When self pollinated seedlings develop they tend to lack vigor (Mirov 1967). Seed production increases with age suggesting that for natural reproduction to be successful residual stands should retain an older component. This requirement was partially met during the logging period by the scattered veterans that were hollow or lightning scarred and hence not suitable for lumber. Older, thick-barked trees also had a better chance of surviving the slash fires that followed most operations. In the open, seed can be disseminated for distances of over 700 feet (Fowells 1965) so that a few good seed trees could cover a large area. The even-aged post-logging white pine stands that occur in the Lake States owe their origin to a chance combination of availability of seed, a favorable seed bed where competition was reduced and to favorable weather during the first summers after seed germination. Since herbaceous and woody plant competition may develop soon after logging, the window of opportunity for stand formation was often relatively brief so it is clear why these post-logging stands are not more abundant. Weather conditions over several years may influence seed production as well as seedling establishment.

To germinate, white pine seed normally requires stratification for about 60 days at a moist low temperature of 1 to 5°C (33-41°F) (Krugman and Jenkinson 1974), a condition readily met in most of its range. Seed shed in autumn germinates rapidly after snow melt forming small seedlings with a short tap root in the first year. Early seedling growth is favored by a light overstory providing 20 percent or more of full sun. Young seedlings appear able to survive at soil moisture levels below the wilting point for several weeks. White pine seed can germinate and become established successfully on a variety of seed beds including moist mineral soil, moss clumps, and moderate grass and deciduous leaf litter (Fowells 1965). White pine is favored by disturbance as are most species of the Lake States forests. Recent burns, tip-up mounds, eroded slopes and other disturbed areas are frequent sites for establishment.

Interactions of white pine with animals and birds of the community are numerous but, save for certain insect pests (discussed in a later paper), are rarely serious. White pine seed is consumed by several small rodents including chipmunks, squirrels, mice, and voles for whom conifer seeds are a major food source. However, enough seed is produced in good years so that natural reproduction is usually not seriously affected. Several of these animals, among them white-footed mice and red-blacked voles, cache seed for future use. The caches are buried below pine litter on the mineral soil and may be visited and consumed during autumn or spring. Occasionally some seeds in a cache survive to germinate in the spring contributing in a minor way to regeneration (Abbott and Quink 1970). Browsing of white pine by white-tailed deer and hare will be reported in a paper that follows.

The success of white pine in different light regimes is in part related to rates of needle formation and needle longevity. On trees under a deciduous canopy needles survive longer (up to 4 years) than do needles on open grown trees, whose needles survive less than two years (Whitney 1982). Since needles of white pine can resume photosynthesis after a few days of warm spring weather (Bourdeau 1959) the older needles can utilize light available before the deciduous canopy develops to provide photosynthate for the developing shoots. Open grown trees appear to have a higher rate of needle production than those in the shade thus forming a denser crown. This results from the production of many lateral branches on each shoot, apparently a response of bud primordia to light levels during the spring (Whitney 1982). Work with other pine species indicates that the ratio of root to shoot growth is greater in seedlings grown in full sun than in those in partial shade, an advantage for open-grown individuals, especially on dry sites (Kozlowski 1949).

The ability of white pine to grow under a partial canopy provides protection from infection by blister rust since little if any dew forms under the canopy, eliminating the opportunity for rust spores to germinate on pine needles (Anderson 1973). This shade tolerance is also useful in reducing the impact of tip weevil, a serious pest in young trees growing in the open. Disease and insect problems are dealt with in detail in later papers.

WHITE PINE AND ASSOCIATED FOREST COMMUNITIES

The Society of American Foresters states that, throughout its range, white pine is a major species in five forest types and that it is present to some degree in 23 others, again suggesting the versatility of the species (Wendel 1980). It is found in each of the forest types that are present in our region. Some of the relationships will be described in the paragraphs that follow.

As the loggers moved west from New England in search of white pine they found it in massive quantities throughout the Lake States and southern Ontario. So vast were these forests that they were said to be inexhaustible -- a vision proved wrong within the short period between 1830 and 1920. These extensive pine forests were growing on soils ranging from dry outwash sand, through sandy loam, to silt loam and even peat. Many were old stands dating at least as far back as 1500 A.D. while others were much younger. The preponderance of white pine, often in mixture with eastern hemlock, can be attributed at least in part to the highly variable climate of the preceding centuries. They were generally cooler and wetter than the present but with intervals of drought, a period that has been called the "Little Ice Age." This period lasted from approximately 1450 to 1850 A.D. (Bryson and Murray 1977, Lamb 1969). Such a diverse climate with an increased frequency of disturbance clearly favored white pine. Major fires during the period initiated extensive stands of white pine and of mixed stands of white pine with red pine or hemlock (Graham 1941, Maissurow 1941, Lutz 1930). The post-glacial movement of white pine into the Lake States and Canada is discussed in the next paper.

Logging resulted in almost complete removal of white pine, first from all areas that were accessible from rivers and lakes and, later, with the advent of logging railroads, from all stands including trees scattered within the extensive hardwood forests. The origin and ecological role of white pine in these various situations is considered below.

The areas classed as pine by the early land surveyors in the Lake States included open jack pine-oak barrens, pure stands of red or white pine, and mixed stands of red and white pine. Fire was common on these sites and was responsible for the initiation of even-aged stands and the removal of hardwood competition. Theoretically, succession would be expected to proceed from the least tolerant species to white pine and eventually to more tolerant hardwoods. However, fire generally interrupted the sequence. Heinselman (1981) states that,

> "At least from Michigan westward, pine stands on fresh to dry sites were subject to light to moderate surface fires, probably at intervals of 20-40 years. Such fires consumed the litter and killed back shrubs and invading tolerant conifers but only scarred or left uninjured pines more than 30 or 40 years old. Perhaps once every 100 or 200 years a high intensity fire killed out patches of mature pines."

This helped to produce a patchy pattern of essentially even-aged stands or stands with several even-aged cohorts. The coarse textured soils of the outwash plains and lake deposits could not support hardwood species and were sufficiently dry to permit frequent fire. In Lower Michigan the average fire return time for the mixed red and white pine forests varied from 120 to 140 years. Common associates in these stands were aspen, oaks, and red maple (Whitney 1986), all of which could survive fire by producing root or stump sprouts. Sometimes enough older pine survived to provide seed for a new stand of young pine to grow in the open oak forest. However, many stands were completely eliminated during the logging era. This removed the pine seed source and shifted the vegetation to an oak-aspen-soft maple complex with little opportunity for pine recovery (Whitney 1987).

In some Wisconsin sites, sprout red oak and aspen were often the first species to recover after fire while aspen, white birch, and scattered pines soon seeded in. As these pines matured and began to produce seed a new generation of pine seedlings joined by red maple began to appear beneath the deteriorating oak and aging aspen. These pines will eventually become the dominant species in the stand.

On more mesic sites (e.g. fine sandy loams with high water tables) white pine frequently grew in mixture with hemlock of the same age or with an understory of hemlock and shade tolerant hardwoods. Fire in these stands was not frequent and blowdowns were the major form of disturbance. Fire often burned in the down timber providing a better opportunity for pine regeneration. Moist areas of various soils supported good pine, e.g. near the St. Croix river, along the north shore of Green Bay (the area burned by the Pestigo fire), in central lower Michigan, southern Ontario, and elsewhere.

On the truly mesic sites with loam and silt loam soils, white pine was often present usually as scattered individuals of considerable size with crowns reaching 120-150 feet in height and extending well above the hardwood canopy of sugar maple, basswood, yellow birch, and hemlock. These stems appear to have been trees remaining from a former white pine forest that had been invaded by hardwoods. Examples of mature pine stands with an understory of pole size or larger sugar maple can be found today. In many cases pine occurs in several age classes suggesting repeated fires, with the hardwood species similar in age to the younger pine. An alternative explanation for the old pine seen in northern hardwood forests is that pine seedlings originated in windfalls or small burns that formed openings in the hardwood stands. However, the age of the large trees and other evidence suggests that in most cases these scattered pines were remnants of old, more extensive pine stands (Graham 1941, Stearns 1947, 1949, 1951).

White pine also occurs on peat soils with tamarack and black spruce (Curtis 1959), where it often becomes established on hummocks. It may invade abandoned fields as it did extensively in New England during the last century. In old fields it grows in association with other pioneer species such as pin and choke cherry, white birch, and aspen. White pine is also successful on the shallow soils of the Canadian Shield and on northern sites where it grows in association with balsam fir and white spruce. Relic stands are also found in sheltered locations in southwestern Wisconsin and elsewhere.

Once again we must recognize the versatility of white pine; a pioneer of old fields, a member of successional communities of aspen and white birch or oak, and a conspicuous member of the terminal hardwood forest. With proper management, white pine could once again become a major component of our northern forests.

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A 7000-YEAR HISTORY OF WHITE PINE

George L. Jacobson Jr.[1]

ABSTRACT. Paleoecological evidence reveals that the distribution and abundance of white pine has varied greatly across northeastern North America during the past 12,000 years. After reaching Minnesota 7000 years ago, its westward expansion was stopped for several thousand years by warm, dry climates of the mid Holocene. White pine later spread across central and northern Minnesota -- often replacing oak, probably in response to lowered fire frequency associated with a cooler, moister climate at the western (arid) end of its range. Generally, however, the species has been most abundant when climates were somewhat warmer and drier than those of northeastern North America today. Maps of temporal changes in pollen abundance in lake sediments suggest that white pine would be favored by future climates that are warmer than today's.

INTRODUCTION

In the past, changing climates have led to numerous continent-scale reorganizations of biota. During the Quaternary Period -- the last 2 million years of earth history -- the climate has alternated regularly from glacial to interglacial conditions. The changing climates, which are driven in part by changes in the earth's orbit, are sufficient to cause the ranges of species to shift hundreds and even thousands of kilometers (Huntley and Webb 1989). Mapped data from paleoecological studies show that modern plant assemblages have generally not existed for more than a few thousand years, and that even the biomes we recognize today were not present through much of the past 18,000 years (see colored maps in Jacobson et al. 1987).

Through time, species such as white pine have had to deal with continuously changing environments. Indeed, most taxa living in North America must be highly capable of adjusting to changing climate and changing biotic environments (Hunter et al. 1988). Careful analysis of past responses to climate change can provide important clues to how a species will react to specified future conditions. In this paper I consider (1) postglacial changes in distribution and abundance of white pine, (2) the 7000-year history of the species in Minnesota, and (3) responses of white pine to climate change.

POSTGLACIAL SPREAD OF WHITE PINE ACROSS EASTERN NORTH AMERICA

White pine (*Pinus strobus* L.) may well persist in eastern North America only because the continental shelves off the mid-Atlantic coast were exposed during the forty or so Quaternary ice ages. Almost nothing is known about where viable populations of the species survived during the glacial maxima (when thick ice sheets covered much of its present range), but the fossil record indicates that this temperate tree may well have lived on land that was exposed off the east coast of our continent as sea-level fell when ice accumulated on land. The earliest post-glacial fossil record of white pine dates to somewhere around 13,000 years ago in the Shenandoah Valley of Virginia (Craig 1969), and the initial spread of the species was northward from that region (see Maxwell and Davis 1972, Davis 1983, Watts 1979).

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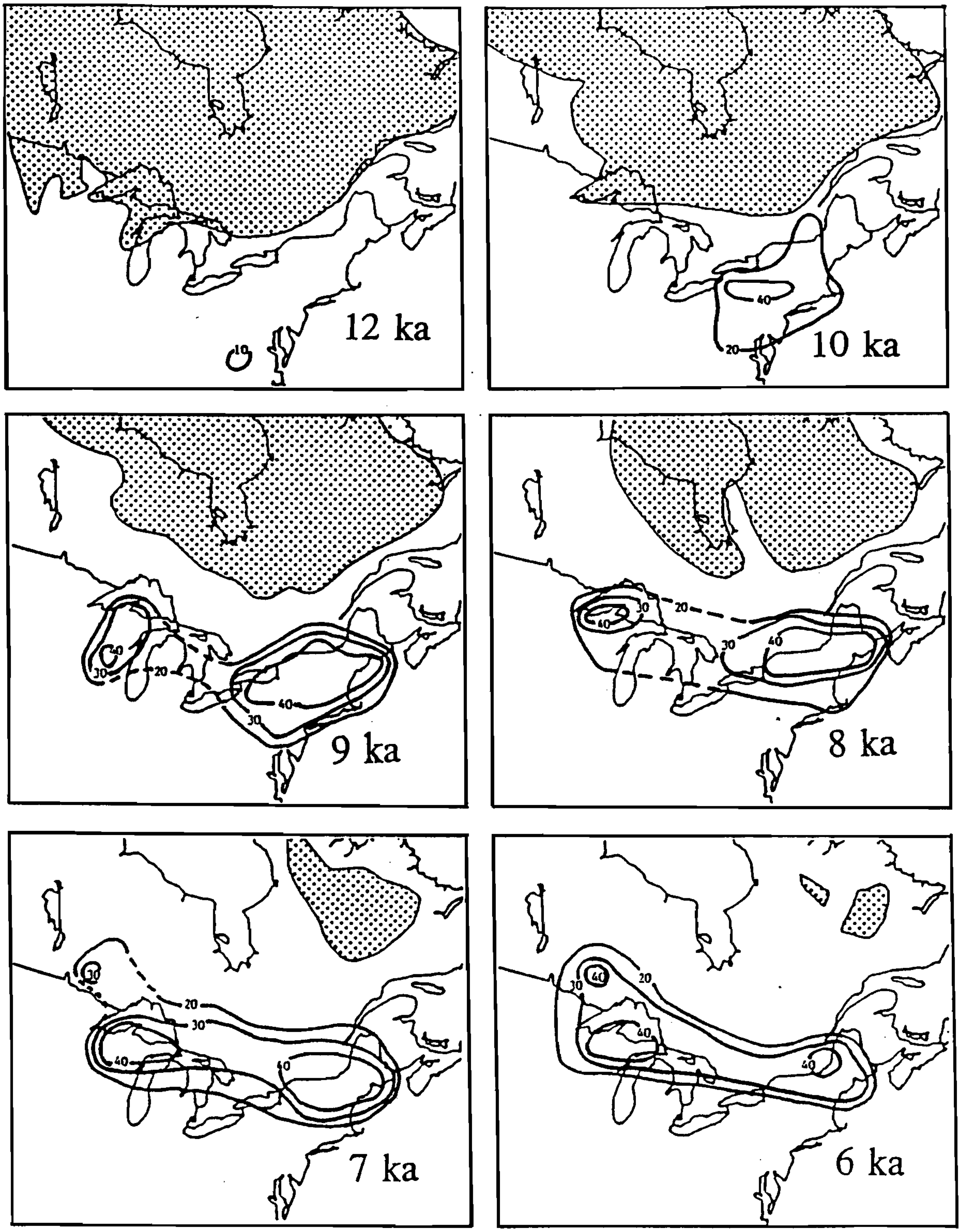

Figure 1. Isopoll maps for white pine during the past 12,000 years (time designated in kiloanni (ka)). Data from approximately 150 sites are summarized by lines of equal proportional representation of white-pine pollen across eastern North America. Stippled areas denote ice cover.

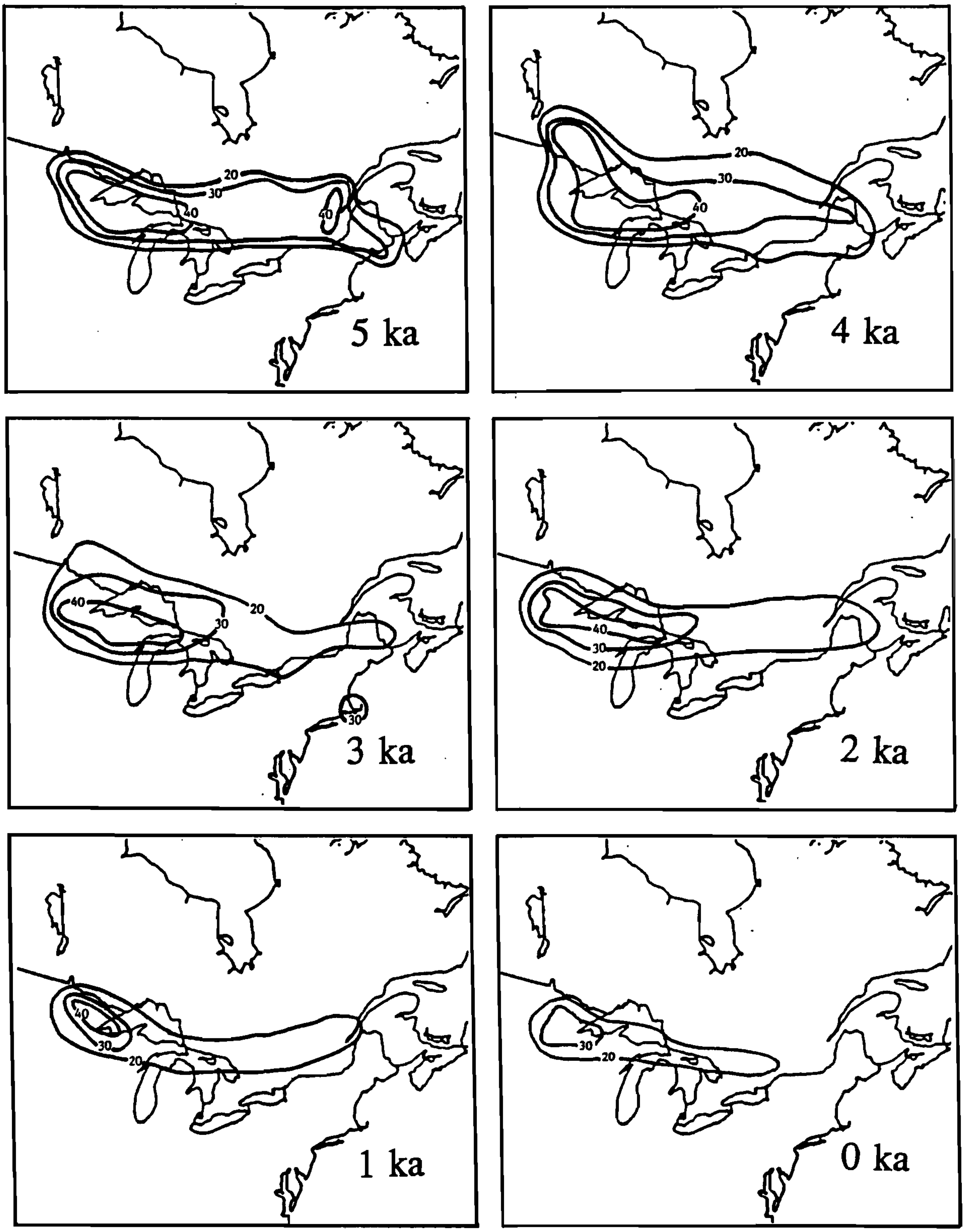

Figure 1 (continued).

Data from numerous paleoecological investigations completed during the past several decades allow mapping of temporal changes in the distribution and abundance of selected plant taxa in eastern North America. T. Webb III, of Brown University, collaborated with many other researchers to compile a computer-based research database for fossil pollen; these data have been used extensively in recent studies of post-glacial climates and vegetation (e.g. COHMAP 1988, Bartlein and Webb 1985, Jacobson et al. 1987). Converted to a format that facilitates use by researchers interested in paleoenvironmental reconstructions, the database has now been designated the North American Pollen Database (NAPD), and is under the direction of E.C. Grimm at the Illinois State Museum, Springfield, IL. Information derived from this database is used here to illustrate the history of white pine during the past 12,000 years.

A time-series of maps (Figure 1) shows the distribution and relative abundance of white pine pollen in lake sediments across northeastern North America, and reveals striking changes since the last ice age. Once it colonized the areas of Virginia and western Maryland, white pine spread rapidly to the north and west, reaching northern New England by 10,000 years ago (Davis and Jacobson 1985) and the western Great Lakes region by 9000 years ago. The centers of highest abundance shifted considerably during the Holocene (the present interglacial), and the extent of those areas varied by approximately an order of magnitude. Isopoll maps of other taxa (Jacobson et al. 1987) provide a useful context for evaluating regional changes in white pine.

Before about 6000 years ago, the major concentrations of white pine were split between the eastern Great Lakes/New England region and an area west of Lake Michigan. Since then they have been strongly skewed toward the western Great Lakes region. The species reached its northernmost extent about 4000 years ago, with the range shrinking southward thereafter. Perhaps the most interesting and dramatic feature of the maps (Figure 1) is the 4000-year-long reduction in abundance of white pine that occurred *prior to the timber harvesting of the past century.*

7000 YEARS OF WHITE PINE IN MINNESOTA

The range of white pine first extended into Minnesota 7000 years ago, apparently arriving from both south and north around Lake Superior (Jacobson 1979, Björck 1985). After spreading rapidly into the area north of the lake, it remained restricted to that region for the next 2500 years or so (Figure 2). The time between about 7000 and 4000 years ago is known informally among paleoecologists as the "prairie period" in Minnesota, because the warm, dry climate of the time led to considerable eastward expansion of prairie at the expense of forests (McAndrews 1966, Bernabo and Webb 1977, Jacobson and Grimm 1986). During that time the prairie-forest border shifted eastward by as much as 100 km, and conditions were not suitable for white pine to move west (Wright 1968). Beginning about 4000 years ago, however, the prairie-forest border began to shift to the west, and white pine followed. This initial westward expansion was rapid, especially across the northern third of the state, where a shift of more than 100 km occurred between 3500 and 2500 years ago (Figure 2). Thereafter, changes continued slowly until the time of logging. In fact, some of the major pine forests, and especially those of central Minnesota, had been present for only a few generations when they were cut for lumber.

Detailed paleoecological investigations of sediments from small lakes on different edaphic and topographic settings have proven useful for reconstructing the changing mosaic patterns of vegetation within a given region (see Brubaker 1975, Jacobson 1979). In Minnesota such studies reveal that in its westward spread across Minnesota white pine largely replaced oak (*Quercus* spp.), which had advanced eastward during the prairie period (Figure 3). The interaction probably involved oak-scrub vegetation similar to that which characterized much of the prairie-forest border at the time of European settlement (see Grimm 1984 for

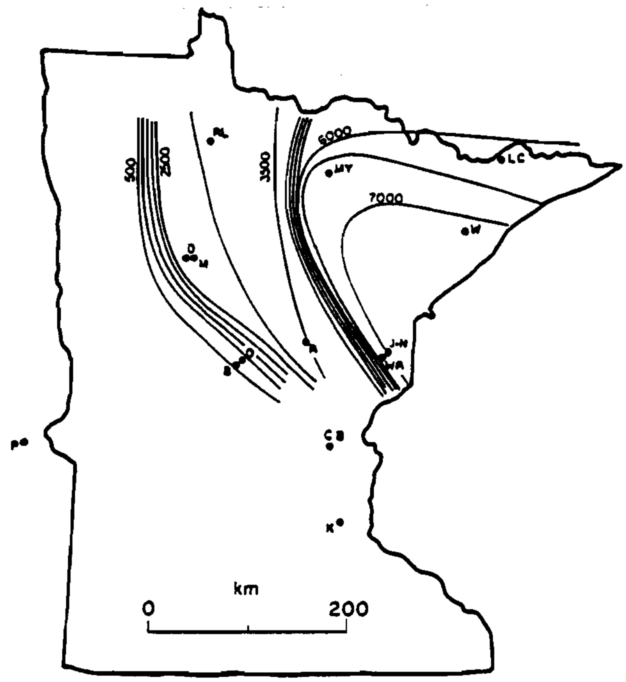

Figure 2. Migration of white pine across Minnesota beginning 7000 years ago, showing the position of the advancing front at 500-year intervals . From Jacobson (1979).

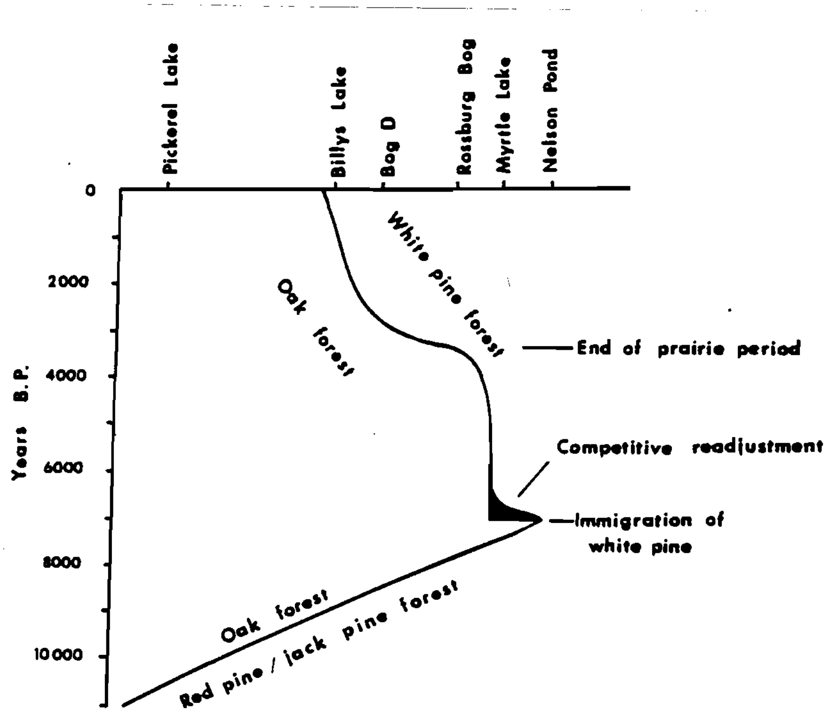

Figure 3. Time-space representation of the shifting zone of transition from oak-dominated forests to pine-dominated forests in Minnesota. Sites are arranged from southwest to northeast according to their present distance from the prairie - forest border. From Jacobson and Bradshaw (1981).

a useful, detailed discussion of these forests). The most likely scenarios for this replacement involve slight reductions in the frequency of fire beginning about 4000 years ago as the climate became cooler and moister (Jacobson 1979). This change allowed white pine seedlings to grow large enough that some could survive subsequent ground fires. Eventually the successful pines would overtop the oak canopy and, by shading, suppress future reproduction of oak. Curtis (1959) describes several examples of a similar process occurring in recent Wisconsin forests. The replacement of oak by white pine was restricted largely to sites where soil parent-materials were glacial tills, typically where local relief was moderate. By contrast, areas of flat, sandy, outwash usually came to be covered by jack pine (*Pinus banksiana*) (Almendinger 1985, Jacobson 1979). A more extensive discussion of the vegetational change from oak to white pine can be found in Jacobson (1979).

RESPONSES OF WHITE PINE TO CLIMATE CHANGE

Transeau (1905) recognized that the western range-limit of white pine occurs approximately where precipitation equals evapotranspiration. At the other end of the moisture spectrum, the species does not do well when conditions become too cool or moist, for example at the transition to the southern margins of the boreal forest in northern New England and adjacent Canada.

The variations in distribution and abundance of white pine (Figure 1) mirror the major changes in climate that have occurred during the past 12,000 years. Extensive regions of high white-pine abundance in the early Holocene coincided with climates that were consistently drier and probably somewhat warmer than present (see COHMAP Project Members (1988) for a broad-scale discussion of changing climates during the past 18,000 years). In general, the regions of highest abundance of white pine are also areas in which the frequency of forest fires was relatively high and precipitation was not much greater than evapotranspiration. For example, lake sediments deposited 10,000 to 7000 years ago in New England have consistently high proportions of pollen from white pine and oak; they also contain considerable quantities of charred particles, as well as evidence of lowered lake levels (Jacobson et al. unpublished, Anderson et al. in press, Webb 1990). Similar conditions have probably occurred throughout the Holocene in much of the western Great Lakes region.

The climate 6000 years ago in the upper midwest was characterized by mean July temperatures approximately 2°C warmer than at present (Bartlein and Webb 1985); the fact that mean July temperatures in central Europe also were 2°C warmer at that time (Huntley and Prentice 1988) suggests that a global phenomenon was involved. A significant shift toward cooler, moister conditions 4000 years ago led to the westward expansion of white pine in Minnesota, and, coincidentally, to the expansion of blanket peatlands at the expense of Scotts Pine (*Pinus sylvestris*) in central Scotland (Gear and Huntley 1991).

The reduction in overall abundance of white pine in northeastern North America during the past 4000 years has taken place as cooling of the climate allowed boreal taxa to move southward. For example, the southern range-limits of spruce (*Picea* spp.) and Balsam fir (*Abies balsamea*) shifted from Canada into the northern tier of states from Maine across to Minnesota, and the general decrease in abundance of white pine has continued essentially to the present (Figure 1). Using equations derived from modern pollen and climate data, Gajewski (1988) estimated a cooling of about 0.5°C during the past 500 years.

WHAT OF THE FUTURE?

Although no one can predict confidently how climates will change in the next few centuries, considerable efforts have been made to model future conditions under the assumption that carbon dioxide and other greenhouse gases will trap heat and produce a net warming. Most such models (General Circulation Models) suggest that mean summer temperatures will increase by several degrees Celsius at the latitude of the Great Lakes and New England. If the success of white pine under the warmer, drier conditions of the mid Holocene is any indication, such a warming might well favor the species in the near future.

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THE RELATIONSHIP OF NATURAL DISTURBANCES TO WHITE PINE STAND DEVELOPMENT

Lee E. Frelich[1]

ABSTRACT. Under natural conditions white pine is most abundant in forests with a rotation period of 150 to 300 years between catastrophic fires. After a fire, white pine seedling establishment occurs slowly, over a period of 20 to 40 years. Seed sources are permanent populations of pines near lakeshores or swamps, on rock outcrops, and individual trees or nearby stands that survive disturbance by chance. Establishment usually occurs under a canopy of faster-growing or sooner-established species such as aspen, birch, red maple, or oak. On relatively dry sites, surface fires every 20 to 40 years gradually eliminate hardwoods and create multi-aged pine forests that may persist for centuries. On relatively moist sites, succession to shade-tolerant hardwoods may occur. Severe windstorms that occur several times each century gradually reduce the pine component and advance succession towards hardwoods. White pine persists indefinitely at a low level in hardwood forests by the mechanism of gap phase dynamics. Succession from shade-tolerant hardwoods back to white pine may occur when intense fires get started in slash from catastrophic blowdowns.

INTRODUCTION

White pine forests persisted for thousands of years under the influence of natural disturbances that shaped their structure and species composition. However, since the era of major harvest during the nineteenth and early twentieth centuries, white pine has fared poorly. Acreages of white pine forest today are a small fraction of those in presettlement times, and the proportional reduction has been larger than for most other species. Thus, the mechanism of persistence under natural conditions is of interest from both silvicultural and conservation biology points of view.

The persistence and wide-spread success of white pine as a species in presettlement forests, and its dependence on fire, is a paradox because white pine does not have adaptations to fire possessed by the classic fire-adapted species. Although white pine responds favorably to exposed mineral soil seedbeds and high sunlight after fires, it does not have serotinous cones like jack pine and black spruce, the ability to sprout vegetatively after fire like aspen, or widespread abundant seeds nearly every year like aspen and paper birch. White pine grows relatively slowly during the critical first few years after germination, allowing faster growing species to dominate young post-fire stands. Compensating life-history characteristics white pine does possess are long lifespan, ability of mature individuals to survive surface fires, and moderate tolerance to shade. White pine seedling establishment is good on mineral or peaty organic soils, but not on thick duff.

The objective of this paper is to examine how life-history characteristics of white pine interact with natural disturbances to determine its niche within the forested landscape of its geographical range. This objective will be approached by answering three questions:

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1. How are white pine forests initiated by natural disturbances?
2. How do white pine stands develop over time?
3. What is the successional status of white pine forests and how do they persist for long periods of time?

WHITE PINE AND CATASTROPHIC DISTURBANCE

Catastrophic natural fires ignited by lightning occur in the range of white pine during spring, or late summer/autumn, after 2 or 3 months of drought at the sub-continental scale (Haines and Sando 1969, Heinselman 1973, Cwynar 1977). White pine is most abundant in areas where the fire cycle (mean rotation period for catastrophic fires) is 150 to 300 years, although mixed red-and-white pine stands occur near the lower end of this range of fire cycles (Table 1, Heinselman personal communication). Where the fire cycle is 100 to 150 years, red pine is favored, while fire cycles less than 100 years favor jack pine, aspen, paper birch, and pin or bur oak. As fire cycles increase above 300 years, northern hardwoods become abundant (Figure 1).

Table 1. Natural rotation periods for catastrophic fire and forest species composition within the range of white pine.

Rotation Period (yr)	Location	Reference	Species Composition
50	BWCA, MN	Heinselman 1973, 1981	Jack Pine-Black Spruce
80	BWCA, MN	Heinselman 1973, 1981	Aspen-Birch-Fir
80-170	N. MI	Whitney 1986	Jack Pine
150	Itasca, MN	Frissell 1973	Red-White Pine
130-260	N. MI	Whitney 1986	Jack, Red, and White Pine
170-340	N. MI	Whitney 1986	Mixed Pine and Oak
180	BWCA, MN	Heinselman, 1973, 1981	Red and White Pine
175-300	Algonquin, Ontario	Cwynar 1978	White Pine-Aspen
800	NE Maine	Lorimer 1977	Spruce-Fir-Beech-Maple
1400-2800	N. MI	Whitney 1986	Hemlock-White Pine-N. Hardwoods
2800-4500	Upper MI	Frelich and Lorimer 1991	Northern Hardwoods-Hemlock

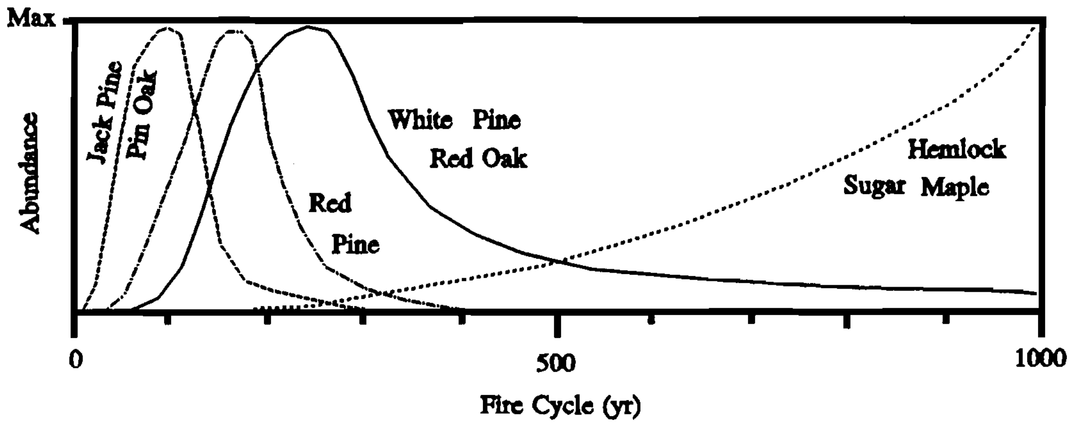

Figure 1. Hypothesized relationship between the fire cycle and abundance of major forest species. The Y axis is a unitless scale of abundance--each species is assumed to reach a maximum abundance at some disturbance cycle.

No forest type in eastern North America is documented to have a fire cycle between 300 and 800 years. This may be due to feedback effects of tree species on fuels that support fires. If the fire cycle becomes more than 300 years, then hardwoods invade and change the fuel type in such a way that fires become much less common. Windthrow then becomes the dominant type of disturbance--hardwood forests within the range of white pine experience windthrow mortality of 10 percent or more every 70 years on average (Frelich and Lorimer 1991), and catastrophic windthrow at intervals of 1000 to 2000 years (Lorimer 1977, Canham and Loucks 1984, Whitney 1986, Frelich and Lorimer 1991). Windthrow is generally not favorable to white pine establishment, although a few white pine generally occur in post-blowdown stands. Only one instance of heavy recruitment of white pine after windthrow is mentioned (Hough and Forbes 1943) by the literature cited in Tables 1 and 2, although many instances of heavy recruitment are documented after fire.

WHITE PINE AND STAND DEVELOPMENT

GENERAL SCHEME

Four stages of stand development after Oliver (1981), provide a useful framework. These are: (1) Stand Initiation, the stage during which a site is being stocked with new seedlings after a disturbance; (2) Stem Exclusion, the stage beginning with canopy closure during which self-thinning (density-dependent mortality) occurs and gaps are quickly filled by surrounding canopy trees, effectively excluding new stems from entering the canopy from below; (3) Overstory Reinitiation, the stage beginning when gaps formed by dying trees are so large that they cannot be filled by horizontal crown expansion of existing canopy trees, and new recruitment from below reaches the canopy; and (4) Old Multi Aged, the stage during which the forest canopy has many age classes of trees. Figure 2 shows a diagrammatic example of these stages in an aspen-white pine forest.

STAND INITIATION AND STEM EXCLUSION STAGES

Seedling establishment by white pine in post-fire stands usually takes place over 20-40 years under a faster-growing or earlier-established canopy of aspen, paper or gray birch, red maple or oak (References in Table 2 and Toumey 1919, Spaeth 1922, Lorimer 1977). Some white pine seedlings may be in the canopy of the new stand from the start if restocking by other species is slow. White pine has ample opportunity for establishment under aspen, because survivor trees can shed seed into the burn over a period of years, while seed sources of species like sugar maple that could outcompete white pine usually do not survive the stand-initiating fire.

The shade cast by post-fire species such as aspen or oak is not as dense as that in sugar maple stands, so growth of mid-tolerant white pine saplings is good--usually one to two feet per year. Near the end of the stem exclusion phase (which varies from 40 to 80 years of age), many of the white pine are tall enough to take over positions in the canopy as the mature aspen begin to die and the stand enters the overstory reinitiation stage (Figure 2).

Table 2. Period of peak recruitment of white pine after heavy disturbance, and associated species being recruited at the same time.

Peak Recruitment (Yr)	Location	Reference	Associated Species
25-30	Ontario	Cwynar 1977	Aspen, Red Pine
25	Kawishiwi N. MN	Frelich, unpublished	Aspen, paper birch, red maple
40	Quebec	Maissurow 1935	Birch, Aspen
20	NH	Henry and Swan 1974	Hemlock, Paper Birch
25-35	NH	Foster 1988a	Paper Birch, Red Maple, Hemlock
10	MA	Hibbs 1983	Red Maple, Cherry, White Ash, Gray Birch
20-40	PA	Hough and Forbes 1943	Chestnut, Red Maple, Red and White Oak
20	WI	Frelich, unpublished	Pin Oak, Bur Oak, and Jack Pine

OVERSTORY REINITIATION AND OLD MULTI-AGED STAGES

During the overstory reintiation stage, white pines enter the canopy at different times, as gaps caused by the death of mature aspen appear. In addition, some white pine may have been in the canopy from the start, and others are suppressed under larger white pines. These processes lead to differential growth rates and the development of a hierarchy with rapidly growing canopy-emergent white pine and slower growing trees in intermediate and overtopped positions. The diameter distribution becomes bimodal (Figure 2).

Two types of non-catastrophic disturbance facilitate the transition from overstory reinitiation to old multi aged, which generally occurs between 100 and 200 years of age. White pine is very susceptible to high winds, susceptibility increasing with the site of the tree (Stoekeler and Arbogast 1955, Foster 1988b). Therefore, trees in the canopy emergent position are often toppled by wind and other white pines from a lower position in the hierarchy are released into the canopy. A second disturbance may be surface fires at intervals of 20 to 40 years (Frissell 1973). If shade-tolerant hardwoods are invading the understory, they may be killed by surface fires. In addition, a few of the large white pines may be killed by surface fires, opening gaps for recruitment of new white pine seedlings and saplings. The gaps caused by wind and surface fires cause a stand to become increasingly multi aged, with a multi-modal diameter distribution. White pine stands may be maintained in the old-multi-aged stage for one to several centuries (Heinselman 1981), until they are hit by another catastrophic disturbance.

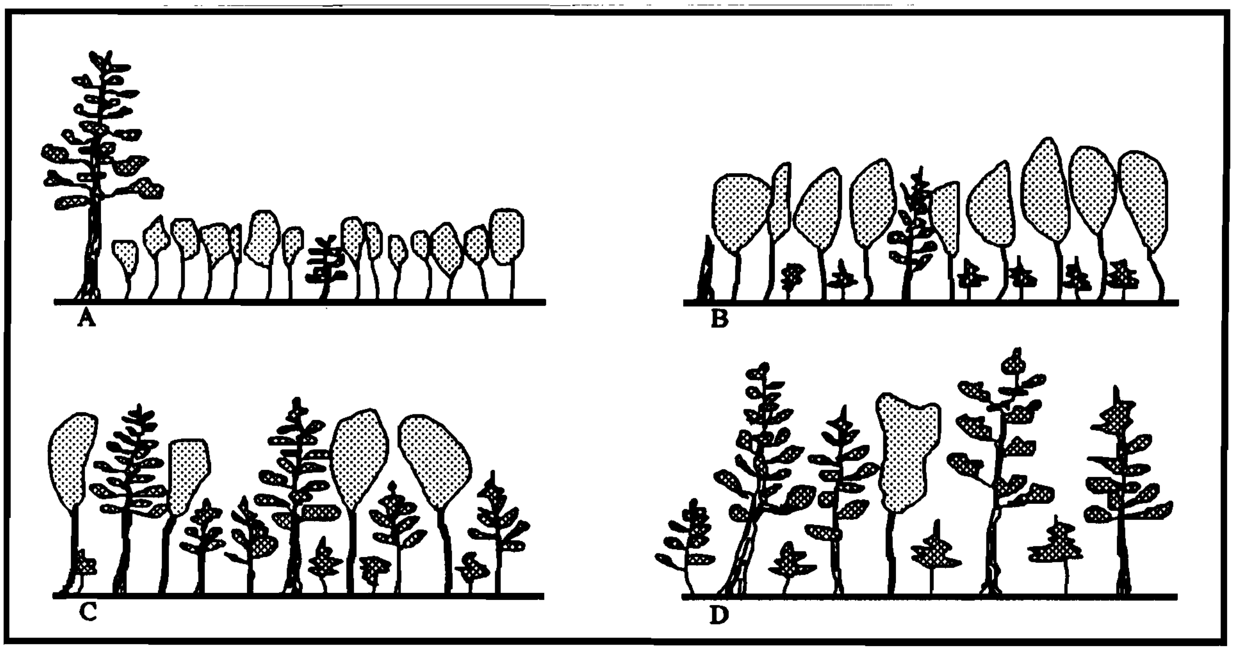

Figure 2. Canopy-structure profiles of the four stages of stand development in an aspen-white pine forest. A. Stand-initiation stage. B. Stem-exclusion stage. C. Overstory-reinitiation stage. D. Old- multi-aged stage.

WHITE PINE AND SUCCESSION

CYCLIC SUCCESSION

A repeating, cyclic sequence of catastrophic fires with intervening light surface fires (Figure 3) can lead to long-term dominance by white pine for several thousand years. There would be pulses of species such as aspen after each major fire, so that some succession would occur from time to time. When old-multi-aged white pine or mixed white-red pine stands are maintained by surface fires, periods of several centuries with little species composition change and little succession are also possible. However, other cycles may occur in which white pine alternates with northern hardwoods (Figure 3). Certain thresholds in disturbance frequency may allow succession from white pine to northern hardwoods or vice versa, similar to the disturbance mediated transition between fire-dependent oaks and northern hardwoods that occurred in Minnesota's Bigwoods in presettlement times (Grimm 1983). A necessary condition for succession from white pine to northern hardwoods is several centuries without major fire and a relatively low frequency of surface fire. Two major factors can cause such successional events:

- A stand is missed at random by fire. Under natural conditions, disturbances that occur at random with respect to stand age may skip individual stands for periods of 1 or more consecutive rotations (Table 3, Van Wagner 1978). For example, if the natural rotation period for a white pine forest is 200 years, then 13.5 percent of stands may survive 2 rotation periods (400 yr) and 5 percent may survive 3 rotation periods (600 yr, Table 3). This would be enough time for succession to northern hardwoods on sites with the appropriate soil type. Successive windstorms would selectively remove the canopy emergent pines, and release very-shade-tolerant species such as hemlock and sugar maple.
- Species composition-fuel feedbacks. If a stand is missed by disturbance for 2 or 3 rotation periods, and species like hemlock or sugar maple become a major component of the forest, then the fuels on the forest floor become more difficult to burn, and the rotation period for fires is greatly lengthened.

Other factors will also contribute to this successional process: (1) a coincident change to cooler/wetter climate (Davis et al. 1992), (2) fine textured soils and (3) presence of topographical fire breaks. In presettlement times, this transition to hardwoods probably occurred more often in mostly white pine stands than in mixed red-white pine forests, due to differences in the fire cycle. Currently, fire suppression is allowing many pine stands to succeed to hardwoods.

Succession from northern hardwood back to white pine (Figure 3) requires an unusually intense fire or series of fires. Two major factors may cause this sequence to occur:

- Windfall-fire interactions. Although fires are not common in northern hardwood forests (Frelich and Lorimer 1991, Davis et al. 1991), slash from a heavy windfall event can be quite extensive and can dry out and provide fuel for intense fires (Stearns 1949, Whitney 1986, Foster 1988a, Lorimer 1977). The post-fire successional sequence commonly included aspen-birch and white pine.
- Severe drought. At any one time on a natural landscape, there are areas of recent windfall. However, they are more likely to burn if a subsequent drought occurs.

Other factors that contribute to conversion of hardwoods to white pine are: (1) coincident change to warmer/drier climate, (2) chance occurrence of more than one disturbance in a short time interval, (3) sandy soil and (4) lack of topographical firebreaks.

Table 3. Percent of stands surviving one to four rotation periods when natural catastrophic disturbances are random with respect to age (Van Wagner 1978).

Number of Rotation Periods	Percent of Stands Surviving
1	36.8
2	13.5
3	5.0
4	1.8

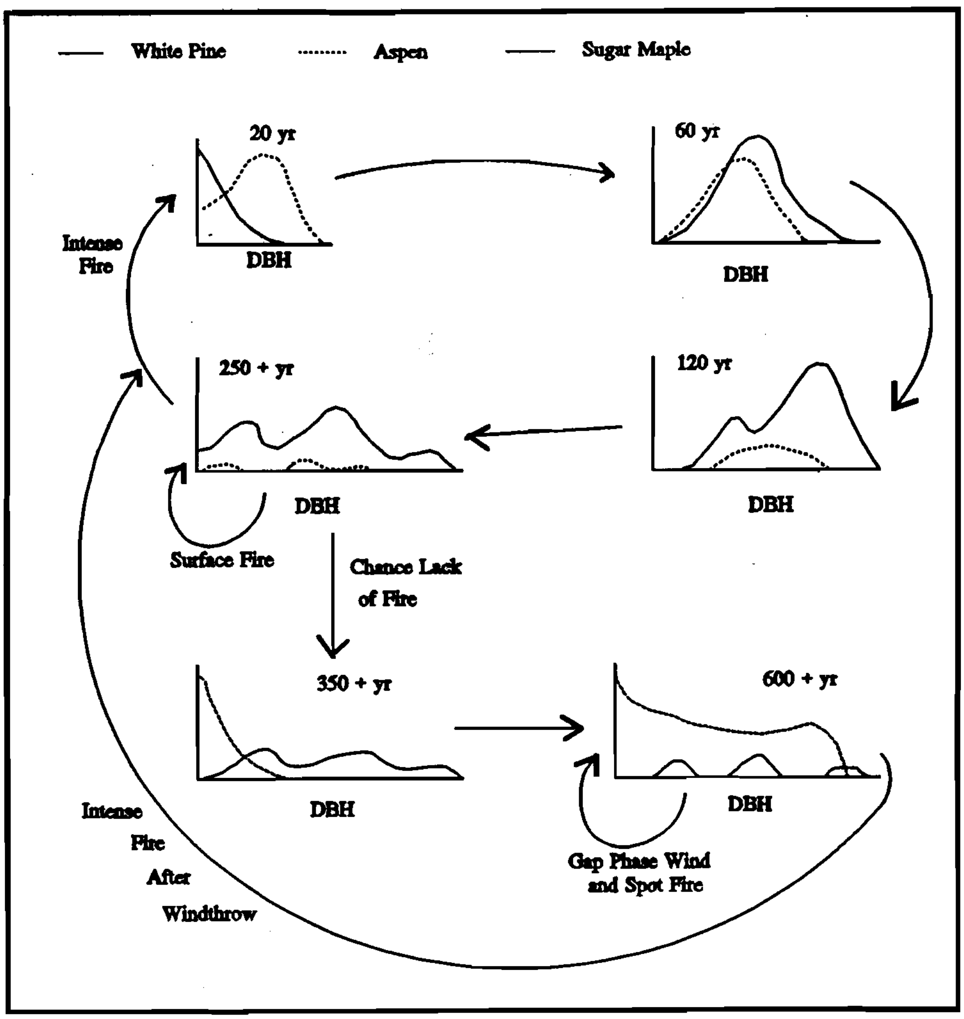

Figure 3. Stand development and cyclic succession in white pine and white pine-hardwood forests. Generalized diameter-frequency distributions are shown for each stage.

SEED SOURCES FOR LONG-TERM PERSISTENCE

Where do the seeds that allow long-term persistence of white pine come from? In northern hardwood stands, repeated thinning by windstorms reduces the white pine component over time (Henry and Swan 1974, Oliver and Stephens 1977, Foster 1988a,b). However, chance establishment in a small proportion of gaps occurs throughout hardwood forests (Hibbs 1982, Frelich, personal observation). Spot fires often result in establishment of a small cluster of white pine and red oak in hardwood forests, and the resulting isolated pines which tower above the hardwood canopy are more likely to be struck by lightning when old, and cause a new spot fire at same the location. Table 4 summarizes sources of seed that in presettlement times were well distributed over large areas. Not many areas in the Lake States or New England were far from rivers, lakeshores, swamps or rock outcrops which often function as a permanent white pine seed source.

Table 4. White pine seed sources allowing persistence of white pine and/or slow reseeding after fire.

Seed Source	Reason for Persistence	Duration
Lakeshores, Riverbanks	Frequent lakeshore spot fires, rocky ledges, sandy berms, erosion.	Permanent
Swamps, Wetspots	Frequent exposed mineral or organic soil due to windthrow of shallow rooted trees.	Permanent
Rock outcrops	Exposed mineral soil always available.	Permanent
Gap Phase Dynamics	Windthrow creates exposed mineral soil on tip-ups, and rotten logs. Spot fires.	Erratic in one stand
Survivor Trees	Erratic fire behavior.	Up to 450 years
Survivor Stands	Missed by disturbances.	Up to 450 years

CONCLUSIONS

Several points about the role of disturbance in white pine stand development are clear at the current time:

- A disturbance regime most favorable for white pine consists of a fire cycle of 150 to 300 years and intervening light surface fires every 20 to 40 years.
- Massive recruitment of white pine after heavy windthrow is/was rare. Conditions for such an event would have to be just right: removal of an aspen overstory by wind releasing the white pine understory, or removal of a white pine overstory in a stand with little hardwood advanced reproduction after a good seed year for white pine.
- Widely scattered seed sources and gradual invasion of post-fire stands over a 20 to 40 year period is the strategy that allowed white pine to be a successful species in presettlement times. Its life-history characteristics of long lifespan, ability of mature trees to survive some fires, and moderate shade tolerance are well suited to this strategy.

- Succession from white pine to shade-tolerant hardwoods depends on random departures from the mean disturbance frequency. A stand must be skipped by major fire for several centuries for this succession to occur.
- Succession from shade-tolerant hardwoods back to white pine depends on an unusual event, such as intense fire following a catastrophic windfall, which may only occur every 1000 to 2000 years at a given location.

