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J. Michael Vasievich and Henry H. Webster, Editors.

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For more information about any paper, contact the author(s) or either of the following.

Dr. Henry H. Webster
Lake States Forestry Alliance
College of Forest Resources
1530 Cleveland Avenue
University of Minnesota
St. Paul, MN 55108
612-624-3079

Dr. J. Michael Vasievich
North Central Forest Experiment Station
USDA-Forest Service
1407 S. Harrison Road
East Lansing, MI 48823
517-355-7740

Lake States Forestry Alliance, Inc.
PO Box 722
Hayward, WI 54843
(715) 634-2006
FAX: (715) 634-5724

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limestones and dolomites form ridges with weaker strata forming the valleys. The most prominent of these resistant layers is the Niagara dolomite that provides the backbone of Door County and rims the Michigan Basin. The Palezoic strata slope eastward into the Michigan Basin and southward into the Illinois Basin. The Unglaciated Area is extensively dissected with the St. Peter Sandstone or the underlying dolomite of the Prairie du Chien group forming the ridges while the earlier Cambrian sandstones and recent alluvium fill the valleys. As in Minnesota and Michigan's Upper Peninsula, the Cambrian sandstone was derived in part from weathering of the old rocks of the Canadian Shield and in part from sandstones of the Superior Basin. A mass of quartzite, the Baraboo Hills, protrudes above the Cambrian sandstones in south central Wisconsin and a second, Rib Mountain, remains above the eroded PreCambrian surface in north central Wisconsin.

The western portion of the Upper Peninsula is underlain almost entirely of the hard rocks of the Canadian Shield with a relatively thin cover of glacial material. On the Keweenaw Peninsula, resistant strata dip steeply into the Lake Superior syncline. Lava flows are a prominent part of the bed rock. Approximately 1.1 billion years ago volcanic activity ceased and about that time copper was deposited in pockets in the lava and associated rocks. In Late PreCambrian time major faults developed both here and in northwestern Wisconsin. Slippage along these faults dragged the older lava beds over more recent deposits. In contrast, the eastern half of the Upper Peninsula is relatively level with bed rock of Cambrian sandstone and overlying strata of limestone and dolomite, now partially covered by glacial and glacial lacustrine deposits. Michigan's Lower Peninsula is underlain entirely by sedimentary Paleozoic strata. These rocks fill the Michigan Basin with at least 14,000 feet of Paleozoic sediments. The youngest, Carboniferous rocks cover much of the State resting on earlier strata that are near the surface only in the northern tip and in the extreme southeastern and southwestern corners. The Michigan Basin is bordered on the west by the Wisconsin Arch, on the south by the Kankakee Arch and on the east by the Findlay Arch.

Glacial Geology of the Lake States

During Pleistocene time, beginning perhaps 2.4 million years ago, several glacial advances covered much or all of the Lake States. Interglacial periods between these events permitted erosion and probably revegetation. The last major glacial stage, the Wisconsonian, covered most of the region and little evidence of earlier stages remains in the Lake States. The Wisconsin stage, beginning about 70,000 years ago, involved several major advances and retreats, as well as numerous minor ones, and was responsible for the complex pattern of substrates and land forms on which the forests and soils developed. The sources of ice included the Hudson upland and areas to the west in Canada. While the timing of major advances was similar throughout the region, there were numerous fluctuations that varied from State to State. All of the ice did not originate in the same source area resulting in differences in the nature of the till deposits. Variation in glacial activity accounts for most of the differences in surface features among the States. The Driftless area of southeastern Minnesota and southwestern Wisconsin was apparently lightly, if ever, glaciated resulting in rough topography with prominent ridges and valleys produced by differential erosion of the sedimentary rocks. Much of west central Wisconsin was not glaciated during the Wisconsin epoch.

Ice movement south and westward was influenced by topography with separate lobes following lowlands such as the Lake Michigan Basin or the Superior-Minneapolis Lowland. The peak advance of the Wisconsin ice began about 22,000 years ago. The ice fronts fluctuated considerably and by about 12,000 years ago had retreated sufficiently to permit establishment of forest communities in eastern Wisconsin. These were later overridden by re-advance of the ice. The several moraine systems (Plate 1) indicate the position of various glacial lobes. The weight of the ice, often hundreds of meters thick, depressed the earth's surface that continues to rebound especially in the North. As various lobes of ice shifted and changed direction, outlets to the Great Lakes were either blocked or created. Melting during early periods of retreat resulted in glacial lakes that covered large land areas. Eventually these lakes were drained as barriers were breached or melting of ice created new outlets. Most ice had melted by 9,500 to 11,000 years ago and the Great Lakes began to approximate their present form.

In western Minnesota, the Red River lowland served as a channel for several advances of ice from the west and north that created major moraines including till from Saskatchewan and the Dakotas. The Wadena, Rainy, and Superior lobes pushed into the center of the State forming another series of looping moraines. As this ice mass began to disintegrate, streams formed under the ice eroding deep valleys in the Duluth-Minneapolis Lowland. Later the Red River lobe pushed south and eastward and the vigorous Des Moines lobe moved down the Red River-Minnesota River lowland and spread across most of the central and south-central part of the State depositing a till rich in shale and limestone that became the parent material for soils in southern and western Minnesota. Advances of the Superior and Rainy lobes left till that was generally acid and relatively rocky and infertile.

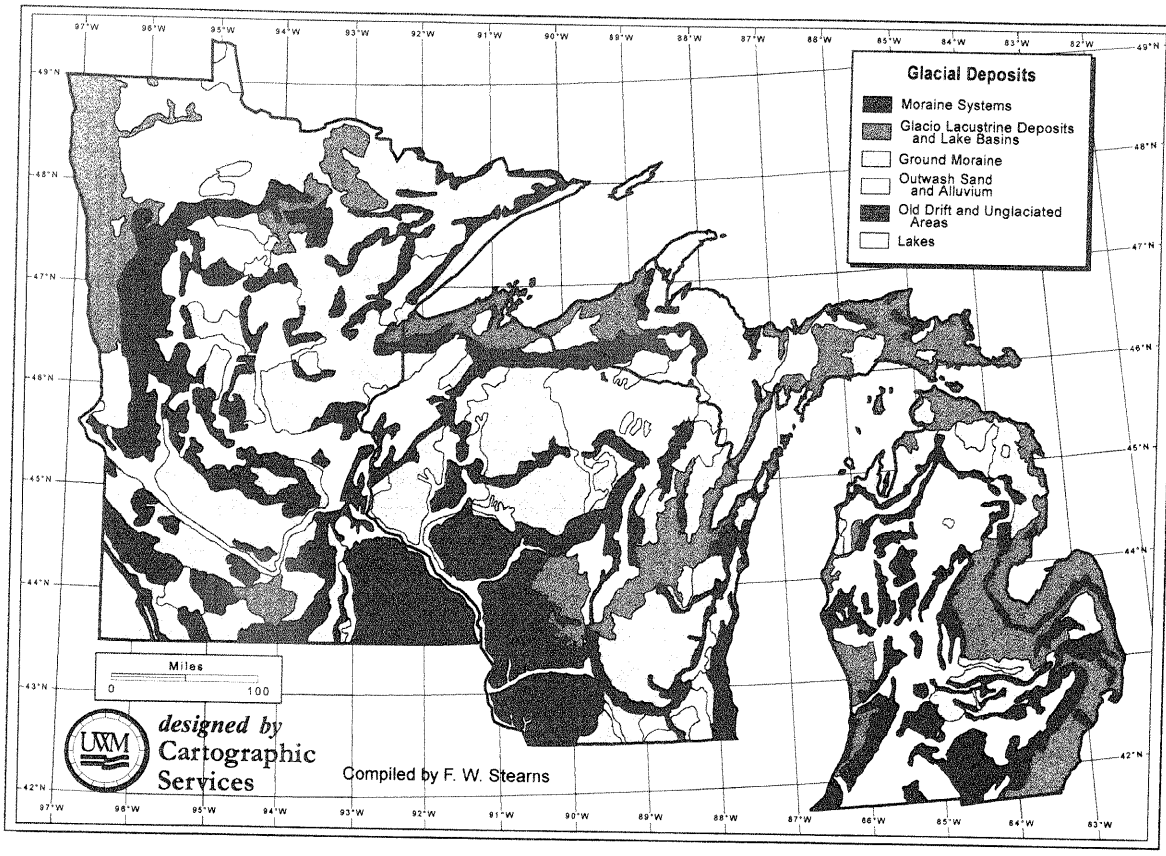

Plate 1.—*Glacial deposits in the Lake States.*

Melting of the Des Moines lobe served to deepen the Minnesota River valley and a recessional moraine blocked southward drainage and formed Lake Agassiz that soon covered much of northwestern Minnesota as well as huge areas in Canada. As that lake drained northward it left vast expanses of level, poorly drained land that is now covered with peat. In a similar fashion, moraines and ice in the northeast confined Glacial Lake Duluth. That lake drained first into Lake Superior and later into the St. Croix and Mississippi basin.

Glacial ice advanced in Wisconsin with several lobes moving from Lake Superior southward. Major lobes also occupied the Lake Michigan basin and the Green Bay Lowland. Advances were not constant, but alternated with retreats and stagnation. The greatest advances occurred perhaps 20,000 to 16,000 years ago when the Lake Michigan lobe reached northern Illinois and the Green Bay lobe formed a terminal moraine in Rock and Walworth Counties just north of the Illinois border. The Green Bay lobe split with a branch moving northward to meet the southward expanding Langlade lobe. The proximity of the Green Bay and Lake Michigan lobes resulted in a long interlobate strip of outwash and till from both lobes. This strip, called the Kettle Moraine, remains a prominent feature of eastern Wisconsin. Similarly the proximity of the Green Bay and Langlade lobes resulted in a complex of morainic hills and outwash, deposits that with those of the Wisconsin Valley, Chippewa, and Superior lobes form an almost continuous ridge across northern Wisconsin that includes several of the highest points in the State. In the west central part of the State, an extensive area has recently been shown to be covered only by PreWisconsin glacial deposits. Another feature is the extensive sandplain that formed the bed of Glacial Lake Wisconsin that developed when flow of the Wisconsin River was blocked. Many advances and retreats of various ice lobes occurred before final retreat of the ice, perhaps 9,500 years ago. The pitted moraine and outwash deposits in northwestern and north central Wisconsin are responsible for the exceptional number of lakes, much more abundant here than in Michigan or Minnesota. As the ice retreated vast quantities of meltwater formed broad valleys that are now occupied by far smaller streams.

Glacial deposits in the western Upper Peninsula are generally thinner than in northern Wisconsin and there are few areas of pitted outwash and few lakes. The streams emptying into Lake Superior flow largely over bedrock at a steep gradient. In the eastern Upper Peninsula the relatively weak sedimentary rocks were eroded by the ice, leaving large level and poorly drained areas. An extensive plain slopes south toward Lake Michigan and a shorter one slopes north toward Lake Superior. Major glacial-lacustrine deposits occur along

the Lake Superior shoreline west of the Keweenaw Peninsula, while much of the eastern UP is covered with glacial lacustrine deposits. In the Lower Peninsula, lacustrine deposits fringe the tip and occupy low areas along the Lake Michigan coast. Large areas of these deposits border Saginaw Bay including the "Thumb" and often extend inland as far as 30 miles. An extensive band of lacustrine deposits varying from 10 to 30 miles wide extends south and southwestward to the State boundary and Lake Erie. Looping lateral moraines within the lacustrine deposits indicate earlier ice borders. For a considerable period, the entire Lower Peninsula was covered by the ice of the Michigan lobe and the Saginaw sublobe of the Huron lobe. Movement of these lobes left behind complex moraine systems embedded in ground moraine, outwash sands, and ice contact deposits. Both till and sands are often calcareous originating from dolomite and limestone in the Huron Lobe.

Soils of the Lake States

Soil results from the interaction of three factors: climate, parent material, and organisms, both plant and animal. Precipitation and temperature affect evapotranspiration influencing the movement of salts in the soil, the leaching of nutrients as well as the water available for plant growth and for micro-organisms. The size of substrate particles, whether coarse (e.g., sand or gravel), intermediate (e.g., silt), fine (e.g., clay), or a mixture of sizes (e.g., sandy loam) play an important role in retention of water, in nutrient availability, in soil aeration and drainage, etc. The organisms that become established provide organic matter, larger drainage ways and through translocation of nutrients from roots to leaves influence plant productivity.

Leaves and litter of deciduous trees are generally richer in calcium and other mineral elements and tend to make soil less acid while accumulation of conifer needles may lower the pH of the soil resulting in leaching of organic matter and minerals to form a podzol (leached) layer. Insects, worms, and various arthropods, as well as mammals, mix the soil body improving its structure. Over time, soils develop layers or horizons characteristic of the particular climate, parent material, and vegetation of the region.

For simplicity, soils of the Lake States are grouped into four major categories: light colored soils formed under forest vegetation; dark colored soils that developed under prairie grasses as a result of the accumulation of organic matter under generally dry and neutral or alkaline conditions; other dark soils that resulted when poor drainage prevented the decomposition of organic matter; and lastly, young, poorly developed soils formed on steep slopes or in thin layers of parent material (Plate 2).

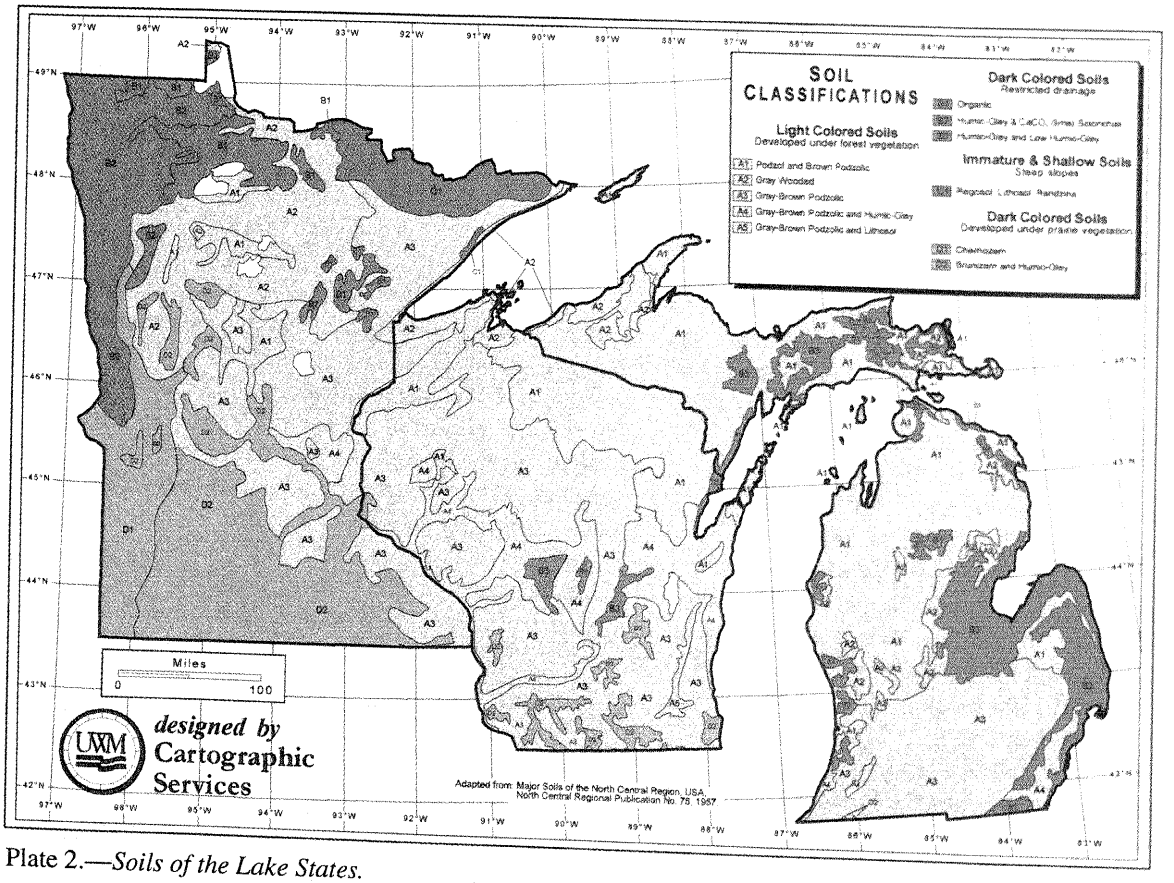

Plate 2.—*Soils of the Lake States.*

Lake States soils are young, developing since the retreat of the Wisconsin ice sheets. The complex nature of the glacial parent material makes generalization difficult. For example, outwash sand may have been deposited over lake clay, silty morainic material, or even gravel, while the surface may or may not have been covered with loess.

The forest soils are of special interest and form a continuum from north to south. Those in the colder northern areas generally have a surface organic layer above a well-developed light-colored layer from which iron, aluminum, other minerals, and organic matter have been leached. Those soils often developed under conifers on sandy and loamy material derived largely from igneous and metamorphic rock. They tend to be acidic and are often strongly podzolized. Southward, soils found under deciduous forests show less leaching and more often develop from calcareous parent material whether till, sand, or clay. In the glaciated landscape, north or south, the surface is often uneven with poorly drained depressions that accumulate organic matter and often become anaerobic resulting in the development of peat or gley soils.

- Podzolic and Brown podzolic soils commonly originate in outwash sands and are often acidic and excessively drained.

- Gray wooded soils (the northern equivalent of the Gray-Brown podzolic soils) are usually moderately well drained and often originate on a glacial lake plain.

- Grey Brown podzolic soils often form in a well drained silty sediment lying over acid sandy loam on brown till.

- Grey Brown podzolic with humic gley soils include low poorly drained pockets of humic gley that have a thick dark colored surface horizon and grey-gleyed subsoil.

- The dark prairie Brunizem soil is well drained save in depressions where humic gley occurs. It tends to have a thick, dark, surface horizon and develops in acid sands and also in loess.

- Chernozem, a prairie soil with a deep highly organic surface layer, forms over calcareous loamy sand or till and develops a calcareous horizon as calcium is moved upward by evapotranspiration.

- Solonchak, a dark poorly drained soil also forms over a calcareous substrate.

Soils in Minnesota differ considerably from those in Wisconsin and Michigan. Much of southwestern Minnesota has dark colored prairie soils, Chernozems and Brunizems, while much of the northwest supports organic and CaCo-Solonochak soils with restricted drainage. The northeastern border of the State has extensive areas of immature and shallow soil and the remainder of Minnesota developed forest soils ranging from Pozols through Gray Wooded and Gray Brown Podzolics. Humic Gley soils are present throughout.

Light-colored forest soils predominate throughout Wisconsin ranging from Podzols and Brown Podzolic and Gray-Brown Podzolic soils in the north to variants of Gray-Brown Podzolic in the central and southern areas. Several large areas of Humic-Gley soils occur in the central sandplain while areas of dark Humic-Gley and Solonochek soils are scattered across the southern fourth of the State. Smaller patches of peat and humic gley are widespread. Patches of prairie Brunizem soils occur in southern Wisconsin, but no Chernozem soils are present.

The western half of Michigan's Upper Peninsula is similar to northern Wisconsin with primarily Podzol, Brown Podzolic, and Gray Wooded soils, while the eastern UP has extensive areas of Organic and Humic-Gley soils. Small areas of poorly drained soils are found along the tip of the Lower Peninsula and along Lake Michigan while extensive areas are found in eastern central Michigan, on the "Thumb," and along the southeastern side of the State. The remainder of the Lower Peninsula soils range from Podzols and Brown-Podzols in the north, and small areas of Grey-Wooded soil in the central area to predominately Grey-Brown Podzolic forest soils in the south

Climate of the Lake States

The northern Lake States lie between the boreal and the cold temperature regions with strong north-to-south and west-to-east temperature and moisture gradients. The climate of the western portion is similar to that of the Great Plains, while eastward precipitation increases and extremes of temperature are moderated. A pronounced snow belt is present along the shores of the Great Lakes.

A climatic transition zone between colder and warmer temperature regimes trends from northwest to southeast from north central Minnesota to southeastern Wisconsin and then east across lower Michigan. This zone is defined not only by temperature and frontal movement, but also by changes in vegetation; the zone includes plants and animals of both northern and southern affinities. A gradual transition is evident from the continental climate of western Minnesota to the maritime climate east of Michigan. The Lake States are located in latitudes between those that receive a surplus of radiation energy (maximum in the tropics) and those that receive

less than average amounts (minimum in the arctic). This difference results from the angle at which the solar rays reach the earth and contributes to considerable energy exchange modified by the influence of the rotation of the earth and by the presence of the Great Lakes. The Lakes greatly alter air flows and act as huge heat sinks, absorbing heat in the summer and autumn and thus cooling the land near the shore while releasing heat during autumn and winter, warming the land near shore. There is considerable difference from winter to summer in the amount of energy available for warming the land surface, a difference that is increased in winter by reflection of energy from the snow-covered surface. The large area of the Great Lakes results in a steep temperature gradient from north to south especially in the winter

Most of the region lies in the humid, continental, cool summer climatic zone, but there is considerable variation. Minnesota tends to be more continental in climate with hotter summers and cooler winters than Wisconsin and Michigan. Precipitation also varies increasing from northwest to southeast. The region as a whole may be characterized as one with snowy, cold winters and mild to warm summers during which precipitation is fairly evenly distributed. The jet stream is frequently overhead or south of the region in winter and north in Canada during the summer. Highs and lows move rapidly across from west to east resulting in an active climate. Differences between seasons are well defined and change between seasons is often rapid and dramatic especially in spring and fall.

The jet stream develops wavelike patterns, a southward wave may bring up warm, moist air masses from the Gulf of Mexico while a northward wave may bring down cold dry arctic air. When the jet stream lacks the wave pattern, it may bring in air masses from the Pacific that gradually lose moisture and often reach the Great Lakes as dry and mild air. Replacement of a warm air mass with a cold one or vice versa involves frontal development with strong temperature differences between the contrasting air masses. Differences in barometric pressure between the air masses often produce strong winds as air moves from areas of high to low pressure.

Shifts of the jet stream, rotation of the earth, and movement of air masses combine to produce anti-cyclones and cyclones—air masses rotating respectively either clockwise or counter-clockwise and moving in an eastward direction. The Great Lakes themselves alter the amount of precipitation whether snow in winter or rain in summer as well as the cyclonic activity. The region is one with considerable storminess in autumn with unexpected wind shifts and strong winds. It may also occasionally be impacted by severe droughts such as those in 1871, 1891, the mid-1930's and the late 1980's. Extreme precipitation may also occur as in 1993.

Thunderstorms are a frequent summer occurrence in the Lake States and provide much of the summer moisture. Tornadoes are most common in the southern and western portions of these States but may occur in the northern forested areas. The less frequent downbursts that accompany passage of very strong thunderstorm fronts are most evident in the northern areas. The snow belts that receive massive amounts of winter precipitation, the lake breezes that affect fog formation, and their contribution to stabilizing climate during the summer and autumn are among the characteristics of the lake environments.

For Minnesota, the Great Lakes have relatively little effect, both temperature and precipitation are typical of a continental climate that is influenced by the rain shadow of the western mountains. Moisture in the maritime air flowing from the west is lost as the air rises over the mountains. Precipitation, both winter and summer, is relatively low and is concentrated during the summer while summer evapotranspiration is high. Temperatures are higher in summer and lower in winter and drought is more frequent than in either Wisconsin or Michigan. Thunder storms are more frequent in the southern counties than in the north.

The Great Lakes have considerable influence on Wisconsin's climate. Temperatures along Lake Michigan are cooler in summer and warmer in autumn and winter than to the west, accounting for the southward bend of the climatic and vegetational transition zone (and for successful cherry culture on the Door Peninsula). Lake effects are also evident along the Lake Superior shoreline, an area that experiences heavy winter snows. Temperatures are higher and rainfall lower along the western side of the State than to the east. Mean annual precipitation varies from 28-34 inches in the north and west to about 32 inches in the southeast. Estimated evaportranspiration varies from 18 inches in the north and east to 24 inches in the southwest and extreme southeast where growing season water shortages are frequent. Mean January temperatures range from 10-14° F in the north to about 20° F in the south, while mean July temperatures vary from 66-68° F in the north to 72-74° F in the south. The number of frost-free days increases from 100 in the northeast to 160 in the south.

The Great Lakes are also a major influence on Michigan's climate in both the Upper and Lower Peninsula, where proximity to Lakes Superior, Michigan, and Huron result in heavy snowfall in winter and rainfall in summer. Despite being between Lakes Superior and Michigan, the average frost-free period inland from the

lakes varies from only 60 days in the western Upper Peninsula to about 100 days in the eastern portion. However, the tip of the Lower Peninsula has 20-40 fewer frost-free days than do similar latitudes in northern Wisconsin. January and July mean daily temperatures are similar to those at an equivalent latitude in Wisconsin, although the eastern UP is several degrees warmer in winter

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History of the Lake States Forests: Natural and Human Impacts

Forest W. Stearns[1]

INTRODUCTION

Forests in the Lake States are relatively young, dating to the retreat of the ice sheets of the Wisconsin Glacial Epoch 10,000-14,000 years ago. The tree species, shrubs, herbaceous plants, microorganisms, and invertebrates, as well as the birds and mammals of these forests survived mostly south and east of the glacial borders. As the ice retreated, they migrated northward not as intact forest communities but individually as species populations. The forest communities that developed were often short-lived and changed as the climate shifted and as other species reached the area. Much change was driven by natural forces: the opening of new habitats, climatic fluctuation, successional processes, and disturbance by wind, fire, disease, and insect infestation. These factors still operate. In addition, change resulted from human activities as varied as the hunting practices of the PaleoIndians, clearcutting, selective logging, effective fire protection or dam building. In the northern forests, disturbance was the key factor in change, and it remains so today.

Each of the Lake States was heavily glaciated; each has a distinct climatic regime, an individual mixture of soils and of vegetation and a similar but discreet logging history.

This paper provides a brief history of the Lake States forests as a whole and also notes some differences among the forest histories of the three States.

POST-GLACIAL CLIMATE AND RETURN OF THE FOREST

When the first European settlers reached the Lake States they found, in the south, patches of upland hardwood forest interspersed with grassland, savanna, and open wet meadow. The northern forests appeared as vast areas of hardwoods and conifers within which were found many lakes, impenetrable swamps, patches of scrubby pine or oak, open bogs, and scattered areas of burned or windthrown timber. These forests were diverse in species ranging from pines on the sandy soils or hardwood and mixed hardwood-conifers of the more fertile loams to the swamp forests of cedar, spruce, and larch. They varied in age from young stands largely of aspen/birch, pine, or maple, to older stands mostly of pine, hemlock, or northern hardwood that ranged in age from 250 years to over 400 years. These forests were not uniform and were always subject to change as a result of increasing age, natural succession, wind, fire, or other disturbance.

These forests owe much of their diversity to the extensive continental glaciations, especially the last. The Wisconsin epoch persisted for at least 25,000 years and produced a complex pattern of landforms, from level or pitted plains to steep morainic hills, and left the land surface with expanses of outwash sands, lake clays, or extensive areas of unsorted till. The tills ranged in texture from sand, silt, and clay to large boulders. Only west central portions and southwestern Wisconsin and adjacent Minnesota were untouched by the physical action of the ice, but even there, the periglacial climate precluded survival of all but the most cold tolerant species.

As the climate warmed during the retreat of the last Wisconsin ice sheets between 14,000 and 10,000 years before present (BP), trees, other plants, and animals began dispersing northward and westward to re-colonize the land. Each species moved independently from their ice age refuges—some from the southern Appalachians, others from the Ozarks, the central Great Plains and the southeastern Coastal Plain. Since individual species disbursed at different rates, they arrived in the Lake States at different times and under different climatic conditions. The forest communities that developed were often relatively short-lived as the climate changed and additional species arrived.

Most of our species had evolved prior to the advent of the ice ages and had often been influenced by disturbance during 20 to 30 million years of the late Tertiary period.

"Only 14,000 years ago, tundra and spruce-pine woodland covered much of what is now the eastern United States" (Davis 1969). Spruce and larch had grown close

[1]The author is Professor Emeritus, University of Wisconsin-Milwaukee. He currently resides in Rhinelander, Wisconsin. This manuscript was originally prepared in October 1995 for the Lake States Regional Forest Resources Assessment, Lake States Forestry Alliance.

to the tundra or on the ice margin and during re-advances of the ice some of these stands were obliterated and now are found as buried forest. Much of the Lake States was still covered by ice. Larch and spruce that had formed extensive forests in the Great Plains 14,000 to 12,000 years BP (Before Present) were the first tree species to follow the retreating ice sheets northward. They were followed by jack pine, red pine, and balsam fir 11,000-10,000 years BP. White pine arrived in southern Michigan about 10,000 BP, in Wisconsin 9,000 to 8,000 BP and in Minnesota between 7,000 and 5,000 BP.

Deciduous species were also entering the Lake States: oaks from the south between 11,000 and 10,000 BP and maples moving northward and westward several thousand years later. Sugar maple reached northern Wisconsin and Michigan only 7,000 to 6,000 BP. The most recent arrivals were American beech that entered the Upper Peninsula about 4,000 BP and Hemlock that reached its western limit in Wisconsin about 1,500 BP. The pollen record has not been examined in as great detail for shrub and herbaceous species, but they too migrated northward and westward to become part of the forest communities that we observe today.

A slow warming, starting about 16,000 BP, had begun to result in retreat of the continental ice sheets. However, between that time and the final retreat of the ice (about 9,500 BP), there were numerous re-advances of various glacial lobes. Between 10,000 and 8,000 BP, the Midwest sustained a somewhat abrupt change to a warmer and relatively moist climate that favored spruce and pine. As the warm conditions continued, drier conditions became the rule (8,000 to 3,500 BP). By 7,000 BP, grassland and savanna had expanded from western Minnesota into southern Wisconsin and Michigan. This "Prairie Peninsula" also extended eastward from Missouri and Iowa across Illinois and Indiana and into Ohio. Farther north, oak and white pine forests flourished. After 3,500 BP, the climate again became somewhat cooler and more moist permitting westward spread of the deciduous forest. Within these several time periods there were numerous fluctuations as well as variation in climate between northern and southern portions of the Lake States.

Climate and vegetation changes have been deduced from studies of pollen and other materials (charcoal, wood, snail shells, etc.) deposited in bogs and lakes, from varves (layers in lake sediments) and from plant distributions. Sediment layers in major rivers also provide evidence for periods of excessive rainfall and major floods. Recent fluctuations in climate (e.g., the Little Ice Age) can be interpreted from records of ocean ice, plant disease epidemics, movement of mountain glaciers, tree rings, and other data.

The past 1,500 years have shown considerable variation. A warm, moist period began about 500 BC and lasted until about 1300 AD. This was followed by the cool and drier but stormy years of the Little Ice Age and then the warm "corn" climate from 1930 to 1970 AD. Climate also varies from year to year as influenced by changes in atmospheric and oceanic circulation, volcanic eruptions, and similar events. These have resulted in the now familiar effects of El Nino in the Pacific Ocean and the year of the two winters (1883) when Krackatoa erupted in Indonesia.

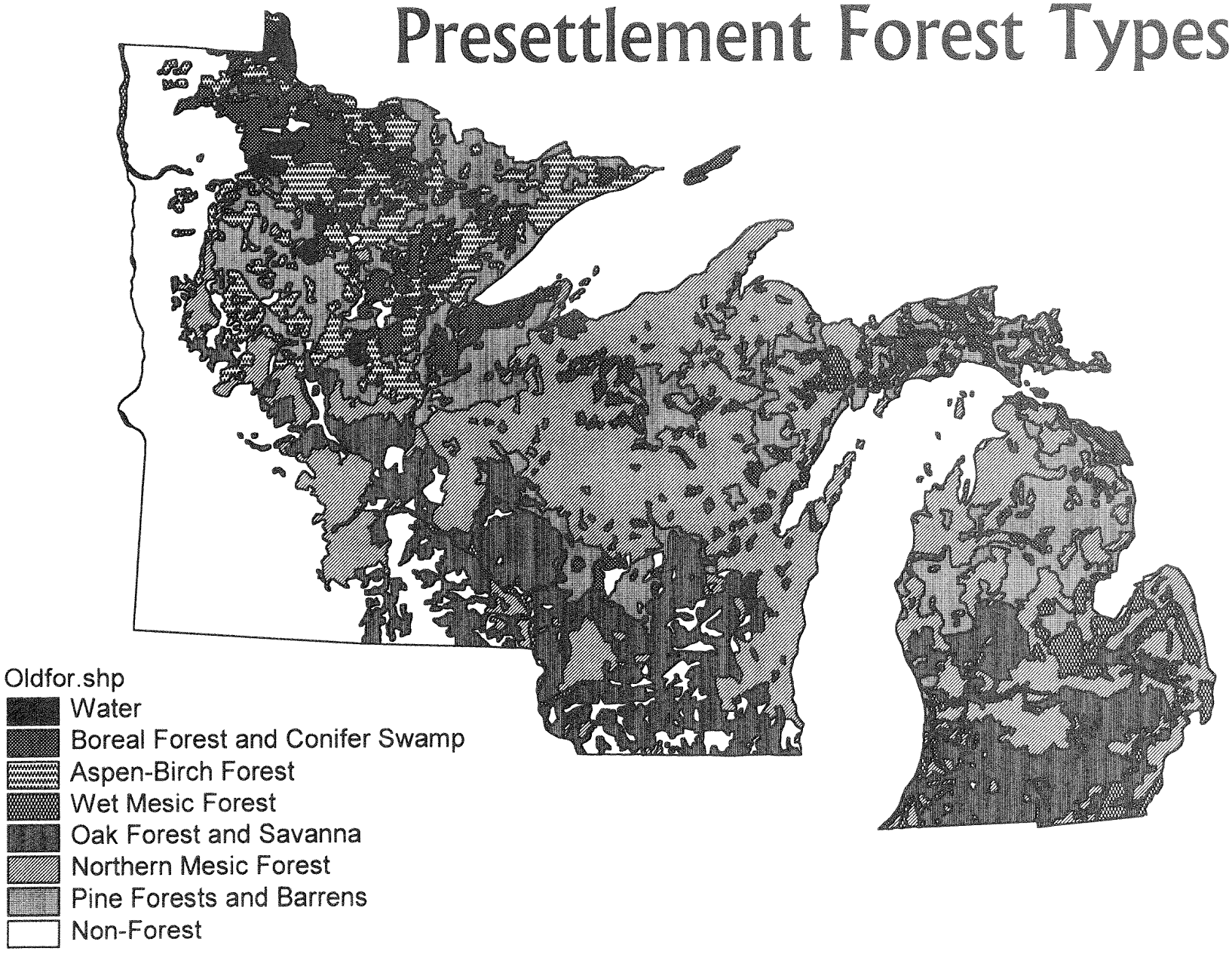
Throughout post-glacial time, shifts in both temperature and moisture have been common and have often persisted for several hundred years. The "Little Ice Age" that lasted from the mid-1400's until the mid-1800's is the most recent example. The major fires of the more recent past were favored by climatic fluctuations of relatively short duration. In addition to climatic shifts, Lake States forests have throughout postglacial time been subjected to much natural disturbance.

EARLY HUMAN ACTIVITY AND NATURAL DISTURBANCE

The first two-legged tourists (PaleoIndians) were few in number and were primarily hunters of big game. They generally made their camps at the juncture of flowing rivers. These hunters may have helped to eliminate the large grazers—mammoths, mastodons, giant beavers, and similar herbivores that may well have influenced early forest development. As the climate became warmer and drier about 7,500 BP, other human groups followed. Between 7,000 and 6,000 BP many more hunters were present. Some used copper spears while others fashioned arrowheads from silicified sandstone. Copper was traded extensively. Many village sites have been found. Cooler climate prevailed after 3,500 BP but with many fluctuations. Warming began again around 3,000 BP (1000 BC).

The Hopewell phase, related to the middle Woodland culture, developed in Ohio and Illinois and by 200 AD had spread into Michigan and Wisconsin. Villages, usually located on river banks or islands, varied in size from 2 to 5 acres; some villages were much larger. This culture collapsed about 400 AD amid unsettled times when large populations resulted in increased competition. The middle Woodland culture that became prominent about 800 AD prospered until about 1300 AD. Village locations shifted to the southeast shores of lakes, and wild rice became a part of the diet. A warm period about 1200 to 1250 AD preceded the "Little Ice Age." For a time after 1400 AD, few Indians were believed to be present in much of the northern forest. However, in the 1600's other tribes were driven westward by the advance of European settlers from Canada and the Atlantic coast.

Presettlement Forest Types



The Chippewa (Ojibwa) reached the Apostle Islands about 1680 AD coming into conflict with the Sioux (Dakota) in Minnesota. Other eastern tribes were driven into Lower Michigan and then Wisconsin. By the early 1700's, following contact with Europeans, disease had greatly reduced Indian populations. (Some estimates suggest a 95% reduction). However, it is clear that Native Americans influenced the Lake States forests long before European settlement began. Their influence was greatest on fire-susceptible communities such as savanna, grassland, and pine forests. These were intentionally burned for ease in travel or to aid hunting. Sometimes considerable areas were cleared for cultivation or around settlements for fuel wood and to build stockades. In some locations, long "fences" of brush were constructed to funnel game to the hunters, whence names like "Fence Lake." The Indians also transported native plants for food, medicinal, and ritual purposes.

The "Little Ice Age" may have had a direct effect on the origin of the forests that so impressed the early settlers. The generally cooler climate was attended by greater frontal activity (storminess), and cool moist periods were interrupted by warmer, drier ones, and even drought. These conditions may have favored the development of the massive stands of white pine and hemlock that appeared inexhaustible to the settlers. In 1850, many of these stands were at least 250-300 years old. Some included two or three age cohorts indicating several periods of disturbance. The landscape also supported patches of aspen and white birch as well as young stands of hardwood and pine. Fire return frequency in the pine forests ranged from 20 to 150 years, but many of those fires were not catastrophic in nature.

Windthrow was the most serious disturbance in the hardwood stands where return time of catastrophic blowdowns has been calculated (based on current storm frequency) to be over 1,200 years. Less severe storms were and are much more frequent, and their effects range from loss of individual stems to major damage over large areas. Less dramatic climatic fluctuations such as major summer and autumn droughts favored the slash fires of the recent past.

The early European visitors appeared to have had little direct impact on Lake States forests. The French controlled the region but had not explored westward before Jean Nicolet landed near Green Bay in 1634. Their period, one of exploration, missionary efforts, and fur trading, lasted until it was ended by the British capture of Quebec in 1760 and the treaty of Paris in 1763 that ceded the region to the English. Small settlements that had been established as trading centers, army posts, and missions persisted through the English period (1763 to 1815) and were then foci for American settlement. During both periods, conflicts with various Native American tribes were frequent; sometimes these were resolved peacefully, but more often violently as allegiances changed. Efforts of the English largely involved the fur trade and their efforts to take control of the region, first from the French and then from the Americans.

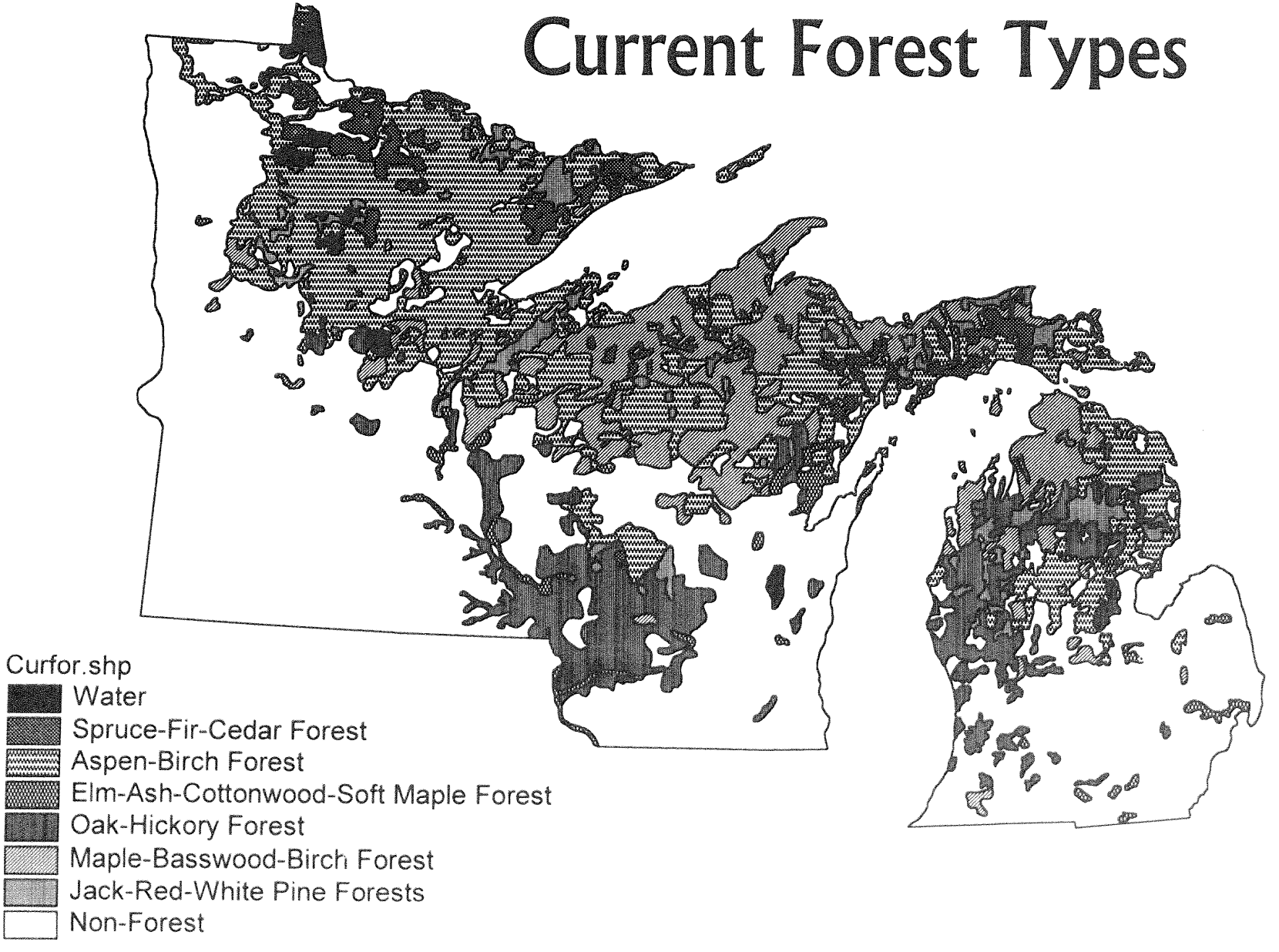
Indirect effects on the forests resulted from activities of Indian populations, including heavy hunting pressure on beaver and large ungulate populations that reduced grazing, browsing, and flooding of lowlands. The Indian populations also declined both as a result of warfare as well as of spread of European diseases. Villages were eliminated lowering agricultural activity. Wildfire probably increased in some areas while in others it probably decreased. These years included the later part of the "Little Ice Age," a period with an unsettled and variable climate during which Indian legend noted at least one catastrophic fire. Reduction in beaver, deer, bison, elk, and moose may, in a small way, have encouraged forest reproduction although the effect would have been small and localized. The growing number of European residents (mostly of French and mixed heritage) and the knowledge gained from the numerous explorers clearly provided the basis for more rapid exploitation and agricultural development.

Well before the end of the War of 1812, Americans had begun to move into what would become the Michigan, Wisconsin, and Minnesota territories, to explore and trade. After 1815, they began to administer the territories and to gradually take over the fur trade.

The General Land Office and the Presettlement Forest

During the early 19th century, major land purchases and various treaties resulted in immense areas of federally-owned land. The Commissioner of Public Lands and the General Land Office were responsible for the disposal of such lands in ways that would encourage settlement and benefit public needs. Before these lands could be made available for sale to individuals or for grants to States for schools, railroads, etc., a survey was essential to locate and divide the land into townships and sections. As the land was surveyed, the surveyors were asked to report on the natural features present including lakes and streams and on the land's agricultural value. The surveyors located section corners in reference to witness trees that were blazed, measured, and recorded in their notes. These records of witness trees have been studied and combined with knowledge of soils and natural features to provide a quantitative picture of what is called the "presettlement vegetation." This record provides the base for comparison of past with present vegetation (Plate 1a, b).

Current Forest Types



The land survey began in Michigan in 1826, in Wisconsin in 1832, and in Minnesota in 1847. In each State, the survey began at the southern border and proceeded northward. Although very useful, this record provides only a "snapshot in time" of the forest before logging began.

As the nation expanded, so did the demand for lumber. Towns that were only frontier settlements in the early 1800's grew rapidly into cities, at first drawing on their immediate surroundings and then reaching out for building materials. By the 1840's, lumbermen in Pennsylvania, New York, Maine, and New Brunswick found their supplies of white pine becoming scarce and their profits declining and so they looked westward to supply the ever-growing demand. Although some logging took place well before legal title to the land was established, major development began after the land was surveyed. As in the East, white pine was considered the only species worth logging in quantity. Easily worked, light and strong, white pine floated well and so was readily transported from the woods to the mill. The Lake States were viewed as having an ample supply.

THE WHITE PINE ERA

White pine logging began in earnest about 1836 when the first white pine was shipped east from central Michigan. Logging also began in Wisconsin and along the St. Croix River in Wisconsin and Minnesota. The cut accelerated rapidly continuing for over 50 years. Logging followed a similar pattern in each of the Lake States. The white pine harvest reached a peak between 1890 and 1910 by which time virtually all of the merchantable pine had been cut or destroyed by fire.

Pine logging usually took place during the winter with the loggers living in camps scattered throughout the forest. The logs were stacked along stream banks where they could be floated to the mill on the spring runoff. Frequently, small dams were constructed on feeder streams to store water to assist in the log drive. As more companies began to use the same large streams, boom companies evolved to better control the log drives and to sort logs from different owners. Lumber mills were usually located along large rivers or where major rivers entered one of the Great Lakes. Lumber from western Michigan and northeastern Wisconsin was transported by schooner to Chicago and other Lake Michigan ports while lumber from Saginaw and ports on Lake Huron was shipped to destinations such as Buffalo and Syracuse. Later, schooners were supplemented by barges and steam-powered tugs. Log rafts were the first form of transportation on the Mississippi, Wisconsin, and other major rivers. When mills were built upstream, log rafts were soon altered to carry lumber southward to Mississippi river towns including St. Louis. From those towns, lumber soon moved westward by rail into the Plains.

When the pine supply in the Lower Peninsula declined, large log rafts were towed from Ontario and the Upper Peninsula to Saginaw. However, rafting had limited early use on the Great Lakes. Later, log rafts were used effectively between 1923 and 1972 to bring Minnesota and Canadian pulpwood to Ashland, Wisconsin. Rafting was relatively inexpensive and an appropriate means of transportation on large rivers but it often proved risky on the Great Lakes. In the 1870's and 1880's, railroads began to spread into the northern forest, and both logs and lumber became major revenue items for the railroads, especially in Michigan's Upper Peninsula, Wisconsin, and Minnesota.

As the timber industry matured, many changes took place in the social and physical arrangements and in manufacturing processes. In the roughly 60 years that white pine was king, lumber mills shifted from reliance on water power to steam power. Waste wood from the mills provided ample fuel. The slow sash saw was replaced by the muley saw and the circular saw. Although circular saws were retained for various uses, their wide kerf wasted much wood and they eventually gave way to the band saw. Larger mills usually had several types of saws and also added planers and other equipment. Mills grew from primitive ones that required only two or three men to operate to complex facilities that employed hundreds of men, and production increased from a few hundred board feet per day to hundreds of thousands of board feet. To provide the raw logs, the wood crews expanded as well. Camps became much larger and more expensive, although most remained relatively primitive. In the woods during the 1870's, the crosscut saw began to replace the ax.

Shingles, at first a major byproduct, were joined by other products including lath, bowls, kitchenware, barrels, boxes, and furniture. In the Saginaw area, where sawmill waste was used as fuel to evaporate the brine, salt was a major byproduct.

The rapid spread of railroads resulted in a large demand for ties, timbers, and poles while the developing cities also needed wood, not only for housing but for plank sidewalks and other needs.

While supporting the explosive growth of the Midwest, the white pine era was one of increasingly rapid and often wasteful exploitation of the forest resource. On the pine lands, the impact of logging was amplified by frequent and often catastrophic wild fire.

In the early 1880's while white pine logging was still in full swing, another vigorous but short-lived forest industry came into being.

Hemlock and the Tan Bark Industry

Eastern hemlock was common in Michigan especially in the western Upper Peninsula and was abundant in much of northern Wisconsin. It grew in mixture with both white pine and northern hardwoods often forming dense stands, many of which were of considerable age. In hardwood areas, hemlock was often associated with yellow birch as well as white pine. Hemlock often occurred on somewhat poorly drained soils of low fertility, but it was also productive on more fertile mesic upland hardwood sites.

During most of the white pine era, hemlock was considered worthless. The wood was brittle, prone to windshake and splintering, weak and coarse-grained. However, in New England and later in Pennsylvania, hemlock bark was widely used to convert hides into leather, and tanneries were often located near sources of hemlock. After the Civil War, the livestock industry began to expand in the Midwest, and soon large numbers of hides became available from the slaughterhouses of Chicago and other Midwestern cities. Beginning in the mid 1880's and continuing into the 1920's, hemlock was cut heavily as a source of tan bark and soon also for rough lumber.

Hemlock bark was not easily transported, and at first it was moved by ship to tanneries in Racine, Kenosha and Milwaukee. By 1909, Milwaukee was the major tanning center of the world. As the railroads extended into northern Wisconsin and as companies made increasing use of logging railroads, the tanneries moved north to be near the source of bark. The market for hemlock bark lasted until other materials (Quebraco bark and various chemicals) came into use in the 1920's.

Peeling of hemlock bark provided jobs for loggers during the summer when hardwood logging was not feasible. The peeling season lasted through May, June, and July. A spud or an ax was used to loosen the bark in 4 to 4.5 ft lengths, and the slabs were piled to cure. Before logging began again in the autumn, the bark piles were removed and shipped to the tanneries. The piled bark was scaled in cords with an average of 2,260 pounds per cord. Some companies might peel as much as 3,000 cords a season. At first, the peeled logs were left to rot in the woods where the branches and remains of the crowns added to the summer fire hazard and the peeled logs were a nuisance when logging the remaining trees. In later years, the hemlock logs that remained after peeling were cut and moved out of the woods to be used for ties, mining timbers, rough lumber, or pulp. Hemlock reproduces irregularly and only under specific site and climatic conditions. So, it is probable that the heavy cutting of hemlock for tan bark may account in considerable measure for the absence of hemlock in large areas of today's forests.

THE HARDWOOD ERA AND RAILROADS

As the supply of white pine declined, the lumbermen considered their next move. In the 1890's, it was clear that for Michigan, and soon for Wisconsin, the white pine bonanza was over. Many large and small lumbermen picked up, sold their holdings and invested elsewhere. Some moved to Duluth to take advantage of Minnesota pine. Others moved to Oregon, California, Washington, and Idaho, or to Texas and Louisiana.

However, some, especially the larger operators familiar with the hardwood resource in the Upper Peninsula, bought more hardwood lands and built new mills or converted their current mills to hardwood production. A few companies, mostly from northeastern Wisconsin, had also had experience in logging and marketing hardwood mostly to flooring, furniture, carriage, and other specialty factories. By 1900, several of these Wisconsin companies had also purchased forestland, both pine and hardwood, in the Upper Peninsula as well as in central and northeastern Wisconsin.

Since hardwood logs float poorly if at all, transport of logs from the forest to the mill shifted from water to rail. A successful lumberman in the hardwood era required rail access to large blocks of land and an expensive mill to effectively deal with the diverse products available from the species mixture typical of the hardwood forest. In the hardwood forest the lumbermen found, intermingled, many different hardwoods: maple, birch, ash, basswood, and elm and some conifers—hemlock, cedar and fir each with special attributes and uses. In contrast, the lumbermen who had removed the pine forest had been dealing with only a few species and primarily with white pine.

The transition from pine to hardwood logging was often rapid. In the mid-1890's, several experienced and well-financed companies had moved quickly into hardwood logging. Each purchased large areas of hardwood timber in Michigan's Upper Peninsula (while the price was still low) in or near locations where they already had holdings.

Railroads were built to provide access to the timber and to markets. Other investments were made to utilize by-products, and company towns were created. When a railroad from Munising on Lake Superior to the main

line of the Chicago Northwestern along Lake Michigan was constructed, it attracted several businesses such as a cooperage firm planning to use elm in production of barrels while another company constructed a mill to use swamp cedar. Soon, Cleveland-Cliffs Iron Company purchased 84,000 acres and the railroad. That company clearcut the area removing trees and limbs of all species with the better material going to veneer plants or for use in supporting mine shafts and much of the rest to pulp wood or fuel wood. Small and rotten material was removed from the forest and shipped to the wood chemical plant. Such a complex operation depending upon a rail network to collect and distribute wood was typical of several large companies.

Rail access was essential. In the Upper Peninsula, most railroads were built at standard gauge so that they could carry heavier loads and so that rolling stock could be moved directly onto the trunk lines that crossed the peninsula from east to west. In Wisconsin, the main trunk lines such as the Wisconsin Central, Chicago Northwestern, and Chicago, Milwaukee and St. Paul Railroads had, by the late 1880's, extended northward into the hardwood country and then beyond. One of the first true logging railroad began operations in 1881. It used the cheaper narrow gauge as did many other such logging railroads in Wisconsin. The last Wisconsin logging railroad ceased operations in the 1940's, but in the 60 years intervening, about 250 different short lines had served both pine and hardwood loggers. In addition to the railroads, other steam-driven machines like the steam hauler, a locomotive with crawler tracks operating on ice roads, were used to move logs from the woods to the mill or the railroad. In the 1920's, gasoline powered tracked vehicles served the same purpose.

In 1870, the Lake Superior and Mississippi Railroad linked St. Paul and Duluth and opened large areas of pine to logging. Earlier, in the late 1850's, rail lines serving the new agricultural areas of western Minnesota were expanding. Documentation of logging railroads in Minnesota is limited, but most were probably standard gauge lines to connect with the trunk lines heading westward.

Changes During the Hardwood Era

During the hardwood period, land holdings grew larger. By 1913 for example, Cleveland Cliffs, then the largest land owner in the Upper Peninsula, held a total of 1.5 million acres. Many other companies such as the Wisconsin Land and Lumber Company of Michigan and the Ford Motor Company also developed large holdings. The period from 1900 to the 1940's was one of rapid change in transportation from water to rail and finally to gasoline and diesel trucks.

For some companies, woods operations also changed from large company-owned camps to elimination of all woods operations. Instead, for logs the company would depend upon small independent operators or jobbers. The company usually retained the timberland but contracted with the jobbers to produce a given amount of timber for the mill. The jobber might be told which tracts to cut or he would locate the timber and negotiate a price for the logs in advance, betting on the weather and his crew. The jobber set up his own camps which might be moved every year or two. Railroad camps using modified railcars were sometimes used to increase mobility. Company towns replaced camps especially for firms that had a mill within a substantial land base.

During the hardwood period, several firms experimented with selective cutting but most soon returned to clearcutting (thus limiting the life of the mill). In addition to the timber, clearcutting utilized most small trees and often some of the slash. In Wisconsin as well as in the Upper Peninsula, hardwood logging, like the earlier pine logging, left few standing trees. Fires in the dry slash, although usually not as hot as those during the pine era, consumed the surface debris and resulted in open "stump pastures." These fires were often set to clear the land for farming or were started from sparks thrown by the railroad locomotives.

After the forest was removed, the lumber companies frequently advertised the cleared land for sale as prime farm land. Earlier, this had also been the case during the pine era when repeated fire had been even more destructive and the sandy soils supporting pine were even less productive than those under most hardwood stands. Cut-over land was a liability save for those few companies that were attempting to practice sustained yield forestry.

After the widespread pine logging, some forests had begun to regenerate, but many pine areas lacked seed trees, repeated fires had eliminated reproduction, organic matter was consumed, and the soil degraded. These conditions favored open areas of brush, grass, and sedges (i.e., "stump pastures") and establishment of pioneer species—aspen, white birch, and cherry greatly changing the previous species mix. Occasionally, some residual pine, a less intense fire and absence of repeated burning permitted the regrowth of pine. Much of that second-growth pine has already been or is now being harvested.

"Stump pastures" and other open lands were also common in cut-over hardwood areas where the land surface was disturbed. These openings persisted where heavy sod had formed and where "frost pocket" conditions existed. In other cases, regrowth from roots and residual seedlings was abundant although the resulting stands are less diverse than the original ones, and sugar maple usually became dominate.

There were several early efforts at reforestation such as a private venture in central Wisconsin in 1876 that used wild seedlings. In 1911, Wisconsin established a nursery at Trout Lake from which seedlings were used in 1913 to create the Star Lake Plantation. In Minnesota, the first State tree nursery was created in 1903, and the first seedlings planted in 1914. However, additional Minnesota nurseries were not authorized until the 1930's when tree planting expanded greatly with the help of the CCC as was also the case in both Michigan and Wisconsin. In 1925, the Nekoosa Edwards Paper Company hired a forester to start the first industrial forestry program in Wisconsin and establish a tree nursery.

The Tree Farm program initiated by the forest industry in the 1940's was also successful in promoting planting and forest management on privately owned tracts. The impetus for forest planting had been building with the growing realization that agriculture was not an appropriate land use in much of the north and that tax delinquency threatened the survival of the northern economy.

As part of an attempt to better manage its lands, Cleveland-Cliffs hired professional foresters and in 1905 started a nursery and soon began to establish plantings near Munising. This effort faded in a few years as did selective cutting and sustained yield experiments. However, the program emphasis on fire control proved valuable and in 1910 resulted in the formation by the industry of the Northern Forest Protective Association. This was later augmented and later replaced by State and, later, federal activity.

White pine blister rust reached the Midwest around 1910. It was introduced on infected nursery stock brought in from France and Germany because tree nurseries in the U.S. could not meet the demand. This serious disease precluded the use of white pine and slowed interest in planting. Other less productive species (Jack, Scotch, and Austrian pine) were planted while only recently has white pine been accepted as a viable choice for management.

In 1923, the Lake States Forest Experiment Station (LSFES) was established at St. Paul, Minnesota, with a staff of five foresters and one clerk. Initial activity was directed to problems of the cutover, i.e., reforestation, fires, and economic factors. Cooperative efforts were emphasized as was timely publication. Prior to establishment of the LSFES, planting had become an important State activity, but information was needed on effective techniques and on probable success under different conditions. The first Lake States Forest Survey was begun in 1933 and by 1938 volume and yield tables had been developed for most species. During the Depression years, much Station effort was expended in support of work in the already established and new National Forests. Experimental plantings, nursery studies, and numerous other projects utilized labor and other support provided by the CCC and other emergency programs (WPA, CWA, and PWA). After 1946, work at the Station and field sites expanded greatly. On January 1, 1966, the Lake States Station was joined with the Central States Station to become the North Central Forest Experiment Station. Research continued; some projects were combined and others were begun while the headquarters remained in St. Paul.

The Great Depression gave major impetus to reforestation through the programs of the federal government. In 1929, there were extensive tracts of tax-delinquent land in each of the Lake States. The Forest Service acquired many of these clearcut, burned, and barren lands in cooperation with the States. With the advent of the Civilian Conservation Corp (CCC), large forest nurseries were developed and pine plantations were established. Many of these pine plantations as well as the regenerated hardwood stands now range from 60-80 years of age and are producing wood. Fire fighting was another major effort of the CCC vital to the reforestation process. Effective firefighting required the building of truck trails to provide access to fires and to recreation facilities that were also being created.

Federal and State Policies in Relation to Forest Lands

Throughout the 19th and early 20th centuries, federal and State policies had favored widespread and intensive logging. It was viewed as a way to clear the land and provide roads and other infrastructure that would lead to the rapid expansion of a permanent agricultural economy as well as to creation of wealth that would accelerate other development. The forest area appeared so vast that few were concerned that the resource would be exhausted. Various treaties had left the federal government with immense areas of land and the desire to have it settled. For these purposes, as new States were formed, they were granted lands for a variety of purposes, for example, to stimulate the building of railroads, or to support schools (e.g., the 1862 Morrill Act). Other federal legislation designed to provide lands to settlers included the Military Bounty Land Warrants (1850's) and the Homestead Act of 1862 as well as cash land sales to individuals. However, much of the land granted or sold to individuals ended in the hands of speculators or lumber companies and much of the land granted for railroad construction that was eventually purchased by lumbermen.

Usually when lumbermen acquired stumpage rights or title to timbered land, they cut the timber as rapidly as possible and moved on. Several major economic depressions (1857, 1873, and 1893) slowed lumber

production, but only briefly until the cut was eventually limited by the available timber. Some large firms held enough land to provide a continuing source of supply for their mills until business objectives changed or taxes increased. A few firms retained lands on which they practiced sustained yield forestry.

