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The Maturing Lake States Forests: A Growing Policy Dilemma

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INTRODUCTION

The forests of the three Lake States—Michigan, Wisconsin and Minnesota—have been steadily accumulating wood and other biomass for over fifty years. They are a rapidly maturing timber resource as witnessed by the fact that many stands once again support sawtimber-size trees. Extensive areas of mature aspen, jack pine and birch are deteriorating with age and may soon convert to other forest types. A central policy dilemma is, "Should the cut be increased sharply to maximize the harvest of wood for a large and growing regional forest products industry, and to provide the growing population with the general economic benefits that the forest could sustain; or should more of the once heavily exploited and depleted forest be maintained for aesthetics, recreation, wildlife habitat and biodiversity?" In either case, the economic and ecological characteristics of our forests are changing rapidly in unstoppable ways and will continue to do so.

What I intend to do in the next fifty minutes or so is to contribute to this policy debate by presenting one view of the Lake States forests as they exist today and the changes they are undergoing. Detailed information on the data sources on which the following discussion is based can be found in Appendix A.

LAND AND FOREST AREA

Glaciers and water are responsible for most of the geological features of the Lake States region. All but a small part of the region's landscapes were glaciated at one time and shallow soils and bare rock still show the scars left by advancing and retreating glaciers. The tens of thousands of lakes, ponds and bogs are divided by glacial ridges or moraines, and the many swampy sites indicate poorly developed drainage systems. Variety is a key characteristic of such a geologically young area.

The rich and varied forest cover of today traces its foundations to the last ice age. These forests reflect both the geological history of the region as well as ecological processes (Stearns, 1994). Superimposed on these patterns are the results of human actions which have added new dimensions to the changes that are taking place in the Lake States forests.

The Lake States include 160 million acres, of which 122 million acres are land and 38 million acres are water. Forests cover approximately 50 million acres and provide the region with a large scenic, recreational, economic and industrial resource base. Forests provide habitat for a rich variety of wildlife; space for recreation of many forms; a large watershed that replenishes thousands of streams, inland lakes and the Great Lakes; and an increasing flow of wood to supply a growing forest products industry.

Forest land changes—Four out of every ten acres are forested in the Lake States. Although the total land area classified as forest declined by about 4.7 million acres between 1952 and 1992, the area of forest land stocked with trees increased. The standard definition of "forest" used in forest surveys includes land that formerly supported tree cover and is not currently developed for nonforest use. In 1952 some 10.4 million acres of this idle land was classified as nonstocked timberland; today just 790 thousand acres are nonstocked. The latest surveys in Wisconsin and Minnesota reveal continued increases in the area of forestland and preliminary data for Michigan show a similar trend. These changes attest to the effectiveness of past reforestation efforts and the natural resiliency of the regeneration process.

Michigan is the most heavily forested state (over half), and Minnesota the least (about one-third). Both Minnesota and Wisconsin extend into the prairie region along their western and southern borders, and tree cover there is limited to the moister sites. As a general rule, forest area increases as one moves from south to north across the region and from southwest to northeast in Minnesota and Wisconsin.

Most forestland is classed as timberland, which is defined as forest that is available for logging and is fertile enough to grow timber of industrial quality. Minnesota and Wisconsin each have just under 15 million acres of timberland while Michigan has about 17.5 million acres. The portion of land that is forested varies widely by forest survey unit, but the southern units tend to have a much sparser forest cover.

The area of reserved forest; that is, forest land that is withdrawn from timber production, more than doubled over the 1952–92 period. Much of the reserved forest land is contained in the Voyageurs National Park and the Boundary Waters Canoe Area in Minnesota, the Apostle Islands in Wisconsin, and the Sleeping Bear National Lakeshore in Michigan.

The dominant forms of land use in the Lake States are farming and forestry, and there is an inverse relationship between the two. Each time the markets for agricultural commodities strengthen, additional land is converted to agriculture. A reverse flow of land from farms to forest occurs when agricultural markets collapse.

Forest ownership—Michigan and Wisconsin forests are approximately two-thirds privately owned and one-third publicly owned. Each of the Lake States has two national forests and all three have national parks. About 5.5 million acres of national forest land, 7.2 million acres of state owned forest land and 4.9 million acres of county owned forest land are spread across the Lake States. The Lake States are leaders in the amount of county and state forest land. However, despite the large areas in public ownership, private landowners control the greatest area of forest land. Farmers and other miscellaneous private owners number about 900,000 individuals and hold 25.2 million acres. Changes in the composition and intentions of this diverse and complex group of owners will in large measure determine the future supply of timber and other benefits from the forests of the Lake States.

Despite the large forest industry in the region, industrial ownership of timberland amounts to just 3.9 million acres, or about eight percent of the total. Industrial ownership was highest in the 1970's, and has declined since then; nevertheless, forest industry continues to own more timberland now than in 1952.