What is not known at this time is how much of the original pine that was logged during the nineteenth and early twentieth centuries was scattered individuals persisting in northern hardwood stands by gap phase dynamics, how much was successional pine that was moving toward shade-tolerant species composition, and how much was genuine pine forest that was perpetuated by the combination of catastrophic and surface fires most conducive to white pine. Oak forests and savannas and forests near the prairie-forest border were changing to sugar maple-basswood forests during the past several hundred years (Grimm 1983), in response to the relatively cool, moist climate of the little ice age. It could be that the same was happening to white pine forests. The process of settlement and subsequent fire suppression tends to accelerate this type of process. Several authors suggest that white pine does not persist under human management because of various combinations of the following variables, in addition to blister rust: (1) removal of seed sources over large areas, (2) substitution of logging for fire as the major type of disturbance, (3) poor seedbed conditions for pine in second growth forests, (4) ability of hardwoods to revegetate forests rapidly by sprouts under short-rotation harvest, and (5) deer browsing (Maissurow 1935, Hough and Forbes 1943, Cwynar 1977, Foster 1988b).

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UNDERSTANDING OLD-GROWTH RED AND WHITE PINE-DOMINATED FORESTS IN ONTARIO

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In the summer of 1991 a variety of forest stands dominated by old specimens of white pine and red pine were sampled across a representative portion of the species' range in north central Ontario, Canada. Plots were established in forty of those stands surveyed.

The objectives of the study were to survey the physiognomy of old-growth stages of red and white pine forests in order to identify the salient structural components of old-growth, to survey the floristic composition (vascular plants and autotrophic non-vascular plants), to survey site characteristics and to estimate the links in understorey alpha diversity with site condition and stand structure. Long-term objectives include a definition of old-growth pine forest, recognition criteria, and prospective management options.

Forest stand structure was enumerated through mapping, mensurational, and age estimation techniques. Forest vegetation, including over- and understorey species was non-destructively sampled according to standard procedures in vegetation study. A range of data on stand and soil-site variables was also collected in conjunction with information on stand variables peculiar to 'old-growth forests (e.g. volume of downed wood). The data set was limited in size but relatively broad in terms of geographical scope and physiographic site type.

Stands ranged from approximately 60 to 300 years in upper canopy age, from 23.3 square meters per hectare (m^2/ha) to 92.7 m^2/ha live basal area, from 0.2 m^2/ha to 31.2 m^2/ha snag basal area, and from 0.0 m^2/ha to 183.8 m^2/ha standing dead basal area, with respective averages of 141 years, 42.1 m^2/ha, 4.6 m^2/ha, and 56.5 m^2/ha.

Understorey floristic richness ranged from approximately 35 species in stands with a uniform canopy and even forest floor environment to approximately 75 species in stands with discontinuous canopies and uneven forest floors. Although graminoids demonstrate increased diversity with site quality, the nature and heterogeneity of forest floor substrata largely determine the total understorey floristic diversity and composition.

Canopy and understorey data were submitted to various forms of multivariate analysis yielding a consistent site related trend among stands from relatively infertile, shallow soil deposits to fertile, deep soil deposits. The gradient is partitioned into three segments for the purpose of discussing ecosystem properties, stand dynamics, and management options.

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SUPERCANOPY WHITE PINE AND WILDLIFE

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ABSTRACT. A survey of the literature showed that scattered supercanopy white pines perform a different wildlife function than do white pine communities. They add structural diversity to the communities in which they occur, providing nesting and foraging opportunities that would otherwise not be available. They are the preferred refuge trees and bedding sites for black bear mothers with cubs, which selected supercanopy white pines for 90 percent of all early spring beds and for 88 percent of summer overnight beds in northeastern Minnesota. Although supercanopy white pines comprise only a fraction of 1 percent of the trees in the Superior National Forest, they held 81 percent of eagle nests and 77 percent of osprey nests in 31 years of nest survey data. Supercanopy white pine snags show higher woodpecker use than do other northern forest snag species. Information is lacking about the importance of specific tree types (e.g. supercanopy white pines) to most wildlife species. It is important to maintain options for the future by maintaining the white pine component, including scattered supercanopy individuals, in all ecosystems in which it naturally occurs.

White pines (*Pinus strobus*) occur in Minnesota as white pine communities (often mixed with other tall pines) and as scattered individuals in other communities. Janet Green (this symposium) will discuss the wildlife values of white pine communities. I will discuss what little is known about the importance to wildlife of the scattered old supercanopy white pines that dot the horizons of northern landscapes. Scattered old white pines create conditions different from those created by white pine communities. The scattered trees add diversity to the aspen, birch, spruce, or fir communities in which they commonly grow. They add a vertical dimension and crown structure that is seldom duplicated by red pines (*P. resinosa*), jack pines (*P. banksiana*), or other northern tree species. In so doing, the white pines give these forests a multilayered quality that provides nesting and foraging opportunities for a greater range of species than otherwise might be the case. Beyond that, the old pines serve particular purposes for black bears (*Ursus americanus*), eagles (*Haliaeetus leucocephalus*), and ospreys (*Pandion haliaetus*).

BLACK BEAR BED SITES AND REFUGE TREES

Although black bears avoid white pine communities (DeBruyn 1992), scattered supercanopy white pines larger than 50 cm DBH are the preferred refuge trees and bed sites for black bears in northern forests (Elowe 1987, Rogers et al. 1988, Elowe and Dodge 1989, Rogers, unpubl. data). Black bear mothers commonly leave their cubs at mature white pine trees, where available, while they forage nearby in non-pine forest communities (Elowe 1987, Rogers et al. 1988). Mature white pines have thick, fissured bark that escaping cubs less than 5 months old can climb more easily than the slippery or shaggy bark of many other trees (Rogers et al. 1988, Elowe and Dodge 1989). Spring observations of habituated black bears in northeastern Minnesota showed that mothers with cubs selected white pines 41-92 cm DBH (average 69 cm DBH) for 26 (90 percent) of 29 beds even though white pines comprised less than 0.4 percent of the trees larger than 13 cm DBH in the study area (Rogers, unpubl. data). In late spring and summer, when food became more patchily distributed, mothers with cubs foraged farther from white pines

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and used them for only 39 (55 percent) of 71 day beds but moved to white pines for 28 (88 percent) of 32 overnight beds (Rogers, unpubl. data). Lone females, by contrast, used white pines for only 14 (22 percent) of 64 day beds and only 9 (60 percent) of 15 overnight beds, using cool, lowland places for 33 (61 percent) of 54 day beds where habitat was recorded (Rogers, unpubl. data).

BLACK BEAR DENS

Supercanopy white pines are unique among northern forest trees in their potential for becoming high quality den sites. They have large diameters, moderately decay-resistant outer wood (Hosie 1969), and a strong tendency to become hollow (White 1953, Heinselman 1973). Tree cavities are preferred den sites for female black bears throughout the range of the black bear (Jonkel and Cowan 1971, Taylor 1971, Lindzey and Meslow 1976, Hamilton and Marchinton 1980, Johnson and Pelton 1981, Rogers and Allen 1987, Weaver and Pelton 1992). Tree cavities provide superior insulation and protection in winter. They may be particularly important to adult females because parturition and lactation occur in winter dens, and dry, well-insulated cavities allow females to expend approximately 15 percent less energy for body temperature maintenance and more for parturition and lactation (Johnson et al. 1978). Den trees in other parts of North America have generally been between 84 and 257 cm DBH (Switzenberg 1955, Pelton et al. 1980, Weaver and Pelton 1992). In northeastern Minnesota, only two hollow trees close to that size were observed in 24 years of study, and both were used as dens (Rogers 1987). The smaller of these was a 81-cm DBH red pine; the larger was a white pine. Both were in the Boundary Waters Canoe Area Wilderness in a single white/red pine stand more than two centuries old (Heinselman 1973, M. L. Heinselman, personal communication, 1991). The bases of both trees had been scarred by fire about a century ago, creating entrances into their hollow centers. Also in that stand was a hollow red pine snag that was used as a den. The snag was 3 m tall with a 126 cm diameter near the base at den level. In another stand, a white pine stump larger than 120 cm in diameter was used as a den. All were used by female bears (Rogers, unpublished data).

OSPREYS, BALD EAGLES, AND WHITE PINES

The open, irregular crowns of supercanopy white pines enable birds with large wingspans to land and nest. Thirty-one years of nest survey data from the Superior National Forest (SNF) showed that 215 (81 percent) of 264 bald eagle nests and 232 (77 percent) of 301 osprey nests were in white pines even though these trees comprise less than 0.5 percent of the trees larger than 10 cm DBH in the SNF (Kingsley and Ramquist, 1992).

WHITE PINES AND OTHER WILDLIFE SPECIES

Supercanopy white pines are used by many other species of wildlife, but no definite obligate relationship has been proven (Martin et al. 1951, Elias 1980, Rogers 1991, Green 1992). The seeds are eaten by red squirrels (*Tamiasciurus hudsonicus*), gray squirrels (*Sciurus carolinensis*), chipmunks (*Tamias sciurus*), deer mice (*Peromyscus maniculatus*) black-capped chickadees (*Parus atricapillus*), red crossbills (*Loxia curvirostra*), red-breasted nuthatches (*Sitta canadensis*), and others (Martin et al. 1951, Elias 1980). The inner bark is a favorite winter food of porcupines (*Erithizon dorsatum*) (Hazard 1982). Raptors that use supercanopy white pines as perches include the rare boreal owl (*Aegolius funerea*) (Personal communication, Steven G. Wilson, Forest Ecologist, Minnesota Department of Natural Resources, 1991).

When supercanopy white pines become supercanopy snags, their decay-resistant outer wood (Hosie 1969) enables them to stand for many years and their tendency to become hollow (White 1953, Heinselman 1973) increases their ability to provide homes for the larger cavity-dwelling birds and mammals. Large snags such as supercanopy white pines can be substituted for smaller ones in forest wildlife management but small snags cannot replace larger ones (Thomas et al. 1979). In Ontario, white pine snags were the snags preferred by woodpeckers for feeding and nesting, and the larger, more decayed snags were the most preferred (Quinby 1989). Fifty-five (49 percent) of 112 white pine snags (average DBH 39 cm) showed woodpecker use, whereas only 3 (14 percent) of 22 red pine snags (average DBH 45 cm) showed use. Only 30 percent of *Populus* snags were used, and only 0-14 percent of other snag species (*Picea glauca, P. mariana, Abies balsamea, Betula papyrifera, Pinus banksiana, Acer rubrum,* and *Thuja occidentalis*) showed use (Quinby 1989). The thick bark of white pine snags often separates from the outer wood of the trunk, providing roosting areas for one of Minnesota's less common bats, the silver-haired bat (*Lasionycteris noctivagans*). White pine snags eventually fall and become large diameter decaying logs that persist longer than smaller logs and permit greater development of dependent communities (J. W. Thomas, Biologist, U.S. Forest Service, personal communication, 1991). Healthy forests are not only growing trees, they are functioning ecosystems, which include dead and dying trees that provide food for insects, homes for wildlife, and microsites for seedling establishment.

THE NEED FOR STUDY

The white pine harvest that began in Minnesota in 1839 brought many habitat changes. Aspen, birch, spruce, and balsam fir replaced much of the white pine and enabled white-tailed deer and coyotes to expand their ranges northward (Longley and Wechsler 1980, Rogers et al. 1981). Effects of white pine harvest on smaller, less noticeable animals are unknown because no wildlife censuses were conducted before the harvest. Most inhabitants of Minnesota's white pine range have not been studied sufficiently to determine direct or indirect relations with specific tree species. Detailed habitat information is still needed for most of Minnesota's mammal, bird, reptile, amphibian, and invertebrate species. Without full information about habitat requirements, forest managers need to preserve all components of Minnesota's ecosystems to reduce the risk of species extirpation.

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ECOLOGICAL FEATURES OF WHITE PINE STANDS FOR WILDLIFE

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ABSTRACT. Using birds as a surrogate for "wildlife", a review of the literature determined that in the case of white pine, both as a species and as a forest type, there are no obligate species or very distinctive bird communities. That in itself is of ecological interest, and the question "why?" deserves both speculation and study, but is not attempted here. A compilation of what is known about habitat specialists and avian communities in relation to white pine is given, first for white pine as a species and then as a community type. Only the pine warbler specializes on pine trees but it uses many different species; mature, open stands are its preferred habitat. The importance of white pine forests is the complexity of the vegetation in older stands that have many layers and a variety of tree and understory species. This vegetational complexity provides habitat diversity for birds and 30-35 species can use a stand. This species richness is a characteristic of old growth white pine forests which should be perpetuated.

INTRODUCTION

The magnificence of white pine, with heights of 150-200 feet and diameters of 2-4 feet (Leverett 1992), makes one think that there must be something special about the wildlife associated with this tree. If not the tree, then the old-growth stands of pine, either alone or mixed with northern hardwoods, that once dominated the north woods from Minnesota to Maine, must have contained distinctive wildlife. Since this old-growth stimulated the social and economic advance of the nation westward from the 17th to the 19th centuries and now only occurs in remnant groves, we will never know if there were species lost that depended on expanses of old-growth pine.

However, for mammals and birds it is unlikely that any full species went extinct in the east before they were identified by naturalists who explored the back country in advance of the large-scale logging. No forest mammals from this part of the country have been lost. The forest birds that are now extinct (ivory-billed woodpecker, Carolina parakeet, passenger pigeon, and probably Bachman's warbler) did not depend on pine communities (Williams and Nowak 1986, Ehrlich et al. 1988). As to all the other types of wildlife, from microorganisms to invertebrates and plants, surveys are even now not complete, to say nothing of what was not done in the nineteenth century. So we will never know.

This brings up the point of how to define "wildlife". The academics tend toward being comprehensive with Hunter (1990) putting forth a simple definition: "any living thing that is part of a natural ecosystem". Managers tend to be more limited in their approach both by history and the statutes that govern their activities. Distinctions are made between plants and animals and, sometimes, between fish and other vertebrate taxa. Microorganisms and invertebrates are usually not given much attention. There is no definition of wildlife in Minnesota statutes but there is in the rules governing Scientific and Natural Areas. Since it is very similar to what some other states have in statute, it is quoted here as a general example:

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> "Wildlife" means all living creatures, not human, wild by nature, endowed with sensation and power of voluntary motion, and includes quadrupeds, mammals, birds, fish, amphibians, reptiles, crustaceans, and mollusks. [Minn. Rules 6135:4700, Subp. 10]

The emphasis is on vertebrates, and most agency wildlife work is confined to mammals and birds. The research that is done in ecology, ornithology and other disciplines is often not integrated into management policies or actions. Many times the relevant information is buried in articles that have a theoretical purpose or is scattered throughout the specialty literature.

In looking for what ecological features of white pine are important to wildlife, birds come forward as being the most useful group for a number of reasons. There are numerous field surveys of birds in relation to habitat because they are relatively easy to census. Also, bird species can be habitat specialists and many (commonly 10-30) can occupy the same forest community, providing possibilities to define habitat structure or composition.

ATTRIBUTES OF WHITE PINE TREES IMPORTANT TO BIRDS

There are three species of birds with pine in their name: pine siskin, pine grosbeak and pine warbler. The first two do not feed or nest in pines so it is a bit of a mystery why they were so named. Perhaps the use of "pine" was meant more generically to mean "conifer", and since they are often found in coniferous habitats, that is a reasonable explanation. The pine warbler is a different case since its breeding habitat is exclusively pines, although not often white pine.

Before I cover what is known about habitat preferences of pine warblers, I want to turn to another species that is white pine adapted: the northeastern subspecies of the red crossbill (*Loxia curvirosta neogaea*). The bill for crossbills is specialized for prying open conifer cones for their seeds and the four species in this genus occur throughout the northern hemisphere where certain species of spruce and pine are found. There are several subspecies of red crossbill that are separated on the basis of bill size and shape that are adaptations to different species of conifers. Using a series of museum specimens collected over the last 100 years, Dickerman (1987) speculated that the population of the "Old Northeastern" subspecies was drastically reduced early in this century as the extensive white pine forests in the northeast were virtually eliminated. This is as close as one can come to an obligate vertebrate species for white pine.

PINE WARBLER USE

Pine warblers specialize in gleaning insect material from the clusters of pine needles in the canopy of mature trees; they also can forage while creeping along the limbs and rough bark of the trunk (an older name for this species was the pine creeper). Their range encompasses the eastern half of North America where there are pine forests. They place their nests almost exclusively in pines of many different species (Harrison 1984). The Breeding Bird Survey conducted by the U.S. Fish and Wildlife Service has produced a map that shows that they are abundant in the southern states from Texas and Arkansas east to Florida and North Carolina and then up the coastal plain to southern New Jersey. Their populations are much less abundant in the northern states and they are virtually absent from the central Mississippi River valley eastward to the Appalachians. In the north they were formally common in the pitch pine barrens of the coastal plain from New York through Massachusetts to Maine, but that region has been subjected to extensive urbanization and the habitat is much reduced and fragmented.

Across the north woods they occur in jack, red and white pine forests but their populations are localized. As Morse observed (1989, p. 103): "Habitat specialists such as [the pine warbler] routinely seek out favorite sites within heterogeneous habitats." Their preference for different species of pine is geographically specific, depending on what species of pine occur in a given area. Referring to a time earlier in this century Bent (1953) stated: "We seldom see it in the denser forests of white pines". They seem to favor open stands of tall pines of all three species.

As an illustration of the difficulty in determining the features of pine that are important to this species, or alternatively, how its preference varies geographically, a compilation of habitat descriptions from individual state bird books in the area encompassed by the range of white pine is presented in Table 1. All sources are in agreement that this species is a habitat specialist on pine. It is also the only warbler species in the east to winter extensively throughout its southern breeding range in the United States without going further south. With one exception, all other eastern warbler species are classified as neotropical migrants (Anonymous 1991).

OTHER AVIAN USE

Another bark foraging species, the brown creeper, utilizes mature stands of white pine at an age when the bark has deep crenulations which offer a good foraging surface to this species as it probes in cracks and crevices with its fine, slightly decurved bill. Other tree species with similar bark features are used as well so the brown creeper is not a white pine specialist, or even a conifer specialist. Old-growth white pine stands also contain snags and live trees with heart rot that provide excellent sites for cavity nesting species. Although most management prescriptions focus on snags, live trees that are infested with heart rot that can be easily excavated by large woodpeckers may be more useful. Long-lived white pine provides both the size needed by large-bodied species (trees 18 inches dbh or larger) and a hollow or easily excavated interior. The pileated woodpecker, hairy woodpecker and northern flicker are the main excavators and the holes can be used by about 10 other species of birds (DeGraaf 1991). The old-growth relic stand, managed by the Superior National Forest as a picnic ground on County Highway 2, Lake County, Minnesota provides a good example of how important hollow trees are for birds. In the summer of 1992 four cavity species (wood duck, northern saw-whet owl, northern flicker, pileated woodpecker) were found within about 300 feet of each other in this stand (Bill Tefft, personal communication). But again, other large trees, like "over-mature" aspen, provide the same heart rot in live trees, so white pines are important where other large diameter trees are scarce. Besides creating hollow trees and snags, old white pines also become downed logs. Unfortunately, eastern old-growth pine forests have not been studied like those in the Pacific northwest to determine the ecological importance of decaying logs on the forest floor. There have been studies on the wildlife importance of super-canopy old-growth white pines and they are summarized in another paper in this symposium.

Table 1. Habitat descriptions for pine warbler from the northeastern states and province within its range and that of white pine.

Minn.	"pine forest of the north . . . especially where jack pine predominates, frequenting in greatest numbers the more scattered or open portions of the forest" Roberts (1932). "most frequently found in large stands of white pine" Janssen (1987)
Wisc.	"northern counties . . . loose stands of tall white pines" Robbins (1991)
Mich.	three areas: Seney "ridges covered with red pines"; "dunes of Lake Michigan in the mixed oak-white pine areas"; "northern portion of the lower peninsula, Jack Pine is the predominant tree . . . over 25 feet high" Walkinshaw in Griscom and Sprunt (1957)
Ont.	"closely tied to the distribution of pine forests . . . high in the tallest pines, with white pine usually preferred but red pines used occasionally . . . moving into pine plantations is SW Ontario . . . after 40-50 years of growth" Cadman, Eagles, and Helleiner (1987)
N.Y.	"exclusively in pine forests in the northeastern states . . . only in mature forest . . . any species of pine as long as the trees are generally well spaced . . . pitch pines on the Coastal Lowlands but favors white or red pines in many upstate locales" Andrle and Carroll (1988)
Vt.	"tall stands of white pine . . . with little undergrowth" Laughlin and Kibbe (1985)
Me.	"Fragmentary data would seem to indicate . . . low white pines or pitch pines" Palmer (1949) "Approaches northeastern limit of breeding range. Restricted to pine stands" Adamus (1983)
W.V.	"forest stands containing large amounts of fairly mature pines. Along the Ohio River . . . found in scrub pine forest . . . eastern Alleghenies . . . found in pitch pine forests . . . is rare in the white pine forests" Hall (1983)
Ohio	"only in tracts of mature pines [on] dry ridges where tall pines are interspersed with younger deciduous trees . . . will also occupy uniform pine plantations" Peterjohn (1989)
Ind.	"Clark State Forest . . . one of the best examples of native nesting habitat left [mixed forest of Virginia pine, chestnut oak, and other deciduous trees] . . . now fewer (and smaller) native pine stands near Lake Michigan, where pine warblers used to nest . . . few do so today" Mumford and Keller (1987)
Ill.	"may have nested in northern Illinois at one time . . . but now seems confined to the south . . . in pines, usually in fairly mature stands" Bohlen (1989)

BIRDS OF THE WHITE PINE FOREST COMMUNITY

COMMUNITY CONCEPTS

The concept of community, both in relation to forests and the birds that inhabit them, does not lend itself to rigorous definition. If what is meant is a list of species that occupy a particular site at a particular point in time, it is purely descriptive. If some greater functional meaning is implied, then there is little detailed understanding of what ecological processes hold the community together and what role birds play in the dynamics of forested ecosystems. Hence the excitement of research is to try and make the relationships clearer and hopefully predictable.

For birds the state of the knowledge about communities is in the descriptive stage but some generalized outlines have appeared. One debate centers on whether competition among species or utilization of the vegetation for habitat-niche purposes is the most important for partioning resources in avian communities (Morse 1985). It is obvious that features of the vegetation are important for birds; for foraging, nesting, display, and shelter (from predation and weather). What is not known is how various species of birds select for different vegetational characteristics both within a stand (microhabitat features) and within a community (macrohabitat features). The essential question is what determines the occurrence of a species in a particular habitat or forest type.

Avian communities respond to the heterogeneity of forest vegetation on several levels. Capen (1979) has listed them as follows: a) vertical habitat diversity, b) horizontal habitat diversity, c) patchiness of habitats, d) size of forest habitats. The first category refers to the layering of vegetation within a stand ("alpha" diversity) and the second to between-stand differences in composition and age ("beta" diversity). The other two describe the forest in terms of size and configuration of patches of different forest types and is important for regional population dynamics. Research is just now beginning to tackle the questions about landscape patterns and their importance for birds.

BIRDS IN WHITE PINE FORESTS

All the scientific uncertainly about why different species of birds choose certain habitats could lead to the dismissive conclusion that it is all chance and forest composition and structure do not matter. This is hardly the case. It is known that a suite of birds are conifer forest specialists. Wiens (1975) identified 82 species of birds recorded in various types of conifer forests in northeastern North America. Not all of them depend on needle-bearing trees for resource use since deciduous shrubs and trees and snags or other habitat features in conifer stands also may be important. Some birds have adapted to human-disturbed landscapes and although they need conifers, are found in suburban as well as forested settings. For Minnesota, 43 species are found exclusively in contiguous forests that are dominated by either boreal conifers or pines (Green 1991). Determining which species are more associated with white pines than other conifers has proved to be very difficult. Most studies do not differentiate between the different species of pine and combine red, white, jack and sometimes pitch pine together in their published results. Although red, white and jack pine occur together, the forest structure and composition of jack pine stands is quite distinct from white pine, particularly in the mature and old-growth stages. There are more published censuses of red pine stands, mainly plantations, than white pine, which may reflect the lack of management emphasis and scarcity of large natural stands for the latter species.

What I could find for censuses that correlate bird species with the white pine type is presented in Table 2. There are two types of surveys: 1) those that are site-specific, used a territory mapping technique, and were published in American Birds (formerly Audubon Field Notes), and 2) those that were more regional in scope and utilized point-count or similar techniques. To make them comparable, I converted the numerical population densities into three descriptive categories: 1) primary - those species that occur in high numbers and dominate the avian community, the top five species are ranked; 2) secondary - those species that are uncommon but regular in the community; and 3) tertiary - those species whose populations are low and occurrence is irregular. Species that show up only a few times in multi-year censuses are given an additional description of incidental and marked by a + in Table 2. This descriptive scheme was necessary because of the paucity of detail on methodology in some of the published surveys. However, the species fall rather easily into three groupings. The Breeding Bird Census that was published by the National Audubon Society through 1983 provides the source of information for the white pine sites. Only censuses that were greater that 20 acres and where white pine occupied 50 percent of more of the canopy were used. As the table shows only two sites fitted those criteria. It will not be possible to make good inferences about correlations, never mind causation, of bird species that use the white pine forest type until more field work is done.

In looking at these species lists a couple of things stand out. First, the difference in the number of species between the Apostle Island stands (13 species) and the Litchfield, Conn. stand (33 average; range 26-40) represents the extremes in terms of complexity of the vegetation and its influence on species richness. On the Apostle Islands, stands were chosen for their homogeneity (Beals 1960) whereas in Connecticut the old-growth stand has five distinct layers with the lowest one again divided into ground cover, shrubs and saplings (Magee 1965). Fourteen species of trees are present in this stand and white pine is only dominant in the canopy. Second, the species that show up as primary in most of the sampled locales are more often than not wide-ranging in both geography and in habitat tolerance. Three of them, veery, red-eyed vireo and ovenbird, are abundant in many different forest types. Other species that I would choose from these censuses to define this community are blue jay, red-breasted nuthatch, brown creeper, solitary vireo, black-throated green warbler and blackburnian warbler.

In New England DeGraaf and Rudis (1986), using expert opinion and unpublished surveys, listed 68 species that utilize mature or old white pine forests with only seven species using it for preferred habitat; long-eared owl, pileated woodpecker, American crow, red-breasted nuthatch, hermit thrush, solitary vireo and pine warbler. There is not much overlap in this list and those selected as definitive users of mature white pine forests from Table 2. The influence of geography and methodology is probably important in not reaching a single list, but the result also reflects the diversity of white pine as a community type. Its importance as a breeding habitat for birds is not in uniqueness but in the breadth of habitat possibilities that it offers.

Table 2. Breeding birds of mature white pine communities. Abundance classes: P - Primary (numbers are for five most abundant species by rank order, ties are *); S - Secondary; T - Tertiary; + - Incidental. Sources: Minn. (a) - Chippewa National Forest, Hanowski and Niemi (1991a); Minn. (b) - Superior National Forest, Hanowski and Niemi (1991b); Wisc. (a) -Apostle Islands, Beals (1960); Wisc. (b) - Northern pine forests, Hoffman and Mossman (1990); N.Y. - Alfred, sw N.Y., Brooks (1974 et seq., 9 years); Conn. - Litchfield, nw Conn., Magee (1965 et seq., 17 years).

	REGIONS				SITES	
	Minn.(a)	Minn.(b)	Wisc.(a)	Wisc.(b)	New York	Conn.
Cooper's Hawk					T	
Northern Goshawk						+
Red-shouldered Hawk					T	
Broad-winged Hawk				S	T	S
Red-tailed Hawk						+
Ruffed Grouse		T		S	+	T
Mourning Dove					+	T
Black-billed Cuckoo						+
Yellow-billed Cuckoo						+
Great Horned Owl					+	T
Barred Owl					T	S
Ruby-throated Hummingbird						T
Yellow-bellied Sapsucker	T	T				
Downy Woodpecker				T	S	S
Hairy Woodpecker				T	T	S
Northern Flicker	T			T	+	S
Pileated Woodpecker				S	T	S
Eastern Wood-Pewee	S		P(4)			S
Acadian Flycatcher						+
Least Flycatcher	T					
Great Crested Flycatcher				S	T	S
Blue Jay	T		S	P(4)	P	P
American Crow	T		T	S	T	S
Common Raven				S		
Black-capped Chickadee	T	T	T	P	P	P
Tufted Titmouse						+
Red-breasted Nuthatch	S		S	P	P	P
White-breasted Nuthatch			S	S	T	S
Brown Creeper	S	P(4*)			S	P
House Wren					S	T
Winter Wren		T				+
Golden-crowned Kinglet	P				P(5)	
Blue-gray Gnatcher						+
Eastern Bluebird						+
Veery	S	T		P(2)	S	P(3)
Swainson's Thrush		T				
Hermit Thrush	S					T
Wood Thrush				T	P	S
American Robin	T	T	S	T	P	S
Gray Catbird					T	T
Cedar Waxwing				P	T	
Solitary Vireo		T	P(5*)		S	P
Red-eyed Vireo	P(3)	P(2)	P(3)		T	P(5)
Blue-winged Warbler						+
Golden-winged Warbler	T			T		
Nashville Warbler	S	T	P(5*)		+	
Northern Parula		T				
Chestnut-sided Warbler	P(5)	P(4*)				
Magnolia Warbler	T				P(3)	+
Yellow-rumped Warbler	T				P	T

	REGION				SITES	
	Minn.(a)	Minn.(b)	Wisc.(a)	Wisc.(b)	New York	Conn.
Black-throated Green Warbler	P(4)	P(3)	P(2)	S	P(1)	P(4)
Blackburnian Warbler	S		T	P(5)	P(2)	P(1)
Pine Warbler	P(2)			P(3)		T
Black-and-white Warbler	P	P(4*)		T		
American Redstart	P		T			+
Ovenbird	P(1)	P(1)	P(1)	P(1)	P	P(2)
Northern Waterthrush						+
Mourning Warbler	S	S				
Common Yellowthroat		T		S	S	S
Canada Warbler				P	T	S
Scarlet Tanager	T			P	S	P
Northern Cardinal					S	T
Rose-breasted Grosbeak	S	T		T	S	T
Indigo Bunting		S		T	S	+
Rufous-sided Towhee						S
Chipping Sparrow		S		T	S	+
Song Sparrow				T	S	T
White-throated Sparrow		S		T	T	T
Dark-eyed Junco					P(4)	
Common Grackle						T
Brown-headed Cowbird				P	S	S
Northern Oriole				T		T
Purple Finch					S	S
Total species	30	22	13	34	33 ave.	33 ave.

RECOMMENDATIONS

The management implications of the foregoing discussion point in one direction: in the face of uncertain knowledge, preserve as many options as possible. In northeastern North America encompassing the range of the white pine, there are 141 bird species that are associated with woodland (water, shore and open country species excluded). Very little is know about the habitat and niche requirements and life history strategies of most of them. Half (73 species) of them showed up in the breeding censuses of white pine forests compiled in Table 2. If there had been more census locales in the far southern and northern parts of the range of white pine, the total list would probably have been much higher. Research will probably never be able to unravel which components of which forest type are important for which species of wildlife. White pine forests come in a rich array of age and species mixtures and that diversity should be perpetuated for its own sake and for all the benefits, known and unknown, it imparts to wildlife.

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WHITE PINE: STATUS IN LAKE STATES[1] FORESTS

John S. Spencer, Jr., Earl C. Leatherberry, and Mark H. Hansen[2]

ABSTRACT. Area of the white pine type in the Lake States increased from 394 to 503 thousand acres between the old and new inventories. White pine growing-stock volume gained from 1.0 to 1.4 billion cubic feet during the same period. The annual surplus of growth over removals in the new inventory is 30.1 million cubic feet.

INTRODUCTION

The eastern white pine forest type in the United States covers an estimated 5.1 million acres[3]--an area slightly larger than the State of Massachusetts-- representing about 2 percent of the timberland in the East[4]. The area of the white pine type today is only a fraction of the size of the original white pine forest. Because it is straight-grained and easily worked, white pine was highly valued in a rapidly expanding nation that needed houses, furniture, boxes, doors, and farm implements. The tall white pines of New England were especially prized for masts on Royal Navy ships in 17th and 18th century England where trees of such size and form no longer grew. As harvesting swept westward from the former colonies, white pine was often replaced by other species better suited to the new conditions.

The first assessment of the Nation's timber supply by the USDA Forest Service, published in 1909 when Gifford Pinchot was Chief Forester, estimated that the area of the original "northern forest", of which white pine was a principal member, was 150 million acres, supporting "not less than 1,000 billion board feet" of all species (Kellogg 1909). By 1909 that resource had been reduced to 90 million acres and 300 billion board feet, 60 percent and 30 percent, respectively, of the original area and volume. White pine was the premium species in the Lake States when logs from their pineries jammed rivers in the late 1800's and early 1900's on the way to sawmills to become the lumber that built midwestern cities and towns.

The first forest inventory of the Lake States was conducted by the then Lake States Forest Experiment Station between 1934 and 1936. This and subsequent inventories were mandated by Congress, and are now conducted periodically by the USDA Forest Service regional forest experiment stations through their Forest Inventory and Analysis (FIA) units. The FIA unit at the North Central Forest Experiment Station in St. Paul, Minnesota, is responsible for forest inventories in 11 North Central states, including the Lake States. This paper discusses the white pine resource of the Lake States, using data

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[3]Includes area of white pine-hemlock forest type in Virginia, North Carolina, South Carolina, and Georgia.

[4]Includes Minnesota, Iowa, Missouri, Arkansas, Louisiana, and all states eastward.

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from recent statewide forest inventories of each state (see Literature Cited for these reports). Inventories were completed for each of the Lake States in the years below:

State	Most Recent Inventory	Previous Inventory
Minnesota	1990	1977
Wisconsin	1983	1968
Michigan	1980	1966

This paper will refer to the most recent inventory of each Lake State as the "new" inventory and to the previous inventory as the "old" inventory.

AREA

According to the new inventory, the eastern white pine forest type is estimated to extend over 503 thousand acres in the Lake States. This amounts to 10 percent of the Nation's total area of the type. However, the white pine type is among the least extensive in the Lake States, representing only 1 percent of the region's timberland area. The new estimate represents a 28-percent gain over the 394 thousand acres found during the old inventory (Table 1). The increase in Wisconsin and Michigan is due to other forest types converting to white pine, in addition to a small area changing from nonforest land to timberland between inventories. The small decline in Minnesota may be due to the earlier onset of management of aspen stands in that state than in the other two states, making aspen less likely to convert to other types, including white pine.

Table 1.--Area of timberland in the white pine type by state and old and new inventory, Lake States.

(In thousand acres)

State	Old inventory	New inventory	Difference
Minnesota	68.3	63.2	-5.1
Wisconsin	177.6	225.6	48.0
Michigan	147.9	214.1	66.2
Total	393.8	502.9	109.1

As the presettlement stands of white pine were logged for the first time in the 1800's, many also were burned by wildfires or slash fires. Conditions on these cutover and burned sites were not suitable for natural regeneration to white pine, but favored pioneer species such as aspen, which succeeded pine on many sites. Now that many of those aspen-birch stands have become mature and overmature and have begun to "break up" or deteriorate (unless managed for aspen), they are being succeeded by other types.

Those with a sufficient white pine component in the understory are likely to convert to pine. In addition, plant succession and disturbances in other types cause the species mix to alter, resulting in changing type areas.

A study of forest type change in Wisconsin, made by analyzing permanent sample plots established during the 1968 inventory and remeasured in 1983, showed that 37 percent of the acres that converted to white pine between inventories had previously been classed as aspen-birch type (Spencer et al. 1988). Much of this area probably had been white pine before being invaded by aspen-birch and is simply returning to pine. Another 22 percent of the additions to the white pine type in Wisconsin converted from the red pine type, and 21 percent converted from the maple-birch type. Small amounts also shifted to white pine from former nonstocked areas, nonforest land, and the black spruce type.

The Wisconsin analysis also revealed the forest types to which stands classed as white pine in 1968 had converted by 1983. Although almost 70 percent of the 1968 white pine area remained white pine in 1983, nearly half of the area that did change types converted to maple-birch. These were probably stands that had been disturbed by some agent such as insects, disease, logging, or wind, and that had an understory predominantly composed of the shade-tolerant species associated with the maple-birch type. Smaller amounts of the 1968 white pine type shifted to the oak-hickory, red pine, and elm-ash-soft maple types, and to nontimberland.

White pine stands in the region have a high proportion of large trees. Sawtimber stands make up 71 percent of the area of the white pine type, followed by poletimber stands with 19 percent, and sapling and seedling stands with 10 percent. The scarcity of sapling and seedling stands suggests that many stands convert to the white pine type as poletimber or sawtimber stands. For example, an aspen-birch stand with a primary understory component of white pine may mature and "break up" if undisturbed to become a white pine poletimber or sawtimber stand--the new stand never having passed through the sapling-seedling stage. The same scenario probably occurs in other mixed stands where white pine grows in the understory or as a minor component of the overstory, and simply outlasts the shorter lived overstory trees. Therefore, the lack of white pine sapling-seedling stands probably does not presage possible difficulty in maintaining the size of the type as white pine sawtimber stands mature and are harvested. It may, however, also reflect the lethal effects of white pine blister rust on young trees, and may suggest a reluctance on the part of land managers to plant white pine.

To provide a perspective on the distribution of large white pine trees throughout the Lake States, we used data from permanent sample plots to generate the map shown in Figure 1. Each square on the map represents 5,000 acres of timberland on which there are at least two sawtimber-sized white pines per acre. Because data are available only for timberland, there are no squares on reserved forest land such as the Boundary Waters Canoe Area Wilderness or Isle Royale National Park. The map illustrates the ubiquitous nature of the species--widespread yet existing as a specific forest type on only 1 percent of the region's timberland area. Sawtimber stands in the white pine type occupy only 0.8 percent of the region's timberland area; however, nearly 10 times this area (7.4 percent of total timberland area) contains at least two live white pine sawtimber trees per acre. The presence of even a few large white pines per acre is important as a seed source for future pine stocking and as shelter for wildlife. Black bear cubs prefer old white pines as refuge trees because they can easily climb the strong, furrowed bark (Rogers 1991). White pines also provide habitat for bald eagles, ospreys, and boreal owls.

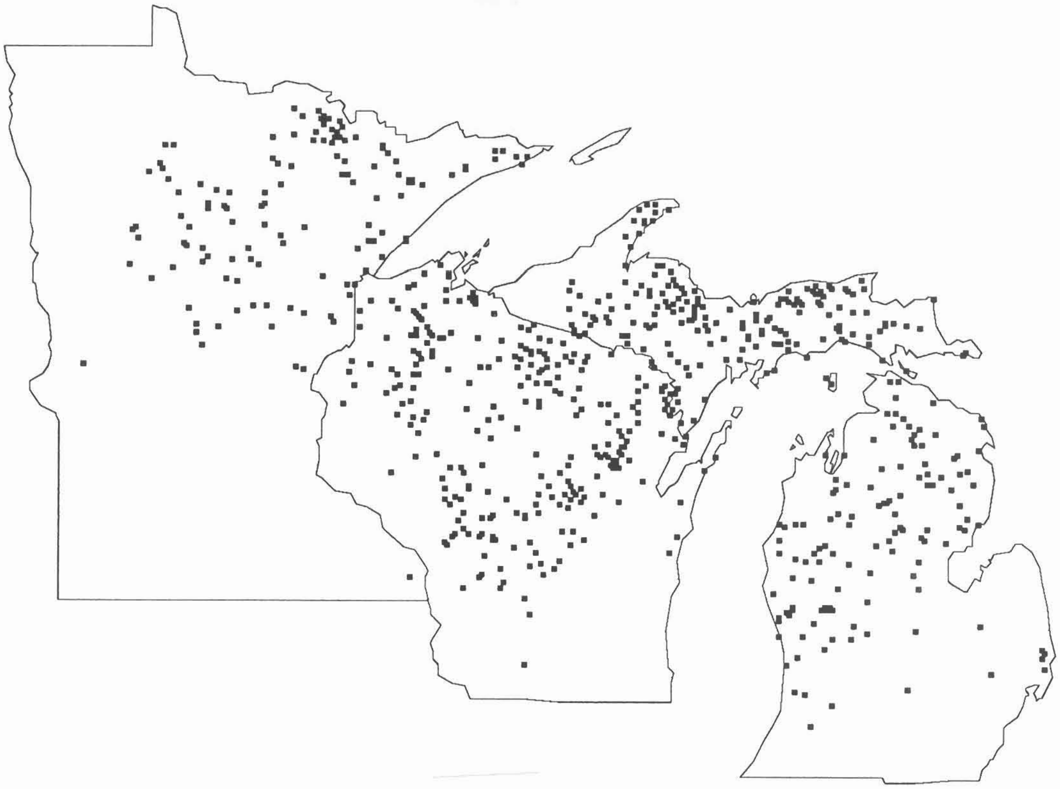

Figure 1. Distribution of timberland in the Lake States containing at least two sawtimber-sized white pine trees per acre. Each square represents 5,000 acres of timberland.

Two-thirds of the white pine type is in private ownership, and slightly more than half of the total is held by nonindustrial private owners (Figure 2). Miscellaneous private owners hold a somewhat greater proportion of the white pine type (37 percent) than of total timberland (33 percent).

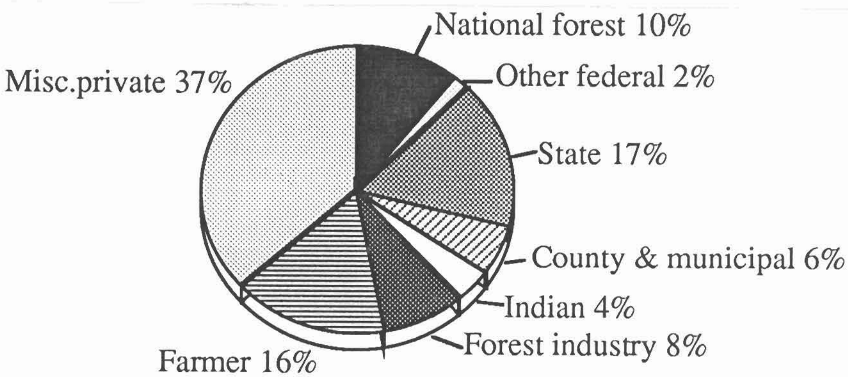

Figure 2. Area of timberland in the white pine type by ownership class, Lake States.

Fifteen percent of the area of the white pine type is in stands older than 100 years (Figure 3). Many of these stands were missed during the original logging because they were inaccessible or because trees were too small or otherwise unmerchantable. The 61- to 80-year age class, the most extensive with 28 percent of the area, became established between 1910 and 1929, a period of high interest in tree planting and forest management.

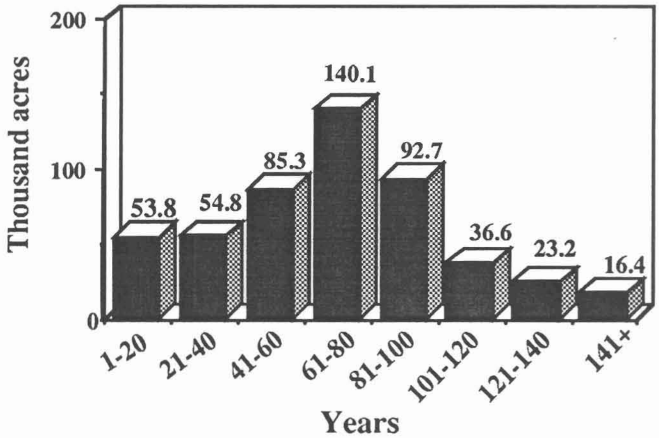

Figure 3. Area of timberland in the white pine type by stand-age class, Lake States.

Nineteen percent of the white pine type area is on sites productive enough to grow trees 71 feet tall and taller at age 50 (Figure 4). Sites are slightly better in Wisconsin where the weighted average site index for white pine is 63 feet, compared with 56 feet in the other two states.

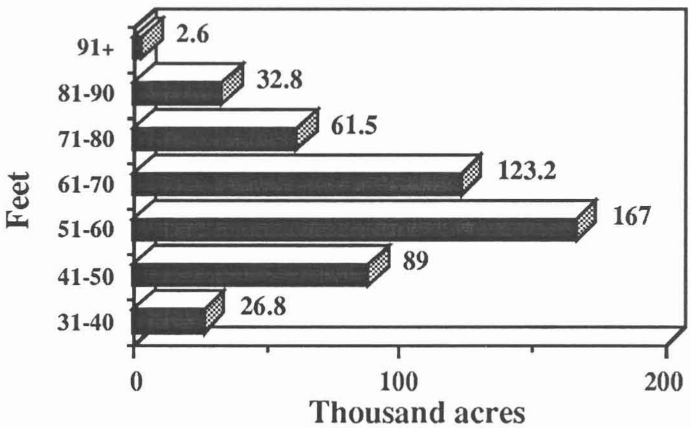

Figure 4. Area of timberland in the white pine type by site-index class, Lake States.

TIMBER VOLUME

The volume of eastern white pine growing stock in the U.S. is 10.3 billion cubic feet, or 7 percent of the total softwood volume in the East. In the Lake States, white pine volume amounts to 1.4 billion cubic feet, 13 percent of the U.S. total for the species.

White pine growing-stock volume in the Lake States gained 35 percent between the old and new inventories, from 1.0 to 1.4 billion cubic feet (Table 2). Volume increased fastest in Michigan (41 percent).

Table 2.--Net growing-stock volume of white pine in the Lake States, by state and old and new inventories.

(In million cubic feet)

State	Old inventory	New inventory	Increase
Minnesota	208	262	54
Wisconsin	424	566	142
Michigan	385	544	159
Total	1,017	1,372	355

White pine is a widespread species, found in combination with many other species in the Lake States, as indicated by its volume in forest types other than the white pine type. Thirty-four percent of the total white pine volume is in the white pine type, but 21 percent is in the maple-birch type, and another 11 percent is in the aspen type. Smaller amounts are found in the red pine type (8 percent), oak-hickory type (6 percent), balsam fir type (5 percent), northern white-cedar type (4 percent), and other types.

Growing-stock volume of white pine by diameter class is greatest in the 14-through 18-inch classes (Figure 5). Of the Lake States, Minnesota has the highest proportion of volume in larger diameter trees. For example, 28 percent of Minnesota's white pine volume is in trees at least 23 inches in diameter (the 24-inch diameter class includes trees 23.0 to 24.9 inches in diameter), compared with 17 percent in Wisconsin and 15 percent in Michigan. Eight percent of Minnesota's volume is in trees 29 inches in diameter and greater, compared to 4 percent in Wisconsin and 3 percent in Michigan.

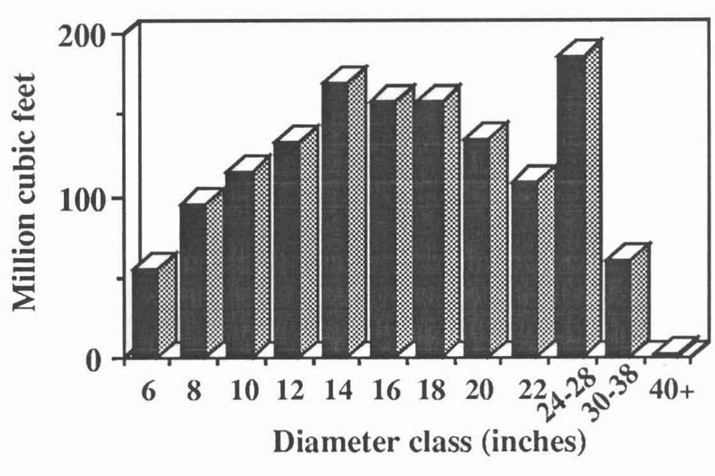

Figure 5. Volume of white pine growing stock by diameter class, Lake States.

Nearly two-thirds of the volume is privately owned, and the percent held by each owner class is similar to that for area of the white pine type (Figure 6). The proportion of state-owned white pine volume in Michigan (27 percent) is greater than the average for the Lake States (14 percent). Likewise, the proportion of white pine on national forest land in Minnesota (30 percent) is greater than the Lake States average (14 percent).

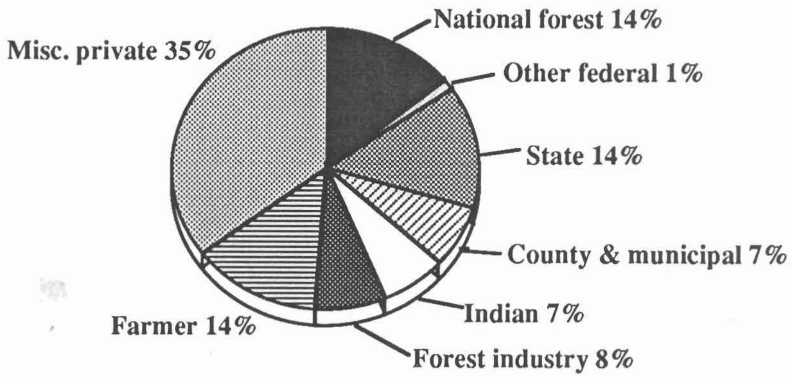

Figure 6. Volume of white pine growing stock by owner class, Lake States.

GROWTH AND REMOVALS

Current net annual growth of white pine growing stock in the Lake States found in the new inventory is estimated to be 47.3 million cubic feet, compared with the 32.4 million cubic feet of growth in the old inventory. The growth rate remained virtually unchanged between inventories at 3.4 percent of inventory. The growth rate is slightly higher in Minnesota than in the other two states. Annual growing-stock removals of white pine found in the new inventory is estimated at 17.2 million cubic feet, compared with 9.3 million cubic feet in the old inventory. The removals rate in the new inventory averages 1.3 percent of inventory for the three states, compared with 0.9 percent in the old inventory. The removals rate in Minnesota (1.6 percent) is slightly higher than that in either Wisconsin (1.4 percent) or Michigan (0.9 percent).

The surplus of growth over removals in the new inventory amounts to 30.1 million cubic feet per year, up from a surplus of 23.1 million cubic feet (Figure 7). As long as this surplus exists, the inventory of white pine will continue to build. The surplus is greatest in Michigan (14.2 million cubic feet), followed by Wisconsin (8.9 million) and Minnesota (7.0 million).

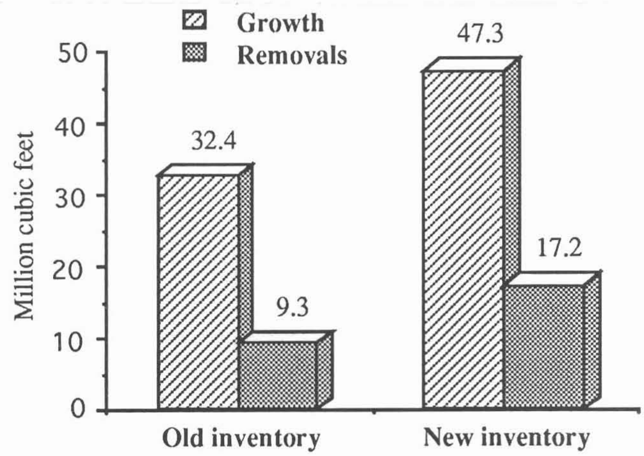

Figure 7. Current net annual growth and current annual removals of white pine for the old and new inventories, Lake States.

MORTALITY

White pine growing-stock mortality in the Lake States for the new inventory amounted to 3.2 million cubic feet, or 0.23 percent of inventory. The mortality rate in Minnesota (0.33 percent of inventory) was higher than in either Wisconsin (0.25 percent) or Michigan (0.16 percent), perhaps because Minnesota is at the western edge of the physical range of white pine. The primary cause of death could be clearly identified by field crews for just under half (44 percent) of the white pine mortality volume. Of the 1.4 million cubic feet of mortality for which a primary cause was identified, disease (principally white pine blister rust and the general class of stem decay diseases) accounted for the largest proportion, followed by weather (Figure 8).