As timberland was cut, tax delinquency soon became a general problem. As more land in a county became tax delinquent, local governments were forced to raise taxes on the remaining land to pay for essential services, that in turn resulted in more delinquencies. By the 1920's, it was evident that the best use for the cut-over lands in the north was for forestry and not agriculture. The soils were not suitable for most crops, growing seasons were too short, and markets were too distant. After logging ceased, the subsistence farmers were left with no opportunity for seasonal employment; the nearby markets, logging camps and towns had disappeared and the marginal farms could not survive. Counties began to recognize the considerable problems (and costs) of serving scattered families and some undertook to zone outlying areas for forestry and even to resettle families from depressed areas.

The problems created by tax delinquency were universal across the region and each of the three Lake States devised somewhat different solutions that varied in timing, direction and result. In Michigan, the problem was first confronted about 1890 in the Lower Peninsula when settlers on the sandy lands in the north had abandoned worthless farms. The State attempted to get these lands back into private ownership and enacted a Homestead Act in 1893 and later approved direct sale of the land. Much land was returned to private ownership, but most new owners merely cut any timber present and again defaulted on taxes. To keep local government alive, the State had paid taxes on the delinquent lands that had reverted to the State but did not have clear title. In 1897, The General Property Tax Law was enacted giving the State full taxing authority and providing for foreclosure of tax delinquent lands. This legislation then vested full title in the State. A Forestry Commission was named in 1899 and was later replaced by The Public Domain Commission in 1900. Reverted lands and other State holdings, that had no value or use in private hands, were placed in Forest Reserves.

The Land Economic Survey begun in 1922 provided data that permitted the State and local committees to adjust the boundaries of the reserves depending on land capability. These reserves later became the State Forests that were much enlarged in 1931. The first forest reserves, established in 1903, are now the Higgins Lake and Houghton Lake State Forests. Reforestation was begun in 1904, and the Higgins Lake State Nursery was established. By 1916, Michigan had seven State forests.

As the pine era neared the end in Wisconsin, tax delinquency was already becoming a major problem, and it increased drastically when prices of farm products dropped after World War I. At the same time, the value of both farm and cut-over land fell severely.

Marginal farmers as well as lumbermen, land agents, and speculators hurt by rising taxes soon began to abandon their lands producing another round of tax increases. The property tax had long contributed to the pattern of "cut and get out" practiced by the lumber industry. In 1878, State Park lands were designated in Iron and Vilas Counties, and in 1903, a comprehensive Forestry Law created a Forestry Commission providing for a superintendent of forests and establishment of a forest reserve. A 1910 amendment to the State Constitution permitting the State to undertake active forestry was invalidated by the State Supreme Court halting progress; in 1924, a second amendment was enacted that allowed the acquisition and management of forest lands as a legitimate State activity. The first State forest was established in 1925. Ten others have followed with land acquired by exchange or purchase.

In Wisconsin, counties are responsible for setting and collecting the property taxes to support local needs, hence tax delinquent land reverted to the counties. By the early 1920's, most citizens had been convinced that forestry, not farming, was the best use for these lands, and the counties began to take steps to deal with the tax delinquent land to which they had title. The State acted to assist the counties by passing legislation to permit counties to establish reserves (i.e., county forests), and later to approve entry of these forests under the 1927 Forest Crop law, a law that provided tax relief to owners of forest land. Other legislation permitted municipalities and schools to establish forests and a 1919 amendment to the Constitution established a mill tax on real estate to provide funds for management of State forest lands.

In time, the counties met the challenge with help from University Extension and other State agencies. Costs were reduced in part by zoning and relocation of isolated and marginal farm families. Many county forests were established, planted, and protected from fire. Today 28 counties have county forests, in aggregate about 2,288,000 acres, now producing timber and providing recreation opportunities.

The situation in Minnesota was similar. Stimulated to some extent by the disastrous Hinckley fire of 1894, a Chief Fire Warden was appointed in 1895 but was allocated minimal funding. In 1899, a Forestry Board was created to manage lands granted to Minnesota by the federal government. The first Forest Reserve established was formed from land donated in 1903. In 1904, the Forestry Board obtained from Congress a grant for an

additional 20,000 acres not suitable for agriculture. A 1914 amendment to the State Constitution designated Trust Fund land as State Forest and stimulated reforestation. The Conservation Commission was created in 1925. Minnesota, following the action of Wisconsin and Michigan 2 years earlier, in 1927 enacted a statute called the Axiliary Forest Law to assist forest owners. This law enabled them to pay a low annual property tax but to be taxed on the forest crop only once at the time it was harvested. Tax delinquent lands in Minnesota reverted to the State but were managed in the interest of the counties and other entities that had tax claims against that land. This resulted in large areas being returned to county control but also left much land in State forests with the intermixture forming a complex ownership pattern.

The Great Depression, National Forests, and the Pulp Era

The Depression of the 1930's shook the financial stability of all levels of government as well as of individuals and companies and resulted in large changes in the forests of the Lake States. Much of the area had recently been logged and burned. Reforestation had progressed slowly if at all and communities were still recovering from the effects of the post-WWI economy. The region was in need of massive help as was much of the rest of the country. One result was the expansion of public ownership that absorbed much of the tax delinquent land in the region. Other federal and State actions were helpful as well.

Establishment of the CCC and location of many camps in the region vastly increased the rate of reforestation by providing essential manpower, developing substantial forest nurseries and controlling wildfire. Other measures such as the Northern Wisconsin Settler Relocation Project were established to help move isolated settlers from marginal farms and concurrently to reduce the cost of relief for the counties. Farms were purchased and help given to the families to relocate. Other federal programs such as the WPA contributed.

The Minnesota National Forest (Chippewa NF) was created in 1908, and a core area withdrawn from sale by the General Land Office in 1908 was increased from public-domain lands and became the Superior National Forest in 1909. Similarly, in Michigan, the Huron National Forest was created in 1909. Tax delinquency increased after 1918 and extensive areas of cutover, burned over, and exhausted lands reverted to the States and counties.

The Weeks Act in 1911 had authorized the purchase of private lands for National Forests east of the Great Plains, and in 1924, the Clarke/McNary Act increased purchase authority and expanded federal-State cooperation on reforestation and fire control. Research initiatives, approaches to encourage private forestry, and cooperative educational programs were also included. In the late 1920's, Purchase Units were created to obtain lands for the Nicolet, Chequamegon, Ottawa, Hiawatha, Marquette (later incorporated into the Hiawatha NF), and Manistee National Forests. These forests were established during the early 1930's. The result was to greatly accelerate renewal of the forest resource on what had been worthless land.

Industrial forestry began to flourish during the years from 1920 to the mid-1940's with many companies beginning to replant burned-over lands, experimenting with selective cutting in hardwoods, establishing nurseries, cooperating with the States in fire control, hiring foresters, and examining sustained yield approaches. This activity was encouraged by laws stipulating that property taxes could be deferred until the growing timber was finally sold. Lands were entered under these plans as well as in the growing Tree Farm programs.

The end of WWII is sometimes said to mark the beginning of the Pulpwood Era or perhaps more appropriately named the Industrial Era. Although the Pine Era was relatively distinct, the Hardwood Era was less so, melding into the Pine Era as it began and exhibiting early industrial characteristics even while emphasis was on hardwood lumbering.

However, major emphasis in each of these exploitive phases sets them apart. Some of the overlaps appear in transportation. Pine lumbering depended largely on water transport. However, during the later part of the 19th century, many firms, in northern Wisconsin and especially in Minnesota, were moving logs from the stump to the sawmill by rail. Railroads were the principle mode of transportation for hardwood logs, but soon after 1900, trucks were sometimes used to move logs, first from the woods to railroads and later from the woods to the mill. Even so, truck transportation of logs only became common after WWII.

Papermaking was closely associated with lumbering. Pulp mills served to utilize the small trees cut during clear cutting of pine and as newer pulping processes developed to utilize the vast acreages of aspen and birch that developed on the cutover and burned lands. In Minnesota, paper mills were constructed during the 1860's at six locations from Cloquet to International Falls. In 1872, a ground-wood pulp mill was built at Kaukana in the Fox River Valley, and a few years later in 1887, an integrated pulp and paper mill was built on the Wisconsin River at Wisconsin Rapids. These locations

have continued as major centers for papermaking. Few, if any, pulp and paper mills developed in the Lower Peninsula of Michigan, but pulp producers and users burgeoned in the Upper Peninsula starting in the 1920's. The increased use of fiber for building materials such as cellotex and wallboard as well as for plywood was a factor. Yet, in 1936 there were only six paper mills in the Upper Peninsula. Much of the pulp wood produced was shipped to the large Wisconsin mills. Aspen became an important pulp species and was also used for shredded packing, boxes, and pallets. Later, aspen and other species became basic components of chipboard and similar building products

The most abrupt change in the evolution of the industrial era came in the late 1940's with the rapid mechanization of logging following WWII. The introduction of the chain saw and the use of trucks for transporting logs changed not only the woods operation but even the living arrangements and logger behavior. Increased mechanization using tree skidders, hydraulic loaders on trucks, and even motorized tree shearers, reduced injuries and labor costs but involved a large investment. Woods labor became scarcer and workers demanded better living conditions.

Many of the younger "rubber tire" loggers commuted to work from home and families. The lumber camps that had been on the decline during the hardwood era disappeared by 1950 and the major pulp and paper companies (that had acquired immense land holdings) obtained their wood from independent jobbers. Many of these loggers depended on company lands for their timber or obtained it from public lands by bid. The jobbers also depended on the big companies for their markets and so lost some independence.

The northern forests have been a popular recreation location ever since the mid-19th century. Resorts and cottages began to fringe our lakes as soon as the railroads made them accessible. The ease of automobile transportation plus the impact of tourist dollars has and is putting considerable stress on the forest environment, and if not better controlled, may destroy both its appeal and many of its functions.

In the immediate future, prospects for the Lake States forests appear good. Growth exceeds wood removal, and most forest managers are giving attention to sustained management. New silvicultural approaches are being investigated, and the public is becoming better informed. Climatic change is probably the major threat, although, the simplification of the many forest systems may produce unforeseen declines as may infestations of exotic insects and disease. Increasing human use, especially for housing sites, also pose short- and long-term dangers.

Our forests are recovering from the destruction visited on them by fire and human need and greed. To continue to do so, they must be managed wisely and conservatively.

SIGNIFICANT EVENTS IN MICHIGAN FOREST HISTORY

1814	First Federal Land Office in Michigan.
1822	First mill in Upper Peninsula built by US Army at Sault St. Marie.
1825	Erie Canal completed.
1826	Federal Land Office survey began in SE Michigan.
1830	A few small sawmills along major streams in Lower Peninsula began producing for local markets.
1836	First large tract of pine land purchased by eastern lumbermen. First lumber shipped to east from pineries of Central Michigan.
1837	Michigan became a state. Federal land grants provided funds for state government operations, railroads, and schools. Michigan has 37,000 residents. Office of Geological Survey established.
1840	Copper mining began in the Upper Peninsula in the Keewanaw. Schooners were built to transport lumber from Menominee, Muskegon and other towns to Chicago and elsewhere on Lake Michigan. Used until the 1890s and were supplemented in the 1870s by barges.
1843	State Land Office created to sell 12,000,000 acres from federal land grants.
1850	Michigan population reached 398,000 (consisted largely of farmers in the southern four rows of counties) in contrast to about 8,800 Europeans present in 1820.
1853	Court determines that a stream with capacity for floating logs is navigable. Gives all individuals equal rights to streams. Origin of early water laws.
1854	Marquette Iron Range opened in Upper Peninsula.
1855	St. Mary's Falls ship canal completed.
1862	Menominee Boom Company formed to handle logs from the many logging firms on the Menominee River.
1871	Fires burned 4,000 square miles, from Muskegon to Lake Huron. Coincident with

the Peshtigo fire in Wisconsin. Twenty-five thousand loggers working in Michigan forests.

1872 1874 and 1879 major fire years in central Lower Peninsula.

1873 1,600 sawmills operating in Michigan, 100 on the Saginaw River.

1876 W.S. Gerrish of Clare County builds the first narrow gauge railroad changing the lumbering industry in Michigan.

1880 Market hunters shipped 100,000 deer carcasses from the northern Lower Peninsula.

1881 Fire burned 1,500 square miles in the thumb and again in 1891. First course in Forestry offered at the University of Michigan. Detroit, Mackinac, and Marquette Railroad completed. The railroad received land grant of 1,300,000 acres.

1882 Peak year for lumber shipment from Saginaw (over 1 billion board feet).

1885 Log rafting from Canada and Upper Peninsula to Saginaw and to eastern ports began and continued into the 1890s. Farm population on sandy cutover land in northern Lower Peninsula reaches peak, farm abandonment begins in 1888.

1887 Forestry Commission established to preserve, protect, and restore Michigan's forests, soon the Commission legislation was repealed. Peak year for Muskegon (730 million board feet) production.

1889 Railroad logging pioneered along the Ontonagon River in the UP.

1890 Peak year of lumber production in Michigan.

1893 General Property Tax Law enacted. Gave taxing power to state and enabled foreclosure on tax delinquent cutover lands.

1894 Michigan Academy of Science was organized and soon became an advocate for forest conservation and better use of cutover lands.

1897 Calculations indicated that total cut had reached 162 billion board feet, equal to 29,100 sq. miles—or almost 50% of land area of Michigan.

1899 State Forestry Commission re-established.

1900 First state land reserves established for reforestation.

1902 State Forestry Commission reports that the success of forest management depends on effective fire protection. This was followed in 1903 by passage of a comprehensive fire law that authorized state to take part in fire control outside of state forest land reserves.

1903 First state forests established in Roscommon and Crawford counties (Higgins Lake and Houghton Lake). Charcoal furnaces in Upper Peninsula were burning average of 30 acres of hardwood per day smelting iron.

1904 Between 1904 and 1908, the state sold almost a million acres of land, an amount about 17 times greater than that entered as tax homesteads. A commission reported that the state lost about $10.5 million on land sales from 1902 to 1908. Huron National Forest created.

1909 Public Domain Commission created absorbing State Land Office and Forestry Commission. Forest Reserves established.

1910 Peak cut reached for Manistique in the Upper Peninsula.

1913 A reforestation policy is established—provides seedlings.

1917 First appropriation to purchase State Park land approved and Interlochen State Park acquired.

1918 Elk introduced to Pigeon River State Forest.

1920 Michigan cut of pine was exceeded by hardwood cut.

1921 Department of Conservation was created with nine divisions including Fire Control, Game Protection and Propagation, Fish Culture, Predatory Animal Control, Public Lands, State Parks and Education. Conservation Commission established to oversee the Department.

1922 Land Economic Survey established. Over 11 years of the survey, 8.4 million acres were examined in 18 northern Michigan counties.

1923 Forest Fire Law enacted providing authority for fire control outside of state forest preserves.

1924	Congress passed the Clarke-McNary Act providing for cooperation between Federal, State and private entities on fire control, reforestation, land purchase and exchange, etc.
1925	Commercial Forest Act created. Required a permit to cut forest products. Also, a fire year with 3,887 fires that burned 733,750 acres.
1929	Forest campground system began with Spring Lake in the Fife Lake State Forest.
1931	Purchase orders approved for the Ottawa, Hiawatha and Marquette National Forest units formed primarily from cutover lands.
1932	Between 1921 and 1932, the state had obtained title to almost 2 million acres of abandoned land that clearly could not be made permanently productive in private ownership. There were now eight forest reserves with 170,000 acres managed and 105,000 acres in unmanaged, unnamed units.
1933	Enabling legislation for the Civilian Conservation Corps signed by President Roosevelt. In time, over 100,000 CCC members reforested 134,000 acres, installed thousands of waterwells for fire fighting, and carried out many other valuable activities. Called the "single most productive conservation effort in our history."
1934	Conservation classes began in schools.
1935	Land Use Planning Program using results of the Land Economic Survey to involve local citizens on study committee. Committee recommended that over 80% of state-owned lands should remain in state ownership.
1936	Worst year for forest fires in the Upper Peninsula.
1937	Wood workers unsuccessful strike in the Upper Peninsula.
1940	Michigan Wisconsin Timber Producers Association formed. Timber sale program begun on state land to improve food and cover for game (deer).
1944	Funds appropriated for land purchase in southern Michigan and for the Porcupine Mountains. State forest lands total nearly 2 million acres with 13 State Forests under management.
1946	All state Game Area lands (1,400,000 acres in northern Michigan) were transferred to the Forestry Division and dedicated as State Forests.
1947-1950	Chain saws came into common use in the woods.
1948	After 6 years of study and controversy, the Conservation Department was re-organized, decentralized, and several new or renamed divisions including both forestry and recreation divisions were added to the field units.
1949	Since 1931, 642 school forests and 223 community forests had been established on 65,433 acres of Conservation Depart,emt land (mostly tax reverted).
1950's	Logging camps became rare, none remained by 1960. Most large industrial users depended on "independent" jobbers for timber. Motorized and gasoline powered logging machinery became the rule.
1960	State Forest ownership reached 3,765,000 acres and included 105 campgrounds.
1968	The Department of Natural Resources replaced the Conservation Department that had been reorganized in 1948 and again in 1964-1965. The Department of Natural Resources was itself reorganized in 1973 and in 1976.
1973	Department of Natural Resources divided into two branches: natural resources and environmental protection, each with its own funding.
1977	Forestry and Forest Fire Divisions were merged and given management responsibility for managing 3,800,000 acres of state forest lands and fire and insect control on all forested lands.
1983	Michigan Forest Resources: Directions for the Future—A Statewide Forest Resources Plan is released giving recommendations.
1984	The Task Force on Public Lands Policy provided recommendations for the role of the state in land ownership. Strongly opposed disposal of state lands as not in the State's best interest.
1988	Forest and Mineral Resources Development Act created fund to promote forestry and forest products in Michigan.

1990 State Park System downsized because of budget constraints. Governor creates Michigan Forest Finance Authority to finance investments in the State's best interest.

1993 Department of Natural Resources reorganized and new department is created by Executive Order.

1995 Executive Order creates a Department of Environmental Quality and transfers its functions from the Department of Natural Resources leaving the Divisions of Wildlife, Parks and Recreation, Fish, Forestry, Real Estate, Administrative Services, and Law Enforcement. The DNR is again reorganized eliminating the regional field structure.

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SIGNIFICANT EVENTS IN MINNESOTA FOREST HISTORY

1821 A primitive sawmill was erected at St. Anthony Falls to cut lumber for construction of Fort Snelling.

1837 Treaty with the Chippewa (Ojibwa) and Sioux (Dakota) tribes transferred a large area of Indian lands to the United States.

1838 Treaty was ratified.

1839 First settlement with a lumber mill named Marine was established on the St. Croix. Mill used water power and a muhley saw and began to cut timber in 1839. The mill was hauled in by steam boat, and with some changes, it remained in operation for 50 years.

1840 Rafting logs and then lumber southward on the Mississippi began using man power. Within a few years, tows were pushed by steam boats to Winona, St. Louis, and other river towns. Towing continued even after 1900.

1843 Stillwater was established and its first lumber mill built in 1844.

1847 General Land Office Survey began in Minnesota.

1848 Government Land Office opened at St. Croix Falls selling land in the St. Croix Valley including sites of St. Paul and Stillwater. Water-powered sawmill was erected at St. Anthony Falls to serve the local market.

1849 Territory of Minnesota was organized.

1850 Minnesota population now 6,000 grew to 150,037 by 1857.

1851 Treaty of Traverse des Sioux brought Minnesota about 19,000,000 acres of farm land on west side of State, increasing lumber markets. A log boom was chartered on the St. Croix near Stillwater. By 1874, 3.5 billion feet of logs had passed through this boom.

1853 Land purchases began on a large scale paid for either in cash or with military bounty land warrants.

1854 Stillwater now had 5 mills including the first steam powered mill with gang and

circular saws. Minneapolis had 3 door and sash companies. Lumber industry was a major factor in development of Minneapolis, exceeding grain. Food for settlers and lumber camps was sometimes a limiting factor.

1855 Settlement began at Winona, and one sawmill was built followed within 2 years by two others. Farmers traded produce for lumber. Duluth also began to attract interest and a small sawmill was built.

1858 Minnesota gained statehood.

1859-1860 Low water on the Minnesota River influenced price and availability of lumber from St. Anthony Falls to Mankato.

1860 At Stillwater, a large steam powered mill with two gang saws was built to serve the St. Louis market. The 1860's were a period of great expansion in the lumber industry and in rail transportation. By 1859 the existing railroads were experiencing difficulty in transporting westward all the lumber needed. Railroads themselves used much wood-for ties, bridges, poles, and grain elevators as well as for the associated towns. In 1867, the city of Minneapolis had 67 miles of boardwalk, a total of 6 million board feet.

1862 Morrill Land Grant Act provided States large land grants to support agricultural and engineering colleges. Homestead Act also increased land transfer to individuals, but the land often ended up in the hands of the lumber companies.

1870 Completion of the Lake Superior and Mississippi Railroad from St. Paul to Duluth opened a large area (enough pine to last until 1880). Other centers were developing, such as Anoka and Brainerd. By 1869, the population of Duluth had reached 3,500 people. During the past decade paper mills were built at Cloquet, Grand Rapids, International Falls, Brainerd, Little Falls, and Sartell to utilize smaller trees being cut. Likewise during the 1870's the crosscut saw was replacing the ax, and horses were replacing oxen in the woods.

1871 Tree bounty law was passed providing payment for trees planted on the prairies and other open land.

1876 The Minnesota State Forestry Association was formed.

1877 An act was passed that required that standing timber be estimated, appraised, and sold before the land could be sold.

1887 A company from Saginaw, Michigan established a sawmill in Duluth followed during the next few years by at least 4 other Michigan companies that purchased sizable holdings.

1888 A log boom opened at St. Paul and between 1888 and 1913 moved 1,709,062,520 ft. of logs. Even so, yellow pine from Arkansas became competitive and fewer logs were sent down the Mississippi from the St. Croix and the Chippewa drainage in Wisconsin.

1890's Timber ownership became concentrated in a few hands. The land grant of the Northern Pacific RR was purchased by Weyerhaeuser who had also begun operating in Washington Territory in 1887.

1891 Legislature established Itasca State Park, and in 1892, Congress granted the federal lands within the park to the State.

1893 Panic of 1893 reduced the cut as did low water in 1900 and no snow in 1901-1902. In 1893, Duluth firms stopped competing westward and shipped mostly eastward.

1894 Hinckley Fire caused 418 deaths. In the late 1890's and early years of the 20th century, agitation began for conservation legislation.

1895 The legislature named the state auditor as Forest Commissioner and authorized him to appoint a chief fire warden to enforce the fire laws. General C.C. Andrews was appointed. Only $5,000 was allocated for fire control for a forest area estimated by Andrews at 11,890,000 acres.

1899 A Forestry Board was created by the legislature to manage lands granted to the State by the federal government.

1891-1902 Fraud involved in sales of Indian land referred to as the "Red Lake Pine Muddle." Stumpage on thousands of acres of Indian land was vastly under-estimated resulting in large losses to federal government and to Indians from 1896 sale. Eventually resulted in the Morris Bill amending the Nelson Act, that established reserve areas including the one designated as the Minnesota National Forest and controlled timber

sales. It brought in greater returns to the government but also left the Indians with large cutover areas. In 1917, half of the Red Lake Indian Forest was clearcut. Similar serious problems affected the White Earth Reservation after 1906 when that tribe agreed to accept individual land allotments.

1899 Minnesota State Forestry Board was created and in 1900 received 990 acres of cutover land. That land was combined with 1,000 acres of cutover land given by Gov. Pillsbury and was designated as a forest reserve in 1903 and later became the Pillsbury State Forest. A nursery was established to produce seedlings.

1903 University of Minnesota School of Forestry was formed.

1904 Congress was asked by the Forestry Board to grant land not fit for agriculture to State and agreed to deed to Minnesota 20,000 acres that was accepted in 1905 as the Burntside Forest Reserve.

1908 Congress established the Minnesota National Forest, renamed the Chippewa NF in 1928. After Chisholm fire, the chief fire warden was authorized to appoint fire rangers to help fight fires, but funding was not adequate.

1909 Land withdrawn by the General Land Office at request of General Alexander became nucleus of the Superior National Forest established with 909,734 acres by Presidential Proclamation.

1910 Baudette and Spooner were destroyed by fire with 42 victims.

1911 Revised legislation for fire control. Appointment of State Forester W. T. Cox who organized the State forest protection system with district rangers.

1914 A constitutional amendment was passed designating trust fund land as State forests, and soon, extensive tree planting was in progress.

1918 Cloquet Fire destroyed Cloquet and numerous small villages with a loss of 438 lives. Resulted in passage of a law requiring burning permits.

1923 Lake States Forest Experiment Station set up by U.S. Forest Service.

1924 Passage of the federal Clarke-McNary Act provided State with funds for fire protection and other activities.

1925 First Conservation Commission was created, and Department of Conservation formed laws regarding forestry were codified.

1927 Law was enacted regulating cutting of Christmas trees. Changes to this law in 1935 required that all Christmas trees must be tagged.

1931 Department of Conservation was reorganized, and the Conservation Commission was enlarged to 5 members appointed by the Governor. Most of duties regarding State lands and resources held by the State auditor were transferred to the Commissioner of Conservation. Made sale of State timber and management of State parks the responsibility of the Division of Forestry. Production of conifer planting stock was authorized.

1932 Appointment of Minnesota Committee on Land Utilization by Governor. Report was published in 1934 with title "Land Utilization in Minnesota: A State Program for the Cut-Over Lands."

1933 Legislation passed that specified that all income from acquired lands within State forests would go to the general revenue fund and that 50% of gross amount would go to the county where the revenue was generated. Civilian Conservation Corps was created by Congress and 13 additional State forests were created by the legislature.

1935 Lake States Forest Experiment Station published Forest Survey Release No. 2 on the Forest Situation in the Cloquet-Superior District. Separate State Parks Division established as were 13 more State forests. Peat lands were withdrawn from sale, and various fire control regulations were authorized.

1937 Conservation Department again reorganized. Conservation Commission abolished and Commissioner appointed by Governor.

1939 County land zoning was authorized. Eight counties zoned their lands. New law required the classification and appraisal of timber on tax-forfeited lands and approval by the Commissioner before sale.

1943 State forest laws codified, and 29 State forests were re-established. Minimum cutting regulations were enacted.

1944 Keep Minnesota Green was organized in Minnesota providing for forest fire prevention education and the Tree Farm program. By 1958, over 1,000 tree farms established including over 600,000 acres.

1945 Legislature authorized establishment of county memorial forests from tax-forfeited lands.

1946 Assistance in management of private forest lands provided by forest industry and in 1947 by State funds. State nurseries were authorized to produce planting stock for privately owned lands.

1953 Norway pine was designated as the Minnesota State tree and the Chengwatana State Forest was established. This was followed in 1954 by the White Pine State Forest, totaling 34 State forests.

1956 Division of forestry was reorganized into 4 regions with 74 Ranger Districts. Cooperation was undertaken with Soil Bank Conservation Reserve Program and Agricultural Conservation Program providing planting stock and technical assistance. Nurseries were enlarged.

1957 Passage of the Minnesota Tree Growth Tax Law to permit privately owned forest lands to be taxed on the annual increase in value.

1959 Commissioner of Conservation reserved 830,116 acres of State land to be added to State forest system. Fire laws were strengthened.

1963 Legislature established and/or re-established 54 State forests total of 2,926,570 acres. Minnesota Outdoor Recreation Act was passed.

1965 Bill passed prohibiting Land Exchange Commission approval of federal acquisition within the Superior National Forest and land exchanges between the U.S. and the State in this area.

1967 Legislature again reorganized the Department of Conservation and repealed or updated various earlier legislation.

1993 Minnesota Environmental Quality Board releases the draft of the Generic Environmental Impact Statement and 15 briefs that summarize the report.

1995 Massive July blowdown in two areas southwest of Bemjidi and south of Grand Rapids totaling 188,000 acres of forest land for total of 2,790,000 cords of mostly aspen in west and conifers in east. Salvage is planned.

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SIGNIFICANT EVENTS IN WISCONSIN FOREST HISTORY

1809 First sawmill built on Fox River near DePere.

1819 Sawmill built on Black River near Black River Falls.

1822 Permit for timber cutting issued in Chippewa Valley by Indian Agent.

1831 Sawmills built on Menominee River (Marinette Co.), on Red Cedar River (Dunn Co.), and on Wisconsin River (near Nekoosa).

1832 General Land Office Survey begun at the intersection of Illinois State Line and the 4th Principal Meridian.

1837 First permission given by Indians to white men to cut timber and build mills in the St. Croix River Valley.

1840 Lumber rafts dispatched down the Wisconsin River from Biron (near Wisconsin Rapids).

1841 Law passed regulating dam construction on navigable rivers relative to log drives.

1848 Papermill using rag stock to make newsprint built at Milwaukee. Steam tow boats used to tow log rafts on the St. Croix River. Wisconsin gains statehood.

1854 Boundaries of Menominee Reservation established after treaty.

1858 Upper Wisconsin River log drive from Eagle River to Mosinee.

1867 Legislature authorized Forestry Commission to study forest destruction in Wisconsin.

1871 The Peshtigo Fire and associated fires in Brown and Door Counties resulted in great loss of life and property.

1872 Kaukauna becomes site of first groundwood pulp mill in Wisconsin. Forest fires were common in Wisconsin during the later half of the 19th and early 20th centuries. Serious fires were recorded in 1863, 1864, 1868, 1880, 1891, 1894, 1897, 1908, 1910, 1923, 1931, and 1936.

1873 Wisconsin Valley Railroad built from Tomah to Grand Rapids (Wisconsin) was the start of rail transportation for logs and lumber in central Wisconsin.

1876 Private reforestation project near Hancock using wild stock.

1878 State Park lands (50,000 acres) established in Vilas and Iron Counties.

1881 Steam-driven logging railroad became operational for the Shell Lake Lumber Company in Washburn County. Strike of mill workers in Eau Claire called the "Sawdust War."

1883 Veneer plant established near Antigo.

1884 Plywood plant built in Two Rivers, and woodpulp mill built on the Wisconsin River at Centralia (Wisconsin Rapids).

1887 Integrated pulp and paper mill established at Centralia. Menominee tribe rejected option in General Allotment Act that would have permitted division of tribal communal lands to individuals.

1894 Forest fire destroyed town of Phillips (Price Co.).

1895 Legislature authorizes formal forest protection organizations.

1900 Groundwork begun through first land acquisitions for future St. Croix Interstate Park.

1903 Comprehensive Forestry Law creates a Forestry Commission, provides for a Superintendent of Forests and establishment of a forest reserve. Instruction in forestry offered at the University of Wisconsin.

1904 E. M. Griffith appointed as first State Forester.

1905 State Board of Forestry created consisting of President of University of Wisconsin, Dean of College of Agriculture, Director of Geological Survey, Attorney General, and one citizen appointee.

1907 State Park Board established.

1908 Construction of modern sawmill at Neopit provided by LaFollette Act.

1910 Forest Products Laboratory established in Madison for research on forest products by U.S. Forest Service. Wisconsin State Constitution amended, enabling the State to engage in forestry as work of internal improvement.

1911 First integrated Kraft (sulphate) pulp and paper mill in North America built at Mosinee. State-operated tree nursery and headquarters of State Forester established at Trout Lake in Vilas County.

1913 Pine plantation near Star Lake (Vilas Co.) planted by State with seedlings from Trout Lake Nursery.

1924 Forestry consulting firm organized in Milwaukee supervised first selective logging operation in Wisconsin in Oconto County. Second forestry Amendment to State Constitution was adopted providing authority for forest land acquisition and management. Clarke-McNary Act enacted by Congress provided for State-Federal cooperation in fire control and reforestation, etc. Tax delinquency in cutover counties becomes critical problem.

1925 Northern Highland State Forest established in Vilas County. Industrial forester hired by Nekoosa-Edwards Paper Co. established nursery and began forestry program. State gave approval to federal government to begin purchase of land for National Forest.

1926 Agreement between Wisconsin Conservation Department and University of Wisconsin to establish a program to improve forestry for private land owners and farm forestry extension work began.

1927 Forest Crop Law passed providing tax relief for forest land owners. School districts and municipalities permitted to own land for forestry purposes. Initial meeting of Conservation Commission.

1928 Goodman Lumber Company enters land under Forest Crop Law. U.S. Forest Service acquires 12,940 acres near Three Lakes as initial purchase for the Nicolet National Forest. Farm abandonment and tax delinquency addressed by report entitled "Making the Most of Marinette County Lands." Laona and Crandon School Districts establish school forests.

1929 Mill tax on real estate passed to provide funds for management of State-owned forest lands.

1930 Marinette County establishes county forest under Forest Crop Law. Cooperative fire control agreement arranged between the Nekoosa-Edwards Paper Company and the Wisconsin Conservation Department.

1933 Creation of the Chequamegon and Nicolet National Forests.

1933 Nicolet National Forest receives first two CCC camps in Wisconsin. Within a short time the Nicolet and Chequamegon NF had many camps aiding in reforestation, road building, and other activities. Oneida County adopts first Rural Zoning Ordinance in United States.

1934-1940 Northern Wisconsin settler relocation project. Moved over 400 families from isolated marginal lands in cutover.

1941 Industrial forests had grown to 800,000 acres.

1944 Trees for Tomorrow (funded by 9 paper companies in cooperation with USFS) initiates conservation education programs. Forest tree planting machines, developed by University of Wisconsin, Department of Agricultural Engineering and Extension, come into widespread use.

1946 Wisconsin Conservation Department appoints farm foresters to assist farm woodland owners.

1950 Cooperative State/Federal/County forest inventory undertaken.

1965 Wisconsin Arborist Association founded.

1967 Wisconsin Department of Natural Resources created from Department of Conservation with added responsibility for air, water, and other environmental issues, a result of the Kellet Commission.

1970 Peeled aspen pulpwood production hastened by satellite debarking, first plant built at Mercer.

1972 Aspen chips for pulping produced by satellite chipping plant at Ashland.

1974 Chippewa Indians sue for timber harvest rights on northern Wisconsin public lands. The case was finally resolved in 1991 when a federal judge ruled against the Chippewa claim.

1976 Industrial tree farm area reaches 1,351,535 acres. Forest History Association of Wisconsin formed. UW Stevens Point established an urban forestry option as part of its undergraduate forestry major. Serious drought hit Wisconsin lasting into 1977 when ended by late spring rains. In 1976, 4,000 fires burned 48,000 acres and 100 structures and in 1977, 3,000 fires burned 60,000 acres.

1977 By this year there were 328 school forests (25,084 acres) most with active education and/or forestry programs. A major storm crossed the State leveling about 344,000 hectares of forest in 25 separate downbursts including much of the Flambeau State Forest. Project Learning Tree began, co-sponsored by WDNR and WI Depart,emt

of Public Instruction. With numerous changes over the years, the program continues under the guidance of an advisory committee.

1979 Association of private non-industrial woodland owners organized. Waferboard plant constructed at Hayward by Louisiana-Pacific Corp.

1980 Lake Superior District Power Co. at Ashland began to produce electricity burning chips, sawdust, and bark. Two fires in northwest Wisconsin burned 16,000 acres and destroyed 100 homes and other buildings. A Governor's Commission on Forest Fire Control was appointed and encouraged cooperative efforts between local and State agencies.

1981 Hayward State Forestry Nursery acquired by WNDR from USDA Forest Service. Planting from State nurseries had already passed the one-billionth seedling.

1983 Wisconsin forest land area reached 14.8 million acres increasing by 300,000 acres since 1968.

1984 Great Lakes Forest Fire Compact formed. States of Wisconsin, Michigan, Minnesota, and Province of Ontario agreed to share resources for wildlife management.

1985 Managed Forest Law enacted replacing the 1927 Forest Crop Law and the Woodland Tax Laws. This law provides tax incentives to manage forest resources for multiple benefits. Federal Farm Bill established the Conservation Reserve Program (CRP) with the result that, from 1985 to 1995, 60,000 acres were planted to trees in Wisconsin.

1989 Congress passes the 1990 Farm Bill authorizing federal urban forestry assistance to states. Within a year, WDNR hired a State Urban Forestry Coordinator.

1991 A blister rust resistant white pine seed was collected from a WDNR seed orchard. Wisconsin Legislature amends statutes to establish a state urban forestry grant program to begin in fiscal year 1993.

1992 First State Urban Forestry Conference and appointment of an Urban Forestry Council.

1994 Wisconsin Forest Accord signed by 13 organizations with the purpose to improve communication concerning statewide forest management. Included agreement that the Habitat Classification System and National Hierarchy of Ecological Units can work together to achieve resource management goals.

1995 County forests' revenues exceed $8,000,000 annually. Wisconsin Department of Natural Resources loses former apolitical status as 1996 Budget Bill places Secretary in Governor's Cabinet. Departmental reorganization is begun. DNR issues major report "Wisconsin's Biodiversity as a Management Issue."

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Health of Lake States Forests—1992

Manfred E. Mielke[1]

INTRODUCTION

Forests have always been subject to forces in the natural environment and exist because of their capability to respond to those stresses. Drought, fire, forest succession, and forest pests have always shaped the extent and character of forests. But increasingly, human-caused factors, such as newly introduced pests, air pollution, and the possible effects of changes in global climate, are influencing forests and focusing attention on how society can best sustain the health of today's forests.

It is difficult to assess the general health of forests at any point in time because they are dynamic systems undergoing continuous change. Forest health can be defined as the ability of a forest to recover from natural and human-caused stresses. Some traditional measures of forest health are the age and composition of the forest; trends in tree growth and mortality; condition of tree crowns; condition of soil, water, and wildlife; frequency and severity of pest outbreaks; and a vulnerability to pests.

Over time, single or multiple stresses may alter trees to a point where they can no longer recover and they begin to "decline," exhibiting crown dieback and deterioration. This decline may be reflected by changes in rates of succession, forest composition and structure, or general productivity. Large outbreaks of insects and diseases do not automatically indicate a deterioration in forest health. The frequency and intensity of outbreaks of native pests reflect normal ecosystem dynamics. However, combinations of stresses, such as prolonged drought and insect defoliation, sap tree energy. It is desirable to establish and maintain forests that are as resilient as possible to natural and human-caused stresses, while meeting the values, needs, and expectations of society.

This paper presents information about the health of Lake States forests and the effects of forest stressors (insects, pathogens, weather, and air quality) on major forest types. Included is a historical perspective on the influence of the various forest stressors and an assessment of the recent impact of pests on the forests in Michigan, Wisconsin, and Minnesota.

[1]The author is a Forest Health Specialist, USDA Forest Service, Northeastern Area State and Private Forestry, 1992 Folwell Avenue, St. Paul, MN 55108.

HISTORICAL INFLUENCES

By the middle of the twentieth century, most of the Lake States region had been cut over and many acres burned. Many abandoned and protected areas were reclaimed by trees, resulting in a forest that frequently differed from the original. Many tree species now occupy the landscape.

Lake States forests have been affected by the introduction of forest pests from Europe and Asia. These pests are of particular concern because specific predators and parasites from their native habitats rarely exist here, and the natural resistance of individual trees and forests has not evolved to accommodate their insults. Dutch elm disease, white pine blister rust, and gypsy moth have, in some cases, virtually eliminated significant components of the original forest and have permanently changed the composition and health of today's forest.

Other pests known, or thought, to have been introduced have localized effects and species-specific impacts. Basswood thrips, ash yellows, and butternut canker have harmed forest health; butternut canker now even threatens the existence of a tree species. The European strain of scleroderris canker and beech bark disease have struck in Canada and Ohio, the common pine shoot beetle has gained a foothold in Michigan, and the Asian gypsy moth has the potential to destroy forests throughout the Lake States.

Native insect populations (forest tent caterpillar, jack pine budworm, spruce budworm, pine engraver beetle) and endemic diseases (root disease, cankers) have periodically erupted to damaging levels when weather conditions have been favorable. Adverse weather, drought, flood and ice damage have directly resulted in tree mortality and growth loss, and have predisposed forests to secondary insects and diseases. Other diseases, such as oak wilt and decay, have expanded because of construction and deleterious management practices.

However, despite all these stresses, pest activity is not uniformly threatening the overall condition of Lake States' forests. In fact, Forest Inventory and Analysis data (Jakes 1980, Spencer 1983, Spencer and Jakes 1980, Spencer *et al.* 1990, Spencer *et al.* 1988) show an increase in forest acreage, volume of growing stock and volume of sawtimber:

Minnesota	1977	1990
Area of timberland	13,613.1 M acres	14,773.4 M acres
Volume of growing stock:	12,379,339 M cubic feet	15,093,975 M cubic feet
Volume of sawtimber	24,441,259 M board feet (Int 1/4" rule)	34,810,467 M board feet
Wisconsin	**1968**	**1983**
Area of timberland	14,536.8 M acres	14,759.4 M acres
Volume of growint stock:	11,168,000 M cubic feet	15,498,185 M cubic feet
Volume of sawtimber	21,755,745 M board feet (unadjusted)	35,035,413 M board feet (unadjusted)
Michigan	**1966**	**1980**
Area of timberland	18,857.3 M acres	17,489.5 M acres
Volume of growing stock	15,050,000 M cubic feet	19,103,800 M cubic feet
Volume of sawtimber	33,863,300 M board feet (unadjusted)	47,669,136 M board feet

However, the effects of all of these pests and stresses and their interactions need to be continually monitored to determine the relative health of forests at a particular time.

THE FOREST RESOURCE

The forest resource contains various tree species found in pure stands or in association with other tree species. Forest type is a classification of forest land based on the tree species growing on the land. The forest types are described by the Society of American Foresters in Forest Cover Types of the United States and Canada (Eyre 1980) and are named after the predominant tree species. The occurrence of a forest type in a particular area is dependent on soil characteristics and climate. The species composition of a stand varies according to past history, use, and current growing conditions. Forest types may change due to disturbance or natural succession to other forest species.

The many forest types that occur in the Lake States are combined by the USDA Forest Service, Forest Inventory and Analysis Unit, into major forest type groups. Of the 121.9 million acres in the Lake States (Table 1), 50.4 million acres (41%) are forested. About 45.9 million acres (91%) of the forested acreage is land considered available for production of wood products, and the remainder is in wilderness, natural areas, urban forests, and parks. The major forest types in the Lake States (Table 2) are white-red-jack pine, spruce-fir, oak-hickory, elm-ash-cottonwood, northern hardwoods, and aspen-birch (Jakes 1980, Spencer 1983, Spencer and Jakes 1980, Spencer *et al.* 1990, Spencer *et al.* 1988).

Table 1.—*Land area by class and state (in thousands of acres)*

	Michigan	Minnesota	Wisconsin	Total
Timberland	17,489.5	13,695.1	14,759.4	45,944.0
Noncommercial forest	879.3	3,014.1	591.9	4,485.3
Nonforest	17,994.1	34,035.6	19,481.5	71,511.2
Total land	36,362.9	50,744.8	34,832.8	121,940.5

Table 2.—*Timberland by forest type group and state*

	Michigan	Minnesota	Wisconsin	Total
White-Red-Jack Pine	1,706.7	816.0	1,250.3	3,773.0
Spruce-Fir	2,544.5	2,944.1	1,347.2	6,835.8
Oak-Hickory	1,773.6	893.9	2,858.7	5,526.2
Elm-Ash-Cottonwood	1,326.4	738.1	1,240.6	3,305.1
Northern Hardwoods	6,098.4	1,283.9	3,996.9	11,379.2
Aspen-Birch	3,781.4	6,848.8	3,903.1	14,533.3
Unstocked	172.2	169.4	160.4	502.0
Total	17,489.5	13,694.2	14,759.4	45,944.0

Note: Totals include exotic species for Wisconsin (2.2) and Michigan (86.3).

CONIFER TYPES (BURNS AND HONKALA 1990)

White-Red-Jack Pine Forest

White, red, and jack pine frequently overlap within the white-red-jack pine forest. About 3.7 million acres of this type occur throughout the region. One of these species tends to predominate, depending on soil fertility and soil moisture. On some sites, eastern white pine is much more prevalent than on other sites where red pine is more successful. Jack pine often occurs in pure stands in areas where fire has exposed mineral soils and on dry, sandy, or gravelly soils. Eastern hemlock is a common associate of eastern white pine, and their ranges closely coincide, although eastern hemlock does not extend as far west and north as eastern white pine. Each of these species has distinctive ecological requirements and is usually managed in a unique way.

Eastern White Pine

Eastern white pine, found throughout the Lake States occurs in pure stands and commonly with other species, such as eastern hemlock, red maple, and northern red oak. It grows on a wide range of soil types from coarse, droughty soils to moist sites and is found in association with the northern hardwood, aspen-birch, spruce-fir, red pine, and jack pine forests.

Eastern white pine is affected by many factors, such as the white pine weevil, various needle diseases, trunk and root rots, and excessive salt spray, and certain individual trees are especially susceptible to ozone air pollution injury. However, the most serious threat to the health of eastern white pine is white pine blister rust. White pine blister rust was first found in Geneva, New York in 1906 and, was present throughout the range of eastern white pine by 1960. This disease infects and kills trees of all ages throughout the range of eastern white pine. In the mid 1900's an unsuccessful attempt to control infection by eradicating currant and gooseberry bushes, the alternate hosts for the disease, was made. Today, blister rust, white pine weevil, and deer browsing continue to be the major limiting factors in the culture of this important timber species.

Red Pine

Two-thirds of all the red pine type in the country occurs in the Lake States. It occurs naturally in pure stands or in a mixture with northern pin oak, eastern white pine, or jack pine. Red pine has also been planted extensively. It is most common on sandy, well-drained soils. On some sites, red pine may be found with red maple, northern red oak, white spruce, and balsam fir. Red pine will often succeed less shade-tolerant jack pine, paper birch, and aspens, and it will be replaced by eastern white pine, white spruce, and balsam fir, which regenerate more readily in the understory.

Red pine is susceptible to various insects and diseases, especially scleroderris canker, red pine scale, red pine adelgid, and pine sawflies. The red pine scale and red pine adelgid, both introduced pests, are causing mortality of trees of all ages in southern New England and south-eastern New York, and their range is expanding. Scleroderris canker is found in scattered locations in the Lake States. It was a major concern in the 1970s, when the area of infection increased dramatically due to weather conditions. Cool, wet conditions favor spore dispersal and infection by this fungus.

The European pine sawfly is a common defoliator of red pine, often in young plantations. Repeated defoliation can cause growth reductions and mortality. The red pine beetle commonly causes scattered mortality when red pine is subjected to other stressors, such as drought or a recent blowdown. Red pines planted outside their natural range are often attacked. Drought from 1987-1989 resulted in widespread mortality throughout the range of red pine.

Jack Pine

Jack pine occurs throughout the Lake States. It is often found in pure stands, but commonly includes other species. Associated species are oaks, aspen, white and red pine, eastern larch, spruce, and fir. Jack pine is a short-lived, shade-intolerant species. It often originates after forest fires, which kill competitive species, prepare the seed bed, and release seed from cones. Without repeated disturbance by forest fire, jack pine is replaced by more shade-tolerant species, such as eastern white pine, red pine, and northern hardwoods or spruce-fir forests.

Defoliating insects, such as the jack pine budworm, jack pine sawfly, and the redheaded jack pine sawfly, cause varying degrees of growth reduction, dieback, and mortality during occasional population outbreaks. Outbreaks of the jack pine budworm occur in cycles. Moderate to heavy defoliation occurs for 2 to 3 years, followed by 6 to 10 years of no detectable feeding. Defoliation results in needle loss, top kill, and in some instances, mortality of the entire stand. In the 1970s and 1980s, the Lake States sustained heavy losses in older stands on droughty soils. In 1991, jack pine budworm defoliated more than one-half million acres in the northern Lower Peninsula of Michigan, approximately 50,000 acres in the Upper Peninsula, and scattered places in northern Minnesota. An additional 170,000 acres were defoliated in 1992.

Eastern Hemlock

Eastern hemlock ranges from northern Michigan to eastern Minnesota. It occurs in pure stands, or is commonly associated with eastern white pine, balsam fir, sugar maple, American beech, and yellow birch. Eastern hemlock grows best on moist, well-drained sites, but also grows in wet, almost swampy areas or sandy streambanks. Unlike eastern white pine, eastern hemlock is very shade-tolerant and can endure decades of suppression, but does not tolerate dry conditions.

Eastern hemlock is seldom affected by diseases. However, it can decline rapidly when suddenly exposed after cutting, and it is affected by several insect pests. The hemlock woolly adelgid was introduced into the Unites States in the early 1900s and was first reported in the eastern United States in 1953. It is a serious pest on eastern hemlock (and Carolina hemlock in the south) in both forested and urban areas. In some locations, the elongate hemlock scale is found in conjunction with the hemlock woolly adelgid. Recently, the adelgid has been reported damaging eastern hemlock from southern New England and New York to New Jersey, Pennsylvania, Maryland, and West Virginia. Infestations are expected to spread, and mortality is expected to increase.

Spruce-Fir Forest

About 6.8 million acres of spruce-fir forest are found in the Lake States, mostly in the northern regions. On some sites eastern white pine, red maple, yellow birch, paper birch, aspen, eastern hemlock, and sugar maple intermingle with the spruce and fir.

Spruce-fir forests are typically found on poorer growing sites with cold temperatures and thin, poorly drained, acid soils. The most historically important and damaging pest has been the spruce budworm, which prefers to feed on balsam fir, red spruce, and white spruce, but will also defoliate black spruce. Major outbreaks occur every 40-50 years; the last occurred in the late 1970s and early 1980s. In 1991, the only visible spruce budworm defoliation in the Lake States occurred on about 100,000 acres in northern Minnesota. In 1992, 125,000 acres were defoliated in Minnesota.

HARDWOOD TYPES (BURNS AND HONKALA 1990)

Oak-Hickory Forest

The largest and most diverse forest in the eastern United States is made up of oak-hickory. It occurs from Texas, north to the Dakotas, and eastward into New England. About 5.5 million acres occur in the Lake States. Within the broad oak-hickory forest, various forest types are included: bur oak, northern pin oak, chestnut oak, white oak-black oak-northern red oak, white oak, black oak, and northern red oak. Hickories are consistent but minor components.

The varied nature of the oak-hickory forest supports numerous insect and disease organisms. The major threat to oak-hickory forests, and perhaps the most well known, is the gypsy moth. This defoliator has been gradually spreading south and west from in Massachusetts where it was introduced in 1864. The oaks, particularly the white oaks, are preferred foods of the gypsy moth and are attacked more severely than other species within the oak-hickory forest. The trees are stressed and then may be attacked by the two-lined chestnut borer and Armillaria root disease.

In 1992, 712,000 acres were defoliated in the Lower Peninsula of Michigan more than were defoliated in the U.P. Nationally in 1991, more than 4 million acres were defoliated by the gypsy moth; most of this occurred in the oak-hickory forest. An estimated 125 million acres of susceptible forest in the Northeast are considered to be generally infested with the gypsy moth. This includes acres of northern hardwood and oak-pine forest, although the gypsy moth is primarily a problem within the oak-hickory forest. Large acreages of land are sprayed

annually to maintain tree health and vigor. Most of this treatment occurs within urban and residential areas.

Oak volumes tend to decrease after repeated gypsy moth defoliation. No overall estimates exist of how much oak has been killed; however, the figure is certainly well into the thousands of acres. A recent study in West Virginia found that an average of 25% of a forest stand was dead or dying after 2 consecutive years of heavy defoliation by the gypsy moth followed by attack from other organisms.

The third major factor to affect oak-hickory forests has been oak wilt, a vascular disease which is transmitted by sap-feeding beetles and through root grafts. Oak wilt affects predominately northern red, pin, and black oaks. It was first recognized as an important disease of oaks in Wisconsin and is now found in 21 states. The disease has killed thousands of trees in localized areas but has been particularly severe in the Midwest. In 1992, this disease was most prevalent in the oak-hickory forests of Michigan and Minnesota. A survey conducted in 1991 estimated 3,000 oak wilt infection centers in the five-county Minneapolis-St.Paul area. Oak wilt is expected to continue to have a serious impact on the oak species within the oak-hickory forests.

Oak decline and mortality was reported in 1991 throughout the Lake States. In general, oak decline is thought to be initiated by a variety of stressors, such as site conditions, foliage diseases, insect defoliation, and especially drought. The 1987-1989 drought in the Midwest made the forest more susceptible to attacks by the two-lined chestnut borer, which resulted in extensive oak mortality scattered over 750,000 acres in 1991.

Elm-Ash-Cottonwood Forest

The elm-ash-cottonwood forest grows along river corridors and is commonly referred to as lowland or bottomland hardwoods. About 3.3 million acres are found in the Lake States. This forest is comprised mainly of eastern cottonwood, American elm, green ash, white ash, black ash, and red maple. It occupies moist to wet soils and is found in swamps or in lowland areas along streams. Eastern cottonwood and willow commonly invade bare riverbanks and sandbars.

Many pests affect the elm-ash-cottonwood forest, the most serious of which is Dutch elm disease. This vascular wilt, spread by a bark beetle, attacks the American elm most often but can attack other members of the elm family. Dutch elm disease has eliminated American elm as an important timber species and is continuing to threaten shade trees. It has drastically altered the composition of the elm-ash-cottonwood forest. From 1963 to 1990, the city of Minneapolis lost approximately 90,000 out of an estimated 200,000 American elms to Dutch elm disease. In 1963, only four American elms died there; then the level of mortality gradually increased and, in 1977-1978, more than 51,000 elms were killed.

Regionwide, green ash and white ash are affected by dieback associated with drought. Some of the ash dieback and mortality can be attributed to ash yellows, caused by a mycoplasma-like organism (MLO). Ash yellows has been reported from New York and Pennsylvania west to the central states. This disease is present in several counties in southern Wisconsin, and symptoms of the disease are being reported throughout much of Minnesota.

The elm-ash-cottonwood forest is somewhat susceptible to the gypsy moth and may experience defoliation when it is adjacent to more susceptible hardwoods. This forest is also susceptible to many abiotic hazards. Changes in the water table can cause stress and mortality in the shallow-rooted elm-ash-cottonwood forest.

Northern Hardwood Forest

Approximately 11.4 million acres of northern hardwood forest are found in the the Lake States. The northern hardwood forest is comprised mainly of sugar maple, American beech, yellow birch, red maple, and black cherry; it occurs on a wide range of soil and site conditions, ranging from shallow bedrock to poorly drained soils.

The species composition can vary from stand to stand. Older stands are dominated by sugar maple, American beech, and yellow birch, while younger even-aged stands contain paper birch, white ash, and red maple, along with other hardwoods. Conifers grow in with the hardwoods, especially in shallow soils on steep slopes or in poorly drained soils at lower elevations. Repeated cutting, fire, and past land use have created numerous combinations of stand conditions, age classes, and species. In the southern extent of the range, the northern hardwood species blend with the oak-hickory forest.

Northern hardwood forests are affected by many insects and diseases. The most visible damage is caused by various defoliators, such as the forest tent caterpillar (FTC), pear thrips, Bruce spanworm, fall cankerworm, and the saddled prominent. In 1992, about 260,000 acres were defoliated by FTC, primarily in northern Wisconsin.

The sugar maple borer, an important pest that reduces wood quality, can be found in stands throughout the range of sugar maple. Diseases, such as stem cankers,

vascular wilts (sapstreak and verticillium wilt), anthracnose, and stem rots associated with wounds from logging and tapping, have also caused damage to sugar maple.

Sugar maple "decline" (dieback and mortality) has been reported at various times throughout this century, but surveys suggest that damage was mostly related to pests, drought, and/or management practices. Beginning in 1988, sugar maple stands have been monitored in the Lake Statesas part of the international North American Maple Project. Results indicate that overall sugar maple conditions have improved, and any crown damage observed was attributed to defoliation and drought. Forest survey inventories within the last 10 years have shown more sugar maples of a higher quality than in previous surveys.

Red maple is affected by insects and pathogens similar to those affecting sugar maple. However, the maple "decline" reports are largely confined to sugar maple, and red maple is affected to a lesser degree. The species is highly susceptible to damaging canker diseases and decay that reduce wood quality.

Yellow birch is susceptible to various agents, which together cause episodes of "decline." The most significant episode occurred in the 1930s. Areas of northern New England and New York were affected as thousands of square miles of dead yellow birch, along with paper birch, were evident. Although a cause has never been positively identified, it is suspected that lack of snow cover and low winter temperatures led to death of the roots. Sporadic episodes have also occurred in the 1960s and 1980s. Yellow birch is affected most noticeably by cankers, which cause decay and discoloration. Like beech, yellow birch is very susceptible to decay after partial cutting of a stand. In 1991, birch leafminers and skeletonizers defoliated yellow birch in northern New England and New York. Dieback of white birch occurring in the Lake States is thought to be related to repeated defoliation by forest tent caterpillar defoliation and drought. A survey conducted in Minnesota showed that more than 37 million white birch have at least 30% crown dieback, and the average annual mortality between 1988 and 1992 was over 13 million cubic feet.

Butternut is a decreasing component of the northern hardwood and oak-hickory forests due to continuing tree mortality caused by butternut canker. Tree dieback and decline due to this disease have been reported since the 1960s. Mortality was widespread in southwestern Wisconsin in 1967, and the disease became established in southeastern Minnesota by the early 1970s. Severe losses throughout the range of butternut are threatening the survival of the species, as the disease continues to spread. Most of the remaining butternut is in Wisconsin. About 58% (38,952 M cu ft) of the total growing-stock volume and 68% (123,867 M bd ft) of the sawtimber are located there.

The impact from insects and pathogens on the northern hardwood type has ranged, from the devastation of butternut canker to cyclic episodes of insect defoliation and drought. Overall, most northern hardwood tree species are growing well. Tree-ring studies have concluded that hardwood species in the Northeast have not shown a steady decline in the last few decades. They do show short periods of poor growth in response to below normal precipitation and insect defoliation.

Aspen-Birch Forest

The aspen-birch forest is the most common forest type in the Lake States, making up about 14.5 million acres. It is comprised mainly of quaking aspen, bigtooth aspen, paper birch, and balsam poplar. These forests chiefly occur in areas of old burns, clearcuts, or abandoned fields and pastures. Without repeated disturbance, the aspen-birch forest is succeeded by spruce-fir and pine in the northern region or northern hardwoods and eastern hemlock to the south.

The aspen-birch forest is favored by the forest tent caterpillar, which can defoliate large areas, such as occurred in 1992. Outbreaks usually last only a few years. Approximately 2 million acres have been defoliated by the forest tent caterpillar from Maine to Minnesota since 1987. The gypsy moth readily defoliates aspen-birch forests throughout the generally infested area. Repeated defoliation by these insects, in association with other organisms, will cause reduction in volume, mortality, and a reduction in the number and quality of root and stump sprouts for regeneration.
In 1992, several other insects caused damage in the aspen-birch forest. Birch leafminers, large aspen tortrix, and a leaf tier/leafroller complex defoliated about 385,000 acres.

GENERAL STRESSORS

Weather

The primary weather concern about has been drought. Defining what constitutes a drought historically has been based on crop successes or failures; no single measure of drought perfectly represents moisture conditions in all areas. However, the United States Department of Commerce, National Oceanic and Atmospheric Administration, attempts to represent meteorological drought (or moisture excess) conditions by area units referred to as climate divisions. Three hundred forty-four climate

divisions across the country are based on several factors, including crop types, old crop reporting districts, and political boundaries. Thousands of individual daily weather station reports are summarized, and these data are entered into mathematical models; different indexes are then calculated that represent meteorological moisture conditions in various ways.

The Palmer Index (Palmer 1965) is one of several measures used to describe meteorological moisture anomalies. One, called the Palmer Hydrological Drought Index (PHDI), ranges from extremely wet (4.0) to extremely dry (-4.0). The Palmer Indexes are computed as the product of a climate weighting factor and moisture departure. The weighting factor standardizes the index to enable reasonable comparison of index values in different locations and different times of the year. Moisture departure is the difference between water supply (precipitation, stored soil moisture) and water demand (potential evapotranspiration, the amount needed to recharge the soil, and runoff needed to keep rivers, lakes, and reservoirs at normal levels).

The PHDI attempts to represent water table and ground water effects of drought and is slow to respond to sudden changes in weather. According to the annual average PHDI (based on monthly summaries from October to September), large areas of Minnesota and Wisconsin began to experience severe to extremely dry conditions starting in 1987 and continuing through 1989. Several climate divisions, mainly in the northwestern Minnesota, had a continuation of drought conditions into 1990 and 1991.