Public forest land occurs predominantly in the northern survey units. For example, two-thirds of the forest in Minnesota's Aspen-Birch unit above Lake Superior is in public ownership. This unit also includes the most area in county and federal forest ownership, and only Michigan's Northern Lower Peninsula unit has more state-owned forest. Conversely, Western Upper Michigan has the largest forest industry holdings—about one-third of the region's total. The largest area of private timberland occurs in the Northern Lower Michigan unit, although the Southwestern Wisconsin unit has a higher proportion of private forest.

Plantinga, *et al.* (1989) examined some of the factors that influence changes in land use and ownership in the region. They concluded that

> Recent demographic data suggest that populations in the Lake States are shifting away from large cities and into rural areas. This change is evidenced most notably in decreases in populations of large urban centers and increases in populations of smaller urban areas. People also appear to be moving to areas which border cities, suburbs, or the metropolitan fringe. Some of this apparent population shift may be due to changes in the definition of urban population, but truly remote and rural areas are also showing population increases (Plantinga, *et al.* 1989, p. 4).

Rural settings and small towns have become more attractive to people. Population shifts have led to changes in forest land ownership, especially transfers from farmers to miscellaneous private owners. For example, between 1968 and 1983, forest land owned by Wisconsin farmers decreased 27 percent, whereas that held by miscellaneous private owners rose 45 percent. Similarly, farmer-owned timberland in Minnesota declined by 34 percent between 1977 and 1990, while timberland held by miscellaneous private owners rose by 68 percent.

The study by Plantinga, *et al.* (1989) did not address the question of how much of this change resulted from farmers selling to nonfarmers and how much was caused by farmers taking up other occupations while retaining ownership of their forest land. The sharp decline in area held by farmers parallels the drop in numbers of farms and farmers. However, the implications of these trends are not clear. Some farmers who enter other vocations continue to own and manage their land as before even though it is no longer classified as farmer-owned, and such changes in ownership category may result in little, if any, change in the extent or quality of forest management.

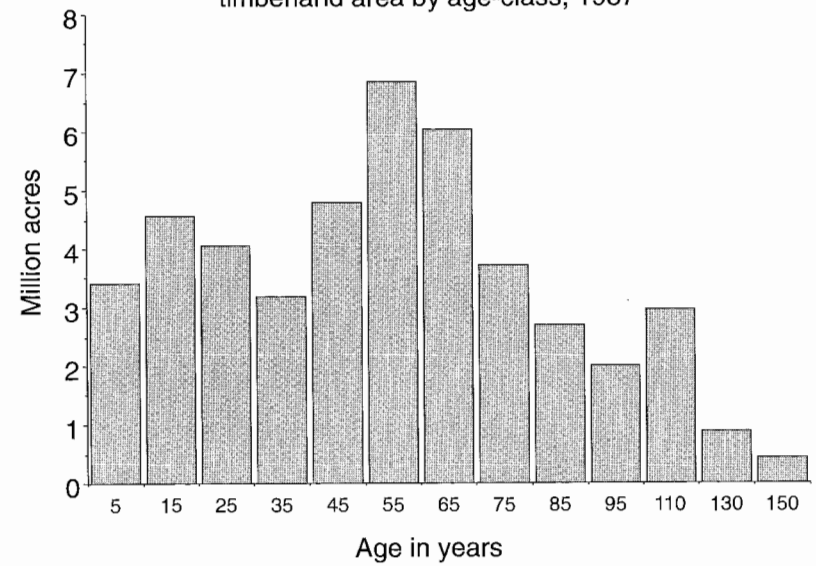
Distribution of forest types—The Forest Service recognizes 14 distinct forest types as occurring within the Lake States. The distribution of timberland by forest type, state, and survey unit illustrates the complexity of the Lake State forests. In descending order of area, the five predominant Lake States forest types are: maple-basswood, aspen, oak-hickory, elm-ash-soft maple and black spruce. Aspen was the leading forest type in all three states for many years, but recently it was supplanted by the maple-basswood type in both Michigan and Wisconsin; in Minnesota, aspen still holds a commanding acreage lead. Indeed, over half of the region's aspen acreage occurs there. Black spruce occurs principally in Minnesota. Michigan has more acreage of northern white cedar than black spruce, whereas Wisconsin has more paper birch than black spruce.

A similar mixture of patterns occurs in the distribution of some forest types within individual states. The northern forest survey units have heavy concentrations of swamp

conifer forest types and most of the pine forest types, whereas the downstate units have much more area in the oak-hickory, maple-basswood and elm-ash-soft maple types.