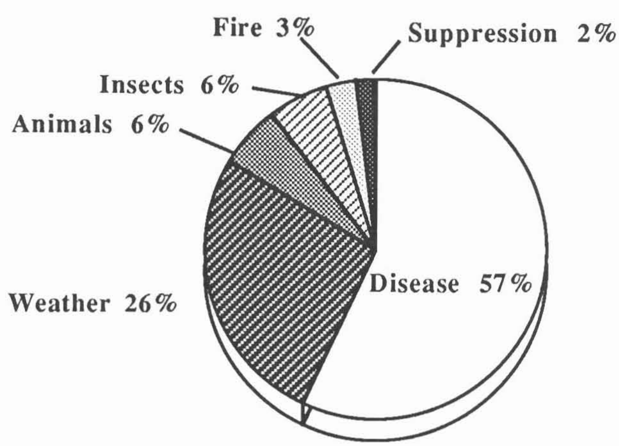

Figure 8. Annual mortality volume of white pine growing stock for which a cause of death could be identified.

ROUNDWOOD PRODUCTS

Roundwood products from white pine--logs, bolts, or other round sections cut from trees for industrial or consumer uses--totaled 17.1 million cubic feet in the new inventory (Table 3). Half of the roundwood products volume came from Wisconsin. Michigan and Minnesota each accounted for about one-fourth of the Lake States production. Saw logs accounted for 78 percent of the roundwood production from white pine, followed by pulpwood (16 percent) and fuelwood (6 percent).

Table 3.--Timber products from white pine roundwood, by product and state, new inventory.

(In thousand cubic feet)

Roundwood product	All states	Minnesota	Wisconsin	Michigan
Saw logs	13,412	3,466	6,220	3,726
Pulpwood	2,685	159	1,676	850
Fuelwood	1,009	54	920	35
Veneer logs	7	2	5	0
Posts	4	4	0	0
Poles	3	3	0	0
Other products	3	3	0	0
All products	17,123	3,691	8,821	4,611

CONCLUSIONS

Area of the white pine type in the Lake States increased by 109 thousand acres between the old and new inventories, a 28 percent gain. The immediate trend is for this increase to continue, although perhaps more slowly, as other types, occupying sites that may have originally supported white pine, convert back to white pine. Much of the above expansion was at the expense of the aspen-birch type, and as more aspen stands come under management, more of them will remain in the aspen type. The scarcity of sapling-seedling stands probably does not suggest that area of the white pine type may decline over the long term. This is true because stands of other types with white pine in the understory and an overstory shorter lived than white pine may convert naturally to white pine as poletimber or sawtimber stands. Two-thirds of the area of the white pine type is privately owned, suggesting wide variations in the level of management applied. White pine growing-stock volume increased 355 million cubic feet between inventories to 1.4 billion cubic feet, a 35 percent gain. The surplus of net annual growth over annual removals found in the new inventory amounts to 30 million cubic feet. Disease is the greatest cause of mortality of white pine. Almost four-fifths of the volume of timber products from roundwood harvested from white pine is in saw logs.

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THE PROBLEM WITH WHITE PINE

Alan C. Jones[1]

ABSTRACT. White pine is a valuable tree well adapted to Minnesota conditions. However, white pine does have a number of problems that must be considered when trying to establish and culture this species. Problems are both inherent in the species and caused by conditions that are independent of the species. These problems include diseases and insects, animals, air pollutants, establishment problems, tree improvement efforts, shrinking budgets, the impatience of people, and the polarization of the stakeholders. These problems are not insurmountable, but they do add to the cost of managing white pine. Without consideration of these problems, investing in white pine will be an investment with little return.

INTRODUCTION

White pine is unquestionably a valuable tree. Ever since white people set foot on North America, white pine was recognized for its value and "was the species on which the United States was built" (Howard 1986). The Royal Navy reserved white pine for ship masts, and it was a crime if colonists cut down a white pine larger than 24 inches in diameter. "Prior to 1889, eastern white pine supplied at least half of the nation's softwood requirements" (Howard 1986). And, white pine's value goes beyond wood products. It is important to a variety of wildlife species, it is prized for its aesthetic qualities, and for some white pine is a balm to sooth one's troubled soul.

White pine grows best when "July temperatures average between 18° and 23° C...White pine grows on nearly all the soils within its range but generally competes best on well drained sandy soils of low to medium site quality" (Wendel and Smith 1990). Temperatures and soils sound like Minnesota. Yes, "white pine" and "Minnesota" go together like "lutefisk" and "Norwegians." Take a valuable tree and combine it with environmental conditions ideal for its survival and growth, and you have a winning combination. White pine and Minnesota. That's what we are going to hear about during this Symposium where the virtues and values of white pine will be repeated over and over again.

But white pine has a number of significant problems. The problems are either inherent in the species or created because of external situations. It is critical to consider these problems. When Fats Waller, the legendary jazz pianist, was asked what jazz was, he replied, "If you don't know, don't mess with it" (Collier 1978). The same advice should be given about white pine. If you don't know the problems with white pine, don't mess with white pine. To successfully establish and culture white pine, the problems must be recognized and managed. If not, we will be making investments without any returns.

DISEASES AND INSECTS

Wendel and Smith (1990) report that "there are a total of 277 insects and 110 disease organisms known to attack white pine." Garrett (1986) makes the claim that "there are more diseases and insects associated with eastern white pine than with any other species of tree in North America." However, Wendel and

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Smith (1990) say that "only 16 insects and 7 diseases cause sufficient injury or mortality to be of concern."

Whether white pine has one disease and one insect that can cause significant damage or white pine has more damaging diseases and insects than any other tree species, diseases and insects have a significant impact on white pine. At the worst, diseases and insects cause mortality; at the best, they alter management practices and add to the cost of establishing and culturing white pine. I will briefly mention two significant diseases and two significant insect problems.

WHITE PINE BLISTER RUST

White pine blister rust has dominated white pine conversations and actions since it was first recognized as a potentially catastrophic disease. White pine blister rust was first introduced into Minnesota in about 1916 (Sauerman 1992). By 1930 the disease was still not present throughout the state; its westward spread was barely into the Chippewa National Forest (Jones 1988). Efforts to control blister rust constituted the largest tree disease control program ever under taken. Control centered on eradication of the alternate hosts, *Ribes* spp. Eradication efforts began in 1909 and ended during the 1950's. During this time in excess of $100 million was spent, but despite the cost and the efforts, 650 million board feet were lost to this disease in 1952 (Anderson 1973).

The importance of white pine blister rust continues to be an ongoing debate. Forest pathologists emphasize its importance; forest managers deemphasize its importance. Sauerman (1992) and Mielke (1989) found lower than expected levels of blister rust infections in plantations they surveyed. However, they admitted that the heavy deer browse may have masked the incidence of blister rust or simply may have reduced the target areas for the fungal spores to start infections.

There is no definitive long term impact information for white pine blister rust since the disease is a relatively newcomer in the state, and we have few examples of older plantations where blister rust has been active for many years. Sauerman (1992) found in northern Minnesota that younger trees tended to have a greater frequency of infection. Eighty-three percent "of the branch cankers (81 percent of the stem cankers) observed were in trees less than 12 years old since establishment." These findings are not surprising since plantation ages in Sauerman's survey ranged between 6 and 29 years. Blister rust may also have culled out significant numbers of trees as the plantations aged.

We must be cautious drawing definitive conclusions of blister rust impacts based on surveys of young plantations. Most surveys are only glimpses; they are not long term views of what occurs over the lives of stands. There are few long term studies that track the development of blister rust in a stand over a long period of time. Because of the nature of the surveys, it is unknown if blister rust is simply a thinning mechanism or if blister rust will eventually lead to total stand elimination over the life of the stand. We therefore need to keep in focus that we have very sketchy information related to what happens to these plantations as they age. Inferences from survey results are limited to stands of similar ages, and inferences are based on a snapshot picture of disease development over a short period of time.

However, management practices are available which will help reduce blister rust to acceptable levels (Anderson 1973, Jones 1988, Robbins 1984, Sauerman 1992, Van Arsdale 1979). These practices include: microsite evaluations to avoid planting in high risk areas, underplanting, avoiding planting in small openings, pathological pruning, and *Ribes* eradication. Sauerman's (1992) survey illustrated the effectiveness of underplanting and pathological pruning. Ninety-two percent of the underplanted stands "had no incidence of rust...No underplanted stands had trees with stem cankers." Seventy-two percent of the pruned stands "had no incidence of blister rust...(and)...83% had no stem cankers."

All of these control practices require extra expense in dollars and human labor, and all of these practices, if they are to be successful, require a long term commitment to maintain them. It can be argued that with the low incidence rate of blister rust that Sauerman found in his survey (5 percent of the trees infected), that the expense of these blister rust control practices cannot be justified. However, blister rust is not the only problem on white pine. There are other diseases and insects, there are animal problems, air pollution problems, and competition problems. Any of these are capable of preventing white pine seedlings from developing into sawlog and super canopy size trees. It would be foolish not to invest in blister rust control practices so that white pine is given as much help as possible to survive and grow. These practices provide a hope that there will be a return on the investment. That's good economics. Without these practices, the risks are much greater that there will be nothing to show for the investment. That's bad economics!

WHITE PINE WEEVIL

White pine weevil is the major insect pest of white pine. Houseweart and Knight (1986) say that white pine weevil "has been one of the most intensively studied forest insect pests, ranking comparably with the gypsy moth, the spruce budworm, or the southern pine beetle. Yet, the white pine weevil continues to be *the* major impediment to the culture and management of eastern white pine." However, Sauerman (1992) in his survey of 126 white pine plantationsin Minnesota found that only 23 percent of the stands and only 9 percent of the trees showed weevil damage.

Whether white pine weevil damage is the major problem as it has been characterized in the northeastern United States or is a relatively minor occurrence as found in Sauerman's survey, white pine weevil has the capacity to alter management practices. Weeviled white pine certainly will survive, but to produce a wood product and to keep white pine even with or above woody competition, weeviling needs to be controlled.

The standard weevil management practice is to grow white pine under an overstory since shade reduces weevil attacks (Houseweart and Knight 1986). Katovich and Morse (1992) point out that "growing white pine in shade requires a tradeoff." Understory white pines generally grow slower and in dense shade white pines will not survive (Wendel and Smith 1990). As white pines grow taller and their leaders become intertwined with the overstory, leader damage and death often results. Controlling weevil damage by maintaining an overstory increases costs of implementing the management practice. Weevil management also necessitates a periodic monitoring and release to prevent damaged leaders which is what the practice was intended to prevent in the first place.

OTHER DISEASES AND INSECTS

Red ring rot caused by *Phellinus pini* (Thore:Fr.) A. Ames and the potential of defoliation by gypsy moth *(Lymantria dispar* L.), should also be mentioned. Red ring rot is the most significant decay organism on white pine (Shigo 1989, Wendel and Smith 1990) because it is a canker rot organism. Trees cannot wall off canker rot organisms, and decay is more extensive (Shigo 1989). This fungus invades dead and broken branches (Wendel and Smith 1990), and there is some evidence to suggest that dead leaders from white pine weevil attacks serve as infection courts for this decay organism (Ostrander and Foster 1957). It is interesting to note that even during Colonial times white pine reserved for ship masts had significant decay problems. "One record indicated that 102 of 106 large trees cut for that purpose had so much decay that they had to be discarded" (Garrett 1986).

Mosher (1915) reports white pine as favorite food for late instar larvae of gypsy moth. Later studies both in Canada and in the northeastern United States rate gypsy moth as avoiding white pine (Mauggette, et al. 1983) or as being intermediate in preference where "white pines were frequently nibbled on but were rarely defoliated heavily" (Campbell 1979). Campbell did observe that pure stands of white pine were "immune" to gypsy moth, and Brown et al. (1988) found that overstory white pines were rarely fed upon by gypsy moth. But both observed that when white pine was an understory tree, larvae moved to the pines when the more favorable food in the overstory was depleted. Understory white pine heavily defoliated by gypsy moth sustained heavy mortality. The recommended control practice for blister rust and white pine weevil is to establish and culture white pine as an understory tree. This practice may lead to significant white pine mortality when gypsy moth arrives in Minnesota in the very near future.

ANIMALS

A number of animals feed on white pine. Porcupines will girdle the tops of trees and hares will girdle seedlings and saplings. However, the animal that has the greatest impact on white pine is the white tailed deer. From Sauerman's survey (1992), he concluded that "deer are the most important serious damaging agent to white pine in Minnesota." Mielke (1989) concluded the same after his survey of white pine plantations on the Chippewa and Superior National Forests. He states in his report, "The general condition of most plantations is poor to fair. Repeated deer browse injury is probably the greatest limiting factor in plantation establishment. Some type of deer control measures must be implemented if plantations are to succeed."

The good news from Sauerman's survey (1992) was that deer damage decreased about 11 years after white pines were planted or the trees reached at least 9 feet in height. He also found that underplanted white pines "were not generally more susceptible to deer browse." However, he mentions that "control is difficult due to the mobility of the deer, recent high density populations, and associated costs." He then recommends implementation of "some economically effective means of deer control."

Deer population trends have been increasing. Minnesota DNR Wildlife officials stated in a recent news release that Minnesota deer populations are record high, and the herd is estimated to number about 1.2 million (Anonymous 1992). Steve Caron, Minnesota DNR Area Wildlife Supervisor said, "Currently we have 22 to 23 deer per square mile in the Bemidji area and this is the largest population we have ever had...Even if we have a severe winter in 1992-93 and we have a high harvest next fall, we shouldn't lower the population to less than 18 or 19 per square mile" (Miller 1992). With the popularity of deer hunting, the activism of deer hunting groups, and the high demand for harvesting of aspen, deer populations will not be reduced in the foreseeable future.

White pine stands developed in the absence of both heavy deer browse pressure and white pine blister rust. There has been significant change since white people first set foot in Minnesota. Things simply aren't the way they use to be. If we get caught up into thinking that since white pine was significant in Minnesota at one time it can be significant again, we are only fooling ourselves. Deer numbers and blister rust have greatly reduced the chances of returning the Minnesota landscape to what it was even 100 years ago.

Deer browsing will have to be managed to successfully establish white pine. Repellents, protective coverings, and fencing are techniques available to manage deer damage (Sauerman 1992). These techniques require annual or semi-annual maintenance to be effective. What agency, industry, or group has the funding, personnel, and commitment do this required maintenance for ten years or more?

AIR POLLUTANTS

Garratt (1986) states that white pine is "probably more susceptible to air pollutants than any other tree species in North America." And Hodges (1986) concludes that "eastern white pine is generally considered one of the most sensitive conifers" to air pollution. Damage ranges from "post-emergence chronic tipburn" to "chlorotic dwarf disease", the latter appearing in trees as old as 40 years (Garratt 1986).

In addition to the direct affect of air pollutants causing needle burning and tree dwarfing, air pollutants can indirectly cause problems. Garrett (1986) in a review of the literature reported several indirect effects of air pollutants. There was a higher susceptibility to *Phellinus pini* infections of trees with foliage injury due to air pollutants. White pine damaged from air pollutants could not compete with other woody vegetation, and there was speculation that widespread air pollution damage to existing white pine stands may lead to cover type conversions. Finally, it was reported that gypsy moth had a preference for needles "spiced" with ozone.

ESTABLISHMENT PROBLEMS

Times and forest conditions have changed since white people first stepped foot in Minnesota. One change is the decreased role fire plays in shaping the natural landscape. Fire probably played a significant role in the development and maintenance of white pine stands in Minnesota prior to the arrival of white people. In Ontario, "most of the white pine stands...are of fire origin...(and)...improved fire control...could result in the elimination of...white pine..." (Wray 1986).

Significant regeneration of white pine will not happen on its own. And, because fire is no longer a dominant shaper of the landscape, practices that duplicate the disturbances of fire will have to be used to regenerate white pine. This will take an investment to scarify sites to expose mineral soil and then manage competition so that newly established white pines do not die from suppression.

A second change is the change in cover types in Minnesota. When white people first started settling in Minnesota, 58 percent of the cover type acreage, or 18.2 million acres, was conifers, and 13.3 million acres were hardwoods. Pine acreage made up only 5.8 million acres of the 18.2 million acres of conifers. Aspen-scrub oak type made up 2.9 million acres of the hardwood types or only about 9 percent of the forested land in Minnesota (Cunningham et al. 1935).

The 1977 forest looked much different. Only 30 percent of the forested acreage, or 4.2 million acres, was in conifers. Pine accounted for 1.3 million acres, and black spruce and balsam fir dominated with a combined acreage of about 2.1 million acres. There were almost 10 million acres of hardwoods, and the aspen type alone accounted for 5.4 million acres, or 38 percent of all forested acreage in Minnesota (Jakes 1980).

White pine is rated as being "intermediate in shade tolerance, and vegetative competition is a major problem...Against the stronger competition of species such as the aspens, oaks, and maples, however, white pine usually fails to gain a place in the upper canopy and eventually dies (Wendel and Smith 1990).

Because of the changes in cover types, the decrease in fire occurrences and intensities, and white pine's inability to compete with sprout origin woody vegetation, establishing white pine will be no easy task. Methods exist for controlling competition, but those methods can be hard on the land (mechanical site preparation) or objectionable (chemicals) to a lot of groups that now favor the establishment of white pine. Whatever the choice of techniques will be, an investment will be required. Are we willing to make the investment and then continue to make additional investments to see that white pine survives and thrives beyond the seedling stage?

TREE IMPROVEMENT EFFORTS

Producing genetically resistant trees is perhaps the ultimate control of white pine blister rust. Many managers hope that a resistant (i.e., immune) tree will be produced, and a viable and significant white pine planting program can be started in Minnesota. We need to keep in focus that the track record for solving forest tree diseases through genetic manipulations has not been sterling. We have yet to embark on an American chestnut or an American elm planting program. Given the long time trees live, the long time for trees to produce flowers, and the many other genetically controlled attributes that made the tree desirable in the first place, producing even a genetically resistant tree to a particular disease is a slow and difficult task at best.

A genetic improvement program for white pine in the Lake States was started during the early 1960's (Meier 1988). Since then "genetically resistant" planting stock has been made available to the National Forests and limited numbers made available to the States. This has created problems. Enthusiastic managers have either ignored the geneticists warnings of the limits of this stock, or geneticist simply have not told the whole story. It is stock that shows some resistance, but not immunity. Meier, in discussions at the White Pine Workshop that was sponsored by the Chippewa National Forest in 1988, commented that the stock was only 20-30 percent resistant. When asked whether he would still recommend following all standard white pine blister rust management recommendations (i.e., microsite evaluations, underplanting, pathological pruning, and *Ribes* eradication) with this genetically resistant stock, Meier at this same workshop replied affirmatively.

Managers have failed to consider that resistance does not necessarily mean the trees will not become infected. Resistance may mean that the trees will live longer with the infection before succumbing. The resistant stock has not been tested long enough to see if it is any more susceptible to air pollution damage, to see if it produces a straight tree, to see if it differs in its attractiveness to the white pine weevil, or to see if deer have any different responses to this new stock. We need to use resistant stock cautiously. We still need to use the white pine blister rust and weevil management techniques with the resistant planting stock, and we still need to protect the stock from deer browsing.

SHRINKING BUDGETS WITH GREATER DEMANDS

With all the problems presented above, there are solutions. We know how to manage white pine to reduce blister rust, weevil damage, and animal damage. We know how to establish white pine. We know better how to communicate between researcher and manager. But all of this know-how implemented on the ground costs money and requires expenditures of people power. Yet for public agencies, there is a decline in budgets and personnel while at the same time society is increasing the demands it puts on public agencies. We no longer practice forestry the way we used to when we regenerated harvested stands by intensive mechanical site preparation, planted one species in row after row, used herbicides to maintain dominance of the species we established, and replanted the area with the same species if stocking levels fell below some standard. These changes have come about by societal demands, but also by reductions in budgets, precluding such investment on as many acres as even five years ago.

To successfully establish and culture white pine, an investment will be needed. We will have to do more underplanting which will increase the cost of planting. More periodic thinnings will be necessary, increasing the investment we put into a stand. Some kind of sustained deer control measure, such as fencing, spray repellents, or individual tree guards will be critical until the trees get above the deer. These all will increase investment in the stand, and investments in white pine management do not stop after establishment. Investments will have to continue to maintain both the protection practices and the stands themselves. Public agencies simply may not have sufficient budgets to make both the initial and continuing investments necessary to grow white pine.

I-WANT-IT-NOW GENERATION

We are an impatient people. We like to see instant results. When working with trees, instant results may be 100 years. Few are willing to wait 20 years. Yet to see the results of all our investments and efforts to establish and culture white pine, we will have to wait 80 to 100 years. How are we going to sell practices that take so long to produce a return?

Karen Bennett (1986) an Extension Forester with the State of New Hampshire says, "It is...difficult to convince (private landowners) to convert a site growing poor quality hardwoods to pine, to prune, to do pre-commercial thinnings; in short, to make an out-of pocket investment for a return they will never realize." Politicians who control budgets will also be difficult to convince, for it seems they have trouble seeing beyond the end of the fiscal period or end of their own term. And in all fairness, how can we get commitment from politicians to invest in white pine when there are so many other societal needs competing for limited funding?

POLARITY AMONG STAKEHOLDERS

The tremendous popularity of white pine has galvanized a strange association of bed fellows. White pine has brought together foresters, forest industry, wildlife managers, wildlife special interest groups, non-game managers, recreationists, and "environmentalists." Seemingly this group has come together in harmony with the goal of establishing more white pine in Minnesota. But this group has many hidden agendas. White pine for timber production. White pine for wildlife game species. White pine for eagles and bears. White pine for old growth. White pine for super canopy trees. White pine to walk and sled through.

Already white pine has caused polarization. The Kawishiwi pine sale produced head on confrontation among public agency foresters, the forest industry, recreationists, environmentalists, non-game wildlife personnel, and tree spikers. Professional resource managers who took strong stands related to the Kawishiwi pines became the object of animosity and personal scrutiny by opposing viewpoints.

Such polarity exists with many tree species and forestry practices. But nowhere does it exist with a greater diversity of stakeholders and with greater passion than with white pine. This polarization will only increase the costs of managing the resource. 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 of 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."

CONCLUSION

White pine does have problems. Some are inherent with the species and others are a reflection of the times we live in. The problems can be managed, and we can increase white pine in Minnesota. However, white pine will never occupy the predominance it had when Minnesota was first settled by white people. We will never see white pine established and cultured as red and jack pine are managed. We will never see acres and acres of pure white pine in plantations. At best we will see white pine mixed with other species, and perhaps in this mixture white pine will be able to satisfy all the diverse needs.

To manage white pine, then, is to manage the problems associated with white pine. If we choose to ignore the problems with white pine or we choose to be ignorant of the problems, then we have no right to mess with white pine.

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THE TREE OF PEACE: SYMBOLIC AND SPIRITUAL VALUES OF THE WHITE PINE

Herbert W. Schroeder[1]

ABSTRACT. The original meaning of the word "spirit" (i.e., breath or wind) suggests an experience in which one feels touched or moved by something that can be felt but cannot be seen or grasped. The experience of spirit is often depicted through the use of symbols. Symbolism allows a concrete object, such as a tree, to represent an experience that is intangible and hard to describe. Trees have been important spiritual symbols in many human cultures. Evergreens often symbolize immortality and eternal life because they retain their leaves throughout the winter. To the Iroquois people, the white pine is a symbol of the Great Peace that united their separate nations into an enduring League. The Peace Tree is related to the Tree of Light, a central symbol in Iroquois cosmology. Similar mythological trees are found in European traditions, including the Norse World Tree and the medieval Christian Tree of Life. The World Tree symbolizes the unity of all life, and the struggle of order and growth against chaos and disintegration. The white pine is thus linked to one of the most universal spiritual symbols of the human species.

INTRODUCTION

I spent 11 years in classrooms and laboratories at the University of Arizona, learning how to do science. As an undergraduate, I learned the basics of physics, chemistry, and biology. As a graduate student I went more deeply into the social sciences, especially psychology and economics. I learned how to design experiments, how to collect data, and how to perform statistical analyses. But I did not learn anything that can help me now in speaking about the spiritual values of the white pine. When it comes to spiritual values, science seems to have a major blind spot.

Fortunately, while I was in school I didn't spend all of my time attending lectures and labs. I spent a lot of time walking through the mountains, canyons, and deserts of southern Arizona. I did a lot of reading beyond the textbooks and articles required in class, and I joined an informal workshop with a group of local poets. That was the beginning of a different kind of education, one that has perhaps prepared me better for speaking on the topic of spiritual values.

What is spiritual value? How can we talk about the spiritual value of a species of tree, such as the white pine? According to the dictionary, the word "spiritual" means "relating to or having the nature of spirit". But "spirit" itself is a difficult word to define in any precise way (Jung 1958). My dictionary lists 14 different meanings of "spirit", ranging from "a supernatural being" to "an alcoholic beverage". Clearly, there is a lot of opportunity for misunderstanding and confusion in using this word.

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THE EXPERIENCE OF SPIRIT

When I talk about spirit, I am not referring to supernatural beings or metaphysical essences. Rather, I am speaking about a certain kind of experience that people have. In many ancient languages, the word for spirit is the same as the word for wind or breath, and this gives a clue as to what the experience of spirit is like. The wind is invisible. You cannot see it or take hold of it, but you can feel it and be moved by it. So an experience of spirit is one in which a person feels touched or moved by something that they can feel but cannot see or grasp. It is a very intuitive and emotional kind of experience, in which a person may feel caught up and carried along by a feeling, an idea, or a creative impulse.

The experience of spirit can be evoked in many ways. People often associate the word "spirit" with religion, and many people experience spirit in religious rituals and disciplines. But the experience of spirit can also occur in the absence of any religious belief or practice. Some people experience spirit in creative processes such as art and music. Still others find this kind of experience through falling in love, or through being a part of their family or their community. And many people experience spirit through contact with forests and other natural environments.

Like the wind, the experience of spirit can vary in intensity from a barely perceptible stirring to a powerful storm. At its gentlest, we are hardly aware it is there. At its strongest, it can whirl us around and turn our lives upside down. And like the wind, the experience of spirit is unpredictable. We can never be exactly sure where, when, or how it will arise.

Although it is difficult to define and predict, the experience of spirit is not rare or exotic. In fact, some psychologists have concluded that spiritual experience in one form or another is a normal function of the human mind and an essential factor in health and well-being. Through the experience of spirit, a person may come to feel deeply connected or related to a reality that is greater (or at least other) than they are, and that gives a strong sense of meaning or purpose to their life.

SYMBOLISM AND SPIRIT

The experience of spirit is difficult to talk about in precise scientific terms. It arises from an unconscious, intuitive level of the mind and may be very difficult to express in words. There is something mysterious about the experience that seems to elude rational definition and analysis. For that reason, the experience of spirit is more often expressed in the symbolic language of art and poetry than in the literal language of science.

A symbol is a word or an image that stands for something other than itself. Symbolism allows a concrete object, such as a tree or an animal, to represent an idea or an experience that is intangible, indefinite, or only vaguely understood. The human imagination has a natural capacity for forming symbols. When we dream, our minds spontaneously create symbolic images and stories about the things that concern us as individuals. Similarly, myths and religions use symbols to express the basic issues and questions of a whole culture. The symbols in dreams and myths point to things within or beyond ourselves that may not be consciously understood, but that have tremendous importance for our sense of who we are and how we relate to the world (Jung 1964). These symbols speak directly to the intuitive level of the mind, and can evoke strong feelings of awe, wonder, and fear. It is not surprising, then, that symbolism and the experience of spirit are closely linked.

TREES AS SYMBOLS

Much has been written about the symbolism of trees. Trees and forests have been important in the mythology and religions of many cultures. Trees have been used to symbolize fundamental values and beliefs relating to life, growth, health, fertility, regeneration, wisdom, enlightenment, strength, and steadfastness. With its many branches and leaves, all originating from a single stem, a tree is a natural symbol for the unity that underlies the diversity of living things. (Eliade 1959, Karas 1991).

Evergreens, in particular, have come to symbolize immortality and eternal life, because they retain their leaves and their appearance of life in the winter, when other trees are barren and appear to have died. To ancient people, this made it seem that the power of life was stronger in evergreens than in deciduous trees. In ancient Europe an evergreen tree was placed inside the house at the winter solstice - the longest night of the year - as a sign of hope and a reminder of the continuity of life through the darkness of winter. This custom is preserved today in the form of the Christmas tree (Karas 1991).

Large ancient trees have been especially important as symbols in many religious and spiritual traditions, probably because they so effectively evoke the experience of awe. To appreciate this, it is not enough to read lists of symbolic meanings in scholarly books. You have to go outdoors, stand under the trees, and experience them firsthand. Even scientifically trained people are apt to experience something of spirit when entering a grove of very large trees. In reference to the giant sequoia, Harlowe and Harrar's (1958) textbook of dendrology says, "... a feeling of reverence comes over one upon entering a grove of these patriarchs whose gigantic red trunks are like the supports of some vast outdoor cathedral (p. 202)." John Muir (1989) was similarly impressed with the sugar pine: "In approaching it, we feel as if in the presence of a superior being, and begin to walk with a light step, holding our breath (p. 123)."

The eastern white pine, the largest conifer in the northeastern part of our continent, can evoke a similar feeling. Earlier this year, I visited some of the last remnants of virgin white pine in the Allegany Mountains of Pennsylvania. The oldest of these trees approach 400 years in age and 200 feet in height. At first glance, they look strangely out of proportion. Their diameter appears too small for their great height, and it seems remarkable that anything so tall and slender can remain upright. The tops of the largest trees float in the air, far above their smaller neighbors. At eye level, the largest trees are 3 to 4 feet in diameter. From this modest base, the trunk seems to shoot into the sky like a giant rope, gently curving as it rises. A tree this tall seems to inhabit two worlds. The roots and the base are close at hand, solid and tangible. But the top of the tree is adrift in the sky, ethereal and beyond reach. It is easy to see why trees such as these have been viewed in many cultures as a link between earthly life and the realm of the divine.

THE TREE OF PEACE

The white pine plays an important role in the history and traditions of the Haudenosaunee, the Iroquois people who once occupied most of New York State and part of Pennsylvania. In the mid 1400's, the Seneca, the Oneida, the Cayuga, the Onondaga, and the Mohawk nations were engaged in constant wars and bloody feuds among themselves. According to Iroquois tradition, a man known as the Peacemaker came from the north shore of Lake Ontario and traveled among these five nations. He convinced them to stop their fighting and to form a League that for many years dominated the northeastern part of North America. The story of the founding of the Iroquois League is described in Paul Wallace's (1986) book The White Roots of Peace (originally published in 1946).

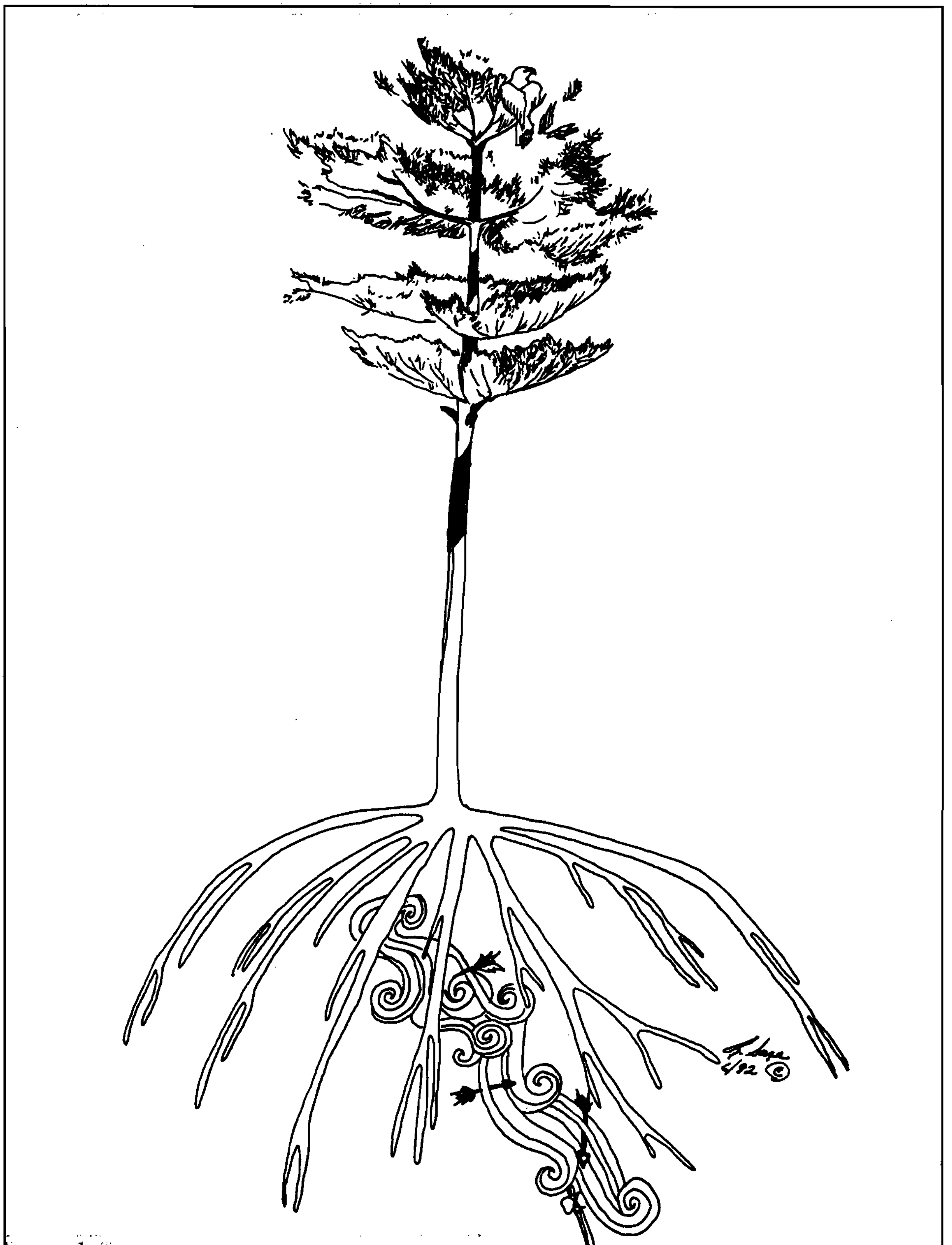

Figure 1. The Iroquois Peace Tree.

At the council which established the League of the Iroquois, the Peacemaker declared that he had planted a white pine, which he called the Tree of the Great Peace (Figure 1). Beneath the shade of the Tree of Peace, the leaders of the five nations would sit to conduct the affairs of the League. The Peacemaker told the lords of the five nations that the Peace Tree had sent out great white roots in all directions, to bring the Peace into the territories of nations beyond the original five. The white roots of peace would guide other nations back to the tree, where they would be welcomed into the League. An eagle kept watch from the top of the Peace Tree, and if any evil approached the League, it would scream to give the alarm. Then, according to the tradition, the Peacemaker uprooted the Peace Tree and exposed a cavern, through which a river ran down into unknown regions under the earth. He cast the weapons of war, the hatchets and war clubs that had divided the five nations, into the river. Then he replaced the Tree and declared that the Great Peace had been established.

The union of the Iroquois tribes was a carefully thought out political system, which preserved the diversity of the separate nations while providing the strength and security of union. According to Wallace (1986) The Peace Tree symbolized the law that governed the League of the Iroquois. Its branches represented shelter and protection in unity under the law; its roots represented the extension of law and peace to all nations; and the eagle represented watchfulness in the defense of peace. These vivid symbols "seized the imagination and so gave both interpretation and example a power to drive the human will (Wallace 1986, p. 4)."

For the Iroquois, Peace and Law were one and the same. Peace was not an abstraction, but a way of life, embodied in social institutions. The white pine became the symbol of Peace, both as an institution of government and as a way of life. The League itself was named the Great Peace, and was sacred. After years of bloodshed, Peace was a gift from the Creator, brought to earth by the Peacemaker. The towering white pine, which "pierces the sky" and "reaches the sun", was a natural symbol for this sacred gift of Peace (Wallace 1986, p. 8).

THE TREE OF LIGHT

Symbolic trees, such as the Peace Tree, are prominent in many aspects of Iroquois tradition, ritual, and art. Tree symbolism is perhaps more fully developed in this region than anywhere else in North America (Bierhorst 1985). The Seneca creation myth tells of a celestial tree that grew in a world above the sky. A luminous blossom at the top of the tree gave light to the sky world, and its fruit fed the beings who lived there. The tree was supported by great white roots that extended out in the four directions. The chief of the upper world one day became angry at his wife because he thought she had deceived him. He uprooted the celestial tree and pushed his wife through the hole left by the roots. She fell into the world below, which at that time was entirely covered with water (Parker 1989).

The animals of the lower world created a place for the Sky-woman to live, by placing dirt on the back of a turtle. The turtle grew larger and larger, and in this way the earth was created. The creation of the world was completed by the Sky-Woman's eldest grandson, who is called Good-Mind. He traveled around the earth, creating the plants and animals. His brother, Evil-Mind, followed him and tried to undo the good things that Good-Mind had created.

In the version of the creation story told by Parker (1989), a root of the celestial tree was planted at the center of the newly formed earth. From this root grew the Tree of Light, so called because an orb at its top illuminated the earth before the sun was made. Good-Mind and Evil-Mind struggled against each other, and in their fighting Evil-Mind injured the Tree of Light, whose branches had supplied them with food. After this, Good-Mind overpowered Evil-Mind and imprisoned him in a cave.

Iroquois mythology and art sometimes depict the Tree of Light as a flowering tree, with the light coming from its blossoms (Parker 1989). Other traditions, however, seem to associate the Tree of Light with the pine. For example, in the tradition of the Peace Tree, the white pine is referred to as the "Tree of the Long Leaves", and Parker (1989) notes that the Tree of Light in Iroquois art was generally depicted with long, sword-like leaves.

The Tree of Light at the center of the world is important in Iroquois ceremonial rites. The top branches of this Tree touch or pierce the sky and its roots run down to the waters of the underworld. Because it connects the earth and the sky, the Tree at the center of the world is a source of great power. This Tree is guarded by an invisible giant, who fills his turtle-shell rattle with the power of the earth and the sky by rubbing it against the trunk of the Tree. The members of the Iroquois False Face Society imitate this act in their healing rituals by rubbing their rattles against pine tree trunks (Parker 1989).

The role of the pine tree as a link between the earth and the sky also appears in the Iroquois legend of the star dancers. In this story, seven dancing brothers were lifted into the sky to become stars. Their mother saw them leaving the earth and began to cry. One of the star dancers heard her voice and looked back. In so doing, he fell down from the sky and into the earth. From the place where he entered the earth a towering pine tree grew up, pointing toward the other brothers in the sky (Karas 1991). According to Bierhorst (1985), the Iroquois associated pine trees with starlight, because of the latent fire in pitch-wood. In Huron embroidery, the topmost flower of an emblematic tree is called a "star", and Parker (1989) regards this as a reference to the Tree of Light.[2]

The white pine as the Peace Tree is more than just a convenient symbol for a political system. The Peace Tree reflects the mythic image of the Tree of Light, which stands at the center of the world and connects the earth with the sky. Thus the story of the founding of the Iroquois League reflects the creation and the unity of the universe itself, and this reinforces the sacred nature of the Great Peace.

THE WORLD TREE

As a child, I lived in New York State, near where the Genesee River flows into Lake Ontario. The countryside where I played was once the home of the People of the Great Hill - the Seneca nation. The tradition of the Peace Tree grew from the land that I call my home, but by the time I was born there were no more great white pines there. My roots in that land are shallow compared to the Haudenosaunee who lived there and planted the Tree of Peace among themselves.

My family's roots go back to central and northern Europe. My great-grandfather moved to New York State from Germany in the middle 1800's. The ancient spiritual traditions and myths of his homeland had been swept away centuries before, but some record of them was kept in the writings of the Roman conquerors and Christian missionaries. The best preserved of the northern European traditions are found in the Norse myths, which were among the last to be replaced by Christianity.

[2]It is an interesting coincidence that Henry David Thoreau, in his famous essay "Walking", compares a flower at the top of a white pine tree to a star. Thoreau climbed to the top of the pine and found "on the ends of the topmost branches only, a few minute and delicate red cone-like blossoms, the fertile flower of the white pine looking heavenward." He carried the topmost spire of the tree to the village and when he showed it to the people there, "not one had ever seen the like before, but they wondered as at a star dropped down (Thoreau 1981, p. 412)."

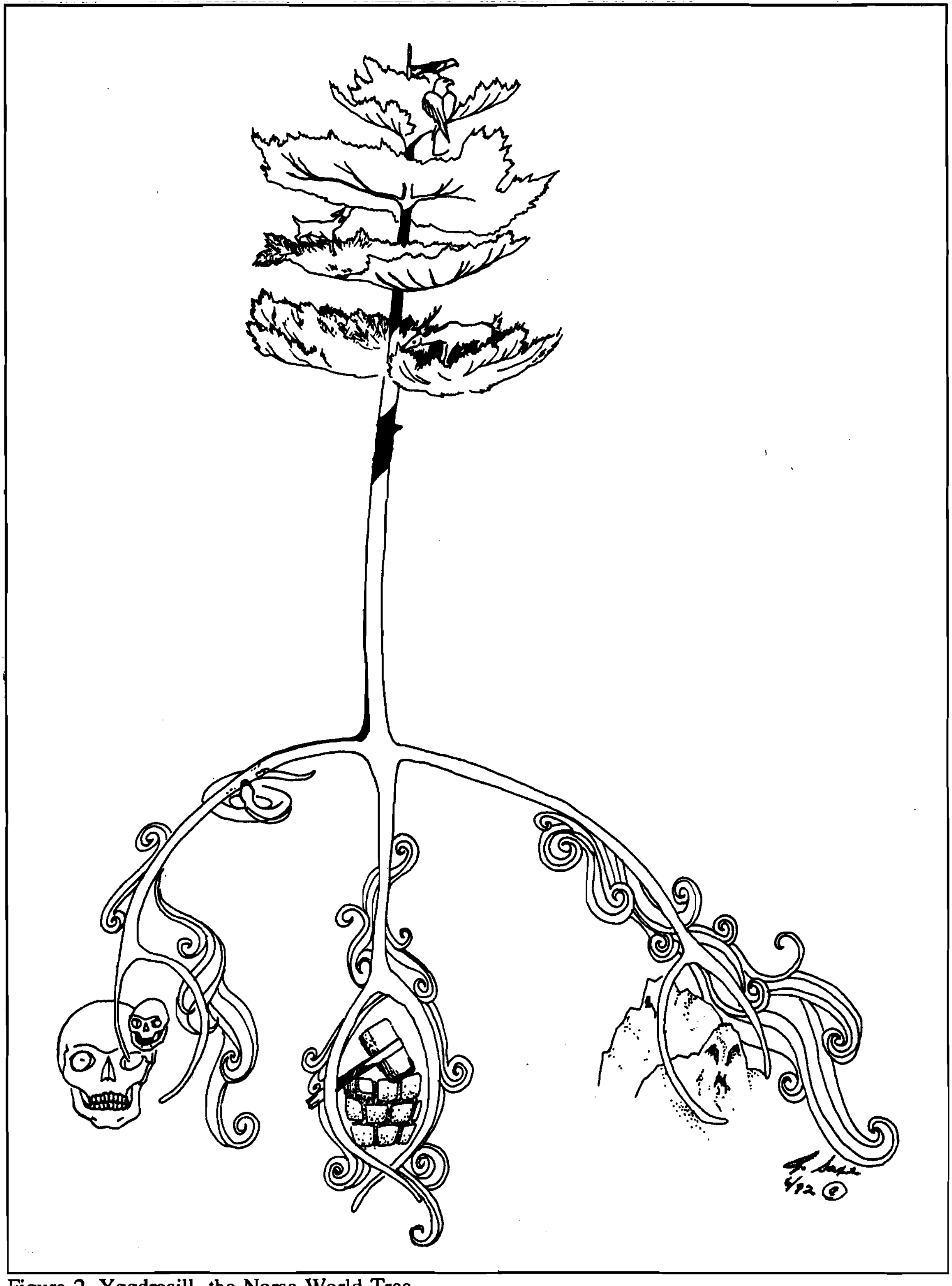

Figure 2. Yggdrasill, the Norse World Tree.

Like the Iroquois, the Norse traditions tell of a tree at the center of the world (Figure 2). According to these myths, the giant tree named Yggdrasill existed before the world was made, and will survive beyond the end of the world. Yggdrasill is generally considered to be an ash tree, although in solstice rituals it is often represented by an evergreen. It is so huge that its branches stretch out over heaven and earth. It has three great roots, which link together the worlds of the Norse cosmos. One root extends into the realm of the gods, one into the realm of the giants, and one into the realm of the dead. Springs of water with special powers are found at each of the roots. On the highest branch of Yggdrasill sits an eagle, and on the brow of the eagle perches a hawk, keeping watch over the world. A cock in the top of the tree will crow to warn the gods when their realm is under attack (Davidson 1964, Karas 1991, Jordan-Smith 1989).

The tree Yggdrasill has the power of healing and is a source of life for the world. The fruits of the tree feed the gods and according to one myth are supposed to aid women in childbirth. But the tree is also continually threatened. Deer and goats leap among the branches, devouring the leaves and shoots. A great serpent lies beneath Yggdrasill and gnaws at one of the roots, trying to destroy the tree. The eagle at the top of the tree and the serpent beneath the tree are constantly at war. A squirrel runs up and down the tree carrying insults from one to the other (Davidson 1964, Jordan-Smith 1989).

The Iroquois Peace Tree and the Norse Yggdrasil stories contain many elements that are remarkably similar -- roots that reach out to link separate worlds or nations, vigilant birds in the top of the tree; and flowing water associated with the roots. Both stories are examples of a myth-pattern that occurs in many places around the world. Many cultures believed that there was a tree at the center of the world, which connected the world of human beings with spirit worlds that lay above and below the earth (Eliade 1976). This mythical tree, called the World Tree or the Tree of Life, can be interpreted as symbolizing the principle of order, life, and growth; and the unity and interrelatedness of all things in the universe. Order and unity are constantly threatened by the forces of disintegration and chaos, symbolized in the Norse tradition by the serpent that tries to destroy the tree. In the Iroquois traditions similar forces of strife and disunity are represented by the weapons cast into the subterranean river beneath the Peace Tree, as well as by the evil brother who is imprisoned in the cave after he damages the Tree of Light.

Similar themes can be found in Hebrew and Christian stories of the tree of life, which grew in the garden of Eden and later became identified with the cross of Jesus. The Hebrews probably thought of the Tree of Life as a pine, because their story of Eden was drawn from Indian and Babylonian traditions about a sacred pine (Karas 1991). In the medieval European Legend of the True Cross, Adam's son Seth returns to Eden. There he sees the Tree of Life, a magnificent evergreen tree standing before a fountain that gushes forth in four streams. A great serpent coils around the base of the tree, scorching the bark with its breath and devouring its leaves. Beneath the tree is the pit leading to Hell. The branches of the tree reach up to heaven, and are covered with green leaves, flowers, and fruit. At the top of the tree a radiant woman holds a small baby who glows like the sun and is encircled by seven doves (Karas 1991). In this image of the Tree of Life we see several elements that are similar to the Iroquois Tree of Light and the Norse Yggdrasil -- in particular the light at the top of the tree; and the flowing water, the cave, and the devouring serpent at the roots.

These similarities show that the World tree is a truly universal symbol. The symbol of the white pine as the Peace Tree is thus linked to one of the most fundamental myths of the human species, a myth that represents the underlying unity of all living things, and the struggle of light and order against darkness and chaos.

THE PEACE TREE TODAY

The League of the Iroquois flourished in the northeast of this continent for almost three centuries. In the early 1700's, the original five nations were joined by the Tuscarora, to make six. The Six Nations lost most of their lands during and after the Revolutionary War, but the tradition of the Peace Tree survived, and the founding of the Iroquois League is still celebrated today. Along with the Turtle on whose back the earth rests, the Peace Tree is a principal emblem of the modern Iroquois Nation (Bierhorst 1985), and appears frequently in contemporary Iroquois art. Paul Wallace's 1946 book on the Peace Tree was recently republished, with a new prologue and epilogue highlighting the struggle of contemporary Native Americans for sovereignty and protection of their treaty rights.

Ironically, even as the Six Nations were being forced from their lands, the Tree of Peace and the political system it stood for served as an inspiration for the newly forming union of English colonies. A resolution of Congress passed on September 16, 1987 acknowledges that the United States constitution was explicitly modeled after the Iroquois confederation.

The Iroquois once hoped that their Great Peace would extend to include all the nations of the world (Wallace 1986). Today, the Peace Tree might once again serve as a symbol for the hope of world peace. Enos Mills, a government lecturer on forestry under Teddy Roosevelt could have been speaking about the Peace Tree when he said,

> Enter the forest and the boundaries of nations are forgotten. It may be that some time an immortal pine will be the flag of a united and peaceful world (quoted by Becknell 1991, p. 68).

Paul Wallace begins and ends the original 1946 edition of his book about the Iroquois Nations by drawing a parallel between the founding of the Iroquois confederation and the establishment of the United Nations. We must recognize, however, in this 500th year after the voyage of Columbus, that if we desire peace with other nations then we must also honor the sovereignty and treaty rights of the native nations on our own continent, as they struggle to preserve their languages, traditions, and lands.

CONCLUSIONS

Resource managers understand very well the economic and environmental importance of trees such as the white pine, but they often do not seem to grasp the cultural and symbolic significance of trees and the traditions that surround them. The Tree at the Center of the World is a symbol that is rooted deeply in the human imagination. The Iroquois traditions of the Peace Tree and the Tree of Light, as well as the European myths of the World Tree, express an experience of wonder at the beauty and diversity of living things, and an intuition of the unity that lies beneath that diversity.

Symbolic stories and images, such as the Peace Tree, can help to channel the spiritual and emotional energy of the human mind in positive directions. In the book Black Elk Speaks, an Oglala holy man describes a vision of a Sacred Tree that he had as a child:

> Then I was standing on the highest mountain of them all, and round about beneath me was the whole hoop of the world. ... And I saw that the sacred hoop of my people was one of many hoops that made one circle, wide as daylight and as starlight, and in the center grew one mighty flowering tree to shelter all the children of one mother and one father (Neihardt 1932, p. 43).

Like the Peace Tree of the Iroquois, Black Elk's Sacred Tree is a symbol of unity and peace among the people of many nations. This Sacred Tree has been adopted as the central symbol in a modern educational program developed by a Native American inter-tribal group to teach spiritual values and combat addiction among indigenous peoples of the world (Four Worlds Development Project 1984).

We should not underestimate the emotional power of this kind of symbolism and its ability to motivate and inspire people. In our scientific and technological culture we too easily forget that the connections between humans and the natural world involve more than just physics and biology. The human mind and heart evolved out of the natural world, just as did the human body. The emotional, symbolic, and spiritual connections between people and trees are therefore just as real and just as important as the physical and biological links. If we treat the white pine as simply an object or a commodity to be managed for economic and environmental benefit, then we miss what may be its most important contribution to the ecological community of the earth -- a symbol of the unity of life, and an image of peace which the world so desperately needs.

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VISUAL AND RECREATIONAL VALUES OF WHITE PINE

Wayne G. Tlusty[1]

ABSTRACT. White pine, more than any other tree, tends to symbolize the northwoods for purposes of recreation and viewing experiences. Currently, no specific research is available. However, since all forest activities, planned or unplanned impact the quality of the experience, it is essential to present a rational approach in establishing how white pine might be managed for recreation and viewing. A brief description and history is presented for current recreation management and the Recreation Opportunity Spectrum (ROS) system is advocated. In addition, a new approach for managing the appearance of the forested landscape is also proposed. Researchers, planners and resource managers should recognize the difference in managing for landscape scenery and landscape aesthetics.