This extended period of drought has had serious consequences for tree health throughout the affected area. Drought was directly responsible for the death of millions of oak and pine trees in the Lake States in 1989. Much of the mortality that has occurred since then is a result of the lingering effects of drought, including the mortality of green and white ash. Trees that survived the direct effects of the drought were weakened and made susceptible to other stressors that under normal circumstances would not have been significant, such as the two-lined chestnut borer on oaks and deteriorated crown conditions on maple in Wisconsin.

Late spring frosts can kill new growth on sensitive species whenever frost occurs after new growth begins. Severe frost occurred over 712,000 acres of low lying oaks in the Lower Peninsula of Michigan, and this area was later defoliated by the gypsy moth.

Ice storms can damage trees by breaking tops and branches, snapping trunks, and uprooting trees. Severe damage can cause limbs to droop and can also cause internal injuries, which take longer to detect. Two severe fall ice storms damaged between 300,000 and 400,000 trees in southern Minnesota. Replacement and cleanup costs exceeded $9 million.

AIR POLLUTION

Three major aspects of air pollution that can affect forests: gases (specifically ozone), wet acidic deposition, and dry acidic deposition. Ozone is a gas that may injure sensitive tree species, which may show up in such symptoms as purple speckling on the upper surface of the leaf on hardwoods or yellow mottling on white pine. Acidic deposition is a direct result of sulfur and nitrogen compounds in the atmosphere and, in the case of wet deposition, involves a reaction with precipitation. Acidic deposition is measured in amounts of hydrogen (or pH, a measure of acidity), sulfate, nitrate, nitrite, and ammonium ions. This deposition can influence nutrient cycling in the forest. Monitoring information for ozone and wet and dry deposition comes from a series of networks throughout the United States, and the number of individual monitoring sites varies from state to state (Garner *et al.* 1989).

Ozone has been monitored only since the early 1960s, so long-term information is limited. In addition, the number of sites has been increasing, and many of the sites are in urban locations. Ozone damage within a localized area can be scattered, and two neighboring trees of the same species can exhibit different levels of damage. In addition, ozone values can differ significantly within a few miles due to elevation changes and other site factors. The tree species more sensitive to ozone damage are eastern white pine and black cherry. Other species of pine, ash, maple and oak are also sensitive.

The ozone levels for the Lake States are generally low compared to other eastern states, except for parts of the Lower Peninsula of Michigan and the western shore of Lake Michigan in Wisconsin. During high ozone episodes, occasional symptoms are observed on particularly sensitive eastern white pine. In general, acidic deposition has not shown any visible effects on forests in the east. In the summary of the Forest Response Program (Hertel and McKinney-McNeal 1990), the conclusions from numerous research studies stated, "... that most forests in the United States do not show unusual visible symptoms of stress, marked decreases in the rate of diameter or height growth, or significant increases in mortality due to acidic deposition."

Guidelines in the new Clean Air Act may help reduce deposition.

CONCLUSIONS

In general, pest activity in the Lake States can be found every year. Periodic drought is perhaps the most serious threat to individual trees and forest types, causing mortality directly, and indirectly by predisposing them to secondary pests. In spite of these problems, forest land area continues to increase, and annual growth continues to exceed annual harvest.

The most serious concern in the Lake States is with introduced pests: gypsy moth, white pine blister rust, Dutch elm disease, and butternut canker. These are singled out for several reasons: (1) their actual or potential ecological significance to the forest; (2) their economic significance in terms of affecting economically important species or valuable shade or ornamental trees; and (3) their potential for continued impact.

Abiotic factors are also of concern, including ozone damage on sensitive species such as eastern white pine, effects of acidic deposition, and drought-caused tree mortality. We must understand that trees die because of drought and contributing stress factors.

Attempting to rank the relative health of the overall forest, individual forest type groups and individual tree species within a forest type group, is very difficult; it is also somewhat arbitrary, dependent on the perceptions and values of the individuals making the assessment and on the timing of that assessment. For example, decay and canker incidence in aging aspen-birch forests is high and increasing, but this is a natural consequence of aging and does not threaten the long-term sustainability of the forest type. On the other hand, fewer stresses currently affect the northern hardwood forest and the oak-hickory forest, yet the very existence of a small component, butternut, is threatened by butternut canker. Losing butternut would not affect the overall health of these diverse forest types, but a relatively uncommon tree species adding to the overall diversity may be lost. Likewise, losing American elm to Dutch elm disease has not had drastic long-term detrimental effects on the health of the forest, but the species was once a predominant component of many forest types. And the introduction of white pine blister rust has forever altered the character of the pine forest type. If one uses tree species diversity as the main measure of forest health, given that a diverse forest can better adapt to changing stresses and introduced pests, forest type groups can be ranked by forest health, from best to least: northern hardwood, oak-hickory, elm-ash-cottonwood, spruce-fir, white-red-jack pine, and aspen-birch. With the indicated caveats, and as defined in this paper, forest health overall in the Lake States must be regarded as good and improving. Localized problems are noticeable, but overall the resource is very resilient and therefore in good health.

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Great Lake States Forest Trends, 1952-1992

Robert N. Stone[1]

EXECUTIVE SUMMARY

Remarkable restocking and recovery mark the Lake States forests over the last 70 years. The following facts log the range of changes between 1952 and 1992 when a wave of young stands grew to poletimber, and much of the poletimber grew to sawtimber stands:

1. Forest area in the three Lake States is rising after decades of gradual decline, a reaction to declining farmland use.
2. More than 9 million acres of nonstocked forest were reforested between 1952 and 1992, most by natural regeneration although several million acres of forest plantings were added.
3. Timberland acreage declined about 6 million acres between 1952 and 1992, but timberland stocked with trees actually increased about 3.5 million acres.
4. Only forest industrial owners have more timberland in 1992 than in 1952.
5. Sawtimber stands nearly tripled in acreage, to become the dominant stand-size class.
6. Lake States forests inventories have staged a major comeback. Average per acre timber volumes are accumulating rapidly, and now exceed 15 cords including 2,992 board feet of sawtimber. In sawtimber stands sawtimber volume averages 5,710 board feet per acre.
7. Just five species: aspen, hard maple, soft maple, red oak, and paper birch, account for half of the timber volume.
8. Timber growth rose by more than one-fourth over the 40 year period but is below the peaks of the 1980's. With most acres stocked with poletimber and sawtimber trees, the ingrowth windfall of small trees growing to commercial size is largely past. The volume of sapling trees that grow to reach 5 inches d.b.h. each year, called ingrowth, is a large component of timber growth in young forest stands.
9. Timber harvesting trends upward to supply expansions in wood processing plants, many using new technologies, taking previously undesirable species and producing products unknown in 1952.
10. Timber growth exceeds timber harvests but the difference is shrinking.
11. The forests are attracting rising demands for timber, winter and summer sports, hunting, fishing, camping and other forest benefits.
12. Pioneer species such as aspen, jack pine and birch are gradually being replaced by more shade tolerant trees such as maple.
13. Lake State forests are complex with 12 major coniferous tree species and 51 major hardwood tree species.

INTRODUCTION

Data Sources, Dates and Analysis Methods

Much of the forest resource data used in this analysis comes from the recompilation of forest survey inventories for Michigan and Wisconsin and a new inventory of Minnesota. This information had been updated to 1992. Statistics from the recent Minnesota forest inventory were studied to substantiate or condition conclusions drawn from the older data bases. The updated state statistics were combined for the entire Lake States by the Forest Inventory Analysis unit of the USDA Forest Service's North Central Forest Experiment Station and dated 1992 (NC 1992).

These updated Lake States forest resources statistics provided most of the resource estimates used in this analysis.

A problem in compiling forest resource estimates for the region is the time orientation of the basic forest survey data. Each Lake State is sampled independently. Each takes 2 to 4 years to complete. Each was sampled at a different time. For national compilations some updating (never backdating) manipulations arrange regional estimates as of a single year or day as in the estimates of area and volume, and for the prior year for estimates of timber growth and cut (removals).

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[1]The author is Forestry Consultant, Madison, WI and retired Project Leader, Forestry Products Laboratory, Madison, WI. This manuscript was originally prepared on August 18, 1992 for the Lake States Forestry Alliance.

Most of the current timber resource data for Wisconsin comes from a forest inventory conducted by the Forest Survey Project of the North Central Forest Experiment Station of the U.S. Department of Agriculture's Forest Service in cooperation with the Wisconsin Department of Natural Resources. This survey dated 1983 unfortunately omits nearly one decade of change. Nevertheless, this survey provides a wealth of detailed timber inventory information comparable to earlier surveys even at the county level. Data available from this survey includes forest area statistics by forest type, ownership and stand age; timber volume by species, tree size and class in cubic feet and board feet units. (In the text of this report volume units are shown in cords.) Similar but less statistically reliable information is presented for timber growth and timber removals.

The last completed forest survey of Michigan's forests was dated 1980. A new inventory is now underway. As for Wisconsin, the inventory was updated to 1992 using computer projection techniques developed for this purpose. Minnesota's fifth forest inventory, completed in 1990, provided the most current resource estimates and when compared with estimates for the fourth Minnesota inventory, the latest indications of recent changes.

For this project, the Forest Service, using advanced computer projection models, updated the 1983 Wisconsin inventory and the 1980 Michigan inventory to 1992 and compiled estimates for the region, for each state, and for the survey units (groups of adjacent counties) as of 1992.

Timber removals were updated to 1992 from the 1982 statistics using newer pulpwood production estimates as the basis for estimating the changes in removals. Timber product output statistics are compiled annually for pulpwood by species and county.

LAND AND FOREST AREA

The Land

Glacial ice deposits and water formed and carved out the geological features of the Lake States Region. Shallow soils and bare rock show the scars left by advancing and retreating glaciers. All but a small part of the region's southwestern extensions are glaciated. The tens of thousands of lakes, ponds and bogs divided by glacial ridges or moraines witness the geologically young terrain. The many swampy sites indicate the poorly developed drainage systems.

The rich and varied forest cover of today traces its foundations to the ice ages. These forests are forests of change geologically. Human actions have interceded and added new dimensions to the changes.

The area of land and water in the Lake States totals 160 million acres. Of this, 122 million acres are land; 38 million acres are water.

The forests of the Lake States, covering approximately 50 million acres, provide the regions' population with a large scenic, recreational, economic and industrial resource. It provides habitat for a rich variety of wildlife, space for recreation of many forms, a large watershed supplying water to thousands of streams, inland lakes and the Great Lakes as well as an increasing flow of wood for a growing forest products industry.

It is a forest resource in change. Against a background of rising timber cut this forest continues to accumulate inventory by 1 billion cubic feet each year. All the inventory indices trend upward; for hardwoods and softwoods, for sawtimber and poletimber.

Forest Land Changes

More of the land of the Lake States is forested than is the case for the U.S. as a whole. Here 4 acres in 10 are timberland (Figure 1). Although land classed as forest has declined about 4.7 million acres between 1952 and 1992 forest land stocked with trees gained. The standard definition of forest used in forest surveys includes land formerly having had tree cover and not currently developed for nonforest use. In 1952 some 10.4 million acres of this idle land was classed as nonstocked timberland. Now just 790 thousand acres are classed as nonstocked.

The latest surveys in Wisconsin and Minnesota detected gains in forest land, undoubtedly due to restocking of idle farm land and wooded pastures. The two major land uses in the region are forest and agriculture. They are inversely related.

Of the Lake States, Michigan is most heavily forested; over half, and Minnesota the least, about one-third. Both Minnesota and Wisconsin have prairie inclusions along their western and southern borders where the climate limits tree cover to the wetter sites. As a general case the degree of forest increases from south to north across the region; and from southwest to northeast in Minnesota and Wisconsin. The proportion of conifers relative to hardwoods tends to increase from south to north.

The vast majority of forestland is classed as timberland. Timberland is defined as forest available for logging and fertile enough to grow timber of industrial quality. Minnesota and Wisconsin have just under 15 million

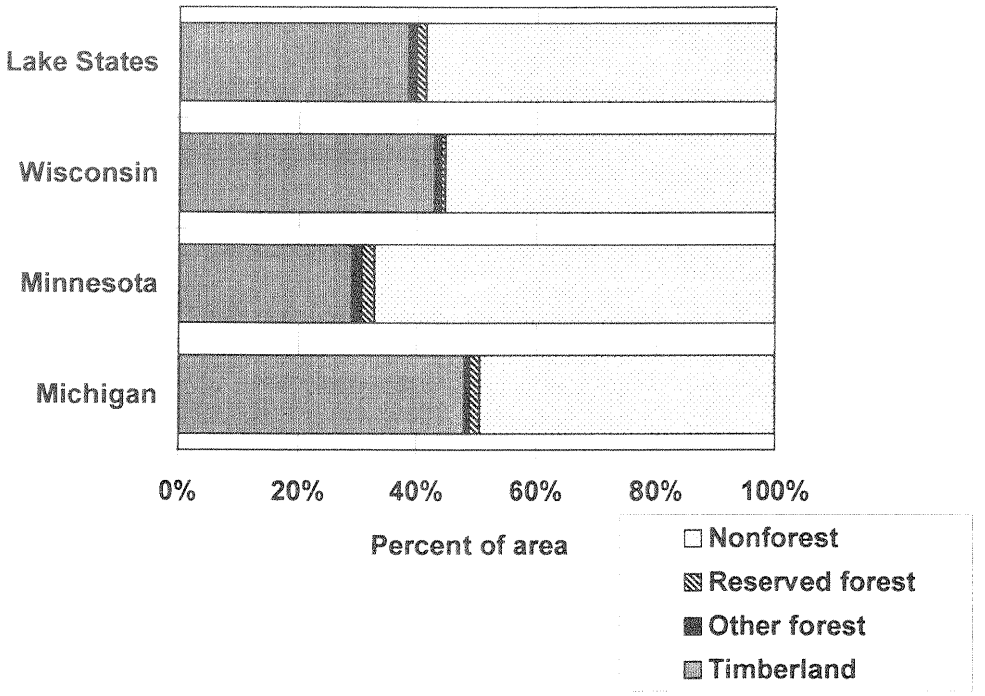

Figure 1.—*Area by land class, 1992.*

acres of timberland. Michigan has about 17.5 million acres. The total for timberland in the Lake States of 47.1 million acres is 6.1 million acres less than in 1952. The portion of land that is forest varies widely by forest survey unit. In general the southern units are much less forested.

In Michigan about two-thirds of the nonforest is in the Southern Lower Peninsula. This unit is 17% forestland. The most heavily forested area in the region is Eastern Upper Peninsula with 88% forested.

Conversely, Minnesota's Prairie Unit of nearly 20 million acres of land is just 3% forest. Likewise, the southern units in Wisconsin are lightly forested when compared to the northern Wisconsin units. Minnesota's Aspen-Birch Unit is 86% forest and includes two-thirds of the region's reserved forestland, mostly in the Voyagers National Park and the Boundary Waters Canoe Area. Between 1952 and 1992, 4.6 million acres of forest land was converted to nonforest uses.

Reserved forest area over the 1952-1992 period more than doubled as the Voyageurs National Park was added, the Boundary Waters Canoe Area was modified in Minnesota; and the Apostle Islands and Sleeping Bear National Lakeshore were set aside in Wisconsin and Michigan, respectively.

Most land in the Lake States is used for farming and forestry. This leads to an inverse relationship and to cycles of gains and losses in forest land. Each surge in markets for agricultural commodities leads to land clearing and reversion to farming of forestland. The gains in crop area come at the expense of forest. The reverse occurs when agricultural booms fade and again the forest returns. The gains in forest area in Minnesota and Wisconsin reflects the most recent drop in cropland which occurred after the last survey of Michigan. This is not a new situation. Much of the present county and state forest land once was farmed and privately owned. The Great Depression of the 1930's caused economic failure and abandonment of farms across the region. Most failed farms via forfeitures for nonpayment of advalorem taxes went to the counties and states. These lands have reverted to woodlands and now comprise most of the nonfederal public forestland.

Forest Ownership

Michigan and Wisconsin forests are roughly two-thirds private and one-third public (Figure 2). Minnesota has more public forest than private. Each of the Lake States has national forests; Michigan has three, Minnesota and Wisconsin have two each. All have national park lands. Across the Lake States are about 5.5 million acres of national forest timberland, 7.2 million acres of state owned timberland and 4.9 million acres of county owned timberland. The Lake States are leaders among the states in the amount of county and state forest land. However, it is the private timberland that dominates the ownership scene. Farmers and miscellaneous private owners control 25.2 million acres of timberland in the region. These private owners of less than 1,000 acres of forestland number about 900 thousand individuals. They own

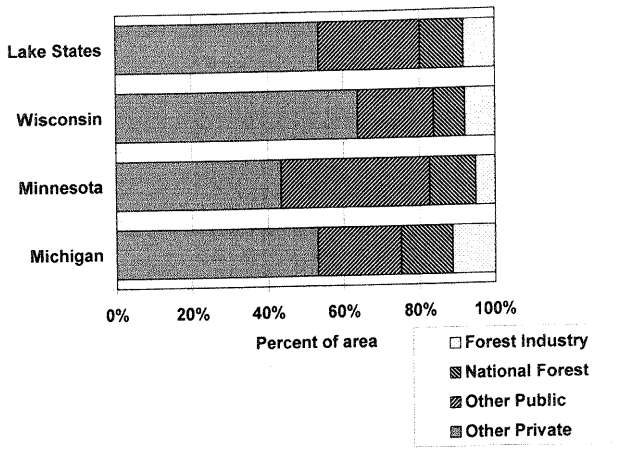

Figure 2.—*Area of timberland by ownership class, 1992.*

over 9 million acres of timberland in Michigan and Wisconsin, and over 6 million in Minnesota. Changes in the composition and intentions of this diverse and complex group of owners will in large measure determine the kind of forestry practiced and the future supply of timber and most of the other forest benefits in the Lake States.

Despite the considerable forest industry in the region industrial ownership of timberland amounts to just 3.9 million acres or 8%. One might expect, with the considerable new investment in new processing facilities and the accumulating timber inventory, to see rising industrial forest ownership. This is not the case. Although higher now than in 1952, industrial ownership was higher in the 1970's. Of the ownership classes only forest industry had more timberland in 1992 than in 1952.

Public forest land is more prevalent in the northern survey units. In Minnesota, timberland in the Aspen-Birch Unit above Lake Superior is two-thirds publicly owned. This, of all the units, includes the most county and federal timberland. Only Michigan's Northern Lower Peninsula Unit has more state forest. Western Upper Michigan has the most forest industry timberland—about one-third of the region's total. The most private timberland is in the Northern Lower Michigan Unit although the Southwestern Wisconsin Unit has a higher proportion of private forest.

A study by Plantinga *et al.* (1989) looked into some of the factors and changes influencing land use and ownership in the region. There are more people. There are fewer farmers and farms. Urban areas have grown. They concluded, "Recent demographic data suggest that populations in the Lake States are shifting away from large cities and into rural area. 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).

Rural settings and small towns have grown increasingly more attractive to people. These population shifts led to changes in forest land ownership especially from farmers to miscellaneous private owners. In Wisconsin between 1968 and 1983, holdings of timberland by farmers in Wisconsin decreased by 27%, while timberland held by miscellaneous private owners rose 45%. In Minnesota between 1977 and 1990 farmer owned timberland declined by 34%, while timberland held by miscellaneous private owners rose by 68%.

The study (Plantinga *et al.* 1989) did not determine how much of this change resulted from farmers selling to nonfarmers and how much was caused by farmers taking up other occupations and still retaining their land. The sharp decline in holdings by farmers parallels the drop in numbers of farms and farmers. Too much can be read into this change because farmers who enter other vocations and leave day to day farming may continue to own the land as before even though no longer classed as farmers by the enumerators. Such changes in the owner category probably change little, if any, the quality of forest management.

Forest Type Distribution

The regions forests are classified into 14 forest types by the Forest Survey. The patterns of timberland by forest type, state, and survey unit reveals the complexity of Lake State forests.

The five forest types with the largest areas in the Lake States are in order of size: maple-basswood, aspen, oak-hickory, elm-ash-soft maple, and black spruce (Figure 3, Table 1). Aspen, long the leading forest type, now trails maple-basswood in area. The four most common forest types in Michigan and Wisconsin are the same as for the region. Black spruce is the fifth most abundant type in the Lake States, although Michigan has more acreage of northern white-cedar than of black spruce. Wisconsin has more paper birch than black spruce. In Minnesota, aspen is still far and away the dominant forest type. Its acreage exceeds the next four forest types combined. Over half of the region's aspen acreage occurs there. Maple-basswood, black spruce, elm-ash-soft maple and oak-hickory make up the rest of Minnesota's top five forest types.

A similar pattern occurs in the distribution of some forest types across the three states. The northern forest survey units have almost all of the swamp conifer forest types and most of the pine forest types. The downstate units have much more oak-hickory, maple-basswood, and elm-ash-soft maple. In Michigan and Wisconsin the most abundant type in the northern units is maple-basswood, but in the northern Minnesota units aspen is the leading forest type.

Stand-Size Distribution

A clear sign of the maturing of the regions forest stand is found in the distribution of the timberland by stand-size. More of the forest now supports sawtimber than poletimber or saplings and seedlings (Figure 4). Since 1952 the acreage of sawtimber-sized stands has nearly tripled in each of the Lake States. Nonstocked forest, which totaled 10.4 million acres in 1952, now is below 1 million acres. There are 6 million acres less of seedlings and saplings. Within this decade over half of the regions' timberland will be covered with stands of sawtimber trees.

In 1952, stands of sapling and seedling size covered some 20.4 million acres and with nonstocked timberland amounted to 58% of the timberland. In 1992, 40 years later, two-thirds of the stands are sawtimber and poletimber—a remarkable case of forest rebuilding.

The many consequences of such large changes in the character of the forest stands on not only timber supply, but on wildlife populations, forest recreation, and water flows is yet to be widely understood and appreciated.

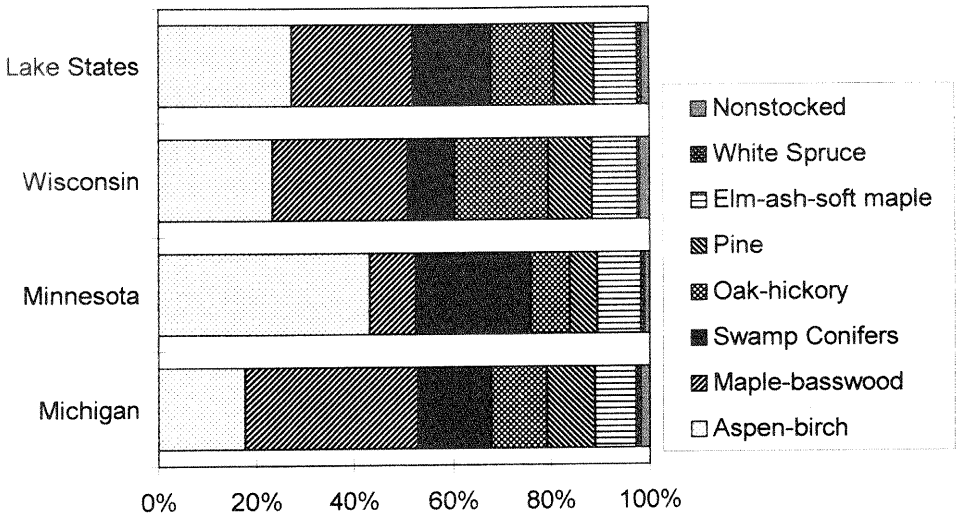

Figure 3.—*Area of timberland by forest types, 1992.*

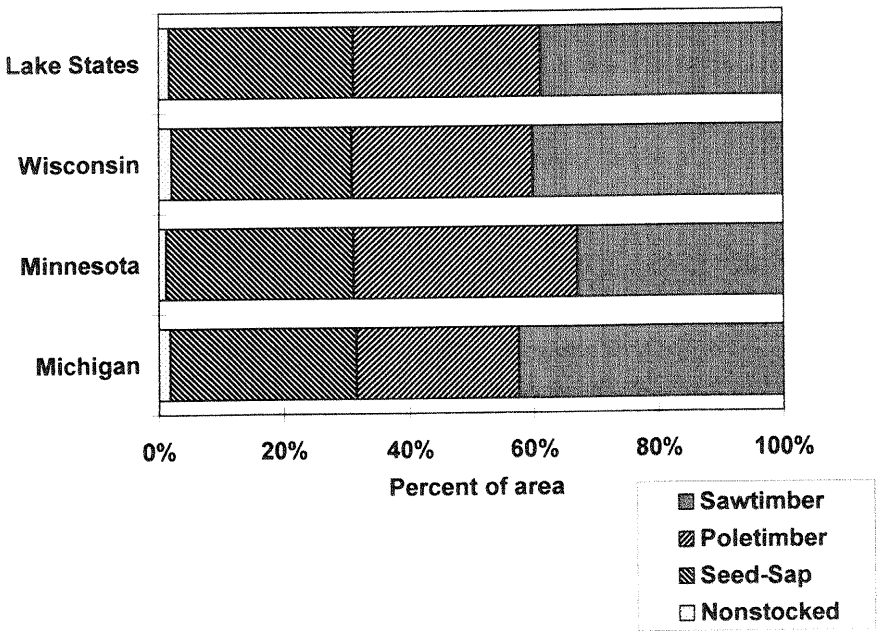

Figure 4.—*Area of timberland by stand size, 1992.*

The east to west pattern of the early logging and land clearing era is apparent in the distribution of present day size classes. First logged Michigan has 7.4 million acres of sawtimber stands, Wisconsin 6.0 million acres, and last logged Minnesota 4.9 million acres

Although the area of timberland declined by 6.2 million acres between 1952 and 1992, the area of nonstocked forest decreased even more. In 1952 the area of stocked timberland was 42.8 million acres and in 1992 was 46.3 for a net gain of 3.5 million acres. Even Minnesota which had the largest decline in timberland over the period actually had an increase in timberland stocked with trees.

Age Class Distribution

The consequence of one characteristic of the Lake States forests dwarfs all others. It is the skewed age-class distribution (Figure 5, Table 1). An unequal proportion of the forest stands were established in the late 1920's and early 1930's. The development of this large acreage over time has created a wave much like a pig in a boa constrictor, first creating a bulge in the sapling and seedling class, then in poletimber (the latter stage of this phase still dominates the Lake States forests) and then in sawtimber stands. Stands in the biggest wave are now 55-75 years of age, a virtual wall of ripening timber. For forest types such as aspen, birch, and jack pine, the trees are fully mature and facing decline if uncut. The maple-beech, white and red pine, and oak stands are short of full development, at most a decade or two off.

Such a forest, unseen before in America, while full of promise is difficult to manage and use. The dimensions and quality of its timber are ever changing, as are the acreages of stands ripe for harvest. Much of this forest needs thinning to fatten crop trees. As the wave matures the supply of marketable timber may glut existing markets insuring low stumpage returns. It presents a changing habitat for the numerous wildlife species. 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 and wider. The ongoing changes in stand structure, tree sizes and species mix also impact wildlife. Gone are millions of acres of brushy clearings and seedling and sapling stands. In their place now stand hardwood sawtimber stands that are becoming dense, shady, and fairly open beneath the tree crowns.

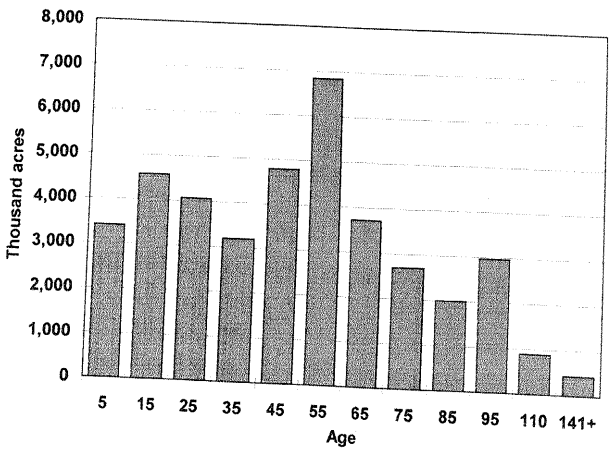

Figure 5.—*Timberland by stand age, Lake States, 1987.*

The latest data about forest changes in the Lake States comes from the recent Minnesota forest inventory. In each Minnesota survey unit timberland increased since the 1977 forest survey, most likely from farm land reversion.

The forests of the Lake States are changing in composition, in ownership, as well as in the size classes of stands they support. The impacts or consequences of these changes form the dimensions of future Lake States forests. The trends suggest they promise to deliver an expanding bundle of benefits, goods and services to Lake States residents and visitors in the decades to come.

THE STOCK OF TIMBER

Biomass

Timber resources traditionally have been characterized by stand tables showing numbers of trees and stock tables showing growing-stock volumes by species and tree diameter classes. Recent forest surveys have included estimates of the woody biomass (all live trees and shrubs) to help answer environmental, ecological, wood fuel and fire risk questions not answerable with growing-stock volume estimates. Biomass estimates may include foliage, tops, limbs, bark, for all live trees and shrubs although below ground stump and root components are not yet available.

The 1980 Michigan inventory found the total biomass of all live trees at least 1 inch in diameter on timberland totaled just over 1 billion tons green weight. This averages about 60 tons per acre. The biomass of shrubs and trees smaller than 1 inch d.b.h. varied wildly by forest type from as much as 4 tons per acre in Wisconsin's tamarack type to a few hundred pounds in Minnesota's white spruce. All biomass in Wisconsin forests in 1983 averaged 65 tons per acre, slightly above the 61 tons per acre of Minnesota's forests in 1990.

As a rule of thumb for the Lake States, about half of the woody biomass on timberland is in the main stems of

growing stock trees over 5 inches d.b.h. with another one-fourth in their tops and limbs. Smaller trees and cull trees split the remainder except for about 1% in shrubs. The amount of wood in live trees is double the usual growing-stock volume estimates. This fact underpins the interest in technologies that can economically harvest wood materials as chips; and in products or fuels that can be made from them. Such approaches effectively expand the useable wood supply. However, they also raise concerns about forest soil nutrient depletion where much of the mineral rich foliage and bark are extracted alone with the wood. The mineral content of wood is of the order of 1/2% (Koch 1985). Wood burners are aware of the small amount of ash remaining after wood is completely burnt. Tree bark, when dry, can contain as much as 10% of minerals.

Besides the biomass of the live trees and shrubs are the foliage, grasses, other living plants, dead trees and the surface litter layer. Assuming that biomass is growing at the 2.7% rate of growing stock volume, the Lake States adds about 1 3/4 tons per acre per year, or about 87 million tons annually. Since timber removals are much below timber growth the accumulating woody biomass in Lake States is a significant carbon sequestrant, reducing global carbon dioxide.

A Harvard University research team, headed by Dr. Steven C. Wofsy, recently was reported in the New York Times as having discovered an absorption of about 3,500 pounds of carbon per acre per year in middle aged temperate hardwood stands at Harvard Forest. At this rate Lake States forests are sequestering over 88 million tons of carbon annually.

Timber Volume

Timber inventories in the Lake States are trending upward, continuing a pattern of several decades (Figure 6). Growing-stock volume in the Lake States more than doubled between 1952 and 1992 as waves of young stands reached poletimber size. Growing-stock volume is defined as net volume of growing stock trees 5.0 inches d.b.h. and over, from 1 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. Volume totals 55.2 billion cubic feet; of this 16.2 billion cubic feet is softwood, up from 6.6 billion cubic feet in 1952 and 40.9 billion cubic feet is hardwood, up from 18.3 billion cubic feet in 1952. Growing stock volume has more than doubled; for every ownership class, for hardwoods and for softwoods, and for each of the three states over the last 40 years.

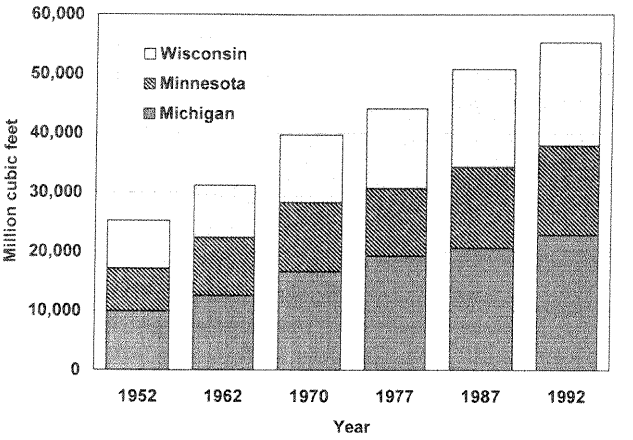

Figure 6.—*Lake States growing-stock volume by state, 1952-1992.*

Changes in inventories between surveys has been remarkable. In Minnesota, growing-stock volume gained 22% between the surveys of 1977 and 1990. In Michigan, between the surveys of 1966 and 1980, growing-stock volume rose 27%. For Wisconsin, timber volume climbed 39% between the surveys of 1968 and 1983.

The improvement in sawtimber volume is even more striking. Nearly tripling between 1952 and 1992, the sawtimber inventory totals about 141 billion board feet (Figure 7). The big change in inventory now is occurring in sawtimber as the forest matures. Ingrowth is slowing in poletimber but expanding in sawtimber as more and more poletimber trees grow into sawtimber size. At this point their total volume moves across the magic size line separating poletimber from sawtimber and is added to growth as ingrowth. Minnesota with 34 billion board feet trails Wisconsin's 45 billion board feet as well as Michigan's 61 billion board feet. Michigan was logged over earlier which explains much of its lead in sawtimber. The large improvement is sawtimber occurred across all ownership classes and for both hardwoods and softwoods.

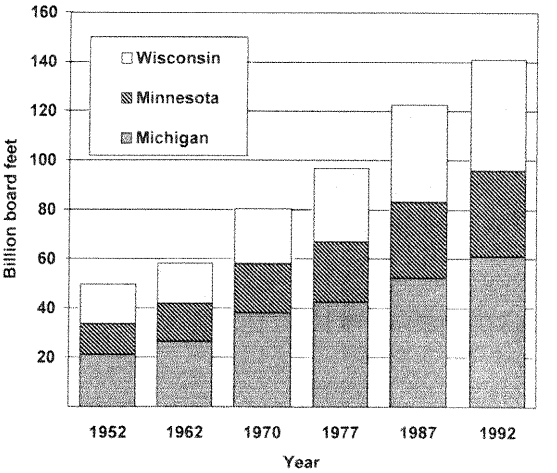

Figure 7.—*Lake States sawtimber volume by state, 1952-1992.*

Average timber volume per acre increases from east to west across the Lake States, another consequence of the pattern of original logging and land clearing. Growing-stock volume per acre averages 1,173 cubic feet (15 cords) for the region. Sawtimber volumes average just about 3,000 board feet per acre.

Volume by Ownership

As with area, private forest owners control the majority of growing-stock volume. The timber ownership proportions closely follows forest area ownership but with one significant difference. Private owners own more hardwood timber volume than their land ownership would suggest; public and industrial have proportionally more softwood timber volume. One reason for this is the more northern concentration of public land where conifer species more commonly occur.

Nonindustrial forest owners control 55% of the timber volume, and 57% of the sawtimber volume, more than twice the volume of state and county forests the next largest class (Figures 8 and 9). These two ownership classes comprise 80% of productive forest land in the Lake States.

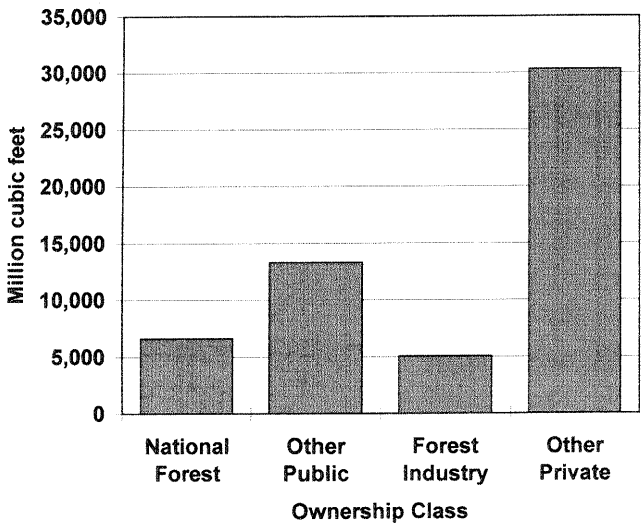

Figure 8.—*Growing-stock volume by ownership class, Lake States, 1992.*

Volume by Survey Unit

The volume estimates by forest survey unit reveal some geographic patterns. The highest stocking of growing stock per acre is found in Michigan's Western Upper Peninsula and the adjacent Northeastern Unit in Wisconsin. The northern units have the most softwood timber. The units with higher stocking of hardwoods are the southern ones. Per acre stocking is lowest in Minnesota's Prairie Unit.

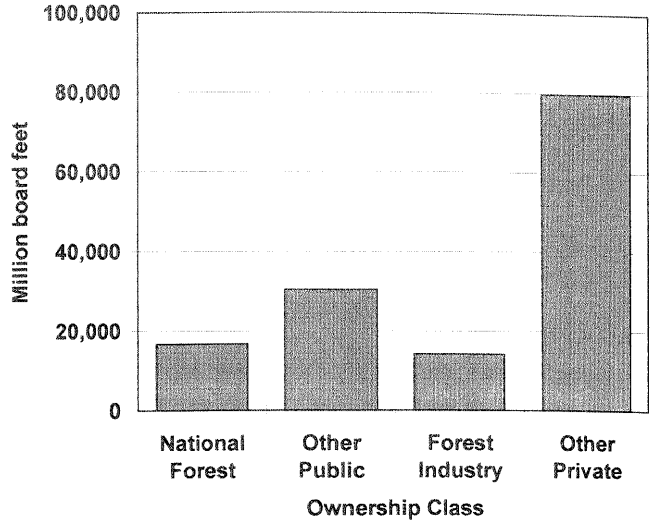

Figure 9.—*Sawtimber volume by ownership class, Lake States, 1992.*

Michigan's Western Upper Peninsula Unit has the most sawtimber volume per acre. It leads in per acre softwood volume as well. Southwestern Wisconsin has the highest volume of hardwood sawtimber per acre.

Volume by Species

Aspen, with 16.8% of the total for all species, has the most timber volume by far. Of the 63 major tree species found in the Lake States, just five, all hardwoods, account for half of the current timber inventory. These are, in order by growing-stock volume: aspen, hard maple, soft maple, red oak, and paper birch (Table 2). Two conifers, northern white-cedar and red pine are the next in order with the most volume.

Each state has a different volume leader. In Michigan it is hard maple, followed by soft maple, aspen, northern white-cedar and red pine. In Wisconsin red oak leads, followed by aspen, hard maple, soft maple and paper birch. In Minnesota aspen has more growing-stock volume than the next three species; paper birch, balsam fir, red oak, put together. In each state these few species include half of the timber volume.

The aspens also lead with nearly 15% of the region's sawtimber volume, mainly found in the smaller sawtimber diameters. This timber is fully mature. Aspen, red oak, hard maple, soft maple, red pine and white pine account for over half of the sawtimber inventory (Table 3).

As with growing stock volume the ranking of sawtimber by species varies by state. In Michigan hard and soft maple, followed by the aspens and red oak, account for a 42% of the sawtimber inventory. White-cedar and hemlock are next most common. In Wisconsin, red oak, aspen, hard maple, white pine and red pine include half

of the sawtimber inventory. More than one-quarter of Minnesota's sawtimber is aspen. Adding red oak, red pine and northern white-cedar raises the percentage to one-half. In Minnesota the maples are not major species.

A number of species gained or lost a large percentage of their growing stock volume between the last two inventories. For the region, soft maple gained the most volume. In Michigan, soft maple, red pine, jack pine, black cherry, walnut, and yellow poplar showed the greatest percentage gains; but hemlock, yellow birch, beech, and elm declined. Between 1966 and 1980 soft maple in Michigan gained nearly 1 billion cubic feet of volume. In Wisconsin red pine, soft maple, white spruce, red cedar, cotton wood, black cherry, and walnut had large percentage gains in volume. Hemlock, elm, and yellow birch declined. Minnesota volume gainers include black spruce, tamarack, and the cedars. The losers were elm, balsam poplar, and river birch. The decline in elm inventory is caused by the Dutch elm disease, which readily kills American elm and has nearly eliminated the species in many areas.

The data do not permit similar comparisons for sawtimber volume.

Volume by Stand-Size Class

Additional evidence of the extent and pattern of forest rebuilding across the Lake States is found in the estimates of timber volume by stand size (Figure 10). Again the pattern is east to west. Some 54% of the growing-stock timber volume is in sawtimber stands—more in Michigan, less in Minnesota.

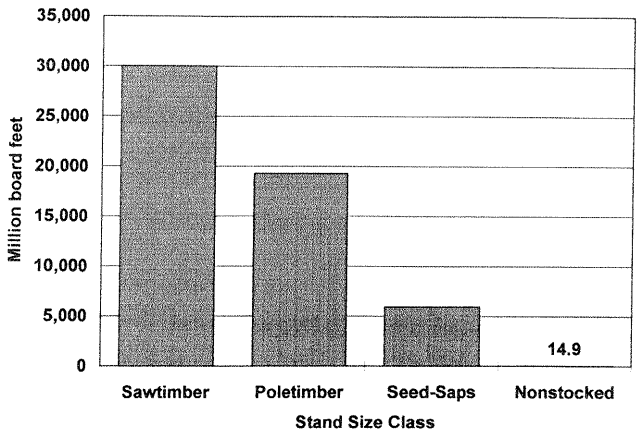

Figure 10.—*Growing-stock volume by stand size, Lake States, 1992.*

An even higher proportion of sawtimber volume is found in sawtimber stands, almost 74% (Figure 11). The Lake States forests, long characterized as cut over and poletimber, have, after a century, regained a majority of its timber in sawtimber stands. Sawtimber stands are taller with less sunlight reaching the understory.

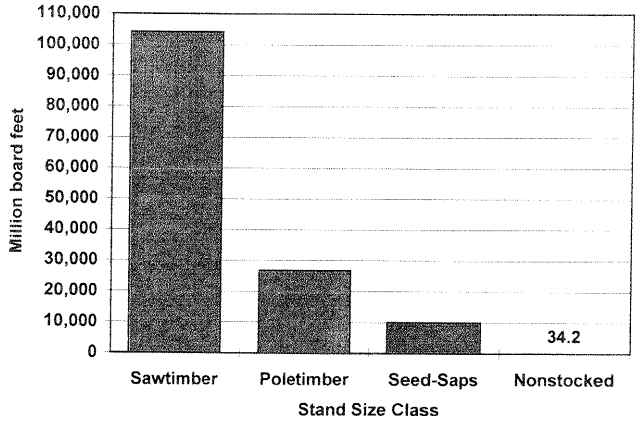

Figure 11.—*Sawtimber volume by stand size, Lake States, 1992.*

As a result, understory cover is becoming sparse and ground level conditions are cooler. These effects of accumulating and maturing timber inventories is changing the forest timber character but also the quantity and composition of all the plants and animals it harbors.

The restocking and large accumulation of timber in the Lake States is a modern forestry success story in a world concerned about timber exploitation and deforestation.

TIMBER GROWTH

Just as timber volumes characterize the current state of the timber resource, timber growth reflects the underlying additions shaping the future forest.

Net annual timber growth as reported by the Forest Survey is a complex concept including not only the annual change in sound wood on growing-stock trees of commercial size but also accounting for the entire volume of trees that die or become cull trees as well as the entire volume of small trees that grow to become 5.0 inches d.b.h. (ingrowth). Adjustments are also made for the volumes of trees in stands on areas changing to or from timberland when land use changes. Timber growth is reported for average annual growth between surveys (periodic growth) and for the report year (current growth). Furthermore, growth is reported separately for growing stock timber in cubic feet and for sawtimber in board feet.

The volume of net annual growth on the timberland of the Lake States rose from 1,180 million cubic feet in 1952 to 1,508 million cubic feet in 1992. Annual net growth was 1,617 million cubic feet in 1977 and has been declining slowly since this peak due to an increase in timber mortality as the higher stocking crowds out weaker or overtopped trees and a decrease in ingrowth because of the diminished acreages of sapling stands.

Trends in Growth

It is useful to explore growth trends from two aspects. Relating it to the land base on a per acre output basis much as conventionally done in agriculture indicates the current productivity of the timberland. Another approach is to present growth as a percentage of timber volume. In this way a measure of the return on timber inventory is obtained. Both growth per acre and growth rates were used in the analysis of growth.

Between 1952 and 1992 the trend in net growth of growing stock has been upward reflecting the improving stocking levels (Figure 12). Growth per acre has risen to 32 cubic feet in 1992 from 22 cubic feet in 1952, a gain of 54%. This is not the case for growth rates. In 1952 net growth as a percentage of growing-stock inventory was 4.7%. For softwoods it was a bit higher at 4.9%. By 1992 growth rates had fallen to 2.7% of growing-stock volume. The large increase in volume of growth was not matched by growth rates. Slower timber growth rates of the maturing Lake States forests are a case of widespread diminishing returns that is as normal as the sigmoid growth curve. Net annual growth per acre in Minnesota was 25 cubic feet, well below the 38 cubic feet per acre in Michigan and 32 cubic feet in Wisconsin.

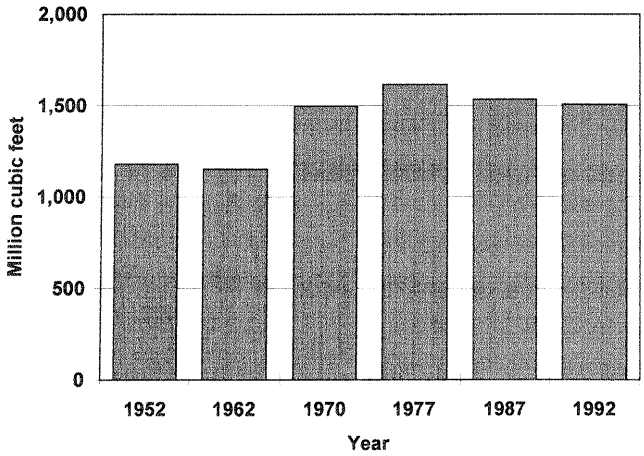

Figure 12.—*Trends in annual growth of growing stock, 1952-1992.*

With more trees and higher stocking per acre competition has increased tree mortality, especially among defective and overtopped stems. Mortality accounts for 12 cubic feet per acre of gross growth. Currently, mortality is equivalent to 37% of growing stock growth.

Total sawtimber net growth is still rising. Between 1952 and 1992 it more than doubled increasing from 2,515 million board feet to 5,196 million board feet (Figure 13). In 1952 sawtimber growth was 47 board feet per acre. By 1992 annual sawtimber net growth had reached 109 board feet per acre. The trends are similar for both the softwood and hardwood species groups. Although the growth rates for sawtimber have moved lower they remain about one percentage point higher than for growing stock.

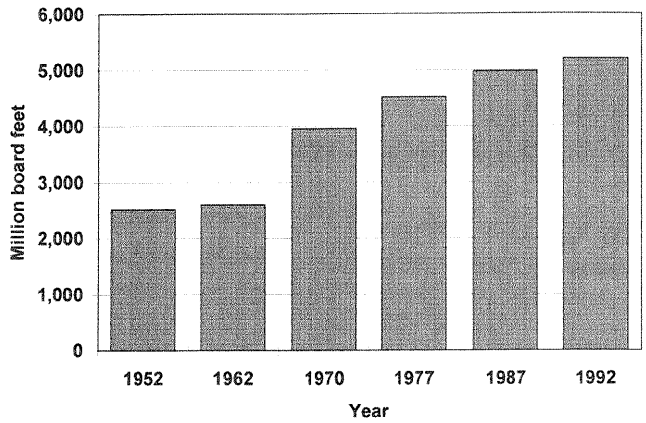

Figure 13.—*Trends in annual growth of sawtimber, 1952-1992.*

Growth Differences Among Owners

Timber growth in a forest is a function of land quality, tree stocking, and forest management. Although these vary by owner, there is little difference between the ownership groups in net growth. The timberlands of farmers and other non-industrial forest owners are only growing an average of 33 cubic feet per acre annually—fractionally higher than industrial timberlands (Table 10). Public forests are growing a little slower. 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 the timberlands owned by farmers and other private owners. Part of the reason for this is location. A larger proportion of the public and industrial timberlands are located in the northern units of the region where conditions favor conifers. These owners have tended to favor softwoods in forest management and made substantial reforestation efforts as early as the 1930's.

Growth as a percentage of timber volume varies even less than per acre achievements among the ownership classes (Table 11). All are near the regional average of 2.7%. The rate for softwoods is slightly higher than for hardwoods.

Significant differences occur between ownerships in sawtimber growth. The highest per acre growth of sawtimber is on national forest timberlands. In 1992 it was 7 board feet above the regional average of 109 board feet. Trailing the national forests and just slightly ahead of industry lands was the sawtimber growth of farmer and other private owner timberland. As with growing-stock net growth the sawtimber growth on these lands is comprised of more hardwood and less softwood than is the case for other ownership classes.

Timber Mortality

Timber mortality is the volume of sound wood in growing-stock trees and sawtimber trees that die annually. Mortality is part of every living forest as trees are lost due to insects, disease, and suppression. These losses are typically small. Losses from wildfires, windstorms, and pest epidemics can be catastrophic in localized areas.

Losses of growing stock due to mortality in the Lake States has been rising mainly due to greater exposure from the large increases in timber inventory. There is more to lose. In 1992 mortality totaled 1.5 billion cubic feet of growing stock, a rate equal to 1% of the inventory. Mortality amounted to 38% of net growing-stock growth. It was equal to 73% of timber removals.

Since 1952 growing-stock mortality has more than doubled. It is now greater than the total timber harvest in 1952 and trends upward (Figures 14 and 15). The pattern for sawtimber trees is similar although the losses are somewhat lower for these larger trees. The increases in timber inventory have expanded competition of growing space in most stands. This has suppressed the smaller and weaker trees and many die. The natural process leaves the superior trees and improves stand quality.

Several serious pests threaten particular species. Dutch elm disease has destroyed much of the American elm across the region in the last two decades. Oak wilt is killing large numbers of red and black oak. A defoliatory gypsy moth is spreading across Michigan and is found in eastern Wisconsin and moving westward with each season. This insect feeds on hardwood foliage and repeated attacks can weaken and kill trees. It seems to prefer oak. These newer pests invade a region having left their natural enemies behind and for some years can do great damage.

Timber Removals

Much of timber growth accrues in response to natural processes gradually and almost imperceptibly. The gains go unnoticed. Few people notice the annual timber growth; a few percent of forest inventory. Not so with timber removals. Tree felling, logging, and other timber harvesting actions are unmistakably evident. Even when logging is silviculturally crafted to improve the residual stand or to develop a superior future stand the change is abrupt and conspicuous.

During the decade 1981-1990 over 8 billion cubic feet of timber was harvested across the Lake States. Almost 80% of this was from hardwood trees. Removals by state for the period 1981-1990 show Michigan leading, but only slightly over Wisconsin:

Michigan	3,035,355 thousand cubic feet
Minnesota	2,148,106 thousand cubic feet
Wisconsin	3,001,564 thousand cubic feet

Timber removals in the Lake States are dominated by a few species. Among the hardwoods, aspen accounted for half the removals in the Lake States during the 1980's. Aspen, red oak, hard and soft maple, and paper birch made up 85% of the hardwood removals. For softwoods, half of the removals were jack pine and red pine. Adding balsam fir, white pine, and northern white-cedar account for 82% of the removals during the 1980's.

As with the timber inventory, timber removals varied widely by Forest Survey Unit. Again the northern units across the region provided the lions share of the timber harvest over the past decade. Of the 13 units in the three states, the five southernmost had one-eighth of the timber removals in the 1980's. The 1:4 ratio of softwood to hardwood removals for the region holds state by state, although the species mix changes.

Trends in Timber Removals

The gains in timber volume since 1952 have fostered higher timber removals of growing-stock and sawtimber trees (Figures 14 and 15). The greater timber supply is accompanied by bigger average trees and higher harvestable volumes per unit area.

These factors tend to reduce harvesting costs and improve logging productivity by reducing hauling distances and number of pieces per unit harvested. They also reduce the relative area logged as more is obtainable per acre.

Between 1952 and 1992 growing stock timber removals rose 51% in total. The gain of 63% for hardwood species exceeds the 19% gain for softwoods. The gains for

sawtimber removals were greater, amounting to 84% over the same period. Removals of hardwood sawtimber have more than doubled, far exceeding the gain in softwood sawtimber removals of 28%.

The 1952 average removals of 9.8 cubic feet per acre had increased to 16.7 cubic feet by 1992. Sawtimber removals per acre have climbed even more. In 1952 some 24.9 board feet per acre of sawtimber were harvested. By 1992 sawtimber removals averaged 51.7 board feet per acre of timberland.

Removals as a percent of net growth has risen some over the 40 years, amounting to 59% of growth in 1992. For softwoods the removal rate has declined. The equivalent of about 40% of softwood net growth was harvested in 1992. Of the major ownership groups, forest industry ownerships currently are harvesting the most per acre and as a percentage of net growth. The often maligned nonindustrial private owners with 54% of the timberland had 56% of the net growth and 48% of the timber removals in 1992.

Timber Growth and Removals

In 1992 timber growth in the Lake States amounted to 1.5 billion cubic feet or about double the timber removals of 786 million cubic feet. The accumulating timber inventories in the region has improved timber supplies in several ways. Merchantable length has increased as trees have gotten bigger and taller. Higher harvestable volumes per acre improve harvesting efficiencies and tend to reduce woods to mill hauling distances. Such changes have resulted in new processing plants and higher timber harvests. Yet, the difference between net growth and removals is greater in 1992 than in 1952 (Figure 14).

In 1992, sawtimber growth in the Lake States totaled 5.2 billion board feet, more than double the harvest of 2.4 billion board feet. Between 1952 and 1992 sawtimber growth more than doubled. Sawtimber removals almost doubled (Figure 15).

The relationship between growth and removals varies somewhat by state but much more so within each state from north to south. The greatest variation in the ratio of removals to growth is among the survey units of Minnesota. In the Prairie Unit removals amount to only one-fifth of the timber growth, compared to the Aspen-Birch Unit where the removals amount to three-quarters of timber growth. The same pattern occurs in Michigan and Wisconsin although the differences are less striking. These patterns are a clear example of the general rule that forest industries locate near the timber supply not the markets.

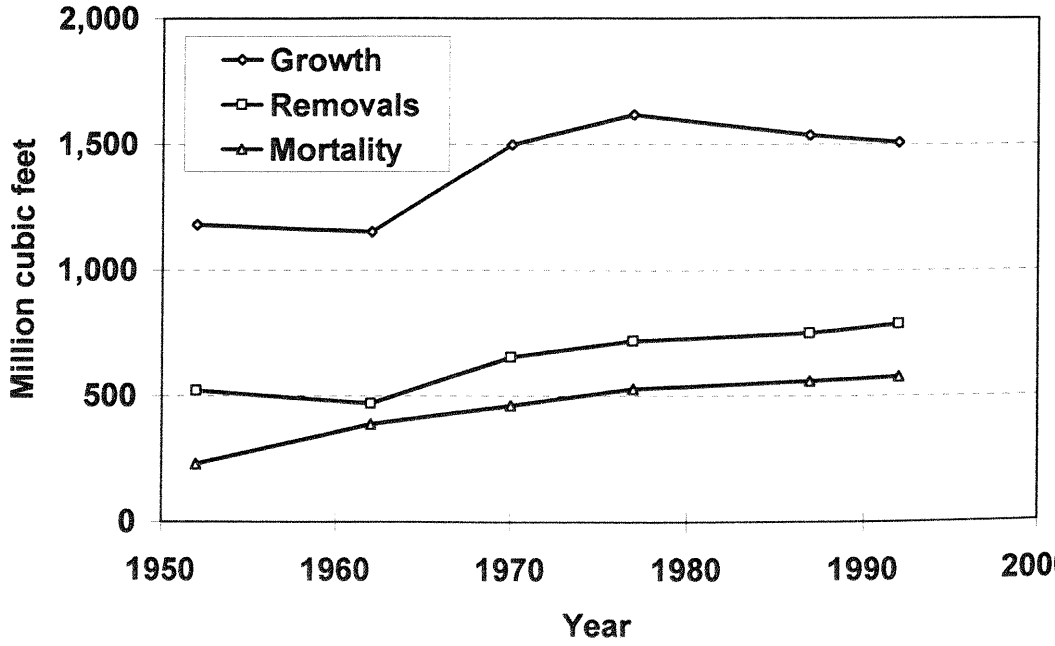

Figure 14.—*Comparison of growing-stock growth, removals, and mortality, 1952-1992.*

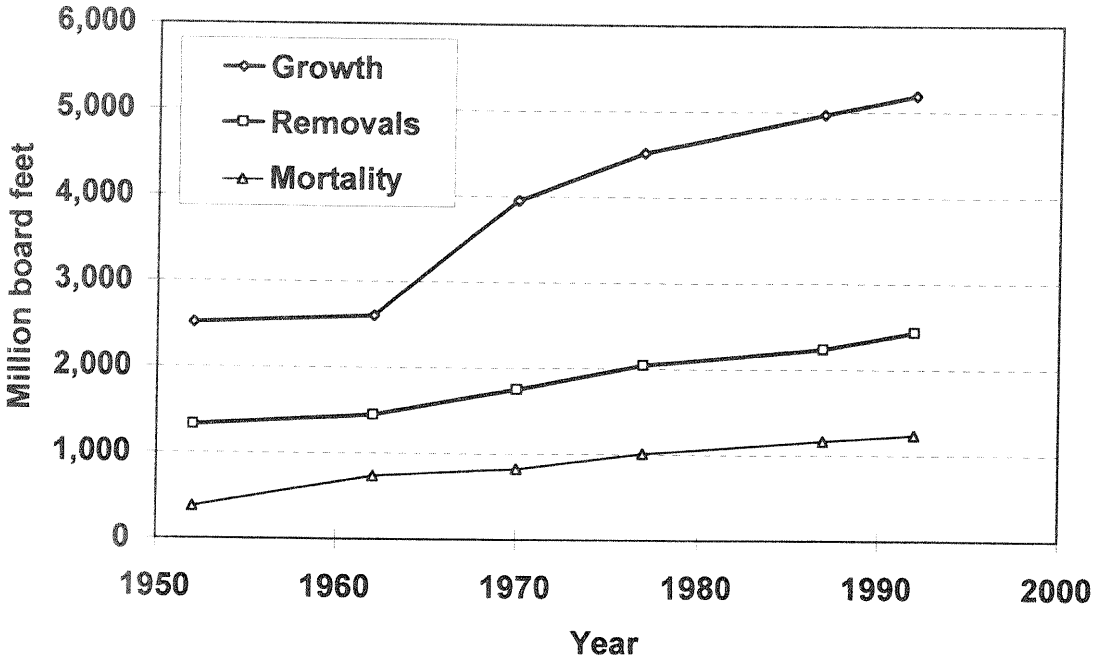

Figure 15.—*Comparison of sawtimber growth, removals, and mortality, 1952-1992.*

The following tabulation shows the ratio of removals to growth and the volume margins by FIA units:

	Growth	Harvest	Margin	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	1,508	786	722	.52

The decades old trend in the Lake States of growing more wood than is being harvested is, over time, adding large increments to the stock of maturing timber. Obviously, such a situation cannot continue indefinitely. In a world concerned about resource depletion and environmental degradation, an expanding forest is special. However, the forest resource situation across the Lake States has situations that either threaten the status quo or afford opportunities to enhance the future forest.

SPECIAL SITUATIONS

The rapidly changing and expanding forest resources in the Lake States present some special circumstances that help define the current forestry situation. This section of the report will focus on five of these.

Aspen

Aspen comprises a major policy conundrum for the region's forest managers and planners. The aspens, the most common species, are short-lived, fast maturing but poorly distributed by stand age. In 1952, aspen was thought of as a weed species with few uses and little or no stumpage value. Some timber companies were bulldozing young aspen stands to make room to plant spruce and other conifers deemed more economically promising.

By 1992 aspen ranked number one among the species in timber harvested. Aspen species provided some 40% of the total timber harvest of the region in 1990. Its growing abundance and low cost encouraged technical developments that multiplied uses. The conspicuous example of the new products is aspen flakeboard, now widely substituted for southern and western plywood. A newer version—oriented strand board—provides a stronger product with growing uses. The use of aspens for pulp and lumber sprang also from new knowledge.

Aspens are a pioneer species, ill equipped to compete silviculturally with most Lake States species. Aspen needs nearly full light. They are disturbance-dependent. If a calamity such as fire, windstorm, or logging kills most of a stand, aspen will quickly re-sprout and continue to dominate most sites. But with competition from other species aspen is usually replaced within a single generation by associates such as balsam fir and soft maple (Alban *et al.* 1991). Much of the area it occupies is well suited for other more competitive species. The ecological winds are slowly blowing it away. The hot fires and clearcuts that provide the mineral soils and full sunlight it needs to reproduce are repugnant to much of the public.