Distribution of age and size classes—The skewed distribution of age-classes (Fig. 1) is perhaps the dominant characteristic of Lake States forests. Although many of the region's pine forests were logged by the beginning of the twentieth century, serious efforts to protect and regenerate softwood forests did not begin until the 1920's and early 1930's. Extensive logging of hardwoods also occurred about this time and many of today's hardwood stands trace their origins to this period. Nonstocked forest land totaled 10.4 million acres in 1952; it is currently less than one million acres, and the seedlings and saplings that covered another six million acres in 1952 have grown into the poletimber size class.

Figure 1.—Distribution of Lake States timberland area by age-class, 1987



The "regeneration wave" which occurred in the 1920's and 1930's showed up first as a bulge in the area of saplings and seedlings, then in poletimber and now in sawtimber stands. The wave in this forest is so large that it will cause echo waves in generations of forest stands to come, although each succeeding wave will be smaller in amplitude. Stands in the biggest wave are now 55–75 years of age and once again contain large numbers of sawtimber-size trees. Indeed, the acreage of sawtimber-sized stands has nearly tripled in each of the states since 1952, and before the decade of the 1990's is over, half of the region's forests will consist of sawtimber-size trees.

Such a forest is full of promise, but it is also difficult to manage and use. The dimensions and quality of its timber are constantly changing, as is the area of stands ready for harvest. Many stands should be thinned to concentrate growth on crop trees. Large areas of aspen, birch and jack pine are approaching maturity and can be expected to decline or convert to other species if they are not harvested. However,

harvesting extensive areas of mature timber over a short time period could glut existing markets and lower stumpage values.

Changes in the character of the forest will also affect wildlife populations, forest recreation, and water flows. Many of these changes are not widely understood and appreciated. For example, gone are millions of acres of brushy clearings and seedling and sapling stands. In their place now stand hardwood sawtimber stands that are dense, shady, and fairly open beneath the tree crowns. These changes in stand structure, tree size and species mix will favor some wildlife species over others.

THE STOCK OF TIMBER

Biomass—Timber resource inventories are traditionally presented in the form of stand tables showing numbers of trees, and stock tables showing growing stock volumes by species and tree diameter class. Recent forest surveys have also included estimates of woody biomass contained in all live trees and shrubs to help address environmental, ecological, wood fuel and fire risk questions not answerable with information on growing stock volume. Biomass estimates may include foliage, tops, limbs and bark for all live trees and shrubs, but estimates of below-ground stump and root components are not yet available. As a general rule of thumb, about half of the woody biomass in Lake States forests is in the main stems of growing stock trees over five inches in diameter, and another one-fourth is contained in their tops and limbs.

The 1980 Michigan inventory estimated the total biomass of all live trees at least one inch in diameter to be just over one billion tons green weight, or about 60 tons per acre. The biomass of shrubs and trees smaller than one inch in diameter varied widely by forest type, and ranges from as much as four tons per acre in Wisconsin's tamarack type to just a few hundred pounds in Minnesota's white spruce type. Total biomass in Wisconsin forests in 1983 averaged 65 tons per acre and Minnesota's 1990 inventory reported 61 tons per acre.

The *New York Times* reported recently that a Harvard University research team headed by Dr. Steven C. Wofsy had discovered an absorption rate of about 3,500 pounds of carbon per acre per year in middle-aged, temperate hardwood stands at Harvard Forest, Petersham, Massachusetts. At this rate, Lake States forests are sequestering over 88 million tons of carbon annually.

Timber volume—The inventory of timber in the Lake States has been increasing for several decades (Fig. 2). Growing stock volume is defined as net volume of growing stock trees 5.0 inches or larger in diameter, from a point on the bole one foot above the ground to a minimum 4.0 inch top diameter outside bark of the central stem or to a point where the central stem breaks into limbs. Growing stock volume in the Lake States totals 55.2 billion cubic feet, which is more than double what it was in 1952. Of this total, only 16.2 billion cubic feet (29%) is softwood. Growing stock averages 1,173 cubic feet per acre (15 cords) for the region.

Changes in inventories between the last two surveys have been remarkable. For example, growing stock volume increased 22 percent in Minnesota between 1977 and 1990. In Michigan, the percentage increase was even higher: 27% between 1966 and 1980 and 40% between 1980 and 1993. Volume also rose 39 percent in Wisconsin between 1968 and 1983.