INTRODUCTION

> If there is one tree which can be used to exemplify the northern forests, it is the white pine. It is the only species which is present in appreciable quantities in all segments of the full moisture gradient from wet bogs to xeric sand plains. It is the largest and the longest lived tree of the region. When the vacation-bound traveler from the hot and steamy cities of the south sees his first white pine, he knows that he is entering the "northwoods."
>
> John T. Curtis
> The Vegetation of Wisconsin:
> An Ordination of Plant Communities

> ...if the loggers had only known the value of scenery they might at least have saved the shorelines and blown up the dams after the logs were out. But we forget that then men thought of the wilderness as something to be eliminated and that forests existed only to be cut. No one had ever heard of recreational values or the conservation of natural resources.
>
> The pine stands were thought inexhaustible, and no one could have imagined a day might come when trees had other values than lumber.
>
> But the pioneer attitude survives and there are some today who still look at a tree as having just so many board feet and no other values. I visited with a cruiser of the old school not long ago while he was estimating the timber in a small stand on a neighboring lake. We stood in the shade of a big pine,..."take this one," said the cruiser as though reading my thoughts, "this is an old one and overripe, should be cut to make room for the young stuff coming underneath. Even the seeds aren't as good as they should be, and with the decay inside it's a nest of fungus and beetles. That tree is dangerous, ought to

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> come out, and that's true of most of the big stuff left. People don't get any more pleasure from such a relic than they do from a healthy young tree."
>
> As I stood there, I could hear the soft moaning of the wind in the high dark tops and feel the permanence and agelessness of the primeval. In among those tall swaying trees was more than beauty, more than great boles reaching toward the sky. Silence was there and a sense of finality and benediction that comes only when nature has completed a cycle and reached the crowning achievement of a climax, when all of the inter-relationships of the centuries have come at last to a final glory.
>
> I paddled by the island in the spring [after the area was logged] and, while some of the shoreline trees had been left, the old skyline was gone....I would remember how it was that night when the snow was drifting down and I listened to the great pines for the last time. The beauty and the mystery of that moment was burned into my memory.
>
> Sigurd F. Olson
> Listening Point

> A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.
>
> Aldo Leopold
> A Sand County Almanac

The first quote, by John Curtis, states what most forest visitors would agree is the symbolism of the white pine in the northwoods. While most travel brochures might include similar comments, it is noteworthy that Curtis elected to include it in his ecological classic which is directed at the science of Wisconsin plant communities.

Sigurd Olson's quote provides a contemporary sense of symbolism and spiritual value that could be read along with the paper by Schroeder (1992). Leopold's quote is especially appropriate as we struggle to understand new concepts of forest ecosystem management and landscape ecology. Leopold would not want beauty left from the discussion.

> Our ability to perceive quality in nature begins, as in art, with the pretty, it expands through successive stages of the beautiful to values as yet uncaptured by language.
>
> Aldo Leopold
> A Sand County Almanac

RECREATION

In 1960 the Multiple Use Act provided recreation with official standing. But again, the emphasis was on developed sites or the poorly defined concept of dispersed recreation. The need for comprehensive recreation planning which included all acres and different experiences was not recognized. Apart from primitive recreation and wilderness planning, there are three notable efforts which have a distinct forested landscape approach. Each is a systematic process which starts with large regions or landscapes and result in site level activities. Each recognized that all acres have potential for recreation experiences. Only the more recent process has gained wide acceptance.

In the early 1920's, landscape architect Arthur Carhart (1919 and 1920) developed the Forest Service's first large area recreation planning process. He was among the first to propose managing national forests to provide different types of recreation experiences (Driver et. al. 1987). In the early 1970's, landscape architect Rai Benhert (FS 1974) developed a recreation planning process titled the Recreation Opportunity Inventory and Evaluation. This visionary process included a classification of land areas for specific types of recreation experiences. It also was effective in the integration of forest resource management under the policy requirements of forest planning.

More recently, Forest Service social scientists (Driver et al. 1987) developed a comprehensive forest recreation planning and management process--Recreation Opportunity Spectrum (ROS). This system, which is research based, has considerable merit in directing recreation decisions on all forested lands. While primarily designed for larger public ownerships, the concepts can also be revised to provide clarity of intent in managing smaller privately owned parcels.

ROS provides a framework for stratifying and defining classes of outdoor recreation environments, activities, and experience opportunities (FS 1986). This has been arranged in a development continuum divided into six classes: Primitive, Semi-Primitive Non-Motorized, Semi-Primitive Motorized, Roaded Natural, Rural, and Urban (Figure 1).

ROS Setting Characterization

Primitive	Semi-primitive Nonmotorized	Semi-primitive Motorized	Roaded Natural	Rural	Urban
Area is characterized by essentially unmodified natural environment of fairly large size. Interaction between users is very low and evidence of other users is minimal. The area is managed to be essentially free from evidence of human-induced restrictions and controls. Motorized use within the area is not permitted.	Area is characterized by a predominantly natural or natural-appearing environment of moderate-to-large size. Interaction between users is low, but there is often evidence of other users. The area is managed in such a way that minimum on-site controls and restrictions may be present, but are subtle. Motorized use is not permitted.	Area is characterized by a predominantly natural or natural-appearing environment of moderate-to-large size. Concentration of users is low, but there is often evidence of other users. The area is managed in such a way that minimum on-site controls and restrictions may be present, but are subtle. Motorized use is permitted.	Area is characterized by predominantly natural-appearing environments with moderate evidences of the sights and sounds of man. Such evidences usually harmonize with the natural environment. Interaction between users may be low to moderate, but with evidence of other users prevalent. Resource modification and utilization practices are evident, but harmonize with the natural environment. Conventional motorized use is provided for in construction standards and design of facilities.	Area is characterized by substantially modified natural environment. Resource modification and utilization practices are to enhance specific recreation activities and to maintain vegetative cover and soil. Sights and sounds of humans are readily evident, and the interaction between users if often moderate to high. A considerable number of facilities are designed for use by a large number of people. Facilities are often provided for special activities. Moderate densities are provided far away from developed sites. Facilities for intensified motorized use and parking are available.	Area is characterized by a substantially urbanized environment, although the background may have natural-appearing elements. Renewable resource modification and utilization practices are to enhance specific recreation activities. Vegetative cover is often exotic and manicured. Sights and sounds of humans, on-site, are predominant. Large numbers of users can be expected, both on-site and in nearby areas. Facilities for highly intensified motor use and parking are available, with forms of mass transit often available to carry people throughout the site.

Figure 1. The spectrum of recreational opportunitiy areas ranging from an,unmodified natural environment to an urbanized environment. (Source: Forest Service 1986)

Land managers can greatly influence the quality of recreation experiences by managing setting indicators such as access, remoteness, naturalness, facilities and site management, social encounters, visitor impacts, and visitor management (FS 1990).

Recreation activities which provide high quality experiences are important. When Americans were asked to rank the attributes which were most important to them in selecting a recreation area, they indicated "natural beauty" was the most important attribute (Presidents Commission 1987). Managing the ROS setting indicator of naturalness in each of the six ROS classes will require several different management strategies to establish the type of white pine forest condition which is most consistent with a quality recreation experience.

FOREST APPEARANCE

Forest resource managers and citizens have developed many terms that encompass forest appearance. Some of the more commonly used ones are natural beauty, scenic beauty, landscape aesthetics, environmental aesthetics, scenic enjoyment, landscape quality, visual quality, scenery, landscape management, and visual resource. Whatever the term used, it is clear that the appearance of the forested landscape is a critical resource for stewards of our public and private forests.

Indeed, the 1970 National Environmental Policy Act (NEPA) requires that federal agencies have the responsibility for aesthetically and culturally pleasing surroundings. Section 102(A) of NEPA requires a systematic interdisciplinary approach which integrates the environmental design arts in decision-making; and Section 102(B) requires the quantification of environmental amenities and values (NEPA 1970).

These requirements of NEPA initiated research activities related to measuring scenic beauty. The pioneering work of Daniel and Boster (1976) provided a methodology for the scientific measurement of the public's perception of scenic beauty. This process, which is known as the "Scenic Beauty Estimation Method," has been used extensively by researchers to determine the different levels of scenic beauty for near-view landscape perception.

Landscape architect Burton Litton (1968) provided a process for conducting visual inventories in what was then referred to as the general forest zone--areas outside wilderness and the travel and water influence zone. This process was important in structuring the 1974 Forest Service Visual Management System (Tlusty and Bacon 1989).[2]

During the late 1960's and 1970's the concept of visual mitigation developed. In the 1980's the concept of writing prescriptions for desired visual character evolved. In addition to these concepts, I propose that the 1990's include the option of managing for landscape aesthetics. This will require further development of earlier concepts.

Basically, there are five levels to consider in managing for white pine and forest appearance.

- No Consideration--the appearance of the forest is the residual of other forest management activities.

- Visual Mitigation--involves the use of techniques or practices that reduce potential adverse visual impacts. For example, harvesting activities are planned to emulate natural conditions through concepts of shaping, controlling the size of harvest unit and establishing distances between units and time of

[2]This paper provides a review of the history of recreation and esthetics, the planning systems, technical and conceptual support, and examples of silvicultural systems which apply to Forest Service recreation and visual resource management.

harvest entry. Techniques of computer simulation and visual absorption capacity mapping can test proposals. Scenic beauty research provides information on public concerns.

- Desired Visual Character--this concept incorporates the concepts under mitigation, but goes beyond basic concepts to direct vegetative management prescriptions which establish and/or maintain features which are found visually desirable by forest users. This generally relates to landscape scenery which favors the visual aspects and the traditions of the environmental design vocabulary. Scenic beauty research establishes the desirable features.

- Landscape Aesthetic Management--when fully developed, this concept can be expected to provide more aesthetic satisfaction emphasis and will go beyond visual or scenery management. It would evolve into a process for sustainable forest management, along with evolving concepts of ecosystem and landscape ecology.

- Preservation--hands-off management, in which natural conditions provide users the diversity of landscape appearances.

PUBLIC AND PRIVATE INTEREST

The Forest Service Visual Management System (FS 1974) is widely recognized--including Canada, New Zealand and Australia--as a systematic approach for managing the forest appearance. It is a descriptive approach that guides the inventory and analysis of what is termed the visual resource. The landscape is classified into three variety classes that identify the scenic quality of the natural landscape. In addition, three levels of sensitivity estimate people's concern for the scenic quality of the landscape. The combination of mapped scenic quality (variety class) and people's concern (sensitivity level) is used to establish standards for the visual management of the landscape. These visual quality objectives include a continuum--from only ecological changes, to management activities which may dominate the landscape. The objectives are: Preservation, Retention, Partial Retention, Modification and Maximum Modification. Concerned publics are encouraged to comment on managing the visual resource during the public involvement process.

After almost twenty years of successful use, the Visual Management System (VMS) is currently under review. The proposed model will combine portions of the Recreation Opportunity Spectrum (ROS) process with VMS. Recreation user analysis will replace the sensitivity levels used in the old model. To obtain citizen input, forest user survey techniques will determine scenery preferences, user preferences, travel ways, setting preferences, and scenic condition preferences.

Another approach to forest appearance management is used by the Wisconsin Department of Natural Resources. They divide state forests into three different aesthetic zones. Timber harvest is guided by a handbook of aesthetic management considerations and techniques (Sloan 1986). Public concerns are part of the forest plan development and individual timber harvest sales.

Both the Forest Service and Wisconsin DNR approaches have merit in accomplishing their respective agency objectives on public land. But, in the Lake States, the vast majority of the forested landscape is owned by private non-industrial landowners. In Wisconsin they control about 60 percent of all commercial forestland, in Michigan about 50 percent, and in Minnesota about 40 percent.

What reasons do these owners have for owning these lands? Is scenic enjoyment, recreation and wildlife important to these owners with small parcels, but vast overall acreage control? Several research studies have addressed the question of reasons for owning. The primary reasons Minnesota owners listed (Carpenter, Hansen, and St. John 1985) were part of my residence (24%); esthetic enjoyment (16%); own use of firewood (15%); and non-motorized recreation (12%). In Michigan the primary reasons listed (Carpenter, Hansen 1981) were part of my residents (20%); land investment (20%); non-motorized recreation (11%); and esthetic enjoyment (10%). Compared to other resource management interests, such as timber production, esthetic enjoyment and recreation are very important to these landowners.

A 1986 Wisconsin study (Roberts, Tlusty and Jordahl) found that wildlife habitat and scenic enjoyment are at the top of the list of reasons for owning woodland. Recreation also enjoys considerable interest. Wildlife habitat and scenic enjoyment are also at or near the top for owners of small and large parcels. Non-motorized recreation increases in importance with larger parcel ownership.

In 1991 another statewide survey was conducted of Wisconsin woodland owners. In this survey the respondents were asked to indicate their reasons for owning (the same question as the 1986 survey) and were also asked to rank their first, second and third most important reasons (Table 1). Scenic enjoyment was the first and second most important reason selected. Wildlife and non-motorized recreation are also of considerable importance.

Table 1. Reasons for owning woodland which owners ranked as the first, second and third most important reason. The five highest owner percentages for each category, by owners of parcels of 10 or more acres, by owners and acres, Wisconsin. 1991. (Source: Tlusty and Roberts, 1991)

First Most Important	Owners	Acres	**Second Most Important**	Owners	Acres	**Third Most Important**	Owners	Acres
1) Scenic Enjoyment	16%	13%	**1) Scenic Enjoyment**	18%	16%	**1) Wildlife Habitat**	**23%**	**21%**
2) Non-Motorized Recreation	14%	18%	**2) Wildlife Habitat**	16%	18%	**2) No Other Reasons**	**19%**	**14%**
3) Part of Farm	13%	14%	**3) No Other Reason**	15%	10%	**3) Scenic Enjoyment**	**12%**	**15%**
4) Prevent Development	12%	12%	**4) Non-motorized Recreation**	12%	12%	**Prevent Development**	**12%**	**10%**
5) Timber Production	10%	12%	**5) Part of Land Around Dwelling**	10%	4%	**5) Non-Motorized Recreation**	**9%**	**11%**
Wildlife Habitat	10%	8%						
Total (152, 200 Owners; 8,329,700 Acres			Total (152,200 Owners; 8,329,700 Acres			Total (152,200 Owners; 8,329,700 Acres)		

(Non-respondents are not included)

In the same survey, Wisconsin owners were asked to select an ownership interest description which best described how they use their woodland (Table 2). Slightly more than forty-percent indicated their interests are primarily related to recreation, scenic enjoyment and wildlife. They control about 3.7 million acres of forestland. Thirteen-percent indicated preservation as the primary reason and ten-percent indicated timber production as their primary interest.

Table 2. Owners self-classification of which description best describes how they use their woodland, by owners of parcels of 10 or more acres, by owners and acres. Wisconsin, 1991. (Source: Tlusty and Roberts, 1991).

Owners	Acres Owned	Ownership Interest Description
41%	36%	Woodland Recreationist--These woodland owners primarily own land for recreation, scenic enjoyment, or wildlife management. Timber is considered a secondary management objective and is harvested only when it is compatible with recreation, wildlife, or scenic beauty.
25%	32%	Woodland Utilitarian--These woodland owners value their woodland primarily because it provides them with products they can use. Firewood, grazing, recreation, and a place to live are some primary reasons for owning land. Timber is sold, but the forest is not actively managed to improve timber.
13%	9%	Woodland Preservationist--These owners primarily own land to preserve it from being altered by human activities. The only changes to their forestland occur through nature. Timber harvesting is not a consideration.
11%	10%	None of the above comes close enough to describing why I have my woodland.
10%	13%	Timber Conservationist--These woodland owners have a strong interest in a financial return from the land and in improving their forests for timber production. At the same time, they may have a secondary interest in managing their woodlands for other resource values, such as wildlife and recreation.
100%	100%	(151,600 Owners; 8, 329,700 Acres; Non-respondents are not included)

In the three states, this large population of owners is clearly interested in the resources of scenic enjoyment, wildlife, and recreation. White pine management prescriptions need to incorporate these social expectations, along with biological criteria.

LANDSCAPE AESTHETICS

Previous sections of this paper addressed the more recognized approaches of forest appearance management. I propose that desirable elements of these previous approaches be combined with new concepts. I would also propose that all these activities come under the heading of "landscape aesthetics," which is advocated as a higher order of management than visual resource or landscape scenery, but includes these early stages of aesthetic perception. Landscape aesthetics can apply to public or private lands, respond to current and future citizen expectations, and apply to changing biological approaches.

Figure 2 provides a conceptual model with three discrete settings and outputs. Each is different in approach, but may use one or more of the same management techniques. For example, some types of visual mitigation may extend across all three settings. The basic differences are in the concept section. Some functionally driven allocations may not allow vegetative changes for aesthetic reasons such as in wilderness. Other functional areas may even avoid minor visual considerations. On the other hand, many functional settings would have the more limited form of aesthetic management called visual mitigation.

By contrast, landscape scenery, which also is a functionally driven allocation from recreation, works toward those ideal natural appearing settings. Aesthetic ecosystems management is proposed to be different from the other two and relate to forest ecosystems management.

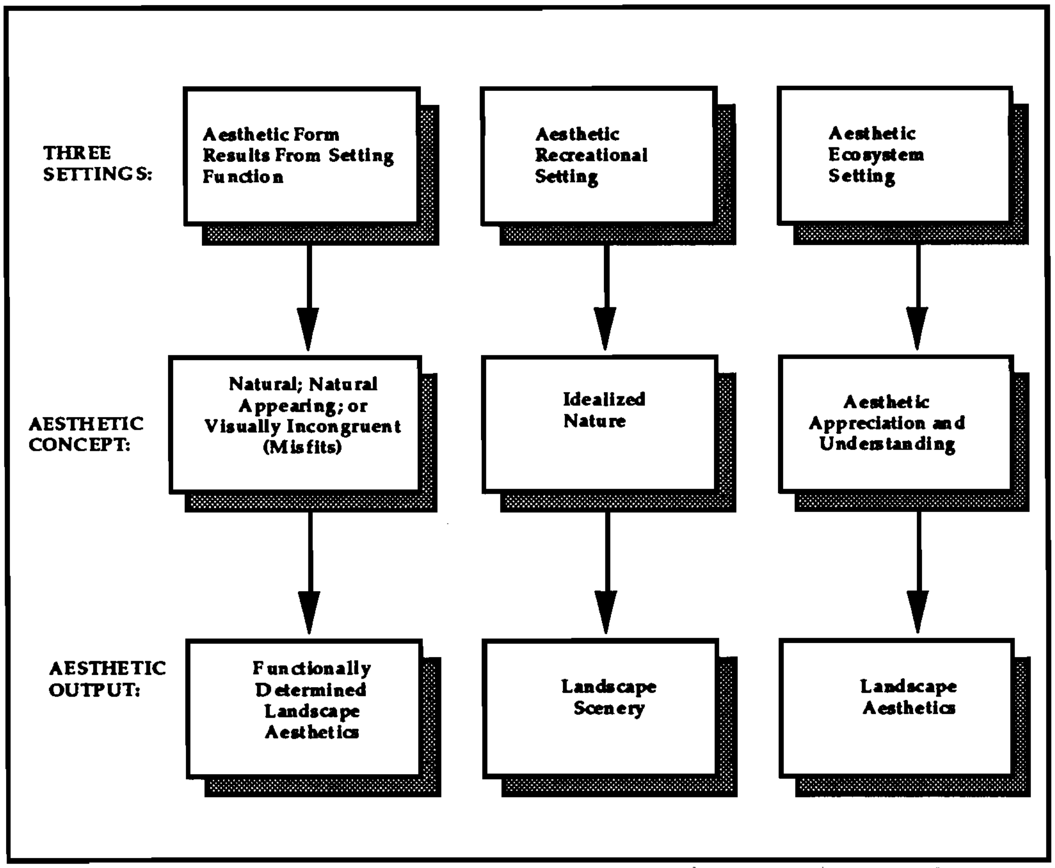

Figure 2. A conceptual model to establish discrete forest aesthetic goals.

Functional settings (Figure 3) include a group of disparate settings which vary in aesthetic output from: natural--in areas of wilderness and natural areas; natural appearing--areas in which visual mitigation techniques are applied; to visual misfits--in which management activities greatly disrupt the landscape appearance. Those areas which require visual mitigation techniques will use the widely established approaches (FS 1980, Sloan 1986, Lucus 1991). Visual quality objectives (FS 1974) can be used to establish the appropriate level of mitigation.

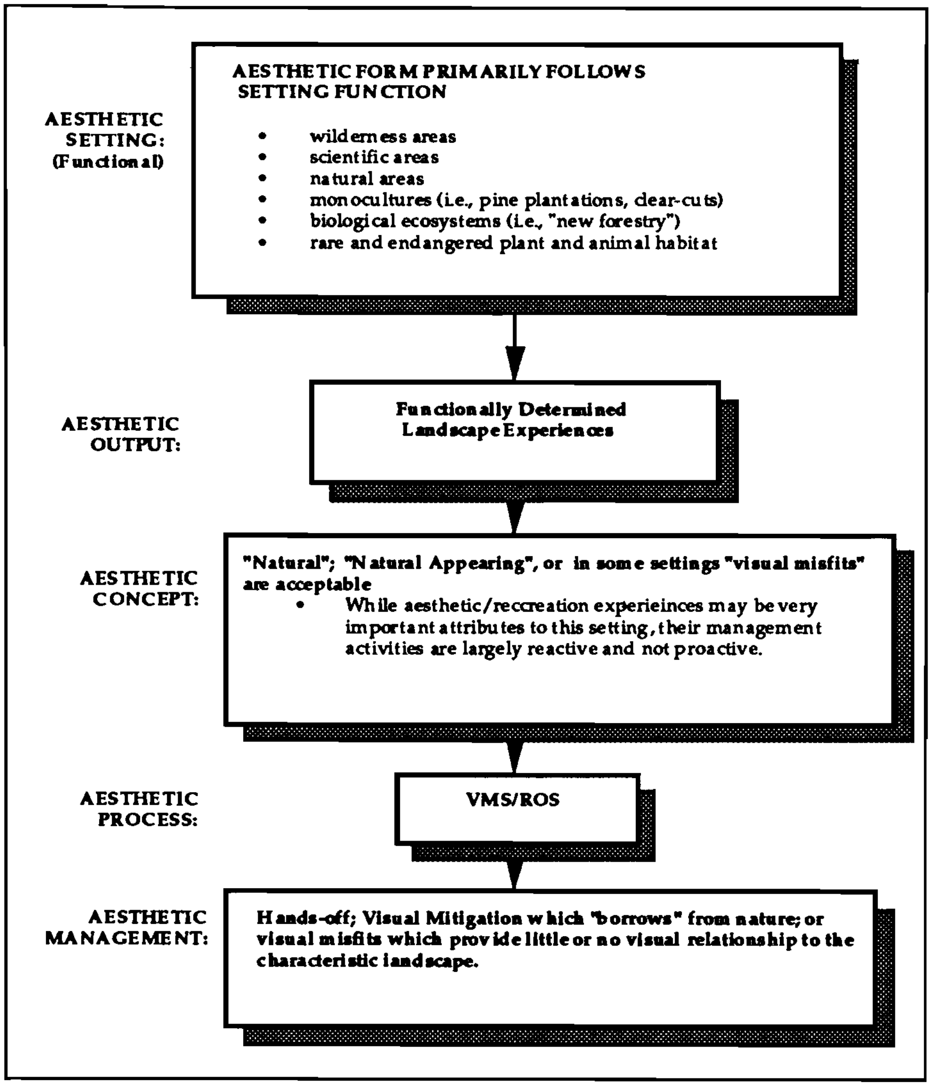

Figure 3. A process framework to manage for aesthetics in the more functionally driven resource allocations which are not directly responsive to aesthetics.

Aesthetic recreation settings are guided by public responses, social science research and design arts principles in providing the public with landscape scenery which emulates idealized nature (Figure 4). This approach most closely reflects what has been termed desirable visual character by the Forest Service. The intent is not, as some would suggest, to manage with the emphasis of fine arts principles. Rather, the intent is to find those vegetative phases of the biological cycle which publics visually prefer. The most visually desirable conditions are then maintained or created. Examples are fully illustrated in the Timber Chapter (FS 1980) for ponderosa pine and lodgepole pine.

Currently, most research has been directed at determining what publics find visually attractive (desired visual character), or management activities which detract (requiring visual mitigation) from scenic beauty. Ribe (1989) provides a thorough review and analysis of what empirical preference research has taught us.

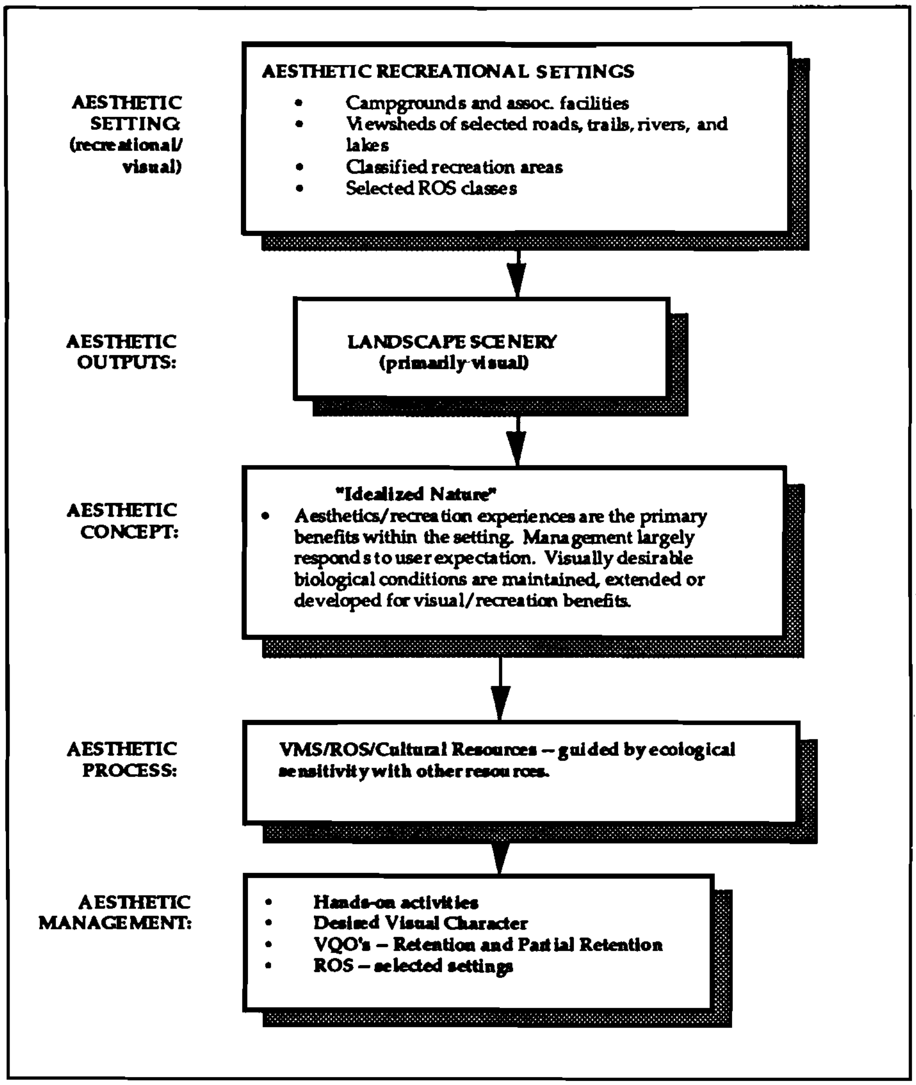

Figure 4. A process framework to manage for aesthetics in areas which have landscape scenery as a primary output.

Aesthetic ecosystems settings (Figure 5) needs an operational process to direct management. The need for this type of approach, for the 1990's and beyond, comes from several situations. First, it is quite apparent that traditional forest management is being challenged and will be revised to more closely approximate ecosystems management or landscape ecology. Second, the evolution of visual resource management has moved through stages from no action, to visual mitigation, to desired visual character (landscape scenery management). It is time to carry the process to the next higher level. Lastly, there are concerns expressed about Western culture's aesthetic experience of nature, in which aesthetic responses are largely acquired through the picturesque and beautiful garden styles, which were borrowed from the painters (Rees 1975, Flader and Callicott 1987, Callicott 1991).

One might quarrel with the rather strict historical interpretations and current application generalizations taken by Callicott. But, it seems reasonable to assume that a significant segment of our society does want "attractive" forest aesthetics, which may be largely linked to visual experiences (e.g., views from the auto). Why not provide this experience as landscape scenery? We understand the principles and the silvicultural techniques. Does it really make a difference if these viewer preferences are the result of acquired tastes related to the arts? I believe we should continue providing these experiences until we can clearly exhibit a manageable process with outputs related to the higher aesthetic.

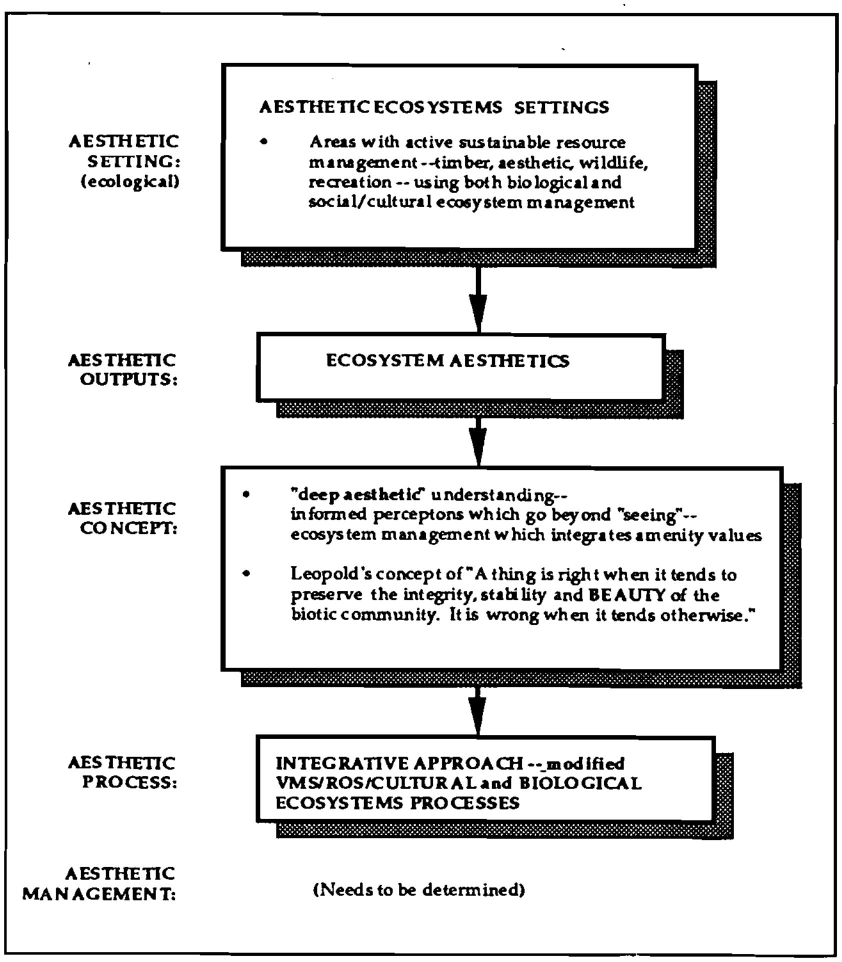

Figure 5. A process framework in which ecosystems aesthetics is an output for actively managed sustainable forests.

Leopold does not provide us with an operational process, but did provide the concept in his 1935 lecture "Land pathology'" (Leopold 1991) and in Sand County Almanac (Leopold 1949). While we lack a tested process, it is clear that some of our publics want this concept developed into usable forms. However, it would be a mistake to assume that "biologically correct" management can ignore social expectations related to forest appearance. The esthetic Leopold had in mind was more than just the residual of the current ecosystems management thinking.

RECOMMENDATIONS

For purposes of aesthetic and recreational management, white pine, unlike some tree species, does not lend itself to limited, well-defined, timber harvesting prescriptions. Publications such as the Timber Chapter (FS 1980) illustrate a full component of general and specific techniques to both mitigate adverse visual impacts and create desired visual character. The wide distribution of white pine in plant community associations is also reflected in the wide variety of innovative management approaches for aesthetics and recreation. It does not mean, however, that spurious, random approaches or concepts driven by associated natural resources will provide forest users with meaningful perceptual and recreation opportunities. Therefore, some general recommendations can guide white pine management practices until more comprehensive research is conducted.

- Attention needs to be given to understanding the objectives and desired outcomes of the different forest "stewards." Are the lands public, industrial, or private non-industrial forests?
- What is the existing and potential aesthetic landscape character? What are the plant community types within the landscape? This information should determine the biological and cultural appropriateness of white pine management.
- What are the desired attributes--landscape preservation, landscape aesthetics, landscape scenery, visual mitigation, or no management, for the appearance of the forest? Each of these attributes will require different management approaches.
- Among the six major classes of the Recreation Opportunity Spectrum, what is the desired management goal--Primitive, Semi-Primitive Non-Motorized, Semi-Primitive Motorized, Roaded Natural, Rural or Urban? What type of white pine vegetative management is most appropriate for the ROS class and the setting indicator of naturalness? The six classes can be expected to provide different user expectations and levels of user satisfaction.
- Managers should recognize that white pine can be planted to provide diverse recreation and aesthetic experiences--it will vary with time, from seedlings to old-growth; it will vary with space, from individual sites to broad landscapes; and it will vary in density, from individual "specimen" trees to dense "pinery" characteristics.
- The complex mix of recreation and biological opportunities needs for be focused to specific landscape units, which have concise management prescriptions for landscape scenery, landscape aesthetics, and recreation experiences.

Research is needed which goes beyond a scenic beauty rating for white pine in the Lake States. Research needs to provide a greater understanding of the aesthetics of white pine in different recreation classes. However, in the absence of research, we can continue to use our intuitive judgments. But, our proposals need to be challenged by critical reviews which encourage the development of more innovative ways to manage white pine.

It would seem appropriate that white pine, perhaps more than any other tree species, can provide the opportunity for the citizen stewards to more fully appreciate and understand the "northwoods" forest communities.

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ECONOMIC VALUES OF NATURAL RESOURCES REALLY DO MATTER!

Daniel E. Chappelle[1]

ABSTRACT. Examines contributions of natural resources (including white pine) to the regional economy, and their role in maintaining societal prosperity. We need both economic growth and environmental quality, not one or the other. Economic growth is needed to maintain economic prosperity, which in turn is needed to pay for environmental improvement and protection. We require wood products to maintain our life styles, and wood must come from somewhere. Industrial raw materials continue to be important in generating employment and income. When a region has comparative advantage, consumption should not be met by wood imports. Economic value is difficult to measure in the case of forest resources because of a multitude of outputs, many of which are not priced by organized markets. Also, information systems for forest resources are not linked to national economic accounting systems. The economic contributions (direct, indirect, and induced) of flows of white pine industrial roundwood to the Lake States regional economy (including Michigan, Minnesota, and Wisconsin) in 1988 appear to be roughly $546 million (1982 dollars) in sales, 6355 jobs, and $136 million (1982 dollars) in personal income. Although not a significant species in supplying industrial raw materials, white pine can play a significant role in local economies.

INTRODUCTION

Most content of this conference is concerned with the health and welfare of white pine and its management. Although the visual, aesthetic, and spiritual values of eastern white pine are undoubtedly important, it is also important to consider economic value of the species. In this paper I focus on the economic importance of natural resources (including white pine) and their contributions to societal prosperity in the Lake States region, consisting of the states of Michigan, Minnesota, and Wisconsin. In so doing, it is necessary to consider trends in the national and global economies.

There are definite links between spiritual values, previously discussed, and economic values. One would certainly be the spiritual value of working and supporting one's family. Another would be the spiritual value of living in a civilized, cultured, prosperous and viable community.

In recent years there has been major concern about the declining middle class in the U.S. (Chappelle and Webster 1992). Industrial jobs traditionally have been important in providing economic security for middle class people. There is need for economic growth to generate jobs, particularly those that can support families. Generally, industrial jobs fill this requirement for individuals without college degrees (the majority of the population), whereas most service jobs do not.

As certain industrial sectors go into decline, it is important that new industrial sectors appear in the economic structure to insure that families will have incomes permitting continuation of the high standard of living to which we have grown accustomed. If we cannot sustain this American Dream, likely our nation and culture will decline over time, possibly with considerable strife based on divisions according

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to class (income and ethnic), race (correlated with class), and geography (correlated with class and race, natural resources, infrastructure and many other variables).

In brief, societal prosperity is important in facilitating human development. Economic growth (especially as exhibited in job creation) is very important in another spiritual matter -- in generating hope for the future among the populace. Also, economic growth is essential in providing funding required to maintain a high level of environmental quality in view of relatively high levels of global population growth and growing disparities between nations.

CONTINUING NEED FOR NATURAL RESOURCE COMMODITIES IN THE ECONOMY: ROLE OF FORESTRY IN ECONOMIC DEVELOPMENT

The forest constitutes a complex set of natural resources to supply basic sectors of the regional economy (including travel/tourism). The forest was once considered primarily as a stockpile of industrial raw materials, but clearly it is a much more complex asset than that. Forested environments have many other functions, including as a source of beauty, assimilative capacity for natural processing of residuals, space for occupancy, and habitat (life support system) for a widely diverse flora and fauna (including human beings).

There is a continuing need for natural resource commodities in spite of downward trends in most commodity prices in the recent past, and declining quantities of them required to produce a unit of consumer goods. Although per capita requirements for wood products have declined in the United States, aggregate consumption levels have increased because of population growth.

It is useful to consider forests as sources of industrial raw materials because they are important in the ways mentioned earlier -- these materials meet human needs and provide jobs that support families. The forest products industry has evolved over time into a rather sophisticated set of technologies using wood fiber (often in combination with other materials) to produce a wide variety of producer and consumer goods. These products are very important to society in ways that most people at this symposium readily recognize.

In contrast to earlier years (say 100 years ago), most people today are not aware of how various goods and services they consume are linked to the natural environment. As we progressed from a largely agrarian nation at our birth, to an industrial nation, and then to the service-oriented society of today, we have largely lost our direct links to the environment as a provider of raw materials involved in the production of goods and services that we consume. Most Americans have come to the point of only visiting natural resource sites as recreationists. To a great extent this isolation from the natural world has occurred as a consequence of the urbanization of the population.

Like agriculture, one of forestry's successes has cost it public support. As technological advances permit large gains in productivity, less and less labor is required to produce the same level of services to the consumer. As a smaller and smaller proportion of the regional population is involved in the activity over time, it generally is taken to be less important by the populace.

Also, most forestry outputs are examples of derived demand. That is, consumers purchase products that require these forestry outputs as inputs, but often involve many processing stages, as well as a broad array of other types of inputs. This means that the population's dependence on natural resources is further veiled as technology advances.

The complex maze of linkages between sectors of our economy leading from primary, to secondary and then tertiary production is largely unrecognized by the general population. Our natural resource managers operate largely in the primary sector and understandably believe that what happens in the secondary and tertiary sectors is not of their concern. Likewise people working in the secondary and tertiary sectors have no particular concerns about primary sectors, as long as it is possible to secure needed raw materials and use the environment as a disposal sink for residuals at reasonable prices.

It is possible to maintain a modern industrialized economy with very little natural resource base and rely on importation of raw materials (e.g., as in the cases of Japan and Taiwan). However, it stands to reason that these materials must be produced somewhere and if a nation blessed with such a natural endowment can also organize itself economically, politically, and socially to take advantage of these resources, then likely it could be even richer than most nations.

It appears that such is the situation of the United States and Canada. Abundant natural resources have been an important base for industrialization and attendant economic growth and development. Although it may be likely that future growth will take place primarily in service and information sectors (emphasizing human resources), our current economic structure historically has been built on natural resources. And our natural resources could provide a base for substantial additional future growth if they are affordable, compared with global competitors. However, future economic growth is unlikely to occur in the same way as in the past, nor take the same form.

Technological change has occurred in the natural resources industries as in the rest of the economy. Although it is often not as dramatic (nor as well recognized by the media) as in other sectors, it is likely to continue and will include increases in materials reclamation.

Over time we have seen the forest products industry largely stop its roving ways and become concerned (albeit with much public pressure) with sustained production and maintenance of a high quality environment. This evolution has led to important industrial complexes based on forestry outputs, particularly in the Pacific Northwest and the South, but also in the Lake States. For example, during the last decade the Michigan forest products industry, designated by the Governor a target industry, has been an important force for diversification of the state's economy. This has led to growing economic importance of the forest products sectors. As noted by Chappelle and Pedersen (1991, p. i) in a recent evaluation of the contribution of the forest products industry to the Michigan economy:

> Following recession-related declines in the early 1980s, employment in forest product firms at the state and national levels grew faster than employment in manufacturing firms as a whole. Employment growth in Michigan forest product firms also outpaced employment growth for the forest product industries at the national level.

These industrial complexes have generated much economic growth in the past and can continue to do so in the future, if appropriate conditions are maintained.

Recent challenges faced by primary producers come largely from beyond their perceived purviews. That is, major issues seem to be imposed from outside traditional boundaries observed by producer groups (e.g., environmental groups, animal rights groups, exporters, importers, etc.). Also, more than ever before, issues are perceived as being international. Note, however, that a major effect of "Earth Days" and environmental summit conferences has been to re-introduce notions of linkages of people to their environment.

To a large extent Americans have been convinced by some environmental groups and the media that harvesting natural resource commodities (e.g., timber, forage, minerals) contributes greatly to decline in environmental quality and hence must be curtailed. This has been the public reaction most especially to clearcutting of timber, a legitimate harvesting and regeneration method for certain species if used correctly.

Apparently a sizable portion of American society no longer recognizes the importance of our forests as sources of industrial raw materials, witness the readiness that media and laypeople dismiss American forests as raw material sources. There seems to be an assumption (most often implicit) among many groups that we should rely on trade to procure raw materials required for our high standard of living (including enormous quantities of consumer products made of wood) while continuing to maintain a high quality environment here. There is a lack of appreciation concerning trade balance impacts or problems of resource exploitation caused throughout the world (particularly in developing countries) by such practices. Focussing on forests as sources of industrial raw materials, it is notable that the United States is an advanced industrialized country that exports raw materials in unprocessed form (e.g., roundwood from the Pacific Northwest to Asia, hardwoods to Europe and southeast Asia). The importance of natural resources in the national economy is reflected in our trade balance with foreign countries.

In view of this situation, to the extent that we have comparative advantage, it is important that we continue to be involved in the production of raw materials from our natural endowment. In so doing, we can apply (if we wish) the most efficient production technologies and at the same time produce in ways that protect the environment, much in contrast to most other industrial nations. Where we have comparative advantage and to the extent that our wood can substitute for foreign wood, we should produce roundwood for export because in so doing we can actually decrease the harvesting of rain forests.

It is apparent that the major activity of the forester, namely growing trees for all their many uses, has not been successfully communicated to the public. Probably to a significant extent the fault for this situation should be assigned to the forestry profession. We have simply failed to educate the increasingly urban population that the multiple use and sustained yield principles on which much of our forest land management has been based are both valid and realistic given the current global environment and economy. As a consequence, a significant portion of the American public appears to believe a real paradox -- that trees are incapable of regeneration and growth and that ancient forests are immune from death!

NEED FOR BOTH ECONOMIC GROWTH AND ENVIRONMENTAL QUALITY

We need both economic growth and environmental quality, not one or the other! In order to pay for a high quality environment we need a lot of economic growth. In order to simultaneously increase economic growth and protect the environment, we need to:

a. invest in human beings so that they will be well informed as citizens (including in regards to natural resource issues), qualify as stakeholders in the polity, and qualified to work productively in the economy;

b. invest in infrastructure (including on natural resources lands);

c. invest in protection of the environment from diverse threats, both natural and man-made;

d. make capital investments to jointly increase economic growth and improve environmental quality; and

e. improve resource management so that resource outputs of every type are produced more efficiently than before. Through forest management we may be able to maintain natural resources that will provide adequate levels of raw materials to meet diverse requirements of our expanding population.

ECONOMIC VALUE IS DIFFICULT TO MEASURE

There are many important points to consider regarding the nature of forests and their management that make economic value difficult to measure:

a. The required production period (i.e., economic rotation) of even fast growing tree species is much longer than for most other economic assets. When interest rates are high, timber production often will not be a sound financial investment because revenue growth is constrained by biological growth and high interest rates force a short-term view.

b. In the case of timber and many other outputs of the forest, products are largely indistinguishable from machinery producing the outputs.

c. As noted above, a major problem in working with natural resource products is that for the most part they are cases of derived demand. Except for wilderness recreation and firewood, very few forestry outputs are purchased directly by final consumers. In order to properly quantify economic contributions of forest resources, it is necessary to trace impacts as intermediate inputs to complicated production processes, i.e., in nearly all cases processing of some sort is required. It is therefore impossible to measure total economic contribution by focussing only on forestry sectors. The whole of the regional economic structure must be considered.

d. Economic and social development affect forestry sectors primarily through effects on final demands. Forecasting future final demands, particularly over the long term (e.g., more than five years) is especially risky -- much more risky than forecasting timber growth and yields -- and about as risky as forecasting pest outbreaks. To forecast final demands requires forecasts of future population structure, including migrants.

e. The complex spatial pricing involved in forestry production often facilitates development of spatial monopolies and oligopolies, particularly on the input side. This complicates economic analysis by introducing more variation in prices.

Laypersons tend to think of economic value strictly in materialistic terms. Rather we need to think of economic value in terms of the human development it permits. Economic values include more than just those measured in dollar terms. In economics both exchange values and utility values of various sorts are considered. Exchange values are those for goods and services transacted in organized markets. These are generally measured in dollar terms and can readily be analyzed using increasingly complex mathematical models.

However, a diverse mix of non-priced goods and services are produced in forestry. Values of these goods and services are very difficult to establish and controversial because they generally are based on techniques of dubious scientific standards (which generally fail to consider effective demand), do not serve any allocation function, apply most directly to the individual, and can be added together only with difficulty, if at all. Also, if values are added, the sum varies depending on the clientele group considered in the analysis. In addition, it should be recognized that the particular attributes of resources considered vary a great deal from case to case -- hence, so does utility value.

In order to try to rectify this situation, many natural resource and environmental economists are working in the area of non-market valuation. In valuing resources, it is important to consider the possibility of substitutes (both those that are forest related as well as others). This is very difficult to accomplish in a comprehensive way, given available data.

Also, a major impediment to completely addressing roles of natural resources in economic development is that our economic accounting systems are not adequate to provide a realistic picture of even current conditions, much less possible future opportunities. The two national economic accounting systems (the income and product accounts, and input-output accounts) provide a valuation (in dollars) of only goods and services transacted in organized markets. This means that many forestry outputs are either totally or partially ignored, particularly recreational services, amenity and visual resources, erosion control, fisheries and wildlife, provision of water quantity and quality, assimilative capacity, and aesthetic services.

There is another major concern here, however, that has received little recognition, much less research. Namely that our operative economic accounting systems are flow systems and fail to monitor conditions of ecosystems. Traditionally, foresters have been concerned with the state of forest resources and this concern has been made operative at the federal level (with state, local, and private sector cooperation) in the form of Forest Inventory and Analysis, USDA Forest Service, our most comprehensive forestry accounting system. This system, although often using merchantability concepts, is not adequately linked with this nation's economic accounts. More seriously, however, because of missing variables, these notable efforts cannot be readily integrated with prevailing economic accounting systems.

Finally, only exploratory research has been carried out to link economic accounts to environmental quality accounts. This lack of integration prevents me from being as comprehensive today as I would like. For example, my rough estimates of the value of white pine relate only to flows of industrial wood. These problems preclude providing comprehensive estimates of the economic value of white pine, or anything else, for that matter.

THE REGION'S ECONOMIC BASE AND ECONOMIC STABILITY

It is useful to consider the nation as being a complex of diverse regional economies. Likewise, each region is made up of a diverse mix of economic activities. These different economic structures lead to differential regional impacts of national policies and to stages of the business cycle. Hence, identical sectors of the economy may be impacted differently depending on region.

The most important characterization of economic structure is the mix of basic sectors. A "basic" economic sector is one producing goods and services within the region beyond regional requirements and hence providing exports to other regions and foreign countries. Economic base theory indicates that regional economic growth increases with expansions in the economic base.

The economic base concept maintains that products exported outside the region bring in "new" money, thereby creating increased economic activity within the region. New money from the outside, to the extent that it actually reaches the producing region, is "multiplied" as dollars are respent within the regional economy. Transfer of expenditures from one product line to another by residents of the region (e.g., less spending for regional recreation and more for regional wood products) do not generate economic growth in most cases. However, to the extent that a region increases activities that substitute for imports, a similar growth response can be expected. Also, to the extent that real prices for exported products increase, economic growth will increase.

Note, however, that lower transportation costs allow raw materials to move further than was once the case. It is necessary, therefore, to analyze economic structure and product flows relative to regional consumption to identify basic sectors of the regional economy.

The total economic impact includes indirect and induced effects in addition to the direct effect, and is the product of the direct effect and a "multiplier." Various measurement scales are used in quantifying economic impact multipliers (e.g., sales, employment, and personal income). The indirect effect includes increased spending by business establishments in response to increases in production as exports increase. The induced effect consists of increased spending for consumption goods by households as they become richer. Needless to say, the "multiplier" also works in the negative direction as exports decrease and imports increase (which is what happens when we buy timber from elsewhere to meet our requirements!).

It is important that foresters correlate differences in regional economic structure with the regional natural resource base, as well as with the infrastructure and resident industries utilizing forestry raw materials. In this way it is possible to provide geographic units suitable for analysis of forest management strategies.

Hence, we can point to various forestry related economic activities as being important in certain regions -- e.g., the importance of the water from Southwest region forests to the growth of cities in that region, the importance of the timber industry to western Oregon, the importance of forest recreation to the Central Rocky Mountain region, etc.

From the standpoint of economic growth and development therefore, strategies to produce stumpage pursued by forest managers in the western Oregon region appear to be more important than is the case in the Central Rocky Mountain region. However, to the extent that forest management decisions are interrelated with and impact the recreation sector and the environment, making it more attractive, say to electronic engineers for employment in local industry, then these decisions may be important for economic growth and development. However, note that outputs involved differ by sector and hence management strategies must also be different. Therefore, to seriously examine the importance of white pine to a region requires that we identify those types of economic activities using white pine there.

If time permitted, we could discuss the diversity of economic bases within the Lake States, but that is a topic in itself. In brief, there are areas within the region where forest products sectors are very important and many where they are of little or no importance.

Forestry production historically has been and can continue to be a very important influence on economic and social stability of locales and regions. Stability of communities that are economically dependent on forestry activities has been a very important consideration, particularly in many parts of the western United States (see Schallau and Alston 1987). In our region the more optimistic question is the possible role of expanding forest products sectors in diversifying the economic structure and facilitating economic growth and stability, which are related.

ECONOMIC CONTRIBUTIONS OF WHITE PINE TO THE REGIONAL ECONOMY

Conclusive statistics regarding economic value of white pine are not available. However, the following highly aggregative statistics are suggestive. All estimates below are for industrial roundwood. Although sounding narrow and business-oriented, industrial wood, including that from white pine, can play locally important roles in advancing societal prosperity.

There are many ways of measuring economic value of the species. One that a forester often considers is stumpage value, the product of stumpage price and production level. For this example, I assume prices for sawtimber at $60 per MBF (International scale), veneer logs at $145 per MBF (International scale), and pulpwood and other wood products at $6 per cord. Converting these to price per MCF, and multiplying by regional production levels of these products[2], yields $5,307,546. This figure is conservative because assumed prices are conservative and higher priced "other wood" was grouped with pulpwood. Rounding this estimate, we can say that regional white pine stumpage had a market value of about $5.5 million in 1988. This value includes only market value for industrial raw material and does not include other values, including some other economic values.

Pedersen and Chappelle (1990, p. 10) summarized a comprehensive analysis of economic impacts of forest product sectors in the Lake States region as follows:

> The forest products industry in Michigan, Minnesota, and Wisconsin accounts [in 1982] for about 8 percent of the region's manufacturing sales, employment, and income. In real terms, sales of forest products are forecasted to grow from $15 billion in 1982 to over $22 billion by 1995. Sales related to wood energy and outdoor recreation in forested areas of the region account for another $2 billion. Adding the multiplier effect, economic activity attributable to these three uses of the forest resource is projected to grow from over $30 billion in 1985 to over $40 billion in 1995.

The above paragraph indicates the need to consider contributions of white pine to the regional economy in addition to stumpage value. If we assume, as a rough approximation, that the composition of products made from white pine is equal to the average of all species, then we can estimate white pine's contribution to the regional economy in terms of sales, employment, and personal income.