Aspen stands still cover over 10 million acres, or one-fifth of the timberland second only to the maple-basswood type. In Minnesota, aspen stocks one-third of the forest. Quaking aspen constitutes one-fourth of Minnesota's growing-stock volume although only 11% of Wisconsin's and 7% of Michigan's. However, as Spencer *et al.* reports, "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" (Spencer *et al.* 1990). As they report, the area of aspen forest type is declining primarily because aspen, a pioneer species, 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, 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 man-made stands can be seen across the region. In 1980 Michigan's forest plantation totaled 1.2 million acres. Wisconsin in 1983 reported 622 thousand plantation acres. The 1990 Minnesota inventory reports 354 thousand acres of forest plantings. About 300 thousand additional acres have been planted since the forest inventories in Michigan and Wisconsin. If most survived they raise the Lake States forest plantation acreage to about 2.5 million acres. Tree plantings have been mainly the native pines: jack, red, and white, plus white spruce. Much of the existing pine and white spruce type acreage are planted stands. For example, in Wisconsin, nearly 80% of the red pine and 66% of the white spruce timberland has been planted (Roussopoulos and Leatherberry 1992).

Although tree planting was not uncommon soon after the turn of the century it began on an extensive scale only after fire control programs insured protection along about 1930. The great depression of the 1930's fostered 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 still operating, were established during the CCC era for plantings on both public and private forest land. The CCC program faded away during World War II but tree planting rose rapidly in the 50's. The Soil Bank program designed to retire surplus farm land by paying farmers to retire crop land spurred a new surge in reforestation, this time on private land. The acreage planted each year peaked under the Soil Bank Program.

The early plantings were mostly on the public forests. By the 1950's plantings by corporations and especially individual land owners were exceeding public planting, a trend that continues (Figure 16). In the 1980's a number of policies and programs were implemented to encourage tree planting.

The older pine plantations, a principal source of pine pulpwood for years, are reaching sawtimber size. A modern sawmill located at McBain, Michigan, was designed to process red pine whole tree logs solely 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 programs providing reforestation incentives. But as the programs come and go the amount of forest planting has also. Consequently, the age structure like much of the natural forest, has an uneven age structure. The result is to imprint a cycle of changing forest characteristics and future conifer wood supply.

White Pine

A symposium held on white pine in 1992 could have been entitled "Where is the white pine?" (University of Minnesota 1992). Once king of the Lake States pinery, white pine, today, is scarcely present. Statistics for Minnesota, the most recent inventory statistics in the region show white pine numbered but 35 out of each thousand trees reported. Across the region the white pine forest type acreage is 520 thousand acres, an area smaller than Minnesota's Carlton County. Just 1% of the forest trees in the Lake States are white pine, although it accounts for 3% of the growing-stock volume. This key species of the legendary pine logging era that brought the region's economic development is surprisingly uncommon in the modern forest. White pine, the largest and tallest of the northern conifers, never recovered from the exploitation of early logging, uncontrolled wild fires and agricultural land clearing early in the century and before. Red pine has been favored in reforestation by owners and agencies reflecting the twin threats of white pine blister rust and white pine weevil.

Still when one looks to the statistics about the very big trees in the region, white pine remains dominant. In trees 29 inches and larger in diameter white pine numbers lead all species in sawtimber volume in every Lake State. Although comparatively few in number, white pine includes about 18% of the conifer sawtimber in the region.

White pine faces two formidable enemies (Jones 1992). White pine blister rust was introduced into the Lake States somewhere around the turn of the century. It spread slowly westward reaching western Minnesota in the 1930's. Although a significant killer of the species,

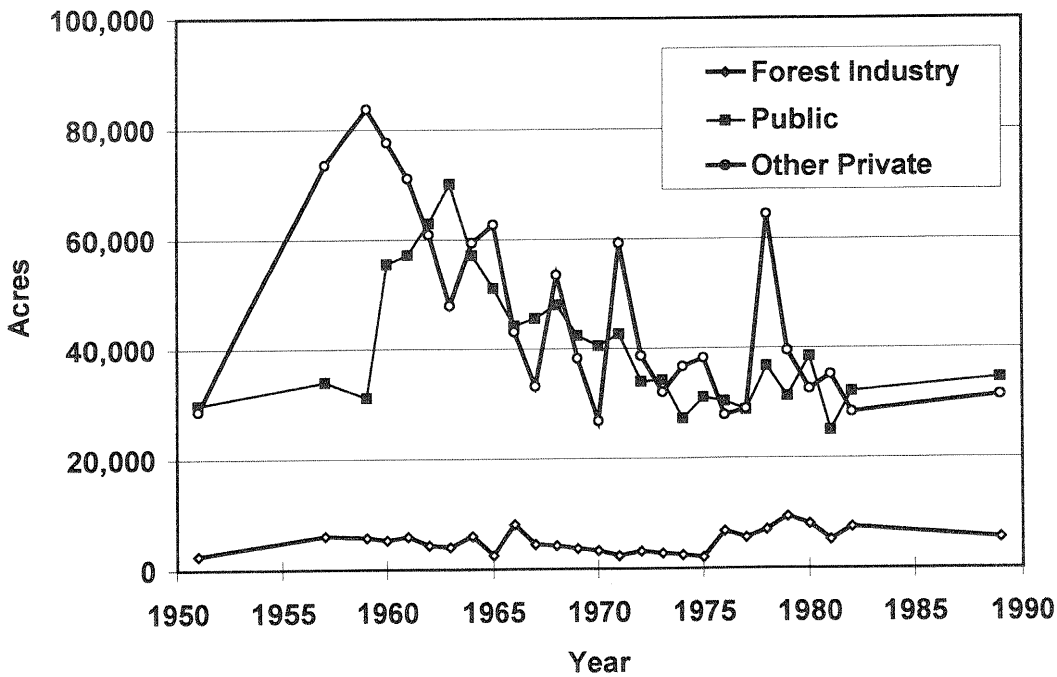

Figure 16.—*Area planted and direct seeded by ownership, 1951-1989.*

management practices are known that will reduce blister rust damage to acceptable levels. Underplanting and pruning seem to control the canker. White pine weevil is the major insect pest, by killing the affected trees leaders and deforming the main stem. Again, white pine growing in the understory is relatively undamaged.

White pine is damaged by a number of feeding animals. Porcupines and hares girdle the trees, but the major damage to white pine is repeated browsing of young trees by white-tailed deer. Record high deer populations in recent years have severely damaged young stands. The species is also affected by air pollutants. Of all the North American species, white pine is most susceptible to atmospheric pollutants.

The key to increasing this largest of the native conifer rests on better solutions to the problems above. There is little prospect that white pine can become a major species in Lake States forests in the foreseeable future.

Hard Maple

Contrasting with the disappointing recovery of white pine are major gains by sugar maple. This prime component of northern hardwood forests shows double digit improvements in volume, growth, and harvest. The gains are found mostly in Michigan and Wisconsin. Sugar maple does not do well in much of Minnesota. Only quaking aspen exceeds hard maple in growing stock volume in the Lake States. Hard maple is the most abundant species in Michigan, second only to quaking aspen in Wisconsin but ranks just fourteenth in Minnesota.

The maple-basswood forest type is more abundant than the aspen and birch types, covering 11.7 million acres. The maple-basswood type is by far the most abundant forest cover in Michigan and Wisconsin. Two common associate species of the type, hemlock and yellow birch, have fared less well.

Red Oak

There is growing concern among the forestry community that red oak sawtimber is being overcut to satisfy a strong market for oak lumber and veneer. However, the new Minnesota inventory shows current red oak sawtimber growth to be more than twice 1990 removals. The concern seems based on the failure following logging for the new stand to be red oak. Red oak has been difficult to regenerate on sites where it is the preferred timber species. This poses a long-term threat to the species abundance. Oak forests are changing ecologically because of successional displacement of oaks by more shade tolerant species, the absence of fire, and increased mortality of oaks caused by gypsy moth defoliation, and oak dieback and decline. The abundance of oak today is an artifact of a disturbance regime that no longer exists (Johnson 1992). The disturbance was a series of recurrent fires that killed competition but allowed the oak to resprout from protected dormant buds near the root collar.

There has been a gradual decrease in the area of oak-hickory forest type. Where well established oak regeneration is lacking, logged stands often come back to sugar and red maple that are less valuable species in current markets. Clearcutting heightens the tendency for red oak to be replaced (Johnson 1993).

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. An expanding fuel load has led some forest fire specialists to state that fires may occur that cannot be controlled with available equipment and methods. Several fires of well over a thousand acres have occurred in recent years. A large forest fire near Grayling, Michigan, destroyed 80 homes. One near Seney, Michigan, ran unchecked until it reached Lake Superior. The large blocks of maturing plantations present special fire control problems. Green wood currently averages over 60 tons per acre with additional fuels present such as dead trees, woody debris, leaves, and grown vegetation. Construction of large numbers of scattered permanent and seasonal homes in forested areas has made fire protection more difficult.

FOREST PRODUCTS, BENEFITS, AND USES

Who wants how much Lake States timber depends on a number of market determinants. Among the factors that change the amount of timber demanded are population, gross domestic product, housing starts, imports and exports, technical improvements and new products. Changes in the supply of timber in other regions of the country (and world) influences Lake States timber markets.

The underlying rate of change from population growth and economic growth for the country is about 2%. The improving supply of maturing timber in the Lake States and the impact of new technologies have resulted in timber harvests that are growing at 3% annually. This rate will double the harvest amount every 24 years.

In the Lake States timber products output has been increasing at 3%—half again as fast as the national rate!

Woodpulp production in the Lake States increased 32% between 1965 and 1990 to 12,560 tons per day. Most gains are from new kraft pulp capacity in Michigan and Wisconsin, much of it at Quinnesec and Escanaba.

Pulpwood makes up more than half of the industrial timber products harvested annually in the Lake States. Pulpwood production between 1965 and 1990 more than doubled, reaching 8.53 million cords in 1990. Hardwoods constituted 76% of the pulpwood production. The main species were aspen, jack pine, hard maple, and white birch. Michigan produced 3.0 million cords, Wisconsin 3.1 million cords and Minnesota produced 2.4 million cords. The major pulpwood species in Michigan are aspen, maple, and pine. The Lake States had 50 pulp and board mills in 1990.

The Lake States have become major producers of both structural and industrial particleboard. Annual production of board increased from 365 million square feet (1/4-inch basis) in 1980 to 1,386 in 1990. Seven mills were constructed in the 1980's.

Saw log production in the Lake States has advanced as the second-growth timber has matured. Some 804 sawmills were in operation in 1990. Lake States saw log production reached 1.5 billion board feet in 1990 compared to 828 million board feet in 1965, 42% was in Michigan. Pine, aspen, red oak, hard maple, and soft maple are the principal lumber species.

The Lake States have 29 veneer mills—17 are in Wisconsin and Michigan has 8. Veneer log production increased 94% between 1966 and 1990 to just under 100 million board feet for 1990. The leading species are hard maple, red oak, aspen, and birch. The output of basswood veneer logs is rising sharply.

One interesting aspect of the housing market is the demand for log cabins. Several firms in Upper Michigan and Wisconsin seem to be prospering manufacturing log structures and shipping them to markets as far away as Japan.

Expanding timber demand always carries a concern about exploitation and overcutting. Although the forests of the Lake States have been recovered and volumes are accumulating annually, the region's history of cutout and getting logging and wholesale land clearing are still to much in evidence. However, current removals amount to about 1.5% of growing-stock volume and about 2% of sawtimber volume, well below current timber growth. The fact that current timber growth levels are much higher than timber removals rates suggests greater demands can be met while maintaining and improving the forest. Current growth per acre is no more than two-thirds of site potential.

The rising demand for Lake States' wood products will tend to bring better timber prices. Added revenues can finance better forestry. But higher prices and greater demand can also encourage conflicts between timber production and the many other forest benefits.

Forest Recreation and Wildlife

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

The appeal of forest recreation cannot be separated from the attraction of forest creatures. The chance to see wild animals and birds in their natural settings is, certainly, one of the attractions bringing the millions of visitors to Lake States forests and recreation areas. The largest wild animal in the Lake States, the moose, is found on Isle Royale and in the Boundary Waters Canoe Area Wilderness, although a few are known to roam Michigan's Upper Peninsula. Elk are found in Michigan. The present herd of about 1,000 animals was reintroduced to northern Michigan in 1917 (Bender *et al.* 1991). The original herds of elk were extirpated from the region in the 1800s. The elk range in Michigan of about 3,800 acres near Vanderbilt and Atlanta 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 the white tailed deer. Deer are found throughout the region and, except for a few urban counties, is the principal big game and numbers at times in excess of 2 million animals. Black bear, bobcats, coyotes, foxes, and a few reported cougar are additional visitor attractions to forest areas although only occasionally sighted.

The increased acreage of sawtimber stands with larger and taller trees enlarges the habitat for wildlife, and especially birds. Just as a 10-story hotel has more rooms than a 5-story one on the same sized area, the taller sawtimber forest stands contain more rooms and niches than the poletimber and sapling stands they grow from. The larger trees contain bigger cavities for nests and dens. The elevated crowns have more strata and become more complex. As the sawtimber stands age, they make more and larger pieces of dead and down wood, bigger stumps and root channels. Among the mammals of mature forests are bobcat, fisher, gray squirrel, lynx, flying squirrels, porcupine, raccoon, and several species of bats (Benyus *et al.* 1992).

The increasing acreages of sawtimber stands are improving cover 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 again permitted. Black bear sightings are reported as far south as Verona, 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 of the 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 and are clearly extending their range. Eagles, cranes, swans, geese, and ducks also frequent the quiet and remoteness of forested and the maturing forest cover will improve their habitat.

Many of the region's bird species frequent and prefer mature forest habitats. Some are: boreal chickadee, brown creeper, common goldeneye, common raven, dark-eyed junco, eastern screech-owl, great blue heron, great crested flycatcher, great gray owl, hairy woodpecker, hooded merganser, house wren, northern flicker, northern goshawk, northern oriole, northern water thrush, pileated woodpecker, pine warbler, red-breasted nuthatch, red-shouldered hawk, scarlet tanager, sharp-shinned hawk, whip-poor-will, wood duck, and yellow-bellied flycatcher (Benyus *et al.* 1992).

More bird and mammal species use mature forest stands, small grass openings, and small shrub-sapling openings than any of the other habitat classes.

A survey for Wisconsin reported that three-fourths of the population engages in some form of forest/wildlife recreation (University of Wisconsin 1987).

The increasing demand for wood and wood products coexists with other ballooning demands for forest oriented goods. More people means more consumers of houses and all the 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

The Great Lakes are special and unique. The Lake States' panorama of forest, farmland, lakes and rivers, and of hardwood and softwood woodlands of great variety gives it a uniquely diverse range of use prospects. In close proximity to the Lake States lives one-third of the U.S. population.

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 characteristic of the Lake States forests dwarfs all others in creating change. It is the skewed age-class distribution. Many of the forest stands were established in the late 1920's and early 1930's. 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, a virtual wall of ripening timber. For forest types such as aspen and jack pine, the trees are fully mature and facing decline if uncut. The maple-beech, red pine, and oak stands are short of full development, at most a decade or two off.

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 about cut cut. About 1940 the volume of rising growth of restocked stands exceeded the volume of timber removals. The long decline in timber inventories ended. During the 40'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 that still continues of timber growth above timber removals. Consequently, timber inventories have increased at an increasing rate. A wave of timber has accumulated and is projected to crest about 2030.

As the wave grew, accumulating volumes per acre were accompanied by increased stand basal area, closing crown cover, and reduced underbrush. As less sunlight penetrated the tree canopy ground cover thinned. 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 60's and 70's were 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. This favorable trend is an accelerating one. The long wave in the Lake States is accompanied by a middle age bulge in stand ages.

Past shifts in land use, on-again-off-again reforestation programs and effective fire programs have caused 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 when most stands are mature and prime for final harvest. A second bulge of aspen is on its way but is only about 20 years of age.

The planted forests present another recent set of waves. Earlier ones came from the Civil Conservation Corps of the 1930's and the Soil Bank Program of the 1950's. These waves are nicely seen in the red pine where a large part of its acreage is about 55 years old or about 35 years old. The first wave is providing poles and small sawtimber for several new sawmills and considerable pulpwood from thinnings.

The Lake States has forests, water, snow, and people in close proximity. It has large public land ownership, good hunting and fishing, lakes and streams in large supply. Beaches and wooded scenery abound. The region has well developed parks and campgrounds. Two fast-growing outdoor activities are canoeing—up 500%, and bicycling—up 300%, in 20 years.

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, are some of the attractions that bring millions of visitors to the regions' forests. Even corporate plant 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. Moose, 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 are spotted where they haven't lived for generations. Small numbers of timber wolves roam parts of upper Michigan as well as northern Minnesota. Occasional sightings of wolves and cougar are reported in Wisconsin's north country.

The forests of the Lake States contain proportionally large acreages of stands at or near maturity. Larger timber harvests are in prospect.

The general expansion in timber inventories increases timber supply and creates a long wave of timber change. Complicating this trend are smaller bulges of maturing timber related to skewed age class structure in several major forest types.

The forests of the Lake States are back. But they are dynamic and changing quickly in size, quality, and utility. They offer a challenge if the opportunities they can offer are to be captured.

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I want to acknowledge Robert Phelps, U.S. Forest Service, Washington, DC, and Neal Kingsley, U.S. Forest Service, North Central Forest Experiment Station, St. Paul, MN. They provided me with the latest Forest Service information and statistics about forest resources and timber demand. Dave McKeever of the Forest Products Laboratory, Madison, WI, wrote the computer program and generated the output ratios and per acre statistics for the owner classes.

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APPENDIX

Table 1.—Area of timberland by forest type and stand age, Lake States, 1987

Table 2.—Growing stock volume by species and state, Lake States, 1992

Table 3.—Sawtimber volume by species and state, Lake States, 1992

Table 4.—Net volume of growing stock on timberland by species group and diameter class, Michigan, 1992

Table 5.—Net volume of growing stock on timberland by species group and diameter class, Minnesota, 1992

Table 6.—Net volume of growing stock on timberland by species group and diameter class, Wisconsin, 1992

Table 7.—Net volume of sawtimber on timberland by species group and diameter class, Michigan, 1992

Table 8.—Net volume of sawtimber on timberland by species group and diameter class, Minnesota, 1992

Table 9.—Net volume of sawtimber on timberland by species group and diameter class, Wisconsin, 1992

Table 10.—Timber production ratio estimators, by ownership class, Lake States, 1992

Table 11.—Timber production per acre estimators, by ownership class, Lake States, 1992

Table 12.—Percent of volume, growth and removals of growing stock and sawtimber, by ownership class, Lake States, 1992

Table 2.--Growing stock volume by species and state, Lake States, 1992

Species	Lake States	Michigan	Minnesota	Wisconsin
		(Thousand cubic feet)		
Jack Pine	1,732,305	655,437	553,019	523,849
Red Pine	2,818,835	1,202,313	585,215	1,031,307
White Pine	1,771,431	775,020	263,829	732,582
Ponderosa Pine	625	--	625	--
White Spruce	1,085,742	530,173	296,414	259,155
Black Spruce	1,208,612	324,730	746,180	137,702
Balsam Fir	2,352,811	784,992	963,830	603,989
Hemlock	1,263,488	840,369	--	423,119
Tamarack	775,789	134,052	475,656	166,081
Eastern Red Cedar	27,103	3,713	14,959	8,431
Northern White Cedar	3,079,910	1,759,272	744,792	575,846
Other Softwoods	129,769	116,249	3,118	10,402
Select White Oak	2,081,848	618,436	647,393	816,019
Select Red Oak	3,515,517	1,192,103	818,970	1,504,444
Other red Oak	823,231	207,191	36,749	579,291
Select Hickory	213,933	69,948	16,348	127,637
Other Hickory	134,007	55,353	9,822	68,832
Basswood	2,432,008	778,798	692,132	961,078
Beech	455,816	423,127	--	32,689
Yellow Birch	700,949	460,540	21,876	218,533
Hard Maple	5,761,791	3,518,341	403,671	1,839,779
Soft Maple	4,469,328	2,683,058	345,140	1,441,130
Elm	962,373	277,244	269,571	415,558
Black Ash	1,431,096	283,044	700,461	447,591
White & Green Ash	1,173,382	607,732	186,757	378,893
Sycamore	19,000	19,000	--	--
Cottonwood	156,907	74,139	52,385	30,383
Willow	97,859	38,921	29,374	29,564
Hackberry	13,926	1,229	9,885	2,812
Balsam Poplar	959,508	320,967	595,247	43,294
Bigtooth Aspen	1,887,640	915,399	279,740	692,501
Quaking Aspen	7,423,865	1,701,451	3,818,498	1,903,916
Paper Birch	3,346,475	811,948	1,458,718	1,075,809
River Birch	10,919	375	37	10,507
Tupelo	4,705	4,705	--	--
Black Cherry	672,795	441,779	15,688	215,328
Black Walnut	77,279	36,129	14,163	26,987
Butternut	67,265	6,224	11,150	49,891
Yellow Poplar	20,328	20,328	0	--
Other Hardwoods	151,573	73,214	51,650	26,709
Softwoods	16,246,420	7,126,320	4,647,637	4,472,463
Hardwoods	39,065,323	15,640,723	10,485,425	12,939,175
All Species	55,311,743	22,767,043	15,133,062	17,411,638

Table 2.--Growing stock volume by species and state, Lake States, 1992

Species	Lake States	Michigan	Minnesota	Wisconsin
		(Thousand cubic feet)		
Jack Pine	1,732,305	655,437	553,019	523,849
Red Pine	2,818,835	1,202,313	585,215	1,031,307
White Pine	1,771,431	775,020	263,829	732,582
Ponderosa Pine	625	--	625	--
White Spruce	1,085,742	530,173	296,414	259,155
Black Spruce	1,208,612	324,730	746,180	137,702
Balsam Fir	2,352,811	784,992	963,830	603,989
Hemlock	1,263,488	840,369	--	423,119
Tamarack	775,789	134,052	475,656	166,081
Eastern Red Cedar	27,103	3,713	14,959	8,431
Northern White Cedar	3,079,910	1,759,272	744,792	575,846
Other Softwoods	129,769	116,249	3,118	10,402
Select White Oak	2,081,848	618,436	647,393	816,019
Select Red Oak	3,515,517	1,192,103	818,970	1,504,444
Other red Oak	823,231	207,191	36,749	579,291
Select Hickory	213,933	69,948	16,348	127,637
Other Hickory	134,007	55,353	9,822	68,832
Basswood	2,432,008	778,798	692,132	961,078
Beech	455,816	423,127	--	32,689
Yellow Birch	700,949	460,540	21,876	218,533
Hard Maple	5,761,791	3,518,341	403,671	1,839,779
Soft Maple	4,469,328	2,683,058	345,140	1,441,130
Elm	962,373	277,244	269,571	415,558
Black Ash	1,431,096	283,044	700,461	447,591
White & Green Ash	1,173,382	607,732	186,757	378,893
Sycamore	19,000	19,000	--	--
Cottonwood	156,907	74,139	52,385	30,383
Willow	97,859	38,921	29,374	29,564
Hackberry	13,926	1,229	9,885	2,812
Balsam Poplar	959,508	320,967	595,247	43,294
Bigtooth Aspen	1,887,640	915,399	279,740	692,501
Quaking Aspen	7,423,865	1,701,451	3,818,498	1,903,916
Paper Birch	3,346,475	811,948	1,458,718	1,075,809
River Birch	10,919	375	37	10,507
Tupelo	4,705	4,705	--	--
Black Cherry	672,795	441,779	15,688	215,328
Black Walnut	77,279	36,129	14,163	26,987
Butternut	67,265	6,224	11,150	49,891
Yellow Poplar	20,328	20,328	0	--
Other Hardwoods	151,573	73,214	51,650	26,709
Softwoods	16,246,420	7,126,320	4,647,637	4,472,463
Hardwoods	39,065,323	15,640,723	10,485,425	12,939,175
All Species	55,311,743	22,767,043	15,133,062	17,411,638

Table 3.--Sawtimber volume by species and state, Lake States, 1992

Species	Lake States	Michigan	Minnesota	Wisconsin
		(Thousand board feet)		
Jack Pine	4,486,231	1,547,905	1,706,422	1,231,904
Red Pine	8,598,351	3,223,110	2,444,196	2,931,045
White Pine	8,411,285	3,679,467	1,297,353	3,434,465
Ponderosa Pine	123	--	123	--
White Spruce	4,219,172	2,090,618	1,152,492	976,062
Black Spruce	1,256,872	410,809	709,531	136,532
Balsam Fir	4,653,774	1,395,489	1,859,325	1,398,960
Hemlock	6,240,832	4,159,567	--	2,081,265
Tamarack	1,433,980	277,612	835,291	321,077
Eastern Red Cedar	46,049	7,546	29,531	8,972
Northern White Cedar	8,137,423	4,406,690	2,193,168	1,537,565
Other Softwoods	217,551	188,662	8,017	20,872
Select White Oak	6,657,090	2,008,787	1,823,232	2,825,071
Select Red Oak	11,841,520	3,982,754	2,638,203	5,220,563
Other red Oak	2,524,069	611,870	123,676	1,788,523
Select Hickory	528,934	186,894	39,396	302,644
Other Hickory	262,028	168,567	10,979	82,482
Basswood	6,797,489	2,308,706	1,822,677	2,666,106
Beech	1,759,496	1,622,784	--	136,712
Yellow Birch	2,103,637	1,440,776	72,782	590,079
Hard Maple	14,053,601	8,802,032	804,576	4,446,993
Soft Maple	9,248,814	6,231,091	503,438	2,514,285
Elm	2,319,429	547,998	638,865	1,132,566
Black Ash	2,025,413	394,443	968,817	662,153
White & Green Ash	3,326,242	1,738,880	485,139	1,102,223
Sycamore	88,649	88,649	--	--
Cottonwood	642,606	275,809	235,374	131,423
Willow	350,437	150,054	95,126	105,257
Hackberry	34,298	3,105	23,940	7,253
Balsam Poplar	2,182,641	892,249	1,157,379	133,013
Bigtooth Aspen	4,943,291	2,274,109	752,257	1,916,925
Quaking Aspen	15,624,199	3,546,503	8,652,491	3,425,205
Paper Birch	3,848,546	1,086,807	1,626,662	1,135,077
River Birch	27,400	727	--	26,673
Tupelo	8,567	8,567	--	--
Black Cherry	1,377,415	952,540	26,808	398,067
Black Walnut	276,171	122,972	46,779	106,420
Butternut	202,722	15,880	33,340	153,502
Yellow Poplar	84,956	84,956	--	--
Other Hardwoods	196,093	65,396	89,096	41,601
Softwoods	47,701,643	21,387,475	12,235,449	14,078,719
Hardwoods	93,335,753	39,613,905	22,671,032	31,050,816
All Species	141,037,396	61,001,380	34,906,481	45,129,535

Table 4.—Net volume of growing stock on timberland by species group and diameter class, Michigan, 1992.

	TOTAL	5.0- 6.9	7.0- 8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19-0-20.9	21.0-28.9	29.0+
					(Thousand cubic feet)						
Jack pine	655,437	136,653	202,916	167,672	99,886	32,835	10,478	4,313	684	--	--
Red pine	1,202,313	211,132	378,351	232,927	130,679	81,673	47,992	50,913	34,822	33,533	291
White pine	775,020	33,363	40,095	67,206	70,471	88,234	96,809	86,026	82,020	174,773	36,023
White spruce	530,173	52,324	88,119	88,199	102,292	77,548	54,699	33,025	21,808	11,325	834
Black spruce	324,730	142,799	104,600	48,282	17,025	5,603	3,547	1,571	362	941	--
Balsam fir	784,992	252,542	247,001	158,562	77,999	33,301	11,899	2,220	418	1,050	--
Hemlock	840,369	24,060	38,057	62,916	88,376	123,297	132,051	116,360	82,097	152,511	20,644
Tamarack	134,052	46,144	34,540	23,305	16,167	8,344	1,842	2,470	779	461	--
Eastern red cedar	3,713	2,281	--	825	--	607	--	--	--	--	--
Northern white-cedar	1,759,272	412,050	484,108	393,775	211,633	126,603	68,749	35,416	13,006	13,362	570
Other softwoods	116,249	38,129	39,242	20,279	12,409	3,652	2,301	--	--	237	--
Select white oak	618,436	41,299	69,234	79,261	81,911	71,143	64,076	51,086	35,778	91,385	33,263
Select red oak	1,192,103	43,554	110,956	175,229	197,193	180,145	139,715	115,558	75,990	125,499	28,264
Other red oak	207,191	11,651	21,403	40,016	41,116	31,951	22,051	14,132	11,539	12,507	825
Select hickory	69,948	5,677	7,729	11,969	14,239	11,244	8,664	5,957	1,442	3,027	--
Other hickory	55,353	1,203	5,596	9,242	12,696	7,872	5,491	5,048	2,869	3,739	1,597
Basswood	778,798	47,857	91,854	138,531	169,677	123,849	79,932	57,550	29,457	35,310	4,781
Beech	423,127	28,264	31,936	39,780	52,651	54,924	57,185	54,426	40,539	58,527	4,895
Yellow birch	460,540	42,814	61,735	63,153	53,849	58,783	64,501	40,932	26,336	43,506	4,931
Hard maple	3,518,341	496,359	540,678	588,153	482138	397,300	330,744	263,930	168,719	223,601	26,719
Soft maple	2,683,058	406,481	454,859	464,263	385,899	292,579	201,510	173,413	98,459	162,706	42,889
Elm	277,244	55,379	48,643	47,137	37,345	35,924	21,378	14,651	8,233	7,417	1,137
Black ash	283,044	85,944	70,608	41,139	40,946	22,125	12,001	3,923	3,139	3,219	--
White & green ash	607,732	79,247	74,596	79,663	99,141	76,363	49,522	51,125	31,613	50,952	15,510
Sycamore	19,000	--	685	1,821	1,092	--	163	1,487	1,199	7,159	5,394
Cottonwood	74,139	2,288	4,376	7,105	9,526	6,438	8,777	10,107	2,761	14,906	7,855
Willow	38,921	2,824	741	2,603	3,944	6,260	4,523	3,307	1,729	8,642	4,348
Hackberry	1,229	510	--	--	361	--	358	--	--	--	--
Balsam poplar	320,967	31,692	41,735	57,222	48,849	44,515	33,615	23,325	14,676	22,502	2,836
Bigtooth aspen	915,399	84,870	140,770	195,742	205,824	151,580	72,586	35,380	17,214	11,433	--
Quaking aspen	1,701,451	234,125	293,883	397,700	327,861	212,715	118,383	67,014	27,540	21,607	623
Paper birch	811,948	163,176	207,340	192,306	131,753	62,827	29,986	16,041	5,114	3,405	--
River birch	375	224	--	--	--	151	--	--	--	--	--
Tupelo	4,705	2,186	470	192	499	839	--	--	--	519	--
Black cherry	441,779	59,429	85,461	86,958	69,853	53,806	39,460	21,130	9,912	14,038	1,732
Black walnut	36,129	2,958	3,178	4,623	4,469	6,255	5,374	3,874	1,629	3,769	--
Butternut	6,224	1,662	967	290	465	1,329	1,272	--	239	--	--
Yellow-poplar	20,328	624	2,374	458	759	2,938	2,158	2,483	1,225	7,309	--
Other hardwoods	73,214	33,525	16,836	8,198	7,165	2,882	2,406	1,111	--	1,091	--
Softwoods	7,126,320	1,351,477	1,657,029	1,263,948	826,937	581,697	430,367	332,314	235,996	388,193	58,362
Hardwoods	15,640,723	1,965,822	2,388,643	2,732,754	2,481,221	1,916,737	1,375,831	1,036,990	617,351	937,775	187,599
All species	22,767,043	3,317,299	4,045,672	3,996,702	3,308,158	2,498,434	1,806,198	1,369,304	853,347	1,325,968	245,961

Table 5.—Net volume of growing stock on timberland by species group and diameter class, Minnesota, 1992.

	TOTAL	5.0- 6.9	7.0- 8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
					(Thousand cubic feet)						
Jack pine	553,019	75,689	134,713	145,501	100,294	60,316	23,311	8,775	2,525	1,895	--
Red pine	585,215	56,562	82,073	79,422	74,811	74,997	69,675	59,730	43,826	44,016	103
White pine	263,829	8,879	13,838	18,447	23,378	26,976	24,401	26,200	28,264	72,623	20,823
Ponderosa pine	625	319	283	23	--	--	--	--	--	--	--
White Spruce	296,414	33,588	46,904	48,045	49,850	36,653	30,881	23,020	15,196	12,277	--
Black spruce	746,180	377,748	233,990	93,462	27,981	6,569	3,680	989	599	1,070	92
Balsam fir	963,830	293,095	290,769	208,324	110,869	39,422	14,250	4,117	1,724	1,260	--
Tamarack	475,656	164,341	147,301	87,282	43,316	19,906	8,999	1,678	1,966	867	--
Eastern red cedar	14,959	3,479	5,720	1,989	2,236	607	418	302	--	208	--
Northern white-cedar	744,792	133,887	182,201	161,670	108,007	74,849	42,028	20,698	11,819	9,563	70
Other softwoods	3,118	362	1,148	657	277	439	235	--	--	--	--
Select white oak	647,393	63,413	85,122	100,137	95,350	82,575	71,742	54,832	33,921	53,241	7,060
Select red oak	818,970	28,667	81,410	134,415	135,126	119,548	103,803	78,259	52,525	74,871	10,346
Other red oak	36,749	1,869	5,408	3,127	4,788	4,255	4,951	2,692	3,180	5,794	685
Select hickory	16,348	1,362	2,503	2,964	3,673	2,997	1,595	867	147	240	--
Other hickory	9,822	2,248	2,853	1,996	1,304	937	205	181	98	--	--
Basswood	692,132	65,307	101,976	133,469	109,971	93,014	66,561	50,473	28,686	38,412	4,263
Yellow birch	21,876	2,027	2,305	2,599	2,495	3,851	2,460	2,010	2,013	2,041	75
Hard maple	403,671	89,456	79,329	58,128	52,147	39,403	33,883	23,359	12,885	14,010	1,071
Soft maple	345,140	102,602	79,344	54,167	28,322	20,113	13,278	10,125	8,891	17,098	11,200
Elm	269,571	39,581	42,450	43,286	38,969	25,471	23,553	16,130	13,172	21,409	5,550
Black ash	700,461	153,097	186,945	149,158	99,879	59,078	28,626	13,542	5,749	4,387	--
White & green ash	186,757	18,274	29,120	34,546	29,952	25,480	18,040	11,096	8,724	8,577	2,948
Cottonwood	52,385	452	1,291	2,775	2,740	2,437	3,768	3,460	4,738	13,538	17,186
Willow	29,374	493	2,495	4,476	4,821	4,461	3,795	3,708	1,683	2,686	756
Hackberry	9,885	1,898	1,456	1,180	1,030	1,341	770	1,099	498	456	157
Balsam poplar	595,247	76,527	120,224	140,848	108,358	71,385	40,383	22,163	8,193	6,871	295
Bigtooth aspen	279,740	16,538	37,128	61,382	69,847	47,990	27,229	13,151	4,305	2,048	122
Quaking aspen	3,818,498	383,975	653,944	871,447	804,576	564,479	316,852	133,039	52,978	36,557	651
Paper birch	1,458,718	294,044	424,051	361,138	206,853	100,929	41,240	19,446	5,225	5,302	490
River birch	37	37	--	--	--	--	--	--	--	--	--
Black cherry	15,688	2,771	3,786	3,055	2,461	1,729	925	777	184	--	--
Black walnut	14,163	172	2,868	1,354	2,005	2,255	2,469	1,789	503	748	--
Butternut	11,150	119	1,828	2,094	2,270	1,404	1,315	949	738	433	--
Other hardwoods	51,650	8,749	11,416	12,156	5,954	5,457	3,885	2,190	1,157	584	102
Softwoods	4,647,637	1,147,949	1,138,940	844,822	541,019	340,734	217,878	145,509	105,919	143,779	21,088
Hardwoods	10,485,425	1,353,678	1,959,252	2,179,897	1,812,891	1,280,589	811,328	465,337	250,193	309,303	62,957
All species	15,133,062	2,501,627	3,098,192	3,024,719	2,353,910	1,621,323	1,029,206	610,846	356,112	453,082	84,045

Table 6.—Net volume of growing stock on timberland by species group and diameter class, Wisconsin, 1992.

	TOTAL	5.0- 6.9	7.0- 8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0 -28.9	29.9+
					(Thousand cubic feet)						
Jack pine	523,849	106,910	163,778	136,971	84,522	24,987	5,355	678	648	--	--
Red pine	1,031,307	163,575	309,118	202,652	130,720	71,337	46,197	46,737	33,068	27,903	--
White pine	732,582	31,943	50,302	58,385	61,748	74,617	74,122	88,278	74,616	170,677	47,894
White spruce	259,155	34,132	41,707	58,657	43,674	29,131	22,887	13,759	7,878	7,028	302
Black spruce	137,702	65,805	46,063	16,131	6,853	1,248	528	1,074	--	--	--
Balsam fir	603,989	160,599	158,907	144,601	81,352	33,715	12,382	11,357	680	396	--
Hemlock	423,119	12,666	22,115	34,898	47,227	49,668	53,037	56,118	48,984	84,311	14,095
Tamarack	166,081	50,726	53,423	24,692	20,245	9,700	3,590	1,841	742	1,122	--
Eastern red cedar	8,431	3,207	3,554	547	335	--	788	--	--	--	--
Northern white-cedar	575,846	116,001	156,701	129,444	86,965	46,485	23,895	11,378	2,842	2,135	--
Other softwoods	10,402	3,699	2,488	1,353	1,408	1,010	--	444	--	--	--
Select white oak	816,019	42,707	73,411	89,018	107,750	106,022	105,149	76,458	53,532	117,222	44,750
Select red oak	1,504,444	49,550	129,007	187,845	239,577	213,167	177,008	145,995	101,586	215,296	45,413
Other red oak	579,291	26,378	65,227	94,494	100,799	85,908	77,792	44,173	30,944	49,011	4,565
Select hickory	127,637	10,748	18,736	25,630	24,327	20,937	12,307	8,689	3,608	2,655	--
Other hickory	68,832	16,733	18,870	12,633	10,240	4,772	3,563	677	978	366	--
Basswood	961,078	60,924	124,421	193,513	199,102	138,645	89,193	54,707	30,921	58,425	11,227
Beech	32,689	1,634	1,504	2,169	4,590	3,983	3,580	4,644	3,797	6,267	521
Yellow birch	218,533	23,438	32,736	38,691	35,919	24,864	18,783	20,049	9,801	12,941	1,311
Hard maple	1,839,779	259,999	301,670	318,194	228,110	186,898	153,437	124,152	85,981	156,822	24,516
Soft maple	1,441,130	305,767	311,866	265,032	177,407	123,896	83,794	54,714	40,960	60,680	17,014
Elm	415,558	36,917	51,536	68,340	65,383	57,267	45,532	38,338	20,893	25,005	6,347
Black ash	447,591	96,979	112,654	92,822	67,306	40,250	18,686	10,929	3,505	4,460	--
White & green ash	378,893	29,942	42,534	63,329	76,035	55,807	36,921	30,474	18,336	20,563	4,952
Cottonwood	30,383	667	790	1,505	2,437	3,037	2,853	1,615	2,950	4,512	10,017
Willow	29,564	1,592	2,107	1,977	2,785	4,982	3,044	4,049	3,335	5,086	607
Hackberry	2,812	207	776	241	266	--	989	--	--	333	--
Balsam poplar	43,294	3,732	5,811	4,900	6,276	8,167	6,917	2,733	592	3,938	228
Bigtooth aspen	692,501	45,505	82,908	141,916	165,392	136,973	65,445	36,493	13,609	3,978	282
Quaking aspen	1,903,916	280,158	360,529	495,636	375,375	213,469	109,796	46,694	15,648	6,332	279
Paper birch	1,075,809	209,365	331,827	266,476	158,473	70,967	25,883	9,392	2,270	1,156	--
River birch	10,507	1,336	1,042	2,515	1,085	1,868	925	335	310	1,091	--
Black cherry	215,328	31,316	47,909	46,374	36,102	19,627	21,306	4,885	4,439	3,370	--
Black walnut	26,987	1,054	1,479	2,000	6,631	5,820	2,857	2,255	3,418	1,473	--
Butternut	49,891	3,213	5,995	8,157	7,292	9,734	5,516	6,965	1,660	1,046	313
Other hardwoods	26,709	7,497	4,739	5,188	3,832	2,939	887	315	892	420	--
Softwoods	4,472,463	749,263	1,008,156	808,331	565,049	341,898	242,781	231,664	169458	293,572	62,291
Hardwoods	12,939,175	1,547,358	2,130,084	2,428,595	2,102,491	1,539,999	1,072,163	729,730	453,965	762,448	172,342
All species	17,411,638	2,296,621	3,138,240	3,236,926	2,667,540	1,881,897	1,314,944	961,394	623,423	1,056,020	234,633

Table 7.—Net volume of sawtimber on timberland by species group and diameter class, Michigan, 1992.

	TOTAL	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
				(Thousand board feet)					
Jack pine	1,547,905	803,249	492,707	168,342	55,942	23,778	3,887	--	--
Red pine	3,223,110	1,174,259	672,670	433,056	261,765	284,668	198,844	196,065	1,783
White pine	3,679,467	308,129	332,768	434,208	494,763	454,973	446,213	992,082	216,331
White spruce	2,090,618	447,011	534,080	418,254	303,642	187,765	126,688	67,979	5,199
Black spruce	410,809	251,575	91,121	30,997	20,117	9,154	2,153	5,692	--
Balsam fir	1,395,489	756,822	384,719	170,254	63,120	12,147	2,346	6,081	--
Hemlock	4,159,567	295,591	429,888	626,139	696,440	634,251	459,697	890,227	127,334
Tamarack	277,612	117,394	83,977	44,830	10,156	14,007	4,507	2,741	--
Eastern red cedar	7,546	4,232	--	3,314	--	--	--	--	--
Northern white-cedar	4,406,690	1,964,363	1,071,417	657,553	366,851	193,602	72,731	76,732	3,441
Other softwoods	188,662	95,551	60,789	18,743	12,186	--	--	1,393	--
Select white oak	2,008,787	--	335,750	313,292	295,017	242,949	174,655	465,279	181,845
Select red oak	3,982,754	--	812,597	797,549	647,755	553,658	373,319	643,190	154,686
Other red oak	611,870	--	171,601	142,733	102,954	68,320	57,102	64,699	4,461
Select hickory	186,894	--	53,288	46,255	37,933	27,386	6,932	15,100	--
Other hickory	168,567	--	47,167	32,548	24,019	23,187	13,706	18,617	9,323
Basswood	2,308,706	--	722,653	566,097	380,578	282,236	147,688	182,890	26,564
Beech	1,622,784	--	233,962	264,777	286,355	280,048	213,272	316,703	27,667
Yellow birch	1,440,776	--	236,222	278,831	318,954	208,277	136,976	233,737	27,779
Hard maple	8,802,032	--	2,006,393	1,796,152	1,565,688	1,288,615	843,341	1,155,375	146,468
Soft maple	6,231,091	--	1,588,621	1,305,886	942,175	837,471	487,280	834,901	234,757
Elm	547,998	--	147,455	153,629	96,461	68,243	39,395	36,746	6,069
Black ash	394,443	--	179,445	104,010	58,379	19,650	16,005	16,954	--
White & green ash	1,738,880	--	413,022	342,374	231,656	247,363	156,961	262,444	85,060
Sycamore	88,649	--	4,747	--	823	7,550	6,196	38,524	30,809
Cottonwood	275,809	--	35,396	26,143	38,076	45,891	13,072	74,340	42,891
Willow	150,054	--	14,730	25,730	19,720	15,071	8,047	43,245	23,511
Hackberry	3,105	--	1,497	--	1,608	--	--	--	--
Balsam poplar	892,249	--	210,213	204,238	159,807	113,765	73,174	115,691	15,361
Bigtooth aspen	2,274,109	--	896,070	703,834	350,337	176,089	87,670	60,109	--
Quaking aspen	3,546,503	--	1,413,446	980,695	567,244	330,497	139,054	112,144	3,423
Paper birch	1,086,807	--	548,118	280,517	139,367	76,594	24,995	17,216	--
River birch	727	--	--	727	--	--	--	--	--
Tupelo	8,567	--	2,043	3,803	--	--	--	2,721	--
Black cherry	952,540	--	292,898	242,687	185,301	102,069	49,137	71,197	9,251
Black walnut	122,972	--	19,778	29,482	26,320	19,348	8,334	19,710	--
Butternut	15,880	--	2,051	6,328	6,260	--	1,241	--	--
Yellow-poplar	84,956	--	3,374	13,812	10,573	12,386	6,286	38,525	--
Other hardwoods	65,396	--	30,067	13,041	11,279	5,348	--	5,661	--
Softwoods	21,387,475	6,218,176	4,154,136	3,005,690	2,284,982	1,814,345	1,317,066	2,238,992	354,088
Hardwoods	39,613,905	--	10,422,604	8,675,170	6,504,639	5,052,011	3,083,838	4,845,718	1,029,925
All species	61,001,380	6,218,176	14,576,740	11,680,860	8,789,621	6,866,356	4,400,904	7,084,710	1,384,013

Table 8.—Net volume of sawtimber on timberland by species group and diameter class, Minnesota, 1992.

	TOTAL	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
				(Thousand board feet)					
Jack pine	1,706,422	700,534	498,063	310,311	124,150	48,149	14,213	11,002	--
Red pine	2,444,196	405,092	390,400	404,170	386,557	339,850	254,728	262,760	639
White pine	1,297,353	85,668	112,024	134,422	126,281	140,122	155,026	417,611	126,199
Ponderosa pine	123	123	--	--	--	--	--	--	--
White spruce	1,152,492	241,082	256,462	194,920	169,617	129,802	87,629	72,980	--
Black spruce	709,531	486,858	149,462	36,103	20,777	5,716	3,521	6,519	575
Balsam fir	1,859,325	995,007	547,062	202,290	75,588	22,558	9,642	7,178	--
Tamarack	835,291	433,159	221,822	105,424	49,096	9,401	11,262	5,127	--
Eastern red cedar	29,531	9,890	11,319	3,173	2,247	1,673	--	1,229	--
Northern white-cedar	2,193,168	807,416	543,805	385,882	222,725	112,388	65,654	54,877	421
Other softwoods	8,017	3,118	1,386	2,256	1,257	--	--	--	--
Select white oak	1,823,232	--	394,016	366,059	331,155	260904	165,201	268,452	37,445
Select red oak	2,638,203	--	557,097	530,963	481,821	374,606	257,739	380,599	55,378
Other red oak	123,676	--	19,791	19,038	23,126	12,894	15618	29,553	3,656
Select hickory	39,396	--	14,110	12,445	7,007	3,973	687	1,174	--
Other hickory	10,979	--	4,921	3,893	889	812	464	--	--
Basswood	1,822,677	--	469,477	425,607	316,877	246,773	143,270	197,675	22,998
Yellow birch	72,782	--	11,060	18,035	12,008	10,115	10,318	10,834	412
Hard maple	804,576	--	216,336	175,979	158,295	112,696	63,687	71,716	5,867
Soft maple	503,438	--	115,015	88,508	60,995	48,034	43,255	86,885	60,746
Elm	638,865	--	153,134	108,673	105,299	74,404	62,426	105,650	29,279
Black ash	968,817	--	435,586	275,472	138,541	67,382	29,079	22,757	--
White & green ash	485,139	--	127,394	115,861	85,349	53,780	43,227	43,769	15,759
Cottonwood	235,374	--	10,308	9,868	16,501	15,739	22,277	67,273	93,408
Willow	95,126	--	18,090	18,330	16,519	16,796	7,881	13,450	4,060
Hackberry	23,940	--	4,051	5,802	3,476	5,159	2,392	2,238	822
Balsam poplar	1,157,379	--	459,496	323,874	190,173	107,125	40,352	34,797	1,562
Bigtooth aspen	752,257	--	301,943	221,893	130,761	64,831	21,628	10,537	664
Quaking aspen	8,652,491	--	3,451,525	2,587,974	1,507,686	650,253	264,486	187,091	3,476
Paper birch	1,626,662	--	847,796	443,866	189,306	91,673	25,221	26,249	2,551
Black cherry	26,808	--	10,044	7,751	4,331	3,769	913	--	--
Black walnut	46,779	--	8,847	10,530	12,028	8,897	2,551	3,926	--
Butternut	33,340	--	9,733	6,475	6,397	4,722	3,730	2,283	--
Other hardwoods	89,096	--	25,538	25,070	18,466	10,706	5,794	2,981	541
Softwoods	12,235,449	4,167,947	2,731,805	1,778,951	1,178,295	809,659	601,675	839,283	127,834
Hardwoods	22,671,032	--	7,665,308	5,801,966	3,817,006	2,246,043	1,232,196	1,569,889	338,624
All species	34,906,481	4,167,947	10,397,113	7,580,917	4,995,301	3,055,702	1,833,871	2,409,172	466,458

Table 9.—Net volume of sawtimber on timberland by species group and diameter class, Wisconsin, 1992.

	TOTAL	9.0-10.9	11.0-12.9	13.0-14.9	15.0-15.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
				(Thousand board feet)					
Jack pine	1,231,904	652,165	415,824	128,051	28,481	3,721	3,662	--	--
Red pine	2,931,045	1,017,266	671,231	377,506	251,755	261,208	188,727	163,352	--
White pine	3,434,465	266,094	290,808	366,489	378,522	467,025	405,772	971,361	288,394
White spruce	976,062	295,563	227,698	157,171	127,410	78,376	45,771	42,201	1,872
Black spruce	136,532	83,776	36,576	6,898	3,027	6,255	--	--	--
Balsam fir	1,398,960	690,905	401,358	173,095	65,702	61,847	3,801	2,252	--
Hemlock	2,081,265	163,328	228,503	251,540	279,100	305,857	274,195	492,421	86,321
Tamarack	321,077	123,244	104,684	51,956	19,806	10,451	4,313	6,623	--
Eastern red cedar	8,972	2,763	1,766	--	4,443	--	--	--	--
Northern white-cedar	1,537,565	641,010	438,020	240,777	127,352	62,250	15,862	12,294	--
Other softwoods	20,872	6,310	6,969	5,170	--	2,423	--	--	--
Select white oak	2,825,071	--	437,006	461,439	478,276	359,907	258,244	589,663	240,536
Select red oak	5,220,563	--	967,176	928,459	807,012	689,991	492,676	1,091,017	244,232
Other red oak	1,788,523	--	415,034	378,855	359,108	210,691	151,364	249,029	24,442
Select hickory	302,644	--	91,936	86,667	54,122	39,676	17,066	13,177	--
Other hickory	82,482	--	38,172	19,223	15,531	3,087	4,651	1,818	--
Basswood	2,666,106	--	840,411	627,046	419,768	265,339	153,349	299,474	60,719
Beech	136,712	--	20,197	18,969	17,575	23,675	19,742	33,647	2,907
Yellow birch	590,079	--	155,201	116,223	91,566	100,609	50,322	68,858	7,300
Hard maple	4,446,993	--	939,151	833,602	716,373	598,731	424,176	802,769	132,191
Soft maple	2,514,285	--	719,714	546,159	387,019	261,032	200,261	307,855	92,245
Elm	1,132,566	--	256,544	242,423	202,736	176,378	98,584	122,718	33,183
Black ash	662,153	--	291,094	186,257	90,039	53,894	17,668	23,201	--
White & green ash	1,102,223	--	314,632	248,331	171,585	145,903	89,894	105,093	26,785
Cottonwood	131,423	--	9,194	12,088	12,367	7,226	13,691	22,350	54,507
Willow	105,257	--	10,205	20,167	13,127	18,172	15,457	24,958	3,171
Hackberry	7,253	--	1,119	--	4,467	--	--	1,667	--
Balsam poplar	133,013	--	26,602	36,831	32,286	13,232	2,938	19,909	1,215
Bigtooth aspen	1,916,925	--	708,949	627,062	311,938	178,742	68,210	20,486	1,538
Quaking aspen	3,425,205	--	1,596,256	971,670	518,970	226,883	77,764	32,159	1,503
Paper birch	1,135,077	--	644,557	311,438	118,306	44,118	10,950	5,708	--
River birch	26,673	--	4,617	8,625	4,482	1,665	1,568	5,716	--
Black cherry	398,067	--	148,960	87,822	98,882	23,616	21,803	16,984	--
Black walnut	106,420	--	28,968	27,413	13,922	11,149	17,304	7,664	--
Butternut	153,502	--	31,812	45,161	26,585	34,353	8,448	5,460	1,683
Other hardwoods	41,601	--	16,163	13,236	4,134	1,512	4,449	2,107	--
Softwoods	14,078,719	3,942,424	2,823,437	1,758,653	1,285,598	1,259,413	942,103	1,690,504	376,587
Hardwoods	31,050,816	--	8,713,670	6,855,166	4,970,176	3,489,581	2,220,579	3,873,487	928,157
All Species	45,129,535	3,942,424	11,537,107	8,613,819	6,255,774	4,748,994	3,162,682	5,563,991	1,304,744

Table 10.--Timber production per acre estimators, by ownership class, Lake States, 1992

Performance estimator	Growing Stock Softwood	Growing Stock Hardwood	Growing Stock Total	Sawtimber Softwood	Sawtimber Hardwood	Sawtimber Total
	(Cubic feet)			(Cubic feet)		
Volume per acre						
National Forest	526	688	1,214	1,576	1,479	3,056
Other Public	386	673	1,059	1,046	1,374	2,420
Forest Industry	448	845	1,293	1,501	2,145	3,645
Farm & Other Private	268	934	1,202	797	2,364	3,161
All ownerships	345	829	1,173	1,011	1,980	2,991
Growth per acre						
National Forest	14.3	17.4	31.7	59.5	56.9	116.4
Other Public	10.5	18.5	29	39.8	59.4	99.1
Forest Industry	11.4	21.8	33.2	43.6	67.4	111
Farm & Other Private	8.3	25	33.4	32.9	79.8	112.7
All ownerships	9.9	22.1	32	38.7	70.7	109.4
Removals per acre						
National Forest	6.8	15.4	22.2	21.1	47.6	68.7
Other Public	3.8	10.3	14.1	11.9	31.9	43.7
Forest Industry	7.4	20.5	28	23.1	63.7	86.8
Farm & Other Private	2.3	12.8	15.1	6.9	39.7	46.6
All ownerships	3.7	13.1	16.7	11.2	40.5	51.7

Table 11.--Timber production ratio estimators, by ownership class, Lake States, 1992

Performance estimator	Growing Stock Softwood	Growing Stock Hardwood	Growing Stock Total	Sawtimber Softwood	Sawtimber Hardwood	Sawtimber Total
	(Percent)			(Percent)		
Growth as a percent of volume						
National Forest	2.72	2.53	2.61	3.77	3.85	3.81
Other Public	2.71	2.75	2.74	3.8	4.32	4.1
Forest Industry	2.54	2.58	2.56	2.9	3.14	3.05
Farm & Other Private	3.11	2.68	2.78	4.13	3.37	3.57
All ownerships	2.86	2.67	2.73	3.83	3.57	3.66
Removals as a percent of volume						
National Forest	1.29	2.24	1.83	1.34	3.22	2.25
Other Public	0.99	1.53	1.33	1.14	2.32	1.81
Forest Industry	1.66	2.43	2.16	1.54	2.97	2.38
Farm & Other Private	0.86	1.37	1.26	0.87	1.68	1.47
All ownerships	1.06	1.58	1.43	1.11	2.05	1.73
Removals as a percent of growth						
National Forest	47.36	88.24	69.81	35.42	83.65	59.01
Other Public	36.5	55.49	48.63	29.85	53.69	44.13
Forest Industry	65.38	94.28	84.36	53.01	94.38	78.14
Farm & Other Private	27.6	51.18	45.29	20.97	49.77	41.36
All ownerships	37.06	59.03	52.26	28.96	57.33	47.29

Table 12.--Percent of volume, growth and removals of growing stock and sawtimber, Lake States, 1992.

Characteristics	Growing Stock Softwood	Growing Stock Hardwood	Growing Stock Total	Sawtimber Softwood	Sawtimber Hardwood	Sawtimber Total
		(Percent)			(Percent)	
Volume						
National Forest	18	10	12	18	9	12
Other Public	30	22	24	28	18	22
Forest Industry	11	8	9	12	9	10
Farm & Other Private	42	60	55	42	64	57
All ownerships	100	100	100	100	100	100
Growth						
National Forest	17	9	11	18	9	12
Other Public	28	22	24	27	22	24
Forest Industry	10	8	9	9	8	8
Farm & Other Private	45	60	56	46	60	55
All ownerships	100	100	100	100	100	100
Removals						
National Forest	22	14	15	22	14	15
Other Public	28	21	22	28	21	23
Forest Industry	17	13	14	17	13	14
Farm & Other Private	34	52	48	33	52	48
All ownerships	100	100	100	100	100	100

Resource Availability From Nonindustrial Private Forest Land in the Lake States

Neal P. Kingsley[1]

INTRODUCTION

An estimated 733 thousand people own forest land in the Lake States (Jakes 1980, Raile 1983, Spencer 1988), but do not own or operate wood using plants. These nonindustrial private forest (NIPF) landowners include farmers, housewives, executives, and others from many walks of life imaginable. NIPF owners also include groups such as clubs and associations, undivided estates, and corporations not engaged in the manufacture of forest products. This diverse collection of owners holds 50% of the region's nearly 46 million acres of timberland (Jakes 1980, Kaiser 1982, Sedjo 1978) and nearly 5% of the region's growing stock, but these private forests are inherently more productive than public lands. Publicly owned lands in the Lake States are typically the less productive areas that were usually acquired by tax forfeiture. Nonindustrial private lands already contribute a larger proportion of timber than public lands do, as evidenced by the ratio of annual growth to annual removals (Jakes 1980, Raile 1983, Spencer 1988). On NIPF land, annual removals account for approximately 58% of net annual growth, while on national forest and state lands annual removals are 32 and 34% of net annual growth, respectively. About 42% of the public land in the Lake States is capable of producing less than 50 cubic feet per year (Jakes 1980, Raile 1983, Spencer 1988). In Minnesota, nearly half the public land is in this low productivity class (Jakes 1980).

Pressure is increasing on public land to supply more of the intangible benefits such as recreation, wildlife habitat and scenery at the expense of commodity production. In the future this land, federal and perhaps state as well, may not be able to contribute the same share of the timber supply as it has in the past. So we will be forced to look more and more at the private sector as the major timber supplier in the Lake States. However, although nonindustrial private forests already contribute more than their share to timber removals, they are the least likely of all owner categories to be actively managed. Much of the harvesting on these lands is simply a case of cutting timber when its mature with no thought given to regenerating the stand. As a result no attempt is being made to realize more of the land's potential to produce timber. Also, many of the NIPF lands are too small for active management or for harvesting. Therefore, the impact of harvesting on larger tracts of nonindustrial private forest land is greater than would be indicated by the overall ratio of growth to removals.

Thus, nonindustrial private forests pose two critical questions for the future development of the forest resources of the Lake States: (Binkley 1981) How much timber and other resources can we reasonably expect from NIPF land? and (Birch 1978) How can NIPF owners be encouraged to produce more of all resources?

OWNERS IN THE LAKE STATES

To answer these questions, we first need to take a close look at the NIPF lands in the Lake States at who owns them and why.

NIPF lands are more heavily concentrated in Wisconsin and Michigan than in Minnesota, which has a significantly higher proportion of state and county lands than most states (Jakes 1980). Wisconsin and Michigan account for 82% of the NIPF owners and 78% of the acreage (Raile 1983, Sedjo 1978). NIPF lands tend to be concentrated in the less heavily forested portions of the region. For example, only 18% of the timber in heavily forested northeastern Minnesota (aspen-birch survey unit) is on NIPF land, but 96% of the timber in predominantly agricultural southwest Wisconsin is held by NIPF owners (Jakes 1980, Spencer 1988).

The high number of nonindustrial private forest owners may appear almost staggering, but we need to put it in perspective. In the Lake States, 83% of the owners hold tracts of 50 acres or less, but they account for only 35% of the acreage (Carpenter 1985, Carpenter *et al.* 1986, Kingsley 1976). Conversely, the remaining 17%—121 thousand owners—control 65% of the acreage in NIPF land. In Michigan, 16,700 nonindustrial owners who hold 100 acres or more own about the same aggregate acreage as in the State Forest system. These owners make up only 4% of Michigan's nonindustrial private owners.