Figure 2.—Lake States growing stock volume by state, 1952-92

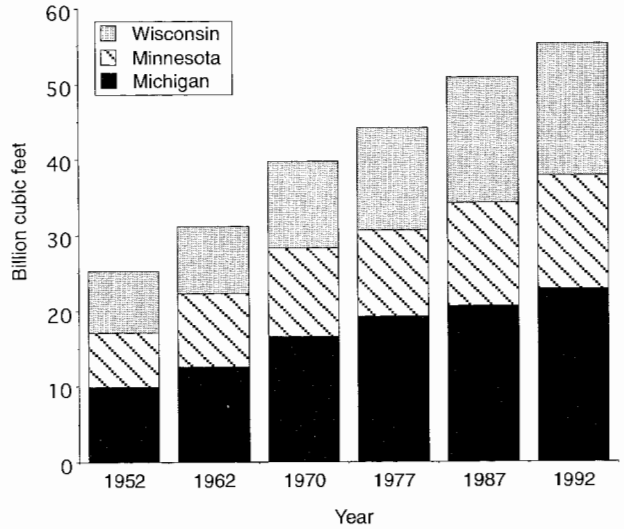
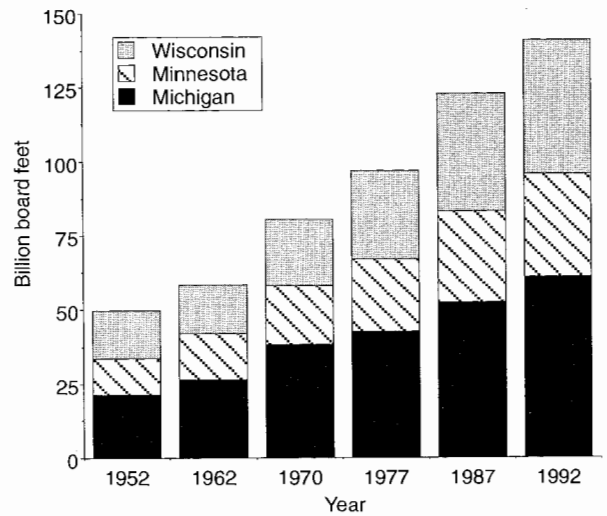


Figure 3.—Lake States sawtimber volume by state, 1952-92



The increase in sawtimber volume is even more striking; the current inventory of 141 billion board feet (Fig. 3) is nearly triple what it was in 1952. Ingrowth is slowing in poletimber but increasing in sawtimber as more and more poletimber trees grow to sawtimber size. Sawtimber volume averages about 3,000 board feet per acre for the

region as a whole, but increases as one moves from west to east across the three states. Minnesota's forests hold 34 billion board feet of sawtimber, Wisconsin's 45 billion board feet, and Michigan's 61 billion board feet. The increase in sawtimber has occurred across all ownerships and in both hardwoods and softwoods. The economic consequences of this change should not be overlooked. Sawlogs typically are worth five to ten times the value of equivalent volumes of smaller products. These gains reflect very large increments in the value of the timber, and I suspect that the value of the trees is often greater than that of the land on which they stand.

Private landowners control the majority of timber volume. The distribution of timber by ownership closely parallels that for forest area, but there is one significant difference. Private nonindustrial landowners control proportionately more hardwood timber volume than forest land area; conversely, proportionally more softwood timber volume lies on public and industrial forests. One reason for this is that conifer species occur more commonly in the northern reaches of the Lake States where public land ownership is also concentrated. The ambitious tree planting programs on public and industry lands in decades past also emphasized softwood species, especially pines.

Although 63 major tree species are native to the Lake States, only a few are important timber species. Aspen comprises about 17 percent of all volume in the Lake States and, together with hard maple, soft maple, red oak, and paper birch accounts for half of the current timber inventory. The three states do differ in the distribution of species, however. Michigan forests are predominantly hard maple but red oak is the leading species in Wisconsin; in Minnesota aspen comprises a larger volume of growing stock volume than the next three species (paper birch, balsam fir, red oak) combined.

Timber growth and mortality—Volumes characterizes the current state of the timber resource, whereas timber growth reflects the underlying additions which shape the future forest. Net annual growth rose from 1,180 million cubic feet in 1952 to 1,508 million cubic feet in 1992. Growth peaked at 1,617 million cubic feet in 1977, and has been declining slowly ever since due to an increase in timber mortality caused by the higher stocking levels crowding out weaker or overtopped trees and by a decrease in ingrowth from the diminished acreage of young sapling stands.

It is useful to explore growth trends from two aspects. Relating growth to the land base on a per-acre output basis, much as is conventionally done in agriculture, indicates the current productivity of the timberland. A second approach is to present growth as a percentage of timber volume. This provides a measure of the "rate of return" on timber inventory.

From 1952 to 1992, annual net growth per acre rose from 22 cubic feet to 32 cubic feet. However, as a percentage of growing stock, growth was 4.7 percent in 1952 but had declined to 2.7 percent in 1992. This decline in percentage growth rate is the direct result of the accumulation of higher inventories; that is, the "principal" on which the rate is calculated has expanded and even though the rate of growth has slowed, the actual volume of growth realized each year has increased.

Net annual growth of sawtimber is still rising. It more than doubled between 1952 and 1992, increasing from 2,515 million board feet to 5,196 million board feet. The trends are similar for both the softwood and hardwood species groups. Although

the growth rates for sawtimber have also declined over time, they remain about one percentage point higher than for growing stock.