From Pedersen, et al. (1989, Tables 4 and 5) the 1985 regional levels for these measures were sales of $16,767 million (1982 dollars), 170,192 jobs, and personal income of $3,848 million (1982 dollars).

[2]Regional industrial roundwood production levels were determined by summing state production levels for the three product classes for Michigan (Smith, et al., 1990, Table 3), Minnesota (Smith and Dahlman, 1991, Table 3) and Wisconsin (Smith and Whipple, 1990, Table 3).

Since white pine amounted to about 1.9 percent of total roundwood removals in 1988,[3] the following estimated contributions of white pine to the Lake States regional economy are sales of $318.57 million (1982 dollars), 3234 jobs, and personal income of $73.11 million (1982 dollars). Although utilized for lumber and wood products to a greater extent than the average for all species, solid wood products made of white pine are priced lower than many other species.[4]

The above estimates include only direct effects. We know there are indirect and induced effects to be considered. Taking these into account by using industry weighted average Type III multipliers from Pedersen et al. (1989, Tables 6. 7, and 8), [5] estimated total economic contributions of white pine are sales of $546 million (1982 dollars), 6355 jobs, and personal income of $136 million (1982 dollars).

These estimates, although rough, are indicative of the total contributions to the regional economy of production flows of white pine industrial wood. If we had consistent estimates of contributions of other resource values, they could be added to these estimates to derive total contributions of the species to the regional economy.

CONCLUSIONS

The following major conclusions flow from the above discussion:

1. Natural resource commodities continue to be required by our economy. If we do not produce these industrial raw materials, we will have to import them, which will add to our trade deficit.

2. Production of consumer products using wood generates industrial jobs, which are important in providing support to families, especially those of the middle class, which has been in serious decline in recent years.

3. Derived demand linkages are complicated and have the effect of veiling the importance of raw materials to societal prosperity.

4. Economic value is difficult to measure. This is true because of the multitude of functions played by forests, and the fact that many products are not priced by organized markets. Our economic accounting systems fail to measure these effects. Also, we have to be seriously concerned with existence, option, and bequest values of environmental resources, and consider maintenance of biodiversity, which is difficult to measure in a scientifically unambiguous way.

5. Regional economies are diverse and forests play important roles in many of them. However, product mixes vary greatly. Regional economic structure affects forest management and vice versa.

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[3]This percentage was calculated by dividing the white pine industrial roundwood production by the all species production level for the region, by summing data for Michigan (Smith, et al., 1990, Table 3), Minnesota (Smith and Dahlman, 1991, Table 3) and Wisconsin (Smith and Whipple, 1990, Table 3).

[4]Saw logs and veneer logs constituted about 80 percent of white pine industrial roundwood production as compared to about 31 percent for all species. These percentages were developed using regional totals derived by summing data for Michigan (Smith et al., 1990, Table 3), Minnesota (Smith and Dahlman, 1991, Table 3) and Wisconsin (Smith and Whipple, 1990, Table 3).

[5]A sales multiplier of 1.714 (Table 6), employment multiplier of 1.965 (Table 7) and personal income multiplier of 1.861 (Table 8) were used in this calculation.

6. In rural areas, forests are important sources of industrial raw materials as well as serving other functions of the natural environment. In urban areas, forests are visual and aesthetic resources that are important inputs of leisure and recreational activities. White pine can be economically valuable in enhancing real estate values in the urbanized areas. Urban forestry values are particularly difficult to estimate, but are undoubtedly locally important.

7. It is important to manage forests to further enhance human society while maintaining a high quality environment. The forestry profession needs to refocus back to forest management to produce multiple outputs to meet diverse societal requirements for goods and services (both priced and nonpriced), including a high quality environment. Forestry can significantly contribute to societal health and prosperity by furthering both economic growth and environmental quality.

8. Even if lacking economic importance at the national level as a source of industrial raw material (in contrast to the early years of forestry in the United States), white pine continues to be economically important in certain areas within the region. Although not a major component of the region's economic base, contributions of white pine in generating jobs and incomes can be locally very important. This statement indicates that this conference is on a topic of limited importance. However, in view of regional and national economic structures and species distributions, one reaches the conclusion that almost all species are only of local economic importance!

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MULTIPLE OBJECTIVES AND ECOLOGICAL TOOLS

David T. Cleland, Thomas R. Crow, and John R. Probst[1]

Under a recently announced policy, the management of the National Forests and Grasslands will follow an ecological approach. People's needs will be met while ensuring that National Forests represent diverse, productive, and sustainable ecosystems. This management of ecosystems will follow multiple-use principles, but with a difference. Elements that we have traditionally managed, such as popular game or commercial tree species, are being placed into a broader context in which they are considered along with the intrinsic and spiritual values that exist for all ecosystems (eg., their history, complexity, beauty and cultural significance). This broader context includes considerations of stability and change through space, over time, and at different scales with respect to species and ecosystems. Conflicts in meeting multiple use objectives which range from the maintenance of wilderness to the preservation of biological diversity to commodity production will be minimized through application of multi-scaled analyses and land use continuum concepts.

Ecosystem management will integrate research and public involvement with operational management. Under this paradigm, natural resource management will be formally recognized as the interminable experiment and learning experience that it has always been. The development and application of ecological concepts and tools will become increasingly important in this evolution. With these developments, our understanding of complex ecological and social systems will improve, and important findings will be implemented through adaptive management.

One premise of ecosystem management is that climate, physiography, soil, water, plants, and animals interact to form ecosystems. These ecosystems occur in a nested geographic arrangement, with small ecosystems contained within larger ones. This hierarchy is organized in decreasing orders of scale by the dominant ecological factors affecting biological systems. The use of hierarchial, multifactor concepts has practical implications for ecosystem management including integrating management objectives, evaluating outputs and trade-offs, and estimating the cumulative effects of management actions at regional to local scales.

Ecosystem management is concerned with the structural and functional attributes of ecosystems at a variety of spatial and temporal scales, and the relationship of man and nature to these. The ecosystem concept brings together the biological and physical worlds, and these in turn intersect with the cultural, social, and economic systems that we, as dominant species, have created. This more comprehensive approach does not mean that resource utilization to meet human needs is being diminished. On the contrary, understanding and protecting ecosystem processes is essential to providing a lasting supply of the materials and experiences that people require. Sustaining both ecological and economic systems is an imperative of ecosystem management, since these systems are inextricably linked and the well-being of either is dependent on the well-being of the other over time.

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CHANGING THE PARADIGM

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ABSTRACT. Ecosystem management, perhaps the biggest change in the paradigm of National Forest Management since the 50's, did not just "happen". Ecosystem management has roots in many areas of the country but a "tap root" is in the Pacific Northwest where a team of scientists and managers jointly developed practical applications, based on the latest scientific understanding of forest ecosystems, to demonstrate the essence of management on an ecosystem basis.

The ecosystem management paradigm change that has resulted from efforts like those in the Northwest can be explained by examining some key "principles of change" that normally must be met to bring about successful change. Those principles include the following:

1. Lead by example;
2. Change requires a champion (s);
3. Remember the "change formula": change requires dissatisfaction with the present;
4. Change involves a blending of social, legal, economic, technical, and political systems;
5. Change must be dynamic; and, in the case of resource management change;
6. Research and management working together provide a synergistic effect.

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THE TEMAGAMI DISPUTE: A NORTHERN ONTARIO STRUGGLE TOWARD CO-MANAGEMENT

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ABSTRACT. This paper examines the complex triangle of community interests that have struggled for ascendancy in the control and direction of land use, resource policy and pine harvesting in the rich pine dominated forests and waterways of the near-wilderness Temagami Country in Northeastern Ontario. Confrontation peaked in 1989. Since 1990, various moves toward systems of co-management and joint stewardship of the forests and other resources have been introduced. The Wendaban Stewardship Authority is the most significant. Half its membership is aboriginal and half is made up of diverse settler Ontarians. Though still precarious, it and other emerging Temagami systems provide a potential co-management model for many other forested areas of the "public domain".

For many years now, resource management conflicts have raged throughout Northern Ontario. They focus on the pine and spruce forests, on wilderness and environmental values, and on aboriginal rights. During the recent past this conflict was most extreme amidst the pine forests and myriad lakes and rivers of the Temagami Country -- the reknown, beautiful and rugged Pre-Cambrian headwaters district, centered on the complex lake by the same name with its fourteen hundred islands, and the neighbouring near-wilderness of the Lady Evelyn watershed. The district is located a hundred miles and more northeast of Georgian Bay. The crisis year was 1989, involving road blockades and other confrontations that severely rocked a government. Now, a serious attempt to resolve these conflicts is underway. At the core of the new initiative is the concept of co-management.

The diverse parts of this co-management are still only coming into place, still very controversial. The entire plan could easily fail.

Co-management involves sharing stewardship -- that is the key emotive word -- over the land, water and natural resources, especially forests in the area. The players or partners are numerous, but they include the Ontario Ministry of Natural Resources, the aboriginal Teme-Augama Anishnabai (T-AA), the environmental recreational interests, and the local municipal and lumbering concerns.

At the very core of the Temagami Country and of the co-management concept is the Wendaban Stewardship Authority.[2] Yet the Wendaban's current area of jurisdiction is only four geographic townships -- 120 square miles; that area contains a large portion of one of the most important Old Growth Pine Forests in Northern Ontario.

The pine ecology and the pine lumber industry are in major trouble throughout Northern Ontario as well as in many jurisdictions to the east and west. This arises both from faulty forest policies in the past and from troublesome marketing circumstances for the present and short term future. The evolving co-management schemes are an important attempt to deal with this complex issue, while also addressing long

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[2]This author is one of the six Ontario members, matched with six from the T-AA and a neutral chair.

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standing aboriginal rights. What is hopefully evolving in the Temagami Country has wide application for other areas in the pine and boreal forests of the near and mid-North.

The history of struggle in the Temagami Country has involved a triangle of competing interests. On the one side has existed the diverse forest harvesting interests (and the mining interests), including their provincial governmental regulators and landlords. On a second side has been the persistent and very articulate aboriginal First Nation, the Teme-Augama Anishnabai (and their supporters) who firmly believe, and the historic record virtually bears out their conviction, that they were not a party to the 1850 Robinson Huron Treaty and have never ceded title to any of their homeland or N'Daki Menan which they have stewarded for thousands of years. The third side has been made up of most of the powerful recreational and environmental interests -- though some of the sport fishing and hunting groups in fact favour the "opening up" activities of the lumber companies. This third side has been concerned with conservation of the Old Growth Forest and preservation of the near wilderness nature of the waterways and their environs. The interests include the summer cottagers, the youth camps, canoeists generally, and environmental organizations both north and south.

At the time of the last century the pine forests of Algonquin Provincial (created in 1893) Park (and reserve for forestry) and the Temagami Country to the northwest were correctly regarded as the most valuable pineries in Ontario and indeed in all eastern Canada. Pine forests to the north and east had been devastated by faulty, short term cutting practices, by settler-set fires, and by agricultural encroachment. To the north lay the spruce dominated boreal forest, more valuable for pulp than lumber. As a great victory for the early conservation movement (for sustained life and yield of resources), the Temagami Forest Reserve had been established in 1901 and drastically enlarged in 1903; it survived in various designations until 1952 (Hodgins and Benidickson 1989). The first north-south railway, the T.N.O.R. now the O.N.R., passed through the area in 1905 but pine lumbering only began in earnest in the mid-twenties. Lake Temagami, especially in the thirties and forties, was the key area for Ontario Lands and Forests to develop sophisticated forest fire fighting techniques, including the use of bush planes and water bombing. Cutting was a labour intensive, winter business; high grading was the technique, and spring was the time to use water courses to haul the logs to mills, usually in villages around the periphery of the Forest (Hodgins and Benidickson 1989, Radforth 1987). Although too much pine in places was cut, few trees were planted, and parts of the Forest deteriorated, much of the pine ecology was saved and preserved, especially shorelines, skylines, islands, and large tracts remote from easy water routes to the mills (Hodgins and Benidickson 1989, Gillis and Roach 1986).

Forest management was all under the direction of the Ontario Department of Lands and Forests whose mandate was to lease out the timber limits or berths, to increase both the yield and the timber duties, and to fight fires. In Ontario, as in other Canadian provinces, most timber has been taken from "crown lands", that is public lands. Private woodlots do exist in the southern agricultural belt, but overall their percentage yield has not been particularly important. In Northern Ontario over 80 percent of the land is owned and controlled by the province, though some of it has been claimed by various Indian communities. Initially regarded as a crown patrimony, it came to be considered as a public patrimony, but ruled as a great fiefdom by Lands and Forests which since 1973 has been styled the Ontario Ministry of Natural Resources (M.N.R.). M.N.R. has claimed that in its Temagami Administrative District over 90 percent of the land is under its direct control, and if the incongruously included urban Tri-town area was excluded, that percentage would be higher.

In 1962, amid growing public concern over the depletion of the pine resource, Lands and Forests, while increasing timber fees, took over control of regeneration responsibilities. Planting and reforestation increased, especially in the eighties and usually under contract. But the move then to establish conservation-oriented Forest Management Agreements with the large companies in most of the spruce boreal forests to the northwest were not followed for the smaller pine-dominated timber units such as those in and around Temagami. At the same time, lumbering became a highly mechanized year-round industry and in the pine forests depended on costly trunk logging roads deep into remote reaches. Clear-cutting became the primary form of extraction.

In the late seventies and especially the eighties, public outcry against many government-sanctioned cutting practices, poor regeneration, and decline in the forest inventory increased. So did the quality and environmental sophistication of wilderness travellers in the Temagami Country and other near-wilderness areas. Frequently their voices were co-terminous with Toronto and other metropolitan-based environmental organizations. In 1983 as part of a province-wide expansion of the parks system and in response to pressure from the preservationists lobby, the Lady Evelyn-Smoothwater Wilderness Park was created in the superb canoe country that is the very headwaters of the Lady Evelyn and East Montreal River systems (Hodgins and Benidickson 1989, Gillan in Bray and Thomson 1990). While some of the area had been lightly high-graded in the forties, a small portion just recently heavily harvested, and a dead ended logging road from the north ran right through the park, all timber activity, hunting, etc. was banned. But this produced only a hill in the struggle.

Tensions soon focused on trunk logging roads and on clear cutting. Generally speaking, the roads were built and maintained by M.N.R. from the highways, long distances to the "gates" and after the gates by the companies with 50 percent subsidies (90 percent for bridges and big culverts). Without this assistance the companies argued, their operations would be uneconomic, and possible high unemployment was an ever present threat. The situation only inflamed the passions of the recreationalists and the environmentalists. Political skirmishes increased.

By 1989, under the shaky umbrella of the influential, well-funded and well-staffed Temagami Wilderness Society (T.W.S.), with offices in Toronto, a stand was taken against the increased westward extension of the Red Squirrel Road, to link up, as a through route, with that road running south through the Park. A third route creeping in from the south threatened to create a T junction deep in the wilderness, at the heart of the Old Growth Forest, in the Wakimika Triangle. In late September, with tensions high, the right of way was blockaded by hundreds of people who had reached the area by boat or bush plane. Arrests were numerous and briefly included Bob Rae, then leader of the Opposition. Premier David Peterson claimed that the Temagami issue was the most vexing and time consuming question of his second administration (Bray and Thomson 1990). At the end he lost most of the province's very powerful environmental vote. Yet slowly the gap between the roads was narrowed.

Meanwhile, since 1973, under the leadership of Chief Gary Potts, the Teme-Augama Anishnabai were increasing their demands for recognition of their claims and for a land settlement. In 1973 they obtained a Caution on the so-called crown land in one hundred and ten geographic townships (about 2,640 square miles), virtually all of the N'Daki Menan, the Temagami Country. This froze all new development, except on private land, land that they excluded from the Caution. It froze the issuing of land patents, though by a circuitous argument provincially directed, logging activity continued. On most of this land, the Caution survives almost twenty years later.

The Indians went to the courts against the province. The issue took eighteen years to reach the Supreme Court of Canada, Part of the problem was deeply constitutional. The 1850 Robinson-Huron Treaty had been negotiated by the British imperial crown. With Confederation in 1867, "Indians and Lands Reserved for Indians" became a federal responsibility, but crown lands and natural resources were a provincial, Ontario matter. Canada, over the decades, gave luke-warm support to the claims of what they called the Temagami Band of Ojibwa. But Ontario, keen on its revenue from great pine forests and mining potentials refused even to recognize the legal existence of the T-AA. Federal authorities even had to buy most of Bear Island (one square mile) in 1943 for the Natives. In 1971, it was designated a Reserve -- probably only one hundredth of what they might have received under The Robinson Treaty.

Strengthened by the greater recognition of aboriginal rights in the constitutional changes of 1982 and by this apparently positive approach of David Peterson's Liberal government which won power in 1985, Chief Potts and his tiny nation increased the sophistication and effectiveness of their pressure. Though frustrated by negative judicial decisions in the Ontario courts they articulated a bold "Vision" for the threefold co-management of the N'Daki Menan. They carefully incorporated the sustainable development and stewardship rhetoric of the United Nations Bruntdland Report into their policy statement (Potts 1989, Hodgins and Benidickson 1989, Bray and Thomson 1990, Masinahigan 1991). They also contracted with a team of Lakehead University foresters and pine ecologists, led by Professor Crandall Benson, to study the state of forests and logging in the territory, from a sustained yield stewardship basis ("sustained life"). Benson, who in two reports was extremely critical of M.N.R. and the logging industry, noted the issues raised by the suppression of natural ground fires, and asserted that the annual allowable cut was far too high (Benson 1982 and 1989).

The Teme-Augama Anishnabai announced in 1988 that the lumber roads would not be hooked up. That summer, they set up camp, amid great solemnity and ceremony, on the Red Squirrel Road right-of-way. Through injunctions, attempted counter injunctions, and long discussions, the autumn passed without clashes or construction.

Then, in November 1989, with the construction from the northwest end and the environmental blockades (T.W.S.) underway for six weeks in the Wakimaka Triangle, the T-AA requested that all work cease and that the T.W.S blockade end (which it did) and announced and initiated a serious passive resistance blockade, mainly at the location of the gate just north of Lake Temagami. It was national, even international news for several weeks. Many TV programs and videotapes were prepared and aired. Hundreds were arrested, aboriginal and non-aboriginal. There was no violence, thanks largely to the leadership of Gary Potts and the disciplined restraint of the Ontario Provincial Police. It was stylized high drama. Nevertheless, with snows blowing, the gap was closed. After a fashion a truck passed over the linked road before the land was given over to winter silence. In the spring run-off, erosion did its work. Probably no road vehicle has since crossed the gap. The unused route now runs directly across the lands of the co-managed Wendaban Stewardship Authority.

In describing two sides of the triangle, the role of the third side, the complex but powerful recreational and environmental interests, had been partially explained. The Temagami Wilderness Society itself did not exist until the late eighties and was never the united leader. Early on and throughout, the Temagami Lakes Association, the Association of Youth Camps, Northwatch (based out of North Bay), Temiskaming environmentalists, the Sierra Club, the Canadian Environmental Law Association and Naturalist and Parks organizations were all involved. Increasingly the interests focused on analyzing the impact and opposing the increase of road access into the interior of the forest and in conserving the pine ascendant ecosystem. This involved both ending all clear cuts and other negative practices and preserving as much as possible of the Old Growth Forest. Research into its nature, patterns, and extent were initiated by teams led by Dr. Quinby (Quinby 1989 and 1990 and in Bray and Thomson 1990). He asserted that very old pine stands did exist, that "over maturity" was a faulty concept, that the white and red pine system had survived for centuries, perhaps millenia, and that ground fires were important and a positive agent but not necessarily essential for the survival of at least the white pine. Where Quinby and the T.W.S. called for full preservation, Benson and the T-AA called for conservation, an end to clear cutting, severe curtailment of the annual cut, and more aboriginal involvement. The M.N.R., with pine research led by Dr. Robert Day (Day and others in Old Growth Forests 1990), while admitting past mistakes and inadequate replanting, basically defended current practices but without conviction on the matter of large unit clear cutting and hill top harvesting. The local municipalities, the small struggling lumber companies and many of their employees and sub-contractors vehemently attacked the radical environmentalists, the canoeists and the T.W.S. leader Brian Back. There was a lot of anti-Toronto, anti-south bashing; much of it was very ugly. Yet many of the Indians were extremely critical of both Quinby and Back and the preservationist ethic, arguing for stewardship with careful use, noting that the T.W.S. seemed arrogantly to want to put the Anishnabai in a big zoo and freeze them and their culture in a time warp.

M.N.R. officials seemed incapable of convincing the environmentalists and the non-local public generally that it was sufficiently distanced from the logging industry and their municipal allies to be proper stewards of the public forests. But they did try. In the Temagami area numerous ad hoc consultative committees were created. Public hearings multiplied. In 1987 M.N.R. created the Temagami Area Study Group made up of appointees from diverse elements from the non-aboriginal sides of the triangle.[3] The only thing its members could agree on was that the chair, President John Daniel of Laurentian University, was too arbitrary and insensitive. In 1988 he himself wrote the report in the first person plural (Daniel 1988); it was rejected by the protagonists. Then the M.N.R. established the Temagami Advisory Council to look into overall resource management, especially pine harvesting. It undertook some considerable research and made several preliminary statements, but it lacked aboriginal membership and the environmentalists and recreationalists considered it quite unrepresentative and too close to M.N.R. Of course, within M.N.R. itself, especially outside of its forestry branches, there existed many committed environmentalist and parks people who had close links and friendships with both the conservationists and the preservationists. These people had helped secure the Wilderness Park and later several local Waterway Parks, and they watched diligently over the non-logging aspects of the environment. Finally, the entire provincial logging practices of M.N.R. were submitted to long drawn out public hearings and investigations before the Ontario Environmental Assessment Board. These hearings continue. This spring (1992), the Board was in the North Bay and Temagami was central to their considerations.[4]

On April 23, 1990, the Peterson government needed significant change in policy, moving part way toward recognizing the aboriginal concept of co-management ("Introduction" Bray and Thomson 1990, Globe and Mail April 24, 1990). The Ministry of Natural Resources signed a Memorandum of Understanding (M.O.U.) with Gary Potts of the T-AA. Negotiations toward a permanent Treaty of Existence would commence and carry on regardless of the outcome of the Supreme Court Decision (though federal involvement would ultimately be necessary for constitutional entrenchment). Ontario would pay for the Indians' research and administration. Use of the controversial road links would temporarily not proceed. Large scale clear cutting of white and red pine throughout Ontario would cease. The controversial and previously supported Milne Lumber Company of Temagami would be bought out and immediately closed down. The T-AA would ultimately receive a relatively large but as yet undefined land base and would have a significant consultive role in all lumbering and resource decisions, and over the most controversial

[3]This author was initially one of them.

[4]Northwatch organized a major session and this author gave a written presentation on the impact of access on the environment.

central core of the district, the Wakimika Triangle. A co-managerial Stewardship Council with 50 percent self-determined aboriginal membership would be established, and financed for the time being from provincial revenue, to administer the area.

This Agreement and linked policy changes took Temagami off the front pages and cut severely into voluntary contributors to the T.W.S. which was, however, far from satisfied. The Teme-Augama Anishnabai were soon very impatient with the slow pace toward negotiations and preoccupied with preparing their court hearings where Ontario was still the enemy.

Then in September 1990, the Peterson Liberal government fell in a premature election, to be surprisingly replaced by Ontario's first New Democratic Party administration, one led by Bob Rae who had been arrested on the barricades. He immediately announced that aboriginal self-government and land settlements were a chief priority and that Bud Wildman would be both Minister of Natural Resources and Minister in charge of the Native Affairs. Secretariat Wildman, a northerner with some Indian ancestry, had been on the edges of the T.W.S. The T-AA established its impressive new office and administration, but erratic lower court decisions concerning those arrested on the blockades caused deep anxiety and frustrations. Some were found guilty, some innocent on grounds of "colour of right". Some were fined, some jailed for a few days, some both fined and jailed. Many were never brought to trial, before all charges were finally dropped in the autumn of 1991.

On May 23, 1991, as an Addendum to the previous M.O.U., Wildman and Potts announced the formal establishment of the co-management Wendaban Stewardship Authority -- but because of a last minute disagreement, it received authority only over the four central townships. The six Anishnabai, many of whom had been arrested, were named by the T-AA. Wildman appointed six Ontario representatives of very diverse backgrounds from the other two sides of the triangle. Two had been arrested.[5] Furthermore, the T.A.C. was replaced by the Comprehensive Planning Council (C.P.C.), a more broadly based organization with a much wider planning mandate and more autonomy from M.N.R.

Although no T-AA on the C.P.C. -- probably for political and juridical reasons -- it soon consulted with them. Moreover M.N.R. itself established close, consultative relations with the T-AA resource management committee. No serious disagreements have emerged, though the recession and depressed markets have curtailed pressures. Although the C.P.C.'s and the M.N.R.'s consultation process with the T-AA is not quite formal co-management, the process seems to be working in that direction.

Also in late May 1991, Gary Potts and the T-AA had four unprecedented days of hearings before the Supreme Court. Then Trent University conferred upon Chief Gary Potts an honourary degree. Bud Wildman was present for the preliminaries. In August, just as the Wendaban Stewardship Authority was getting underway with the first issues of co-management, the Supreme Court rendered its decision.

The Teme-Augama Anishnabai did not win, but neither did they fully lose. The Court ruled that somehow the T-AA had lost their aboriginal ownership over N'Daki Menan and were subject to the Robinson Treaty. But the Court overruled most of the logic, history and reasoning of the lower courts. It declared that the T-AA's version of their history to and including 1850 had been correct, that they had aboriginal ownership, and that they had not signed the Treaty. It was with events thereafter that they had somehow consciously or unconsciously behaved as if under it. So they had unspecified Treaty rights. The "crown",

[5]Including this author. O.N.A.S. releases, May 23, 1991 etc. Wendaban Stewardship Papers and the Nugget, North Bay, May 24, 1991.

it found, had failed in its "fiduciary obligations" to the Teme-Augama Anishnabai and these failings were being and ought to be corrected through the political process (The Supreme Court of Canada, Bear Island Foundation vs. the Attorney General of Canada 1991). But what crown? The old imperial crown? Certainly not after 1867. Was it the federal crown, which had the constitutional obligations and had not secured a large enough land base for the band? Or was it the provincial crown which controlled land and natural resources including pine and had failed to share? Or was it both? Most knowledgeable observers said it was both.

Anyway, negotiations under the Memorandum and its Addendum have slowly continued to the present. These negotiations were long bogged down over the term "fiduciary". A subsequent block emerged from the T-AA's logical insistence on an interim veto over major development in the area, pending the final land selection, method of administration, and the signing of a full Treaty of Co-existence. In a sense they have demanded that the M.N.R. - C.P.C. consultative process be co-management in theory as it was becoming in practice. At the time of writing, this is where matters now stand.

Meanwhile, the pro-development lobby, led now by mining more than the logging or the municipal interests, are bitterly demanding the lifting of the Caution by provincial initiative. The lobby's premise is that the Indians lost their case, so why the delay. They ignore the courts' caveat and the governments' Memorandum. The Caution remains. So, in a further sense the co-management system, while formally denied, actually exists, at least for the moment.

While there is a growing literature on co-management and co-stewardship (Ostrom 1990, Pinkerton 1989, Berkes 1991, Harris 1992, Benidickson 1992) and while it received the formal endorsement of the prestigious Brundtland Report, its articulation in the Temagami case came primarily from the "Vision" of Gary Potts and the Teme-Augama Anishnabai (Potts 1989, Masinahigan 1991-92, Hodgins and Benidickson 1989). At least formally the government of Ontario has bought into the "Vision" with the creation of the Wendaban Stewardship Authority. Probably the full implications of that "Vision" have not been accepted by most of those in government or certainly by the senior and Temagami bureaucracy of the powerful M.N.R. fiefdom. Ministers come and go, governments come and go; the power and ethos of the fiefdom seems to live on. Under the "Vision", all of N'Daki Menan or the Temagami Country must be under the strident ecological stewardship for the generations yet known, both aboriginal and settler. The Supreme Court, in a British Columbian decision (the Sparrow Case 1989) recognized aboriginal rights to prior consideration, under conservationist principles, over the use of at least some of the resources in their ancestral lands beyond their small land bases or reserves.

Under the "Vision", Temagami will be divided into three parts; backed by some consultative joint authority. Over one large part, the T-AA will have total sway and ownership, subject only to the cultural constraints of strict stewardship. Over a second part, including the existing local municipalities and perhaps some new ones, Ontario and Ontarians will have full sway and ownership, public and private, all under the same constraints. Over a third fairly large territory, there will be joint administration on the model of the Wendaban Stewardship Authority. The 30 percent Ontario representation will primarily be local residents or at least those with strong local interests. The "Vision" does not leave much power in the hands of M.N.R. It seems likely that M.N.R. officials instead see the W.S.A. territory remaining fairly small and influenced through the provincial appointed system. The lands of the T-AA would be restricted to the one hundred square miles, somewhere, of the past Robinson proposal, with considerable development potential. The rest of the lands would remain to be controlled much as they have been, modified by further entrenchment of public consultation and stewardship with regard to forestry, mining and recreational development. The basic role of M.N.R. would survive. Co-management would be relatively indefinite outside of a modestly enlarged or doubled Wendaban. Perhaps even the Wilderness Park would also be co-managed, on the model of three in the Northern Territory of Australia (Weaver 1990 and 1991).

Clearly for co-management, the Wendaban Stewardship Authority is the vital test case. But we have no measurement for success, only perhaps for failure. As one prominent Anishnabai member (Mary Laronde) of the W.S.A. asserted recently, "We can not and must not fail". Yet our territory is so relatively small, and so far we are totally dependent on the provincial treasury for survival. The province can and is adjusting the Ontario membership. We might be able to generate a little money from recreational fees or sales. But clearly the primary self-generating revenue, for a long time would have to come from timber or mining duties. Yet many people are determined that the core of the Old Growth Forest must be preserved and that the notorious trunk roads must not be reopened. Gary Potts suggests perhaps a return to highly selective cutting, using low technology and horses and winter cutting roads. Perhaps semi-permanent provincial subsidies for the timber operations will be necessary. Yet these might severely violate the Canada-U.S. Free Trade Agreement - as indeed the old roads policy perhaps do now.

For the moment, twelve people, with a neutral chair (Dr. Desmond Anthony), are personally functioning together, very well indeed. No issue, big or small, has ever divided membership in the slightest on a racial or cultural basis. The Authority needs consensus of at least eight to carry decisions. Most members played significant roles in the controversies of the eighties. All sides of the triangle are represented. Some at least figuratively glared at one another across the blockades. Many were arrested, several others were very angry and bitter against the protestors. Yet the W.S.A. chemistry is working.

A detailed inventory of the forest and the general ecology has been contracted to scholars from the University of British Columbia. The study of the pine ecology and the role of fire is increasing. A permit for a traditional aboriginal family to engage in a tourist operation has been issued. A permanent staff and office is being assembled. The Authority progresses despite the mixed messages which it receives from M.N.R. authorities, many of whom seem very wary. It progresses despite financial cutbacks and despite the fact that the envisioned provincial legislation permanently establishing the Authority has not yet been introduced and is not now expected for some time. Endorsed by the T-AA government and Assembly, it still survives from Ontario's perspective, on a ministerial order and temporary appointments by cabinet. It seems tied to the overall negotiations toward a Treaty of Co-existence. Yet the extension of the model into portions of large James Bay lowlands are seriously under consideration (Andrea Hodgins 1992).

One also suspects that many in M.N.R. see co-management as a dualistic system. To function, co-management must focus on sustainable life and involve the irregular triangle of interests analyzed. It can not be merely M.N.R. and the aboriginal people. Decisions must flow from aboriginal style consensus and aboriginal style commitment to the stewardship of the land in a rapidly changing social and cultural environment.

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GROWING WHITE PINE FOR TODAYS MARKETS

Jack Rajala[1]

ABSTRACT. Eastern white pine has a long and illustrious history in our land. Although not as common as in early settlement days, there is still a viable white pine lumber industry. Unfortunately, over much of the growth range the species has declined dramatically and the future of white pine in lumber is in jeopardy. Simultaneously, we have a keen concern for the ecological importance of this species in the landscape and there is mounting tension between factions as to the future harvesting of white pine. Ultimately, whether white pine is harvested for economic and product values only relates to how long the remnant of what was considered the "Eternal Forest" will last. For surely, even if white pine is not harvested, it is a dying breed unless work is done to regenerate and promote its growth. Precious little has been done to enhance opportunities for propagation of white pine for a myriad of reasons. However, a strong case can be made for both the science and the economics of doing so. It is interesting that in the few places where it is being done, a clear and unabashed economic interest is involved.

INTRODUCTION

The beauty of the topic that I'm presenting today is that there is, to my knowledge, only one similar paper in all written history on this subject; and I just happen to have the original copy. Although this statement might not be absolutely correct, it is safe to say that very little has been written about the eastern white pine industry in the last fifty years and, I believe, equally little has been written about the almost nonexistent efforts of anyone to grow this species, which was once truly "The King of the Forest." What little has been written falls into categories outside of the requisite area practical enough to apply to every day, contemporary forestry. For on the one hand we have highly sterile and empirical research, and on the other hand writings of romance of the white pine era. For other than a yearning to harken back to those good old days when New England, the Ohio Valley and later the Lake States were the center of lumbering activity, the timber industry has certainly seemed to be long gone - to the Pacific Northwest, the South and to the Intermountain States.

And so it's not any big question as to why we haven't heard much about eastern white pine for the last 50..60.. or almost 100 years.

Just the same, there has been a remnant white pine industry throughout the range. And just as the species managed to survive the ravage it suffered (Remember, the forest that was so heavy, dark and extensive that it was referred to as the "Eternal Forest" and no one thought it would ever end, and so was horribly over cut?) there has been white pine and a smaller sawmill industry alive all these years.

THE INDUSTRY/MARKET

The point is this. Although certainly not as glorious as the past, there is a viable white pine industry yet today and there is a significant demand for this wonderful wood.

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The best estimate that can be made is that roughly 300-400 MMBF of eastern white pine is produced in the northeastern U.S. each year, a similar amount in eastern Canada, and approximately 150-200 MMBF in the Lake States. White pine is made almost exclusively into lumber products and is used primarily for millwork, paneling, furniture, finish, siding and sheathing. Smaller amounts are used for novelty products and industrial crating. Just to contrast today, it was earliest used for ship mast, boom, spar and timber (all axe cut and hewn). And then, later, used extensively for architectural millwork and foundry mold. Perhaps, more than any other species, knowing the current use of white pine gives us a picture of the progress of our civilization in North America because white pine is so versatile and often the preferred species in many wood products. And, in all likelihood, many more products could and would be made from eastern white pine today if it were available. For although the species is reproducing well in the New England States, over much of the growth range only a fraction of its pre-1900s volume remains. Whatever the reasons, major forestland areas that once grew white pine have converted to other species or to other uses. And it's safe to speculate that one reason probably is that many forest land managers have long believed that the species is simply too difficult to grow.

It was earlier said that white pine is a preferred species in the market place. This is born out by the fact that in stumpage, log, or lumber form it brings a higher dollar return. In almost any market condition prices for eastern white pine lumber select grades will exceed red oak selects, the moulding and shop grades will compete favorably with number one and number two common red oak, and the common grades easily outstripe the number two and number three grades of red oak. The comparison is even more dramatic when compared to other eastern softwoods such as red pine, jack pine, spruce and balsam fir.

GROWING WHITE PINE

Having made the case for the economic value of white pine (and there seems to be little doubt about the ecological value of the species), focus needs to be placed on how to grow it. Let's look at a case study.

The Rajala Companies have a long history in milling white pine - one of its mills in Minnesota has been sawing it as the major species since 1902. Some ups and downs have occurred but production has been relatively stable for the past 45-50 years. However, the Rajala's have known for some time that customary forest management results in lack of natural regeneration of white pine. The Rajala's also face another challenge on how to manage for an understory crop while managing northern hardwood types. These two factors fit each other well. Whereas other species, especially hardwoods and other pines, could not be grown after the early stages of successional thinning, white pine is sufficiently shade tolerant to do so. Additionally, white pine pops out of the ground well and competes favorably with understory plants. Finally, white pine is more site and soil tolerant than most other species and, consequently, can be regenerated over a wide range of conditions.

Over the past ten years, Rajala's have planted over one million white pine seedlings (both bare root and containerized) and have experienced phenomenal survival. Every indicator says that white pine can be very successfully planted and grown <u>save one:</u> preventing deer browse. And that problem is being attacked with bud capping.

SOME TECHNIQUES THAT HAVE PROVEN SUCCESSFUL

As mentioned, planting has been done in the thinned understory below long-rotational overstory species. A favorable range of overstory is 40-60 percent crown closure and this eliminates any significant concern of tip weevil damage. Often, site work is done by raking the slash from whatever was removed during the thinning. This technique sets back brush and other competitive vegetation and makes hand planting much easier. Planting might take place immediately in the first spring or might follow a fallow season when the site is sprayed with an herbicide.

Seedlings are planted 800-1000 per acre to fully stock the understory allowing for mortality and premature thinning. The goal is to ultimately have 100-150 crop trees per acre carried through the 100 year horizon. Because eastern white pine is extremely long lived (can easily reach 200 plus years) and grows very large, stocking can be dropped down again and again.

There is a definite correlation between tree size and economic value. Although trees are limb pruned early on to improve microclimate and thereby reduce blister rust of juvenile trees, an equally important reason is to start creating clear boles. Eventually, trees are pruned free of limbs to an eighteen foot height. Since crop trees are headed for a long life and large diameter, this early limb pruning pays great economic dividends. Left to natural pruning phenomenon, the trees would have to reach 100 plus years before their trunks would be growing clear faces. And since there is a manifold differential between the value of clear wood and knot-studded wood in white pine lumber (or in any lumber or veneer for that matter) early pruning is dramatically valuable.

In many cases, release efforts have not been necessary. However, it is not uncommon to either hand or chemically set back competitive understory vegetation. In some cases chemical release show signs of harm to seedlings only one or two years in the ground.

SUMMARY

Eastern white pine has a long and illustrious history in our land. Although not as common as in early settlement days, there is still a viable white pine lumber industry. Unfortunately, over much of the growth range the species has declined dramatically and the future of white pine in lumber is in jeopardy. Simultaneously, we have a keen concern for the ecological importance of this species in the landscape and there is mounting tension between factions as to the future harvesting of white pine. Ultimately, whether white pine is harvested for economic and product values only relates to how long the remnant of what was considered the "Eternal Forest" will last. For surely, even if white pine is not harvested, it is a dying breed unless work is done to regenerate and promote its growth. Precious little has been done to enhance opportunities for propagation of white pine for a myriad of reasons. However, a strong case can be made for both the science and the economics of doing so. It is interesting that in the few places where it is being done, a clear and unabashed economic interest is involved.

WHITE PINE BLISTER RUST CAN BE CONTROLLED

D. W. French[1]

Many people gave up on growing white pine because of the fungus disease -- white pine blister rust. The disease was introduced into the United States in about 1908. In spite of the efficiency of this fungus in infecting white pine, there are control measures that promise success. For many years the primary means of dealing with this rust fungus, *Cronartium ribicola*, was to eradicate the alternate hosts which are species of *Ribes*. These species are found in most white pine stands or at least in the near vicinity. The basidiospores land on the needle of the pine host during summer and fall, germinate, and the germ tubes penetrate the pine needles apparently via the stomata. From there the mycelium grows through the leaves into the bark on the twigs.

CONTROL MEASURES

Since the introduction of white pine blister rust into the United States and until recently, *Ribes* eradication has been the primary control for the disease. Economists have shown that *Ribes* eradication is feasible, returning four dollars for each dollar invested. However, their study was based on the questionable premise that eradication of the alternate host prevented infection of the pine. This premise might be true if eradication did eliminate all the *Ribes* plants, but as we know, this is not the case. In areas with a recent fire history, pulling *Ribes* plants actually resulted in more plants. Chemical silvicides such as 2, 4-D and 2, 4, 5-T are more effective than mechanical removal.

The most promising control measure for the future is the development of resistant pine. In early work with eastern white pine, vegetatively reproduced trees from original resistant selections were resistant, while seedlings from these same trees were quite susceptible. The difference was probably due in part to the differences in age of needles. In the Pacific Northwest, resistant western pines have been located, vegetatively propagated, and established in seed orchards. Subsequently, additional resistant trees were located and added to the original numbers, and hybrids of these resistant trees are being produced and evaluated. Genetic gain above the base population ranged up to 24 percent. Two mechanisms seem to be involved in determining resistance in western white pine, (1) premature shedding of infected needles and (2) failure of stem symptoms to develop despite retention of infected needles. Necrotic reactions in branches or main stems in western white pine were a major mechanism of resistance; 26 percent of the seedlings eliminated the fungus this way. Western white pine resulting from crosses of parents selected for resistance had 20 percent infection as compared to 70 percent for mature reproduction. The gain in resistance was doubled in one generation.

In sugar pine, resistance is apparently under major gene control and simply inherited. A cotyledon test for major gene resistance in this tree species is definitive because of the clear macroscopic distinction between R (resistant) and S (susceptible) lesions. A total of 31 major gene carriers were identified out of 178 parents in open and controlled-pollinated seed lots. This test also has potential for detecting races of the pathogen capable of overcoming major gene resistance and such a race has been detected. Major gene resistance (MGR), controlled by a single dominant gene was found in 16 percent of selected

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candidates and was highly effective. MGR was highly stable for up to 14 years, but was lost in one year when favorable conditions occurred for inoculum production and infection.

Most infections occur within six feet of the ground in well stocked stands as well as plantations. Pruning is a feasible control measure. Infected branches should be removed, allowing six inches of what appears to be healthy tissue between canker and main stem. However, if pruning is to be economical, all the lower branches should be removed, thus insuring more complete elimination of the rust and improving wood quality.

Based on efforts to reduce infection by pruning, we have found that it is relatively easy to walk through a young plantation of white pine and prune branches with obvious infections. With practice, this can be a very effective way of avoiding losses to blister rust. In two experimental plantations we have been able to eliminate close to 100 percent of the new infections. Those that are not detected can be eliminated in the following year when they will be more easily seen.

Blister rust can be avoided by planting white pine in low hazard areas such as south and central Wisconsin instead of the northern part of the state. It is important to avoid areas where, because of the terrain, the microclimate conditions will favor infection. A closed canopy should be maintained which keeps the air dry below the canopy. The more susceptible and cankered branches are killed because of the shade. White pine should not be planted in small openings. Canopy openings with a diameter less than the height of the surrounding trees are cool and wet -- ideal for blister rust infection. Planting white pine in high hazard areas should be avoided. Air drainage on slopes and local radiant heat loss favors increased blister rust.

Direct treatment of cankers and infected trees has been tried extensively using among other chemicals, cycloheximide (Actidione) and Phytoactin. These two compounds are antibiotics produced by one of the Actinomycetes, *Streptomyces griseus*. These materials are applied in oil or water to excised cankers, basal portion of trees with cankers, and to the foliage by aerial applications. Although it appeared at first that the fungus had been stopped and there was evidence that the antibiotics were translocated away from the point of application, the fungus survived and later continued its normal development. Apparently these early attempts at a direct chemical control of blister rust have not succeeded but for the future this remains a possible control measure.

In 1961 Virgil Moss reported that from 66 compounds that were screened by *in vivo* testing, two antifungal antibiotics from the genus *Streptomyces* have systemic action when applied to white pine foliage, roots, and trunk bark.

In 1960 Lemin, Klomparens, and Moss found that cycloheximide (Actidione) is absorbed by the tree and persists there as well as being translocated upward in pole-size western white pine. Movement was via the water-conducting elements but was not detected in the bark above the treated area of the trunk. Actidione was translocated to untreated branches of eastern white pine. Phelps and Leaphart found the antibiotic was absorbed faster and moved in greater quantities but at a slower rate in eastern than in western white pine.

In the western United States, a fungus (*Tuberculina maxima*) occurs on blister rust cankers and is responsible for the death of the fungus. Approximately 67 percent of the lethal type cankers had been inactivated by *T. maxima* and aecial production was 18 percent of normal (Hubert 1935). There is no evidence that *T. maxima* is parasitic on the rust *per se* but does act enzymatically on the rust-infected pine tissue. Cankers are susceptible to infection only while producing aecia or pycnia, and sporulation varies with the year, thus restricting *T. maxima*. *T. maxima* invades and kills rust-invaded cortical tissues of western white pine thus destroying *Cronartuim ribicola*. There is no evidence that *T. maxima* is parasitic on the rust fungus and thus it's not a hyperparasite.

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WHITE PINE WEEVIL AND GYPSY MOTH: POTENTIAL PESTS OF EASTERN WHITE PINE

Steven A. Katovich[1]

ABSTRACT. The white pine weevil continues to be the major insect pest affecting eastern white pine. Attacks are concentrated on tree leaders, causing forking, growth loss and subsequent decay and defect. Weevils require white pine growing in full sunlight because of the warmer microenvironment and the larger diameter leaders which develop. Silvicultural practices which develop young stands under shade can produce trees not deformed by weevils. A compromise in the level of shade which allows adequate growth rates yet minimizes weevil presence is necessary. Maintaining high stand densities, at least until trees reach 20-24 ft. in height also appears important, especially in open-grown plantations. This may require precommercial thinning to prevent non-weeviled intermediate crown class trees from becoming suppressed. Currently, direct control of weevils using insecticides is not being widely utilized, though early spring application to terminals has been successful. Narrow strip clearcuts, especially in conifer stands or conifer-hardwood stands, should minimize weevil damage. Gypsy moth has the potential to be damaging to understory white pine in a oak or aspen overstory. Partial release of understory trees should allow them to reach codominant and dominant status and therefore become less susceptible to gypsy moth damage. Growing high quality white pine is possible though it requires a commitment to intensive management.

INTRODUCTION

Following the logging of the original pinery, two major pests, white pine blister rust (*Cronartium ribicola*) and white pine weevil (*Pissodes strobi*) combined to reduce the forestry value of white pine. While blister rust was a newly introduced disease to North America, the white pine weevil was a native insect whose presence and damage were increased greatly in newly established plantations following logging and in open regenerated stands that originated by natural seeding of abandoned farmland. Despite an intensive research effort on the white pine weevil, it continues to be the major impediment to growing high quality white pine in many areas.

White pine weevils attack and kill the terminal portion of white pine, often killing 2 years of growth and at times 3 to 4 years of growth. Loss of the terminal often results in two or more laterals becoming dominant, leading to trees with multiple stems. Each weevil attack reduces height growth by 40-60 percent in that year (Morrow 1965), with the overall effect on height reduction during a single rotation often approaching 10 ft. (Brace 1971). Brace further noted that injury reduced total cubic volume by 3-20 percent and reduced sawlog volume by 20-60 percent. Even trees that appear to recover from weevil attacks often have serious defect associated with attacks, including compression wood (Spurr and Friend 1941), stem decay associated with white pocket rot, *Phellinus pini* (Ostrander and Foster 1957), and bark encased knots and wane (Brace 1971).

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Gypsy moth, *Lymantria dispar*, is an introduced species which has been a notorious pest of hardwood forests in the northeastern U.S. Though gypsy moth favors oak (*Quercus* sp.) and aspen (*Populus tremuloides*), later stage caterpillars will feed on white pine growing under a hardwood overstory. Gypsy moth populations continue a rapid expansion into Michigan's Upper-Peninsula and are attempting to become established in eastern Wisconsin. The western Great Lakes states have a large resource of understory white pine that could be damaged by heavy gypsy moth infestations. Proper release of this white pine now could increase white pine growth while maintaining weevil control and serve an added benefit of making the overall forest more resistant to gypsy moth damage by increasing the presence of white pine in the overstory canopy.

WHITE PINE WEEVIL - LIFE HISTORY

Adults emerge from infested terminals in late summer. The newly emerged adults do not gain full reproductive maturity immediately and therefore must survive at least one winter in hibernation in order to successfully reproduce. Apparently, adult weevils are capable of living more than one year though it is not known if the adult females successfully lay eggs in subsequent years (Wallace and Sullivan 1985). Newly emerged adults begin to feed on current-year buds and stems on lateral branches in the top one-third of host trees (Dixon et al. 1979). Feeding sites are recognized as small, uncapped pits. In Maine, weevils remain feeding from August until mid-October with a peak abundance in mid-September (Dixon et al. 1979). Adults must feed during this period or they will die (Houseweart and Knight 1986). Fall is not the major dispersal period for weevils, though weevils in shaded stands often disperse at this time to areas with more sunlight (Droska 1982), probably due to a strong attraction to ultra-violet light which is minimal under hardwood canopies.

Adults overwinter in the duff, normally within 8 inches of the boles of host trees (Dixon et al. 1979). Emergence from hibernation is dependent upon the warming of the location. Sullivan (1959) observed that adults emerged when the microhabitat had warmed to 43°F (6°C) or higher. Therefore, adults overwintering in exposed locations are activated in advance of those in shaded sites. In Maine, adults began showing up on host trees in late April and peaked in mid-May (Dixon and Houseweart 1983). Spring-emerging adults are positively phototactic (attracted to light), negatively geotactic (move away from a gravitational force) and orient to vertical silhouettes (Dixon and Houseweart 1983, VanderSar and Borden 1977). This combination leads them to the uppermost and most vertically oriented parts of the trees, the terminals. Spring adults begin feeding immediately below the apical buds on the previous years growth. Stout, vigorous leaders are selected. Small diameter leaders are abandoned. Sullivan (1961) reported that leaders less than 0.16 inches in diameter were rarely attacked, but attacks increased to 80 percent on leaders up to 0.35 inches in diameter.

Mating occurs during the spring activity period. While adults generally remain solitary in the fall, aggregations of adults are formed in the spring. Male weevils produce an aggregation pheromone which, combined with host volatiles released during the feeding process, attracts both males and females, thus insuring aggregation and subsequent mating success (Booth et al. 1983).

Spring is considered the major dispersal period for white pine weevils, though studies indicate that the majority of weevils do not move far. Harman and Kulman (1967) and Harman (1975) reported that most weevil adults stayed within 33 to 180 feet of a release point with 65 percent staying within 40 feet, though some individuals were found up to 980 feet beyond a hardwood barrier. This relatively poor dispersal ability may be compensated for by an ability to infest a wide range of conifers in eastern North America, including red pine (*Pinus resinosa*), jack pine (*P. banksiana*), Scotch pine (*P. sylvestris*), white spruce (*Picea glauca*), Norway spruce (*P. abies*), and blue spruce (*P. pungens*) (Smith and Sugden 1969).

About one week after emergence from hibernation, egg laying is initiated. Females excavate small cavities at the bottoms of feeding punctures and deposit one to three eggs in each puncture. Egg laying begins on the leader immediately below the terminal bud and progresses downward. Up to 200 eggs may be laid in a single leader. In sunny locations, egg laying is generally restricted to the 1-year-old internode. On shaded leaders, egg laying may extend over the past 4 or 5 years' growth (Sullivan 1961).

Eggs closest to the top of the leader hatch first and begin to feed in a downward progression. The young larvae begin to come together in a "feeding ring" which extends around the circumference of the leader. Larvae generally have 4 feeding instars, each instar being progressively larger. The number of larvae which can be accommodated within a leader becomes fewer as the larvae grow in size. Large diameter leaders, normally associated with trees growing in full sunlight, produce more weevil offspring per leader than small diameter leaders. At the end of feeding, the larvae form chip-cocoons in the pith or wood of the attacked shoot. Normally, only 4 or 5 larvae complete development. If too many larvae are laid in a leader of small diameter, damage by the young larvae is so severe that the leader is often killed prematurely and no brood survives.