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[1]The author is Program Manager, Forest Inventory Analysis, USDA Forest Service, North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, MN 55108-6148. This regional assessment is a project of the Lake States Forestry Alliance, a joint endeavour initiated by the Governors of Minnesota, Wisconsin, and Michigan to deveolp and promote forest resource management and use in the Lake States.

Who owns nonindustrial private forest land? Typically, NIPF owners are older than the general population; about 2 in 3 are more than 65 years old; and about 1 in 4 is retired. As a result, more than 60% of nonindustrial private owners have low cash incomes. About 1 in 5 nonindustrial owners is a business person or an executive. Many people think of NIPF owners as farmers, but farmers actually account only 5% of NIPF owners in Michigan and 16% of NIPF owners in Minnesota (Carpenter 1985). In numbers farmers do not constitute a major share of the owners, but they typically hold larger parcels than the average owner—48 acres versus 31 acres (Carpenter 1985, Carpenter *et al.* 1986, Raile 1983, Spencer 1988). Although most owners are not farmers, more than half spent their early lives in a rural area or on a farm (Carpenter 1985, Carpenter *et al.* 1986, Roberts 1986).

How long have they owned the land? About one-third of the nonindustrial private owners in the Lake States have held their land for fewer than 10 years (Carpenter 1985, Carpenter *et al.* 1986, Roberts 1986). In Wisconsin, only 2% have owned forest land for more than 50 years (Roberts 1986).

Why do these people own forest land? Only 3% of NIPF owners said they own forest land for timber production (Carpenter 1985, Carpenter *et al.* 1986, Roberts 1986). By far the most common reason given for owning timberland was for enjoying the amenities it provides. Owners of 38% of the region's NIPF land said they owned timberland for amenity reasons, such as the scenery, wildlife habitat, or simply because the timberland is part of the farm for residence. Recreation was the second most important reason for holding forest land; timber cutting for personal use and investment reasons were well down the list.

Holding timberland for nontimber-related reasons does not necessarily mean an owner will not harvest timber. In fact, owners of 56% of the region's NIPF land have harvested timber from their land (Carpenter 1985, Carpenter *et al.* 1986, Roberts 1986). However, there is little to indicate that much of this harvesting was motivated by a desire to manage the forest. Seventeen percent of the owners who harvested said they did so because the timber was mature. They hold 3.1 million acres. Another 12% said they harvested because they needed money. These owners hold 1.7 million acres. However, 15% of the harvesting owners said they did so as part of a Timber Stand Improvement (TSI) project. These owners hold 1.9 million acres. This TSI participation is somewhat higher than has been found in other sections of the country, and may reflect the heightened interest in forestry in the Lake States.

Not harvesting in the past does not mean an owner won't harvest in the future. Forty-five percent of those owners who had not harvested said they did not have enough timber for a harvest (Carpenter 1985, Carpenter *et al.* 1986, Roberts 1986). These owners hold 27%—1.8 million acres—of the land held by owners who have not harvested. This category includes those owners who said their timber was not mature, of poor quality, not enough volume, or too small an area to harvest. The owners of only 446 thousand acres—3%—said that either there was no market for timber in their area or that the price offered was too low. Only 1% of those who have not harvested said they had not because they distrusted loggers. These owners hold only 4%—259 thousand acres—of the land held by nonharvesters.

The second most common reason given for not harvesting was that it would be detrimental to the esthetics of the area or the amenity enjoyment of the owners. These owners hold slightly more than 2 million acres. This category includes those owners who said harvesting would ruin the scenery, destroy the area for hunting, create a fire hazard, or that they were philosophically opposed to harvesting. The owners of an additional 1.4 million acres said they had not harvested because they planned to sell the land, pass it on to their heirs, or the land was tied up in an undivided estate.

It is clear, then, that many owners do not have firmly fixed plans to harvest or not to harvest timber. Recanvassing Delaware owners, Turner *et al.* (1977) found that 35% gave a different response to the question "Do you intend to harvest timber from your land in the future?" than they had only 4 years earlier. Of the 41% who said they planned to harvest, 18% said they no longer did 4 years later. Of the 58% who said they did not intend to harvest, 12% had changed their minds and 5% already had harvested. If intention changes that much in only 4 years, it seems clear that nonindustrial private owners are far from set in their ways. In addition, it appears that the proportion of owners who will or will not harvest timber may remain reasonably constant, but the individuals who make up this segment of the population are constantly changing.

Thus, the conclusion reached by Stone in 1969 appears to still hold true (Stone 1969). He said: "Many owners have nontimber producing objectives most of the time, but during the short period when their timber is merchantable, they are timber value oriented; thus, small (sic) forest owners as a group will tend to dispose of merchantable timber in a regular and largely predictable manner, but due to minimal investments in timber stand improvement, at a rate well below the potential of the sites."

The question then is, how much timber can we expect the nonindustrial private owners of the Lake States to supply? What then if this is not enough in view of projected demands and reductions in production from other sources? How can we increase output from nonindustrial private owners? And, what about the availability of other commodity and noncommodity resources from these lands?

TIMBER PRODUCTION FROM NONINDUSTRIAL PRIVATE FOREST LAND

According to the most recent forest inventories of the Lake States, nearly two-thirds of the region's timber products output comes from NIPFs (Jakes 1980, Raile 1983, Spencer 1988). The ratio of annual growth to removals from NIPFs is 1.6 to 1, compared to a ratio of 1.9 to 1 for all timberland in the region. Clearly, nonindustrial private owners will cut timber when it is mature and when they see a profit in it, but do not actively manage their land or seek professional assistance (Birch 1978; Carpenter 1985; Carpenter *et al.* 1986; Kingsley 1976, 1977; Roberts 1986; Stone 1969).

Sedjo and Ostermeier list seven factors that lead to low levels of investment in timber production by NIPF owners (Sedjo 1978): multiple goals and finite resources, lack of information and education, taxes, low profits, illiquidity and long payback period, diseconomies of scale, and environmental constraints. Each of these can significantly deter nonindustrial private owners from practicing active forest management.

Like most people, forest landowners have multiple financial goals but limited resources with which to achieve them. Conventional economic wisdom tells us that a scarce resource (in this case capital) will first be allocated to the investment that pays the highest return in the shortest time with the least risk. Investments in silvicultural treatments do not fit these criteria, and landowners send their dollars in a different direction.

Lacking information and education, many owners do not manage their lands because they do not understand the ecological consequences. Others do not know where or how to obtain information. Many programs intended to assist forest landowners have been channeled through extension programs directed at farmers. But, most of today's nonindustrial private owners are not farmers and are, therefore, often "out of the extension loop." Often, when owners do seek assistance, they may become discouraged by the alphabet soup of agencies and programs (Brock 1985). Without adequate knowledge of markets and price information, owners may be deterred from harvesting, harvest prematurely, or sell well below market price. One-stop assistance for landowners can overcome many of these difficulties; so can efforts to reach out to owners who hold properties that provide particularly good opportunities for active resource management. Such activities were the core of the "Cadillac Pilot Project" in a portion of the Lower Peninsula of Michigan (West 1990). This project had two objectives. One was to greatly tighten the working arrangements among organizations, both public and private, that provide various aspects of technical assistance and financial incentives for NIPF owners. The other was to identify owners with particularly promising resource management opportunities and then contact them with offers of assistance. The project worked quite well, leading its coordinator to informally say, "...this is the way we should have been doing it all along."

Taxes act as a disincentive to land ownership in general. In the case of forest land, taxes can encourage premature or crisis harvesting, or discourage investment in artificial regeneration.

Profits from investments in timber management are usually low. Very few forest investments are capable of returning as much as 6%. Coupled with the low rate of return on forestry investments is the illiquidity and long payback period. Having money committed for long periods before a return is realized, and having it frozen in an investment that does not promise a higher rate of return significantly constrain investments in management.

Owners with relatively small holdings face significant diseconomies of scale. These owners usually cannot bargain for a better stumpage rate, and often must accept or reject the offered price. Those who hold larger parcels of land may be able to encourage outside investment and bargain for a better stumpage price. One possible solution is joint marketing. In other parts of the world where small private holdings are the rule, such as Scandinavia and eastern Canada, owners have banded together in joint ventures to produce and sell timber. Although this has not caught on in this country, it may provide a realistic approach in some areas. The forest improvement district formed several years ago in several counties of the western Upper Peninsula of Michigan is, however, an example of a joint marketing and management venture in the U.S. (Irland 1991).

Environmental constraints may prohibit the use of less capital-intensive methods of carrying out forest practices. Owners may not be able to salvage dead or damaged trees, and they may not have ready access to professional services like the large owner.

One of the major impediments to sustained management of NIPFs is the length of owner tenure. An individual tract may pass through three or four owners in a single rotation (Casey 1984), and new owners seldom have the

same objectives as previous ones. Assistance agencies have often helped owners with tree planting, TSI, and similar activities, only to have the land change hands in a few years and become the property of someone who grazes livestock on it or subdivides it for a housing development. Each transfer of ownership retards forest management to some degree. In some cases, the delays may be short, until new owners get their feet on the ground. In other cases, all active management may cease throughout the new owners' tenure.

However, it has been observed that the longer an owner holds forest land, the more knowledgeable in forestry matters the owner becomes. Studies have shown that more and more private forest owners are transplanted urbanites. Because of this, they are often outside the network of forestry information and delivery systems, which are usually tied in with the agricultural and rural information and service delivery systems. Thus, it is not surprising that in such urbanizing states as those of southern New England, 63% of owners did not know where to obtain assistance (Kingsley 1976). However, the longer an owner holds the land, the more opportunities that owner has to become familiar with the local mores and the availability of community services, including forestry assistance. The longer people are in the community, the more influence their neighbors will have on their attitudes toward their property. Forest landowners who are established in the community generally become more conservation minded, in part because they do not want to risk offending their neighbors. Seeking out professional assistance to carry out forest management practices is one result.

ENCOURAGING ACTIVE MANAGEMENT ON NIPF LAND

The average net annual growth of growing stock on NIPF lands in the Lake States is 34 cubic feet per acre per year (Jakes 1980, Raile 1983, Spencer 1988)—about 50% of what could be attained from fully stocked natural stands, and far below what could be achieved with intensive management. But, nonindustrial private owners seldom hold forest land for timber production, or consider forest management a good investment. How can we encourage them to manage their land in such a way as to provide a sustained or increasing flow of timber? How, then, can we encourage active management on these lands?

To encourage management, foresters must serve the needs and objectives of nonindustrial private owners. For example, almost 60% of NIPF owners in the Lake States hold land for amenity values or recreation. Foresters need to demonstrate to these owners that management can improve the aesthetic, recreational, and wildlife values of the land.

In most communities, certain people are known as innovators and are looked up to by the rest of the community. The same is true of the forest landowner community. By seeking these people out and promoting management on their lands, it is often possible to encourage others to follow suit.

Extension and forestry promotion programs need to be restructured to reach the white-collar urbanite and ex-urbanite. A high profile clearinghouse is needed for forestry information, one that does not make the owners wade through the alphabet soup. Efforts should be focused on the larger owners in regions with stable timber markets; these owners are the most likely candidates for active management. In the Lake States, 17% of the private owners hold 65% of the land.

Tax policies that treat forestry fairly and realistically should be promoted. Such policies include favorable income tax treatment for planting expenses, to encourage regeneration. Estate taxes that do not promote premature harvesting or land fragmentation should be encouraged. We need ways to encourage holding forest land in the same family. Also, forest lands should be assessed on current use rather than "highest and best" (read: dollar value) use. Landowners need to learn that they can defray the impact of taxes and ensure that their children will inherit the property without major encumbrances.

CONCLUSIONS

Two central conclusions from this analysis can be stated simply as:

- A high proportion of mature timber grown on nonindustrial private forest land does reach the market. Having merchantable timber and being offered reasonable prices are the keys to landowner willingness to harvest.

- Easily accessible and coordinated technical assistance as well as financial incentives are essential if a majority of nonindustrial private forest owners are to practice effective resource management.

Each of these conclusions is in harmony with studies by well-recognized authorities in other parts of the country. The first conclusion is supported by the work of Clark S. Binkley, Dean of the Faculty of Forestry at the University of British Columbia. Working at Yale University several years ago, Binkley carried out an econometric analysis of the behavior of nonindustrial private owners. His analysis showed the way in which higher timber prices cause nonindustrial private forest owners to make timber available to the market (Binkley 1981). In essence he constructed supply curves relating price and amount of timber made available for owners of several

different situations. The second central conclusion is supported by the work of Kaiser and Royer (Kaiser 1982), who compared the actual behavior of owners of recently harvested land in several southeastern states. In counties where landowner assistance and incentives were readily available, five of every six landowners invested in regeneration. In those counties where assistance and incentives were not readily available, only one in six invested in regeneration. Studies of NIPF owners, in other parts of the country suggest that these findings can be readily transferred to other regions, kinds of owners, forest types, and specific management practices, including those in the Lake States.

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A Regional Comparison of Public Forest Resources Management Programs in the United States

Donald G. MacKay and Paul V. Ellefson[1]

INTRODUCTION

This report compares forestry programs in the Lake States to forestry programs in other regions of the United States. It summarizes information on a regional basis and examines the status of forestry programs in 1993, although data from 1991 and 1992 also are discussed. Each region represents a distinct and identifiable section of the country. The regions were: (1) Atlantic Coast, (2) California, (3) Intermountain, (4) Lake States, (5) Midsouth, (6) Northeast and (7) Pacific Northwest.

Each region was compared and described using broad measures of regional and program characteristics. Regional characteristics discussed include landownership patterns, timberland acreage, and the amount land reserved from timber harvesting. Funding for forestry programs in each region was examined at the federal, state, and county levels. Programs directed at private forestland owners were a main focus of the report, however expenditures for the management of federal, state, and county administered lands also were addressed. Finally, the type and effectiveness of forestry programs directed at private forestland owners was discussed in the context of the seven regions.

INFORMATION SOURCES

This report relied heavily on information from published documents. One source, a master's thesis, was unpublished. Some of the information sources contained overlapping data. For instance, data on expenditures for cost share programs are reported twice in this report: once in the section on federal expenditures and again in the section on state expenditures. There was insufficient information in these cases to separate federal and state expenditures.

The major types of data and their sources were:

- Information on timberland acreage and ownership in the United States from a USDA Forest Service report (Powell *et al.* 1993).
- Information on three federal programs directed at private forestland owners (the Agricultural Conservation Program, the Forestry Incentives Program, and the Stewardship Incentive Program) from two reports published by the USDA Agricultural Stabilization and Conservation Service (USDA Agricultural Stabilization and Conservation Service 1994a and 1994b) and one by the USDA Forest Service (USDA Forest Service 1994a).
- Data on expenses related to wood production on national forest lands from the national summary of national forest timber sale revenues and expenses published by the USDA Forest Service (USDA Forest Service 1994).
- Data on expenditures by state forestry agencies from the National Association of State Foresters (NASF 1994). Another report was useful for gathering data on expenditures by county forestry agencies (MacKay *et al.* 1993).
- Information on the types of state government programs directed at private landowners in each state (and their effectiveness) from two reports written at the University of Minnesota (Cheng 1993, Ellefson *et al.* 1993).

REGIONS

The authors aggregated states with similar characteristics into seven regions. These regions were: (1) Atlantic Coast, (2) California, (3) Intermountain, (4) Lake States, (5) Midsouth, (6) Northeast, and (7) Pacific Northwest.

Table 1 shows the states making up each region.

[1] The authors are Research Associate and Professor of Forest Economics and Policy, respectively, Department of Forest Resources, University of Minnesota, St. Paul, MN.

Table 1—*States within each region*

Region	States
Atlantic Coast	Georgia, North Carolina, and South Carolina
California	California
Intermountain	Idaho and Montana
Lake States	Michigan, Minnesota, and Wisconsin
Midsouth	Alabama, Louisiana, and Mississippi
Northeast	Maine, New Hampshire, New York, and Vermont
Pacific Northwest	Oregon and Washington

Location was an important factor used to aggregate states into regions. Regions consisting of spatially contiguous states were preferred. However, several regions were contiguous, which made it difficult to distinguish a dividing line between some regions. Contiguous regions existed in the West and the Southeast. The Atlantic Coast and Midsouth regions were adjacent and the Pacific Northwest region touched both the Intermountain region and California. These adjacent regions were treated separately to distinguish differences between each region and to achieve a rough balance in the relative size of the timberland acreage in each region.

Three criteria determined which states to include within each region. The first criterion was the grouping of states into subregions used by the 1992 RPA Assessment Update. The RPA Assessment Update divided the United States into nine subregions (Powell 1993, p. 3). The second criterion was the total acreage of timberland in each region. A level of balance was desired in the acreage of timberland between regions[2]. The final criterion was the level of removals[3] for all species in 1991 for each state. In each of the seven regions, except for the Northeast, only the states with the highest levels of removals for all species were selected to be included in a region (Powell *et al.* 1993). The authors used the amount of removals as a proxy for the level of harvesting and forest management activity in a state. The Northeast region was exempted from the third criterion because New Hampshire and Vermont would have been excluded and a contiguous block of states was preferred for that region of the country.

ALLOCATION OF TIMBERLAND

The total acreage of land and timberland in each region varied substantially (Table 2). Also, some regions had a large land area, but only a moderate amount of timberland. For instance, the Intermountain region had the largest land area, yet only 21% of this land was timberland. The area with the largest area of timberland was the Atlantic Coast, which contained nearly 55 million

Table 2.—*Land, timberland, and productive reserved land in seven regions of the United States, 1992*

(In thousand of acres)

Region	Total land area	Timberland	Productive reserved
Atlantic Coast	87,519	54,520	1,089
California	99,823	16,200	2,584
Intermountain	146,117	30,337	5,140
Lake States	122,074	47,136	1,968
Midsouth	90,387	52,787	51
Northeast	61,636	41,920	2,958
Pacific Northwest	104,054	37,852	3,962
Total	711,610	280,752	17,752

Source: Powell *et al.* 1993, p. 22-23.

[2] California was treated separately despite its relatively small timberland acreage because it had unique programs directed at private forest landowners.

[3] Removals are losses from timber inventories that occur by causes other than natural mortality.

acres of timberland. The average amount of timberland in the seven regions in 1992 was 40,107,000 acres. The Lake States, which contained 47,136,000 acres of timberland, exceeded the average acreage of timberland. The area with the largest percentage of timberland to total land area was the Northeast.

Using the USDA Forest Service (Forest Service) classification of lands, it was possible to examine how timberland was partitioned in terms of possible uses. For instance, the Forest Service classifies some timberland as productive reserved. Productive reserved lands are lands classified as timberland except they are withdrawn from timber utilization by statute or administrative regulation (Powell *et al.* 1993, p. 120). Nearly 2 million acres, or more than 4% of timberland in the Lake States, were productive reserved lands in 1992 (Table 2). The Lakes States were fourth in terms of percentage of productive reserved lands. The western regions had by far the highest percentage of productive reserved timberland. Productive reserved timberland accounted for 17% and 16% of the timberland in the Intermountain and California regions, respectively. The southeastern regions of the country (Midsouth and Atlantic Coast) had the lowest percentage of productive reserved timberland. The Midsouth region had only 51,000 acres in the productive reserved category, representing less than one-tenth of one percent of the total timberland acreage in the Midsouth region.

Another important difference in the allocation of timberland within each region was the pattern of timberland ownership (Table 3). There was substantial variation in the ownership of timberland by region. Some regions, particularly the Intermountain and Pacific Northwest regions, had a large amount of land in federal ownership. Federal ownership accounted for approximately two-thirds of the timberland in the Intermountain region (19.4 million acres), compared to only 0.9 million acres in the Northeast region. In the Northeast, 94% of the timberland was owned by forest industry or other non-industrial private forest (NIPF) owners. Two important differences between the Lake States and other regions were the comparatively large amounts of timberland in state and county and municipal ownerships. The Lake States had 7,229,000 acres of timberland in state ownership and 4,899,000 acres in county and municipal ownership (Table 3). This represented 49% of the timberland in state ownership and 78% of the timberland in county and municipal ownership in all seven regions. While the Lake States had a large amount of timberland in state and county ownership, a relatively low percentage of its' timberland was owned by forest industry. Forest industry owned 8% of the timberland in the Lake States, the lowest of all the regions. The Lake States had the median ownership of federal and NIPF timberland, with 5,886,000 and 25,212,000 acres, respectively.

REGIONAL PUBLIC EXPENDITURES FOR FOREST RESOURCE MANAGEMENT

Public expenditures to support forestry activities vary by region of the country. Expenditures vary due to many factors, but were largely a result of the patterns of land ownership in each region. The amount of federal, state, and private land strongly influenced the type and level of expenditure. Data was available on expenditures by the Forest Service, state governments, and county governments. Much of the data focuses on expenditures related to timber production.

Federal Programs

Two types of federal forestry expenditures were examined: (1) federal expenditures in the form of cost share programs directed at private forest landowners (includes some state expenditures) and (2) expenditures related to timber sales on Forest Service lands.

Table 3.—*Timberland ownership (in thousands of acres) by region, 1992*

Regions	Federal	State	County and municipal	Industry	NIPF	All ownerships
Atlantic Coast	3,804	765	199	9,868	39,883	54,519
California	8,679	95	12	3,280	4,134	16,200
Intermountain	19,440	1,682	14	2,857	6,346	30,339
Lake States	5,886	7,229	4,899	3,911	25,212	47,137
Midsouth	3,159	771	418	11,999	36,441	52,788
Northeast	922	1,364	416	10,120	29,100	41,922
Pacific Northwest	17,160	2,822	308	9,034	8,526	37,850
Total	59,050	14,728	6,266	51,069	149,642	280,755

Cost Share Programs Directed at Private Forest Landowners

Three programs directed at private forestland owners in 1993 were: (1) the Agricultural Conservation Program (ACP), (2) the Forestry Incentives Program (FIP), and (3) the Stewardship Incentives Program (SIP). All three programs provided cost share assistance to private landowners, a portion of which may have been paid by state governments. Payments cited in this report were the totals of federal and state payments under these programs. Each of the three programs provided cost sharing for different activities:

1. ACP provided financial assistance to agricultural producers. Among the activities funded was the conservation of forest and wildlife resources. ACP funded three categories of practices directly related to forestry: (1) forest tree plantations, (2) forest tree stand improvement, and (3) site preparation for natural regeneration (USDA Agricultural Stabilization and Conservation Service 1994a).

2. FIP provided financial assistance to private forestland owners for tree planting and timber stand improvement (USDA Agricultural Stabilization and Conservation Service 1994b).

3. SIP was designed to enhance the management of nonindustrial private forestlands through financial assistance in the form of cost sharing. Practices funded included the development of forest stewardship plans, reforestation and afforestation, forest improvement, agroforestry projects, soil and water protection and improvement, riparian and wetland protection and improvement, fisheries habitat enhancement, wildlife habitat enhancement, and forest recreation enhancement (USDA Forest Service 1994a).

The total amount of financial assistance provided by each program varied by region (Table 4). For instance, under ACP the Midsouth and Atlantic Coast regions received substantially more funding than the Intermountain region and California in federal FY1993[4]. The Lake States received the fourth highest level of funding ($1.4 million) under this program in federal FY1993. Under FIP, the Midsouth and Atlantic Coast regions also received the vast majority of funding in federal FY1993. Again, the Lake States received the fourth highest level of funding under this program in federal FY1993 ($323,999). While the regional patterns of financial assistance were similar under ACP and FIP, the region that received the highest level of financial assistance under SIP was the Northeast ($1.2 million) in federal FY1993. Under SIP, private landowners in the Lake States received $527,880 in federal FY1993. Under all three programs, private landowners in the Lake States received a total of $2.2 million in federal FY1993.

While total expenditure data provides some information about how the Lake States compare to other regions in terms of program expenditure, it is also useful to look at how program expenditures vary by the amount of NIPF timberland in each region. Table 5 shows total federal FY1993 expenditures for each region under the ACP, FIP, and SIP. This information was divided by the number of NIPF acres in each region to determine dollars expended per acre of NIPF timberland. The Pacific Northwest was the region with the highest level of expenditure per acre, followed by the Midsouth and the Atlantic Coast. The Lake States, with a total expenditure of $0.09 per acre in federal FY1993, was the median level of expenditure in terms of expenditures per acre. The region with the lowest level of expenditure per acre was the Intermountain region.

[4] The federal fiscal year 1993 included the period October 1, 1992 to September 30, 1993.

Table 4.—*Acres affected and level of financial assistance provided under three programs directed at private forestland owners, federal FY1993 (includes federal and state funds)*

Region	ACP acres	ACP dollars	FIP acres	FIP dollars	SIP dollars
Atlantic Coast	43,946	2,250,961	55,742	3,136,638	680,312
California	632	53,752	701	114,323	178,348
Intermountain	291	24,463	398	39,321	109,776
Lake States	18,015	1,361,018	4,424	323,999	527,880
Midsouth	43,339	2,338,958	52,979	3,046,694	1,131,220
Northeast	4,672	477,257	2,033	144,161	1,180,866
Pacific Northwest	21,587	1,755,542	7,173	804,053	725,569
Total	132,482	8,261,951	123,450	7,609,189	4,533,971

Table 5.—*Expenditures per acre of NIPF timberland under three programs, federal FY1993*

Region	Total expenditures ACP, FIP, and SIP	NIPF Timber-land acres	ACP, FIP, and SIP expenditures per Acre
	(In dollars)		(In dollars)
Atlantic Coast	$ 6,067,911	39,883,000	$ 0.152
California	$ 346,423	4,134,000	$ 0.084
Intermountain	$ 173,560	6,346,000	$ 0.027
Lake States	$ 2,212,897	25,212,000	$ 0.088
Midsouth	$ 6,516,872	36,441,000	$ 0.179
Northeast	$ 1,802,284	29,100,000	$ 0.062
Pacific Northwest	$ 3,285,164	8,526,000	$ 0.385
Total	$ 20,405,111	149,642,000	

National Forest Timber Expenses

The Forest Service administers national forests in each of the seven regions. The Forest Service expends funds to manage these lands and to supply timber. In Timber Sale Program Annual Report: National Summary Fiscal Year 1993 (USDA Forest Service 1994), the Forest Service summarized expenses related to wood production on national forest lands for each state. The expense information was generated using the Timber Sale Program Information and Reporting System (TSPIRS) and includes both indirect and direct expenses. The USDA Forest Service generated expense information related to wood production in three categories: (1) timber commodity, (2) forest stewardship, and (3) personal use. Expenses in the timber commodity category were expenses incurred related to the harvest of timber to supply raw material (wood) to meet the needs of society. Expenses in the forest stewardship category were incurred when timber was harvested as part of process to achieve desired ecological conditions and non-timber resource objectives. Expenses in the personal use category were expenses related to supplying firewood and Christmas trees to individuals for their personal use.

In federal FY1993, total expenses related to the three programs totaled $716,715,000. Timber commodity expenses were $525,996,000, forest stewardship expenses $144,523,000, and personal use expenses were $46,196,000. These totals include expenses incurred at the national forests, Forest Service regional offices, and in the Washington, DC office. Expense data also was available for each national forest in the seven regions. Data for expenses on national forest in each of the seven regions is reported in Table 6. The data in Table 6 does not include expenses incurred at Forest Service regional offices or in the Washington, DC office.

The majority of Forest Service expenses related to wood production were in the western United States. The Pacific Northwest region had by far the highest level of expenses ($235,305,000) for the three categories. The Intermountain and California regions had lower levels of expenses, but these were still substantially higher than expenses in the other regions. The higher levels of expenses in the western regions were in part related to the higher levels of revenues received by the Forest Service in those regions and larger total timber harvest levels. The Northeast region had the lowest low level of expenses related to wood production. Total expenses for the three categories in the Lake States were $19,272,000, ranking the Lake States region fourth in terms of expenses (Table 6).

While timber expenses most likely varied with timber volumes, insight into regional variations in Forest Service expenditures can be obtained through examining Forest Service expenses per acre of national forest timberland. As before, the Western regions had the highest levels of expenses in terms of expenses per acre of timberland (Table 7). However, when national forest timberland acreage was considered, other regions, such as the Midsouth, emerged as having relatively higher levels of expenses per acre of timberland. The Lake States has the lowest level of expenses per acre ($3.53).

Table 6.—*Reported expenses (in thousands) related to wood production on national forests by region, not including regional or headquarters expenses, federal FY1993*

(In thousand dollars)

Region	Timber commodity component	Forest stewardship component	Personal use component	Total
Atlantic Coast	$8,393	$3,261	$255	$11,909
California	$63,307	$18,877	$7,321	$89,505
Intermountain	$80,199	$10,304	$6,634	$97,137
Lake States	$13,456	$5,578	$238	$19,272
Midsouth	$14,235	$3,677	$104	$18,016
Northeast	$1,253	$1,604	$27	$2,884
Pacific Northwest	$179,299	$46,181	$9,825	$235,305

Table 7.—*Expenses per acre related to wood production on national forests by region, not including regional or headquarters expenses, federal FY1993*

Region	Total National Forest Expenses Related to wood production	Acres of National Forest timberland	Expenses per acre of timberland
Atlantic Coast	$11,909,000	2,411,000	$4.94
California	$89,505,000	8,370,000	$10.69
Intermountain	$97,137,000	18,005,000	$5.40
Lake States	$19,272,000	5,460,000	$3.53
Midsouth	$18,016,000	2,327,000	$7.74
Northeast	$2,884,000	794,000	$3.63
Pacific Northwest	$235,305,000	15,010,000	$15.68

State Government Programs

Each year the National Association of State Foresters (NASF) reports statistics on forestry activities in each state. The 1993 Report (NASF 1994) showed that in 1993, the state governments included in the seven regions spent more than $840 million on forestry-related activities (Table 8). A portion of this total were federal pass-through grants. Of the $840 million, approximately two-thirds of these expenditures were for fire management activities, the majority of which were in California. Excluding expenditures for fire management, the states in the seven regions spent $263 million on forestry activities. Table 8 shows the remaining forestry expenditures by the broad categories of nursery, other forestry, recreation, and state forests.

Nursery expenditures totaled $20.6 million in the seven regions in 1993 (Table 8). The Lake States region had the largest total nursery expenditure. The regions with the lowest level of nursery expenditures were the Intermountain and Northeast regions, with expenditures of $385,000 and $688,000, respectively.

The other forestry expenditure category reflects a variety of expenditures made by state forestry agencies that do not fit within the categories of fire management, nursery, recreation, or state forests. Instead, other forestry includes expenditures related to cooperative forestry, utilization and marketing, insects and disease, urban and community forestry, and other miscellaneous expenditures. Total state expenditures for other forestry activities were $148.3 million in the seven regions (Table 8). The region with the largest expenditure for other forestry activities was the Atlantic Coast ($34.7 million), followed by the Pacific Northwest ($30.3 million). The Lake States region had the fourth highest level of expenditure for other forestry activities ($22.7 million). The region with the lowest level of other forestry expenditures was the Intermountain Region ($2.3 million).

The regions with the two largest expenditures related to recreation were the Pacific Northwest ($3.8 million) and the Lake States ($3.4 million) (Table 8). It is important to note that in some states, such as in Montana in the Intermountain region, some expenditures for recreation

Table 8.—*State forestry expenditures (in thousands of dollars) by region, 1993*

	Fire management	Nursery	Other forestry[1]	Recreation	State Forests	Total expenditures
Atlantic Coast	50,537	4,956	34,721	528	1,614	92,356
California	381,188	1,077	27,107	320	2,200	411,892
Intermountain	11,369	385	2,340	0	8,595	22,689
Lake States	24,175	5,786	22,747	3,358	21,987	78,053
Midsouth	37,249	3,487	17,903	251	4,084	62,974
Northeast	12,881	688	13,209	1,378	3,761	31,917
Pacific Northwest	60,475	4,193	30,305	3,800	42,327	141,100
Total	577,874	20,572	148,332	9,635	84,568	840,981

[1] Includes all other state government forestry expenditures reported by the National Association of State Foresters.
Note: Table does not sum due to rounding.
Source: NASF 1994.

may be included in the total for state forests. Also, state agencies within some regions may have made recreation expenditures which were not included in the NASF report. Therefore, the estimate of recreation expenditures may reflect the minimum level of expenditure.

State forest expenditures were expenditures on forestry activities within state owned or managed forests. Differences in state forest expenditures vary by region from a low of $1.6 million in the Atlantic Coast to $42.3 million in the Pacific Northwest (Table 8). This difference was due in part to the enormous difference in timberland in state ownership in these two regions (Table 3). The Lake States region was the region with the second highest level of expenditure on state forest management (nearly $22.0 million) in 1993.

Intensity of State Forestry Program Expenditures

The intensity of state expenditures for forestry activities was assessed by examining the level of state expenditures per acre of timberland for each region. State expenditures are only known approximately. For instance, some of funds classified as state funds in the NASF were federal pass-through grants that appear as state expenditures. The intensity of expenditures was examined for two types of timberland: (1) state-owned timberland and (2) privately owned timberland, which consisted of industry and NIPF-owned timberland. Table 9 shows the level of state forest expenditure per acre of state-owned timberland and other forestry expenditures per acre of privately owned timberland. Expenditures for fire management, recreation, and nurseries were not included.

Table 9.—*Per acre expenditures (in dollars) by state forestry agencies by region, 1993*

Region	State forest expenditures per acre of state-owned timberland	Other forestry[1] expenditures per acre of private[2] timberland
Atlantic Coast	2.11	0.70
California	23.16	3.66
Intermountain	5.11	0.25
Lake States	3.04	0.78
Midsouth	5.30	0.37
Northeast	2.76	0.34
Pacific Northwest	15.00	1.73

[1] Expenditures for programs such as cooperative forestry, utilization and marketing, insects and disease, urban and community forestry and others.
[2] Includes both industry and NIPF timberland.

Table 9 shows that in each region, the level of funding per acre for state forests was higher than the level of funding for other forestry activities per acre of private timberland. The western regions had the highest levels of funding per acre for state forests. Funding for state forests was substantially higher in California and the Pacific Northwest, where expenditures per acre were $23.16 and $15.00 in 1993, respectively. One factor which may explain the comparatively large expenditure per acre in California was that the state owns a comparatively small timberland acreage (Table 3). The Midsouth had the third highest expenditure per acre, but this may have also been influenced by the small amount of timberland in state ownership in that region. The Lake States had the third lowest level of state forest expenditures per acre of state timberland. Other forestry expenditures followed a pattern similar to expenditures on state timberland, and California and the Pacific Northwest again had the highest level of expenditure per acre (Table 9). The Lake States had the third highest level of expenditure per acre of private lands for other forestry.

County Programs in Minnesota

Counties and municipalities in the seven regions administered 6.3 million acres of timberland in 1992 (Table 3). Seventy-eight percent of this timberland was in the Lake States (4.9 million acres). Of the 4.9 million acres, 2.5 million were administered by county land departments in Minnesota. In Minnesota, county land departments are the primary agency responsible for managing county owned timberland. These timberlands came into county ownership primarily due to tax forfeiture. The majority of Minnesota's county timberlands are used for timber production and to provide other products and amenities (MacKay *et al.* 1993).

Aggregated management expense data for the various management activities conducted by Minnesota county land departments was available for this study (MacKay *et al.* 1993). Management expense data were available from Aitkin, Beltrami, Cass, Clearwater, Crow Wing, Hubbard, Itasca, Lake, Pine, and St. Louis county land departments, for calendar year 1991. Together, these counties administered 2,026,000 acres of timberland. Table 10 presents aggregated management expenses incurred by the 10 county land departments. Because some counties estimated expenditures, these figures should be used as a guide, rather than as an exact representation of county land department expenditures.

The largest expense category reported in Table 10 is land department administration and personnel. This expense category includes the cost of record keeping, office personnel, administration, and labor costs for management activities ranging from preparing and administering timber sales and other activities. The second largest category is reforestation expenses. Spending for reforestation by the counties was down in 1991, and is likely to have declined further, due to reductions in state grants. The third largest category of expenditures for counties was road construction and maintenance. Average county land department expenditures (including those unrelated to timber production) per acre of timberland were $3.50 in 1991.

Table 10.—*Management expenses of county land departments in Minnesota, 1991*

Type of Expense	1991
Administration and Personnel	$4,920,835
Reforestation[1]	$787,733
Timber Stand Improvement	$19,669
Road Construction and Maintenance	$477,939
Inventory	$255,729
Land Survey and Remonumentation	$60,736
Miscellaneous[2]	$573,421
Total	$7,096,063

[1] Includes expenditures for site preparation, planting, seeding, and release.

[2] Includes expenditures for recreation, wildlife, and other expenses that were described as miscellaneous by respondents.

Source: MacKay *et al.* 1993.

REGIONAL DIFFERENCES IN PROGRAM TYPE AND EFFECTIVENESS

This report assesses regional differences in programs directed at private forest landowners. It draws heavily from Cheng (1993) and Ellefson *et al.* (1993). Cheng (1993) sent a questionnaire to each state forester or forestry program manager to determine the types of forestry programs in that state and the effectiveness of each program, as assessed by the respondent. The responses from each state were available for the regional analyses conducted in this report.

In order to simplify the wide variety of types of programs, the respondents were asked to determine whether their state had any programs directed at private forest landowners which fit within certain categories. The categories were developed by distinguishing programs by two main criteria: (1) method of application and (2) the resource attribute or activity the program was designed to

affect. First, the forestry programs were divided into five main categories which represent alternative methods of affecting management on private lands: education, technical assistance, tax incentives, fiscal incentives, and regulatory programs. Next, the different types of programs were categorized by the main types of resource attributes or activities they were designed to affect. Six categories were developed and they included: programs to protect water quality, programs to promote reforestation, programs to improve timber harvesting, programs to protect from wildfire, insects, and diseases, programs to enhance recreation qualities, and programs to protect wildlife and endangered species.

Education and Technical Assistance Programs for Private Forest Landowners

Technical assistance and education programs were by far the most common type of program directed at private forest landowners in 1992. Relatively few states lack these types of programs for forestry practices (Tables 11 and 12). A few generalizations can be made about regional differences in educational and technical assistance programs. For instance, the Pacific Northwest region had educational or training programs for each type of program objective. However, the programs were often rated as ineffective or very ineffective. For most of the other regions, there were a variety of effectiveness ratings given. In the Lake States, a review of responses suggests that educational programs designed to protect wildlife and endangered species and to enhance recreation qualities were particularly effective.

Tax and Fiscal Incentives Programs for Private Forest Landowners

Tax and fiscal incentive programs were far less common than technical assistance or education programs in 1992. For instance, several regions of the country did not have any tax incentive programs aimed at private forest landowners (Table 13). The Atlantic Coast, California, and the Midsouth do not have any tax incentive programs directed at private forest landowners, while other regions such as the Intermountain and Pacific Northwest have only a few. The Lake States had the most tax incentive programs directed at private landowners. However, several of the programs in Wisconsin were rated as ineffective. The Lake States had more tax incentive programs to promote reforestation. All the states in the Lake States region had a tax incentive program designed to promote reforestation and two out of the three states rated their programs as effective or very effective. There were fewer clear trends in terms of the types of fiscal incentives directed at private landowners (Table 14). However, a few points are worth noting. First, the Lake States was the only region in which each state had a fiscal incentive program directed at protecting water quality, although only two of the states rated their programs as effective. Only one region, the Northeast, had a fiscal incentive program directed at improving timber harvesting.

Regulatory Programs Directed at Private Forest Landowners

While assistance and incentive programs are an important component in the retention and management of forest resources, regulatory programs also play an important role. As with other types of programs, these programs vary by region (Table 15). One clear distinction is that the Lake States had fewer regulatory programs directed at private forestland owners than some other regions. The western regions (in this case California, the Intermountain, and the Pacific Northwest) had the highest number of regulatory programs and these programs were generally rated effective by respondents. However, regulatory programs in the West to enhance recreation qualities were all rated as very ineffective.

Regulatory programs aimed at protecting water quality also varied by region. The Lake States had relatively few regulatory programs to protect water quality, compared to other regions. However, the three states in the Midsouth region all rated the regulatory program to protect water quality as very ineffective. Responses in the Northeast about the effectiveness of programs to protect water quality were mixed. The western regions generally had regulatory programs designed to protect water quality that the respondents judged to be very effective.

Table 11.—*Rating[1] of effectiveness of educational or training programs aimed at private forestland owners by region, 1992*

Region	Protect water quality	Promote reforest-ation	Improve timber harvesting	Protect from wildfire, insects, and disease	Enhance recreation qualities	Protect wildlife and endangered species
Atlantic Coast						
Georgia	1	1	1	1	1	1
North Carolina	4	4	4	1	4	4
South Carolina	6	6	6	6	6	6
California	2	3	3	3	5	4
Intermountain						
Idaho	5	5	5	4	1	1
Montana	2	NR[3]	3	3	2	2
Lake States						
Michigan	4	2	4	3	1	2
Minnesota	4	3	2	4	3	1
Wisconsin	3	4	3	1	1	1
Midsouth						
Alabama	2	2	2	1	2	2
Louisiana	3	4	2	2	3	3
Mississippi	N/A[2]	3	N/A	N/A	N/A	1
Northeast						
Maine	4	4	4	4	4	4
New Hampshire	1	1	1	1	1	1
New York	N/A	N/A	3	1	N/A	1
Vermont	2	2	2	2	1	1
Pacific Northwest						
Oregon	6	5	4	5	5	4
Washington	6	5	6	6	1	2

[1] Effectiveness assessed by respondent on a scale from 1 to 6, with 1 representing very effective and 6 representing very ineffective.

[2] N/A means that the state did not have this program.

[3] NR means that there was no response to the question.

Source: Cheng 1992, Tables 2 and 10a.

Table 12.—*Rating[1] of effectiveness of technical assistance programs aimed at private forestland owners by region, 1992*

Region	Protect water quality	Promote reforest-ation	Improve timber harvesting	Protect from wildfire, insects, and disease	Enhance recreation qualities	Protect wildlife and endangered species
Atlantic Coast						
Georgia	3	2	2	2	4	4
North Carolina	3	3	3	3	3	3
South Carolina	4	4	4	4	4	4
California	5	5	5	2	4	5
Intermountain						
Idaho	3	4	4	1	N/A	2
Montana	3	NR[3]	2	2	3	NR
Lake States						
Michigan	3	3	5	2	2	3
Minnesota	1	1	1	1	1	2
Wisconsin	1	3	1	2	2	3
Midsouth						
Alabama	1	1	1	3	1	1
Louisiana	2	3	3	4	2	2
Mississippi	N/A[2]	1	2	2	N/A	2
Northeast						
Maine	5	5	5	5	5	5
New Hampshire	4	4	3	4	4	3
New York	1	3	1	2	2	2
Vermont	1	1	1	1	2	2
Pacific Northwest						
Oregon	5	4	1	4	4	5
Washington	4	4	4	1	3	1

[1] Effectiveness assessed by respondent on a scale from 1 to 6, with 1 representing very effective and 6 representing very ineffective.

[2] N/A means that the state did not have this program.

[3] NR means that there was no response to the question.

Source: Cheng 1992, Tables 2 and 10a.

Table 13.—*Rating*[1] *of effectiveness of tax incentive programs aimed at private forestland owners by region, 1992*

Region	Protect water quality	Promote reforest-ation	Improve timber harvesting	Protect from wildfire, insects, and disease	Enhance recreation qualities	Protect wildlife and endangered species
Atlantic Coast						
Georgia	N/A[2]	N/A	N/A	N/A	N/A	N/A
North Carolina	N/A	N/A	N/A	N/A	N/A	N/A
South Carolina	N/A	N/A	N/A	N/A	N/A	N/A
California	N/A	N/A	N/A	N/A	N/A	N/A
Intermountain						
Idaho	N/A	3	N/A	N/A	N/A	N/A
Montana	N/A	N/A	N/A	N/A	N/A	N/A
Lake States						
Michigan	N/A	1	1	N/A	N/A	N/A
Minnesota	N/A	4	N/A	N/A	N/A	N/A
Wisconsin	4	2	5	5	5	N/A
Midsouth						
Alabama	N/A	N/A	N/A	N/A	N/A	N/A
Louisiana	N/A	N/A	N/A	N/A	N/A	N/A
Mississippi	N/A	N/A	N/A	N/A	N/A	N/A
Northeast						
Maine	N/A	N/A	N/A	N/A	N/A	N/A
New Hampshire	N/A	N/A	N/A	N/A	N/A	N/A
New York	6	N/A	N/A	N/A	N/A	N/A
Vermont	5	5	5	N/A	N/A	N/A
Pacific Northwest						
Oregon	N/A	N/A	N/A	N/A	N/A	N/A
Washington	N/A	3	N/A	N/A	4	N/A

[1] Effectiveness assessed by respondent on a scale from 1 to 6, with 1 representing very effective and 6 representing very ineffective.

[2] N/A means that the state does not have a program in this area.

Source: Cheng 1992, Tables 2 and 10a.

Table 14.—*Rating[1] of effectiveness of fiscal incentive programs aimed at private forestland owners by region, 1992*

Region	Protect water quality	Promote reforest-ation	Improve timber harvesting	Protect from wildfire, insects, and disease	Enhance recreation qualities	Protect wildlife and endangered species
Atlantic Coast						
Georgia	N/A[2]	N/A	N/A	N/A	N/A	N/A
North Carolina	N/A	1	N/A	N/A	1	N/A
South Carolina	N/A	3	N/A	N/A	N/A	N/A
California	N/A	N/A	N/A	N/A	N/A	N/A
Intermountain						
Idaho	2	2	N/A	3	N/A	6
Montana	N/A	NR	N/A	N/A	N/A	N/A
Lake States						
Michigan	2	5	N/A	N/A	N/A	5
Minnesota	2	2	N/A	3	2	4
Wisconsin	5	N/A	N/A	N/A	N/A	N/A
Midsouth						
Alabama	3	3	N/A	4	N/A	3
Louisiana	4	1	N/A	N/A	5	5
Mississippi	N/A	N/A	N/A	N/A	N/A	N/A
Northeast						
Maine	N/A	1	N/A	N/A	2	2
New Hampshire	N/A	N/A	N/A	N/A	N/A	N/A
New York	5	N/A	N/A	N/A	4	N/A
Vermont	4	4	4	N/A	4	N/A
Pacific Northwest						
Oregon	N/A	N/A	N/A	1	N/A	N/A
Washington	3	2	N/A	N/A	5	N/A

[1] Effectiveness assessed by respondent on a scale from 1 to 6, with 1 representing very effective and 6 representing very ineffective.

[2] N/A means that the state does not have a program in this area.

Source: Cheng 1992, Tables 2 and 10a.

Table 15.—*Rating[1] of effectiveness of state regulatory programs aimed at private forestland owners by region, 1992*

Region	Protect water quality	Promote reforest-ation	Improve timber harvesting	Protect from wildfire, insects, and disease	Enhance recreation qualities	Protect wildlife and endangered species
Atlantic Coast						
Georgia	2	N/A	N/A	N/A	N/A	2
North Carolina	1	N/A	2	2	N/A	N/A
South Carolina	N/A[2]	N/A	N/A	1	N/A	N/A
California	1	1	1	6	N/A	1
Intermountain						
Idaho	N/A	1	1	5	6	3
Montana	1	N/A	1	1	N/A	N/A
Lake States						
Michigan	1	N/A	N/A	1	N/A	1
Minnesota	N/A	N/A	N/A	N/A	N/A	3
Wisconsin	N/A	N/A	N/A	3	N/A	N/A
Midsouth						
Alabama	6	N/A	N/A	2	N/A	6
Louisiana	6	N/A	6	N/A	N/A	6
Mississippi	6	N/A	N/A	N/A	N/A	N/A
Northeast						
Maine	3	3	3	3	3	3
New Hampshire	2	N/A	N/A	2	N/A	N/A
New York	4	N/A	N/A	N/A	N/A	N/A
Vermont	3	N/A	3	N/A	N/A	3
Pacific Northwest						
Oregon	1	1	2	2	6	6
Washington	1	1	1	3	6	6

[1] Effectiveness assessed by respondent on a scale from 1 to 6, with 1 representing very effective and 6 representing very ineffective.

[2] N/A means that the state does not have a program in this area.

Source: Cheng 1992, Tables 2 and 10a.

CONCLUSIONS

This review of regional forestry program and expenditure differences suggests that the Lake States were average (or at least median) in many respects. This was in part due to timberland ownership patterns in the regions. The eastern and southern had a larger amount of timberland in private ownership, while the levels of public ownership were high in the western regions. This timberland land ownership pattern drove many of the program and expenditure patterns. Also, the far western regions generally had higher expenditures per acre for state and private timberlands, and the southern and eastern regions had lower expenditures. In a similar trend, the western regions tended to have more regulatory programs, compared to the eastern and southern United States. The Lake States generally fell between the extremes in these cases. Some specific examples of how the Lake States tended to be median are that the Lake States had:

- less public timberland ownership than the west but more than the east and south
- the median number of acres of timberland in federal ownership (5,886,000)
- a somewhat close to the median level of expenditures per acre on state forest lands
- close to the median level of expenditures directed at private forest landowners per acre of private timberland
- the median level of total forestry related ACP, FIP, and SIP expenditures per acre of NIPF timberland
- educational and technical assistance programs in similar number as the other regions and the programs were not rated much more effective than in other regions.

Some important regional differences were identified in this report. These included:

- state and county timberland ownership was substantially higher in the Lake States
- industry timberland ownership was relatively low in the Lake States
- Lake States national forests had the lowest total expenses per acre of national forest timberland
- the Lake States had more tax incentive programs than other regions, particularly in the area of promoting reforestation and to improve timber harvesting. Other regions had no programs of this type
- the Lake States had fewer regulatory programs than other regions, particularly the western states and perhaps the northeast. The regulatory programs in the Lake States were rated as relatively successful.

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Opportunities to Change Timber Demand in the Lake States Through Altered Timber Utilization

Kenneth Skog[1]

Abstract.—Improvements in timber utilization help meet the rising demand for wood and paper products by increasing the efficiency of harvesting, primary processing, and applications of wood and fiber products. Such improvements may also increase the demand for timber by reducing the cost of wood products relative to that of nonwood products or by developing new products or end uses. In general, changes in timber utilization increase the economic contribution of wood-using industries to an economy when the timber base is limited. The wide range of available technology changes will support the competitive position of the Lake States in current wood and paper product markets; some technologies support an increase in market share for particular products, and others will support a change in the composition of timber inputs for products.

Three types of improvements will be instrumental in causing notable change in the use of timber in the Lake States: the expanding oriented strandboard/waferboard industry, the increasing use of recycled paper in paper and paperboard production, and the increasing use of hardwoods relative to softwoods in paper and paperboard production.

INTRODUCTION

Technological innovations will help maintain or improve the competitiveness of wood sources and products in the Lake States by (1) increasing recovery and decreasing costs for making lumber, panels, and paper and paperboard, (2) developing processes/products that expand the use of underutilized species, mill residue, and residue on harvest sites, (3) decreasing the cost of harvesting, (4) increasing the efficiency of end-use of wood products, and (5) developing new or improved products and end uses that will expand markets for wood. This report identifies many of these technological developments for harvesting, processing composite and hardwood lumber and nonveneered structural panels, processing pulp and paper, using wood products in construction, manufacturing, and shipping, and using wood for energy.

HARVESTING

Timber harvest and transport technologies include machines and processes for which application varies widely by region, season, terrain, tree species, tree size, stand density, portion of stand removed, and distance to market. Timber harvesting involves a wide range of equipment tailored to the unique problems posed by each stand. The characteristics of the harvest system used are determined by the major product of each stand (pulpwood, saw logs, veneer logs, tree-length logs, whole trees, or chips), stand and species characteristics, expected weather conditions, and terrain (flat, mountainous, or swampy).

In general, for a given harvesting system, costs per unit volume are inversely related to the square of average tree diameter and inversely related to trees per acre. This is because stands are harvested one tree at a time and tree volumes increase with the square of diameter.

TECHNOLOGICAL DEVELOPMENTS

Future timber harvest equipment will closely resemble the equipment used today. Tomorrow's logging machines, regardless of improved efficiency, will still need to move over rough surfaces, sever and maneuver heavy trees or logs, and carry trees and logs considerable distances in all kinds of weather. Within these constraints, equipment and system designers seek to improve (1) load capacity, (2) travel and process speed, (3) reliability and longevity, (4) species and product versatility, (5) terrain capability, (6) operator comfort, and (7)

[1] The author is Project Leader, USDA Forest Service, Forest Products Laboratory, Madison, WI.

safety. Flexibility, rather than maximum efficiency for a specific stand, is often the more important goal in developing harvest machines and processes.

Table 1 describes specific changes now in development or contemplated for the felling-bunching, skidding–forwarding, processing, loading, and transporting functions. These changes are stimulated by the following problems that current systems do not adequately address:

1. Operation on steep terrain and sensitive soils
2. Operation in stands that contain significant portions of unmerchantable species or multiple products
3. Operation in low-density stands or stands with many small trees
4. Operation on small tracts required by regulations or caused by fragmented land ownership
5. Increasingly expensive road construction and long distance hauling
6. Need for better utilization of branches, tops, bark, and previously unmerchantable material

Table 1.—*Technology developments in timber harvesting*

Process	Description	Impact
Felling and bunching		
Lighter weight and/or lower ground pressure machines	For flat terrain, feller bunchers either smaller, mounted on lighter chassis, or equipped with larger tires, high speed tracks, or air cushions.	Less soil erosion or compaction; maintains productivity, enables harvests on previously "unsuitable" land; requires fewer roads.
Walking or self-leveling feller bunchers or felling directors	Feller bunchers able to negotiate >50% slopes; in larger diameter western stands, more portable machines that direct felling with hydraulic jacks.	Less soil erosion or compaction; maintains productivity, enables harvests on previously "unsuitable" land; requires fewer roads.
Multistem carriers attached to feller bunchers	For smaller diameter stands and plantations, able to accumulate several stems before dropping.	Economical thinning of plantations and pole timber.
Saw felling heads	In lieu of shears, saw heads eliminate butt splitting.	Improved lumber and veneer recovery from butt log.
Skidding and yarding		
Lighter weight and/or lower ground pressure machines	Skidders and forwarders, either smaller or mounted on lighter chassis, or equipped with larger tires, high speed tracks, or air cushions.	Less soil erosion or soil compaction; maintains productivity or enables harvests on previously "unsuitable" land; requires fewer roads.
Processing		
Mechanized delimbers	Hardwood sawlogs are expensive and dangerous to delimb. Improves softwood log form; delimbing is less problematic.	Reduces labor requirements, improves production and safety.
Debarkers	Remove bark on landing before chipping or hauling.	Reduces hauling cost, increases utilization if clean chips can be produced, leaves more nutrients on site.
Smaller, lighter chippers and/or chunkers	Offers opportunity to recover vast amounts of wood previously wasted. Chunks are very large chips that require less energy to produce than other wood pieces.	Improves utilization, extends timber supply, removes unwanted stocking that hinders regeneration.
Merchandisers	Combined chipping/chunking and roundwood processor in forests that produce and direct species and tree components to highest value use.	Maximizes return to landowners, extending area of "suitable" lands.

Table 1.—*Technology developments in timber harvesting—continued*

Process	Description	Impact
Transportation		
Log weight estimation	Knowledge of log weights allows operator to increase average load size without overloading.	Reduces overload fines and equipment breakage; improves safety.
Automatic truck weighing	Sensors installed on each truck report actual weight.	Reduces overload fines and equipment breakage; improves safety.
Central tire inflation	Compressor and piping on truck could inflate or deflate tires. Dirt roads last longer when tires have low pressure but highways require high pressure for high speeds.	Extends forest road life.
General developments		
Lightweight machine construction	Metal alloys, ceramics, and plastic composites for chassis, engine and components that alter machine design, construction, and performance.	Lower fuel cost, more power available for useful work; machines can range farther, reducing road requirements; less soil compaction and/or erosion.
Improved fuel economy	New engine designs such as fuel-efficient two-cycle engines, air-cooled diesels, gas turbines, and fluidics decrease fuel consumption and the way power is transmitted for traction or processing.	Lower fuel cost, more power available for useful work.
Improved engine, chassis, suspension, and maintenance	Computer monitoring of machine loading and maintenance needs will increase machine life.	Lower fixed machine costs per unit volume; lifetime maintenance costs may exceed purchase price.
Ergonomic design (human factor engineering)	Designing machines and controls to suit human tolerances is a largely untouched but crucial area in harvest equipment design.	Increased production and reduced accidents; decreased cost for workman's compensation insurance.
Computer-aided systems analysis and operation	On-board computer as well as off-machine systems analysis and operations research techniques can make market-sensitive real-time decisions and train employees.	Increased productivity, reduced wood losses or grade reduction, more rapid training.

Other pressures for change include the need to conserve energy and labor and to protect the long-term productivity of forest lands. There are major opportunities to reduce costs in ground skidding, cable yarding, and log transportation. These functions are the most capital- and energy-intensive and the most dangerous. Lighter weight machines and engines, improved tires and suspension systems, along with much improved fuel efficiency, will reduce costs significantly. As a result of these changes, longer economical skidding or yarding distances will reduce the need for expensive roads.

PROJECTED MIX OF HARVESTING SYSTEMS

Substantial shifts in system mix are expected in various regions. On the flat terrain in the East, both in the North and South, loggers will increasingly rely on mechanized feller-bunching and grapple-skidding to centralize landings for processing and loading. Chainsaw felling is generally being replaced by feller-bunchers in pulpwood operations but will continue to be widely used on sawlog and veneer operations to protect valuable butt logs. Grapple skidders are expected to replace most cable

skidders by the year 2040 for safety reasons. Grapple skidders will increase their share of production from 43% to 63% in the South and 5% to 24% in the North. In the North, forwarders are expected to expand from about 26% to 41% by 2040, and whole tree chipping is expected to increase from 9% to 21%.

The East has considerable "mountainous" terrain. About 55%, 6%, 13%, and 11% of the Northeast, North Central, Southeast, and South Central regions, respectively, are considered mountainous. While these regions are not as rugged as the Rockies or Pacific Coast, the proximity of a large concerned population, very erodible soils, and generally less productive sites heighten the need for cost-effective and environmentally sound harvesting equipment and methods. To date, several small-scale cable-yarding systems adapted from European and West Coast systems have been applied with some success. Cable systems could increase the harvest from mountainous terrain from 10% to 40% between 1985 and 2040. Generally, harvesting systems are expected to shift from less to more efficient and from more to less labor-intensive.

COMPOSITE LUMBER PROCESSING

Several new lumber-type products can further increase wood recovery in the manufacture of lumber-type products: laminated veneer lumber, composite lumber, composite wood I-beams, and hardwood structural lumber made by the Saw–Dry–Rip (SDR) process (Table 2). Laminated veneer lumber has gained acceptance for applications that require uniform strength, greater depth and long-span support. Composite wood I-beams with laminated flanges (top and bottom edges) and plywood or flakeboard webs (centers) have also gained acceptance for applications requiring long-span support. Composite lumber for construction has been produced in the form of Com-ply (lumber with a core made from hardwood and softwood flakes and edges made from veneer), but the prospects for its wide use are not clear.

Although there has been little commercial application, structural lumber may be made from medium-density hardwoods, such as yellow poplar and cottonwood, using SDR (Allison *et al.* 1987, Maeglin 1985, Maeglin *et al.* 1981). The SDR process reduces the tendency of these species to warp as a result of growth stresses, and it can also be used to reduce warping in lumber made from logs with a high proportion of juvenile wood.

Table 2.—*Technological developments in hardwood structural lumber and composite lumber processing*

Product type and development[a]	Description	Impact
Hardwood lumber—structural		
Saw–dry–rip (SDR) processing	SDR-sequence for processing warp-prone medium-density hardwoods sharply increases yield of STUD-grade structural hardwood lumber.	Production of structural lumber from plentiful medium-density hardwoods.
Composite lumber		
Laminated veneer lumber (LVL)	Wide dimension lumber made from laminated sheets of veneer efficiently uses smaller diameter logs to replace long, larger structural lumber (2 by 8, 10, 12) made from larger diameter logs.	High recovery from smaller logs to make wide dimension structural lumber
Parallel strand lumber	Long strands of veneer residue are used to make wide, long structural lumber.	Recovery of veneer residue to make structural lumber.
Com-ply lumber	Com-ply lumber is formed of a flakeboard center with several laminations of veneer at the edges. Both hardwood and softwood may be used with high recovery from smaller logs to make structural lumber for housing.	High recovery and combined use of smaller diameter softwoods and hardwood for lumber.

[a]The effects of potential expanded use of these processes is not included in the technology projection model or the timber supply/demand projections.

HARDWOOD LUMBER PROCESSING

Hardwood lumber is remanufactured into furniture, cabinet work, and pallets, or is used directly for flooring, paneling, molding, and millwork. It is mainly graded and sold as factory lumber or processed into dimension parts and finished products. Factory lumber comes in random widths and is graded by the number and size of clear cuttings that may be obtained. This lumber is intended to be cut into smaller pieces (dimension parts) that will be used to make furniture or other fabricated products. Pallet parts are cut from green lumber or cants. Dimension parts are normally kiln dried with specific thicknesses, lengths, and widths.