Timber growth is a function of land quality, tree stocking and forest management. Although these vary by ownership, differences in net growth have declined since 1952. Farmers and other non-industrial forest owners are growing an average of 33 cubic feet per acre annually, whereas public forests are growing less. The major difference between the owner groups is the distribution of timber growth between hardwoods and softwoods. Public and industrial forests are producing much more softwood growth than are those owned by farmers and other private landowners. Part of the reason for this is location. A larger proportion of the public and industrial timberlands is located in the northern units of the region where conditions favor conifers and where tree planting programs emphasized conifer species.

Timber mortality is estimated as the volume of sound wood in growing-stock trees and sawtimber trees that die annually as a result of insects, disease, and suppression. These losses are typically small but losses from wildfires, windstorms, and pest epidemics tend to be concentrated both temporally and spatially, and can be catastrophic in localized areas. Several serious pests threaten particular species. Dutch elm disease destroyed much of the elm resource across the region over the last two decades, and oak wilt is killing large numbers of red and black oak. Gypsy moth is spreading across Michigan and is currently found in eastern Wisconsin.

Mortality of growing stock in the Lake States has been rising, mainly due to exposure of a greater volume timber; that is, there is more volume at risk. Mortality now reduces gross growth by about 12 cubic feet per acre per year. Total mortality was 1.5 billion cubic feet in 1992, about equal to one percent of the inventory and 73 percent of timber removals.

Timber removals—Timber growth accrues gradually, almost imperceptibly, in response to natural processes. Thus, the gains tend to go largely unnoticed by the general public. It is quite the opposite with timber removals. Tree felling and logging and other timber harvesting activities are unmistakably evident, and even when logging is crafted to improve the residual stand or to develop a superior future stand, the change is often conspicuous.

During the decade 1981–1990, over eight billion cubic feet of timber were harvested in the Lake States. Almost 80 percent of this was from hardwood trees. Removals were approximately three billion cubic feet in Michigan and Wisconsin, and 2.1 billion cubic feet in Minnesota:

Aspen accounted for half of all hardwood removals during the 1980's; the combined volumes of red oak, hard and soft maple and paper birch comprised another 35 percent. Half of all softwood removals consisted of jack pine and red pine. The northern forest survey units across the region have provided the lion's share of the harvest over the past decade; the five southernmost units supplied only one-eighth of all removals in the 1980's.

Between 1952 and 1992, removals from growing stock rose 63 percent for hardwoods and 19 percent for softwoods, for a total of 82 percent for all species. Removals have also risen as a percent of net growth over the past 40 years, and currently account for 59 percent of growth. Forest industries currently harvest more on a per acre basis and as a percentage of net growth than do other landowners.

Timber growth in the Lake States amounted to 1.5 billion cubic feet in 1992, or about double the level of timber removals. The unharvested growth has accumulated in larger timber inventory. Merchantable length of trees has increased as trees have gotten bigger and taller, and larger harvestable volumes per acre have enabled improvements in harvesting efficiency and reductions in hauling distances to mills. Such changes have attracted new processing plants and led to even larger timber harvests. Yet, the surplus of net growth over removals is greater now than it was in 1952.

The relationship between growth and removals varies somewhat by state, but much more so within each state as one moves from north to south (Table 1). The greatest variation in the ratio of removals to growth is among the survey units of Minnesota. In the Prairie Unit, only one-fifth of growth is harvested compared to the Aspen-Birch Unit where the removals amount to three-quarters of growth. The same pattern occurs in Michigan and Wisconsin although the differences are less striking.

Table 1. Removals, growth and volume margins by forest survey units in the Lake States.

State	Survey Unit	Growth	Harvest	Margin	Growth to Harvest Ratio
		(———Million cubic feet———)			
Michigan:	East. Upper Peninsula	122	71	51	58%
	West. Upper Peninsula	173	103	70	60%
	North. Lower Peninsula	278	129	149	46%
	South. Lower Peninsula	96	20	76	21%
Minnesota:	Aspen-Birch	132	99	33	75%
	Northern Pine	170	124	46	73%
	Central Hardwood	53	23	30	43%
	Prairie	12	3	9	25%
Wisconsin:	Northeast	132	115	17	87%
	Northwest	167	106	61	63%
	Central	95	61	34	64%
	Southwest	50	34	16	68%
	Southeast	28	8	20	29%
Lake States		**1508**	**786**	**722**	**52%**

In a world concerned about resource depletion and environmental degradation, an expanding forest is special. However, the expanding forest resource situation across the Lake States leads to situations that either threaten the status quo or afford opportunities to enhance the future forest. I will examine five of these.

Aspen—Aspen forests constitute a major policy conundrum for the region's forest managers and planners. The aspens are the most common species but they are short-lived, fast maturing and poorly distributed by stand age. In 1952 aspen was thought to be a

weed species with few uses and little or no stumpage value. Some timber companies were even bulldozing young aspen stands to make room to plant spruce and other conifers deemed more economically promising.