WHITE PINE WEEVIL HAZARD ZONES

Weevil presence and attack intensity is not the same throughout the native range of eastern white pine. In some areas, such as the southwestern portion of Wisconsin, little weevil presence is evident and open-grown white pine are rarely infested. However, throughout the northern one-third of Wisconsin attack intensity is quite high and open-grown trees which have not been attacked can be difficult to locate. Using this information, broad hazard zones have been developed for some states to inform land managers of the likelihood of weevil infestation. Figure 1 illustrates three hazard zones; low, moderate and high for Wisconsin (Goulding et al. 1988). In zone 1 (low hazard), weevils will attack less than 5 percent of trees in open-grown stands. In zone 2 (moderate hazard), weevils will attack 5 to 10 percent of trees in open-grown stands, and in zone 3 (high hazard), 10 to 30 percent attacked trees would be expected. Land managers in the low hazard zone do not need to be concerned about controlling weevils while managers in the moderate and high zones need to consider prevention practices to produce an acceptable number of non-weeviled trees.

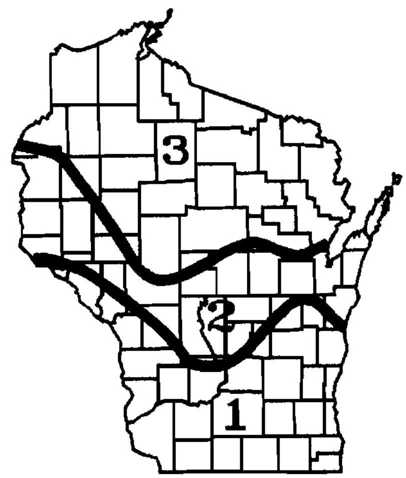

Figure 1. White pine weevil hazard zones in Wisconsin. Zone 1 (low hazard), weevils attack less than 5 percent of open-grown white pine. Zone 2 (moderate hazard), weevils attack 5 to 10 percent of open-grown white pine. Zone 3 (high hazard), weevils attack 10 to 30 percent of open-grown white pine. (From Goulding et al. 1988).

MANAGEMENT STRATEGIES TO MINIMIZE DAMAGE BY WHITE PINE WEEVIL

OPEN-GROWN PLANTATIONS

White pine trees growing in full sunlight in areas where weevils are prevalent will likely be attacked once they develop sufficient leader diameters. Establishing dense plantations has been suggested as a possible way to develop stands with an acceptable number of non-weeviled trees (Stiell 1979). It has long been recognized that denser stands are less affected by white pine weevil (Graham 1926, Peirson 1922). Stiell (1979) reported on a plantation established in 1939 at an extremely close spacing of 2.2 x 2.2 feet at the Petawawa Forest Experiment Station in Canada. In 1958, average stand height was 24.6 feet and stocking was still over 4,050 trees/acre, approximately 60 percent of the trees had escaped weevil attack within the first 16 feet. However, very slow diameter growth was noted and intense competition soon eliminated a large percentage of trees in the lower crown classes which were most of the non-weeviled individuals. A pre-commercial thinning was conducted at age 19 in a portion of this stand with the object of releasing 150 undamaged crop trees/acre, mainly well formed codominants and intermediates. Good response in diameter growth and survival of the released trees was noted. Stiell noted that delaying of thinning until a commercial harvest could be made would likely diminish growth response because of smaller crowns and reduce the number of available crop trees due to tree mortality occurring because of suppression. He concluded that even a dense stand of white pine growing in a high hazard zone will retain only a negligible number of trees without weevil damage to the first log unless the stand is protected or release thinnings are started at an early age. Graham (1926) recommended 1200 to 1500 stems/acre after observing research plots in Minnesota and New York. He noted that attacked trees in high density stands also corrected themselves (did not tend to fork and maintained straight growth) better than trees in less well stocked plantations.

UNDERSTORY WHITE PINE

Growing white pine under shade greatly reduces the amount of weevil injury (Graham 1918). Shade is detrimental to all stages of weevil development. The first reason for this is that the microenvironment in shaded stands is cooler and therefore weevil development is slower than in trees growing in full sunlight. Sullivan (1960) suggested that lower temperatures and therefore slower feeding by the younger larval stages allow more opportunity for mortality by resin flow. Further, weevil adults that hibernate within shaded stands suffer higher mortality when overwintering (Wallace and Sullivan 1985). The second major reason is that shaded leaders are of insufficient diameter to support developing weevil larvae and therefore are not attractive to egg laying females. Weevil adults show a definite preference for thick leaders. This is the reason weevils concentrate attacks on larger trees in a stand, thus compounding the problem from a wood production standpoint since these large trees are often the fastest growing individuals. As noted earlier, leaders of 0.16 inches or less in diameter are rarely attacked by weevils, with attacks increasing on leaders up to 0.35 inches in diameter where 80 percent of leaders have been attacked. Such a large diameter class is rarely found in shaded stands (Sullivan 1961).

Growing white pine in shade requires a tradeoff since shade reduces overall growth and heavy shade can lead to tree mortality. In addition, overstory trees can create a physical barrier to understory white pine and subsequently damage leaders. The management goal should be to provide sufficient overstory to cool the microenvironment and prevent the leaders from developing diameters which make them suitable for weevil attack, yet allow in enough light for adequate growth.

Katovich and Morse (1992) evaluated a white pine release study initiated in 1973 on the Black River State Forest in central Wisconsin. The study compared growth response and number and frequency of weevil attacks of understory white pine under different canopy removal treatments. The treatments were girdling of overstory hardwoods, predominantly oak, to produce 0, 30, 50 and 70 ft^2 of basal area (BA) overstory and an ungirdled control of approximately 100-120 ft^2 BA. In 1973, replicated 5 to 5.25 acre blocks of each treatment were established in a 70 acre hardwood stand. The stand had a well stocked natural understory, approximately 750 white pine per acre, ranging from 5 to 10 feet in height. Ten permanent 1/50th acre plots were established in each block. Leader diameters and lengths were measured annually from 1974 to 1979. In 1990, the permanent plots were revisited, white pine tree diameter (dbh), tree height, and number and year of weevil attacks were recorded. Successful weevil attack kills the terminal shoot and causes a crook noticeable for many years.

For each treatment, Table 1 shows mean tree height and diameter, and the percent of trees that had at least one weevil attack between 1974 and 1990. In 1990, white pine in the 0 and 30 ft^2 BA treatment blocks were taller and were larger in dbh than the other treatments. However, there were significantly more trees attacked by weevils in the 0 and 30 ft^2 BA treatments. Further, those treatments with the highest percent weevil attacked trees also had trees which were more likely to have been attacked more than one time. For the 0 ft^2 BA treatment, 23 percent were attacked three or more times, 32 percent twice and 45 percent once. For the 30 ft^2 BA treatment, 12 percent were attacked three times, 39 percent twice and 49 percent once. For the 50 ft^2 BA treatment, 5 percent were attacked 3 times, 18 percent twice and 77 percent once. Trees in the other two treatments only had single attacks.

Table 1. Percent of trees with at least one weevil attack, mean tree height and mean tree diameter in 1990 on the Black River State Forest, Wisconsin. Treatments (TRT) were basal area/ac (BA) of overstory maintained. Check treatment had 100-120 ft^2 BA.

Treatment	Trees Attacked % ± SD[ab]	Tree Height ft ± SD[a]	Tree Diameter in. ± SD[a]
		N=40 Trees/TRT	N=40 Trees/TRT
0 ft^2 BA	68.7±5.1a	33.8±0.8a	7.0±0.3a
30 ft^2 BA	37.8±3.6b	35.3±0.6a	6.5±0.2a
50 ft^2 BA	15.4±3.8c	30.3±1.0b	4.7±0.2b
70 ft^2 BA	5.7±1.7cd	30.6±0.9b	4.1±0.2b
Check	4.2±2.7d	31.8±0.8b	4.0±0.2b

[a] Means within a column followed by the same letter are not significantly different (P = 0.05), LSD method.

[b] Percent data transformed using arcsine of the square root of percent before testing for significant differences.

In 1990, approximately 93, 165, 265, 205 and 215 unattacked trees/acre, excluding suppressed individuals, were present on the 0, 30, 50, 70 ft^2BAand check treatments, respectively. These values will undoubtably fluctuate on other sites due to differences in initial stocking. However, they do provide a useful comparison between treatments in this study.

In both the 0 and 30 ft^2 BA treatments, within 4 years of overstory removal or partial removal, mean leader diameter was sufficiently large to support weevil larvae. The 50 ft^2 BA treatment was intermediate in growth and number of trees attacked by weevils. In 1990, the 50 ft^2 BA treatment had the greatest number of unattacked dominant, codominant and intermediate white pine per acre. Therefore, maintaining 50 ft^2 BA overstory appeared to be an appropriate compromise to provide a maximum number of unattacked pine as potential crop trees. If more rapid growth is desired, then maintaining 30 ft^2 may be adequate, though it will probably result in a moderate number of weevil attacks. Since basal area is not an ideal measurement of shading, these results should be extrapolated with care to other stands outside the geographic area of this study or to other overstory forest types such as aspen. Ideally, a measurement of crown closure or light penetration would have helped to provide a consistent measurement for extrapolation of this study to other situations. Other studies have suggested that adequate growth rates together with acceptable levels of weevil damage would be achieved under shade conditions in the range of 50 to 75 percent of full sunlight (Stiell and Berry 1985).

To obtain adequate growth rates while maintaining low levels of weevil attacks and mechanical damage to understory white pine, girdling of overstory trees is a viable option. This study indicated that little if any resultant damage occurred to white pines from the dead overstory oak if the girdling was done when the white pine were 5 to 10 feet tall. The removal of overstory trees does not necessarily have to be accomplished by girdling. Any logging should produce minimal impacts, since a well stocked, undamaged understory will result in a higher number of potential crop trees and a more heavily shaded understory, likely resulting in a cooler soil microclimate less conducive to weevil survival. A second release may be required when white pine leaders begin to contact the remaining oak overstory, probably in 10-15 years. Removal of heavily weevil-attacked white pines, which will likely be the largest individuals, also should be done during this operation.

SIDE SHADING

Stiell and Berry (1985) reported on a experiment to limit weevil damage using strip-cuts aligned north-south. The experiment was carried out from 1964 to 1982 at the Petawawa National Forestry Institute, Canada. Strip widths (in relation to stand height) that would admit nominal values of 25, 50, 75, and 100 percent of daily full light were employed. It was concluded that clearcut strips in conifers and mixed conifer and hardwood stands, where the ratio of strip width to stand height is in the range of 0.66 to 1.00, admitting 50 to 75 percent of full light, allowed adequate numbers of white pine to reach a height of 16 feet free from weevil damage, though rate of height growth was diminished. This approach was <u>not</u> effective in hardwood stands. Stiell and Berry speculated that leafless hardwoods do not provide the necessary side shade when adult weevils are active in early spring. They also speculated that strips aligned to minimize exposure to direct sunlight (i.e. east-west), should be more effective than the north-south strips.

DIRECT CONTROL

In forest plantations, very little insecticidal control for white pine weevil is currently being attempted. The economic return involved with spraying and possible effects of insecticides on the overall ecosystem are two major concerns. Fortunately, the weevil's behavior of congregating and feeding on terminals in the spring provides an opportunity to direct sprays to those locations, thus greatly reducing the likelihood of off-site contamination. Diflubenzuron (Dimilin[R])[2] has proven quite effective against white pine weevil in early spring application to terminals and the upper whorl of branches (Dimond and Bradbury 1992). Dimilin is an insect growth regulator that once consumed by weevils affects the ability of adult females to produce viable eggs. As noted earlier, spring emerging females initially feed on terminals prior to egg laying. If they consume Dimilin during this period, egg laying will not be successful. This requires that Dimilin application to terminals be completed prior to any adult feeding in the very early spring. Dimond and Bradbury (1992) recommend spraying by mid-April in Maine and they note that application when some snow cover still exists may be necessary. Fall applications of Dimilin have not been as successful as spring applications. Ground applied applications have proven much more successful than aerial applications. More than one year of application may be necessary to reduce damage to near zero. Thereafter, applications can be eliminated until weevil populations rebound again in the plantation (Dimond and Bradbury 1992). Asana, permethrin, fluvalinate, methoxychlor, and oxydemeton-methyl were found efficacious for control of white pine weevil when applied in early spring with ground sprayers (Bradbury 1986). However, registration of these products for use in forest plantations may not exist in many states and therefore they would not be available for use.

Hand clipping and destruction of infested leaders has been suggested as a control practice. This procedure is probably only practical on small plantations. To be most successful, infested leaders should be removed

[2]Mention of trade names does not constitute endorsement of the product(s) by the USDA. Some states have restrictions on the use of certain pesticides. Check your state and local regulations and confirm product registration for its intended use.

during the last two weeks of July, after infested leaders become obvious but before adults begin to emerge. All but one vigorous lateral branch in the next whorl should be clipped out as well. Clipping also improves quality since it removes the dead leader which serves as an entrance point for decay fungi.

As mentioned earlier, the aggregation pheromone of the white pine weevil has been identified. This pheromone provides the opportunity for specifically attracting white pine weevils. Unfortunately, little work has been conducted utilizing pheromones for control of white pine weevil.

WHITE PINE - GYPSY MOTH INTERACTIONS

Gypsy moth is a polyphagous defoliator that feeds on a wide variety of trees and shrubs. However, definite preference exists for certain tree species, notably oaks and aspen. Most pines, including white pine, are considered an intermediate host (Mosher 1915). Young larvae will not eat white pine needles though older larvae will. Since young larvae will not feed on white pine foliage, relatively pure pine stands are considered quite resistant to defoliation by gypsy moth. However, white pine growing in mixture with or adjacent to susceptible hardwoods may be defoliated by older gypsy moth caterpillars once the more favorable foods are exhausted. This is very possible during years of large outbreaks. Further, heavy defoliation and subsequent tree mortality is much more likely to occur to white pines in an intermediate or suppressed crown class than to white pines with codominant or dominant status in a hardwood/pine stand (Gottschalk and Twery 1989). The problem is the amount of foliage in understory pines versus overstory oaks. When an oak overstory is stripped by gypsy moth there are so many larvae for the small amount of pine foliage that the pine are completely defoliated. Many New England stands of white pine being grown under oak canopies to avoid weevil were lost to gypsy moth in the early 1980's (Pers. Comm., M. Twery, USDA-FS, Morgantown WV). In Rhode Island, white pine basal area losses were greatest (33.7 percent) in oak stands where white pine occurs as an understory, versus basal area losses of 12.7 percent in stands where white pine shared the canopy with oaks (Brown et al. 1988). In Connecticut, following a gypsy moth outbreak, no dominant or codominant white pine died; 26 percent of subcanopy trees died (Stephens 1988). Stephens reported that initial mortality appeared quite low, 7 percent, one year following the defoliation event, but increased to 26 percent three years later.

Gypsy moth larvae prefer to feed on the older needles of white pine though new needles are consumed once older needles are eaten. Because of this feeding pattern, most of the current year needles are not fed upon unless very high gypsy moth populations are present (Gottschalk and Twery 1989). Further, white pine has not completed needle expansion when gypsy moth pupates, so even if fed upon, current year needles expand to provide some needle surface area by late summer. Only when defoliation of <u>new</u> foliage has been greater than 80 percent has white pine mortality been significant (Stephens 1988). Stephens reported that no white pine defoliated less than 60 percent died. No one has reported consecutive years of heavy defoliation occurring to white pines from gypsy moth.

WHITE PINE MANAGEMENT RECOMMENDATIONS

Growing white pine with minimal weevil damage, in a reasonable time period, will require a commitment to intensive management. Open-grown plantations will need to be established at higher densities than is currently being practiced. Precommercial thinnings may be required to release non-weeviled codominant and intermediate individuals in these stands before they become suppressed. White pine growing under an overstory requires release in order to maintain an acceptable growth rate, however release must not be too great or an unacceptable amount of weevil infestation is likely to occur. As with open-grown white pine, high densities of white pine in the understory will be important in providing an acceptable number of non-weeviled crop trees. Direct control utilizing insecticides is currently not being used to any degree. However, insecticides are available which control weevil damage. Application of insecticides may only be practical on a small scale since directed ground applications to the terminal have been most successful.

The occurrence of large gypsy moth outbreaks could effect our ability to grow small white pine under an oak or aspen overstory. The likelihood that a defoliated white pine would subsequently die depends on crown class, severity of defoliation, and time since defoliation (Stephens 1988). Small trees, especially suppressed and intermediate crown class individuals growing under oak or aspen overstories are at risk of dying following a single severe gypsy moth defoliation. A great deal of understory white pine currently exists under oak and aspen overstories, especially in Michigan, Minnesota and Wisconsin. Much of this resource is, or will likely become infested with gypsy moth over the next 5 to 25 years. Partial release of existing understory white pine would allow more of them to move into codominant and dominant forest status. This release would generate white pine less likely to be damaged by gypsy moth, create more gypsy moth resistant forests by increasing the white pine component, and if properly done, create many high quality white pine by maintaining white pine weevil control. Management practices that encourage the growth of white pines to canopy positions where trees are less vulnerable to gypsy moth should be a high priority, but maintenance of overstory shade remains essential to reduce weevil damage. Here is a summary of guidelines for minimizing damage by the white pine weevil and gypsy moth:

ESTABLISHING WHITE PINE PLANTATIONS

1) Plant at high densities, 1000-1500 trees/acre.
2) If insecticidal control is an option, begin a program when weevil damage is first noticed in the stand.
3) Remove and destroy infested leaders in mid-July, begin this program as soon as weevil damage is first noticed in the stand.

ESTABLISHED WHITE PINE PLANTATIONS

1) Consider precommercial thinning of stands at age 18-25, remove heavily attacked dominant and codominant trees. This should prevent well formed intermediate trees from becoming suppressed.
2) Discourage row thinning plantations. The total number of well formed, unattacked trees may be limited.
3) Consider directed insecticide application to terminals in the early spring, especially on the larger dominant and codominant trees in the plantation.

ESTABLISHED UNDERSTORY WHITE PINE STANDS

1) Release understory white pine by partially removing the overstory, attempt to create a shading situation which allows 50-75 percent of full sunlight into the stand.
2) Stands which are good candidates for partial release should have a well stocked understory of white pine, 5-10 feet tall. Release can be accomplished by girdling or removal of overstory trees.
3) If logging to remove the overstory trees, be careful to maintain a high density of understory white pine, at least until the pine reach 16-24 feet in height.
4) Maintain overstory shade for as long as possible, complete release of understory white pine should not be done until the majority of potential crop trees are 20-24 feet in height.
5) If white pine are under an oak or aspen overstory and heavy gypsy moth populations are predicted, consider applying an insecticide to the overstory to reduce gypsy moth caterpillar levels, especially if the white pine are less than 16 feet tall.

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BROWSING DAMAGE TO WHITE PINE

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ABSTRACT. Although not a preferred food of most mammals, white pine is occasionally browsed by ruminants such as white-tailed deer and moose and porcupines. Browsing does not usually kill the tree or seedling, but does affect subsequent shoot growth and form. Control measures against browsing are discussed.

INTRODUCTION

Most conifers are not preferred browse of mammals because the leaf, stem, and bark tissues are difficult to digest (Bryant and Kuropat 1980, Bryant et al. 1991). Because conifers retain needles for several years, they must protect them against physical damage such as wind, ice, or water loss or biological damage by browsing mammals. Consequently, conifer needles have high concentrations of resins and lignin, which shields needles against water loss or physical damage, but which also have the additional effect of making needles difficult to digest. Furthermore, conifer needles often have high concentrations of secondary compounds, such as monoterpenes and pinosylvan, whose sole function seems to be to deter browsing by making the tissues unpalatable or even toxic (Bryant et al. 1991).

Despite these defenses, conifers are still sometimes browsed, usually when supplies of other more preferred foods, such as hardwoods, are exhausted (Krefting 1974, McInnes et al. 1992). Furthermore, conifers are often browsed in winter when metabolism and therefore nutritional requirements of mammalian herbivores are low and when available hardwood browse, especially in northern regions, is in the form of twigs which may have lower nutrient contents than conifer needles. Cedarlund and Nystrom (1981) report that winter rumen inocula of moose can digest 46 percent of dry matter of Scots pine needles but only 8-36 percent of various deciduous twigs also collected in winter. Therefore, some conifers may be more nutritionally beneficial in winter compared with deciduous twigs.

Of the conifers, white cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), and white pine (*Pinus strobus*) are usually taken in preference to other conifers such as various spruces (*Picea* sp.) and jack pine (*Pinus banksiana*). However, there are large differences between herbivores in conifer preference. For example, moose will browse balsam fir heavily (Bergerud and Manual 1968) but deer prefer cedar and hemlock (*Tsuga canadensis*; Anderson and Loucks 1979).

White pine is browsed by a greater variety of mammals than most other conifers. White-tailed deer (*Odocoileus virginianus*), moose (*Alces alces*), and porcupine (*Erethizon dorsatum*) all browse on white pine as well as related pines such as ponderosa pine (*P. ponderosa*), loblolly pine (*P. taeda*), and Scots pine (*P. sylvestris*). Seedlings and saplings are browsed by moose and deer, while porcupines prefer to browse bark in the tops of mature trees.

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This paper will review patterns of browsing by mammals on white pine and other pines, responses of the trees to browsing, and conclude with a brief review of some control measures.

BROWSING ON SEEDLINGS AND SAPLINGS BY MOOSE AND DEER

Generally, moose and deer browse the current annual twigs and needles of the terminal leader (Hay and Rennie 1989) and avoid lateral shoots, although lateral shoots of other pines such as Scots pine (Danell et al. 1991) and Austrian pine (*P. nigra*; Hammer 1989) may be browsed. Deer and moose browsing can be distinguished from hare browsing, which is much less common, by the ragged tip of the browsed shoot in contrast to the clean cut made at a 45 degree angle by hare. When the terminal shoot is browsed during the dormant season, the remainder between the browsed tip and the next lower whorl of branches dies; one or more of the lateral branches from the next lower whorl then assumes a terminal position. If the terminal shoot is browsed during the growing season, one or more adventitious buds form new shoots which then assume terminal positions (Hay and Rennie 1989). In any case, the net result is a fork or crook in the main shoot. Eventually if one shoot gains dominance, it may be impossible to determine if the mature tree was browsed by inspection, but the wood will retain deformed annual rings dominated by compression cells, causing the lumber to break when dried (Hay and Rennie 1989). There are frequent references to the economic impact that severe moose browse causes in Swedish Scots pine stands (Lavsund 1987), but details are often lacking. Therefore, although the tree is not killed and ecological damage may be slight, the commercial value of such a seedling or tree is very low. Height growth and diameter growth are also reduced until the tree recovers a terminal shoot.

The conditions under which moose and deer select pines for forage are unclear. Deer and moose usually browse on pines in lower proportions than the availability of pines across the landscape, unless the pines are heavily concentrated in plantations, populations of moose or deer are high, and supplies of other foods are exhausted. Browsing can sometimes lead to the elimination of a species from particular stands (Alverson et al. 1988), particularly when populations of the animals are high and target plants are uncommon. On Isle Royale, where moose densities range from 1.5 to 3 per km^2, white pine is a relatively uncommon species. However, P. Jordan (personal communication) estimates that moose are continuously keeping 50-80 percent of white pine saplings from exceeding heights of 1-3m, thereby preventing those trees from developing into mature, reproducing individuals. When moose densities decline to the lower value, a certain proportion of the suppressed trees escape. The net effect appears to be the emergence of a future white pine population lower than that present prior to the arrival of moose to the island around the turn of the century. For reasons as yet unknown, moose and deer seem to browse more heavily on pines in plantations than in natural stands (Peek et al. 1976, Furrh and Ezell 1983). Browsing by deer at Itasca State Park in Minnesota curtails recruitment of both white pine and red pine into the overstory in both plantations and natural stands (Ross et al. 1970). Browsing in plantations is heaviest along the perimeter adjacent to cover and along travel corridors through plantations (Hay and Rennie 1989).

As with most conifers, browsing by deer on white pine is most common in late winter, presumably when supplies of more preferred foods have been exhausted (Rogers et al. 1981). Usually, the diets of deer in healthy condition contain only 2-4 percent white pine if other foods are available, but deer in poorer condition may have as much as 50 percent of the diet dominated by white pine (Rogers et al. 1981). Indeed, the high proportion of white pine in the diet when little else is available may contribute to poor condition. Nonetheless, moose can subsist indefinitely on a diet dominated by Scots pine, and so the question of the nutritional quality of pines relative to the animal's condition remains an open question.

The chemical quality of the plant tissues partly determines the intensity and location of browsing. Browsing on seedlings less than three years old is slight, but more intense on older seedlings (Hay and Rennie 1989), indicating ontological changes in palatability. Provenance studies show that northern strains of Scots pine are less susceptible to browsing by moose than southern strains (Niemala et al. 1989) because of greater dry matter (i.e., lignin and cellulose) contents. Among individual pines, those with higher nitrogen (i.e., protein) content, either because of fertilization of because of more productive soils, are more heavily browsed than unfertilized or unproductive pines (Bergstrom and Hjeljord 1987, Danell et al. 1991); however, pines in more productive sites were able to sustain damage more easily than pines in unproductive sites (Danell et al. 1991). Monoterpenes do not appear to deter moose from browsing on Scots pine (Loyttyniemi and Hiltunen 1978).

BROWSING BY PORCUPINES ON MATURE PINES

Porcupines feed on the bark of boles and branches and needles high in the crowns of many pines, including white pines. Girdling of the bole and branches, branch pruning, crown deformation, and sometimes death of the tree result.

Some studies show that in eastern North America, hemlock (*Tsuga canadensis*) and sugar maple (*Acer saccharum*) are more preferred as winter food by porcupines than white pine (Curtis and Kozicky 1944, Reeks 1942). White pine is often a codominant in these communities and may be fed upon secondarily. However, Schmidt (1990) found that porcupines browsed mature white pine in a hemlock-northern hardwood stand out of proportion to its abundance, so selection specifically for white pine does sometimes occur. Selection for white pine may be greater in the western portion of the range compared with that in New England (Tenneson and Oring 1985, Schmidt 1990), although this is not known conclusively. Harder (1979, 1980) suggests that porcupines select particular communities in which to reside rather than specific plants for forage; an important aspect of community structure is the presence of large trees with broad crowns for roosting and denning. However, Smith (1982) found that both community structure and the availability of preferred plant species determined porcupine foraging areas in Oregon. White pine fills these criteria by providing both physical habitat (roost and den structures) and preferred food. In fact, Tenneson and Oring (1985) and Schmidt (1990) both found that the areas of greatest activity of porcupine in two Minnesota forests were centered around large white pines, and Schmidt (1990) found that six of nine known roost trees in her stand were large white pines.

Whether porcupines feed on white pine because they also happen to prefer them for roost and den trees is not clear. However, in Schmidt's (1990) study in Minnesota, the proportion of trunk and limbs that had bark removed on white pine exceeded that of hemlock in the same stand. Although only an average of 2 percent of a white pine's bark was removed, this was concentrated at the apex of the crown, often girdling the stem. Approximately 6-7 limbs per tree had bark removed, more than either sugar maple or hemlock. Furthermore, in Schmidt's study, porcupines fed on white pine bark continuously during the winter, continuing to do so even after initiation of feeding on hemlock in early April. Schmidt as well as others (Curtis 1941, Brander and Stearns 1963, Smith 1982) found that porcupines repeatedly browse the same trees. These patterns suggest that porcupines feed preferentially on white pine rather than casually when roosting in them.

Although porcupine "damage" to large white pine has been decried as a significant economic loss (Stoeckeler 1950), it should be noted that the loss is very small compared with loss by fire, insects, or disease (Curtis and Kozicky 1944). Furthermore, the bulk of the more valuable timber lower in the bole is unaffected. Porcupine damage to mature white pine is an economic loss only if the trees die before they can be harvested or if salvage operations cannot be accomplished within a few years after tree death. Porcupine browsing is therefore of lesser economic importance than deer browsing because most of the value of the tree is obtained by the time porcupines feed, whereas the value of a tree is decreased for the rest of its life when browsed by deer within the first several years.

CONTROL MEASURES

Control of browsing damage can be divided into two general techniques, control of the target animal through hunting or trapping and protection of the trees themselves. Trees can be protected by physical barriers, chemical repellents, selection and pretreatment of planting stock, and habitat modification through silvicultural practices.

CONTROL THROUGH HUNTING AND TRAPPING

Trapping is virtually the only practical way to control porcupine damage to large white pine, as the trees themselves are too large to protect by other measures. In some respects, the reduction in predators of the porcupine, such as fisher, has led to the large increases in porcupine populations during the past several decades. Thus, trapping might in some ways compensate for the loss of natural predators. However, trapping may not be very effective if surplus populations of porcupine simply supply animals to replace those removed.

Although several states in the lower 48 have moose hunting seasons, most notably Maine and Minnesota, these have not been instituted as a browsing control measure because moose populations are rarely high enough to cause widespread damage, although locally damage may be significant.

Deer populations are another matter. Currently in the Lake States, deer populations are at an historic high because of land clearing by farming and logging that creates suitable edge habitat and provides food, because of the success of management programs that helped the deer population expand, and because of political pressure from hunting organizations to limit the harvest to bucks, leaving does to reproduce. For example, in Wisconsin the current population is estimated at 1.35 million animals (Wisconsin DNR quoted in Wisconsin State Journal, November 17, 1991). The large food requirements of such a large herd have substantially changed the species composition of many Wisconsin forests (Alverson et al. 1988). Despite the continuous recommendations of state wildlife biologists to reduce the deer herd through extended seasons and doe harvests, political pressure from hunting organizations has prevented the implementation of such rules. Apparently, the general public does not understand that deer eat an enormous amount of food, and consequently it is impossible to have high deer populations and populations of preferred plant species at the same time. Unfortunately, this leads to a situation where public agencies must spend much money compensating farmers and plantation owners for damage and eventually must feed winter herds to avoid starvation. It has also caused many farmers and plantation owners to assume protection of plants as part of operating costs. Again unfortunately, these are not always trivial costs and there is currently great interest in the development of safe, cheap, and effective ways to protect seedlings.

CONTROL THROUGH PROTECTION OF SEEDLINGS

Various control measures are reviewed by DeYoe et al. (1985) and Craven and Hygnstrom (no date). These fall into two categories: physical protection and chemical repellents.

Physical protection includes devices such as paper or screen bud caps, screen tubes placed around whole seedlings, and fencing. Of the three, fencing is most expensive and should be considered only if the crop is extremely valuable, deer pressure is high, and the size of the field is 40 acres or less. Ten wire fence is more effective than five wire, but also more expensive by approximately 20 percent. Contrary to popular opinion deer usually breach fences by breaks or crawling under them, not jumping over them. Maintenance, especially of the lower strands, is therefore required.

Individual protection of seedlings through paper or mesh barriers are less expensive, but often break down after several years. Furthermore, individual seedlings protected with mesh or paper barriers may suffer heat or water stress on dry, hot sites because the barrier may prevent cooling by wind. However, when installed properly, all physical barriers protect against deer browsing.

Chemical repellents include odor repellents and taste repellents. The former include putrefied egg solids (trade names Big Game Repellent and Deer-Away), putrefied meat scraps (trade name Tankage) bone tar oil (trade name Magic Circle), mothballs, and human hair bags. The latter two are not effective. The putrefied egg solid preparations are most effective. Big Game repellent is already mixed in liquid form and has a short shelf life; it should be applied to dry plants only. In contrast, Deer-Away is a dry powder that should be applied to wet plants and is more useful in areas with frequent rains. However, both products are water miscible and may have to be applied more than once, increasing costs.

Taste repellents work by imparting a bitter or stinging taste to the plant tissues. These include tetramethylthurium disulfide (trade name Thiram), capsaicin (trade name Miller's Hot Sauce Animal Repellent), and Ro-Pel (trade name, a mixture of various aromatic and ammonium hydrocarbons). These generally are more successful than odor repellents, but must be applied with a carrier that prevents rain from washing them off leaves. They are somewhat toxic and are generally not recommended for use in fruit trees.

Care should be taken not to overapply any chemical repellent. Seedlings that are already stressed through drought or transplanting shock may suffer increased stress when treated.

Research continues on developing a chemical repellent that is environmentally safe, need be applied only once per year, and effective.

PRETREATMENT OF PLANTING STOCK

Although little explored, genetic selection of planting stock for high concentrations of natural secondary compounds may be as effective as application of chemical repellents that mimic these compounds (Niemela et al. 1989). Furthermore, pre-treatment of planting stock in greenhouses may also hold some promise. For example, seedlings of loblolly pine grown under natural photoperiod for one year in a greenhouse before outplanting suffered much more deer browsing than seedlings grown under 24-hour sunlight (Hay and Rennie 1989). Apparently, genetic selection and altering growth conditions in the greenhouse may increase natural production of chemical defenses, but no full scale field trials have been conducted as of yet.

SILVICULTURAL PRACTICES

It is theoretically possible to modify the habitat to direct deer away from seedlings requiring protection, but the effectiveness in any one year or locality depends on condition of the deer herd, weather, and other factors. Habitat modifications include planting more preferred forage with the seedlings, improving forage away from the plantation to attract deer elsewhere, piling slash to inhibit movement of deer through plantations, and complete elimination of all other forage, and increasing size of clearcuts. However, the manager should bear in mind that deer require a diverse diet and may actually prefer some plants when they can be mixed in the diet with others; the exact proportions of foods required or preferred are as yet unknown and probably vary from region to region. In general, silvicultural practices should be implemented for their own value to enhance growth, etc, and if possible consideration should be given to spacing and timing of cuts to modify deer behavior. Many silvicultural practices that reduce quality of habitat for deer, such as large clearcuts followed by burning slash and treating with herbicides, have other consequences that may be environmentally unacceptable. In fact, most cutting increases edge length and juxtaposes cover with openings, so silvicultural practices as now accepted actually increase the quality of deer habitat.

CONCLUSIONS

Animals must eat, but what decisions an animal makes when choosing what or where to eat remain unclear. The preference of animals for white pine varies with the animals, condition of its population, habitat, and availabilities of other foods. Browsing on white pine can seriously alter its condition. While death may not always ensue, the quality of wood for lumber may be decreased. When trying to control browsing damage, foresters should bear in mind that they are trying to control the behaviors of free-ranging animals, a complex problem. Therefore the effectiveness of any control measure should be evaluated in light of how much browsing is reduced rather than whether it completely eliminated browsing.

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GENETIC TREE IMPROVEMENT OF EASTERN WHITE PINE

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ABSTRACT. The paper is a literature review of research since Wright's 1970 review in the Genetics of Eastern White Pine. It also gives an overview of current programs as well as a look to the future of white pine breeding for growth and blister rust resistance. Tree improvement programs in eastern white pine are expanding and are expected to continue to expand.

INTRODUCTION

Eastern White Pine (*Pinus strobus* L.) is one of the most valuable timber trees of the forest of the eastern United States. It is also valued for its aesthetic qualities and its usefulness as food and shelter for a variety of wildlife species. It grows on a wide variety of sites and has a very large natural range. These characteristics make it a likely candidate for tree improvement.

GROWTH

PROVENANCE TESTS

Provenance tests have provided the bulk of the genetic information on eastern white pine. The USDA Forest Service originated a large range-wide provenance study in the late 1950's. Results of these studies indicate that southern Appalachian sources should be used for planting as far north as central Pennsylvania (Garrett et al. 1973, Demeritt and Kettlewood 1975); needle lengths are greatest from southern sources (Garrett et al. 1973, Demeritt and Kettlewood 1975); above 45° north latitude, the southern sources lose their superiority. It should be noted that the difference between the southern sources and northern sources diminished between ages ten and sixteen (Demeritt and Kettlewood 1975).

Some of the same material was planted in three southern locations; Georgia, North Carolina and Virginia. As expected, the southern sources were superior for the first three years and sources from Minnesota, Ontario, and Maine were the poorest performers (Sluder 1963). Twelve sources from the same test were planted at two locations in southern Ontario. Provenances from maritime climates were faster growing with fewer forks, wider branch angles, and finer branch diameters (Abubaker and Zuffa 1990). These two plantings were heavily damaged by white pine weevils (*Pissodes strobi* Peck) that masked some of the differences in height.

Another set of provenance tests was assembled, grown in the nursery, and outplanted at three locations in Maryland as well as other locations in the United States and abroad. The most outstanding growth in Maryland was from some sources from Tennessee, Kentucky, and North Carolina (Genys 1987). In a broader conclusion, Genys (1990) states, "that eastern white pine is a very variable species. Some sources have superior characteristics for production of wood and fiber. Also, some sources may be more resistant to various destructive agents such as ozone, sulfur dioxide, white pine weevil, etc."

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Yet another large set of provenances was assembled by the USDA Forest Service and distributed in 1981. This was material from clones in various tree improvement projects. Outplanting was at six sites in the northeast. Southern sources were absent from this population. Early results show that a few seedlots performed well at all locations and, in general, Lake States, Ontario, and Quebec seedlots grew relatively slowly (Kuser et al. 1987). The poor performance of the Lake States and Canadian seed lots may be an adaptation to a more continental and drier climate. Another study of the same material shows that date of fall yellowing of old needles and variationin in second-winter needle retention are correlated with latitude of origin of the female parent (Kuser et al. 1989).

A small provenance test in West Virginia included only seed sources from West Virginia and southward. Again, the southern sources were the fastest growers (Olson et al. 1981). They found a positive correlation between height and diameter, but a negative correlation between extracted specific gravity and both height and diameter. Another small study with mostly southern sources was established in Wisconsin in 1986. Three northern locations showed local sources had superior growth while the three southern plantations had the southern sources with the best growth (Edge et al. 1991). This corresponds well with the 45° north latitude limit for southern sources described by Garrett (1973).

GENETIC STUDIES

Much of the early work in white pine genetics was concerned with the crossability within and between species. Critchfield (1986) provides a good review of many of these studies. The most complete work on eastern white pine genetics is assembled in Wright (1970). Much of the work reported in this paper is later data taken from the tests described by Wright. Little has been done to elucidate the genetic variability of the species. Within stand variation is limited to very few studies. Enzymes were used to show variation within the stand in a three hectare natural white pine stand (Brym and Eckert 1987). Dr. P.R. Gast of Harvard University was responsible for the establishment of the earliest test of eastern white pine. Remarkably, these studies had a within stand component. They produced evidence of genetic diversity in growth rate among individual white pine mother trees and suggested that breeding of these trees would yield progenies of increased vigor (Pauley et al. 1955).

Heritability estimates were derived from an open pollinated progeny test of eighteen clones in New Hampshire. Heritabilities of three-year height and survival in a nursery setting were in the .5 range for both characteristics (Adams and Joly 1977). Early heights were strongly correlated with seed weight in one year, but were negligible in the other seed year. They also concluded that selection for height growth on a family basis appears to be better than individual tree selection in the nursery as long as costs associated with family selection and loss of selection differential are small.

Olson et al. (1981) estimated heritabilities for extracted specific gravity. The narrow-sense heritability was .11. This low heritability, combined with the negative correlation with height and diameter, indicates that it would be best to select for the best growth and ignore the specific gravity in all but the most intense programs.

BLISTER RUST RESISTANCE

Genetic resistance to white pine blister rust (*Cronartium ribicola* Fisch.) is common in western white pine (*Pinus monticola* Dougl.) and sugar pine (*Pinus lambertiana* Dougl.). Both single gene and polygenic resistance mechanisms have been noted (Kinloch and Dulitz 1990). *P. strobus* x *P. Peuce* (Macedonian pine) hybrids were tested for growth and rust resistance (Blada 1987). Five years of results showed that there were differences both among parents and hybrids for resistance and growth; the hybrid's performance was intermediate between the two parents. General combining ability was much greater than specific combining ability, which suggests additive genetic variance in the parents for rust resistance. Rust resistance and growth narrow-sense heritabilities were .52 and .41 respectively, a 26 percent increase in rust resistance could be expected if the best three of 21 families were selected. There are also highly significant differences among clones of *Pinus cembra* (Swiss stone pine) for blister rust resistance (Blada 1990). There is evidence of an indirect selection mechanism for resistance to fusiform rust (*Cronartium fusiforme* Hedge & Hunt) in slash pine (*Pinus elliottii* Engelm.) using monoterpenes (Michelozzi 1990). There is no evidence of this in eastern white pine at present.

Garrett (1985) reviewed pest resistance in eastern white pine. His review indicates that white pine blister rust resistance is under polygenic control in eastern white pine, provenance resistance does not exist, and few trees in the wild contain some level of resistance. He does regard breeding for rust resistance as a worthwhile effort.

WEEVIL RESISTANCE

Little work has been done on the genetics of white pine weevil resistance. Studies of indirect selection techniques have been unsuccessful. Rate of resin crystallization, resin viscosity, and terminal bark thickness have not proven effective (Wilkinson 1979, Wilkinson 1983, Zsuffa 1981). Significant differences in the number of weevil attacks among provenances in different provenance tests show some level of provenance resistance (Wilkinson 1983, Abubaker and Zuffa 1990). The variance component due to provenances was 11.5 percent of the total variance in one of the tests (Abubaker and Zuffa 1990).

PRESENT PROGRAMS

Present programs are very limited. Region 9 of the USDA Forest Service is working on genetic resistance to white pine blister rust. This program combines "laboratory/greenhouse" techniques with field testing. A level of genetic resistance has been found, but is difficult to quantify at this point. Selections are being made for rust resistance and growth. Development of a rapid screening technique continues.

Lakehead University in Thunder Bay, Ontario is embarking on a white pine improvement program. This is a new program under the direction of Dr. W. Carmean. Dr. George Buchart of the Ontario Ministry of Natural Resources is also interested in blister rust resistance.

The Minnesota Tree Improvement Cooperative is in the selection phase of a new program. Some of the material used in their program will be material shared from Region 9 of the Forest Service.

A cooperative agreement between USDA Forest Service's North Central Forest Experiment Station and Region 9 was signed in 1989. This combines the material from Region 9 with the technical expertise of two projects dealing with blister rust. The projects are headed by Dr. Darroll Skilling and Dr. Bruce Haissig.

FUTURE PROGRAMS

The future of eastern white pine is as bright as it has been in recent years. The above mentioned cooperative agreement should serve to hasten the development of blister rust resistant planting stock. Silvicultural techniques have been established to minimize the loss from the white pine weevil. Support for the tree for aesthetics and wildlife values above and beyond its inherent high value for timber have raised interest in the tree.

Research in other countries such as that of Dr. Blada in Romania and the new interest in Canada can only help the programs in the United States. States as well as forest industry are showing increased interest in planting and nurturing the species. The future for eastern pine will get even better as new knowledge develops from the new programs.

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MANAGING WHITE PINE: FINDING THE PROPER NICHE

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ABSTRACT. White pine occurs on the widest range of sites and was historically a component of most forest cover types within its botanical range. Across this range it plays different ecological roles. It differs in establishment requirements, competitive ability, productivity, and successional status. With emphasis on the Lake States Region, this paper provides means for ecological grouping of diverse sites and describes white pine management implications for each site category.

INTRODUCTION

Before we attempt to address the question of "proper niche" for white pine we must first take a glance at the record of historic occurrence of white pine. As a species it occurred (and still does) from Maine to Minnesota and south along the Appalachian mountains. Within this range it grows on nearly every type of soil. Because of its exceptionally wide ecological amplitude, it can be found in association with almost every species occurring within its geographic range. Wendel and Smith (1990) acknowledge the role of white pine in no fewer than 28 SAF forest cover types. As can be expected, its role in community dynamics varies greatly along the gradient of site conditions and from region to region. This is readily apparent if one reads the section on white pine in the Silvics of North America (Wendel and Smith 1990). While there is much useful information for management of white pine in this publication, one must still find a way to identify those aspects that apply to a particular geographic region. In order to do so my discussion is limited to the Lake States region and particularly to Wisconsin and Upper Michigan.

Because of the well-known historic role of white pine in the hey days of the early logging era, it is often assumed that white pine forests covered the entire Lake States region. Although forest ecologists and historians have been trying to dispel this myth (Bourdo 1983), old beliefs still too often show up in popular literature. While there were well-known areas or either pure white pine of white pine-red pine mixtures (the pineries) in every Lake State, most of the white pine occurred as small groups or scattered individuals in mixtures with other species including the northern hardwoods.

Because white pine grows on such a wide range of soils (hundreds of soil series and thousands of soil mapping units in Wisconsin alone) it is essential to find a way of grouping soils into a manageable number of ecologically significant categories. What is most important in terms of white pine's success on a given soil is the relative competitive intensity of associated species.

ECOLOGICAL ROLE OF WHITE PINE ALONG AN ENVIRONMENTAL GRADIENT

A useful framework for evaluating interspecific relationships is the arrangement of sites (landform-soil combinations) and occurrence of various species on a moisture-nutrient gradient (Fig. 1). The model in Figure 1 shows that the most aggressive competitors (tolerant hardwoods plus hemlock) occur primarily on mesic medium to rich sites. It is well known that regenerating and maintaining white pine on such sites is difficult, but is much easier on the dry-mesic and dry segments of the gradient.

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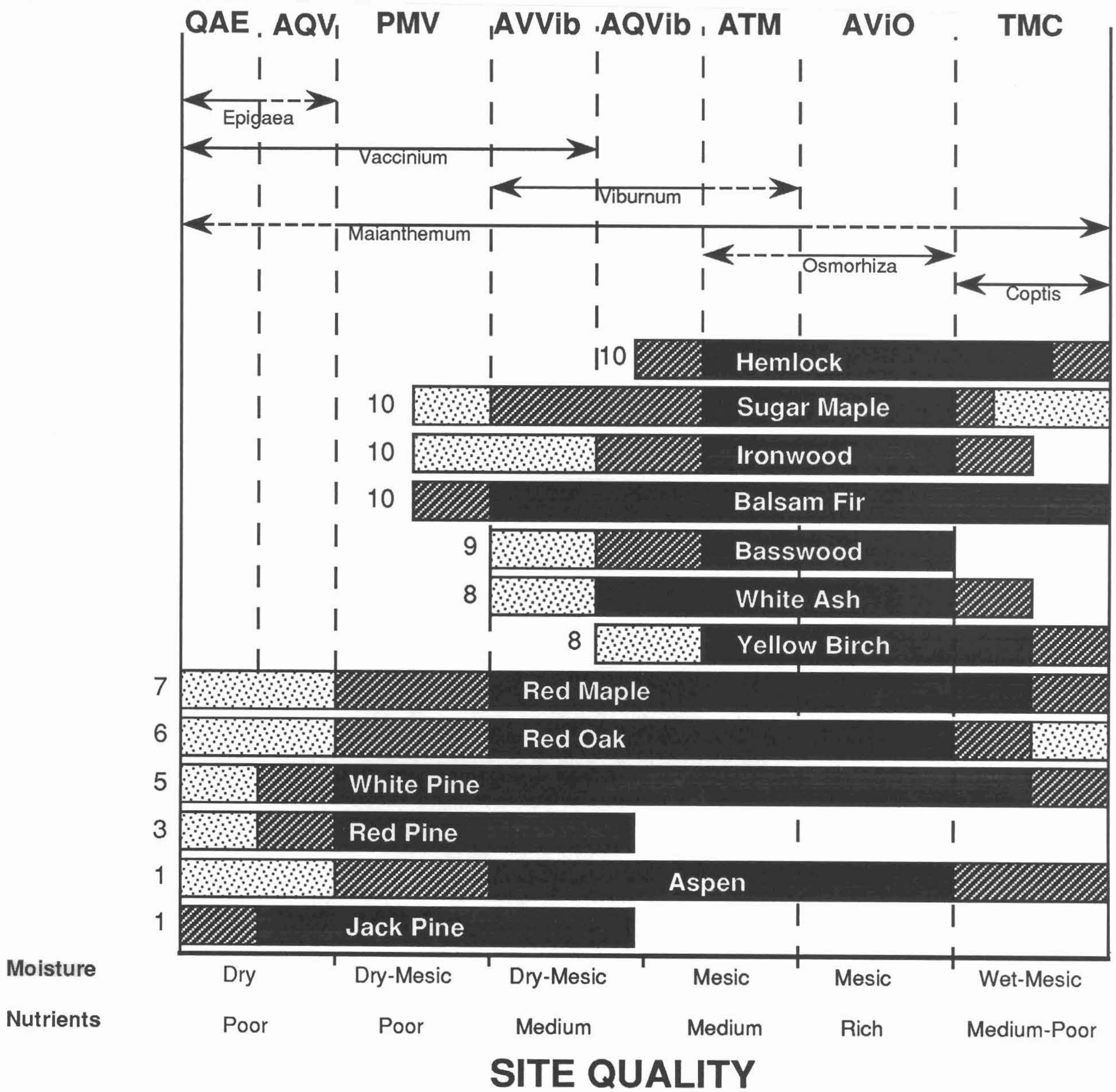

Figure 1. Site relationships of major Lake States tree species. At the top are abbreviations for names of plant associations that characterize segments of site quality gradient (i.e. habitat types). Discussion in this paper is limited to general ecological characteristics of site quality segments. For detailed treatment of individual habitat types refer to Kotar et al. 1988. Horizontal bars indicate relative growth potential as follows: dark segment - high; lighter segment - moderate; dotted segment - poor. Numbers on the left of the bar represent relative understory tolerance: 1 least; 10 most tolerant.

Because of great complexity of soils, particularly in the glaciated region of the white pine range, it often is difficult to determine whether a site is dry, dry-mesic, or mesic. There is no reliable or easy-to-use field method to interpret the cumulative effects of properties of various soil strata on any given site. In other words, there is no direct way of categorizing landscapes into segments of environmental gradient in order to apply the model depicted in Figure 1. A more effective, indirect way is by interpreting the composition of natural vegetation occupying a site. Various methods of using vegetation as indicators of site capability have been developed in different parts of the world including the United States and Canada (Pfister and Arno 1980, Corns 1986, Sims et al. 1989).

In Wisconsin and Michigan the "habitat type" system of classification (Kotar et al. 1988, Coffman et al. 1983) is being used widely for assessing management options for various forest cover type - landform/soil combinations. Although the habitat type system provides identification keys and specific names for abstract plant associations that characterize individual segments of environmental gradient, classification is not its primary purpose. While it provides common language and improves consistency of use, its main contribution to managers lies in ecological interpretations it provides for forest communities found along an environmental gradient. Relative growth of various tree species and potential community dynamics are translated into management implications which enable managers to identify ecological and economically viable management options.

For purposes of discussion of the potential role of white pine in various forest cover type - site type combinations I grouped sites (habitat type) into four site quality categories or classes as follows:

1- dry/nutrient-poor
2- dry-mesic/nutrient-poor to medium
3- dry-mesic/medium nutrient
4- mesic/nutrient-medium to rich

Regardless of current dominant vegetation, white pine can play a role in each of the above site categories. For a given site category, any combination of species shown in the stack of horizontal bars in Figure 1 may comprise a successional stand. Composition of any stand is a function not only of site quality and time since last disturbance, but is to a large extent also affected by the composition of the original stand, timing and nature of disturbance, and climatic conditions for several years following disturbance. One can never exactly predict the outcome of a potential disturbance, but one can identify current trends in succession and in many instances either augment the current process or, within limits, redirect it. It is in this context that a manger can include or exclude white pine from management considerations.

First step in this decision-making process is to assign a site in question to one of the site categories outlined above. This can be done by examining the understory vegetation together with the current forest cover type. Wendel and Smith (1990) do this remarkably well in their general treatment of the silvics of white pine across its botanical range with the following description:

> " In general, on dry sites the understory vegetation is usually of one or more species of blueberries (Vaccinium spp.), teaberry (Gaultheria procumbens), dwarf bush-honeysuckle (Diervilla lonicera), sweet-fern (Comptonia peregrina), bracken (Pteridium aquilinum), clubmoss (Lycopodium spp.), and broom sedge (Andropogon virginicus). The moist, rich sites support a ground vegetation made up principally of several species of woodsorrel (Oxalis), partridgeberry (Mitchella repens), wild sarsaparilla (Aralia nudicaulis), jack-in-the-pulpit (Arissaema spp.) and hay-scented fern (Dennstaedtia punctiloba). Intermediate

sites have ground vegetation containing various amounts of the above with dogwood (Cornus spp.) and false lily-of-the-valley (Mainthemum canadense)."

Although this description best fits the New England conditions it does not contain any contradictions when applied to the northern parts of the three Lake States. Perhaps the biggest difference between the two regions is the composition of communities on the moist - rich sites which in the Lake States contain many more characteristic species.