In general, the production of hardwood lumber is less automated and less sophisticated than that of softwood lumber. A majority of hardwood mills have wide-kerf circular headrigs instead of narrow-kerf band headrigs, and the production capacities are much smaller than those of softwood mills. Sophisticated log scanning, computer-assisted log processing, and computer-controlled edging and trimming are technologies developed for softwood sawmills and are seldom used in the hardwood industry. In general, this technology is too expensive for most options or does not apply to the production of hardwood lumber. Most hardwood logs are processed to obtain the highest appearance-grade lumber possible. Processing for higher grade lumber usually stops when low-grade faces appear on the remaining center cants. Cants are subsequently processed for lower grade lumber or pallet parts at the same mill or at a pallet plant.

The drying of hardwood lumber is more critical than that of softwood for two reasons. First, hardwood lumber must be dried to 6%-8% moisture content for furniture; most softwood lumber used in construction is dried to 15% moisture content. Second, hardwood lumber must be dried more slowly to avoid drying degrade such as splits, checks, warp, staining, and internal honeycombing, which reduce the value and usefulness of the lumber.

After drying, hardwood lumber is converted into cuttings for furniture, cabinets, moldings, flooring, stair treads and risers, and other product parts in processing facilities called rough mills. The lumber is planed, crosscut and ripped, or ripped and crosscut into parts or cuttings. Many cuttings are edge glued, planed, and then re-ripped into parts. In some systems, finger jointing is used to make long parts from short cuttings. In the future, more rough-mill-type processing may be tied directly to sawmill and drying operations. For secondary quality lumber, production of green dimension cuttings may be followed by drying. With this system, the waste lumber that is discarded when lumber is cut into dimension parts would not have to be dried. This system would increase the capacity of existing kilns to produce dry dimension parts.

The main pressures to improve or change hardwood lumber processing stem from the need to manufacture enough better grade material for important export and domestic markets. Processors need to improve yields, but they must improve quality and contain costs to maintain markets and reduce the potential competition from other wood or nonwood products. Modernization with computer-aided manufacturing and computer-controlled processing is the key. However, as stated before, this equipment will be used to increase the recovery of higher grade material and will not necessarily cause major increases in overall yields or reductions in wood consumption.

Technology improvements such as computerized log-shape scanning and computerized sawing decisions are available and are being adopted by some large mills. These systems provide better sawing consistency, closer tolerances, and therefore smaller lumber target sizes, greater lumber yields, and more higher-grade lumber from lower quality logs.

A hardwood computer-aided edging system has been developed to properly edge random-width hardwood lumber, and a more sophisticated system is being investigated that would provide the operator with information on how to obtain the highest grade after edging. Similar systems for hardwood trimming should be available in the future. These systems will be designed to increase grade output.

A system under development that will incorporate many technologies described here as well as additional technologies is the Automated Lumber Processing System (ALPS). ALPS will include new techniques for log processing, detection of board defects, and optimum board cutting to maximize the yield of clear wood parts for furniture manufacture. In an ALPS sawmill, logs are scanned internally to locate the position of defects. Computers use this information to determine and control log breakdown and thus maximize grade or value yield of boards. After the boards are dried and superficially surfaced, video image analysis is used to locate and classify defects. Computers use this information on defects to determine and control board cutting to yield the maximum number of clear parts for a given cutting. The boards are cut by computer-controlled conventional methods or high-powered lasers. ALPS will increase the recovery of high-grade material (McMillin *et al.* 1984).

NONVENEERED STRUCTURAL PANEL PROCESSING

Nonveneered panels consist of wood wafers or strands smaller than veneer sheets but larger than wood fiber. Unlike the material for conventional particleboards, the raw material for structural products usually comes directly from roundwood sources rather than mill byproducts; exterior-type rather than interior-type adhesives are used; and particles are usually aligned in several discrete layers rather than laid down at random.

TECHNOLOGICAL DEVELOPMENTS

Technological developments in processing oriented strandboard (OSB) and waferboard are likely to focus on two areas: increasing the range of applications and decreasing wood loss during flaking, forming, and trimming processes. Technologies that will contribute to these changes are described in Table 3.

Oriented strandboard and waferboard have been used as sheathing in walls and roofs and for floor underlayment; technology has recently been developed for using these nonveneered panels as concrete forms and siding. Suitable performance is being achieved by using phenolic paper overlays to stabilize the surface and provide a suitable basis for paint or concrete forming. To improve panel stability, the trend has been to displace phenolic adhesives with isocyanate adhesives, either totally or in part. While more costly than phenolics on a unit for unit basis, isocyanate adhesives are more profitable for a given level of panel stability than are phenolic adhesives because they allow shorter press times and more moisture in the furnish.

Likely to be adopted in the future are better flaker designs to reduce the generation of fines (pieces of wood too small to be used) and better forming techniques to increase wood utilization. Disc flakers are generally used in mills. These machines usually require logs to be reduced to 4-ft (1.2-m) bolts for processing. The flakers generate from 8%-10% fines and about 4% kerf losses from primary and secondary slasher saws. To reduce these losses, whole log flaking that utilizes ring and disk waferizers is likely to be adopted (Pallmann GMBH 1987). This machinery will also generate 8%-10% fines, but slasher kerf losses will be lower (about 2%).

Panel strength increases with greater uniformity of particle alignment (Fyie *et al.* 1980). Electrostatic orienters achieve higher orientation ratios than do mechanical orienters. Electrostatic orientation can produce strong panels using smaller particles than those used for mechanically oriented panels. However, since the effectiveness of electrostatic orientation decreases with large particles, electrostatic orienters will likely complement mechanical formers rather than displace them (Buecking *et al.* 1980).

PROJECTED RECOVERY AND COSTS

The recovery of wood for nonveneered structural panel wood is estimated to average between 55% and 60% (based on losses of 4% for trimming log ends and log rejects, 8%–12% for fines, 35%–38% for panel densification, and 3% for panel trim).

Improved glue blenders have reduced manufacturing costs for OSB and waferboard during the past 5 years. Volumes of liquid phenolic resins have declined from >5% to <4%. Powdered resin volumes have also been reduced (3% to 2%). Further potential for savings in this area is limited, so the projections of processing costs for waferboard show more modest declines than those for plywood. The adoption of modern technology by mills is expected to account for the bulk of the projected 4% reduction in processing costs between 1986 and 2040.

Table 3.—*Technological developments in nonveneered structural panel processing*

Product type and development	Description	Impact
Isocyanate binders	Replace phenolic resins for gluing panels.	Reduced energy requirements; shorter press time increases output on thicker panels.
Long log flaker	Produces flakes from long logs.	Reduced random generation of fines and saw kerf.
Continuous press	Allows uninterrupted mat flow	Reduced trim loss.

FOREST SERVICE PROJECTIONS OF OSB/WAFERBOARD PRODUCTION

Technology for OSB/waferboard is projected to substantially expand its market share in the manufacture of U.S. structural panels (Figure 1) (Haynes, personal communication). In 1986, 3.4 billion ft^2, 3/8-inch (306 million m^2, 10-mm) OSB/waferboard was produced, or 14% of all structural panels (OSB plus softwood plywood). By 2010, OSB/waferboard production is projected to expand to 11.0 billion ft^2 (990 million m^2), or 36% of structural panels. Production of OSB/waferboard in the North Central states is projected to increase from 1.6 billion ft^2 (144 million m^2) in 1986 to 3.7 billion ft^2 (333 million m^2), or about 3.5% per year. Production will increase even faster in other U.S. regions—from 1.8 billion ft^2 (162 million m^2) in 1986 to 7.3 billion ft^2 (657 million m^2) in 2010 or 6.1% per year. As a result, North Central market share will decrease from 48% in 1986 to 34% in 2010.

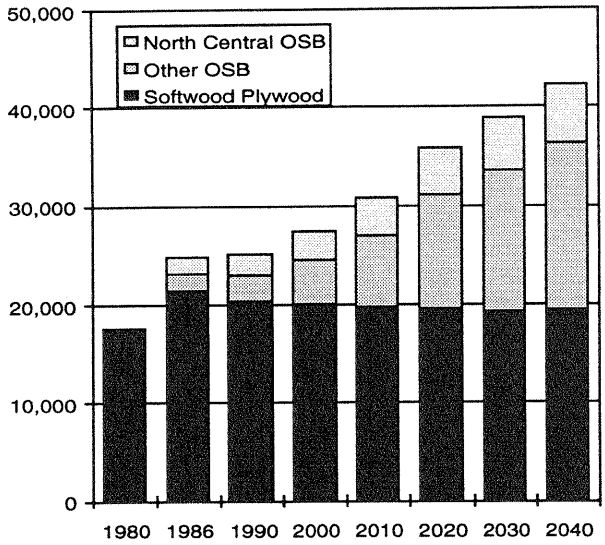

Figure 1.—*U.S. OSB/waferboard and softwood plywood production in million square feet, 3/8 inch basis. Source: USDA-Forest Service*

PROCESSING OF PULP, PAPER, PAPERBOARD, AND RELATED PRODUCTS

Paper and board products are made primarily from new or recycled wood fiber. New wood fiber is in the form of wood pulp, which is made from pulpwood. Recycled wood fiber is derived from wastepaper, which consists of old newspapers, old corrugated containers, mixed grades, pulp substitutes, and high grade deinking. Different mixes of wood pulps, wastepaper, and other fiber are used for different paper and board products. The mix, or fiber furnish, reflects the requirements for a particular product grade, the level of technology, and the availability of fibers.

Paper and board products are classified into paper and paperboard grades. The major paper grades include tissue (sanitary products, napkins, toweling), printing and writing (bond paper, computer paper, copying paper, paper for books and magazines), packaging and industrial (wrapping paper, bags, sacks), and newsprint. The major paperboard grades include unbleached kraft (linerboard for corrugated boxes), semichemical (corrugating medium for boxes), solid bleached (folding boxes, food containers), and recycled (variety of products, including gypsum wallboard facing).

TECHNOLOGICAL DEVELOPMENTS

Technological developments in the U.S. paper and board industry focus on the ability to improve production efficiency and product quality while mitigating or eliminating negative impacts on the environment. Some technical challenges facing the industry include the need to reduce energy costs, reduce capital equipment costs, improve strength and quality of recycled fiber, increase fiber recovery, develop processes that can use more hardwood fiber, develop processes that are more environmentally benign, and provide better quality paper products for present and future uses. Many current and likely technological developments address these challenges. Various developments in paper and board processing and their likely impact on wood requirements are described in Table 4.

PAPER AND BOARD MANUFACTURING PROCESSES

Technological developments result in new, more cost-effective processes that use more wastepaper and mechanical pulps and have lower nonfiber manufacturing costs. For example, four processes are currently used to make newsprint:

Newsprint process	Furnish
1, 2	mostly mechanical pulp with smaller fractions of chemical pulps
3	only wastepaper; lower nonfiber manufacturing cost than processes 1 and 2
4	equal amounts of mechanical pulp and wastepaper

Table 4.—*Technological developments in pulp and paper processing*

Type of development	Description	Impact
Meeting needs for improved stacking strength in corrugated boxes	Edgewise compressive strength eventually the principal criterion.	Compressive strength is improved with higher density linerboard, increased use of higher-yield pulps and more hardwood; improved quality control in kraft linerboard.
Meeting increasing demands for quality and uniformity in printing and writing papers with improved papermaking technology	Increased use of higher quality fillers, drainage and retention additives, coating pigments, and hardwood fiber; more machine finishing and alkaline papermaking.	Less total wood fiber use per ton of product; lower basis weight with more uniform quality; more hardwood.
Meeting demand for printability and quality in linerboard with improved forming and finishing technology	Development of multi-ply forming; improved stock preparation systems; use of hardwood fiber for printability on surface, or sandwiching hardwood or recycled fiber in core for economy.	Higher proportions of hardwood fiber and recycled fiber in unbleached kraft paperboard; separate pulping and refining for hardwoods and softwoods.
Gradual replacement of traditional groundwood pulp by modern mechanical pulps in newsprint and other groundwood papers	Thermomechanical (TMP), chemithermomechanical (CTMP), and pressurized groundwood (PGW) replace some older groundwood and refiner processes, with improvement in pulp quality.	Wider market potential for higher yield mechanical pulp; greater ability to substitute for lower yield chemical pulp.
Improvement in pulp bleaching systems to reduce capital costs and operating costs and to meet environmental objectives	Adoption of short-sequence bleaching systems, chlorine dioxide in bleaching, and lower yield in bleached kraft pulping; development of peroxide and other bleaching technologies for TMP and CTMP; use of higher yield bleached mechanical pulps.	Greater use of bleached mechanical pulps will reduce wood input requirements although lower yield kraft pulping will increase wood requirements.
Modenization of equipment and processes in older mills to improve efficiency and reduce costs	More tree-length wood handling and chip thickness screening; improvements in stock preparation, paper machine systems, and kraft chemical recovery; energy savings through use of variable-speed drives, high-efficiency motors, and upgraded turbine generators; use of more wood or bark for fuel.	Lower wood requirements as a result of gains in wood utilization efficiency, especially in older bleached kraft and sulfite mills; offset somewhat by more use of wood for fuel
Better recycled fiber recovery, improved contaminant removal technology for wastepaper furnish, and increased use of recycled fiber; technological responses to increased supply of recyclable paper	Improved centrifugal cleaners, slotted screens, deinking systems, and high-consistency refining; technology for removing contaminants such as "stickies;" chemical treatment to restore some bonding strength to recycled fibers.	Modest growth in recycled paperboard production, but substantial growth in use of recycled fiber in traditionally virgin fiber grades, such as kraft linerboard, semichemical corrugating medium, newsprint, and tissue.
Displacement of chemical pulp fractions by modern high-yield mechanical pulp in newsprint and tissue and to some extent in printing and writing paper, reducing capital requirements and wood costs	TMP and CTMP with higher percentages of hardwood fiber will replace some chemical pulp fractions in newsprint and tissue, providing better opacity and bulk; substitution in printing and writing limited by color reversion and brightness.	Higher yield and cost savings; increased use of hardwoods with CTMP

Table 4.—*Technological developments in pulp and paper processing—continued*

Type of development	Description	Impact
Continued adoption of improved pressing technology in papermaking, reducing sheet drying costs, increasing throughput, and improving product quality	Wide-nip and high-impulse press sections will continue to be installed in linerboard mills and will be installed in mills producing other grades.	Increased ability to use hardwood and recycled fiber in kraft linerboard; higher production rates; energy, and capital cost savings.
Commercial adoption of impulse drying, press drying, or related improvements in pressing and drying technology	Interfiber bonding and substantial strength improvements with higher yield pulps, especially with hardwoods, result from drying under pressure or simultaneous pressing and drying.	Substantial savings in capital, energy, and wood requirements; increased use of higher yield pulp and more hardwood in grades like kraft linerboard.
Further development of nonwoven products and improvements in sanitary products based on fluff pulp	Innovation in sanitary products and new durable nonwoven products; use of new specialty market pulps; some displacement of wood pulp by "superabsorbent" additives.	More efficient use of wood fiber per unit in sanitary and nonwoven products; more use of bleached CTMP.
Development of laminated paper and packaging products	Development of laminated or co-extruded packaging structures based on paper or paperboard with plastic or metal foil surfaces.	Expanded product market potential but lower wood use for current paper and board packaging.
Continued displacement of some fiber products by plastics and other substitutes	Continued innovation and substitution of plastics in packaging, especially food packaging, bag and grocery sacks, and shipping containers; use of synthetic polymers to reinforce paper and paperboard.	Decline in long-term rate of growth in demand for packaging grades relative to GNP and population growth.
Substitution of paper by electronic means of communication and information storage	Gradual long-term displacement of print media and written communication by electronic and computer technology; short-term complementary effects on demand for printing and writing paper.	Decline in long-term rate of growth in demand for newsprint and printing and writing grades relative to GNP and population growth.
Regulation related to recycling	Decreasing availability of landfill capacity and escalating waste disposal costs prompting legislative initiatives on recycling.	Increased supply of recycled fiber from wastepaper.
Increased demands for product uniformity and quality control; better control of inventory in packaging and shipping	Improvements in instrumentation and on-line testing for product quality control, mill test labs, and computer controls in production.	With assurance of better quality control and uniformity, lower basis weights will be acceptable in some markets; more consumer demand will be satisfied per ton of product output.
Expanded use of new chemical treatments to improve properties of paperboard	Chemical impregnation to increase strength and moisture resistance; chemical saturation for flame resistance.	Improved product performance can be achieved for specialty applications.

Table 4.—*Technological developments in pulp and paper processing—continued*

Type of development	Description	Impact
Speculative developments (next 50 years)		
Expanded use of anthraquinone (AQ) in kraft, sulfite, and soda pulping	AQ additives provide marginal enhancement of chemical pulping processes; neutral sulfite AQ process is an alternative to bleached kraft for high tensile strength products.	Marginally higher pulp yield is achieved, but concept is limited by cost of AQ chemical, plus differences in capital and energy inputs.
Biological fiber treatment, and "biopulping"	Pretreatment with biological lignases or fungi prior to mechanical pulping; treatments could include biobleaching.	Improved efficiency in mechanical pulping processes with application of biotechnology; development in early stages
Advances in biological effluent treatment systems	Use of microbial agents for decolorization, removal of waste, and improvement in effluent treatment systems.	Improved efficiency in effluent control and waste treatment; potential impact on optimal pulp yield or pulping process
Commercial development of nonsulfur chemimechanical pulping process (NSCMP)	Potential application in corrugating medium and linerboard mills; a relatively high yield process suitable for small or medium size mills using hardwoods or mixed species	Elimination of inorganic sulfur emissions; less wood imput with higher pulp yield.
Organisolv pulping	Development of pulping processes based on organic solvents instead of water; includes alcohol pulping as substitute for kraft and ester mechanical pulping with chemical recovery.	Economic advantages from higher yield and lower capital costs; likely to require additional development.
Fiber-based structural products	Development of molded fiber structural components and products; includes potential products reinforced with high-strength polymers or carbon fibers.	New product market potential for use of wood fiber in high-performance products, but mass-commodity markets likely to be met by lower cost solid-wood products.
Production of new food substances for animals or humans from wood or pulpmill byproducts	Traditional examples include vanillin, torula yeast, animal feed molasses, shiitake mushrooms, wood chip animal fodder, and ruminant feed.	Product development likely to be limited except in a national emergency.
New chemicals from wood	Various chemical feedstocks can be produced from wood, in addition to conventional silvichemicals, naval stores, lignosulfonates, and other pulpmill byproducts; direct acid hydrolysis, "wood–to–oil" processes, and fermentation offer alternatives.	Technologies will remain available, but will not likely be developed so long as adequate supplies of petroleum, coal, and other resources are available at low cost.
Substitution of wood fiber by kenaf or other natural fibers	Kenaf, bagasse, straw, cotton, and other natural fibers are used for specialty products or in regions with scarce wood resources.	Limited development potential in United States because of abundant wood resource.

Process 3, which uses only wastepaper, is projected to become the dominant process for manufacturing newsprint in the United States, although the Canadians are expected to continue to make newsprint largely from raw wood fiber. Another example is the processing of unbleached kraft pulp:

Unbleached kraft process	Furnish
1, 2 (current)	principally chemical pulp; small portion of wastepaper
3 (future)	higher yield kraft pulp and more hardwood
4 (future)	substantial portion of furnish consists of high-yield me chanical pulps; uses more wastepaper

Projections show a shift from unbleached kraft processes 1 and 2 to processes 3 and 4. Nonfiber manufacturing costs are highest for process 1 and lowest for process 4.

FOREST SERVICE PROJECTIONS OF RESOURCE USE FOR PULP AND PAPER

Forest Service projections of resource use for the production of pulp and paper were derived by the North American Pulp and Paper model (Ince, personal communication). Technology changes will facilitate two significant changes in fiber resource use in the Lake States. First, the shift to technologies using a high proportion of recycled paper will hold down increases in pulpwood use. Second, the shift to technology using a high proportion of hardwoods will increase the use of hardwood pulpwood relative to softwood pulpwood.

The rate at which recycled paper is used to make paper in the United States (tons of recycled paper input per ton of paper output) increased from 24% in 1985 to 29% in 1991 and is projected to increase to 41% by 2010. This trend will be reflected in the North by a 93% increase in the use of recycled paper between 1990 and 2010 or 2.8% per year (Figure 2). In contrast, the use of pulpwood roundwood will increase by 37% or 1.3% per year.

In the North Central states, pulpwood use is projected to increase 33% between 1990 and 2010 or 1.4% per year (Figure 3). During this period, hardwood roundwood production will increase from 344 to 509 million ft^3 (10.3 to 15.3 million m^3); softwood roundwood production will increase from 139 to 145 million ft^3 (4.2 to 4.4 million m^3). The share of hardwood roundwood will increase from 71% to 78%.

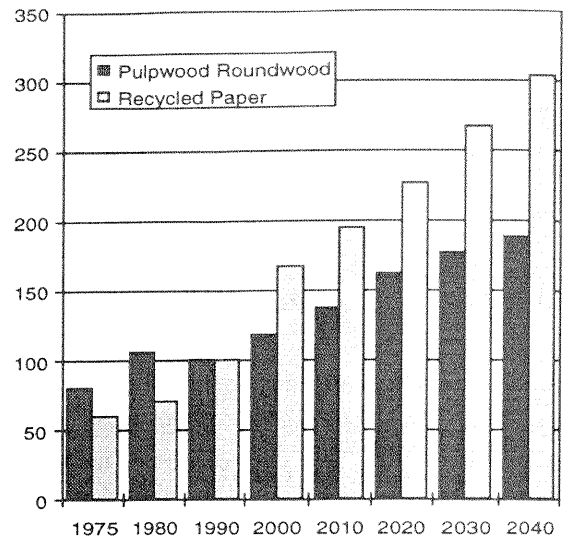

Figure 2.—*Index of pulpwood roundwood production and recycled paper use in the U.S. North (1990 = 100). Pulpwood roundwood, 1990: 1.1 billion cubic feet. Recycled paper use, 1990: 13.4 million tons. Source: USDA-Forest Service*

USE OF WOOD PRODUCTS IN CONSTRUCTION

Most structural lumber and structural panels are used for construction and repair/alteration of houses, apartments, and nonresidential structures. There are many opportunities to improve construction practices to reduce the volume of wood used and at the same time maintain the quantity and quality of construction (Row and Hagenstein 1988). There are also opportunities to expand wood use, such as using wood in place of concrete in residential housing foundations.

POSSIBLE CHANGES IN TECHNOLOGY

There are many ways to save wood in construction because most wood structures are built stronger than needed (NAHB Research Foundation 1971). For example, 90% of exterior wall framing is spaced at 16-inch (406-mm) intervals (McKeever 1988), even though 24-inch (610-mm) spacing gives adequate strength for one-story homes and the top floor walls of multistory structures. Similarly, 91% of interior wall framing is spaced at 16-inch intervals. Even in roofs, where structurally efficient wood trusses are widely used, 28% of roof framing is placed at 16-inch intervals. Approximately 400 board feet[2] of lumber could be saved in walls and partitions of a typical single-family home by converting to 24-inch spacing.

Overdesign extends to floors where bridging between joists and overlapping of joists on the center girder are common. Adoption of "optimum value engineering" practices such as those listed above could save 10%-15%

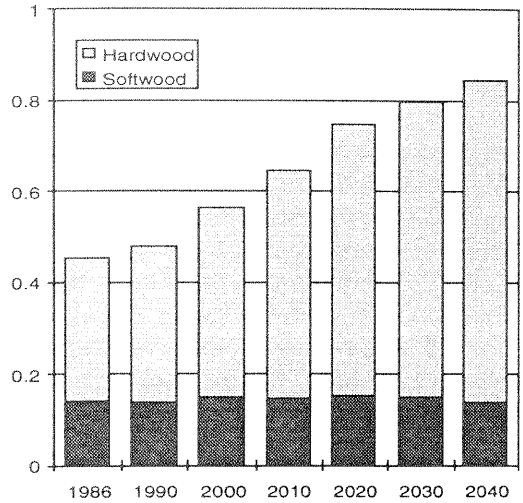

Figure 3.—*Hardwood and softwood pulpwood roundwood production in the North Central States in billion cubic feet. Source: USDA-Forest Service*

of the dimension lumber required in a conventional house. Another way to economize on wood use is to develop more efficient building materials. The metal-plated wood roof truss is one example. Roof trusses transfer loads to exterior load-bearing walls, eliminating outward thrust and the need for interior load-bearing walls. Wood roof trusses are widely used in increasingly diverse shapes and configurations in all construction sectors. Generating savings by expanding the use of trusses in housing is limited since trusses are already used in a high percentage of residential structures.

A recent wood-saving product is the prefabricated wood I-joist. I-joist design recognizes that the most critical parts of a member are its top and bottom edges. Accordingly, most material is contained in the two flanges (the edges). The flanges are connected by a web of plywood or structural flakeboard. I-joists are usually used in floors where they replace traditional 2x10 and 2x12 joists, but they can be used for longer spans up to 40 ft (12 m).

Another engineered product that uses less wood is laminated veneer lumber (LVL), a solid structural product made from 1/10- or 1/8-inch- (2.5- or 3-mm-) thick veneers; lengths range up to 80 ft (24 m). The veneers are laid together in parallel grain pattern and coated with waterproof adhesives that are cured by heat and pressure. LVL is somewhat stronger and stiffer than lumber. LVL has been used for flanges of joists, headers and beams, concrete forms, scaffold planks, and partition framework. When used in prefabricated housing, the high strength of LVL makes the wood better able to resist forces while house sections are moved.

[2] 1 board foot = 0.0024 m^3.

Structural members are also being made from reconstituted strands of wood. One product is made by laminating long strands of wood with exterior adhesives and heat-pressing the laminates into shapes similar to that of dimension lumber. The properties and uses of this product are similar to those for LVL. Another product, the stressed skin panel, which typically consists of two outer layers of plywood or OSB with foam insulation in the core, can reduce wood use in residential timber frame wall construction and in wall and roof construction in industrial and commercial buildings.

The rate of adoption of these wood-saving techniques will depend in part on the in-place costs of wood products and the resultant pressure to reduce the cost and use of wood.

SUBSTITUTION OF NONWOOD MATERIALS FOR WOOD

Wood use may decrease or increase in certain types of construction as its competitive position changes with respect to steel and concrete. In evaluating suitability for various types of construction, wood products are compared to steel and concrete in structural capability, fire resistance (in large structures), insulation, and cost.

The main structural property of concrete is compressive strength. In addition, reinforced concrete possesses good tensile strength. However, these favorable properties are in excess of what is typically required in residential and smaller commercial structures. At more than $100/cubic yard,[3] this material is expensive for the required performance levels in such structures. Moreover, other positive features of concrete, such as its fire-insulating capabilities and low sound transmission, become crucial factors only in large structures. Thus, no major displacement of wood by concrete is expected in most construction markets.

Like concrete, steel has superior strength properties compared to wood, and it can cost less than wood in some cases. However, heat is conducted through a 2x4 steel stud about 2-1/2 times faster than through a wooden stud. Sound transmission is also faster through steel. These drawbacks cannot be overcome without incurring expenses that negate any initial economic advantage. Nevertheless, steel is more likely than concrete to displace wood in construction, particularly in larger residential and mid-sized commercial structures. The extent of displacement will depend on relative changes in the in-place costs of wood and steel.

[3] 1 cubic yard = 0.76 m^3.

PROJECTED WOOD END-USE RATES

The USDA Forest Service projects that softwood lumber per square foot of floor area in residential construction will decline by 24% between 1986 and 2040. Total structural panel usage is more stable, however, because one consequence of more efficient lumber use is a need for thicker structural panels in walls, roofs, and floors.

Wood needed for repair and alteration per household is projected to remain relatively constant for softwood lumber and plywood, but it is expected to increase for OSB and waferboard. Wood use per dollar of nonresidential construction is projected to remain stable for softwood lumber, to decline for softwood plywood, and to increase for OSB and waferboard.

USE OF WOOD PRODUCTS IN MANUFACTURING AND SHIPPING

More lumber and panel products are consumed in manufacturing and shipping than in any use except new residential construction. Manufacturing includes production of furniture, other wood products made for sale,[4] and wood products used in various production processes. Shipping includes pallets and skids, wooden containers, and dunnage, blocking, and bracing. In 1986, an estimated 72% of all hardwood lumber was used for manufacturing and shipping (7.3 billion board feet). Lesser volumes of softwood lumber (4.3 billion board feet) and structural panels (1.6 billion ft^2 [144 million m^2], 3/8-inch [10-mm] basis) were also used. Use of nonstructural panels for manufacturing and shipping was 44% of total usage in 1986 (8.0 billion ft^2 [720 million m^2], 3/8-inch basis). Nonstructural panels include hardwood plywood, hardboard, insulating board, particleboard, and medium-density fiberboard.

Improvements in manufacturing and shipping technologies have the potential to decrease or increase wood consumption. Technological changes may decrease wood use by enabling producers to use less wood in the manufacturing process, finished products, and packaging and shipping of the finished products. Other technological changes may increase wood use by permitting substitution of wood parts for nonwood parts, by requiring more wood per unit output, or by opening new markets for wood products. Technology changes may also extend timber supply by allowing products to be made from trees, logs, and lumber of previously unused species, sizes, or grades.

The greatest volume of wood in manufacturing and shipping is used for furniture and pallets. In 1986, 43% of the lumber used in manufacturing was for furniture and 93% of the lumber used in shipping was for pallets. Traditionally, large amounts of hardwood lumber have been used for these products. Half of all lumber used in furniture and more than three-fourths of all lumber used for pallets is hardwood (McKeever and Martens 1983, McKeever *et al.* 1986, McCurdy *et al.* 1988).

The production of furniture and, to an increasing extent, the production of pallets tend to be highly mechanized. Adoption of new technologies by furniture and pallet manufacturers can hold down timber demand by reducing the amount of wood used per unit of output. Selected technologies likely to affect furniture and pallet production are discussed in the following section.

POSSIBLE CHANGES IN FURNITURE PRODUCTION

Several technological developments may reduce the wood needed to make a given furniture part or reduce the proportion of high-grade lumber needed to make a given set of parts. Such technologies could increase the efficiency of the breakdown of hardwood lumber and, to a lesser extent, softwood lumber to make furniture parts. These technologies, which are included in the Automated Lumber Processing System (ALPS) (McMillin *et al.* 1984), will increase both the value and volume of lumber recovery by expanding and improving existing technologies such as edge, end, and finger jointing; computer-assisted cross and rip sawing; and better finishing of less desirable species. Other technologies, such as computer numerical control of woodworking operations in furniture plants, will lower costs by speeding production, improving accuracy, and using labor more efficiently.

Technological improvements in structural and nonstructural panel processing will increase the substitution of panels for lumber and the substitution of nonstructural panels for structural panels. As a result, demand will increase for hardwood veneer and panels using paper overlays. These two types of substitution will reduce the demand for medium-to-high grade hardwood lumber and will generally hold down timber demand as more efficient panel-making techniques are used to convert logs to products.

[4] Includes sporting goods, musical instruments, boats (building and repair), toys and games, luggage and trunks, handles, wood pencils, mortuary supplies, shoe and boot findings, wooden matches, commercial refrigeration, signs and displays, patterns and jigs, truck bodies and trailers, general machinery, agricultural implements, electrical equipment, and textile machinery supplies.

Other factors affecting the use of lumber and wood products for furniture include changing consumer preferences for wood compared to nonwood furniture, particularly for higher value furniture; relative cost of producing furniture from wood compared to other materials such as steel; and competition from foreign producers. Increased use of nonwood materials is expected in low-to-middle quality furniture and relatively constant use of wood in high quality furniture. Foreign trade in unassembled wood furniture and parts is expected to increase.

PROJECTED WOOD-USE RATES IN FURNITURE PRODUCTION

Overall, hardwood lumber use per unit of furniture production is expected to fall over the next 50 years even though use may increase for high value furniture. The decline will be caused by several factors, including technological changes that increase the efficiency of lumber conversion to furniture parts, substitution of panels for lumber, substitution of nonwood materials for wood in low- to middle-quality furniture, and increasing imports of unassembled wood furniture. The use of softwood lumber and structural panel is also expected to decline, but not as much as that of hardwood lumber, because the relative lower cost of these products makes substitution of other nonwood products less profitable. The use of nonstructural panels is expected to increase.

POSSIBLE CHANGES IN PALLET PRODUCTION AND USE

The pallet industry is the single largest consumer of lower grade hardwood lumber. One-third to one-half of all hardwood lumber is used for pallets. Traditionally, pallets were a way in which sawmills used lower grade lumber. One or two types of pallets were produced, using little or no automated equipment. Today, up to half of all pallets are produced using nailing machines; a limited number of producers have large, modern facilities with automated sawing, lay-up, and nailing and a large product line. There is great potential for raw material savings through increased use of new sawing and pallet construction techniques.

The greatest potential for saving wood in pallets is from increasing the use of new computerized pallet design systems. Such systems permit producers to quickly change pallet design based on the type of load, which results in more efficient use of the lumber. The use of wood in pallets may also be affected by a shift from reusable to expendable pallets. Although expendable pallets use less wood per pallet than do reusable pallets, their life span is shorter and therefore more pallets need to be produced. Reusable pallets require more wood but last longer, especially if damaged pallets are repaired. The salvage and repair of reusable pallets could save large amounts of wood. Salvage and repair are expected to increase with increasing costs associated with pallet production and disposal of damaged pallets.

Lumber consumption in pallets may also decrease as more composite materials are used in pallets. Pallet decks made from structural panels provide a flatter, more uniform surface than do lumber decks. Pallets made from molded particleboard can be custom-made to meet the specific transportation needs of products.

Growth in pallet production is also expected to be held down by increasing competition from substitute materials-handling products, such as plastic slipsheets, and by increasing saturation of industries that can use palletized shipping.

PROJECTED WOOD-USE RATES FOR SHIPPING

The use of hardwood lumber in shipping per unit of manufacturing output is expected to decrease over the next 50 years. This decrease will be caused by several factors, including technological changes that increase the efficiency of lumber use in pallets, substitution of panels for lumber, a trend towards greater re-use of damaged pallets, and increased use of pallets made from nonwood materials. Use of OSB and waferboard in shipping per unit of manufacturing output is expected to increase as these products become an acceptable substitute for lumber decking. The use of softwood lumber and plywood is also expected to decline with the rapidly declining use of wooden containers in favor of paper and plastic and the virtual elimination of wood for dunnage, blocking, and bracing during transportation. A small increase is expected in the use of nonstructural panels.

USE OF WOOD FOR ENERGY

Wood, together with bark, is most widely converted into energy by direct combustion. Black liquor, a wood pulp byproduct, is also used to produce energy at pulp plants. Some wood or black liquor is used to produce electricity in cogeneration plants. Technology is also available, although not always economical, to convert wood (1) to gas by thermochemical gasification and burn it in boilers, dryers, and kilns or internal combustion engines, (2) to synthetic gas for manufacture of liquid fuels such as methanol or chemical feedstocks, (3) to gas, liquids, and solids (such as charcoal) by pyrolysis, and (4) to other liquid fuels such as ethanol by hydrolysis and fermentation.

ADVANTAGES AND DISADVANTAGES

Recent and future technology for converting wood to energy will improve the competitive position of wood relative to other fuels and to increase the use of wood for energy. Technology will also improve the efficiency of converting wood to energy and will tend to hold down the demand for using wood for energy.

With decreasing fossil fuel supplies and environmental and economic problems in the use of alternative energy sources such as nuclear energy, there is an overall tendency for increased use of wood for energy. Using wood for energy has both environmental benefits and costs. Unlike much coal and some petroleum, wood has little or no sulfur and appears less likely to produce nitrogen oxides during combustion. Therefore, wood-burning emissions are less likely to contribute to the production of acid rain. Continual reproduction of forests also means that as wood is consumed and converted to atmospheric carbon dioxide, new wood is grown that removes atmospheric carbon dioxide. The net effect is no change in atmospheric carbon dioxide. However, caution must be used to prevent excessive removal of biomass in forest harvests to avoid nutrient depletion or increased potential for soil erosion. Wood burning may have other environmental costs. Combustion of wood in inefficient combustors without proper controls adds smoke and particulate emission to the air. Consequently, the U.S. Environmental Protection Agency has developed residential wood stove performance regulations that limit particulate emissions. There has also been concern about proper combustion of wood contaminated with materials such as paint, adhesives, and/or preservatives.

Improved wood conversion technology may make wood for energy more competitive, even with oil prices increasing more slowly than anticipated. However, a major factor in using more wood for energy is the high cost of forest harvesting. When selecting wood for energy, it is prudent to use wood that is less valuable and less suited for use in other consumer products. However, the lower value wood is often from smaller trees that are more expensive to harvest. Harvesting is also more expensive for lower density stands and stands that have a higher proportion of hardwoods than softwoods.

POSSIBLE CHANGES IN TECHNOLOGY

The use of wood for energy may be divided into three roughly equal categories: residential wood burning, black liquor burning, and industrial wood waste/roundwood burning. Lesser, but increasing, amounts of wood are consumed in power generation and commercial and institutional applications.

For residential use, the traditional approach has been the burning of roundwood in fireplaces, simple stoves, and fireplaces. Fireplaces are inherently inefficient and are more esthetic than utilitarian. However, fireplaces are being used more efficiently with newer technological developments in the control of makeup air and hot air distribution and in the use of better designed insert units (stoves) for fireplace spaces. Stoves are also being designed to use roundwood more efficiently with better control of air for combustion.

A newer development in residential wood burning is the combining of improved fuels with improved combustion units to attain more efficient and more automatic operation. Fuels may be made more efficient, cleaner-burning, and easier to handle by control of size and moisture content. Examples of such fuels are dried chips and pellets. More sophisticated stoves and furnaces have been designed to take advantage of these new kinds of fuels.

In industrial applications, older boiler technologies such as the Dutch oven and traveling grate are still operating satisfactorily, but new technologies such as the fluidized bed and gasification are providing advantages in combustion and emission control. Promising developments for industry in the future are a gravel bed combustor, new technology for gas, liquid, and char fuels, and burning wood in combination with coal. Development of a pressurized gravel bed combustor may allow wood to be used to power gas turbine engines, primarily for generation of electricity. Advanced industrial and utility power systems often use gas- or liquid-fueled turbine engines. These systems burn fuels directly in a turbine, without going through an intermediate heat exchanger to heat air for use in the turbine. This is an efficient means of generating electricity. Using coal or wood combustion gases to directly power a gas turbine has yet to be accomplished commercially, primarily because the ash can cause erosion, deposition, and corrosion of the turbine blades. Successful completion of this work could make wood power generation in the range from 10 to 50 MW more competitive.

Improvements in converting wood to gas, liquid, and char fuels are possible. If wood is to become a viable, more general replacement for oil as oil becomes more expensive, wood needs to be used in ways other than as a boiler fuel and residential heating fuel. Wood may be converted to liquid and gaseous fuels and to improved forms of solid fuel such as charcoal. Technology is available to make ethanol from wood at a cost comparable to making ethanol from corn, but this technology is only economical with a large subsidy in today's market. Increasingly, wood may be burned along with coal in industrial boilers. Emission limits for sulfur dioxide and

nitrogen oxides from combustion of coal and wood are based on total heat input, regardless of the wood fraction. These regulations provide an incentive to burn wood in combination with coal in large boilers (Dykes 1988).

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Tree Species Diversity in Lake States Hardwood Forests

J. Michael Vasievich and Sharon L. Hobrla[1]

INTRODUCTION

Tree species richness is only one component of biological diversity, but one that may be a useful indicator of forest health. Information describing how site and management factors affect tree diversity is useful if we want to sustain diverse forests. Using forest survey data, we were able to characterize tree species richness in Lake States hardwood forests. We identify stand and management factors that are correlated with tree species diversity. We also provide a comparison of the tree species diversity of the hardwood forest types in the Lake States, and discuss the effects of natural and anthropogenic disturbance factors that influence the mix.

DATA

Data for this study were taken from the two most recent forest surveys in each of the Lake States: Wisconsin, 1968 and 1983, Minnesota, 1977 and 1990, and Michigan, 1980 and 1993 (USDA Forest Service 1991). For most analyses, data from all six state surveys were pooled. Plot records were grouped into 13 sub-state forest survey units (Figure 1) and six major hardwood forest types: aspen, balsam poplar, elm-ash-soft maple, maple-beech-birch, oak-hickory, and paper birch.

We used Shannon's index and the number of tree species found as indicators of growing stock tree species richness. Calculated Shannon's index values ranged from 0 to 1, with 0 representing no diversity and values approaching 1 indicating higher diversity. Shannon's index values and number of tree species present were calculated from measurements on 27,171 forest inventory plots. These plots represented about 25 million acres of timberland in Michigan, Wisconsin, and Minnesota, or more than 53% of the total timberland base.

METHODS

We used multiple linear regression analysis to explore the data and test our suspicions that tree species richness was related to stand conditions and history. We correlated Shannon's index and number of tree species as the dependent variables with basal area, stand age and site index for the six hardwood forest types.

Indicator or dummy variables (0 or 1) were also used to test the relationship between Shannon's index and number of tree species as the dependent variables, and evidence of past timber clearcutting, partial cutting, grazing, and natural disturbance on measured plots. We used a stepwise regression procedure with forward

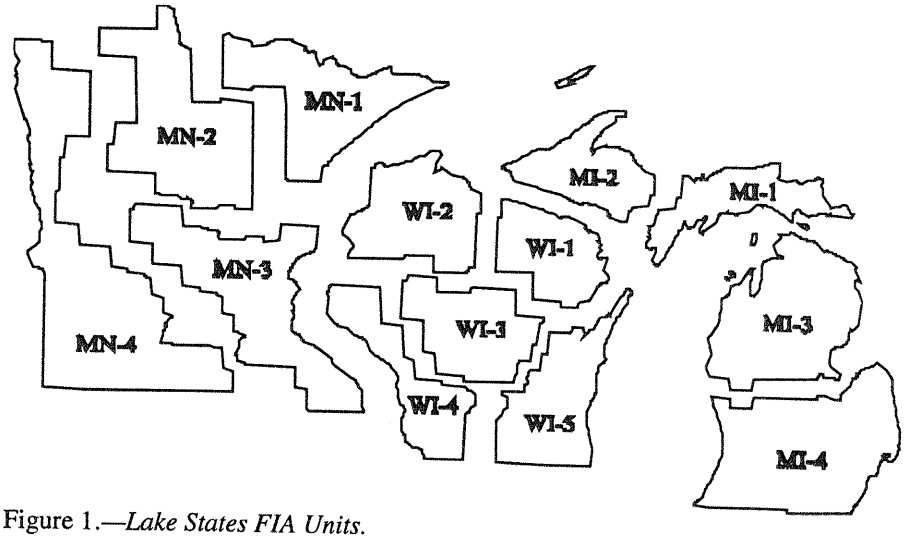

Figure 1.—*Lake States FIA Units.*

[1] Authors are Project Leader and Statistician, respectively, North Central Forest Experiment Station, USDA Forest Service, 1407 South Harrison Road, East Lansing, Michigan 48823.

selection to determine the effects of clearcutting, partial cutting and timber stand improvement, natural disturbance, and grazing on species richness. Almost one-fifth of the plots showed some type of cutting, grazing, or natural disturbance. Although we have not specifically tested for normality, a plot of the frequency distribution shows that Shannon's index appears to be approximately normally distributed within each forest type (Figure 2).

RESULTS

A Geographic Comparison of Species Diversity

On average, Shannon's index ranged from 0.33 to 0.53 for all plots on different survey units in the region (Table 1). The mean number of species present ranged from a low of 3.5 to a high of 7.7 for all plots on each survey unit (Table 2). As many as 20 different tree species were found on some plots.

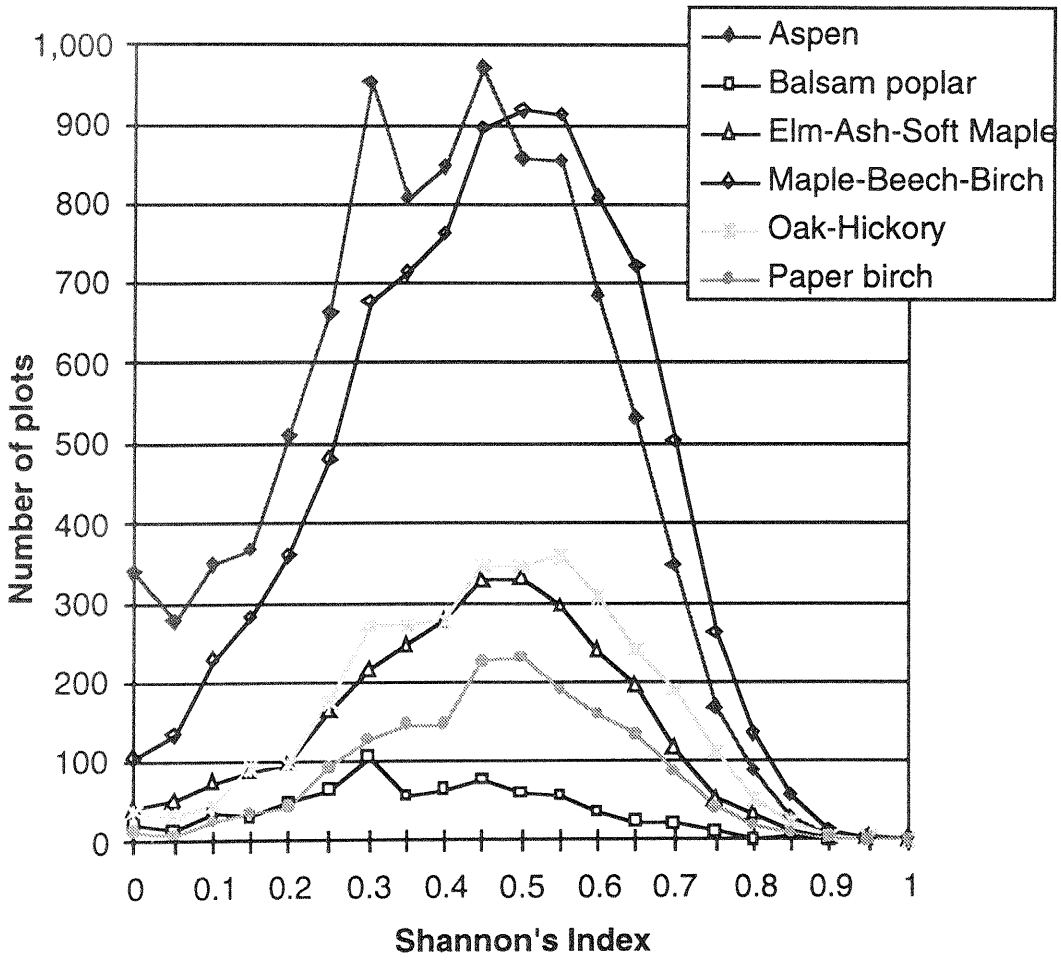

Figure 2.—*Distribution of plots by forest type over Shannon's Index.*

Table 1.—*Mean Shannon's index for each forest inventory unit by forest type**

Survey Unit	Aspen	Balsam poplar	Elm-ash-soft maple	Maple-beech-birch	Oak-hickory	Paper birch	All types
MI-1	0.42	0.42	0.49	0.40		0.51	0.42
MI-2	0.42		0.55	0.43		0.52	0.44
MI-3	0.36		0.42	0.39	0.39	0.52	0.39
MI-4	0.45		0.38	0.45	0.48		0.44
MN-1	0.36	0.39	0.38	0.40		0.41	0.37
MN-2	0.41	0.34	0.43	0.54	0.46	0.48	0.43
MN-3	0.36		0.40	0.50	0.47	0.40	0.43
MN-4	0.26	0.23	0.36	0.48	0.36		0.33
WI-1	0.46		0.51	0.48	0.46	0.52	0.48
WI-2	0.46		0.45	0.48	0.53	0.48	0.47
WI-3	0.46		0.50	0.56	0.44	0.45	0.48
WI-4	0.49		0.43	0.52	0.54		0.53
WI-5			0.41	0.50	0.45		0.46
Type mean	0.40	0.37	0.44	0.45	0.46	0.46	

*Survey units without values had less than 30 plots.

Table 2.—*Mean and standard deviations of number of tree species found for each forest inventory unit by forest type***

Survey Unit	Aspen	Balsam poplar	Elm-ash-soft maple	Maple-beech-birch	Oak-hickory	Paper birch	All types
	avg [std]	*avg [std]*	*avg [std]*	*avg [std]*	*avg [std]*	*avg [std]*	
MI-1	4.7 [2.2]	4.1 [1.9]	5.6 [1.8]	5.1 [1.9]		5.5 [1.7]	5.0
MI-2	4.5 [2.0]		6.4 [2.0]	5.6 [2.0]		6.0 [2.1]	5.4
MI-3	3.8 [1.8]		4.8 [1.7]	4.5 [2.6]	3.7 [1.5]	5.7 [2.2]	4.1
MI-4	4.4 [2.0]		4.5 [2.1]	5.3 [1.8]	5.4 [2.4]		5.1
MN-1	3.7 [1.6]	4.1 [1.7]	4.3 [1.6]	4.9 [1.8]		4.2 [1.4]	4.0
MN-2	4.5 [2.0]	3.6 [1.8]	4.9 [1.7]	6.6 [1.9]	4.9 [2.0]	5.5 [1.9]	4.9
MN-3	3.6 [1.8]		4.3 [1.9]	5.3 [2.1]	4.8 [2.0]	4.1 [2.2]	4.5
MN-4	2.5 [1.5]	2.2 [1.0]	4.0 [1.9]	5.4 [2.1]	3.5 [1.6]	6.8 [1.9]	3.5
WI-1	6.4 [2.2]		7.2 [2.5]	7.0 [2.1]	5.9 [1.9]	6.6 [2.2]	6.7
WI-2	6.2 [2.3]		6.4 [2.2]	7.3 [2.1]	6.9 [2.4]	7.2 [2.0]	6.7
WI-3	6.0 [1.9]		7.1 [2.5]	8.2 [2.2]	5.7 [2.2]	6.3 [1.7]	6.5
WI-4	7.7 [2.8]		5.2 [2.0]	8.3 [2.2]	7.7 [2.3]		7.7
WI-5			5.8 [2.2]	7.4 [2.6]	6.6 [2.5]		6.6
Type mean	4.7	3.8	5.3	6.0	5.7	5.5	

**Survey units without values had less than 30 plots.

We ranked the 13 forest survey regions based on the average Shannon's index for all plots occurring within the unit. The data show that Wisconsin's five survey units had the highest overall tree species richness in the region. Wisconsin's Southwestern Unit, stretching generally north to south along the Mississippi River, had hardwood forests with the greatest overall richness. Michigan's western upper peninsula also was highly ranked for tree species richness. The least diverse forests were found in Minnesota's Prairie and Aspen-Birch Units.

Regression Results

Multiple linear regression results indicate that three commonly measured stand characteristics—basal area, stand age, and site index—explained 83 to 89% of the variation in both Shannon's index and number of tree species present for each of the hardwood forest types we tested. Table 3 contains regression results for Shannon's index. Table 4 has results for number of tree species. All three variables were significant and positively correlated for all six forest types. Stands increase in tree species diversity as they get older. Higher site indexes have greater potential for sustaining higher levels of tree species richness. Higher stocking translates into a greater number of species. Site index generally showed the strongest correlation and explained most of the variability in Shannon's index and number of tree species for all forest types tested.

Temporal Effects

We tested for temporal effects by including a dummy variable in the Shannon's index regression—1 for the most recent survey or 0 for the prior survey. After this adjustment, shifts in mean Shannon's index were statistically significant for only two forest types—aspen and oak-hickory. The mean Shannon's index for these types increased slightly after accounting for other sources of variation. The coefficients for the survey dummy variable were highly significant, but small. The coefficient was 0.002 for aspen and 0.001 for oak-hickory.

Effects of Disturbance

Forest inventory plot records contain stand history information to describe past evidence of cutting and stand disturbance. Various measures of stand disturbance were highly significant and positively correlated for five of the six forest types—all except paper birch for the regression on Shannon's index, and for four forest types—all but the paper birch and elm-ash-soft maple types for the regression on the number of tree species present.

Table 3.—*Regression results for Shannon's index of growing stock trees using pooled forest inventory data*

	Aspen	Balsam poplar	Elm-ash-soft maple	Maple-beech-birch	Oak-hickory	Paper birch
Number of plots	9,636	731	2,840	8,955	3,272	1,732
Mean Shannon's index	0.398	0.368	0.437	0.452	0.463	0.465
Mean squared error	0.033	0.026	0.032	0.038	0.029	0.026
r^2	0.830	0.847	0.858	0.842	0.883	0.893
coefficients***						
basal area (ft^2/acre)	0.00121	0.00141	0.00145	0.00112	0.00112	0.00086
stand age (years)	0.00155	0.00151	0.00101	0.00060	0.00082	0.00139
site index (ft)	0.00336	0.00303	0.00412	0.00440	0.00513	0.00505
clearcutting (0/1)	0.07733	0.12818		0.13168	0.07389	
partial cutting (0/1)	0.06237	0.08063	0.06929			
natural disturb. (0/1)	-0.04955		0.05488	0.03453		
grazing (0/1)				0.08251		

*** All variables with values listed are significant at the a=0.01 level.

Table 4.—*Regression results for number of tree species using pooled forest inventory data*

	Aspen	Balsam poplar	Elm-ash-soft maple	Maple-beech-birch	Oak-hickory	Paper birch
Number of plots	8,592	750	2,454	6,949	2,501	1,345
Mean Number of Species	3.155	3.024	3.770	4.398	3.685	3.961
Mean squared error	1.91	1.39	2.40	2.75	2.25	2.05
r^2	0.849	0.880	0.864	0.879	0.864	0.889
coefficients***						
basal area (ft^2/acre)	0.01704	0.01975	0.02417	0.02288	0.0172	0.01551
stand age (years)	0.01884	0.01202	0.00869	0.00827	0.00866	0.02082
site index (ft)	0.01623	0.01859	0.02352	0.02639	0.02931	0.02607
clearcutting (0/1)	0.18729					
partial cutting (0/1)	0.51234	0.63994		-0.22626		
natural disturb (0/1)						
grazing (0/1)					-0.59939	

*** All variables with values listed are significant at the a=0.01 level.

We also tested for the effect of natural disturbances. This indicator variable was significant in estimating Shannon's index for three forest types—maple-beech-birch, elm-ash-soft maple, and aspen. The relationship was negative for aspen, but positive for the other two types. Natural disturbance was not a significant factor for any of the six hardwood forest types in estimating the number of species present.

Timber cutting reduces average stocking, and hence negatively affects Shannon's index. But, after accounting for stocking changes, we found that evidence of past clearcutting and/or partial cutting was highly significant and positively correlated with Shannon's index for five of the forest types. On average, plots where past cutting activity was evident were positively correlated with diversity values on all hardwood forest types, except the paper birch type for Shannon's index and the maple-beech birch type for the number of tree species present. Although most of the variation in both diversity measures was explained by site index, stocking, and stand age, past clearcutting and/or partial cutting activity increased Shannon's index values from 0.06 to 0.13 and changed tree species present estimates by -0.23 to 0.64, other factors being equal.

Harvesting appears to affect tree species richness, as measured by Shannon's index, for two reasons. Because different species prefer different habitats for best growth, harvesting often creates conditions that encourage a mix that thrives in both shade and sunlight. Also, harvesting of the most common tree species leads to a proportional decrease for these species and a proportional increase for less abundant species, resulting in greater diversity according to Shannon's index.

Although evidence of grazing was limited, this variable was highly significant and positive in estimating Shannon's index for the maple-beech-birch type. Disturbance caused by grazing had a negative correlation with the number of tree species present for the oak-hickory type. Grazing was not a significant factor for other forest types.

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Implications of Ecosystem Management Concepts for the Practice of Silviculture in the Lake States

John Kotar[1]

Abstract.—My interpretation of the goal of ecosystem management is an attempt to develop methods of extracting human commodities from forest ecosystems in ways that do not greatly alter the processes that shape development of natural forest communities.

In natural forests composition is in a constant state of flux as individual populations react to both internal and external forces. Managed forests are manipulated to produce specific outputs. They are generally less complex than natural forests.

Silviculture can be applied to manipulate forest composition for any of a wide range of purposes. The basic unit should be a stand sufficiently uniform to be treated silviculturally as an essentially homogeneous ecological unit. Forest cover types are a major simplification based on present dominant species. Any given cover type may contain a wide range of local conditions.

Composition and structure of managed forests can be varied over time to mimic the dynamics of natural stands. This is in essence resource utilization through ecosystem management.

The intent is to include in managed forests some compositional and structural elements not regularly found in forests after the initial wave of forest utilization. However, the intent is not to reestablish presettlement patterns of forest vegetation. This approach will continue to yield wood products and other commodities.

Note: John Kotar is a Senior Scientist in the Department of Forestry, University of Wisconsin-Madison. His specialty is forest ecology and silviculture. He has over 20 years of experience with the Lake States forests based on graduate work at the University of Minnesota, a faculty position at Michigan Technological University and his current activities in Wisconsin. His ecological forest classification system in Wisconsin is being widely used as a tool in forest resource management.

This paper reports analyses carried out as an element of the Lake States regional resource assessment. The regional resource assessment is a project of the Lake States Forestry Alliance, a regional mutual-help organization formed by the governors of Minnesota, Michigan and Wisconsin.

This is an in-kind contribution of the author and The University of Wisconsin-Madison to the regional resources assessment.

[1] The author is a faculty member, Forestry Department, University of Wisconsin-Madison. This manuscript was originally prepared in March, 1994.

A WORKING DEFINITION OF ECOSYSTEM MANAGEMENT

Ecosystems comprise all living and non living components that interact on a particular segment of a landscape. For research or management purposes boundaries between different terrestrial ecosystems can arbitrarily be established, but absolute boundaries between adjacent ecosystems can not be defined. No one claims the understanding of functions of even the simplest of ecosystems to the degree necessary to manipulate it with predictable results. Thus, ecosystem management is more an approach to management rather than a cause-effect method of control, the more common meaning of the term "management". My interpretation of the goal of forest ecosystem management is an attempt to develop methods of extracting human commodities from forest ecosystems in ways that do not greatly alter the processes that shape the development of natural forest communities. In other words, we are not attempting to take control of the ecosystem processes themselves since we do not fully understand them, but we wish to interfere with them as little as possible. Presumably, with our current state of knowledge, this approach is the best way to assure sustainability of those ecosystem outputs upon which societies depend.

STRUCTURE AND COMPOSITION OF NATURAL VS. MANAGED FORESTS

"Natural" or "native" forests are assemblages of those regional floristic and faunal components that can co-exist, in a particular environment. This composition is in a constant state of flux as individual populations react to changes in their immediate environments brought about by internal as well as external forces. Natural forests can be simple or complex in terms of species composition and arrangement of age classes (structure), depending on the stage of their development and on physical limitations of the site. On a landscape scale, and over long periods of time, natural communities display the greatest amount of biological diversity possible under the prevailing climatic and edaphic conditions of a given region.

Managed forests are manipulated to produce specific commodities. Traditionally, wood production and consumptive wildlife have been the dominant commodities. Managed forests are generally less complex than natural forests because management attempts to optimize only a few species: those of high commercial value, fast growth, or those that can be grown in pure stands or in relatively simple mixtures. Economic considerations often lead to other structural and compositional limitations such as economic rotation age, maximum diameter, fixed spacing, elimination of competing vegetation, and others.

These simplifications of the composition and structure of managed forests reduce the number of possible niches in a forest ecosystem, resulting in lower biodiversity.

SILVICULTURE AND FOREST MANAGEMENT

Although these two terms have very different meanings within the forestry profession they are often used interchangeably and contribute greatly to misunderstandings between foresters and other resource managers as well as the public. Furthermore, both terms are often interpreted as synonyms for timber production. Silviculture has been defined in various ways: the art of producing and tending a forest; the theory and practice of controlling forest establishment, composition and growth; the application of the knowledge of silvics (biological and ecological characteristics of trees) in the treatment of a forest (Smith, 1968). The aim of the practice of silviculture has traditionally been production of a certain crop. However, silviculture can also be applied to manipulate forest composition for other purposes.

Forest management, as defined by the Society of American Foresters, is "The application of business methods and technical forestry principles to the operation of forest property" (Davis, 1966). It is obvious that owner's objectives and economic factors limit the range of silvicultural options for managing a given forest. However, because social and economic conditions, and therefore owner's objectives, are always changing it is appropriate from time to time to reexamine and reevaluate silvicultural techniques. This is essential because we know that under any management system some secondary forest benefits are always being compromised. At the same time we must not assume that any adjustment in silvicultural techniques to better accommodate another forest benefit is necessarily uneconomical.