By 1992 aspen provided 40 percent of the total timber harvest. Its abundance and low cost have encouraged technical developments that have multiplied its uses. A conspicuous example of these new products is aspen flakeboard, now widely substituted for southern and western plywood. A newer development—oriented strand board—provides a stronger product with expanding uses. The use of aspen for pulp and lumber sprang also from new knowledge.

Aspen stands still cover over 10 million acres, or one-fifth of the timberland in the region. In Minnesota, aspen covers one-third of the forest. However, Spencer, *et al.*(1990) report that, between the mid-1960's and 1987, the area of timberland in the aspen forest type declined from 13.2 to 11.8 million acres, a 10 percent loss. The area of aspen forest-type is declining primarily because it is being replaced by other species when management favoring aspen is not practiced. Stands older than about 60 years are considered over-mature, and they tend to decay or break up quickly. As the mature stands deteriorate, the more shade tolerant species present in the understory such as maple, balsam fir or white pine replace the aspen. The present forest industry faces a declining aspen base and will need to depend more on other species as this century fades.

Plantations—Reforestation activities have a long history in the Lake States and planted stands can be seen across the region. In 1980 Michigan's forest plantation area totaled 1.2 million acres. Wisconsin had 622 thousand plantation acres in 1983, and the 1990 Minnesota inventory reported 354 thousand acres of forest plantings. About 300,000 additional acres have been planted since the forest inventories in Michigan and Wisconsin, thus raising the Lake States forest plantation acreage to about 2.5 million acres. Plantings have been mainly of the native pines; i.e., jack, red and white, plus white spruce. Much of the current acreage in the pine and white spruce types stems from these plantings. For example, in Wisconsin, nearly 80 percent of the red pine and 66 percent of the white spruce has been planted (Roussopoulos and Leatherberry, 1992).

Although tree planting began soon after the turn of the century, it was practiced on an extensive scale only after about 1930 when fire control programs insured protection. The depression of the 1930's fostered creation of the Civilian Conservation Corps (CCC) which incorporated reforestation as a major activity to employ young men. Tree planting became a common spring and fall activity throughout the three states. Public tree nurseries, many of which are still operating, were established during the CCC era for planting on both public and private forest land. The CCC program faded away during World War II but tree planting rose rapidly in the 1950's. The Soil Bank program was designed to retire surplus farm land by paying farmers to retire crop land. It spurred a new surge in reforestation, this time on private land. The yearly acreage planted peaked under the Soil Bank Program. Early plantings were mostly on the public forests, but by the 1950's plantings by corporations and individual land owners exceeded public planting, a trend that continues today.

The older pine plantations have been a source of pine pulpwood for years, but they are now reaching sawtimber size. A modern sawmill located at McBain, Michigan was designed to process whole tree red pine logs from plantation thinnings. A sister complex makes lumber and treated poles in Prentice, Wisconsin.

In the 1980's a number of new policies and programs were implemented to encourage tree planting. Land managers have responded to the reforestation incentives, but as the programs wax and wane, the amount of forest planting does also. Consequently, the age structure of plantations is uneven. The result has been to imprint a cycle of changing forest characteristics and changing future conifer wood supply.

White pine—A symposium held on white pine in 1992 (Stine and Baughman, 1992) could have been entitled "Where is the white pine ?" Once king of the Lake States pinery, today white pine is scarcely present. Statistics for Minnesota from the 1990 inventory show white pine numbered but 35 out of each thousand trees reported, while the 1993 Michigan survey found just 16 white pine per 1000 trees. Across the region the white pine forest type covers just 520 thousand acres, an area smaller than Minnesota's Carlton County. This key species of the legendary pine logging era is surprisingly uncommon in the modern forest. White pine is the largest and tallest of the northern conifers, but it has never recovered from the exploitation of logging, uncontrolled wild fires and farmland clearing that occurred early in this century. Red pine has been favored in reforestation by owners and agencies who fear the twin threats of white pine blister rust and white pine weevil.

Still, when one looks at statistics on very big trees in the region, white pine remains dominant. In trees 29 inches and larger in diameter, white pine leads all species in sawtimber volume in all three states. Although comparatively few in number, white pine includes about 18 percent of the conifer sawtimber volume in the region.

The key to increasing the white pine component in the Lake States forest rests on better solutions to problems of regeneration and protection, but there is little prospect that white pine will become a major species in the foreseeable future.

Red oak —There is growing concern among the forestry community that red oak sawtimber is being overcut to satisfy strong domestic and international markets. However, the new Minnesota inventory shows current red oak sawtimber growth to be more than twice 1990 removals, and statistics for Michigan show the growth of red oak was 2.6 times removals during the last decade. The concern seems based on the failure to regenerate oak following logging. Red oak has been difficult to regenerate on sites where it is the preferred timber species. Oak forests are changing ecologically because of successional displacement by more shade tolerant species, the absence of fire, increased mortality caused by gypsy moth defoliation and oak dieback and decline.