Based on 15 years of my own extensive vegetation sampling and comparisons of floristic composition of forest communities in Wisconsin and Michigan, I can provide more specific characterization of the four site categories as they apply to the Lake States. Although it is important to remember that total floristic composition of communities representing the four site categories varies somewhat even within the Lake States region (these differences are accounted for by recognizing region-specific associations and habitat types) the following descriptions provide a common denominator that can be used across the Lake States region.

1- DRY/NUTRIENT-POOR SITES

These sites are occupied by any mixture of jack pine, red pine, white pine, northern pin oak, bur oak, red maple, aspen, and paper birch. Because most of these species also play successional roles on more productive sites, their presence alone does not characterize the site. Some of the following understory species are consistently present: blueberries (Vaccinium spp.), wintergreen (Gaultheria procumbens), bush honeysuckle (Diervilla lonicera), sweet fern (Comptonia peregrina), cow wheat (Melampyrum lineare), bearberry (Arctostophylos uva-ursi), New Jersey tea (Ceanothus americanus), trailing arbutus (Epigaea repens), northern bedstraw (Galium boreale).

White pine does occur naturally on this site type but its regeneration capacity, seedling survival, and growth rate are clearly less than optimal.

2- DRY-MESIC/NUTRIENT-POOR TO MEDIUM SITES

This category represents sites with a somewhat higher moisture regime than that of the previous category but with low available nutrients. All of the tree species listed above may be present, but white pine, red oak, red maple, and aspen show distinctly better growth than do the other species.

Understory flora may include many species from the preceding group, particularly blueberries and wintergreen, but also include some of the following: big-leaf aster (Aster macrophyllus) with generally higher coverage than in the first group, fly honeysuckle (Lonicera canadensis), wild sarsaparilla (Aralia nudcaulis), false Solomon's seal (Smilacina racemosa), bunchberry (Cornus canadensis), yellow beadlily (Clintonia borealis), partridgeberry (Mitchella repens), and ground pine (Lycopodium obscurum).

Surveyor's records (Finley 1976) and common presence of large white pine stumps clearly show that white pine was most prevalent on this site category in presettlement times. Where an adequate seed source was retained following early logging and fires, white pine regenerated well and it shows great ability to maintain itself on these sites. However, over most of the Lake States region, the white pine seed source has been virtually eliminated and this site type is most often dominated by aspen and birch, red maple, red oak or by some mixture of these. Nevertheless, potential for white pine management on this site type is very high. More than on any other site category, seedlings and saplings are found in all cover types whenever a nearby seed source is present.

Of the mesic hardwoods, only ironwood and sugar maple are sometimes found on these sites but they do not form dense seedling and sapling layers as they do on richer sites and do not present serious competition problems.

3- DRY-MESIC/MEDIUM NUTRIENT SITES

While site classes 1 and 2 always occur on sandy soils of outwash plains or pitted outwash landforms the dry-mesic/medium nutrient sites are strongly associated with end moraines, recessional moraines or so called washed moraines. Surface soil may be sandy loam or loamy sand, but the underlying till, even though coarse textured, results in distinctly richer site conditions than those normally found on outwashes.

The understory flora may include any of the species listed in site category 2, but those of site category 1 are absent except for blueberries and wintergreen, which are often present with low frequency. The presence of some of the following additional species helps to identify this site category: maple-leaf viburnum (Viburnum acerifolium), witchhazel (Hamamelis virginiana), leatherwood (Dirca palustris), hog peanut (Amphicarpa bracteata), tick-trefoil (Desmodium glutinosum), rosey twisted stalk (Streptopus roseus), trillium (Trillium spp.), interrupted fern (Osmunda claytoniana).

Successional forest types on this site category are similar to those of category 2 but some mesic hardwoods are usually also present. In more northern regions only sugar maple and ironwood are commonly found while further south nearer the floristic tension zone (Curtis 1959) basswood and white ash are also common. However, most current stands on these sites are dominated by red oak and red maple or the two species comprise a significant stand component. High quality aspen stands are also common.

Based again on the early survey records, it is evident that white pine comprised a significant component of presettlement forests on this site type as it did on site type 2. Where sugar maple and red maple are absent and a white pine seed source is present, the latter regenerates as well here as it does on sites of category 2. While growth potential for white pine is even higher here than it is on the preceding site category, the management options will be strongly influenced by the presence or absence of competing mesic hardwoods.

4- MESIC/MEDIUM TO RICH SITES

Unless planted to other species these sites are most often occupied by various mixtures of mesic hardwoods or by aspen if a site was severely or repeatedly burned following early logging.

Understory flora on this site type usually contains many of the species listed for site type 3 but also includes some of the following: baneberry (Actaea spp.), spinulose shield fern (Dryopteris spinulosa), lady fern (Athyrium filix-femina), maidenhair fern (Adiantum pedatum), downy yellow violet (Viola pubescens), large-flowered bellwort (Uvularia grandiflora), sweet cicely (Osmorhiza claytoni), jack-in-the-pulpit (Arisaema atrorubens), blue cohosh (Caulophyllum thalictroides), and elderberry (Sambucus pubens).

This site category has always been considered the "domain" of mesic hardwoods and hemlock. Although white pine can not compete with these species, historic records (as well as some remaining stumps) clearly show that white pine occurred as scattered trees in presettlement times. Most ecologists concur that white pine occurrence on this site type was almost certainly associated with major disturbance such as fire, or more typically windthrow that created soil mounds by tree uprooting (Bourdo 1983, Loucks 1983). White pine grew to exceptional size on these sites and was actively sought by early loggers. Because a seed source is now entirely lacking on these sites and artificial regeneration is expensive due to the need for control of competing vegetation, future forests on these sites are not likely to contain white pine as an important component.

THE NICHE OF WHITE PINE IN SOUTHERN PARTS OF THE LAKE STATES

In those parts of the Lake States where oak forests, oak savannas or oak openings dominated the landscape, white pine was largely absent in presettlement times. It is generally believed that presettlement oak communities were fire maintained. While oaks have many adaptations to fire, mesic hardwoods are sensitive to fire damage and were presumably eliminated from areas where fire frequency was high. Although old white pine trees are also fire resistant, seedlings and young trees are easily killed by fire. Thus, one may conclude that the same fire regime that maintained oak communities and eliminated mesic hardwoods also eliminated white pine from most of the region. However, a number of small pine relics that are found in less fire prone landscapes throughout the region provide evidence that white pine is equally suited for southern climatic and edaphic conditions. Not only is white pine maintaining itself in these relic communities, but since wild fires have been eliminated from the southern environment, it has been spreading into surrounding oak communities. White pine is also doing extremely well in numerous plantations throughout the region. Its height growth commonly exceeds that of any associated species. I believe that once an adequate seed source is reestablished throughout the region, white pine will provide an additional management option in mixed oak forests.

CONCLUSION

It is my belief that white pine has been prematurely excluded by most foresters as an important potential component of the Lake States' forests. Primary reasons for this are virtual disappearance of a seed source with early logging and fires that followed, and the overstated threat of white pine blister rust and tip weevil.

Over the last 50 years the remaining scattered young white pine trees have matured enough to once again provide a significant seed source on many sites. Many aspen, red oak, and red maple stands now contain sufficient advanced white pine regeneration to make commercial release possible. This is particularly true for site categories 2 and 3 discussed earlier.

It is also important to emphasize that ecological requirements of white pine are significantly different from those of red pine, the basis of our plantation management systems. Unlike red pine, white pine does not require soil scarification (except where a thick mat of needle litter develops) and it does not especially thrive in open plantings. It is sufficiently tolerant of the understory environment to be well-suited for the shelterwood system of management. Because of its exceptional longevity and large size, individual trees can be left in mixed-species stands to provide some old growth characteristics while also functioning as seed trees for regeneration of future stands. Based on observations of white pine's performance in many stands currently dominated by oaks and on historic records of white pine occurrence, I conclude that white pine can be established everywhere that stands of red oak, white oak, red maple or mixtures of these occur. Where no pine seed source exists to initiate natural regeneration, underplanting is a viable alternative, at least from an ecological point of view. Perhaps we should view white pine's role in our forests more as a component of many forest types rather than as pure stands, much as it was prior to the early logging era.

In conclusion I could offer one generalization regarding site selection for white pine management: maintain or introduce white pine with confidence in any stand where blueberries or wintergreen grow but do not dominate the ground vegetation layer.

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WHITE PINE MANAGEMENT ON THE MENOMINEE AND ITS EVOLUTIONARY PROCESS

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ABSTRACT. This paper notes the history of early pine management efforts on the Menominee Forest. A review of investigations leading to the recent natural regeneration prescription is discussed. A detailed account of continuing efforts involving observations, demonstrations, analysis, and integration of outside research leading to a revised silvicultural prescription for regeneration is presented.

INTRODUCTION

The Menominee Reservation Forest exists as a unique vegetative entity, easily distinguished from the agricultural and recreational land use patterns that surround it (Heckman et al. 1985). It has long been recognized as a singular example of successful forest management according to sustained yield principles (Hole et al. 1967). Professional resource managers and lay people alike are often impressed with the species composition, size, and density of the timber found on the Forest's 220,000 Sustained Yield acres. It is frequently perceived as a large virgin forest, or at least a forest with large volumes of mature timber that has never been managed.

John T. Curtis, in his classic ecological work "The Vegetation of Wisconsin" (1959), stated that contrary to common belief, northern Wisconsin was not a vast, dense, and continuous forest of mature trees, unaffected by time and natural processes. Rather, it was a mosaic of grasslands, brush, and thin poletimber stands interspersed with pockets of mature sawtimber. This condition has been thoroughly documented in government surveyors' notebooks of the 1850's and 1860's. These notes recorded large areas of pine sapling and pole stands, probably originating less than thirty years previous.

It is areas such as this, often resulting from windstorm and wildfire, that were the beginnings of the present day stands of white pine (*Pinus strobus* L.) on the Menominee Forest. Recent Continuous Forest Inventory data indicate that the white pine component is currently comprising 18,514 acres of sawtimber, 1,631 acres of poletimber, and 1,126 acres of seedlings and saplings. Most of the sawtimber stands are mature and range in age from 160 to 200 years, with some small acreages containing individual trees having been in existence for well over two centuries.

White pine is a very important part of the Menominee Forest, sharing the spotlight with eastern hemlock (*Tsuga canadensis*, L. Carr.) and sugar maple (*Acer saccharum*, Marsh.) as the top three species in terms of board feet of growing stock. White pine makes up 20 percent of the Forest's total sawtimber volume, yet that cover type is only 8 percent of the total Forest acreage. Nearly three hundred fifty million board feet of white pine sawtimber currently contribute to the resource base that supports extensive logging operations and a lumber mill.

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While the Menominee Forest is part of the historic Lake States pine belt (Burns and Honkala 1990), its white pine component is beginning to succumb to the inevitable influences of succession. Some stands that were dominated by large diameter white pine in the overstory are converting to hardwood or hemlock-hardwood in the understory (Curtis 1959). Conventional single tree selection methods of harvest in these stands, in the absence of any natural disasters, will likely yield a future largely devoid of a significant amount of white pine sawtimber.

EARLY EFFORTS

It was this concern for the future, stimulated by the absence of natural regeneration in the vast majority of sawtimber stands, that led earlier forest managers on the Menominee to intensive investigation of the silvical requirements of white pine. It was noted that the Forest possessed soils capable of supporting dominant white pine over a wide range, and that rainfall amounts received on an annual basis were more than adequate to sustain impressive growth. They concluded that the only factors critical to germination, establishment, and growth were the frequency of seedfall, condition of seedbed, overstory crown cover, and protection from natural damaging agents, i.e., fire, insects, and disease (Riddlington and Winner 1954).

Classic textbook recommendations for maintaining the white pine presence within a forest suggested strip or patch clearcutting on well-drained soils, and a shelterwood operation on heavier soils where competition from hardwood was expected to be severe (Westveld 1939). An early work from the Lake States area briefly described a modified shelterwood system in which selection harvesting followed the initial shelterwood cut, delaying final overstory removal for up to twenty years (Baker 1934). Subsequent teachings tended to focus increasingly on the shelterwood method of natural regeneration as the more desirable option because of its flexibility in controlling levels of sunlight, soil temperature, and competing woody vegetation (Smith 1962).

INITIAL WORK

The first serious attempts to address the problem of declining white pine acreage on the Menominee Forest occurred in the late 1960's and early 1970's when a cooperative effort between the Wisconsin Department of Natural Resources Forester and the Menominee Tribal Forester sought to establish regeneration on some of the white pine stands in the south-central portion of the Reservation. Up until that time, activity in these pine stands was largely a matter of either avoiding them because of perceived problems with red rot (*Fomes pini*), or "mining" them through a periodic selection process that simply removed some of the pine sawtimber, while allowing subsequent conversion to hardwood (Heinz 1992).

Field observations indicated that where road maintenance activities occurred in white pine stands, the ditch line and portions of right-of-way frequently exhibited heavy densities of vigorous white pine regeneration. The fact that disturbance of the mineral soil and increased levels of sunlight tended to favor seedling germination and establishment was readily apparent. At the time, State DNR silvicultural prescriptions did not adequately address the issue of white pine regeneration. The nature of silvics textbooks in the same subject area was rather general, and it was felt necessary to take actions a step beyond the textbook recommendations (Vande Hei 1992).

The actual demonstration consisted of two adjacent stands. On both, most of the understory was removed, while the overstory was thinned to approximately 90 square feet of basal area, which was somewhat less than the 100 percent of sunlight that occurred on the ditch line of the road. There was a range of 70 - 90 square feet of residual basal area targeted for the overstory; the lack of any acceptable measuring device made percent crown closure estimations less than desirable. The control stand received no additional treatment. Adjacent to this, the regeneration stand was also site prepared by removing the understory, unsuccessfully attempting treatment with an herbicide, and finally scarifying with a skidder blade where this could be done with no damage to the residual stand (Vande Hei 1992). Despite this project being undertaken in a good seed year, it was largely unsuccessful, with very little seed germination and establishment. It was observed that high levels of upper canopy shade, if not excessive, would not hinder the seedling germination and development, while low shade from understory competition was often a limiting factor on seedling establishment (Heckman et al. 1985).

RECENT TIMES

In part because of this initial disappointment with regeneration efforts, as well as the impact on manpower and logistics of Dutch elm disease which peaked during the 1970's, long-term white pine management concerns were put on hold for more than a decade. However, successional trends in the white pine type continued unabated. Increasing acreage was converting to northern hardwood, particularly on soils well-suited to growing quality in this cover type (Sloan 1984). The situation was noted by Tribal Forestry staff, and efforts began in 1980-1981 to build on past experience, draw from current knowledge, and devise new methods where needed, in order to finally arrive at a practical and effective silvicultural system that could consistently produce results.

SHORTAGE OF REGIONAL INFORMATION

It quickly became apparent that very little research had been done in the Lake States region concerning white pine management in general, and white pine regeneration in particular (Sloan 1984). This may have been due simply to a lack of interest, or to a stereotypical belief that white pine was nothing but trouble: insect and disease prone, slow-growing, and worthless to industry in pulpwood form. While there may have existed some instance, somewhere, to support these negative contentions, the Menominee experience with white pine did not agree.

In turning to areas outside the Great Lakes for recent information, initial efforts focused on the northeastern United States. It was reported that on moist sites, heavier shade (only 40 percent of full sunlight) tended to slightly reduce seedling emergence compared with the same overstory density on drier sites. Seedling mortality that did occur was found to be attributable to establishment failure on the dry sites, and damping off fungus on the more moist sites (Graber 1968.) Observations and experiences on the Menominee Forest over the years have tended to support Graber's findings.

Additional research (Lancaster and Leak 1978) determined that site disturbance in order to expose mineral soil was critical in providing a medium for holding available soil moisture more consistently than a litter layer that is highly susceptible to desiccation. They also noted that herbicide application might be necessary in order to control hardwood stump sprouting following the regeneration cut.

Investigations of site, seedfall, seed viability, germination, and seedling establishment were undertaken by State and Tribal Foresters on the Menominee in the early 1980's (Heckman et al. 1985). These efforts, combined with past Menominee experience, investigative observations, demonstration plots, and research from outside the area, led to the development of a method for naturally regenerating white pine that was shown to work on the Menominee Forest. It emphasized the following three points: 1) scarification of the seedbed, 2) manipulation of the overstory canopy, and 3) control of the understory competition through herbicide application, as necessary.

NEW PRESCRIPTION

The resulting prescription (Heckman et al. 1985) calls for an evaluation of the site according to a habitat classification system, with emphasis on those sites indicating both a strong successional path and optimum growth potential for white pine. Since only one of the habitat types occurring on the Menominee Forest (PMV<Q>) has white pine as the climax in succession (Burger and Kotar 1989), any other site suitable for regenerating and growing quality white pine would also have to deal with greater competition from other species, principally the hardwoods.

Following site evaluation, the prescription requires site preparation consisting of removal of all understory hardwood through a combination of commercial harvest and herbicide application, as necessary. Further preparation is accomplished through a scarification operation using a patch scarifier. Manipulation of the overstory canopy is achieved through commercial harvest in which the crown density is reduced to between 70 percent and 80 percent by thinning from below and discriminating against hardwoods. The objective is to control the amount of sunlight reaching the soil by maintaining a condition in which any shading of the seedbed comes only from the overstory canopy (Heckman et al. 1985).

Once germination and establishment have been achieved, the site is evaluated for both white pine seedling vigor and competition from herbaceous and woody plant material. If necessary, a chemical application is made to release the seedlings. The overstory density is then reduced to between 40 percent and 50 percent, timed to coincide with the onset of rapid height growth of the seedlings, if possible. A maintenance program of thinnings to retain the 40 percent to 50 percent crown density is followed until the understory reaches a diameter of five inches, at which time the residual overstory can be totally removed or left, depending upon its condition and the expected damage to the regeneration (Heckman et al. 1985).

CONTINUING EDUCATION

Since the accomplishments of the early 1980's, culminating in the development of a specific prescription (Heckman et al. 1985), continuing effort has yielded information and knowledge that has contributed to a refinement of the existing system.

HABITAT CLASSIFICATION SYSTEM

A significant concept has been the implementation of a habitat classification system. Its origin in the Lake States, in an applied format, can be traced to studies done in the Upper Peninsula of Michigan and northern Wisconsin (Coffman et al. 1980, Kotar et al. 1988). The objective of habitat classification is to identify key understory plant species, their abundance and frequency, and their association with other ground plants in a manner that indicates a significant occurrence. This information, combined with additional data on site productivity, has great relevance in management decisions.

In an effort to develop locally specific habitat information, a survey and study was contracted, culminating in the publication of a field guide for the Menominee Forest (Kotar and Burger 1989). Nine major habitat types and two phases were identified on the Menominee Forest; some of them have also been noted in previous field guides (Kotar et al. 1988). These types cover a soil nutrient range from poor to very rich, and a soil moisture range from dry to wet-mesic. Indications are that five of them appear suitable, in varying degrees, to white pine management; this accounts for approximately one-third of the Forest acreage.

A white pine management objective will not automatically be pursued on these acres. There are a number of factors that must also be considered, including site productivity, hardwood competition, potential insect and disease problems, species diversity on the Forest, and the species/product mix that will be available to the Tribal sawmill under sustained yield principles.

CORELATION WITH INVENTORY

A Continuous Forest Inventory (C.F.I.) system has existed on the Menominee for approximately forty years. Individual tree growth data is obtained from a series of 888 systematically located fixed-radius permanent plots. It was therefore a logical step to attempt correlation of this C.F.I. growth data with the habitat type on which the inventory plot is found. While analysis of this information is not yet complete, preliminary figures not only support the management implications described in the Menominee habitat field guide (Kotar and Burger 1989), but identify specific growth rates of white pine on each of these habitat types.

For example, the Acer-Tsuga/Maianthemum (ATM) habitat type exhibits white pine growth rates in excess of 140 board feet per acre per year, nearly double that of the next most productive type for white pine. However, the ATM type occurs in the medium nutrient/mesic regime (Kotar and Burger 1989), and thus is subject to eventual domination by sugar maple and eastern hemlock if site disturbances are minimal. Hardwood competition with white pine regeneration could easily be a significant problem on this habitat type, and must be seriously considered in the decision-making process. On the habitat types where the hardwood competition is less severe, data indicates somewhat reduced growth rates for white pine.

SCARIFICATION

Initially, site disturbance treatments were done with a double-row Braacke scarifier in two passes at right angles to each other. This resulted in a grid pattern of small patches, exposing less than 20 percent (estimated) of the available site. In order to increase the area of mineral soil exposed, attempts were made to have the skidder operator churn up the site with the blade during the normal harvest operation of the regeneration cut. This process dramatically increased the amount of area treated, but had the downside of reduced harvest productivity and a tendency to move whatever organic soil was present into small berms or piles, rather than mixing it with the mineral component.

In 1989, an anchor chain scarifier was fabricated based on a design originating in British Columbia in the late 1970's and reported by the U.S. Forest Service (U.S.D.A. MTDC 1988). It consists of ship anchor chain with a heavy crossbar welded to each link, and attached to a drawbar trailing three parallel thirteen-foot chains. This system pulls easily behind a 60 horse power skidder, and has been found to provide scarification over 60 to 70 percent of the available area. The advantage is that it maneuvers easily, causes very minimal damage to the roots and boles of residual trees, and does not dig deeply into the soil, but mixes the duff with the mineral layer. The principal drawback is that scarification is less than adequate for spots that have relatively green tops and slash concentrated in piles or heavily matted layers. Because of this latter point, scarification is now usually delayed until several years after the regeneration cut in order to allow for drying and initial decomposition of logging residue.

CROWN CLOSURE

The regeneration prescription developed in 1985 (Heckman et al. 1985) recommended a target crown closure of 70 to 80 percent. In 1982, one unit was thinned to approximately 80 percent residual crown closure by marking from below and controlling closure through even distribution of the dominant/codominant crown. This treatment resulted in 76 percent of the area stocked with at least 1,000 seedlings per acre, the average being nearly 50,000 seedlings per acre. By 1987, when an herbicide release was performed, the crown closure had increased to nearly 90 percent, the average number of seedlings per acre had decreased to slightly over 20,000, but the stocking had gone up to nearly 80 percent. A subsequent overstory thinning was done to a level approximating 40 percent residual crown closure in 1987/88. By 1991, this unit had a stocking level of 100 percent, with an average of 5,200 well-established white pine seedlings per acre.

On this unit, average annual height growth based on internodal measurement was 1.4 inches from 1985 through 1988. Following the crown thinning to 40 percent residual, the annual average increased to 2.2 inches, with a slight decrease noted for the drought years 1988 through 1990.

An adjacent unit was also harvested for regeneration in 1982. It was thinned from below, controlling closure in the overstory dominant/codominant canopy. However, this one was marked to remove all hemlock only, and not to achieve a target percentage. The residual was approximately 60 percent crown closure. This treatment resulted in 56 percent of the area stocked with at least 1,000 seedlings per acre, the average being nearly 18,000 seedlings per acre. In 1987, with crown closure remaining near the 60 percent level, this unit also received an herbicide release. The stocking had increased to 100 percent, but the average number of seedlings per acre had decreased to 2,200. An overstory thinning to approximately 40 percent was performed in 1987/88, and involved some salvage of lightning struck pine. Surveys taken in 1991 indicate that this unit is 100 percent stocked, with an average of 5,500 well-established white pine seedlings per acre.

On this unit, average annual height growth based on internodal measurement was 3 inches from 1985 through 1988. Following the crown thinning to 40 percent residual, the annual average increased to 3.8 inches, despite experiencing the drought years.

Although starting out at different levels of crown closure and initial stocking, both units were thinned to approximately 40 percent closure. At this point, with each being 100 percent stocked, the number of white pine seedlings per acre is nearly identical. There is a slight advantage in average annual height growth and average total seedling height for the area that started out at about 60 percent crown closure. This holds true even when attempts are made to factor out the influence of continual new seedling acquisition and development subsequent to the initial regeneration of 1982.

CURRENT RECOMMENDATION

Based on these studies, the current prescription calls for the regeneration cut to be made as before (Heckman et al. 1985), with the exception that the target crown closure is now 60 percent. This percentage will take advantage of the better growth potential experienced at that level, without any apparent detriment to the regeneration.

The regeneration cut has become difficult to coordinate logistically with a good seed year because of timing and machinery availability. The problems with scarifying through logging residue previously mentioned also contributed to the decision not to schedule these cuts to coincide with an acceptable seed year, but to allow time for some slash decomposition to take place. Scarification and herbicide treatment of any understory competition is then done in late summer of an expected good seed year.

SEEDLING RELEASE

Follow-on release in shelterwood operations involves "high crown shade" as well as the herbaceous/woody shrub layer that will respond to any reduction in crown closure. It is the lower competition layer that is of most immediate concern to the development of established seedlings. While it will vary with site and the degree of control obtained from any initial chemical site preparation, the most aggressive competitors were found to be stump-sprout hardwoods and *Rubus* sp., followed by perennial herbaceous materials.

Trials two years after seedling establishment involved two different chemicals approved for conifer release. They were applied after bud dormancy at 1) the minimum recommended rate and 2) one-half the minimum recommended rate. All chemical treatment plots exhibited total ground cover mortality, including the white pine seedlings. While this is certainly not conclusive, it does indicate that there may be a short period of time during which seedlings are very sensitive to chemicals, even during dormancy. This would tend to support the importance of chemical site preparation that will carry the site through the first critical three or four years that may be necessary to establish and develop the seedling. This additional time may be useful in hardening the seedling to subsequent chemical release exposure should that become necessary sometime within the first ten years following establishment. A chemical release using backpack equipment in 1987 was effective in setting back most of the competition and allowing the white pine seedlings an opportunity to grow rapidly.

The reduction of overstory crown density to 40 to 50 percent in a second cut was implemented on the previously mentioned demonstration plots in 1987/88. In practice, the target became 40 percent residual crown closure, in part to reflect the change to a crown density target of 60 percent closure during the initial cut, and since little additional seedling growth was expected following a mere 10 percent decrease (60 to 50 percent) in overstory canopy.

OVERSTORY REMOVAL

Conventional shelterwood theory for white pine management generally subscribes to a two-cut process involving the initial regeneration cut followed several years after seedling establishment by total overstory removal (Lancaster and Leak 1978, Wray 1985, Smith 1986, Chapeskie et al. 1989). There appear to be various reasons for this.

Of major concern has been the potential negative impact on seedling development and growth associated with retaining any kind of overstory beyond the first several years following regeneration. Another factor is the increasing level of logging damage to the regeneration that might occur the longer that final overstory removal is delayed (Chapeskie 1985, Smith 1986).

There is recognition of these valid concerns, and acknowledgement that all evidence and logic attributes maximum growth potential to a condition in which the white pine seedlings have no overstory competition.

It is known that less damage is likely when the complete overstory is removed while the seedlings are relatively short and pliable; increasing destruction is likely as the regeneration moves into the sapling/pole category; and that some damage is certain at any stage of development (Smith 1986).

THREE-CUT SHELTERWOOD

However, the three-cut shelterwood prescription followed on the Menominee (Heckman et al. 1985) is not without precedent. Wray (1985) describes in detail a four-cut uniform shelterwood, with a preparatory cut, followed by the regeneration cut, and two additional cuts at twenty year intervals, with the last cut made when the regenerated stand is 35-40 years of age. This is very similar to the practice on the Menominee Forest. Smith (1986) discusses the uniform shelterwood concept as one involving a single, or several removal cuttings, with the objective of assisting the regeneration to replace the mature stand at a rate consistent with the decline of the mature stand. This objective is tempered with the ability to assure somewhat continuous production at a level that is greater than would occur if the site were occupied only by the developing stand.

A Canadian study (Chapeskie 1989) recognizes that the timing and number of cuts until final removal require a balancing or compromise of the concerns about potential growth and/or vigor reductions of the regeneration. This must often be weighed against 1) the value of the residual overstory in terms of both additional growth and quality, and 2) the potential threat posed by the white pine tip weevil.

The Menominee considerations for a three-cut shelterwood extending approximately twenty-five to thirty years beyond seedling establishment center around the following factors: 1) the need to ensure minimal negative impact from potential white pine tip weevil (*Pissodes strobi*) infestations, 2) aesthetic and wildlife concerns of Tribal members, and 3) the need to maintain a reasonably even flow of sawtimber volume to the Tribal mill, while lessening the possibility of either dramatic fluctuations or long periods of only marginal production.

INSECT CONCERNS

The white pine tip weevil is and has been a factor in the growth and development of quality white pine on the Menominee Forest. Observations are that in stands with various levels of partial canopy, there is minimal or non-existent tip weevil damage. Open grown trees, without any appreciable side competition from other pines or hardwoods, have shown themselves to be much more susceptible to weevil attack.

This situation is not inconsistent with reports (Houseweart and Knight 1985) that some overstory shading is a sound silvicultural control of the weevil. A western Wisconsin study (Katovich and Morse 1992) of weevil damage to natural stands occurring in a low-grade oak type concluded that maintaining a basal area of 30 to 50 square feet in the overstory would be an acceptable compromise between increased growth and weevil damage. Obviously, even this type of stand will eventually need total overstory removal. While there will always be some minimum logging damage to the regeneration regardless of timing, and it is likely to be less the younger the seedlings, early overstory removal may result in considerable weevil deforming of the seedling main stem (Chapeskie et al. 1989).

In informal conversations with various Wisconsin State foresters, it was related that there appears to be a notable decrease in the incidence of tip weevil attacks across the traditional range of the insect in this State, when compared with twenty or thirty years ago. If true, it is only speculation that this may be due to some inherent decline in tip weevil populations that is independent of any outside influences. It may very well be due to regional natural successional changes in stand composition and size causing less favorable conditions for the weevil. If this is the case, then a return to more open stand conditions on a large scale may favor the weevil and precipitate increasing populations and incidence of attack.

AESTHETIC CONCERNS

The potential aesthetic impact of shelterwood removal cuts cannot be ignored when making silvicultural decisions. The Tribal perception of this treatment has been weighed in terms of their heritage and traditions, of their belief in the long-term nature of the commitment to sustained yield forest management. They are concerned about the future forest, and recognize the need to regenerate the white pine type. But they also seek assurances of a relatively smooth transition from mature stands to regenerated stands, without abrupt transitional periods, largely devoid of any sawtimber trees in the stand. Davis (1986) alluded to this need when he noted that retaining some overstory presents a more acceptable aesthetic impact on the public. This of course, can be a critical distinction, because if the Tribe (or the public on outside lands), finds a treatment abhorrent, they possess the capability of threatening the entire practice. This point becomes even more important when it is noted that retaining a partial overstory as discussed by Wray (1985), Smith (1986), and Chapeskie (1989), while probably sacrificing some growth, does not jeopardize the viability and continued development of the regenerated stand.

ECONOMIC CONCERNS

Because the Menominee Forest possesses a relative acreage imbalance favoring larger diameter mature white pine types, the regeneration needs would tend to be concentrated in time. This presents a potential problem for the delivery of pine sawtimber to the Tribal sawmill. While many of the stands should have been regenerated some time ago, thus smoothing out the harvest flow, this was not done for reasons already mentioned. Today, management decisions must deal with the need to regenerate all planned shelterwood sites within the next 25 years, because of the current age of the overstories. Even with a three- or four-cut shelterwood, there will likely be a notable low period in volume deliveries to the sawmill.

CONCLUSION

Continued observation, testing, research of literature, and sharing of information and experiences over the last seven years has led to improvements in the white pine regeneration prescription followed on the Menominee Forest. Habitat type classification has become an integral part of all management activities, and is critical to sound decision making. The recommended residual crown closure for the regeneration cut is now 60 percent. Timing of these cuts has been changed to allow more logistic flexibility; the logging is done several years prior to the expectation of a good seed year in order to allow slash to decompose somewhat and any hardwood stump sprouting to occur. The actual site preparation, consisting of herbicide treatment of the understory, and site disturbance is timed to coincide with an acceptable seedfall. Scarification is now done with an anchor chain. The subsequent reduction in overstory canopy to 40 percent crown closure is still timed to take advantage of the onset of rapid height growth and may be teamed with an herbicide release, if necessary. Individual sites and stands do vary, and flexibility in the timing of these treatments is expected.

The white pine regeneration prescription followed on the Menominee Forest is a compromise, but it is designed to optimize the development and growth of the new stand, while meeting all Tribal objectives. It is a viable method.

There is still a tremendous need to research and share information on the silviculture and management of white pine. Concerns of insect and disease, pruning, release from overstory competition, logging practices in shelterwood removal cuts, silvicultural prescriptions, as well as the marketability of various white pine products, are but a few of the areas that should be examined. Perhaps the first hurdles that must be overcome are the negative stereotypes standing in the way of: "White Pine: The Thinking Forester's Alternative."

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WHITE PINE
ARTIFICIAL REGENERATION SYSTEM

Craig T. Locey[1]

ABSTRACT. Improve our ecological sensitivity to identify sites in which white pine is a significant species in the successional pathway for those sites. Be creative, look for unique biological opportunities, and don't let traditional artificial regeneration systems limit your creative artificial regeneration techniques.

INTRODUCTION

We must move out of our traditional red pine mentality when considering methods to artificially regenerate white pine. Consider means to introduce or regenerate white pine as a component of a future stand rather than the traditional single species plantations. Be prepared to accept a percentage loss to blister rust and tip weevil as a cost of doing business.

ARTIFICIAL REGENERATION SYSTEMS

There appears to be a gray area between what we identify as artificial regeneration systems and natural regeneration that has been assisted by a harvesting system and/or scarification. That is of relatively little concern since our goal is successful regeneration of white pine. Many of the following thoughts are a compilation of experience gained from other resource managers, to whom I will try to give credit, and 25 years of personal experiences and observations. I have also been in this business long enough to know we can find exceptions to all of these generalized recommendations.

The first step in successful artificial regeneration is to identify appropriate sites. In addition to the obvious presence of white pine stumps, site index has been a standard site evaluation tool for many years. However, site index is just one of many tools we have to today to help us make site decisions. Soils and landform information is improving, Ecological Classification Systems are being developed, and by incorporating all of this information, we can focus regeneration efforts on sites where white pine is or has been a component of the ecosystem. This will increase our success ratio and help us predict the degree of competition we will have to contend with in establishing white pine.

SHELTERWOODS - stands cut to 50-70 percent crown closure with underplanting are showing promise in both Minnesota[2] and Wisconsin[3]. Harvest to 50-70 percent crown closure provides enough light for early development without encouraging tip weevil. Shelterwoods installed concurrently with a good seed year and scarification followed by underplanting if the natural regeneration is insufficient is also proving to be an effective combination.

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GROUP SELECTION HARVEST - introducing white pine as a component of a stand with an oak management objective may have promise since oak and white pine regeneration requirements are similar.

CLEARCUT AND PLANT - planting immediately following clearcut of an aspen-birch-oak stand has produced good results where aspen and birch sprouts have provided some cover and acted as a nurse crop for the white pine. Tip weevil problems have also been minimal with this system.[4]

OPEN FIELD PLANTINGS - planting of white pine in former agricultural lands has had mixed results, ranging from poor survival and severe tip weevil in northern and central Wisconsin to successful plantations in southeastern Minnesota and southwestern Wisconsin with little or no weevil problems.

NATURAL OPPORTUNITIES - We should continually be looking for natural phenomena and opportunities for planting white pine. One current opportunity is the declining condition of white birch across the Lake States due to drought, over maturity and insects. White birch is often a pioneer species in ecosystems of which white pine is a component, so underplanting white pine on these sites and depending on the continued decline of the white birch to release it would harmonize with the natural successional process and increase white pine where present seed source is inadequate. Windstorms are a normal phenomenon, particularly in the Lake States, and the root tip-up mounds (exposing mineral soil) and canopy openings are ideal micro sites for the introduction of white pine. Look closely when you encounter natural white pine and note how many of them are situated on old root tip-up mounds from previous windstorms. A high percentage of them apparently become established under these conditions. There are undoubtedly many other natural types of opportunities waiting to be recognized.

CONCLUSION

We should improve our ability to interpret white pine ecosystems and coordinate our artificial regeneration systems to harmonize within the successional pathways for those ecosystems. We should recognize and consider white pine as a component of other stands. Pure stands of any species are not the natural norm. Traditional concerns over blister rust and tip weevil can be reduced by site selection and cultural techniques for establishing white pine. Mortality as a result of these pests should be considered a cost of doing business.

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SILVICULTURAL PRACTICES IN ONTARIO'S WHITE PINE FORESTS

Fred Pinto[1]

ABSTRACT. Uniform shelterwood and clearcut silvicultural systems are the most common methods used to manage Ontario's white pine forests. Use of the shelterwood system has been increasing, it currently accounts for 77 percent of the harvest in white pine dominated stands, up from 65 percent six years ago in central Ontario, where most of the province's white pine is found. Forest managers are increasingly prescribing the retention of live trees under both silvicultural systems for the maintenance of structural components that can be eliminated from the stand through forestry operations. Future work will have to focus on comparing forestry operations and natural disturbances at the landscape and stand levels. Additional efforts are needed to understand the impact of forestry operations on gene conservation in white pine ecosystems. Work on these areas has commenced in Ontario.

Ontario's white pine forests stretch from the Southern Deciduous into the Boreal Forest Regions. The majority of stands dominated by white pine are found in transitional forests between these two major forest biomes, within the province's Great Lakes St. Lawrence Forest Region (Figure 1). Total area of white pine dominated stands in the province is 660,000 hectares (ha) (Ontario Ministry of Natural Resources 1986) with an even larger area occupied by stands where white pine forms a smaller component relative to other species. Within this large and diverse area, a number of management techniques are practiced. These practices reflect the needs of local communities, stand and site conditions, available resources, and local limitations.

In areas where forestry operations are permitted, silvicultural systems most commonly employed are shelterwood and clearcut (Chapeskie et al. 1989, Wray 1985). Application of these systems is modified or restricted to protect ecological, cultural, and economic values identified by the public and local agencies during the preparation of plans for timber access, harvest, and renewal.

The uniform shelterwood system is the preferred method under which stands dominated by white pine are managed, for reasons stated by many authors such as Smith (1951) and Lancaster and Leak (1978). Margolis and Brand (1990) and other authors have shown that white pine is capable of acclimating to moderate availability of light, moisture, and nutrients. This makes white pine stands candidates for partial cutting systems where clearcutting is not desired. Use of the shelterwood system has been increasing in recent years as awareness, knowledge and experience of forest managers increased and spread, as competition for funds has led resource managers to look for more opportunities in natural regeneration methods, and public pressure to reduce clearcutting has increased. For example, the shelterwood system accounted for 77 percent of the harvest in white pine stands in the Central Region of the Ministry of Natural Resources compared to 23 percent that was clear cut in 1990-91 (Figure 2).

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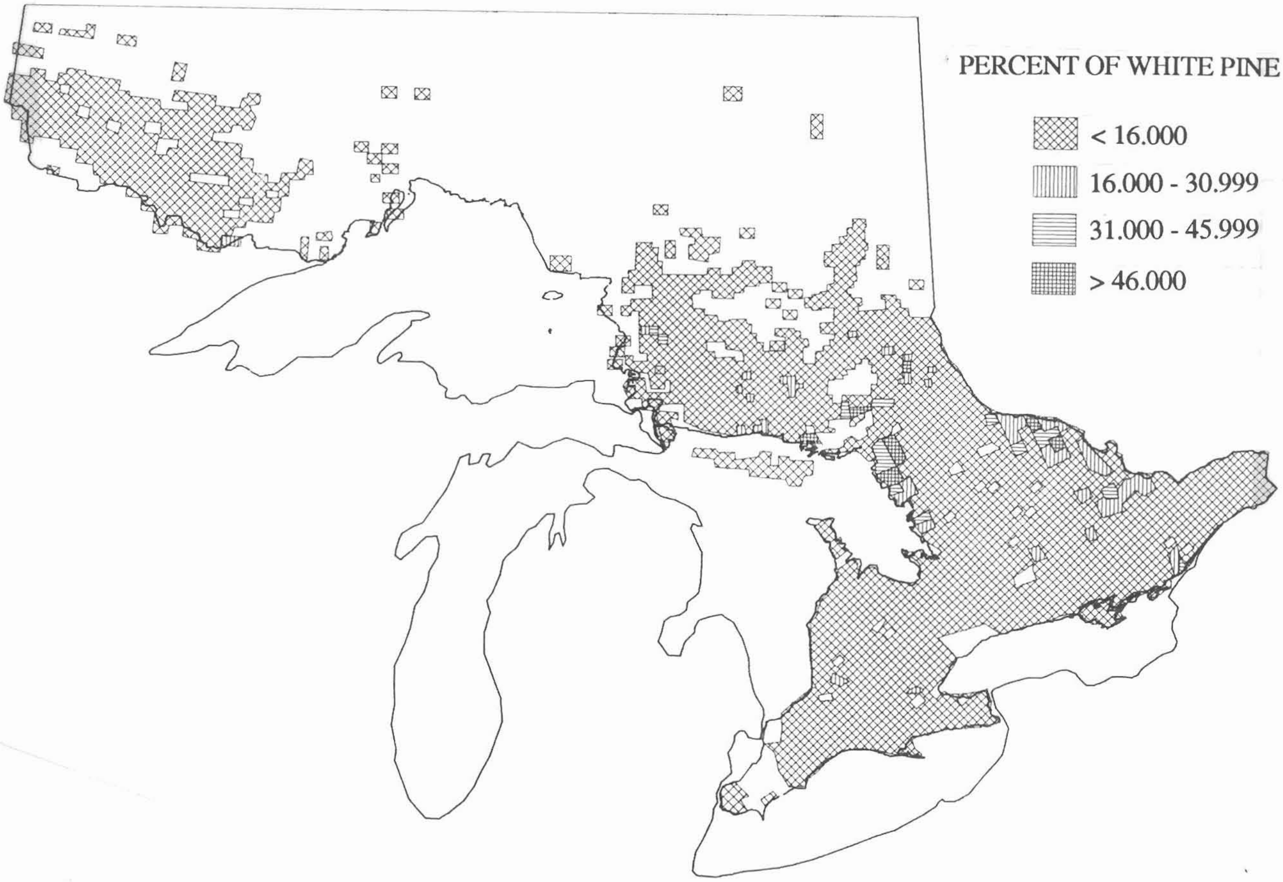

Figure 1. White pine dominated stands are found as far as 50°N in Ontario. Highest concentrations of white pine stands are in central Ontario, along the banks of the Ottawa River and eastern shores of Georgian Bay. This figure was created by expressing the area of white pine stands as a percent of the area of each of the 6000 map-sheets covering Ontario by the Inventories Management Unit of the Land and Resource Information Branch in the Ministry of Natural Resources (Osborn 1990).

YEAR	1990-91	1989-90	1988-89	1987-88
Shelterwood (ha)	3565	3847	3341	3316
Clearcut (ha)	1056	1520	1936	1780
% Shelterwood	77.1	71.7	63.3	65.1

Figure 2. Area of white pine dominated stands harvested under the shelterwood and clearcutting silvicultural systems in the Central Region of the Ministry of Natural Resources. This region accounts for the majority of white pine growing stock in the province. The area of clearcutting includes strip cutting, seed tree cuts, and complete overstorey removal. These data were obtained from the unit forester or delegate for each management unit in the region. Note the increasing area that is being treated under the shelterwood system.

The shelterwood system is usually applied by a series of up to four cuts, in stands that have a basal area greater than 8-12 square meters per hectare (m^2/ha) of healthy white pine. The type of cut in a particular stand is selected by considering its structure and site conditions. At each stage, trees are retained as future crop trees, seed sources, and for ecological or aesthetic reasons. Crop and seed trees are selected for retention based on the following criteria:

1) they are in the dominant or co-dominant crown class
2) they are disease-free with clear, straight boles
3) they have well-formed crowns, preferably with fine branching
4) they show signs of good growth as evidenced by small, tight bark-flakes and good coverage of foliage on branches.

Trees retained for ecological reasons are selected so that some of the structural and functional attributes that would have been eliminated from the stand by forestry activities are kept. These trees are selected for mast production, cavities for wildlife use, and their future contribution to coarse woody debris in the new forest. Currently, retention of at least six live, saw-log sized cavity trees per hectare is recommended (B. Naylor, pers. comm.[2]). These cavity trees will in time become snags and coarse woody debris within a stand of seedling- and sapling-sized trees and will serve the needs of wildlife and some of the ecological processes about which we currently know very little.

Cavity trees selected for retention are characterized by a number of hollows of different sizes near the upper bole, rather than the butt. Cavity trees having these characteristics are less subject to post-harvest blow-down. Since most cavity-using wildlife are territorial, an even rather than clumped distribution of these trees is sought at the stand level. Retention of cavity trees has some benefits to timber production as they provide habitat for some vertebrate predators of the white pine weevil (Szuba and Pinto 1991).

The earliest cut to a stand, the preparatory cut, is used to give more growing space to individual trees in dense stands of merchantable size. This allows crop trees to increase in crown size, seed production and stem volume. Trees are ideally spaced at 25-30 percent of their height. This cut can be considered a thinning, except that one of the objectives is to create conditions suitable for future seed production in the residual trees.

The next cut, called the seeding cut, is used in stands with fully developed crowns. Residual trees are spaced at about 40 percent of their height. Its purpose is to favour germination and early development of white pine by providing partial shade which reduces extreme diurnal variation in moisture and temperature, but allows sufficient light for growth. On rapidly drained, dry, and nutrient-poor sites, recruitment may be expected without any other treatment after logging. Additional treatments are necessary to obtain recruitment of seedlings on sites with fine-textured soils and fresh-to-moist moisture regimes (Chambers 1991, Lancaster and Leak 1978, Horton and Bedell 1960). For example, permanent plots established before harvest and remeasured four years after cutting on these dry types of sites showed adequate white pine recruitment, while deep to moderately-deep tills with a fresh moisture regime showed increased site occupancy of pre-harvest shrub species, precluding white pine recruitment (Figure 3).

The most common techniques currently used to control vegetation are a skidder-mounted air-blast herbicide sprayer, mechanical site preparation, and brush saws. A four-year chronosequence study of the

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response of understorey vegetation to mechanical site preparation and a combined herbicide and mechanical treatment suggests that the abundance of pioneer species such as poplar, white birch and *Rubus* increases after mechanical site preparation only. The latter, combined treatment, had a lower proportion of these pioneer species (Figure 4) and an increasing number of white pine recruits.

On fine-textured fresh soils the usually scant natural recruitment is supplemented by planting at low densities, approximately 500 seedlings/ha, when resources are available.

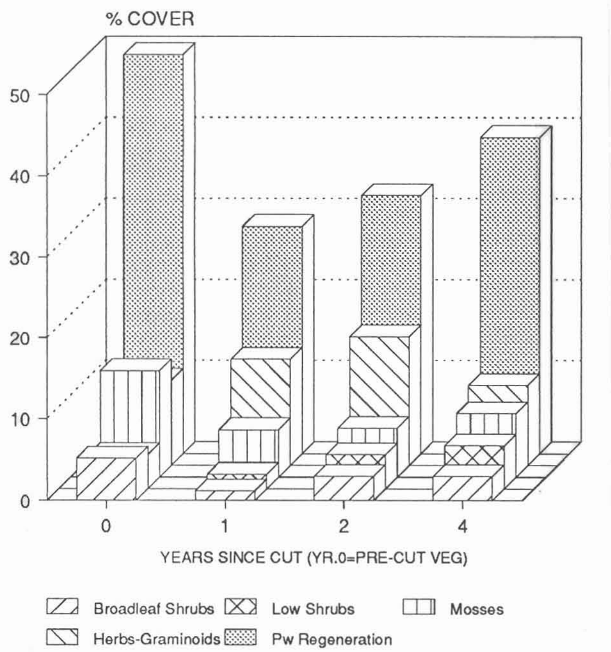
Once white pine is established and while it is less than 6 metres (m) tall, a removal cut is scheduled. This is a partial cut which leaves crop trees spaced about 50 to 60 percent of their height. Residual trees provide microclimatic conditions that favour insect predators, such as *Lonchaea corticis* (Harman 1966), and parasites to reduce white pine weevil damage while providing suitable growing conditions for white pine seedlings and saplings. The overstorey canopy reduces risk of blister rust (*Cronartium ribicola*) infection by providing a barrier that minimizes cooling of the understorey in evening, and promotes dew formation in the upper canopy (Hodge et al. 1989). Lower light levels under residual trees may also help to reduce competition from shrubs. Recommendations for the retention of cavity trees and downed woody debris assist in maintaining populations of insect, avian, and mammal predators of white pine weevil.

Once regenerating white pine is over 6m in height, a final removal cut can be prescribed. Some larger trees within the mix of sapling and polewood size may be retained to protect aesthetic and ecological values.

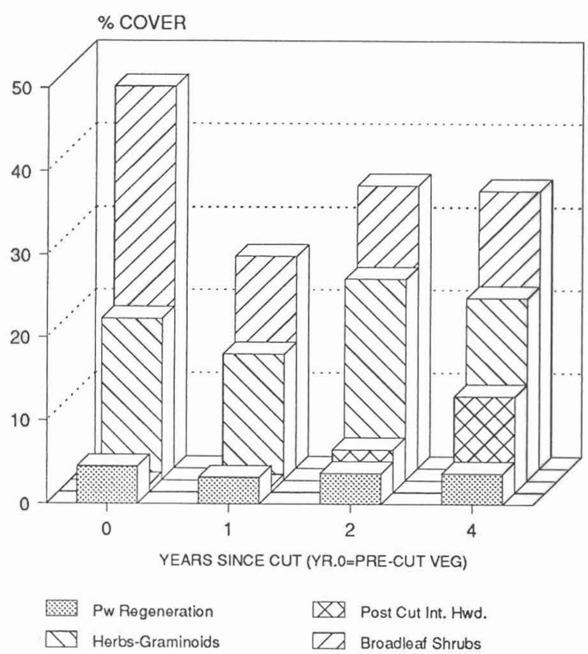
The shelterwood system may be used in stands that do not have white pine, if local site and management objectives permit. The stand is opened to obtain about 50 percent crown cover and planted with white pine. Site preparation and tending are usually necessary on these sites to create plantable sites and control understorey vegetation.

The clearcut silvicultural system is typically used in stands with small amounts of white pine, in other words, where the white pine basal area is less than 8-12 m^2/ha. Retention of seed-bearing, windfirm white pine is recommended to encourage natural regeneration and to provide some structural diversity in the cutover. At least six additional trees per hectare of any species suitable for cavity-using wildlife are recommended for retention.

Since white pine natural regeneration cannot be expected to form a large portion of desired stocking when the clearcutting system is employed, site preparation, planting or seeding and tending may be required. Artificial seeding efforts have not been successful in the past, due to variable micro-climatic factors in the early part of the seedlings' growth, and a lack of vegetation management. The availability of cup-sized, photo-degradable plastic shelters promises some improvement by controlling the micro-climate around germinants. Initial results of a comparison between bare spot seeding and seeding within plastic shelters, at six seeds per spot, are very encouraging. After two growing seasons 34 percent of bare seeded spots were stocked, compared to 85 percent of sheltered spots (Figure 5).

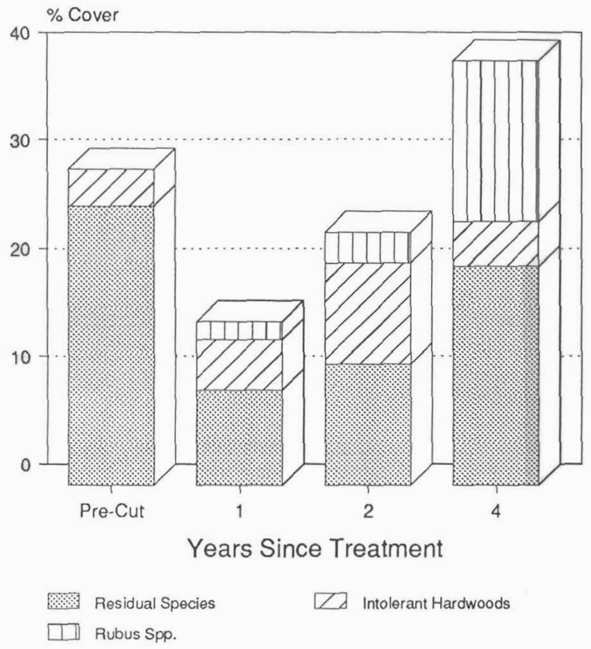


Coarse textured, rapidly drained soil, with an understorey of low ericaceous shrubs described as Vegetation type 13 on soil types 6 and 9 in the Pine Forest Ecosystem Classification (Merchant et al. 1989).