SILVICULTURAL METHODS AND SILVICULTURAL SYSTEMS

Silvicultural methods are procedures by which stand properties are controlled. A reproduction method, for example, is a procedure by which a stand is established or renewed. The process is accomplished during the regeneration period by means of natural or artificial reproduction. The term *silvicultural system* is more comprehensive and it signifies a planned program of silvicultural treatments during the whole life of a stand; it includes not only the reproduction cutting but all intermediate manipulations. The reproduction method employed has such a significant influence on the subsequent handling of the stand that the name of the method is commonly applied to the silvicultural system as well. The shelterwood system, for example, leads to reproduction by means of the shelterwood method of cutting.

Under this method a stand is cut in two or more stages, each stage creating conditions favorable for seed germination or establishment of young trees. The method is generally applied to species that do not reproduce under dense shade of normal stands.

The distinction between these two terms is important for several reasons. First, because there are only a few standard reproduction methods (single tree selection, group selection, shelterwood, seed-tree and clearcutting), one may get a false impression that silvicultural systems themselves are equally limited. Second, in light of considerable public opposition to clearcutting in general, it does not help to label a silvicultural system that uses partial cuttings for most of the life span of a stand, after a clearcutting reproduction method. Third, as forest management changes to give more equal weight to other forest values, silvicultural systems as practiced in the past are likely to lose their meaning while forest reproduction methods will always be needed.

FOREST STANDS AND FOREST COVER TYPES

The basic unit of silvicultural manipulation is a stand. A stand may loosely be defined as a contiguous group of trees sufficiently uniform in species composition, arrangement of age classes and general condition to be a homogeneous and distinguishable unit. Although the stand has been a unit of silvicultural manipulation historically, it does not necessarily represent a homogeneous ecological unit. The properties by which it is recognized (e.g., species composition, age structure, diameter distribution) are more likely to be a result of past treatment than the expression of community development under the control of a homogeneous site. This is especially so in the United States where the so called "extensive" rather than "intensive" forestry is more commonly practiced. In extensive forestry there is a tendency to treat large groups of dissimilar stands as if they conformed to some hypothetical average. For most effective ecological approach to management, the policy should be to recognize the smallest stands that can be conveniently delineated on the type maps used in administration. Where means of classifying physical sites are available, an attempt also should be made to place stand boundaries so that they do not encompass more than one ecological site unit.

Forest Cover Type May Not be a Good Basis for Selection of Silvicultural Systems

Because so much of silvicultural experience and literature is organized by forest cover type, it is essential that we understand to what extent ecological factors are considered in defining cover types and how the cover type concept of management relates to the proposed ecosystem approach to management.

The English-language version of *Terminology of Forest Science, Technology, Practice and Products* (Ford-Robertson 1971) gives two definitions of forest type: (1) Forest site type—generally a category of forest or forest land, actual or potential; and (2) Forest cover type, crop type, stand type—more particularly a category of forest defined by its vegetation (particularly its composition) and/or locality (environmental) factors. The *Forest Cover Types of the United States and Canada* (Eyer 1980) follows the second definition with some further restrictions. In short, *forest cover type* is a descriptive classification of forest land based on present occupancy of an area by particular tree species. Forest cover types are named after predominant tree species as determined by basal area. Because an almost unlimited number of combinations of tree species occur in nature, only those of relatively wide distribution were formally recognized and described by Eyer (1980). Ninety-five cover types were described for the Eastern United States.

Forest cover types are useful for describing and mapping composition and distribution of forest vegetation as it appears at various periods of time, and for summarizing the known ecological characteristics and silvicultural information. However, there are severe limitations to the use of generalized cover types as ecological units of vegetation management. Most tree species have a wide ecological amplitude (they occur over a wide range of environmental conditions) and therefore do not grow at the same rate, nor respond uniformly to competition, or disturbance. For same reasons they also do not respond uniformly to given silvicultural techniques. Thus, for management purposes, models of ecological behavior of cover types across a range of sites must be developed locally.

Cover Types as Components of Natural Forests are Dynamic

To approach forest management on an ecosystem basis, foresters need to overcome the common practice of treating most cover types as natural, more or less permanent vegetation units. This practice was borrowed directly from the European experience of growing successive crops of economically desirable species on the same site for many generations. In fact, all silvicultural systems were originally developed for this type of crop-oriented management. However, the sustainability of such forest practices is now coming into question in many parts of the world (Oliver 1992, Leslie 1993, Smith 1993).

While ecologists have long been aware that many forests do not return to their original state in a one-step process, following a disturbance, the mechanisms driving succession were not well enough understood to be incorporated into silvicultural systems. This is especially true for central European forests where human influence has been historically most intense. More importantly, until very recently, the need for management strategies that follow natural forest development processes has not been widely advocated by the scientific community, nor has it been demanded by society.

SILVICULTURAL SYSTEMS CAN BE DESIGNED TO MIMIC NATURAL COMMUNITY DYNAMICS

To mimic natural community dynamics, composition and structure of managed forests should change with time. That is, cover types should be recognized and treated as successional or developmental stages and should not necessarily be perpetuated in place, but should occur on the landscape at different times and in different locations in a cyclic process. Opportunities, of course, always exist to adjust the extent and duration of an existing type if desired for specific reasons. This, in essence, is resource utilization through ecosystem management.

New silvicultural techniques are not required to begin management based on ecosystem concepts. What is needed are a reassessment of management objectives for individual stands and willingness to use a variety of available silvicultural techniques simultaneously. For example, shelterwood, clearcutting and single-tree selection methods may all be appropriate to establish regeneration in a same large heterogeneous stand. Most importantly, this means that specific stand treatments will have to be developed on the site and not in the office.

If we model silvicultural systems after natural processes that shape forest community development in a given environment (i.e., site type), a long-term regional "master plan" for so called "desired future condition" is not necessary, or even possible, since conditions will be changing continuously. It is assumed that by applying this method all "future conditions" of the forest as a whole will be ecologically acceptable because individual stands received ecological considerations.

Nevertheless, some qualification of a plan to manage by accepting and aiding natural development and successional trends is necessary. If carried out universally and rigidly the practice may lead to under-representation of young stages. To avoid this trend, region-wide landscape monitoring systems should be developed. In some circumstances it will be justifiable to maintain a particular successional stage for more than one generation. Also it must be accepted that maintenance of many intolerant groups will require aggressive silvicultural measures. Relying on natural disturbances to accomplish this is no longer an option in human dominated environment.

SUMMARY OF THE LAKE STATES FOREST CONDITIONS

Conditions Prior to Euro-American Settlement

In order to implement management strategies that accommodate a variety of natural forest development processes and community structures, an understanding of the forest history of specific regions is necessary.

The upland forests of the Lake States region in presettlement times could be grouped into three broad categories: mixed pine, mixed oak and hemlock-white pine-northern hardwood. It must be understood that individual forest communities within these types exhibit considerable variation in composition and structure. The pine forests were primarily a function of the substratum. The drought-prone, coarse-textured soils promoted a forest type which was extremely flammable and subject to stand-initiating fires at 130-260 year intervals (Whitney, 1987). Fire eliminated most competing hardwoods and the few pines that escaped fire restocked the land. Relative proportions of the three pine species (*Pinus banksiana*, *P. resinosa*, *P. strobus*) varied as a function of fire frequency and intensity. Red pine was most prevalent in mixtures in the region as a whole. Jack pine dominated on sites most prone to frequent fires while white pine was more common on somewhat less xeric soils.

Oaks (largely *Quercus rubra-velutina-ellipsoidalis* complex and *Q. alba*) were generally not well represented in the canopy, but were common as sprouts in the understory. Oak forests were more common in southern parts of the region where fires were even more frequent than in the north, and pines as well as mesic hardwoods were largely eliminated.

Fires were much less frequent in the moist hemlock-white pine-northern hardwood forests which occurred on finer-textured morainic soils. Sugar maple (*Acer saccharum*), hemlock (*Tsuga canadensis*), yellow birch (*Betula alleghaniensis*) and, in eastern parts of the region, beech (*Fagus grandifolia*), were the dominant species. Many of the largest white pine trees also were found scattered within this type. Aspen (*Populus tremuloides* and *P. grandidentata*) and paper birch (*Betula papyrifera*) communities were relatively uncommon.

The Post-Logging Condition

The intensive logging that preceded or paralleled European settlement profoundly altered the nature of the Lake State's forests. Selective logging of white pine and later hemlock and the better hardwoods, converted the hemlock-white pine-northern hardwood type to sugar maple dominated stands. Waves of fires, which closely followed the logging, also upset the apparent equilibrium of the Great Lakes mixed pine forests. The ignition of the logging slash destroyed the remaining seed trees and the seedling pine. The result was a forest of oak sprouts and aspen root suckers. Many of these post-logging stands were poorly stocked. Red maple (*Acer rubrum*) is another species that was seldom mentioned in descriptions of presettlement forests, but became common in the burned-over landscape.

Wild fires continued in the Lake States following the logging era, and reforestation was impossible until they were brought under control mainly in the period of 1920-1950. Early reforestation was hampered by the lack of seed source of most species, but particularly the pines. Artificial regeneration accounts for most of the recent increase in the areal extent of the pine type with strong predominance of red pine.

The cessation of fires and maturation of aspen and jack pine set the stage for the development of the new pulp-oriented industry. Most of the aspen and jack pine forests are managed by clearcutting on a 30-60 year rotation (Chase *et al.* 1970). Gradually other species, particularly red pine, but also various hardwoods have been entering economic maturity for pulpwood production and are increasingly being managed for this purpose.

It is not the use of the forest resource that is causing conflicts with ecosystem management, but rather the methods we have developed for utilizing it. Because the pulpwood industry is based on utilization of relatively small-dimension wood, it encourages perpetuation of short-lived species, usually in pure cultures, or young stages of species with potentially greater longevity. This strategy perpetuates forests that have been compositionally and structurally simplified during the logging and settlement period.

Perhaps the first step toward the development of the ecosystem approach to management of the Lake States forests is to move away from the concept of maintaining existing forest cover types and guide their development through any of a variety of pathways that are a part of natural forest development for a particular site. The intent is not to reestablish the presettlement pattern of forest vegetation, but to include in our managed forests some of the compositional elements that have been lost in the initial wave of forest utilization. This approach will continue to yield wood products and other forest commodities, but in different mixtures of species and by different schedules. Some express fear that this type of management would make it too difficult for procurement planning. However, the rapid expansion in computer technology should make monitoring and projecting of the available forest resources less of a problem than we now perceive it to be.

SOME EXAMPLES OF OPPORTUNITIES FOR APPLYING ECOSYSTEM CONCEPTS TO MANAGEMENT

Very broadly speaking, three types of forest communities represent the vast majority of forest currently managed in the Lake States: (1) aspen, (2) red pine, and (3) "northern hardwood" which has an overwhelming dominance of sugar maple.

Aspen in particular dominates landscapes that are capable of supporting a much greater range of community composition. To be sure, some aspen stands at maturity contain little or no advance reproduction of other potential species simply because their seed sources have been eliminated. Such stands can, of course, continue to be harvested and regenerated back to aspen until recruitment of other species occurs naturally, but artificial introduction of such species as white pine, for example, is also an alternative.

On the other hand, many aspen stands already contain adequate reproduction of white pine, red oak, red maple, balsam fir and other species. These species will not be able to reach canopy status under the clearcutting system aimed at perpetuation of aspen. This is because aspen-regeneration clearcuts remove all size classes regardless of species. Rapidly growing aspen root suckers subsequently outgrow all other species that may have become established in the clearcut. There are many silvicultural techniques available, however, to maintain, or at least prolong, the presence of aspen in the stand and encourage other species. Perhaps white pine offers the best opportunities for co-management with aspen. When white pine saplings in aspen stands are of sufficient height, they are capable of staying ahead of aspen sprouts as mature aspen is removed from the stand. Because stocking of white pine saplings is usually relatively low, another aspen generation can still be established. In fact more than one rotation of aspen can be produced during a single rotation of white pine. If enough white pine is retained on the landscape to maintain the seed source, pine and aspen can be managed together indefinitely. Similar strategies may be possible with red oak and perhaps other species on appropriate sites.

As described earlier, where pine has been reestablished by artificial regeneration, pure red pine plantations rather than mixed stands prevail. At the time these plantations were established, artificial regeneration was the only alternative. However, it does not follow that a system based on clearcutting, site preparation, and replanting remains the only alternative to managing future pine forests. Where white pine seed sources exist, thinned red pine plantations often exhibit prolific advance reproduction of white pine which can be regenerated with the shelterwood system.

Red pine plantations have been notorious for their lack of structure and often lack of any understory development. However, there is ample evidence that, with proper silvicultural treatment, such plantations can be transformed into much more diverse and structured stands. Many thinned plantations have a significant component of red oak regeneration. This species is not only valuable for wildlife, but as all deciduous species, plays an important role in the nutrient cycling process that improves soil fertility. Prolonging the rotation of some red pine and carrying oak through the stand regeneration process will preserve more management options for the future. Under favorable conditions mixed stands of all three native pines can at least temporarily occupy a site. On all former mixed-pine landscapes, a mosaic of stands of the three pine species of various ages can be maintained.

The "northern hardwood" complex is a much oversimplified term for mixed communities usually dominated by shade tolerant sugar maple or American beech with various mixtures of other shade tolerant and mid-tolerant species. Two other species, eastern hemlock and yellow birch also shared dominance on many sites prior to the logging era, but are now much less abundant, and often entirely absent. Single-tree or group selection management as commonly practiced today successfully maintains this type, but it leads toward increasing dominance of sugar maple at the expense of all other species. Stand structure is maintained by following stocking guides based on control of basal area, stem density and average diameter. Furthermore, stocking guide norms are achieved by removing stems in following order of priority: (1) those that may not survive to the next cutting cycle, (2) those with unacceptable amount of cull, (3) those showing poor vigor, and finally, (4) species considerations. In order to improve species composition, stocking guides may have to be followed more loosely and criteria for order of removal may have to be adjusted according to local conditions. In addition, if hemlock and yellow birch abundance is to be increased, silvicultural procedures to stimulate regeneration will have to be applied. In those stands where hemlock and yellow birch seed sources are lacking, artificial introduction of the species may be considered.

CONCLUSIONS

Forest ecosystem management can only be carried out in the context of resource utilization. Although forests in all parts of the United States have been altered to one degree or another since European settlement, they have for the most part not lost the capacity to support again those compositional and structural components that have been eliminated. Managed forests can function as natural and sustainable ecosystems if we move from the static, cover type based system to a dynamic approach to management. Although much remains to be learned about the function of forest communities and ecosystems, the essential tools for embarking on this type of management are clearly in the hands of the forestry profession. No forest ecosystem management is possible without the use of the scientific and empirical knowledge accumulated by the forestry profession.

The primary obstacle to implementation of this new management strategy will not be the lack of ecological or technical knowledge, but rather the difficulty of reaching society's consensus on which forest values will prevail. To illustrate this difficulty we only need to look at the example of aspen resource described earlier. Aspen is not only an important species for pulp and paper industry, but is also vigorously promoted by wildlife interests. For example, the aspen resource today supports much higher population levels of popular game species such as white-tailed deer (*Odocoileus virginiana*) and ruffed grouse (*Bonasa umbellus*) than ever before. In order to proceed with the ecosystem approach to management some of these values will have to be compromised. We must accept the reality that science cannot provide objective basis for prioritizing society's values.

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U.S. Structural Economic Changes and the Lake States Forestry Sector[1]

Edward M. Bilek[2] and Jeffrey C. Stier[3]

HIGHLIGHTS

- The decline in the rate of productivity growth that occurred since 1973 represents a return to the lower long term rate at which U.S. productivity has been increasing (2.0%-2.5%), a rate which is more likely to hold for the future than the much higher rate which the U.S. recorded from 1940 through about the mid-1960's.

- There is considerable evidence to support the "growth towards convergence" hypothesis, which states that nations that started with lower standards of living than the U.S. will achieve faster rates of growth and will close the gap between their standard of living and that of the U.S.

- Earnings cannot grow faster than productivity without rendering a nation's exports noncompetitive and leading to a decline in the international purchasing power of that nation's currency. This adjustment began for the U.S. in 1987.

- The "deindustrialization" of the American economy is neither unique to the U.S. nor a new phenomenon. Rather, it is characteristic of all industrialized economies and is the natural result of improved productivity performance in the sector which is losing workers relative to the sector which is growing in employment.

- The growth rate of productivity is not uniform among manufacturing industries. The lumber and wood products industry has matched or bettered the average performance of industries in the manufacturing sector, while the paper and allied products industry has tended to lag the average.

- Part of the growth of the services sector represents a shift of traditional manufacturing practices, such as marketing and technical support, to contract services.

- There are differences among service industries. The conventional wisdom that all service jobs are low paying and part time is not true for all industries within the sector. However, it is an accurate characterization of jobs in the retail trade industry and in the "services" industry itself; earnings are lower and jobs frequently provide few or no benefits compared to manufacturing jobs.

- Regardless of how "middle class" is defined, the evidence indicates that it has been shrinking since 1973, with older families and families in the upper portion of the distribution benefiting at the expense of those which are poorer and younger.

- Changes in the relative earnings of workers of different gender and with different skills and educational levels have reflected both demand and supply factors. This is especially true for education level. The earnings premium associated with a college education has been increasing in recent years in response to higher fractions of young workers entering the work force with only a high school education. Both the manufacturing and service sectors are expected to demand higher educational and skill levels in the future.

- Families have been able to improve their economic status by having a greater percentage of wives participate in the paid labor force, but this is not a new trend caused by the recent decline of the middle class. It has been taking place since World War II and the fraction of working wives is expected to continue to increase in the coming decades.

- The decline of real income for lower income households has limited home ownership, especially among younger families for which home equity is the principal source of net worth. Conversely, increased income of older Americans has made it easier for older families to own their own home.

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[1]Prepared for the Bureau of Forestry, Wisconsin Department of Natural Resources, and the Lake States Forest Resource Alliance, November 1993.

[2] Visiting Professor, Department of Forestry, University of Wisconsin-Madison, Madison, WI 53706.

[3] Professor, Department of Forestry, University of Wisconsin-Madison, Madison, WI 53706.

- American lifestyles may be changing as reflected in an emerging trend for rental housing among older families which prefer greater flexibility and time for travel, and in the trend towards shorter, more frequent vacations by working families faced with less total time available for leisure.

- Bureau of Economic Analysis projections are for total U.S. employment to increase by 0.5% per year between 1988 and the year 2020, with employment in the services industry growing at double that rate but manufacturing showing virtually no change. The Lake States are expected to mirror national trends in the shifting of employment from manufacturing to services, but manufacturing will continue to constitute a larger proportion of the economic base of the region than the nation as a whole.

- Employment in the region's lumber and wood products industry is expected to increase at 1% per year, more than twice the rate for the national industry. The pulp and paper industry is projected to reduce employment by about 0.2% annually at both the regional and national levels.

- The net result of changes in the region's forest products industries is projected to be an increase of about 16,000 jobs by the year 2020, with a similar number of jobs being created in supporting industries such as services.

- Much of the tourism and recreation in the Lake States is natural resource based and this industry should experience growth in the coming decades. There are no projections available specifically for forest resource-based tourism.

- The nature of outdoor recreation has been changing in the region in recent years, with growing interest in biking, cross country skiing, and all-terrain vehicles and with more balance between summer and winter activities. Demand for many of these activities is expected to stabilize as the population ages and participation in some forms of recreation, such as hunting, is expected to decline in the future.

- With greater numbers of single-parent families and families in which both husband and wife work, demand has grown for shorter, more frequent trips to higher quality facilities closer to home which offer a broader range of activities on site or within close proximity.

INTRODUCTION

The U.S. experienced a period of steady and prolonged economic growth following World War II. Overall economic growth advanced at an annual rate of 3.8% from 1960 to 1973, at which time the oil supply crisis and subsequent recession changed the picture. However, unlike in previous recessions when recovery was characterized by a return to the long term economic growth trend, real gross domestic product (GDP) from 1974 through 1991 expanded at an annual rate of only 1.8% (Economic Report of the President 1992) while our main international competitors in Europe and Asia recorded substantially higher rates of growth. The lagging performance of the U.S. compared to its international competitors was matched by a rapid increase in the merchandise trade deficit and by a 25% rise in the rate of unemployment between 1973 and 1987 (Economic Report of the President 1992).

Concomitant with these changes in overall U.S. economic performance have been trends in a host of leading economic variables. Among these are the following (Litan *et al.* 1988, Mishel and Simon 1988, Bowles *et al.* 1990, Burtless 1990, *The Economist* 1990, Hulten 1990, Shor 1991):

- stagnating income—in 1990-1991, median family income in real terms was only 4.5% greater than it was in 1973

- decline in weekly earnings—average weekly earnings in 1990-1991 were only 88% of their level in 1973; in fact, both average weekly hours worked and the real wage rate fell after 1973, resulting in a real weekly earnings decline to the level of 1960

- increase in two-earner families—the wife participated in the paid labor force in 42% of married couple families in 1973 versus 59% in 1991, and families in which the wife did not work outside the home experienced a 9% decline in median real income

- shifts from labor to property income—73% of national income was derived from compensation to workers in the early 1970's; by the early 1990's, this had fallen to 59%

- decline in personal savings rate—Americans saved an average of 8% of their disposable personal income in the early 1970's versus less than 5% in 1991

- increasing inequality of income—in 1959 the bottom 35% of individuals and families made as much as the top 4%; by 1989 the top 4% made as much as the

bottom 51%. Income inequality also increased *between* groups defined by age and education for both men and women as well as *within* groups defined by age, education and gender

- "deindustrialization" of the economy—since 1973, manufacturing's share of total nonagricultural employment has declined from 26% to 17%, a change which has been exactly offset by a corresponding increase in jobs in the service sector

- decreasing leisure time—workers now spend more time on the job than they did 40 years ago and, if the present trend continues until the year 2000, will be spending as much time working as they did in the 1920's.

This paper examines the main economic forces underlying these trends and attempts to assess their significance for the U.S. as a nation and for the Lake States as a region.

LONG-TERM PRODUCTIVITY GROWTH IN AN INTERNATIONAL SETTING

All of the changes outlined above have been interpreted as implying that American living standards can be expected to rise more slowly or perhaps even decline in the future, and most of them have been linked to the slowdown in productivity growth. The rate of growth of productivity is important for a nation because it is the principal determinant of increases in the standard of living. Indeed, Baumol *et al.* (1989, p. 2) conclude that "In terms of human welfare, there is nothing that matters as much *in the long run* ([emphasis in original])." Therefore, from the standpoint of long term U.S. competitiveness and living standards, it is important to try to discern whether the record in the post-1973 period represents a short term structural adjustment or is part of a long term secular trend.

The recent slowdown in productivity growth is commonly interpreted as an aberration in an otherwise record of strong U.S. performance, but the long term trend does not comport with this view. Maddison (1982, 1987) examined the rate of change in real gross domestic product (GDP) per hour worked for 16 industrialized countries since 1870. The results for just the twentieth century are presented in Table 1. The U.S. led the field only during and immediately following World War II, and even during the golden years of growth from 1950-1970, virtually every other country grew at a faster rate than the U.S.

The slow rate of long term productivity growth recorded by the U.S. compared to its international competitors has led some economists to hypothesize that nations that are initially poorer will tend grow at a faster rate and thereby to narrow the gap in living standards between themselves and the initially wealthier nations (Abramovitz 1986, Baumol 1986). This has come to be known as the "convergence hypothesis" and there is substantial

Table 1.—*Growth rates in real gross domestic product per worker-hour for 16 industrialized countries, 1900-1980*

Country	1900-1913	1913-1929	1929-1938	1938-1950	1950-1960	1960-1970	1970-1980
			—Percent per year—				
Australia	1.50	0.72	0.21	1.61	5.69	5.90	4.32
Austria	1.01	1.49	0.88	2.20	2.76	2.22	2.83
Belgium	0.90	1.79	1.01	1.14	3.14	3.88	4.88
Canada	2.70	1.21	0.00	5.36	3.09	2.72	1.83
Denmark	2.21	2.57	0.43	1.23	2.97	4.90	3.06
Finland	2.42	1.95	1.89	2.10	3.96	6.37	2.60
France	1.82	2.34	2.83	0.75	4.39	5.38	4.09
Germany	1.41	1.40	2.34	-0.40	6.64	5.29	4.50
Italy	2.35	1.92	2.96	0.56	4.27	6.69	3.91
Japan	1.88	3.42	3.41	-3.20	5.57	9.96	5.03
Netherlands	1.07	2.44	-0.10	1.93	3.33	4.93	4.06
Norway	2.02	2.78	2.61	1.88	4.03	4.52	3.66
Sweden	2.62	2.40	2.66	3.43	3.43	4.79	2.55
Switzerland	1.26	3.18	1.01	1.52	2.98	3.69	1.91
U.K.	0.90	1.44	0.87	2.21	2.19	3.56	2.77
U.S.	**1.98**	**2.39**	**0.74**	**4.03**	**2.41**	**2.51**	**1.92**

Source: Baumol *et al.* (1989, p. 88).

empirical support for it. For example, when Summer and Hetson (1984) analyzed the productivity growth performance of 18 industrialized, 21 intermediate, 9 centrally planned and 23 less developed nations for the period 1950-1980, they found that the convergence hypothesis was supported by the record of all but the less developed countries. Baumol *et al.* (1989), conclude that because the U.S. started with such a high standard of living, it has thus far been able to retain its advantage in terms of absolute living standards even with its slower rate of productivity growth. However, unless America's international competitiveness is improved in the future, other nations will eventually overtake the U.S.

The loss of international competitiveness has also been blamed for causing the "deindustrialization" of the American economy. Under the deindustrialization hypothesis, the relatively slower rate of U.S. growth relative to that of other industrialized countries is thought to render the U.S. unable to compete in international markets, thus producing a slow erosion of market share and a decline in the relative size of manufacturing in aggregate U.S. output. As U.S. products become less competitive, manufacturing is shifted to countries with superior growth performance and American workers who are released from manufacturing are forced to move into the lower paying service sector (Stone and Sawhill 1987, Hatsopoulos *et al.* 1988, Krugman 1991, Williamson 1991). The forces shifting the labor supply outward in the services sector are thought to be reinforced by a high income elasticity of demand for services.

The U.S. did indeed run large trade deficits in its merchandise account during the 1980's. However, even over this period, U.S. exports of industrial and manufactured goods increased rapidly and the U.S. share of world trade in manufactured goods grew (Drucker 1986, Economic Report of the President 1992). The trade deficit arose because U.S. imports increased at an even faster rate than exports. Short run trade deficits do have consequences for labor, but the precise impacts are difficult to isolate. For example, O'Neill (1987) notes that some manufacturing industries which experienced large increases in import penetration in the 1980's; e.g., furniture and fixtures, were also industries in which employment was expanding. On the other hand, both the lumber and paper and paper products industries saw the ratio of imports to total consumption increase while employment was falling.

Differences in productivity among nations should not lead to long term imbalances in trade because ultimately deficit countries will experience reduced demand for their currency by foreigners, with a resulting drop in the foreign exchange rate. This adjustment process began with the weakening of the U.S. dollar in 1987 and the gap between the value of imports and exports has narrowed substantially since then (Figure 1).

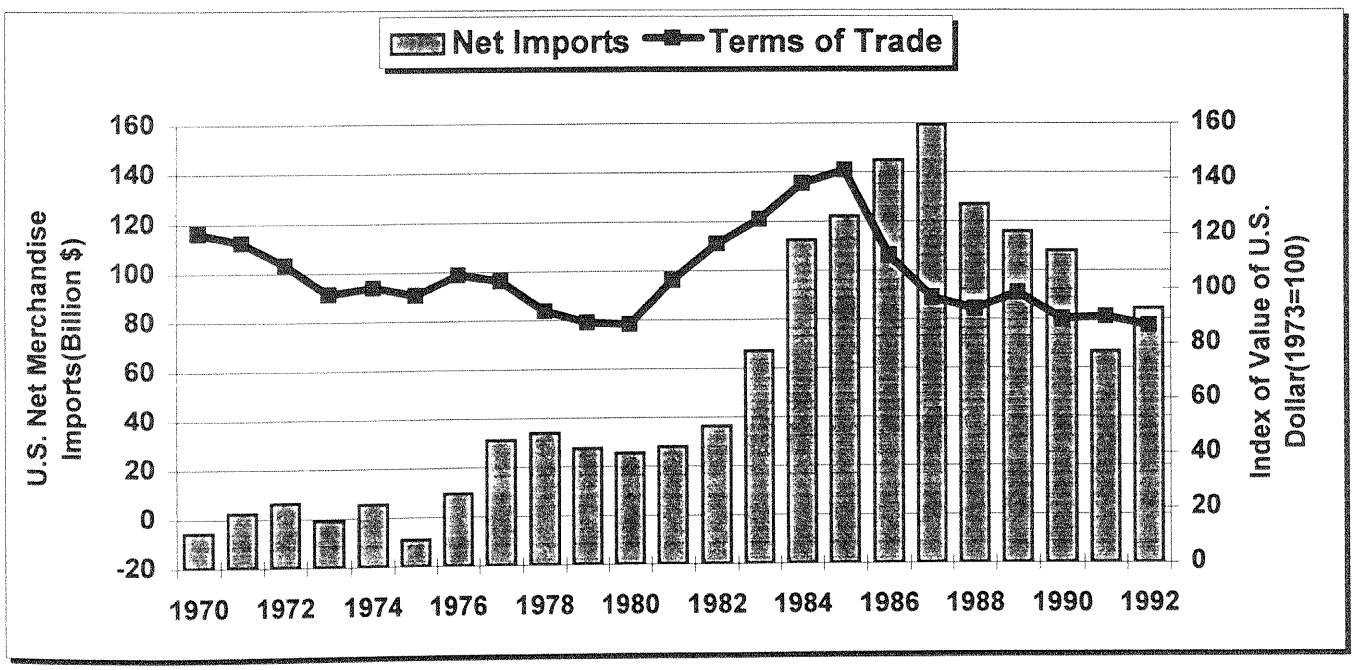

Figure 1.—*U.S. net merchandise trade balance and trade weighted index of dollar value, 1970-1992.*

A falling exchange rate is not without costs because it is equivalent to a reduction in the real wage rate of labor; i.e., to a reduced rate of improvement or even an absolute decline in living standards, leading Baumol (1989, p. 611) to observe that "... the cure [for lagging productivity growth] will indeed be worse than the disease."

If the recent slowdown in American productivity growth were responsible for the "deindustrialization" of the economy, competitor nations which are achieving greater productivity gains should be expanding their manufacturing sectors at the expense of the U.S. and should exhibit stagnant or shrinking services sectors. However, neither of these conditions holds true. The shift from manufacturing to services is a long term phenomenon that is shared by all the major industrial nations (Table 2).

Baumol (1987) also compared the share of the labor force in services in the U.S., Canada, Japan, New Zealand and 15 European countries. While the U.S. led the field with the largest share of labor in services in 1980, it had the second lowest percentage gain among the 19 countries over the preceding 15-year period, and nine nations registered increases that were two to three times that of the U.S. It is simply not true that America is shifting to a service sector employer at a faster rate than its more productive competitors. This evidence led Baumol (1989, p. 611) to conclude that while "Productivity is acknowledged as the key to what the U.S. economy has achieved in the past and what it can hope to accomplish in the future, ... its effects do not include the 'deindustrialization' of the U.S. economy."

Rather, productivity in manufacturing has grown faster than it has in services, thus freeing workers from manufacturing even as aggregate manufacturing output has increased. Workers displaced from manufacturing and new first time workers entering the labor force who could not find employment in that sector have had to search for employment elsewhere and the services sector has provided the needed jobs. This process has proceeded at an even more rapid pace in precisely those countries with which recent U.S. productivity growth has compared unfavorably. Indeed, the irony of the situation is that the U.S. would have deindustrialized at an even faster rate if it were a world technological leader in manufacturing.

Table 2.—*Distribution of employment by sector for six industrialized countries, 1870-1984*

Year	France	Germany	Japan	Netherlands	U.K.	U.S.
			Percent of total			
			AGRICULTURE			
1870	49.2	49.5	67.5	37.0	22.7	
1913	37.4	34.6	64.3	26.5	11.0	
1950	28.5	22.2	48.3	13.9	5.1	
1960	21.9	13.8	30.2	9.5	4.6	
1973	11.0	7.2	13.4	4.9	2.9	
1984	7.6	5.5	8.9	3.3	2.6	
			INDUSTRY			
1870	27.8	28.7	13.8	29.0	42.3	
1913	33.8	37.8	13.9	33.8	44.8	
1950	34.8	43.0	22.6	40.2	46.5	
1960	36.3	48.2	28.5	39.2	46.7	
1973	38.4	46.6	37.2	35.7	41.8	
1984	32.0	40.5	34.8	26.4	32.4	
			SERVICES			
1870	23.0	21.8	18.7	34.0	35.0	
1913	28.8	27.6	21.8	39.7	44.2	
1950	36.7	34.8	29.1	45.9	48.4	
1960	41.8	38.0	41.3	51.3	48.7	
1973	50.6	46.2	49.4	58.6	55.3	
1984	60.4	54.0	56.3	68.7	65.0	

Source: Maddison (1987, p. 689). "Agriculture" comprises agriculture, forestry and fishing. "Industry" includes mining, manufacturing, electricity, gas, water and construction. "Services" is a residual which includes all other economic activity, including government.

This phenomenon, in which all industrialized nations find that their share of manufacturing in aggregate output remains approximately constant while the share of the labor force in manufacturing declines, is what Drucker (1987, p. 775) calls the "... uncoupling of manufacturing production from manufacturing employment." Drucker argues that this is such a strong long term trend that no increase in manufacturing production is likely to reverse either the decline of manufacturing employment as a share of total employment or the number of blue-collar jobs, and that any country or industry that places the preservation of blue-collar jobs ahead of international competitiveness will preserve neither jobs nor production.

In summary, the long term trends in international competitiveness indicate that, even if the U.S. is able to improve its overall rate of productivity growth, the standard of living in other industrialized nations can be expected to continue to advance at a faster rate and the process of shifting labor from manufacturing to the services sector will not be reversed.

CONSEQUENCES OF THE RISE OF THE SERVICE ECONOMY

Several decades ago, Baumol (1967) hypothesized a "cost disease" model of unbalanced productivity advance. The deindustrialization model implies that labor is "pushed" out of sectors in which productivity is lagging relative to international competitors and into the services sector where labor intensity is greater. This transition should shift the labor supply outward for the services sector, thereby leading to lower relative prices for services. In contrast, the cost disease model implies that labor is "pulled" into the sector with lower productivity growth and higher labor intensity, and that this process leads to higher relative prices. These price increases have little chance to be mitigated by foreign trade because most services are not traded on the international market. The general trends in inputs, output and productivity (Table 3) support the cost disease model. Multifactor productivity, which is the residual growth in output that is not explained by changes in capital and labor inputs and which therefore measures the extent to which output can grow without additional use of scarce inputs and the means by which payments to labor and capital can be increased without raising output price, has advanced much faster in the manufacturing sector, especially since 1980, than in the private non-farm business sector as a whole and this has enabled prices of manufactured goods to rise more slowly than prices of services.

While the general trends with respect to the manufacturing and service sectors are clear, not all industries have been affected equally. Multifactor productivity for the manufacturing sector as a whole grew at the rate of 1.3% per year from 1949-1988. The lumber and wood products industry (SIC 24) fared far better (1.6% per year) and has consistently increased productivity even in the post-1973 period (Figure 2). In the most recent decade examined by Gullickson (1979-1988), the price index for all inputs in the lumber and wood products industry rose at an average annual rate of 3.2% but total factor productivity increased at 1.6% per year, thus cutting the increase in the price of output to a similar rate. This was the third lowest rate of price increase among the 20 manufacturing industries analyzed by Gullickson (1992). In contrast, the pulp and paper industry (SIC 26) managed to approximate the sectoral

Table 3.—*Annual indexes of input, output and productivity for U.S. sectors (1982=100)*

Measure	1960	1970	1980	1990
		PRIVATE NON-FARM BUSINESS		
Output	51.9	76.2	101.7	137.2
Labor	74.4	91.7	101.8	123.1
Capital Services	38.4	68.7	92.0	128.3
Output per worker-hour	69.8	89.1	99.9	111.5
Output per unit capital services	135.1	126.6	110.5	107.0
Multifactor productivity	84.8	98.5	102.8	110.1
		MANUFACTURING		
Output	55.0	82.3	100.9	147.0
Labor	94.2	106.5	112.9	107.6
Capital Services	40.3	64.3	70.4	112.0
Output per worker-hour	58.4	77.2	96.6	136.6
Output per unit capital services	136.6	128.0	113.4	131.3
Multifactor productivity	72.6	87.5	100.5	135.1

Source: Monthly Labor Review, May, 1993, p. 116.

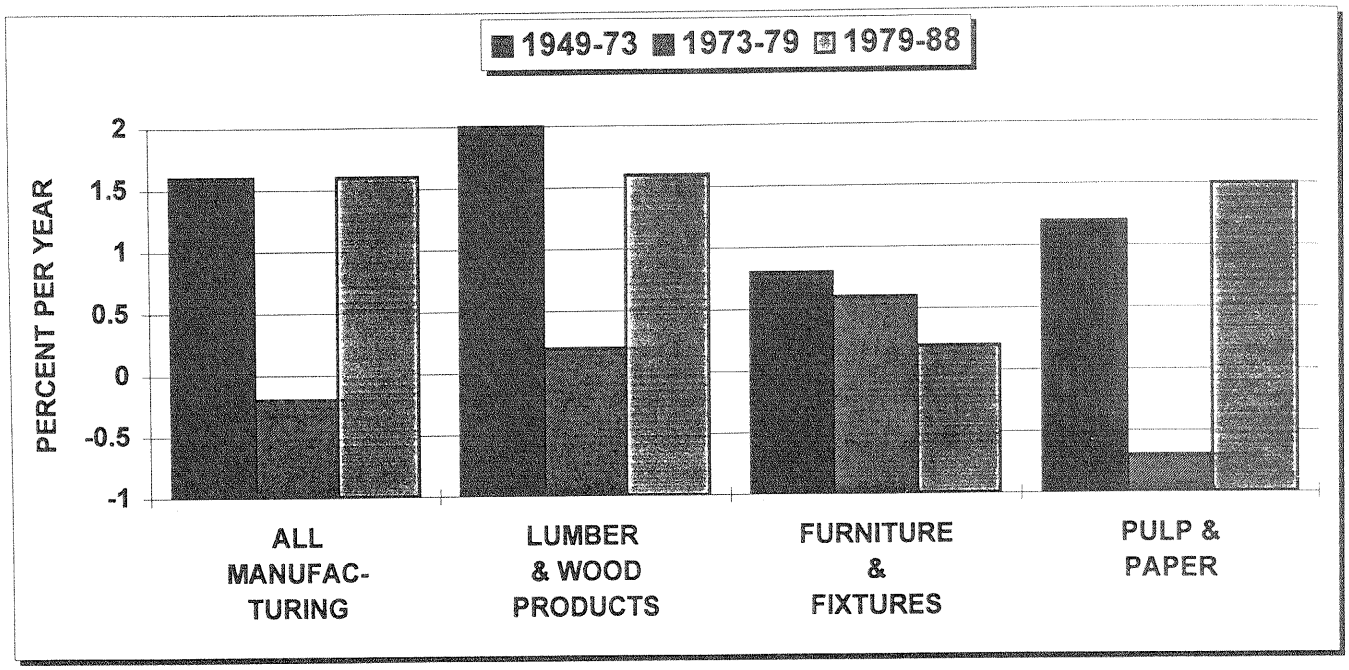

Figure 2.—*Annual rates of multifactor productivity change by manufacturing industry, 1973-1988 (from Gullickson 1992).*

rate of productivity increase only over the last decade and the furniture and fixtures industry, of which only a portion involves wood products, performed well only during the energy crisis (Figure 2).

Despite only average growth in productivity, the pulp and paper industry has been competitive in the international marketplace. Galbraith (1991) suggests that high wage jobs are to be found primarily in those industries which fare well in international trade because industries that do well tend to share their profitability with labor in the form of higher wages. Using this criterion as a filter, Galbraith analyzed U.S. manufacturing industries and identified a cluster of successful "advanced technology" industries, which included pulp and paper. He concluded that industries in this cluster did well because they benefited from the position of the U.S. as a country of relatively cheap land, low energy prices, and preeminence in science, technology and advanced training. Industries in which the U.S. lost ground were labor- and materials-intensive, but Drucker (1986) points out that cheap labor costs will likely become less of an advantage in international trade in the future because labor costs will shrink as a fraction of the value of finished products. Indeed, in what would seem to be one manifestation of this principle, General Motors announced in July, 1993 that, as a result of the expected reductions in tariffs under the North American Free Trade Agreement, the firm is planning to move production of 70,000 cars per year from Mexico back to Michigan where the infrastructure is stronger and workers are more productive.

There is also evidence that some of the increase in the services sector is more apparent than real. The broad services sector is comprised of transportation, retail and wholesale trade, finance, services and government. Some of the reduction in manufacturing and increase in services is due to the move towards higher value-added products, which involves more attention to marketing and customer servicing, and some is due to an increased tendency for manufacturing firms to contract for more business services; e.g., legal work, engineering design, data processing, maintenance or market research (Schmid 1988, Testa 1989). After examining the situation for the Great Lakes Region, Testa concluded that the services sector has absorbed many activities which would formerly have been included in manufacturing, and that this has led to underestimation of the contribution of manufacturing to the national and regional economies.

Nor is it true that all service sector jobs are low paying. Weekly earnings in manufacturing were equal to or exceeded those in several service industries in 1992 (Figure 3), but in wholesale trade earnings were on par with, and in transportation exceeded, those in manufacturing. Retail trade pays very poorly, and those employed in "services," which includes legal, social, personal, business and medical service occupations, fare little better (Figure 3). The retail trade industry is characterized by a preponderance of part time work (average 28.8 per week) and low average wages ($7.14 per hour). However, despite the poor performance of the American economy in 1992, average weekly wages in

the services industry equaled those in manufacturing ($11.40 per hour), and it was only the lack of full time employment in the former (average of 32.5 hours worked per week) which precluded equality of average weekly earnings in the two industries. Medical services has been the fastest growing field of employment, expanding by 125% between 1973 and 1992, and continuing to increase during the past 2 years when unemployment was rising even among white collar workers (Nardone *et al.* 1993).

When comparing returns to labor, wages are not the total story. An increasing portion of labor costs is devoted to fringe benefits, which currently comprise about 28% of total employee compensation (Kosters 1992). Part time jobs and even full time jobs in many industries within the services sector do not include medical coverage or retirement benefits (duRivage 1992). For example, 75% of all workers in manufacturing are offered pension plans by their employers versus only half of those in the services and 40% in the retail trade industries (Gendell and Siegel 1992). As the share of employment in the goods producing sector declines and the share in the services sector increases in the future, older workers will have to rely more upon Social Security and personal savings to finance their retirement.

WHAT DO THESE TRENDS MEAN FOR THE U.S. STANDARD OF LIVING?

Public perception of what constitutes a "middle class" job can take two general forms. If it is interpreted as a job which returns sufficient real earnings to purchase the typical goods and services associated with a middle class life, such as a car and house, then the number of middle class jobs could grow even as earnings inequality increased due to the entire earnings distribution being shifted outward. But if a middle class job is viewed as one which returns an income in the middle of the earnings distribution, then the polarization of the earnings distribution will imply a reduction in the number of middle class jobs regardless of the value of real earnings. Thus it is important to examine changes in both the level and distribution of earnings in arriving at conclusions about how the middle class has been faring.

The real dollar value of the median income of males in 1991 was $1,200 less than in 1979, and throughout the 1980's it exceeded the 1979 level in only 2 years. Levy and Murnane (1992) conducted an extensive analysis of recent changes in the level and distribution of earnings in the United States. They concluded that earnings inequality increased since 1979, especially for men but also for women, and that this inequality was the result of variation in wages rather than in hours worked. For men, the inequality took the form of polarization around a stagnant earnings level; i.e., the proportions of men earning less than $20,000 and more than $40,000 in 1988 constant dollars both increased while the proportion in the middle of the distribution declined. Their conclusion is that, at least for men, the number of "middle class" jobs is fewer now than in the previous decade, regardless of which definition of middle class one applies.

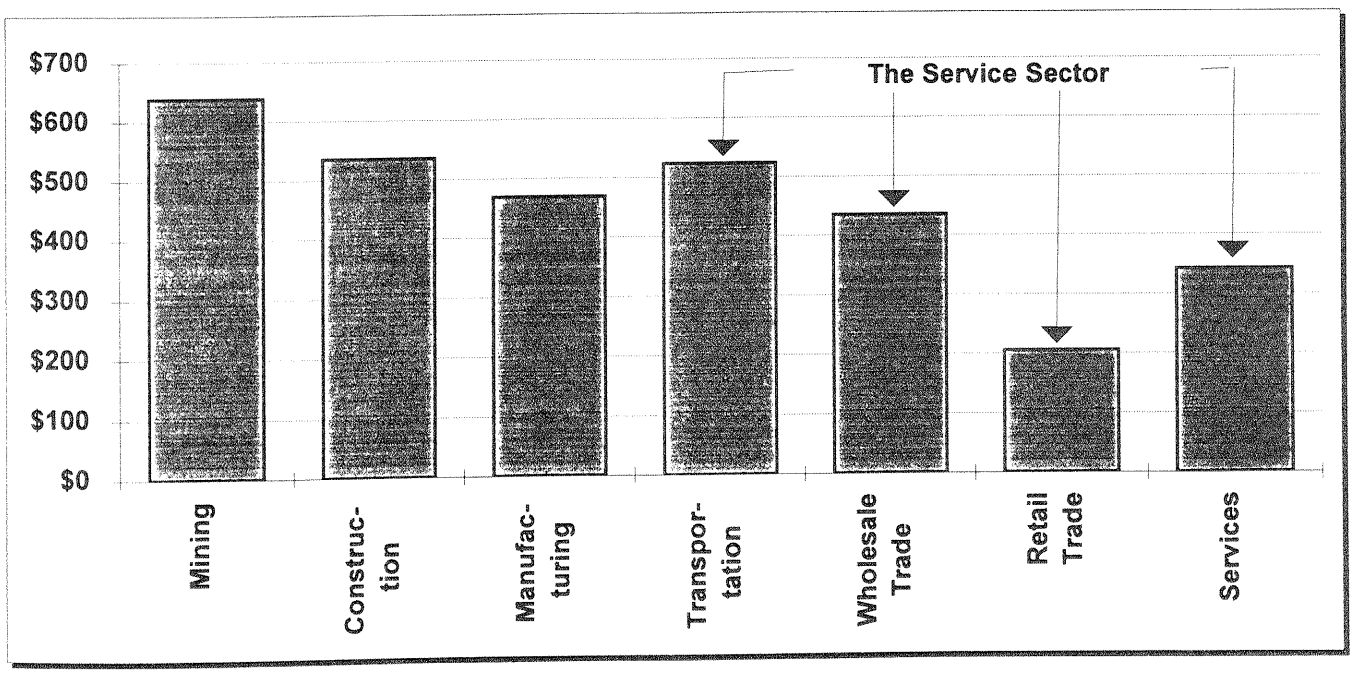

Figure 3.—*Average weekly earnings by industry—1992*

Most economists have attributed the loss of middle class jobs to demand factors, more specifically to the post-1973 deindustrialization of the American economy which has been discussed previously. But this ignored Lawrence's (1984) earlier findings that the share of men with middle class earnings declined within *both* the manufacturing and the services sectors. Thus, the shrinking middle class cannot be attributed totally to sectoral shifts from manufacturing to services.

The evidence suggests that supply forces were also at work. The earnings premium for college education; that is the ratio of earnings of college graduates relative to high school graduates, fell dramatically between 1971 and 1979 for men age 35-54 years. The earnings premium then increased from 1979-1987, but did not recover to its 1971 level. For men age 25-34 years and for working women of all ages, the earnings premium associated with a college education fell from 1971 to 1979, but then recovered to its 1971 level (women) or recorded an overall increase over the 1971-1987 period (men). On the other hand, the earnings of older workers relative to those of younger workers increased for both men and women over the 1971-1987 period, regardless of education. Katz and Murphy (1992) attribute these trends principally to changes in the rates of growth of the different segments of the labor force (supply shifts) working in tandem with a stable rate of growth in the relative demand for college educated workers (a demand shift). The 1970's saw a huge influx of college educated workers enter the labor force and this drove down the earnings premium associated with a college education (Ryscavage 1993). Just the opposite happened in the 1980's; i.e., the largest growth occurred among high school graduates and there was a deceleration in the growth of college educated workers as a fraction of the work force. These young (25-34 years) workers with only a high school education were typically those displaced from the manufacturing sector and were forced to find jobs in the services sector where wages were lower both because of lower productivity and because they faced competition with women who were less commonly employed in manufacturing sector (Levy and Murnane 1992).

The increase in inequality of earnings, especially between groups with different educational levels, is the result of both demand and supply factors. The traditional employer of less educated workers is the manufacturing sector, but declines in the relative demand for these workers occurred both in manufacturing in general and within specific industries. Nor are the declines likely to be reversed in the near future. The Bureau of Labor Statistics reports that a much larger fraction of layoffs in the 1990's have been permanent rather than temporary (Nardone *et al.* 1993). This suggests that industries are undergoing a structural transformation to try to reduce labor costs and that even if the manufacturing sector were to expand in the future, the demand for workers who do not have a college education cannot be expected to increase at a comparable rate.

While real per capita income has declined from its high in the early 1970's, households have been able to raise their income slightly and families have done even better. Families have actually been improving their economic status even more than the trend in median income indicates because family size has been decreasing over time. Families and households have been able to raise their incomes by putting more members into the labor force. Seventy percent of households are families. The wife's participation in the paid labor force has increased steadily since 1973 and this has frequently been attributed to a need to supplement the husband's earnings. While there is no denying the contribution of wives' earnings to family income, wives' participation in the paid labor force has been increasing at a steady rate throughout the post World War II period (Figure 4) and shows no sign of having been accelerated by the stagnation of per capita earnings which occurred since 1973. Only about 60% of all wives currently work in the paid labor force and there is no evidence of a slowdown in the growth of participation. Therefore, it seems likely that a higher percentage of families will augment their incomes with the earnings of wives in the future .

The economic and demographic changes that have taken place since 1970 have had the effect of benefiting older families at the expense of younger families (Table 4). Families headed by men or women age 24 years or younger have seen their median income drop to just 73% of what it was in 1970, and it is now no higher than it was in 1960. Even families headed by someone age 25-34 years experienced a decline, although it was much more modest. In contrast, families of retirement age (65+ years) have continuously improved their real income since 1950, and registered a 56% gain just since 1970 (Table 4).

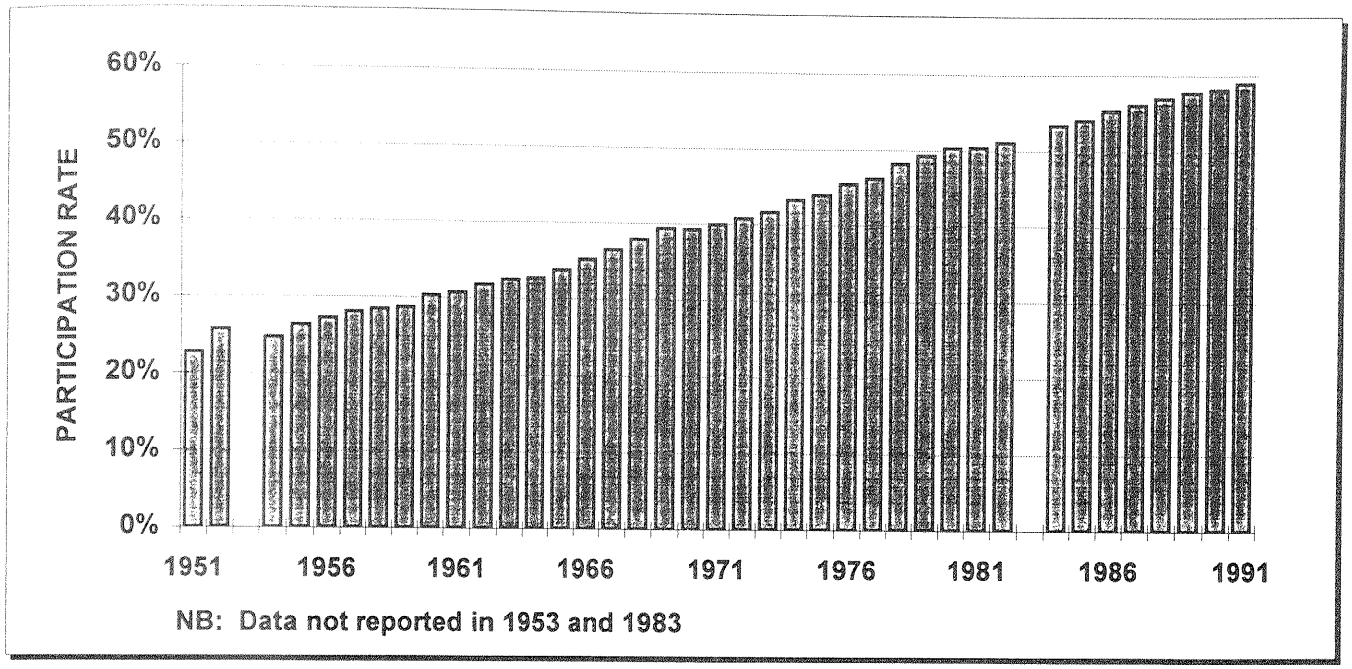

Figure 4.—*Participation rate of wives in the paid labor force for married-couple families, 1951-1991.*

When the wife in a married-couple family enters the paid labor force, family income rises. But single parent families face a much more difficult time. In 1950, 11% of all families were headed by a female with no husband present; by 1991 the fraction had doubled. Only 69% of all working women hold full time jobs. Part time jobs, such as those that are more frequent in the services industries, typically do not include medical and retirement benefits (duRivage 1992). In addition, the median earnings of women who do work full time are only 60% those of men.

The economic effects of changes in earnings are evident in home ownership patterns. During the 1960's and much of the 1970's, home prices and mortgage rates were low to moderate and families in the 45-64 year age group recorded the highest rate of increase in home ownership (Hitschler, 1993). Both home prices and mortgage rates rose dramatically in the late 1970's and early 1980's. The real income gains of those age 65 years and older versus young families are reflected in changes in the pattern of home ownership. U.S. Bureau of Census data indicate that in 1990, 78% of households headed by someone age 65 years or older owned their homes, up from 70% in 1980 (Figures 5a and 5b). Recent studies show a positive relationship between household formation and *current* income of younger Americans (Kent 1992), and this is evident in the pattern of ownership in recent years. Among households headed by someone age 34 years or younger, the rate of home ownership fell from 44% in 1980 to 40% in 1990. And the median age of home purchase is also expected to rise from 29.8 years in 1990 to 31.8 in the year 2000 (Howard 1993).

Table 4.—*Median real ($1991) earnings of families by age of head of household, 1950-1990*

	Age of head of family (years)					
Year	15-24	25-34	35-44	45-54	55-64	65+
1950	$13,584	$17,493	$18,943	$19,151	$16,937	$ 9,893
1960	$16,978	$24,068	$27,155	$27,401	$23,611	$12,254
1970	$23,207	$32,493	$37,628	$39,973	$34,235	$16,664
1980	$22,826	$33,780	$40,829	$45,108	$38,944	$21,319
1990	$16,902	$32,822	$42,789	$49,149	$40,678	$26,103

Source: U.S. Department of Commerce, Bureau of the Census, 1992.

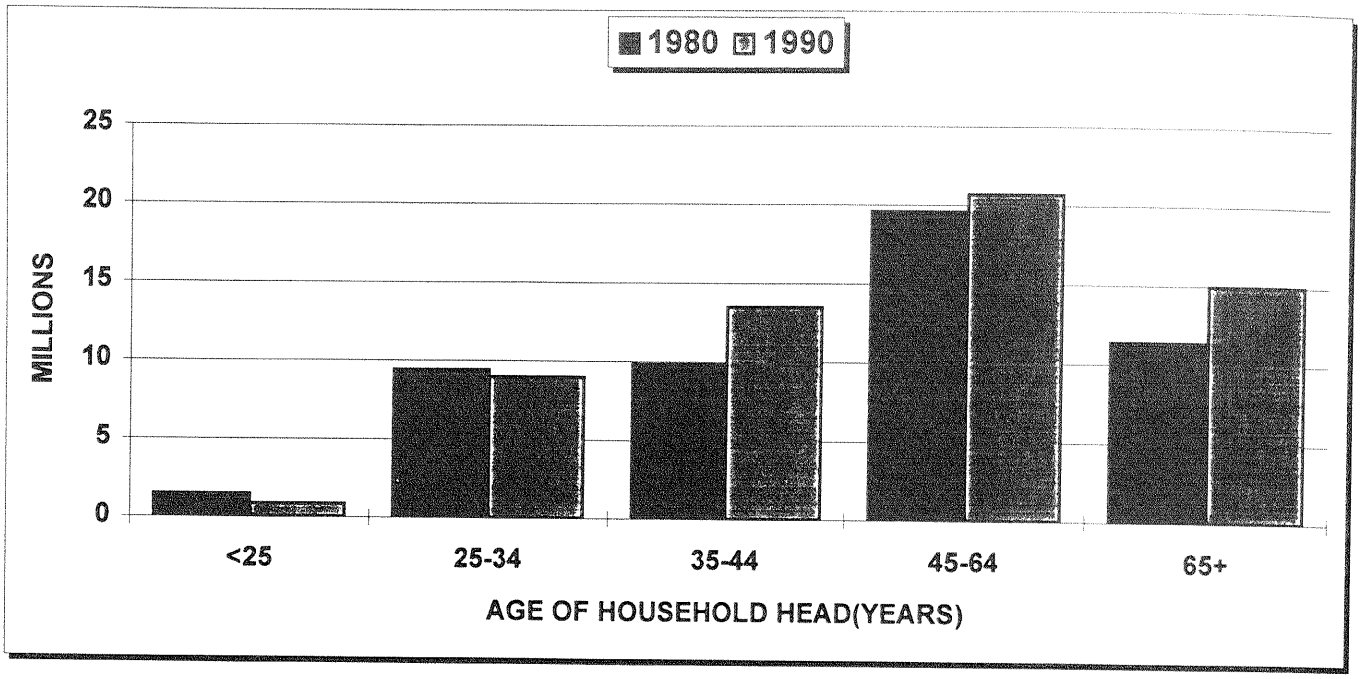

Figure 5a.—*Distribution of owner-occupied housing units by age of head of household, 1980 and 1990*

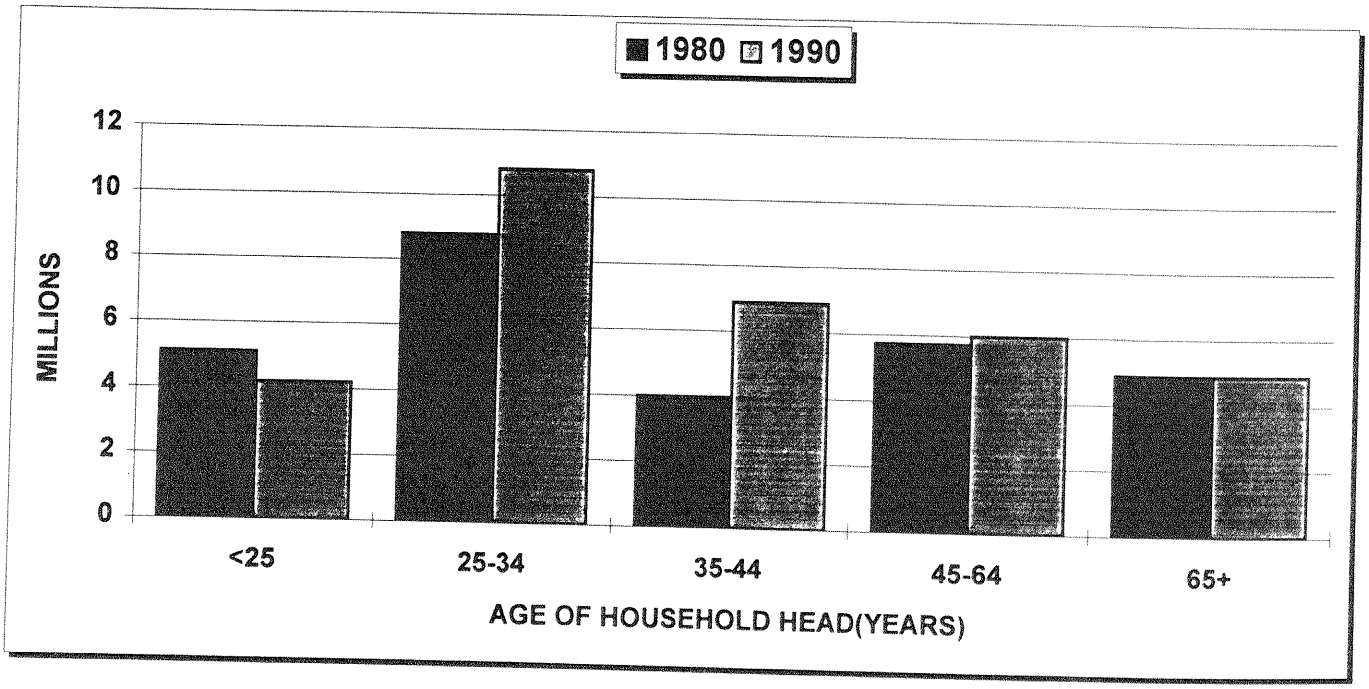

Figure 5b.—*Distribution of renter-occupied housing units by age of head of household, 1980 and 1990.*

Home ownership is also important because it is the principal source of wealth for most families, but especially among those with lower incomes. For households in the bottom two income quintiles, home equity constitutes half or more of their total net worth (Figure 6). Thus, home ownership is a form of investment which is extremely important to families, one which is promoted through national tax and lending policies and which has held or increased its value through time. Gross and Weinstein (1992) argue that the recent economic climate and tax policies have encouraged both investment in housing in preference to other assets and a view of home equity as a form of personal saving, and that this helps explain why the U.S. personal savings rate has declined in recent decades. They conclude that this has led to over investment in residential construction. Other economists contend further that real housing prices will not rise as fast in the future or might even decline, especially in the West and the Northeast, and that if this occurs households could reverse the decline in personal savings rates by investing in other assets to fund their retirement (Gross and Weinstein 1992, Kadlec 1993).