Potential for catastrophic forest fires—The accumulating timber inventory has increased greatly the stock of potential wood energy and the risk of large forest fires. Several fires of more than one thousand acres in size have occurred in recent years. A large forest fire near Grayling, Michigan recently destroyed eighty homes, and one near Seney, Michigan ran unchecked until it reached Lake Superior. The large blocks of maturing plantations present special fire control problems and some forest fire specialists have concluded that fires could occur which cannot be controlled with available equipment and methods. Green wood currently averages over 60 tons per acre with additional fuels present in the form of dead trees, woody debris, leaves and ground

vegetation. Construction of large numbers of scattered permanent and seasonal homes in forested area has made fire protection more difficult.

FOREST PRODUCTS, BENEFITS AND USES

Among the factors that affect the demand for timber are population, gross domestic product, housing starts, imports and exports, technical improvements and new products, and changes in the supply of timber in other regions of the country (and world). The underlying annual rates of population growth and economic growth for the country are about two percent. The improving supply of maturing timber in the Lake States and the introduction of new technologies have resulted in timber harvests that are growing at about three percent annually.

More than half of the industrial timber products harvested annually is pulpwood. Pulpwood production more than doubled from 1965 to 1990, when it reached 8.53 million cords. Hardwoods constitute 76 percent of all pulpwood with the principal species being aspen, jack pine, hard maple and white birch.

Some 804 sawmills were in operation in the Lake States in 1990. Sawlog production rose from 828 million board feet in 1952 to 1.5 billion board feet in 1990. Michigan supplied 42 of the total. Pine, aspen, red oak, hard maple and soft maple are the principal lumber species.

Expanding timber demand is always accompanied by a concomitant concern about exploitation and overcutting. Although the forests of the Lake States have recovered and the inventory is increasing, the region's history of logging and wholesale land clearing is still much in evidence. The fact that current growth is much higher than timber removals suggests that greater demands can be met while still maintaining and improving the forest. In addition, further gains in productivity could be realized because current growth per acre is no more than two-thirds of site potential.

The rising demand for Lake States' wood products will lead to increased prices for timber. Added revenues can finance better forestry, but higher prices and greater demand can also encourage conflicts between timber production and the many other benefits forests provide.

Forest Recreation and Wildlife—The Great Lakes forests provide a rich, varied and changing habitat for a great many wild birds and animals. Tens of thousands of inland lakes and hundreds of miles of lake shoreline add a diversity that is unique to the region.

The appeal of forest recreation cannot be separated from the attraction of forest creatures. The largest is the elk, which is currently found only in Michigan. The original herds of elk were extirpated from the region in the late 1800's and the present herd of about 1,000 animals was reintroduced to northern Michigan in 1917 (Bender, *et al.* 1991). The elk range in Michigan consists of about 3,800 acres near the cities of Vanderbilt and Atlanta. The elk herd attracts visitors throughout the year and each December a carefully controlled hunt maintains the herd within the capacity of the range.

Smaller, but far more abundant than elk, are white tailed deer. Deer are found throughout the region and is the principal big game species. The deer herd numbers in excess of two million animals. Black bear, bobcats, coyotes, foxes and a few reported cougar are also sighted occasionally.

The region's sawtimber stands are enlarging the habitats for turkey, black bear and timber wolves. Wild turkeys were reintroduced into the region in the 1950's. After a slow recovery the turkey population has now bloomed to such a degree that hunting is permitted. Black bear and coyotes now occur as far south as Dane County, Wisconsin. Timber wolves, long few in number and largely confined to the Arrowhead country of Minnesota above Lake Superior, are dispersing far beyond this area and number somewhere near 1,900 animals. Minnesota-born wolves have crossed into northern Wisconsin and established resident packs in that state, numbering about 40 animals. Another 30 wolves live in Upper Michigan. Wolf pups have been born in Wisconsin and Michigan in recent years and these states have more wolves than at any time since the 1950's. Eagles, cranes, swans, geese and ducks also frequent the quiet and remoteness of the forests.

The increasing demand for wood and wood products coexists with other ballooning demands for forest-based goods. More people mean more consumers of houses and other wood products. These same consumers are recreationists, hunters, hikers, trappers, bird watchers and environmentalists. Just as technical changes have fostered new uses for timber, new devices have changed other forest demands. Snowmobiles, RV's, trail bicycles, and off-road cycles use up more space than snowshoers, skiers, and hikers did.

CONCLUSIONS

Forests are dynamic communities. This is especially true in the Lake States with its conglomeration of glacial soils, mixes of northern conifer and hardwood stands and history of fire, logging and land clearing.