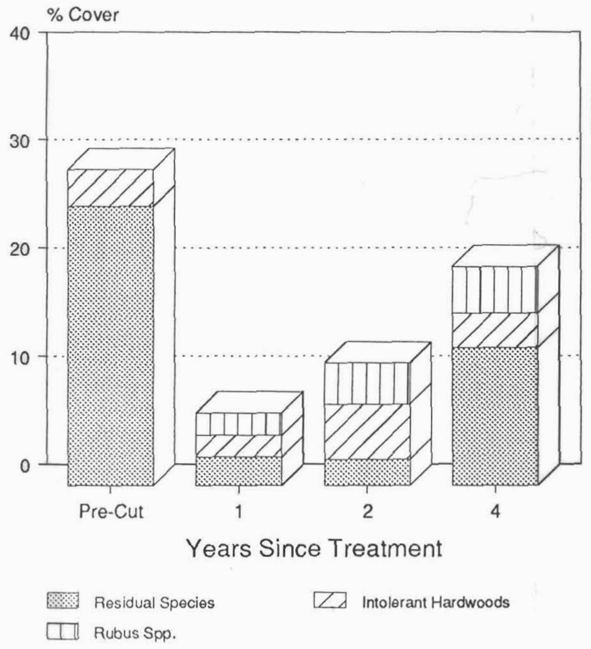


Pine dominated mixed wood occurring on silty fine sands with a fresh moisture regime, described as vegetation type 14 on soil type 2 in the Pine Forest Ecosystem Classification (Merchant et al. 1989).

Figure 3. Changes in white pine regeneration and selected classes of understorey vegetation following a shelterwood cut on two different sites (from Chambers 1991).



Mechanical site preparation with a straight blade after a shelterwood seeding cut.



Mechanical and chemical (glyphosate) site preparation after a shelterwood seeding cut.

Figure 4. Percent cover of broadleaf shrubs before and after treatment on sandy loam soil of variable depth and moisture regime, described as vegetation type 6 or 7 on soil type 3 in the Pine Forest Ecosystem Classification (from Chambers 1991).

Herbicides and brush saws are the main methods by which tending is currently accomplished. First year results of a comparative trial indicate that ground-level broadcast application of glyphosate reduces both density and average height of woody stems, while brushing reduces only average height (Mutchmor 1991). Severed stems were quickly replaced by sprouts and suckers. If later results bear out this response pattern they would confirm the results reported for other forest types (Richardson 1980, Sutton 1984).

Emphasis of past work on white pine in Ontario has focussed on improving our understanding of stand level processes, functions and management. This is insufficient to answer questions we face today on forest sustainability, biodiversity, and environmental quality. Work is required to improve the knowledge base and management practices at landscape and genetic resource levels as well. Ontario is already working in these areas through its Sustainable Forestry Program (eg. Old Growth Forest Fragmentation and Biodiversity, and Genetic Heritage Conservation programs), and has an operational process of science and technology transfer through its Regional Science and Technology offices so that silvicultural practices change as new knowledge becomes available.

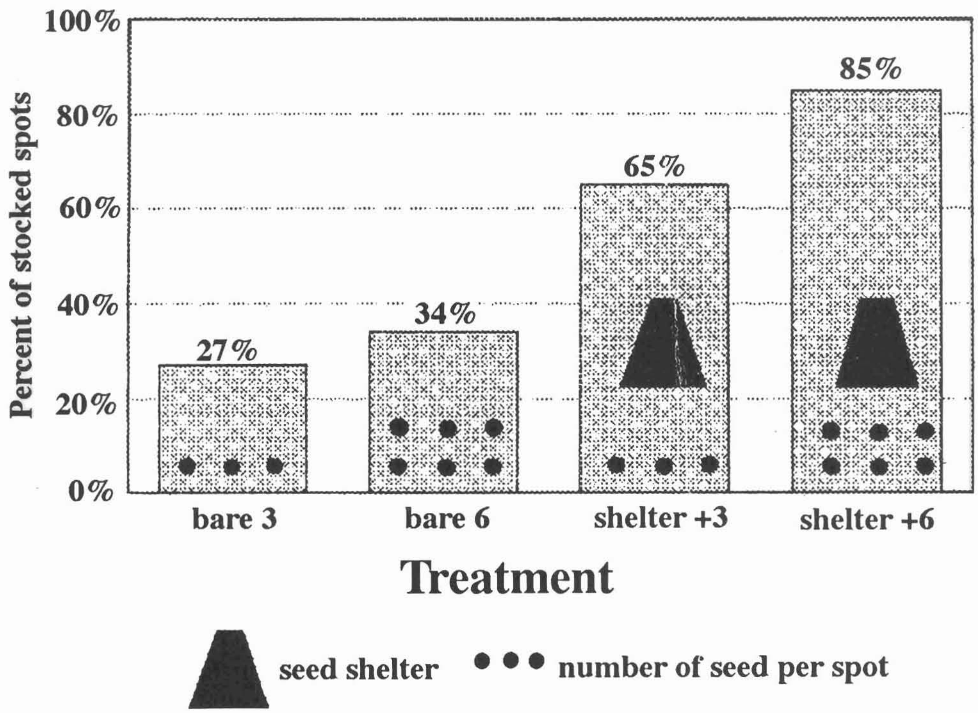


Figure 5. Second year stocking of white pine spot seeded in a patch clearcut on fresh loamy soil where white pine had formed a minor component of the previous stand. All treatment means were significantly different ($p < 0.05$)(from Focken 1992).

Additional information is needed at the stand level to achieve sustainability of our white pine ecosystems. Managers will need to determine how closely harvest and renewal operations mimic or differ from natural disturbances. This will require a move away from comparing only tree growth responses between silvicultural treatments to comparing silvicultural treatments with simulated natural disturbances. Responses of a number of key components of that forest community, such as the understorey vegetation, insect populations, nutrient and energy fluxes, and tree growth will have to be monitored. Plans for such a trial have reached an advanced stage between the Central Ontario Forest Technology Development Unit and the Petawawa National Forestry Institute of Forestry Canada.

Although there is a lot to learn and a need for more research, there must be a mechanism that allows for the application of what is already known. Research results have to be readily accessible by resource managers in a form that can be used operationally. A key reason for our successes in Ontario has been the role of Regional Science and Technology offices which serve to translate and transfer new developments to resource managers and make research needs of the field known to researchers. In pursuit of sustainability, silvicultural practices applied to Ontario's white pine forests are continuing to evolve as new information becomes available.

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BIG TREE SILVICULTURE

Darrell E. Zastrow[1]

ABSTRACT. Big tree silviculture features the aesthetic and recreation values of large diameter trees. Forest cover types on selected habitat types or sites are managed for these featured values. Habitat types provide insight into the dynamics of forest succession and are key in determining big tree potential and sustainability. Management guidelines are developed for Wisconsin state forests with objectives for maintaining and enhancing the big tree cover types. A highlight of these guidelines emphasize rotation ages correlated to the biological maturity of trees, rather than economic maturity.

INTRODUCTION

The number, variety and complexity of demands placed upon public lands continues to increase everywhere. Wisconsin designated state forests, totaling about 500,000 acres, present an opportunity to meet a variety of demands as intended by state law. Current statutory language found in s. 28.04 Wi. Stats. identifies the purpose of the state forests "... is silviculture and the growing of recurring forest crops, with scenic values, outdoor recreation, public hunting and stabilization of stream flow as extra benefits." Due to the variety of purposes identified in statute, and the constraint of a relatively small land base, the concept of integrated resource management has been a guiding principle for state forest lands. Competition between resource professionals, academia, special interest groups, industries, legislators, and the public for single purposes requires sophistication of integrated resource management. Modification of traditional forest management practices provides tools for public forest managers to integrate a variety of forest values. Big tree silviculture is one tool being implemented on the Wisconsin state forests to meet the challenges for some of these demands.

THE DEVELOPMENT OF BIG TREE SILVICULTURE

In 1971, Wisconsin's Governor Patrick J. Lucey appointed a committee to review timber management policies on state-owned lands. In their final report of March 1974, the Governor's Committee recommended that "Big Tree Silviculture" should govern the management of selected forest types on the state forests in recognition of the recreational and aesthetic values of "old growth" and big trees. The need for large diameter trees by some industries was also recognized as an extra benefit for this type of management. The Committee's recommendation of big tree silviculture is to achieve an objective of aesthetic, large diameter trees and would take precedence over maximizing timber volume yields.

When the Governor's Committee referenced the old growth characteristic of big tree silviculture, old growth implied the relative "old age" of a tree necessary to achieve a large diameter. Today, the discussion of old growth has important ecological implications that are not yet fully understood for Lake States forests. The presence of big, large diameter trees is only one characteristic of old growth forests. The guidelines developed for big tree silviculture are found in the Wisconsin Department of Natural Resources Silviculture and Forest Aesthetics Handbook (Locey et al. 1990). These guidelines apply only

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to the development, enhancement or maintenance of stands with large diameter trees, and not to the ecological structure or function of old growth forests. As we improve our understanding of the ecological attributes of old growth forests on various habitat types, these guidelines may be modified.

FOREST COVER TYPES AND THE IMPORTANCE OF SITE

The implementation of big tree silviculture on state lands is limited to several forest cover types and corresponding forest sites that can support the old, large trees. Forest cover types include white pine, red pine, northern hardwood, hemlock-hardwood and red oak and generally have 50 percent of the stand comprising the cover type species. These cover type species have the silvical characteristics that permit individual tree selection and growth to large diameters.

Determination of site capability is critical in predicting the biological potential of trees, including the physiological attribute of large tree diameters. The habitat type classification system ecologically quantifies forest communities and the land (or site) on which these communities develop (Kotar et al. 1988). A habitat type includes all sites or areas that are capable of producing similar plant communities at successional climax regardless of the current cover type. The habitat type classification system uses the plant community as an integrated indicator of environmental factors as they affect species reproduction, competition, productivity, and plant community development. Predictability of big trees in the present cover type is tied to these environmental factors.

It must be emphasized that habitat types are characterized by specific **plant associations** (definite combinations of species with predictable frequencies of occurrence relative to one another). Habitat types are NOT defined by individual "indicator" species. This distinction is often overlooked by casual users of the system. This can lead to incorrect identification of the habitat type and ultimately faulty objectives and management scenarios.

The climax community type or association provides a logical name for the habitat type on which it occurs; for example, Pinus\Maianthemum\Vaccinium (White Pine/Wild Lily-of-the-valley/Blueberry). The first part of the name (preceding the slash) represents the dominant tree species in the climax association. The second part of the name (following the slash) represents a characteristic understory species in the climax association. Sometimes two co-dominant climax tree species or two understory species are used in the name, resulting in a lengthy designation. Therefore for brevity and convenience, abbreviations are normally used. In the preceding example, the abbreviation would be "**PMV**".

The forest cover types identified in Table 1 are managed under big tree silviculture criteria on state forest lands when they occur on habitat types that can sustain large trees of that forest cover type. Some corresponding habitat types that can support big tree requirements are listed for example purposes.

Table 1. Big Tree Silviculture cover types and corresponding habitat types for northern Wisconsin. (Locey et al. 1990)

Forest Cover Type	Potential large diameter growth for the indicated cover type is possible on these habitat types for northern Wisconsin
White pine	AQV, PMV, PAm, AVVib, AQVib, AVDe, ATM
Red pine	AQV, PMV, PAm, AVDe
Northern hardwood	ATM, ATD, AViO, AH, ACaCi
Hemlock-hardwood	ATM, ATD, TMC, AFD
Red oak	AVVib, AQVib, AVDe

As a species, white pine (*Pinus strobus*) grows well on a variety of sites. The habitat types identified in Table 1 represent a range from dry/nutrient-poor sites to mesic/nutrient-medium sites. Only the very dry/nutrient-deficient sites and mesic/nutrient-rich sites are not considered for big tree silviculture. The poor sites generally cannot support the silvical requirements for white pine. The very good sites can support the silvical needs but competition by aggressive hardwoods generally discriminates against white pine. Table 2 summarizes the habitat types referenced for white pine as they relate to moisture and nutrient availability.

Table 2. Habitat types and moisture/nutrient availability for white pine big tree silviculture in northern Wisconsin. 1992

Habitat Type	Moisture/Nutrient Availability
AQV	Dry/nutrient-poor
PAm, PMV	Dry/nutrient-poor to nutrient-medium sites
AQVib, AVDe, AVVib	Dry-mesic/nutrient-medium sites
ATM	Mesic/nutrient-medium sites

As a relationship to site and stand origin, typical rotation ages for white pine in Wisconsin range from 90 to 130 years. These rotation ages are based on achieving maximum timber production but are not used in the implementation of big tree silviculture. The rotation age is extended to approach biological maturity and many times individual trees can reach or exceed 200 years. Big tree silviculture is applied judiciously to prevent succession to undesirable cover types, to impede regeneration of less desirable species, to maintain stand quality, and to guard against excessive volume losses.

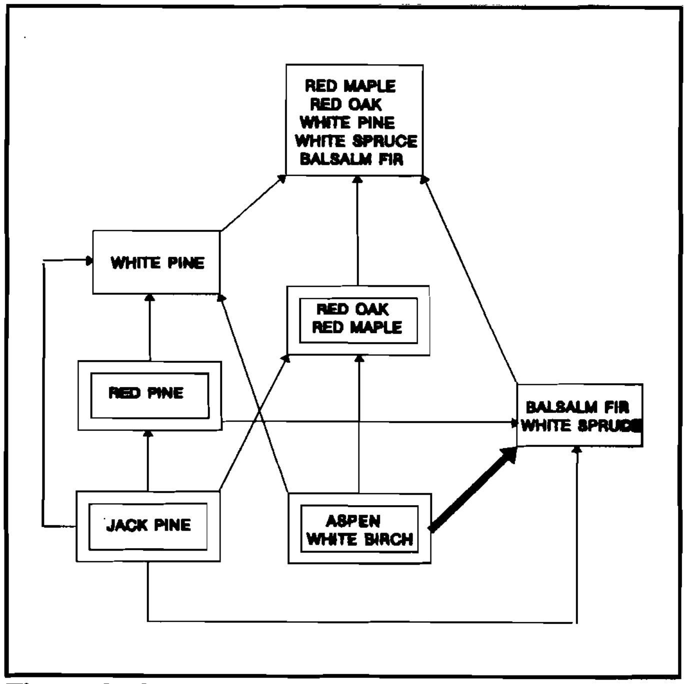

Figure 3. Common successional stages and probable successional pathways on the Acer-Quercus/ Vaccinium(AQV) habitat type (Kotar, et al. 1988).[2]

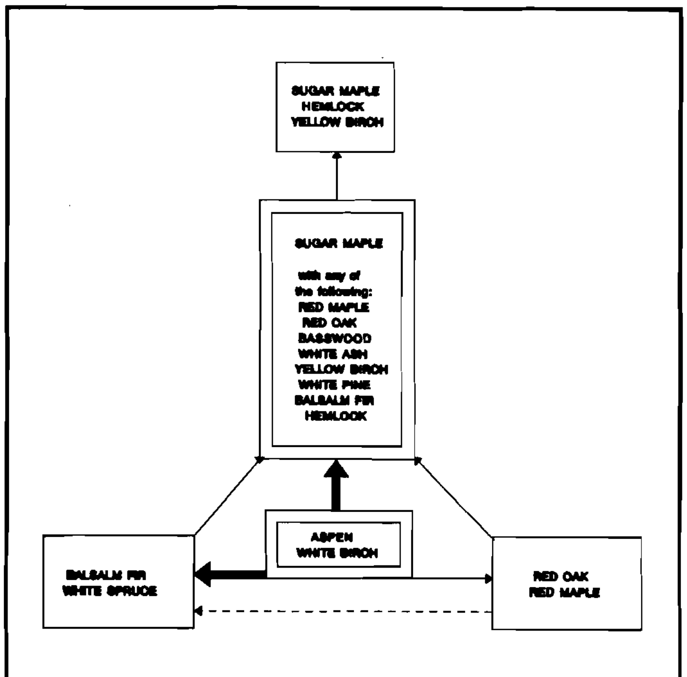

Figure 4. Common successional stages and probable successional pathways on the Acer-Tsuga/ Maianthemum (ATM) habitat type (Kotar, et al. 1988).[2]

Habitat types can identify the successional stage represented by the forest cover type. Silvicultural prescriptions based on big tree silvicultural principles must focus on enhancement, maintenance or interruption of succession. Common successional pathways for the AQV habitat type (dry/nutrient-poor) and the ATM habitat type (mesic/nutrient-rich) are compared in Figure 1 and 2. Using these examples, the white pine cover type would represent a later successional cover type on the AQV habitat type. Management efforts would feature this white pine stage for as long as biologically feasible. It must be recognized that this site does not provide much moisture or nutrients for other tree species to compete. The biological rotation of white pine will not have the longevity on an AQV habitat type as compared to better mesic/nutrient sites. Prior to rotation, regeneration efforts can focus on the specific regeneration silvical needs of white pine since competition of other species is limited. As a comparison, a white pine cover type on the ATM habitat type represents a successional stage in the early to mid-succession continuum for that site. Management efforts would be able to utilize the longer biological rotation of the white pine overstory in managing the aggressive development of many hardwood species. Interruption of the successional path and discrimination against the competing species would influence white pine regeneration efforts. Successful regeneration of white pine on the ATM habitat type will require more intensive, costly management.

Many forest cover types, not identified for big tree silviculture, occur as successional stages on all the habitat types. To compliment these cover types with the aesthetic value of big trees, individual trees or clumps of red pine (*Pinus resinosa*), white pine or eastern hemlock (*Tsuga canadensis*) can be treated in

[2]The thicker arrows indicate relatively rapid rate of succession from one stage to the next. Double-lined boxes represent the most commonly observed successional stages on that habitat type.

a similar manner as their respective forest cover types. When stands other than those designated for big tree silviculture are marked or designated for cutting, the risk and vigor of the individual big tree species within the stand must be considered in relation to the cutting cycle. For example, individual white pines scattered through an aspen (*Populus* sp.) stand that is designated for harvest can be viewed in relation to their ability to remain through the next aspen rotation without undue loss or degeneration.

MANAGEMENT GUIDELINES

The following guidelines govern the marking and harvesting of forest cover types under big tree silviculture management:

1. Risk and Vigor

   The health (risk and vigor) of individual trees will govern the determination of which trees are to be removed from the type. Diameter breast height (DBH) is not to be used as a factor in determining which trees to mark. Timber management guidelines that specify a maximum diameter based on economic relationships are not employed in big tree silviculture types.

2. Thinning Cycle

   The time between harvests is approximately ten years for even-aged types and ten to fifteen years for all-aged types. Consideration can be given to shortening the cutting cycle in young stands and extending the cutting cycle in older stands to lessen the impact on residual timber and aesthetic quality.

3. Residual Basal Area Levels

   The residual basal area levels for thinnings in even-aged types can be lower than the usual basal area levels used to achieve maximum timber production. Lower basal area levels in big tree silviculture types will help to achieve larger diameter growth in a shorter period of time.

   Even-aged types should be marked to a basal area level approximately 20 square feet lower than normal timber management levels, but no lower than the B-curve level on the stocking chart for the managed species or cover type (Benzie 1977, Erdmann 1986, Philbrook 1973, Sander 1977, Tubbs 1977).

   All-aged residual basal area levels should be 10-20 square feet below normal timber management basal area levels.

4. Regeneration Cutting

   Regeneration cutting of even-aged big tree silviculture types will be determined by the risk and vigor of the stand as a whole as it approaches biological maturity on that site. No firm rotation age can be prescribed because of stand variation in the site quality-rotation age relationship.

DISCUSSION AND CONCLUSION

As the Wisconsin forests mature from a history of disturbance, including logging and fires, our opportunity to manage for large diameter trees increases. Since 1974, Wisconsin has implemented the guidelines of big tree silviculture on state forest lands. Other public forests within the Wisconsin county forest program have implemented these guidelines to meet similar integrated resource management objectives. Public uses on these forests have increased dramatically and are likely to continue to do so.

In meeting some of the aesthetic and recreational demands, big tree silviculture identifies forest cover types on appropriate habitat types where large diameter trees can develop or maintain health and vigor. The habitat classification system provides a basis of decision-making for big tree silviculture, interpreting the site potential and the successional stage of that site by the existing cover type. The ability of forest managers to predict big tree potential, and to sustain big tree cover types, depends on the ecological insight provided by habitat typing.

Although big tree silviculture gives primary attention to the value of aesthetics, harvesting commercial products regularly occurs with management modifications generally using an individual selection harvesting system. These modifications recognize that rotation ages for stands may be greatly extended. The time between thinning intervals can be increased, limiting the physical and visual disturbance of logging. Thinning of stands may reduce stocking levels below normal thinning guidelines to enhance diameter growth. Marking criteria, or the selection order of tree removal, will not use diameter as a criteria for removal. These thinnings require stocking levels to maintain full site utilization.

There has and always will be social, economic, and biological appreciation attributed to big trees. The implementation of big tree silviculture recognizes the compromise necessary for the integration of these values.

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WHITE PINE: CHALLENGES FOR THE FUTURE

Steven G. Thorne[1]

ABSTRACT. White pine, as a species and as part of a forest ecosystem, is valuable for a wide variety of products and services. These diverse values, together with its affinity for mixed, multistory forests, make white pine particularly attractive for multivalue forest management, and as a result, to a broad and diverse constituency. The primary challenge for the future is to energize this natural constituency for effective, concerted support of a comprehensive regional white pine restoration and management project.

INTRODUCTION

The previous papers have painted a series of vivid pictures of the ecological, social, and economic characteristics and values of white pine. These pictures show a species that is characterized by great diversity through time and space. In fact if I were to choose one word to describe eastern white pine, it would be "diversity." The remarkable diversity of attributes and values of this species offers unique opportunities for increasing the quality, quantity, and distribution of white pine in the forests of North America. What follows is my attempt to identify these opportunities and to suggest some possible strategies for exploiting them.

A STUDY IN DIVERSITY

Eastern white pine expresses diversity across a number of different continuums. For example, it succeeds in a variety of soil, moisture, and temperature regimes, from rocky ridges through old fields to peat bogs. It grows in everything from pure stands to stands in which it is only a minor component. In mixed stands it associates with many different species from aspen/birch to oak/hickory. White pine also flourishes in a variety of physiographic regions from the Maritime Provinces south to the Great Smoky Mountains and west to the edge of the Great Plains (Harlow and Harrar 1968). Part of its adaptability, as Lee Frelich reminds us, is a result of its moderate shade tolerance, which allows it to survive in a range of light conditions, and its long life span and fire resistance, which allow it to take advantage of changing stand conditions over time.

As a timber resource, white pine has gone from boom to bust and currently contributes only slightly to the forest products economy of North America, even though with its impressive growth rate the volume of growing stock has been steadily and substantially increasing (Spencer and Leatherberry 1992, Wharton and Powell 1986). White pine is suitable for a wider variety of uses than almost any other North American softwood, everything from structural timbers, to millwork, furniture, novelties, and pulp (Howard 1986, Schuman 1986). The lumber industry of the late nineteenth century was based on white pine, which continued to dominate the softwood lumber market until about 1900, and the farms, factories, and cities of the East and Midwest were built largely of this strong, easily-worked wood (Williams 1989).

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Today, however, white pine sawtimber is only regionally important. Nationally, white pine and red pine combined account for no more than 1.6 percent of the softwood sawtimber harvest (Marty 1986), which is even less than one might expect given that they comprise about 3 percent of the net volume of softwood growing stock in the United States (USDA Forest Service 1990). White pine exploitation in Canada followed a similar historical pattern with similar results (Wray 1986). Nevertheless, according to Dan Chappelle, the return on high grade white pine sawlogs is good and getting better, making white pine management an increasingly attractive opportunity.

Timber production is only one of the many values of white pine. Its scenic, spiritual, recreational, and ecological values are also significant. White pine is the largest and longest-lived softwood species in eastern North America with a maximum age, diameter, and height of perhaps 500 years, 6 feet and 220 feet respectively (Harlow and Harrar 1968). Its size and growth form combine to make it one of the most strikingly beautiful and impressive trees in the forest. I know that all of us can easily call to mind a vision of the clean trunks of ancient white pines soaring above the canopy of lesser trees beneath them, their distinctive, feathery outlines silhouetted against the horizon.

As Michael Williams explains in his paper *The Role of Forests in North American Society* and in his classic book *Americans and their Forests* (Williams 1989), we have always invested forests with moral and spiritual meaning. At various times in our history, we have viewed forests as places of evil and dread and as sources of divine inspiration. Whatever your philosophical viewpoint, it is clear that the vast "forest primeval" of eastern North America, of which white pine is a powerful symbol, has evoked strong emotional reactions throughout our history and, as Herb Schroeder's paper highlights, has created a mythology that has become part of our common cultural heritage.

In part because of the emotional and spiritual renewal Americans and Canadians draw from their forests, and in part because of the more prosaic effects of economics and demographics, the period since the end of World War II has been characterized by a phenomenal growth in forest recreation. As an urbanized, wealthy, and environmentally sensitive populace has turned in larger and larger numbers to the forests for recreation, they have begun to demand not only facilities like campgrounds and trails but also landscapes that match their aesthetic ideal of what forests ought to look like. Summarizing the research on aesthetic preferences in a recent article, Mark Brunson and Bo Shelby of Oregon State University conclude, "Studies have generally found that mature forests are preferred over young ones, 'natural looking' stands over those with obvious human impact, and partial-cutting techniques over clearcuts" (Brunson and Shelby 1992).

Of course, that conclusion merely validates what everyone here knows intuitively, but it is worth mentioning because it highlights how important white pine is as part of the recreational setting. There can be no doubt that the existence of large, old pines in Voyageurs National Park, The Boundary Waters Canoe Area Wilderness, or the St. Croix National Scenic Riverway are among the major attractions of these internationally significant areas. In addition, the shelterwood techniques described by Fred Pinto and Marshall Pecore make white pine particularly attractive for integrating recreation and aesthetics with timber production.

White pine also provides valuable ecological services by itself and as part of a diverse community of plants and animals. Dr. Lynn L. Rogers describes the important role supercanopy white pine play as refuge trees for black bear cubs and nesting sites for eagles. Janet Green emphasizes that, while white pine is important for particular species of animals, the diversity of species and structure that is so characteristic of many white pine forests is even more important.

This leads us back to my initial point about diversity: white pine is defined by the diversity of its values. This creates some unique opportunities.

AN OPPORTUNITY FOR MULTIVALUE MANAGEMENT

During the past few years, resource managers, environmentalists, the forest products industry, recreationists, the tourist industry, and a host of other interests have been at odds more and more frequently as competing demands on our forests have multiplied. Critics have claimed that the old multiple use forest management model or "paradigm" is a failure and that a new paradigm is emerging that focuses expressly on protecting ecosystems, that is integrative rather than reductionist in its approach, that speaks in terms of values rather than uses, that treats commodity and noncommodity values equally and that is grounded in a broader concept of sustainability than sustained yield. Many different terms have been suggested to describe this new paradigm; ecosystem management, integrated resources management, new forestry, holistic forestry, multivalue management, and multiresource management, among others.

An intense debate is raging within the natural resource management professions about whether these concepts really define a new paradigm or are just a gloss on the still-sound principle of multiple use. Whether you believe that this change is evolutionary or revolutionary, it is clear that change is occurring. I have chosen to use the term "multivalue management" to emphasize that these emerging natural resource management trends are creating an important opportunity to build a broad-based consensus to pursue an energetic, creative white pine restoration and management program.

These trends have come together in a shift "toward concern for the whole forest and its diverse values" (Holmes and Coufal 1991) and toward the "least cost, simultaneous production of several interdependent and useful substances and services" (Behan 1990). An essential component of this shift has been an emphasis on conserving biodiversity (SAF 1991). As we have seen, white pine ecosystems tend to be biologically diverse, and they can be managed in mixed, multistory stands to provide a variety of products and services on a sustainable basis.

The growing acceptance of the principles of multivalue resource management, therefore, should increase interest in and support for white pine research and management. I think that the content of this symposium and the breadth of interests represented by the speakers and the audience are strong support for this proposition.

OBSTACLES TO EXPANSION OF WHITE PINE MANAGEMENT

If white pine is such a valuable species, why has it not been given greater management attention? Other symposium contributors discuss a number of obstacles to the expansion of white pine management programs. Al Jones does a fine job of cataloguing them in his paper, *The Problem with White Pine*, but he also makes the point that none of them are insurmountable. Management techniques have been developed that can reduce damage caused by blister rust and white pine weevil to acceptable levels, and according to Richard Meier, tree improvement programs show promise of creating blister rust resistant planting stock. Management techniques used to control white pine weevil and blister rust may increase the potential for serious gypsy moth defoliation in understory white pine, but Steve Katovich is optimistic that this "no-win" situation can be avoided by careful manipulation of the overstory. Establishment of white pine also has been identified as a problem, but Marshall Pecore, Craig Locey, and Fred Pinto explain how it too can be managed effectively.

These problems can all be overcome, but they require active, relatively intense management, and management is costly and increasingly controversial. This is probably the fundamental "problem with white pine." Many of our white pine ecosystems have been so disturbed and degraded by decades of careless exploitation and neglect that the natural processes that created and sustained them over the past 7,000 years are no longer able to repair the damage without significant, ongoing human intervention.

If we are to restore white pine to a more significant place in our forests, we must develop, fund, and implement a long-term, region-wide white pine restoration and management program. This will require interest, commitment, coordination, and funding at levels that have not existed in the past.

Until recently, white pine restoration and management commanded relatively little attention in the forestry community. So far as the forest products industry, forest landowners, and public forestry agencies were concerned, the relatively high cost of white pine management was rarely justified by the return on investment. Except for high quality logs, markets were limited and prices were low. In any event, as John Spencer tells us, growth was considerably greater than drain, so it was hard to justify increased management expenditures.

Environmental and conservation groups also were uninterested. They were too occupied with preserving the few remaining large tracts of old growth white pine by creating parks and wilderness areas to have any time for the even more complex task of dealing with white pine ecosystems on a regional scale. Moreover, many environmentalists viewed active forest management as part of the problem and favored preservation as an alternative.

Times have changed. There is renewed interest in white pine for timber production. The supply of cheap western softwoods is rapidly declining; western pine prices are increasing (USDA Forest Service 1990). Eastern white pine production and prices are on the upswing. Although the area of the white pine type in the Lake States is up substantially, John Spencer warns us that there is a disturbing scarcity of sapling - seedling stands that may point to a future decline of the type. At the same time environmentalists and natural resource managers have begun to turn their attention from protecting places to managing whole ecosystems to preserve biodiversity and other ecological services. A new commitment to management is the common denominator. As a result, the time may be right to forge an effective coalition among these various interests in support of a white pine restoration and management initiative.

A PROPOSED WHITE PINE MANAGEMENT AND RESTORATION INITIATIVE

The ideas and information brought together and presented by this symposium will undoubtedly increase interest in white pine restoration and management. They may even stimulate some organizations to undertake or expand their efforts in this area. Those would be important accomplishments, but I think we should do more. If I am right in concluding that we are faced with an unprecedented opportunity to build a broad-based constituency for white pine restoration and management on a region-wide basis, the biggest challenge for the future is how to turn that opportunity into reality.

This is unlikely to happen unless a group of committed people take responsibility for making it happen. The cause of white pine restoration and management needs a coordinated effort to increase its visibility, to move it up the priority lists of the various agencies, groups, and institutions, and to make it possible to manage on a regional scale. Most of the people who can begin to make that happen are participating in this symposium, and I would like us to leave with a common resolve to get on with this task and with an endorsement for a representative group to meet and draft a proposal for a coordinated, interdisciplinary, international, region-wide white pine restoration and management project.

The proposal should address the full range of white pine issues, values, and interests, and it should include recommendations on project organization and participation, goals, objectives, content, regional scope, and funding. It should also include strategies for involving and gaining the support of key interests in the public and private sectors, and it should consider the full range of tools available, including research, management, and education. A draft should be circulated for review and comment by symposium participants and other appropriate individuals and organizations. Early support for the concept should be sought from provincial, state, federal and other public agencies, from universities, from industry, and from major environmental groups such as The Nature Conservancy, which has a particular interest in biodiversity conservation and sustainable development.

This will not be an easy task. There may be apprehension within some segments of the forest products industry that more white pine may reduce the supplies of other important commercial species, but that can be addressed relatively easily in the planning phase of the project. There certainly will be disagreements over reservation of some of the remaining old growth and over the intensity and kind of management that should be applied to white pine forests. Past distrust among some of the participants may lead to misunderstandings like the current fight over "bioregional" planning for the Sierra Nevada mountains in California (Buckley 1992). Nevertheless, I believe the realization by all parties that management of white pine for a variety of values is the only way of expanding and improving the white pine type will lead to a workable consensus.

This general approach is hardly unprecedented; in fact, it has been successfully applied to other regional natural resource management issues. The Northern Forest Lands Project in New England and New York is one well-known example. This project arose from a concern that the large private timberland holdings of the region were in danger of being broken up and converted to non-forestry uses thus causing significant disruption to local timber dependent economies and the possible "loss of the lands as traditional open space for the public to hunt, fish and recreate on" (Northern Forest Lands Council 1991). This threat mobilized broad support in four states and resulted in the federally funded Northern Forest Lands Study, which was prepared by the United States Forest Service in cooperation with the Governors' Task Force on Northern Forest Lands. In addition, the task force prepared its own report that included 28 potential strategies for addressing the problem (The Governors' Task Force on Northern Forest Lands 1990). As a result, in the 1990 Farm Bill Congress appropriated $1.075 million for the Northern Forest Lands Council to continue the work begun by the study. The Interior Appropriations bill approved by the House Appropriations Committee on June 29, 1992, includes another $1.165 million for Fiscal Year 1993 (Land Letter, July 1, 1992).

The New Perspectives Program of the United States Forest Service (soon to be known as "Ecosystem Research and Management Program") is the source of several good examples of ecosystem management projects. These include the Blue Mountains Natural Resources Institute, the Olympic Natural Resources Center, the Cascades Center for Ecosystem Management, and the Copper River Delta Institute.

The Blue Mountains NRI, which was formed in 1990 to deal with such problems as forest health, biodiversity conservation, anadromous fisheries, and the welfare of timber dependent communities east of the Cascade Crest in Washington and Oregon, is particularly interesting. It is governed by a board of directors that includes representation from the full spectrum of forest management interests. Its stated purpose is "to enhance the long-term economic and social benefits from the area's natural resources in a way that is ecologically sound," as a goal it intends to achieve through "research, development, application, and education" (Blue Mountains NRI 1991). More specifically:

> Research into ecological, economic, and social interrelations will provide people with knowledge about impacts and trade-offs that result from management decisions and public policies. This information will be used to develop management strategies and technology to apply them. Demonstration areas will validate and showcase applied management strategies. An adaptive team will work with extension agents, land managers, landowners, university students, and the public to facilitate rapid transfer of information from researchers to user information (Blue Mountains NRI 1991).

Many of the ideas generated by projects like these two examples could be applied to restoring and managing white pine ecosystems. In addition, existing grant programs should be evaluated as possible sources of funding for a white pine project. Consider the Forest Legacy Program, another product of the 1990 Farm Bill. It seems to be tailor-made for innovative federal-state-private efforts to conserve forest ecosystems. The law states that the program is to be established:

> for the purposes of ascertaining and protecting environmentally important forest areas that are threatened by conversion to non-forest uses, and, through the use of conservation easements and other mechanisms, for promoting forest land protection and other conservation opportunities. Such purposes shall include the protection of important scenic, cultural, fish, wildlife, and recreational resources, riparian areas, and other ecological values [16USCA Sec. 2103(c), subs.(a)].

Although the initial application of this program is for the purchase of conservation easements to protect timberlands in the Northern Forest Study Area (the Fiscal Year 1993 House Appropriations Bill includes $5 million for this purpose), the Secretary of Agriculture is directed to establish additional Forest Legacy programs in the Northeast, Midwest,and other regions [16USCA Sec. 2103(c), subs. (d)(2)].

Three other programs administered by the USDA Forest Service, State and Private Forestry, are also worth looking into as potential funding sources: (1) Economic Well Being (through forestry); (2) Focusing of Federal Assistance; and (3) Forest Stewardship. A multi-state request for project organization and planning would seem to be consistent with the guidelines for either of the first two programs (USDA Forest Service 1992). On the other hand, developing informational materials and providing training to landowners on appropriate white pine management practices seems like a good use of stewardship funds.

Of course, the federal government is not the only possible source of funds for the development and implementation of a white pine restoration and management project. The elements of biodiversity, sustainable development, and cooperation among government, business, and environmentalists ought to make it attractive to state agencies and private foundations as well.

In summary, a regional white pine restoration and management project could take advantage of the foundation laid by other regional natural resource management projects. It also would be well-positioned to compete for funding from various sources. The first steps are to better define the project, to build consensus and support, and to secure planning funds. A work group should be established to begin this task. One possibility would be for the symposium steering committee to form the nucleus of the project work group and to invite additional participation. As part of its extension activities, the University of Minnesota might continue to provide coordination and staff support on a temporary basis.

CONCLUSION

White pine provides a multitude of benefits; economic, aesthetic, spiritual, recreational, and ecological. Because of these diverse values, and because it lends itself to management in mixed, multistory stands, it is peculiarly suited to multivalue forest management. This has created an opportunity to develop a broad-based consensus in favor of expanding the quality, quantity, and extent of white pine in our forests. Our biggest challenge is to turn this opportunity into real change on the land, not just locally but regionally.

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HOW MUCH AIR POLLUTION INJURY IS THERE ON EASTERN WHITE PINE?

James P. Bennett, Robert L. Anderson, Manfred L. Mielke and James J. Ebersole[1]

This report contains a thorough review and critical evaluation of field surveys from 1900 to the present of foliar injury to *Pinus strobus* supposedly caused by air pollution. Most surveys failed to meet current scientific standards of acceptability. Data were obtained from the few that met screening criteria and injury incidence and severity were mapped. Three fourths of the counties in the natural and planted range of eastern white pine have not been scientifically surveyed.

Air pollution injury surveys of eastern white pine have not been presented well or conducted scientifically. Almost three fourths of the 93 reports we evaluated have not been peer reviewed. Likewise, random sampling of trees was not used in almost three fourths of the surveys. Most of the surveys did not sample enough trees to detect even a 50 percent incidence level with 95 percent confidence. In addition, about three fourths of the surveys were not far enough away from roadsides to avoid road effects. Three fourths of the surveys did not use quantitative methods to estimate severity of injury. Possibly as many as two thirds of the surveys used plantations or stands where trees may have been predisposed to injury. Stratification of trees by age class is also not used by three fourths of the surveys. Almost half of the surveys used the chlorotic mottle symptom, probably because foliage was examined in the hands.

The available historical survey data of air pollution caused foliar injury on eastern white pine are geographically insufficient or methodologically flawed to such an extent that conclusions regarding spatial patterns of white pine foliar pathological conditions were not possible. Peer review of surveys has been poor: we are only about 50 percent confident that the correct injury is being identified and that the surveys were conducted scientifically. However, recent growth and inventory data indicate that growth throughout the natural range regardless of air pollution or other stresses (e.g., blister rust) is excellent, suggesting that regional performance and foliar conditions are unrelated. Sufficient compelling corroborative evidence was found to conclude that a general decline of white pine throughout its range is not a tenable finding.

The putative air pollution sensitivity of eastern white pine appears to be based on studies published between 1963 and 1973 on hypersensitive individuals that are no longer being reported in the field. Current researchers working on eastern white pine have noted lack of sensitivity and/or high variability of response in more recent publications. The notion that eastern white pine as a species is highly sensitive to air pollution is not supported by the available evidence. Instead, hypersensitive juvenile individuals apprising no more than 8-9 percent of the total population probably germinate and grow for a brief period of time (because old enough parent trees still occur), but soon succumb to current levels of ozone and sulfur dioxide in the environment or are suppressed by tolerant neighbors. Mature hypersensitive individuals are not being reported in the field. This pattern has been documented at least anecdotally and is more aptly called tree decline as opposed to forest decline. We propose as a working hypothesis that sufficient time has elapsed for this process to occur to such an extent that the elimination of sensitive genotypes from population has taken place.

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GREENWOOD LAKE WHITE PINE RESEARCH AND EDUCATION AREA

Willard H. Carmean[1]

The Greenwood Lake old-growth White Pine Forest is part of an approximately 500 ha reserve located in northwestern Ontario. Quetico Park is about 16 km west of the area, and the northern edge of the Boundary Waters Canoe Area is about 24 km to the south.

This is an almost pure, well-stocked white pine forest that is about 300 years of age. Many trees exceed 90 cm in diameter with clear boles extending up to 18 to 21 m. These large pine have developed in a dense closed canopy, and they are not the rough open-grown tree often found in poorly stocked areas. No past disturbance or cutting is evident, and biodiversity is favored by frequent standing snags and down logs that provide a variety of microhabitats. Soils are developed from a strony glacial till capped with a loamy surface soil indicating possible loess origin. Such deep, moist, well-drained soils result in excellent growing conditions (site quality) for trees thus accounting for the impressive tall trees with large diameters and long clear boles.

The Ontario Ministry of Natural Resources recently recognized the Greenwood Lake Forest as a "Research and Education Area". This reserve is on Crown land and is a part of the FMA (Forest Management Agreement) between the Ministry and Canadian Pacific Forest Products Limited. An Advisory Committee composed of Ministry and industry foresters, university foresters and biologists, and members from conservation organizations will recommend policies and programs for the area. Plans are to maintain the area as an undisturbed forest for research and educational purposes. Research guidelines are being developed for ecological, forestry, and wildlife studies. The area also is available for educational purposes for university and high school students and for conservation groups.

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GENETIC EFFECTS ON IN VITRO ADVENTITIOUS SHOOT REGENERATION OF EASTERN WHITE PINE (PINE STROBUS) EMBRYONIC COTYLEDONS

Anita R. Foss, Don E. Riemenschneider[1], and John E Preece[2]

Mature seeds from a population of 21 families from a 5 parent diallel mating design, including selfs, were sterilized and imbibed 72 hours in 1 percent H_2O_2. Excised embryos were cultured upside down 2 weeks on Schenk & Hildebrandt basal medium (SH) that contained 1 mg/L 6-benzylaminopurine (BA), in the light or dark. Then, cotyledons were excised and cultured in the light on SH without BA, and transferred every 4 weeks. Number of shoots at week 2, 4, 8 and 12 was counted and fresh weight of the shoot cultures recorded at week 12. Families differed in rate of shoot regeneration, indicating significant genetic effects. Inbred (S1) families differed in regeneration ability and produced fewer shoots than outcrossed families from the same parent. Reciprocal effects were significant. Treatment x family interactions were not significant except at week 8. Histological analyses of cotyledonary explants showed that a 2 week BA exposure induced meristematic activity in the subepidermal layer that organized into promerestemoids, precursors to shoot regeneration. Overall, the results of this study suggested that selection for high regeneration rates of adventitious shoots was possible with eastern white pine but that complex inheritance would need to be considered.

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WHITE PINE: EVALUATION OF SITE CONDITIONS RELATED TO BLISTER RUST HAZARD

Alan C. Jones[1]

Because microsite conditions play an important role in the incidence and severity of white pine blister rust, a study was undertaken to identify microsite conditions in Minnesota which tend to lead to a higher incidence and severity of blister rust. By identifying significant microsite conditions, planting guidelines can be developed to identify sites less hazardous from white pine blister rust.

Site conditions identified for each white pine stand evaluated included blister rust hazard zone, site index, overstory characteristics and composition, understory characteristics and composition, topography, slope, aspect, proximity to water, the presence or absence of *Ribes* spp., and soils. Height, DBH, and stocking of the white pine component of the stand were recorded.

In each stand 50 trees were randomly selected and evaluated. Individual tree evaluation included the number of fatal cankers (cankers on the stem or within 3 inches of the stem), the number of lethal cankers (branch cankers beyond 3 inches from the stem but less than 10 inches), the number of nonlethal cankers (branch cankers beyond 10 inches from the stem), the average height of canker (>9 feet or <9 feet), and the presence or absence of weeviling.

110 stands and approximately 5,500 white pine were evaluated. Evaluation results and site recommendations will be presented during the poster session.

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The following MN DNR personnel assisted in collecting and evaluating the data for this study: Jerry Hecht, Mike Carroll, Mike Albers, Jana Albers, Ed Hayes, Olin Phillips, and Chung-Muh Chen.

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VARIABILITY IN RESPONSES OF EASTERN WHITE PINE TO OZONE

David F. Karnosky[1], J.G. Isebrands[2], Z.E. Gagnon[1] and R.E. Dickson[2]

Eastern white pine (*Pinus strobus* L.) has long been described as sensitive to ozone. Recently, however, several researchers have suggested that the species is ozone tolerant. Because of its importance as a forest resource throughout much of the eastern half of the United States, we believe that it is important to better characterize eastern white pine's ozone sensitivity.

For the past two years, we have been examining the growth responses of young, potted eastern white pine seedlings exposed to concentrations of ozone. Recently, we have established eastern white pine seedlings from a pristine area (western Upper Peninsula of Michigan) and a polluted area (northern Ohio) in a field plantation to examine the long-term responses of eastern white pine seedlings to ozone, alone and in combination with elevated CO_2. Our preliminary results suggest that: (1) the species is highly variable in ozone sensitivity and (2) there are ultrasensitive individual genotypes that are as ozone sensitive as any known agricultural plant.

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REGION 6 WHITE PINE BLISTER RUST RESISTANCE PROGRAM - DIVERSITY THROUGH TREE IMPROVEMENT -

Dorena Tree Improvement Center
Umpqua National Forest
Joe Linn, John Petrick, Rob Mangold[1]

Our mission is to preserve and restore white pine and sugar pine as viable components of Northwest ecosystems through disease-resistance breeding.

Western white pine and sugar pine are highly-valued conifer species, occurring in mixed conifer stands and are important components of the ecosystem. However, both species have been greatly impacted due to mortality caused by white pine blister rust, a stem canker disease. This pathogen was introduced from Europe around 1910 on nursery seedlings and spread rapidly throughout the Northwest. The use of white pine and sugar pine for reforestation in the Pacific Northwest has been greatly reduced because of problems caused by blister rust. Our ability to use these species for reforestation is important for the added diversity they provide, as well as their usefulness in root-rot areas, cold pockets and droughty sites.

Healthy-looking western white and sugar pine trees, selected within the Pacific Northwest Region, are screened for rust resistance at the Dorena Tree Improvement Center on the Umpqua National Forest. The initial phase of testing is nearly complete and screening of second generation material is under way. More than 10,000 white pine and sugar pine families have been screened at Dorena and approximately 2800 families have shown some level of resistance to blister rust.

Seventeen western white pine and sugar pine seed orchards are being established in their respective breeding zones throughout Region 6 using vegetative cuttings from the tested, resistant progeny. In the interim, until orchards provide seed, field collections are being made from tested parent trees. Dorena Tree Improvement Center is working closely with customers in deploying seed properly by helping match the resistance level of the seed with the rust hazard of the out-planting site.

Through selective breeding and testing, Region 6 is producing disease-resistant white pine and sugar pine that are being used throughout the Pacific Northwest. The level of resistance has a broad genetic base and should be stable enough to protect these species from more virulent strains of the fungus. This program is an example of the Forest Service's efforts to help retain species diversity through tree improvement.

[1]Dorena Tree Improvement Center, 34963 Government Road, Cottage Grove, OR 97424.

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SIZE CLASS DISTRIBUTION AND FLORISTIC DIVERSITY OF AN OLD GROWTH WHITE PINE FOREST IN NORTHWESTERN ONTARIO

A.U. Mallik[1]

Fully stocked old growth white pine forests are rare in Ontario, particularly in the northwestern part of the Province. Recently such a forest containing large trees, covering an area of 125 ha was identified in the Greenwood Lake area, 16 km east of Quetico Park. The forest was declared as a research and education area by the Ontario Ministry of Natural Resources.

Understanding of the self sustaining ability of old growth natural forests and their biodiversity is of fundamental importance. However, our knowledge base is very limited in this regard. In the summer of 1992 a study was undertaken to determine the size class distribution of the old growth white pine forest and its floristic diversity. The present poster will summarize the preliminary results of the study. The dbh of the oldest trees of the forest varies between 90 and 110 cm and they are over 300 years of age.

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KAWISHIWI TRIANGLE TIMBER SALE

Minnesota Department of Natural Resources -- Orr Forestry Area[1]

The Kawishiwi Triangle timber sale was sold by the Minnesota Department of Natural Resources (DNR) to Hedstrom Lumber Company in 1989. Public objections to the harvest of the pines surfaced shortly afterwards.

To address concerns over thinning a potential old growth white pine stand and maintaining the visual quality along a recreational trail in the sale area, the DNR worked with environmental groups and Hedstrom Lumber to redesign the timber sale.

Harvest regulations and regeneration plans were prepared for a variety of individual sites in the redesign; this poster depicts how the sites looked before and after the harvest. During the 1991-1992 winter, 650,000 board feet of pine and over 400 cords of pulpwood species were harvested from 148 acres in this sale.

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IN VITRO STUDIES OF ADVENTITIOUS SHOOT FORMATION IN PINUS STROBUS

Paula M. Pijut, Charles H. Michler, and Therese M. Voelker[1]

Pinus strobus (eastern white pine) is an economically important conifer species in the northeastern and midwestern United States, with value in all areas of forestry including recreation, timber, and wildlife. *P. strobus* can attain heights of 70 m and stem diameters of 3 m on favorable sites. Before 1900, 50 percent of U.S. lumber revenue was generated from this species. Overlogging, conversion of forest land to agriculture, and pests such as white pine blister rust, white pine weevil, and grazing by deer have contributed greatly to the decline of the white pine population. Interest in planting white pine is increasing in the northeast and the Lake States. Reforestation with white pine has been limited because of few pest resistant genotypes and unreliable vegetative propagation methods. Development of *in vitro* propagation methods would improve vegetative propagation and facilitate application of biotechnological methods such as somaclonal selection and genetic transformation to develop new genotypes with enhanced tolerance to damaging agents.

The effect of explant orientation and cytokinin type and concentration on adventitious shoot initiation on embryo explants was examined. Mature seeds were surface sterilized in 25 percent Clorox for 25 minutes, rinsed three times in sterile, distilled water, and imbibed for 72 hours in 1 percent hydrogen peroxide at 26°C in darkness. Seeds were re-sterilized following imbibition. Zygotic embryos were excised from the surrounding gametophytic tissue and cultured on a modified Schenk and Hildebrandt (SH) medium supplemented with 30 g/l sucrose, 0.8 percent Difco Bacto agar, and growth regulator treatments [thidiazuron (TDZ) 0-22 mg/1; zeatin 0-50 mg/1; benzyladenine (BA) 0-10 mg/1]. Embryos were placed in seven different orientations, including vertical and horizontal placement either on the surface or submerged into the medium. Cultures were incubated under an 18/6 hour photoperiod (125 $uE/m^2/sec^1$) in a growth chamber at 26°C.

Cytokinin had the greatest effect on percent responsive embryos, with BA inducing more growth than either zeatin or TDZ. Higher concentrations of BA increased shoot production, but reduced shoot elongation. The best response for shoot initiation and shoot length was observed with 0.1 mg/1 BA. In orientation experiments, vertically placed embryos with only the cotyledons submerged into the medium produced the greatest number of shoots per explant. Completely submerged embryos failed to produce adventitious shoots. These results will improve methods for shoot elongation and root regeneration of eastern white pine.

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