One must back away in time and space to see the long term timber wave in the Lake States. The original forests were exploited throughout the late 1800's and early 1900's. Timber volumes declined steadily as most land suitable for farming was cleared of trees and old growth stands were cut. Around 1940 the growth of restocked stands exceeded the volume of timber removals and the long decline in timber inventories ended. During the 1940's the large area of "brush" and "scrub"—in reality young stands of mostly hardwoods—began entering the inventory as small poletimber. A new trend began, one of growth exceeding removals; consequently, timber inventories have increased.

A wave of timber has accumulated and is projected to crest about 2030. As this wave of single-aged stands grows through the size classes, it generates large changes in the inventory, timber growth and the quantity and character of harvestable timber. Stands in the biggest wave are now nearing 70 years of age and represent a virtual wall of maturing timber. For forest types such as aspen and jack pine, the trees are fully mature and will decline if left uncut. The maple-beech, red pine, and oak stands are short of full development, but it is at most a few decades away.

Accumulating volumes of timber per acre are accompanied by increased stand basal area, closing crown cover and reduced underbrush. As less sunlight penetrates the tree canopy, the ground cover thins out. The surviving trees grow larger and taller, crowding each other. The stands require more water and nutrients to sustain development. Weak sites become obvious. Small defective and intolerant trees, long considered a major silvicultural problem in the understocked stands of the 1960's and 1970's, are crowded out naturally. Better trees are beginning to dominate the stands. The second growth forests are changing, not only in tree size and quality, but also in stand height and density.

Past shifts in land use, on-again-off-again reforestation programs and effective fire programs have led to an uneven age class distribution in several important forest types. The aspen type, mainstay of the Lake States forest industries, presents such a situation. The largest component in the aspen type is the 50–60 year age class which is mature and ready for final harvest. A second bulge of aspen is on its way but it is currently only about 20 years of age.

The planted forests present another set of waves. Early ones stem from the Civilian Conservation Corps of the 1930's and the Soil Bank Program of the 1950's. These waves are nicely seen in red pine in the 55–year old or about 35–year old age classes. The first wave is providing poles and small sawtimber for several new sawmills as well as considerable pulpwood from thinnings.

The three Lake States have forests, water and people in close proximity. The region has large public land holdings, good hunting and fishing, and lakes and streams in large supply. Beaches and wooded scenery abound, and well-developed parks and campgrounds are common. Forest scenery, fall colors, camping, canoeing, bicycling, hiking, skiing, snowmobiling, observing and photographing fauna and flora of all kinds to say nothing of hunting and fishing, bring millions of visitors to the region's forests. Even corporate headquarters locations are selected these days with an eye to the quality of life aspects found in or near forests.

Wildlife populations change when forest cover changes. Elk and turkey are again hunted in the Lake States. Fisher and pine martins roam the forests. The deer herd is so large that record harvests are recorded nearly each year and their browsing threatens some tree species. Bear and coyotes are spotted where they haven't lived for generations and timber wolves roam parts of upper Michigan and northern Minnesota. Occasional sightings of wolves and cougar are also reported in Wisconsin's north country.

The forests of the Lake States are maturing. But they are dynamic and changing quickly in size, quality and value. It is clearly time to craft policies for their future.

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APPENDIX A: DATA SOURCES

Most of the current timber resource data for Wisconsin are drawn from a forest inventory conducted by the Forest Survey Project of the North Central Forest Experiment Station in cooperation with the Wisconsin Department of Natural Resources. This survey, which is dated 1983, is nearly a decade old. Nevertheless, it provides a wealth of detailed timber inventory information comparable to earlier surveys. Data available from this survey include forest area statistics by forest type, ownership and stand age and timber volume by species, tree size and class in both cubic and board feet. Similar but less statistically reliable information are presented for timber growth and timber removals.

Minnesota's fifth forest inventory was completed in 1990. It provides the most current resource estimates and, when compared with estimates for the fourth Minnesota inventory, the latest indications of recent changes. The last published survey of Michigan's forests is dated 1980. Field work for a new inventory was completed in 1993, and preliminary statistics from that survey provide a more up-to-date picture.

Using advanced computer projection models, the Forest Service updated the 1983 Wisconsin inventory and the 1980 Michigan inventory to 1992, and compiled estimates for the region, for each state, and for individual survey units (groups of adjacent counties) as of 1992. Timber removals were updated to 1992 from the 1983 statistics using newer pulpwood production estimates as the basis for estimating changes in removals. Timber product output statistics are compiled annually for pulpwood by species and county for each of the three states.

Statistics from the 1990 Minnesota forest inventory and preliminary results from the 1993 Michigan resurvey were studied to substantiate conclusions drawn from older data bases. The updated state statistics were combined with those gathered since 1952 for the entire Lake States by the Forest Inventory Analysis unit of the USDA Forest Service's North Central Forest Experiment Station (USDA Forest Service, 1992).