The income distributions shown in Table 4 are snapshots taken at single points in time. They do not capture the dynamics of the family income "life cycle," in which earnings of young families typically increase as they age and gain experience in the work force, and then decline upon retirement. Thus, if a young family headed by someone age 15-24 years can expect to increase its earnings according to the pattern shown as one moves to the right in a row of Table 4, then they have the prospect of earning a current middle class income of $35,000. U.S. Census Bureau studies of changes in income during from 1985 to 1986 indicate that 34% of young families were able to move out of the lowest quintile of the income distribution in one year versus only 18% for all families (Kosters 1992).

Education was a key factor in mobility. For example, while 37% of the families headed by someone with a college education moved up from the lowest quintile, the comparable percentage was only 11% for those with a high school diploma and less than half of that for those without a high school education. Kosters (1992), citing longitudinal studies of families in two 9-year intervals (1967-1976 and 1977-1986), also indicates that half of all families which start in the lowest quintile were no longer there 9 years later. U.S. Treasury studies of income mobility for 1979-1988 showed a similar pattern of movement. Thus, data from both surveys and tax returns show that even in the period since 1973, families did move up in the income distribution and that as they did so, they were replaced by others which typically began at the low end. With trends towards more single parent families, a smaller percentage of entrants into the labor force having a college education and the continued shift from manufacturing towards services, it is not clear that these movements upward in the income distribution will proceed at the same pace in the future.

There are also signs that some major changes in lifestyles may be occurring. For example, home ownership by singles rose from 11% of total homes in 1987 to 19% in

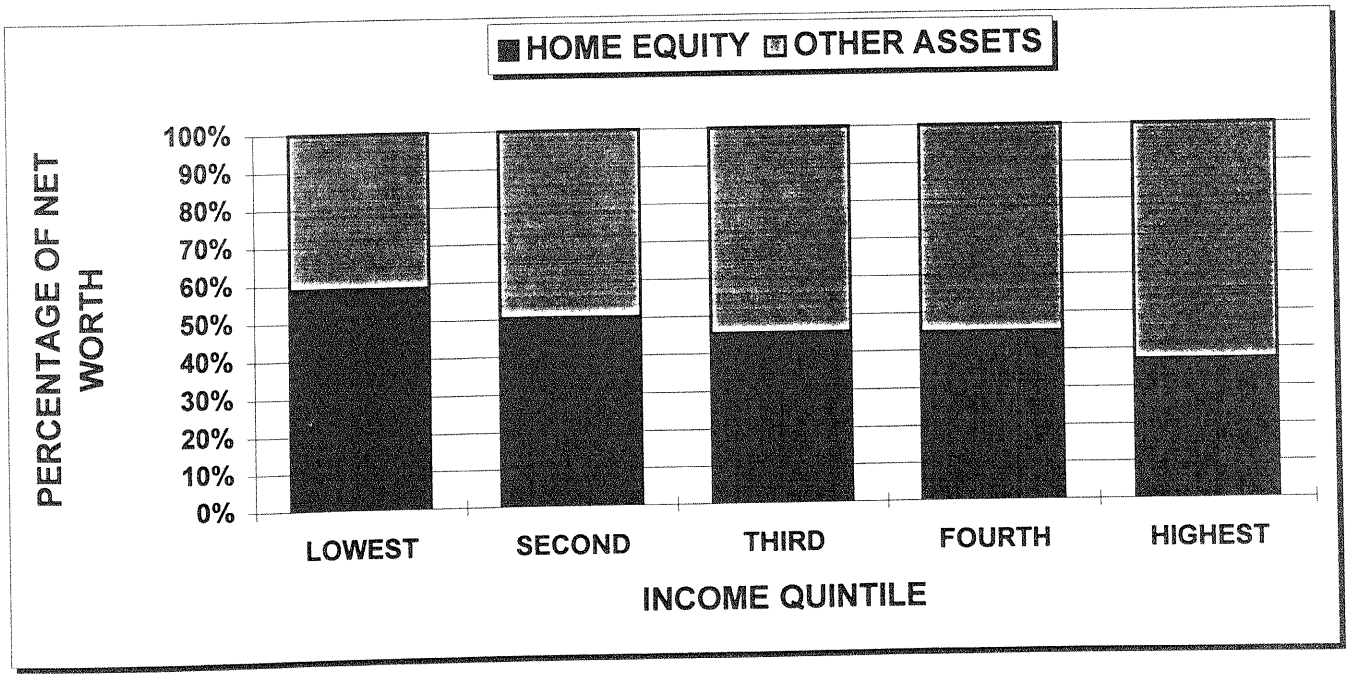

Figure 6.—*Source of net worth by income level, 1988.*

1992 (Gaines 1993). On the other hand, despite the increase in home ownership among older Americans, some property management firms are reporting that the number of renters between ages 35 and 64 years will increase by 28%, with the largest gains (53%) in the 45-54 year age bracket (Howard 1993). Analysts attribute the trend to a decline in the rate of appreciation of home prices, and the desire of older families to maintain greater mobility without the responsibilities of home ownership. This mobility is reflected in the threefold increase between 1980 and 1990 in expenditures on travel by Americans aged 65 years and older (Hitschler 1993).

It is too early to determine whether the increase in renting by older Americans that Howard (1993) cites will become a permanent trend. If it does, the demand for multi-family residential structures should increase relative to that of single family homes. In addition, any shift to rental properties by the many older families which already own homes would place existing homes on the market, and many of these homes would be the smaller, more affordable size that appeal to young families who are purchasing their first home. Thus, if older Americans who have benefited from rising incomes change their spending patterns in favor of rental housing, it could both decrease the future demand for wood products in housing and benefit younger families whose incomes have not been rising by placing more existing homes on the market.

Lifestyle changes are also being reflected in Americans' pattern of leisure activities. The President's Commission on Americans Outdoors (1987) reported that the amount of time devoted to leisure has declined since 1970, and had fallen by eight hours per week by the mid-1980's. And Shor (1991) noted that working hours are currently longer than they were 40 years ago and that if present trends continue to the year 2000, workers will be spending as much time at their jobs as they did in the 1920's. Yet, the number of hours devoted to recreational activities of all types has remained constant and many Americans perceive outdoor recreation as an enjoyable part of a healthy lifestyle (Thorp and Smith 1991). The aging of the population, the increase in single-parent families and the reduced time available for general leisure have led to increased demand for more frequent but shorter trips to vacation and recreation sites which provide a higher level and broader range of conveniences and experiences.

IMPLICATIONS FOR THE LAKE STATES FORESTRY SECTOR

The national shift from manufacturing into services is expected to continue in the future and to carry over into the Lake States (Figure 7). The U.S. Bureau of Economic Analysis (1990) projects employment in the service sector to increase in the Lake States, from its 1988 level of 25% of total employment to 30% by the year 2020. This approximately mirrors the level and increase expected at the national level. However, the Lake States region is more specialized in manufacturing than the U.S. as a whole and the decline in manufacturing employment is also expected to be slightly less, from its 1988 level of 20% to 17% in the year 2020 (Figure 7).

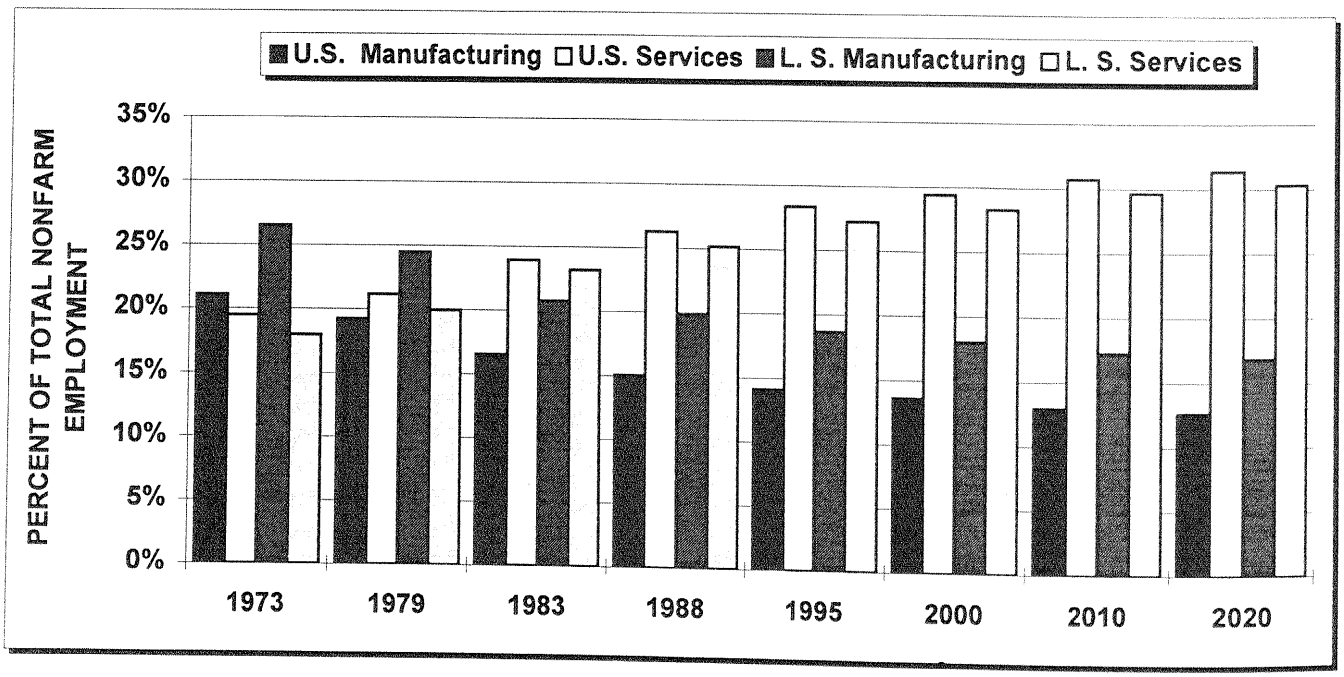

Figure 7.—*United States and Lake States employment in manufacturing and services as a percent of total non-farm employment, 1973-1988, with projections to 2020.*

Over the past 20 years, real per capita personal income trends have differed among the three Lake States (Figure 8). Michigan recorded substantial declines in personal income relative to the national average during the recessions of the mid-1970's and the early 1980's when well paying manufacturing jobs were lost. However, neither recession had much effect on average incomes in Minnesota where incomes have remained at or slightly above the national average. In Wisconsin relative income rose throughout the decade of the 1970's, but then fell steadily throughout much of the 1980's. All three states have shown gains in relative income over the last 3-5 years, with Wisconsin registering the most consistent recovery (Figure 8). If the region is successful in retaining its specialization in manufacturing, real personal income should grow at a slightly faster rate than for the rest of the U.S.

Demand for products produced by the U.S. paper and allied products industry (SIC 26) is closely associated with aggregate economic performance. During the period prior to 1975, total U.S. consumption of paper and board was about 18.5 million tons per billion dollars of GDP (constant $1982), but after the energy crisis the ratio fell to about 17.5 million tons per billion dollars. The energy crisis did have a long term effect on the industry. Purchased energy consumption fell from an average of 21,700 Btu's per ton of output in 1972 to just 13,500 Btu's per ton in 1991, thus enabling total purchased energy consumption to drop by 12% when output was increasing by over 40% (American Paper Institute 1992).

The paper industry is relatively mature and future growth is likely to be tied directly to growth in aggregate GDP; i.e., in the range of 2.0%-2.5% per year over the coming decades. There has been a strong push to increase use of recycled fiber in the industry and this is expected to continue. The population centers within the Lake States and neighboring Midwest states should continue to give the region a comparative advantage in both the demand for and supply of recycled fiber products.

The paper industry is also technologically advanced and both wages and weekly hours worked exceed the average for the manufacturing sector. However, the slow rate of expected output growth, combined with productivity improvement stemming from technological change, are anticipated to result in continued loss of jobs in the industry (Franklin *et al.* 1993, U.S. Bureau of Economic Analysis 1990).

Future growth in the U.S. lumber and wood products industry is closely tied to events in the construction industry, and especially residential construction, which absorbs 75%-80% of all softwood lumber and structural panels (Widman Management Ltd. 1991). The Lake States is primarily a hardwood producing region and therefore has not been as dependent upon the construction industry for markets as have the West or the South. The largest single market for hardwoods is in materials handling; viz., pallets and boxes, and demand for these products is tied directly to the performance of the aggregate economy. Therefore, growth in the hardwood market is expected to be similar to that for paper and paperboard over the next few decades.

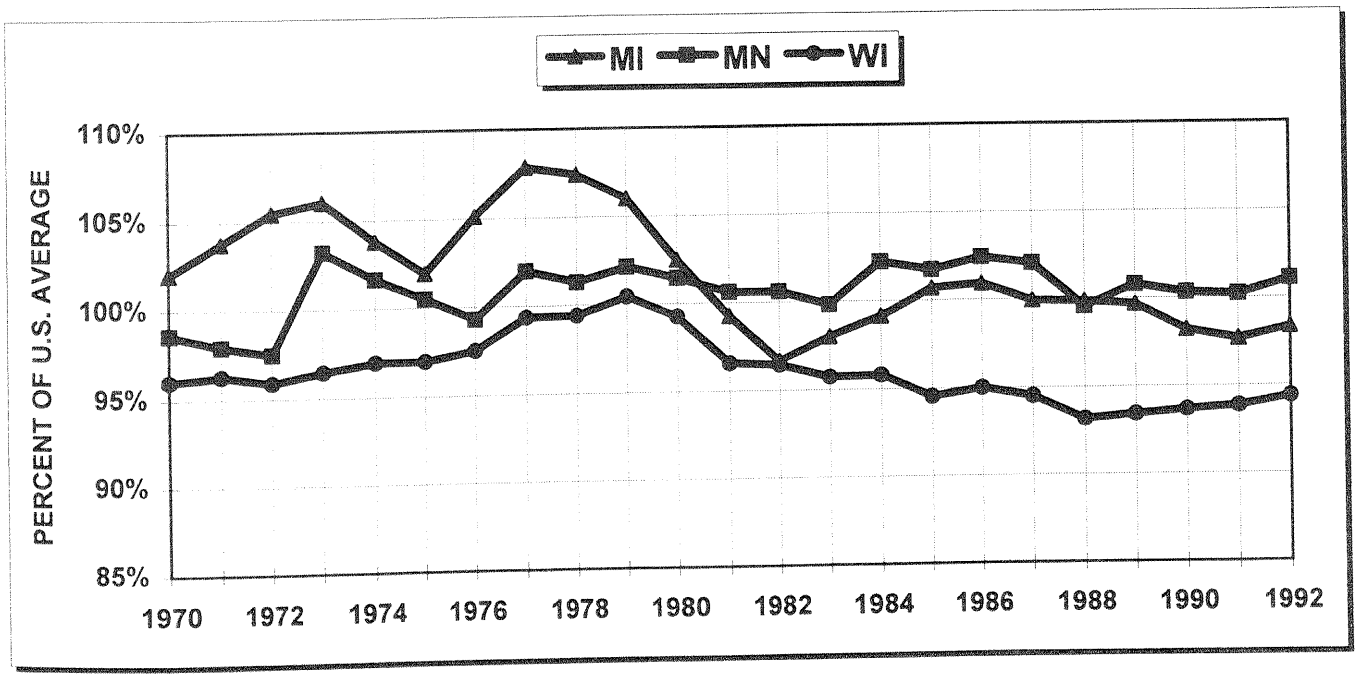

Figure 8.—*Lake States per capita real personal income as a fraction of the U.S. average, 1970-1992.*

If there is a shift towards greater preference for multi-family housing units in the U.S., especially among older Americans, it is likely to have less of an effect on the Lake States forest products sector than in other regions. Single family housing typically uses 25%-33% more softwood lumber and plywood per unit than multi-family structures do and a shift in preference towards multi-family units could dampen future growth in demand for wood products. Multi-family structures use about 40% of the amount of oriented strand board (OSB) per unit as do single family homes, so that growth in demand for OSB would be affected less than for softwood products. The Lake States has become the principal supplier of oriented strand board (OSB), which currently accounts for about 20% of the structural panel market. OSB is expected to increase market share steadily in the future as it continues to substitute for softwood plywood in additional uses (Widman Management Ltd. 1991). Therefore, regardless of the relative share of single family versus multi-family housing constructed in the coming decades, the Lake States should enjoy continued market growth.

Total employment in both the U.S. and Lake States pulp and paper industry remained approximately constant from 1973-1988 with the exception of a drop during the recession of the early 1980's, and the U.S. Bureau of Economic Analysis projects a further loss of 6%-7% of both the national and regional work forces by the year 2020 (Figures 9a and 9b). In contrast, employment in the U.S. lumber and wood products industry increased by one-third from 1973-1988 and by 46% in the Lake States. U.S. Bureau of Economic Analysis projections are for the region to continue to outperform the national average and to increase the work force by another 34% by 2020 (Figures 9a and 9b). Despite the decline in jobs in the paper industry, by the year 2020 the lumber and wood products and the paper and allied products industries together are expected to represent 10% of all manufacturing employment in the region, up from just under 9% in 1988. Each job in manufacturing directly contributes to the creation of 1-1.5 additional jobs in supporting industries which provide inputs and services, such as transportation and marketing (Schmid 1988). Employment multipliers for the forest products manufacturing industries are estimated to be of similar magnitude (Pedersen and Chappelle 1989, Sample and LeMaster 1992, Anon 1993). Thus, the additional 16,000 jobs anticipated in those industries in the Lake States by the year 2020 can be expected to spur creation of a similar number of jobs in supporting industries.

Expansion of forest industry jobs should help reduce employment instability in parts of the region. Orr and Buongiorno (1991) found a positive correlation between forested area and employment instability at the county level, but that the presence of forest industries, especially if they involved smaller firms, mitigated this effect. The region's employment growth is expected to occur mainly in the lumber and wood products industry which is characterized by small to medium size firms. Hence, while economic diversity is also associated with employment stability, other things being equal, some expansion of the forest products manufacturing industries should contribute to overall employment stability.

The natural resources of the Lake States provide a rich base for year-round outdoor recreational activities such as hunting, fishing, biking, skiing and snowmobiling. The intensity of both summer and winter sports is illustrated by the fact that Michigan, Minnesota and Wisconsin rank among the top six states nationally in the number of registered boats and among the top four in registered snowmobiles. Hunting is typically dominated by residents, but fishing draws a significant fraction of nonresidents; indeed, Wisconsin and Michigan are the top two states in sales of nonresident fishing licenses.

Consumptive uses of wildlife resources are expected to decline in the future. For example, while hunting is still a major activity in all three states, the number of hunters has been dropping nationally since 1980 and this trend is projected to continue into the next century (Heberlein and Beckley 1990). Even among those who have hunted in the past, Kellert (1980) found that about half no longer do so. Women and urban residents have a more negative attitude towards hunting than do men. With the increase in female-headed households, greater urbanization and an aging population, participation in sport hunting is expected to decline in the future (Heberlein, 1991).

Relatively new types of recreational activities are becoming increasingly important. Thorp and Smith (1991, p. 126, emphasis in original) refer to bicycling as "... *the* outdoor recreation vehicle," and point out that bicycle sales have outnumbered automobile sales in recent years. Skiing is also popular, but downhill skiing appears to have peaked and has been growing at only about 1% in recent years whereas cross country skiing continues to show strong growth. Both bicycling and skiing are more popular among younger recreationists and as the average age of the population increases, the growth of these activities can be expected to slow.

The amount and kinds of participation in outdoor recreation are correlated with income and age; specifically, participation tends to increase with income at least through the middle income classes but participation in more strenuous activities declines after middle age. A shrinking American "middle class" coupled with an aging population can be expected to lead to increased demand for more moderate, more environmentally

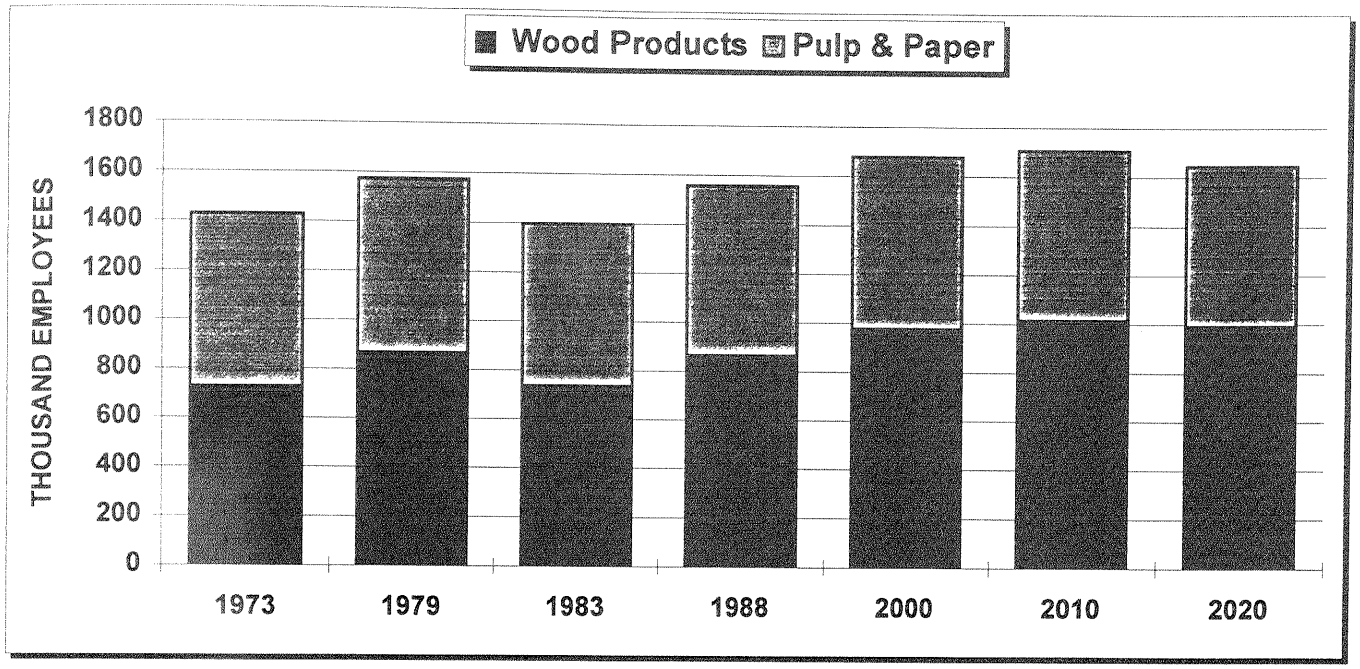

Figure 9a.—*Employment in the U.S. forest products industries, 1973-1988, with projections to 2020.*

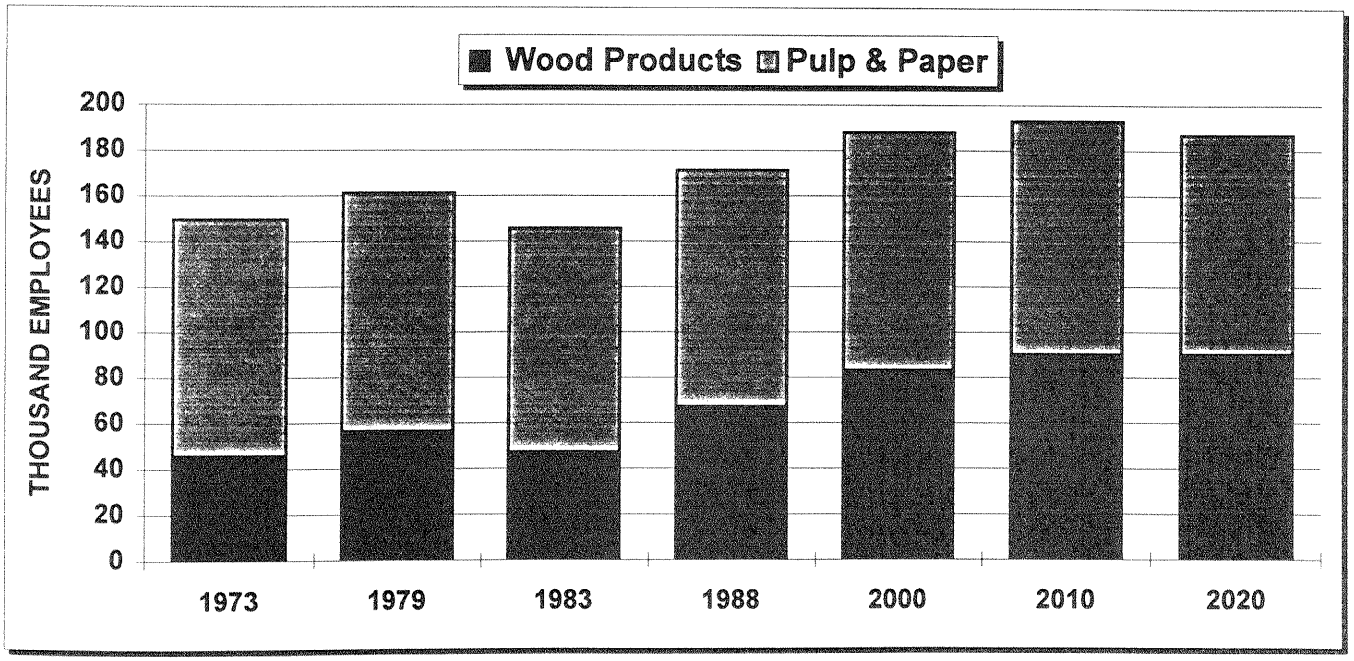

Figure 9b.—*Employment in the Lake States forest products industries, 1973-1988, with projections to 2020.*

appreciative forms of recreation, such as walking for pleasure, sight-seeing and bird watching (Marcin 1993), all of which tend to be done relatively close to home.

Families in which both the husband and wife work have a more difficult time coordinating vacation schedules and the number of hours devoted to work has been rising. In addition, the percentage of single-parent families has been growing. This has created greater demand for high quality facilities close to home which offer a broader range of activities, and for shorter (3-4 day) trips. Numerous projections of the future cost of oil and gas indicate costs rising at between 1% and 2.5% per year, but the U.S. Bureau of Economic Analysis estimates that both total miles traveled and the number of miles driven annually per passenger vehicle will increase. With its close proximity to major population centers in the Midwest, the Lake States tourism and outdoor recreation industry can be expected to exhibit a positive rate of growth.

In summary, the economic changes that the United States is currently undergoing are expected to continue for the next several decades, and to lead to a period of positive but slower growth than was experienced in the decades of the 1960's and 1970's. While the Lake States did not experience the past economic growth that other regions such as the West did, the stage is set for the region to recover some of its manufacturing base, especially in the wood products industries. And, while the spectrum of activities that takes place in forested areas is expected to undergo some change in the future, the rich and varied natural resources of the Lake States will continue to provide a strong base for the tourism and recreation industry in the coming decades.

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Recreation Activity and Tourism Spending in the Lake States

Daniel J. Stynes[1]

EXECUTIVE SUMMARY

Lake States forests support a variety of recreation and tourism activities. Using existing data, estimates are made of person days of participation in 18 outdoor recreation activities for each county in the states of Michigan, Minnesota, and Wisconsin. Estimates of tourism spending are also derived by county and within five market segments. As the estimates draw from many different data sources for the period 1985-1995, they should be interpreted as representing activity circa 1990. The estimates are generally conservative relative to other reported figures, as we have enforced consistency across data sources and used county level lodging inventory, sales, taxes, and other economic measures as control totals.

Inconsistency of data across sources and a general lack of time series data for recreation and tourism preclude quantitative measures of recent trends. The indicators that do exist point to reasonably stable levels of outdoor recreation activity in the Lake States for most activities and areas, and modest increases in tourism activity and spending since 1985. Some local areas and activities are, of course, experiencing significant increases or decreases in recreation and tourism activity, but local data is generally inadequate at this time to confidently document these changes quantitatively. Trends and likely futures are summarized for the region as a whole using qualitative information gleaned from recent studies.

Annually, the region generates about 200 million person days of participation across 14 resource-based outdoor recreation activities, roughly 12 days of activity per person per year. The region receives about 230 million days. The Lake States are net importers of outdoor recreation generally, drawing many visitors from the surrounding states of Ohio, Indiana, Illinois, and Iowa. Activities accounting for the largest number of days are fishing, camping, boating, golf, hunting and hiking.

Our estimates of tourism spending cover only spending in destination counties on trips of 50 miles or more or trips involving an overnight stay. Airfares, en route spending, spending for major durables, government spending, and spending on day trips of less than 50 miles are not included. With these omissions, we estimate that tourists spend about 9 billion dollars annually in the Lake States. In terms of spending, the two most important market segments are visitors staying in motels (43% of total sending) and users of seasonal homes (20%). Campers account for about 5% of all tourism spending, 19% is attributable to visitors staying with friends and relatives and 12% is spent on day trips of 50 miles or more.

Using input-output models for the three states, the economic impact of tourist spending can be estimated. About 6 of the 9 billion in tourist spending is captured by the region's economy. This spending directly generates $3.2 billion in income to the region and supports 214,000 jobs. The multiplier effects of tourist spending are primarily induced (household spending of income earned in tourism industries) as the lion's share of tourism spending goes directly to income (wages, salaries, rents and profits). Linkages to production sectors of the economy are limited. With indirect and induced effects, tourism spending supports almost 400,000 jobs in the region and contributes $8.6 billion in income. Outdoor recreation trips represent between a third and a half of all tourism spending in the three states.

The three states are very similar in terms of the types of outdoor recreation activities, kinds of tourism development, and general patterns of flow of tourists from southern population centers and out-of-state markets to northern forested counties. The nature, size, and relative importance of outdoor recreation and tourism varies significantly, however, across individual counties. Urban counties receive the largest amount of tourist spending, but much of this is not directly related to forest resources. Northern and rural counties are much more dependent on resource-based tourism. Four types of counties can be identified :

1. tourist destination counties that have substantial motel and resort development, along with a mix of attractions and forest recreation opportunities,

2. seasonal home areas, where over 40% of housing units are seasonal and other tourist development is more limited,

3. day use areas closer to population centers, and

4. multiple use areas that have a balance of day use activity, camping, seasonal homes, and motels.

[1] The author is a Professor, Department of Park and Recreation Resources, Michigan State University, East Lansing, MI.

Trends and implications for forest management vary considerably across these four types of areas. Forests surrounded by tourism development centered around resorts, casinos, ski areas and other attractions have potential opportunities to expand markets and support area tourism development. Such forests are also under increasing use and development pressures.

Growth in seasonal homes in the Lake States along with related patterns of retirement and elderly migration is perhaps the most significant trend affecting Lake States forest management. While populations statewide are growing very slowly, populations in many northern counties are increasing more rapidly, due primarily to elderly migration, seasonal home conversions and other amenity migration.

Historically, seasonal homes around inland lakes, rivers, Great Lakes, and in forested areas have generated a considerable share of outdoor recreation and tourism activity in the Lake states. Seasonal home owners and retirees use local forest resources primarily for outdoor recreation and amenity services. They generally do not depend on forest resources or the local community for income and are therefore less likely to support commercial uses. We estimate that seasonal homes account for 20% of tourism spending in the Lake states, and perhaps half of outdoor recreation and forest-related tourism activity. Much of this is concentrated in northern forested areas. Seasonal homes have important implications for water quality, forest fragmentation, access, and outdoor recreation, as well as fire and timber management (Stewart and Stynes 1994).

Water is by far the most important forest resource for outdoor recreation and tourism. Further waterfront development and recreational use will continue to put increasing pressures on water resources in the Lake States. Much of the private shoreline on Great Lakes, inland lakes and rivers is already developed making access an increasingly important issue. Development and use will continue to move northward from population centers and existing tourism areas, as people seek areas that are less expensive and less congested. Conflicts over land use, public land management, and between development and preservation interests will inevitably follow this migration.

Lake States forests must meet the needs and wants of an aging population and more diverse set of customers and stakeholder groups. With increasing time pressures, many Americans are taking shorter trips, recreating closer to home, and seeking higher levels of quality and service. The private sector is providing an increasing share of recreation by filling specialized market niches. Public providers have raised fees, expanded partnerships, and adopted marketing methods to better serve their customers. They have not, however, been able to adapt as rapidly as the private sector, and in many cases face declining resources and dwindling markets for their more traditional products and services. Forested regions of the Lake States will continue to undergo a transition from commodity to amenity uses. Public land managers will need to balance the demands of traditional stakeholder groups with a diverse array of new interests. Generally this will mean serving a broader public interest and giving greater importance to environmental and amenity uses relative to commodity interests.

INTRODUCTION

The purpose of the recreation and tourism analysis is to document current supply and demand conditions in the Lake States Region (Michigan, Minnesota and Wisconsin) and to assess potential future opportunities and threats. Our approach relies solely on existing data, as no new data were to be gathered in this analysis.

There is a wealth of recreation and tourism data covering the Lake States. Much of the information about outdoor recreation (particularly public providers and resources) is summarized in the three State's most recent Comprehensive Outdoor Recreation Plans (SCORP's). Tourism studies provide greater coverage of the private sector and focus more on linkages to the state economies. The most detailed recreation information comes from studies of individual activities, industries, sites/areas, or markets. There are many examples of studies of campers, boaters, anglers, and hunters in the region, although each study has somewhat distinct objectives and uses different methods and measures.

Recreation participation rates from household surveys vary considerably depending on the response rate, method of contact, age cutoff of the population, definitions of activities, and how questions are asked. Differences in all of these factors makes it virtually impossible to discern trends from surveys conducted at different points in time. Assembling a clear picture of current conditions, trends, and likely futures is complicated by the lack of consistency in the many data sources or for that matter a clear framework for organizing the information that exists. There are many inconsistencies and gaps in data over space, time, activities, and markets.

Estimates of recreation and tourism activity are impossible to interpret or evaluate without the accompanying details on how the estimates were generated and what is covered. Unfortunately there are few standard definitions or procedures, making most estimates largely incomparable. For example, Woodruff (1981) estimated that tourists to Wisconsin spent $6.2 billion in 1981. Van Pelt and Kelly (1988) report $1.8 billion in outdoor recreation spending in Minnesota in 1985. The US Travel Data Center (1992) estimates tourism spending in Michigan at $ 6.7 billion in 1990. These studies each estimate something different and use completely different

methods. The Wisconsin estimate is extremely high as they used sales taxes and counted all restaurant sales in the state as tourism spending.

Relating this kind of information to the Lake States forest assessment is further complicated by problems in isolating the pieces of recreation and tourism relevant to Lake States forests. The majority of tourism spending takes place in urban areas and depending on the study can include visiting friends and relatives and business travel. On the other hand urban recreation, shopping, and computer games are potential substitutes for forest recreation. For these reasons, we have chosen to view recreation and tourism rather broadly in hopes of putting forest-related recreation and tourism into a broader context. Forest managers generally know much more about what is happening on their own forest, than they do about external factors that are likely to influence the future.

Instead of simply developing another set of recreation and tourism estimates and forecasts, we have attempted to develop a framework for integrating existing information, evaluating its reliability and consistency, and making fairly detailed estimates and forecasts. Regularly recurring county level data are combined with parameters estimated from sample surveys in order to be able to estimate recreation activity and tourism spending at the county level within a set of market segments. A set of simple models are implemented in a spreadsheet format to facilitate sensitivity analyses, and make it relatively easy for estimates to be updated based either upon new information or alternative assumptions. Estimates can be made using a set of default state or regional rates, or users can replace the assumed rates with better local information. Two somewhat distinct analyses are carried out, one a recreation analysis focusing on outdoor recreation activities, and the other a tourism analysis focusing on visitor spending and economic impacts.

Before describing the two thrusts and summarizing our estimates, we digress briefly to clarify the distinctions between a recreation and tourism analysis. These orientations imply distinct conceptual bases, lead us to different data sources and methods, and lead the assessment in two somewhat different directions. Stynes and Stewart (1991) map out the general strategy for the recreation/tourism part of the assessment in greater detail.

Recreation vs. Tourism Orientations

The terms recreation and tourism imply quite distinct orientations as well as different measures of "demand" and distinct data sources and analyses. A tourism orientation focuses attention on attracting visitors from outside the region for the income they generate. Tourism, like manufacturing, is an export activity. Tourism businesses depend on the natural resources of the area to attract tourists and support many tourism-related activities. Revenue from tourists is generally captured by lodging establishments, restaurants, attractions, amusements and other retail establishments rather than through direct charges to tourists for access to forest resources. Tourism involves increasing income and jobs in an area by selling goods and services (including natural resource services) to people from outside the local region.

Only a portion of the outdoor recreation supported by a region's forest resources, are, however, "sold" to tourists. In most areas the greatest share of the benefits/services from local forest resources accrue to local residents. These benefits include recreation as well as a variety of other amenity services. Maintaining environmental quality and providing recreational facilities and access will generally benefit both locals and tourists. There are, however, inevitable tradeoffs and potential conflicts in decisions to allocate scarce forest resources to one use/ user group versus another.

A comprehensive look at forest resources must therefore consider both local users and tourists. Seasonal home owners represent a third stakeholder group sharing some characteristics with tourists and others with local residents. Seasonal home owners have intentionally located in an area because of forest resources and outdoor recreation opportunities.

Recreation vs. Tourism Analysis

Tourism is generally defined as travel outside of one's home community usually for pleasure. Formal definitions usually restrict tourism to trips of 50-100 miles or more and/or involving an overnight stay. Statewide tourism demand is typically measured in household surveys conducted in a state's principal market areas. Tourism demand studies may include general pleasure travel, outdoor recreation, convention and business travel, shopping, and visiting friends and relatives. While outdoor recreation is the most closely associated with forest resources, other types of trips can also involve forest resources to varying degrees. A tourism orientation helps focus the assessment on economic impacts and potential, although it also makes the linkages to forest resources less clear. Tourism encompasses many activities only weakly related to forest resources. Tourism also typically has a stronger private than public sector focus, involving businesses not typically considered as forest product industries.

Recreation is generally conceptualized as a set of activities people engage in, either at home, in their local community, or while on trips. Only the last category of recreation activities is included in most tourism analysis. Recreation can also be divided between indoor and outdoor pursuits. Most recreation demand analysis and

forecasts (e.g., English *et al.* 1993) are carried out for individual activities. Outdoor recreation activities depend to varying degrees on forest resources. Water resources are by far the most important natural resource for outdoor recreation. Recreation "demand" at a state or national level is generally determined by means of household surveys to estimate and forecast rates of participation by various population subgroups in different activities (e.g., the 1982-1983 National Recreation Survey, USDI 1986). Recreation economic studies have more typically measured benefits to users in the form of willingness to pay or consumer surplus rather than spending and economic impacts. A recreation orientation for the assessment helps to establish more direct linkages to forest resources, dictates consideration of both monetary and non-monetary benefits from forest resources, and puts more attention on local residents versus visitors from outside the local area (tourists).

Cutting across recreation and tourism demand analyses are site or area specific demand studies. These studies generally employ on-site surveys or visitor counts to estimate use/demand or to identify trends over time. The "site" may be a downhill ski area, a state park, a campground, or an entire National Forest. Due to the large number of potential "sites", and inconsistencies in site specific data across the region, we do not attempt any site specific demand analysis. Instead we seek an intermediate level of analysis between state and national studies and site specific studies. The smallest geographic unit for which estimates are derived is the county. County level estimates can be aggregated to yield estimates for individual states or subregions.

The Lake States Forest Assessment clearly calls for an analysis of both recreation and tourism demand. To this end, we have carried out a two-pronged analysis to develop county level estimates of (1) tourist spending and (2) participation in 18 outdoor recreation activities. The two analyses are carried out separately, but draw from a common county level database and market segmentation approach.

THE GENERAL APPROACH

Given a general lack of consistent time series data about either recreation or tourism and widespread concerns among most experts about the quality and comparability of the data that do exist, the challenge was considerable. Weaknesses and gaps in the database would need to be filled by some logical models and validated wherever possible by control totals and consistency checks. The more we could disaggregate our estimates spatially, by activity, and by market segment, the easier they would be to validate against expert opinion and independent data sources, such as county level sales and tax data. Instead of just generating our own estimates and forecasts, we have assembled a database and set of spreadsheet models that planners and policy analysts in the region can use to make estimates and forecasts. These tools are described more fully in a technical report (Stynes 1995). Here we provide an overview and summarize findings to date.

The spreadsheet models make use of two types of secondary data:

1. county level data covering population size, seasonal homes, use/sales taxes and inventories of motel rooms and campsites; and

2. recreation participation, occupancy, and spending rates estimated from recreation and tourism surveys and other sources.

The county level data help to ground the estimates in data for each county. Data series were chosen based on availability, usefulness for the problem at hand, and ease of being updated. Sales and use tax data are available on an annual or quarterly basis. Population and housing counts are updated every 10 years by the U.S. Census Bureau and can be estimated or projected between Censuses. The lodging inventory data may be the most difficult to keep up to date, although this is not a major task for an individual county or group of counties. Parameters used in the models are typical of what is estimated in most recreation and tourism surveys. These can therefore be updated by new national, state, or regional studies or replaced by estimates for local areas.

Recreation participation and tourist spending are estimated separately for five market segments:

MOTEL	Parties staying overnight in hotels, motels, cabins, and related lodging
CAMP	Parties staying overnight in campgrounds
SEASONAL	Parties staying overnight in seasonal homes
F&R	Parties staying overnight with friends and relatives
DAY	Day users

For the tourism spending module, only spending by day visitors from outside the immediate area (county) is included. Recreation participation is estimated separately for day users from within the county and those from outside the county.

The county level estimates summarized here are based upon the data we have been able to assemble along with "guesstimates" of several model parameters. Local

planners and recreation and tourism analysts will be able to refine or update these estimates by replacing local data with more recent or more accurate estimates, or by making more informed guesstimates or empirical estimates of parameters for their local area. For example, analysts may replace model estimates of recreation participation rates or motel occupancy rates with better estimates for a local area. Since these data are generally not available below the state level, we either assume a statewide rate can be applied to all counties in the region, or tried to explain spatial variations in the parameter using simple models. Either approach may yield errors at a county level.

OUTDOOR RECREATION ACTIVITY

Methods

Recreation participation is estimated at both origins (days generated) and destinations (days received). We do not attempt to model flows of activity between counties, but instead estimate origin and destination activity independently. The need to balance origin and destination activity estimates (after taking into account flows outside the region) provides an additional consistency check. Person days of participation for 1990 are estimated for each origin county by multiplying the resident population of the county in 1990 by a rate of participation in the activity (percent of the population participating one or more times in the last year) and then by a frequency of participation (the average number of times that participants have engaged in the activity within the past 12 months). Variations in participation for different age groups are taken into account by applying age-specific rates and frequencies to the population of each age group and then summing.

Management and planning of outdoor recreation facilities requires estimates of demand for specific destinations. An adequate database to model the distribution of outdoor recreation trips from origins to destinations in the Lake States did not exist. We therefore developed a simpler approach to estimating recreation participation at destinations. This approach also has the advantage of grounding the estimates in recreation and tourism supply measures.

Participation in activities at destinations is estimated by dividing participants into the five market segments defined above. Participation by local day users in a given county is estimated as a percentage of the days generated in the county (i.e., the percentage of days generated that stay in the county) and a share of statewide day trips outside the county of residence. Overnight visitors staying with friends and relatives are assumed to be covered in the day use model. Participation by each of the other three overnight visitor segments is obtained by multiplying a segment-specific participation rate by the number of overnight stays in the county from each segment. Overnight stays are estimated by multiplying a count of motel rooms, campsites, or seasonal homes by an average occupancy rate for the county.

Outdoor Recreation Participation Estimates

A set of regional and statewide age-specific recreation participation parameters (rates and frequencies) were estimated for the Lake States region by drawing from several household surveys, most notably a 1990 National Sporting Goods Association study. Rates for each of the three states are reported in Table 1 and regional rates by age group are reported in Table 2. To capture variations in participation across individual counties, the statewide rates are adjusted at the county level based on an index of the supply of opportunities in the county (a simplified version of the EROS approach developed by English and Cordell 1993). These adjusted rates are multiplied by county populations (within age groups using 1990 Census data) to yield person days of participation generated at counties of origin.

Annually, the Lake States Region generates about 200 million person days of participation across 14 resource-based outdoor recreation activities, roughly 12 days of activity per person per year (Table 3). The region receives an estimated 229 million days. The Lake States are net importers of outdoor recreation, drawing visitors particularly from the surrounding states of Ohio, Indiana, Illinois, and Iowa. Activities accounting for the largest number of days are fishing, camping, boating, golf, hunting, and hiking. The outdoor recreation estimation procedures do not yet include a number of other important activities such as wildlife viewing, using off-road vehicles, fall color viewing, mushroom gathering, etc. These activities are, however, included in the tourism estimates below.

The participation estimates depend on a number of parameters that will continue to be refined via comparisons with other sources. For example, the hunting and fishing estimates have been adjusted to be comparable to the 1991 National Survey of Hunting and Fishing (USDI 1991).

Outdoor recreation activity estimates for the state of Michigan, Minnesota, and Wisconsin are summarized in Tables 3A-3C. Similar tables can be produced using a spreadsheet program for any county or group of counties in the Lake States. For Michigan, we estimate a total of 344 million person days of participation across all 18 activities. If we delete bicycling, swimming, tennis, and golf, since most of the activity in these categories is not directly associated with forests, there were 98 million days of outdoor recreation generated in Michigan in

1990. The state hosted an estimated 101 million person days of resource-based outdoor recreation (14 activities). The ratios of days generated to received indicates that the state is a net importer for many activities (ratios less than one), although some of the ratios suggest possible inflated participation rates for some activities (e.g., camping). NSGA rates have been adjusted downward by about 15% in making these estimates to take into account the general upward bias in household survey-based estimates.

The methods for estimating recreation activity in destination counties is suggested by Table 3A. Days at destination counties are obtained by summing the contribution from six distinct segments. The "Local participation" column determines what percentage of days generated in the county stay in the county. The remainder of days are separated into day trips outside the county and overnight trips. Participation in activities on overnight trips is estimated from the number of overnight stays in each county in campgrounds, seasonal homes, or motels. Separate activity participation rates for each lodging category are applied to the estimates of overnight stays. This avoids the need for a trip distribution model, automatically includes participation on overnight trips from out-of-state, and grounds the local estimates in lodging capacity data. It also provides estimates of the relative contribution of each market segment to recreation participation.

Using freshwater fishing to illustrate (Table 3A), of the 25 million days generated, 15 million took place in the local area (county of residence). Of the remainder, 8 million days were on day trips outside the county and 2 million on overnight trips. There were 28 million days of fishing at destination counties in Michigan, 15 million by local residents, 9 million on day trips outside the county of residence, and 4.5 million on overnight stays. Of the latter, 2.6 million days of fishing were by people in seasonal homes, 1.3 million by visitors staying in motels, and 553,000 by campers.

Estimates of spending by activity can be generated by multiplying the number of person days of participation by an average per day spending figure. The segmentation scheme permits the application of distinct spending profiles for day users, campers, etc., although this type of spending detail is not currently available for most activities. Using our best guesses yielded total spending figures that are generally consistent with those derived independently in the tourism analysis that follows. An estimated $9 billion was spent in the Lake States in 1990 on 14 outdoor recreation activities (trip spending only). Five billion of this outdoor recreation spending is associated with trips outside the county of residence. Based on estimates of outdoor recreation equipment purchases in Minnesota (van Pelt and Kelly 1988) another $4 billion is spent in the three states each year for outdoor recreation equipment.

TOURISM SPENDING

Methods

Analysis of tourism activity tends to be targeted at motel, airline and travel arrangement industries or at statewide tourism promotion programs. It is therefore difficult to isolate outdoor recreation or forest-related activity in most tourism data. A somewhat revised approach was therefore called for to assess tourism activity associated with the Lake States forests. By separating tourists by type of lodging, we can more readily identify forest-related tourism activity such as camping, seasonal home, and automobile-based tourism.

Tourist spending is a convenient and useful measure of tourism activity, particularly if our interest is in linkages to regional economies. Estimates of tourist spending for each county are derived by estimating spending separately for each of five market segments. By summing across segments total tourist spending can be derived. This approach provides a reasonably complete estimate of tourist spending in each county, while also yielding individual estimates for categories (market segments) of tourism more directly linked to forests.

Spending by each of the five market segments is estimated using available data. The purpose is to estimate spending by tourists in each county (i.e., at destinations). The general model for estimating spending by overnight visitors staying in motels, campgrounds and seasonal homes is:

Spending in the county = # rooms, campsites or seasonal homes in the county * occupancy rate (nights per year) * average spending per party per night in the local area.

Distinct spending and occupancy rates are used for each segment and region. For example, a county with 1,000 campsites that are occupied 30 nights a year by camping parties that spend $50 per night in the local area would generate 1,000 * 30 * $50 = $1,500,000 in local spending. This simple model is adjusted to accomodate better information, when available.

Room use taxes and hotel receipts are probably the best indicators of spending by visitors staying in hotels, motels, and cabins. The Michigan room tax is a relatively clean estimator of room receipts at the county level. Spending by motel guests in Michigan counties was therefore estimated by the following equation:

Motel Segment spending = (1990 Room tax receipts/ 0.04) * (Avg. motel guest spending/avg. room costs)

Room receipts are computed by dividing room tax collections by the 1990 tax rate (4%) and then expanding to total spending by motel guests in the local area. Average spending patterns of motel guests are used to estimate what motel guests spend in the local area beyond the cost of their room. Room costs generally represent between a fourth and a third of spending by motel users.

Spending associated with visiting friends and relatives (F&R) and on day trips are two of the most difficult components of tourism to get a handle on. Tourism activity and spending estimates can vary widely depending on whether or how much of this activity is covered. This alone is a good reason for separating out these two segments. Lacking any clear county level indicators of activity or spending associated with these two segments, a top down approach is used. Instead of estimating spending separately for each county and then adding across counties to get a statewide total, statewide totals are estimated first and then allocated to counties using appropriate allocation formulas.

Statewide numbers of day trips and visiting F&R were obtained for Michigan from D.K. Shifflet and Associates Ltd. Estimates for Wisconsin and Minnesota assumed similar ratios as in Michigan of day trips and visiting F&R relative all tourism activity. Person days were converted to party days/nights and then multiplied by an estimated spending per party. Some judgment was used in selecting an average spending per party day, as the estimates from different sources varied widely. In the model, we assume both day users and parties staying overnight at friends and relatives spend about $50 per party per day. Allocations of spending to counties for day users and visiting F&R are then made based on county-level indicators. Spending by the visiting F&R segment was distributed in proportion to county population, as this is probably the best indicator of potential friends and relatives to visit. Day trips are the most difficult to allocate to counties. A weighted average of population and motel-based spending was used.

Since the model is based on spending at destination counties, some tourist spending is not fully included. For example, en route expenses not associated with an overnight stay in a given county are not presently included, nor are day trips from out-of-state, airfares, spending for major durables, government spending, or construction and maintenance of seasonal homes.

Tourism Spending Estimates

Tourists spend about 9 billion dollars annually in the Lake States (Table 4). The two most important market segments are visitors staying in motels (43% of total sending) and users of seasonal homes (20%). Campers account for about 5% of all tourism spending, 19% is attributable to visitors staying with friends and relatives and 12% is spent on day trips of 50 miles or more (shorter day trips are not included). Outdoor recreation trip expenditures represent between a third and a half of all tourism spending in the three states.

Tourism spending is estimated by segment in each county and then aggregated to produce state or regional estimates. Spreadsheets have been developed for each state to carry out the calculations.

The state level analyses reported in Tables 4-6 can therefore be carried out for any county or group of counties in the Lake States. The relative importance of tourism to the economy of each state can be seen by dividing tourism spending by an overall measure of economic activity. Ratios of tourism spending to total industrial output (TIO) are mapped in Figure 1. TIO includes sales to final demand and intermediate sales. The county level estimates of TIO come from IMPLAN county databases for 1990. Tourism spending figures also provide a basis for estimating the economic impacts of outdoor recreation and tourism in the Lake States.

ECONOMIC IMPACTS OF RECREATION AND TOURISM

Methods

By applying the spending estimates to input-output models of each state's economies, direct and secondary effects can be estimated in terms of sales, income, or jobs. Using the IMPLAN system, this analysis can be carried out for any region defined by a set of counties. Profiles of the types of goods and services purchased by each segment have been assembled along with procedures for bridging the tourism spending to the IMPLAN regional economic modeling system (Stynes and Propst 1995). To illustrate, impacts are estimated for each state using the tourism spending reported in Table 4.

Results

About 6 of the 9 billion in tourist spending is captured by the region's economy (Table 5). The primary leakages are goods purchased by tourists that are produced outside the region, (e.g., petroleum, souvenirs, and clothing). Tourist spending directly generates $3.2 billion in income in the region and supports 214,000 tourism-related jobs. Michigan receives about 46% of the Lake States Region's direct tourism income, Wisconsin 29% and Minnesota 25%.

A total of $4.2 billion in tourist spending was applied to the Michigan input-output model. This spending yields

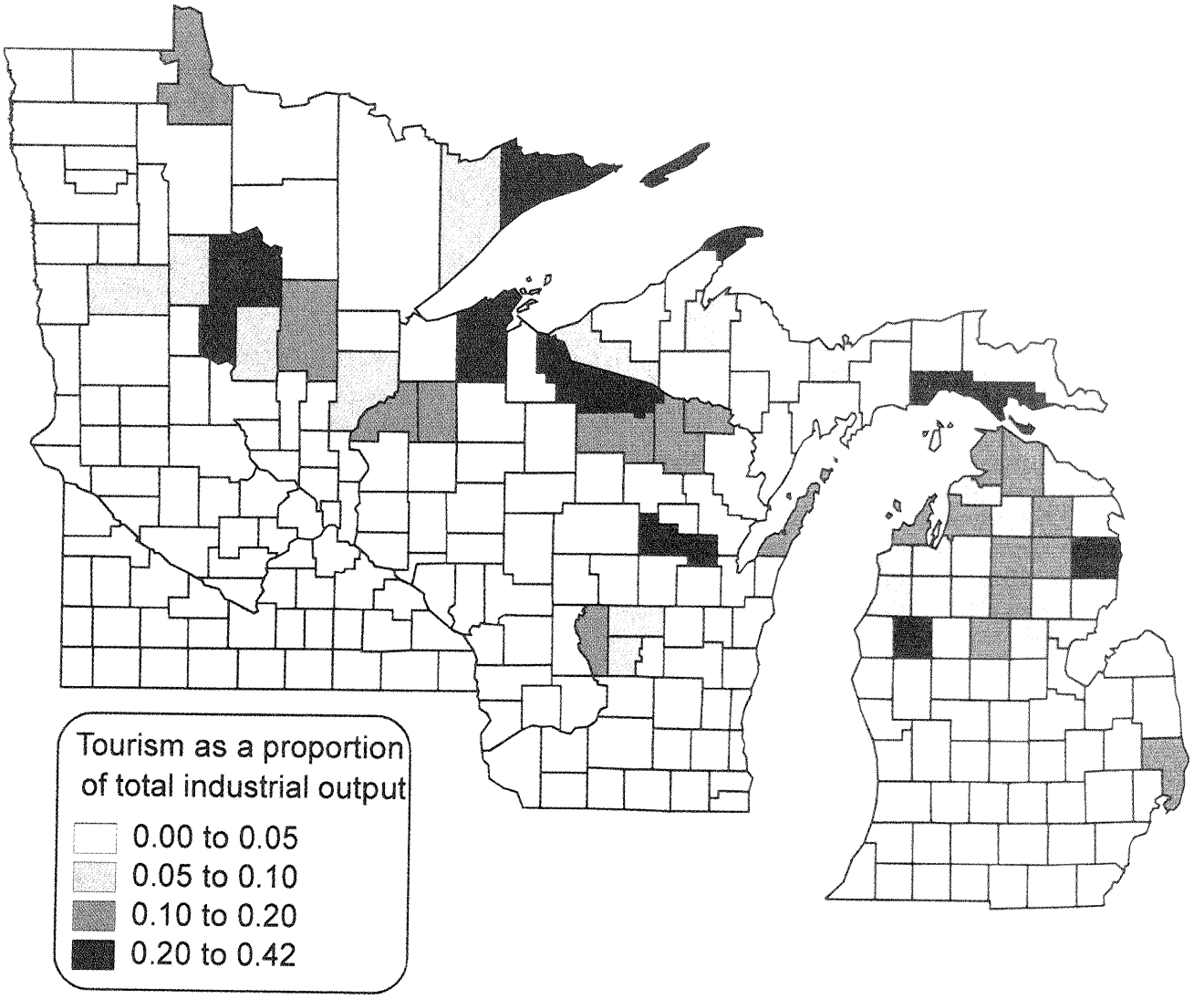

Figure 1.—*Tourism as a proportion of industrial output.*

$2.7 billion in direct sales effects, $1.5 billion in income and about 100,000 jobs in Michigan. In spite of a number of differences in assumptions, these results are similar to statewide estimates made by the USTDC (1992) for Michigan. There are some considerable differences, however, in county level estimates, generally reflecting the larger contributions to tourism spending that we estimate from seasonal homes and camping.

Multiplier effects can also be estimated with the input-output model. Total effects reported in Table 5 are a sum of direct, indirect and induced effects. The tourism output/sales multiplier for Michigan is 2.4. For every dollar of direct sales from tourism, an additional $0.30 is generated through sales to backward linked industries and another $1.10 in sales comes from induced effects (household spending of income earned directly or indirectly from tourism). Secondary effects of tourism are mostly induced, as a high percentage of tourism sales goes to household income. After adjusting for the proportion of spending that is captured by the Michigan economy, the effective spending multiplier is 1.5. This number may be multiplied by tourist spending to estimate total sales effects.

Multipliers for Minnesota and Wisconsin are slightly higher, increasing their shares of the region's total tourism income. Michigan claims 39% of the $8.6 billion in tourism generated income, Wisconsin 33% and Minnesota 28%. Every dollar of tourism spending in Wisconsin and Minnesota generates $2 in total sales effects, i.e., the effective tourism spending multiplier is 2.0. When these secondary effects are included tourism spending generates a total of $16 billion in sales, $8.6 billion in income and almost 400,000 jobs in the Lake States. Outdoor recreation accounts for between a third and a half of this total.

The impacts on individual sectors of the economy provide a useful validity check for the spending and impact estimates. Tourism's relative importance to the

state economy can be seen by dividing total tourism spending impacts by measures of total sales, income or jobs in each state for 1990. Using jobs as the measure of economic activity, tourist spending in Michigan accounts for about 55% of hotel/motel jobs, 45% of recreation/amusements jobs, 15% of restaurant jobs, 6% of retail jobs and 4% of all jobs in the State. These comparisons suggest that our model is not overestimating tourism spending. Not all hotel jobs are accounted for since the model only includes room sales, which on average account for between 50 and 60% of hotel receipts. The consistency of these estimates helps to validate the model. This is no small matter as tourism impact studies frequently predict more jobs in some sectors than exist in the area, usually due to inflated estimates of use or spending.

TRENDS AND FORECASTS

Data Problems

Quantitative indicators of trends in the Lake States cannot be reported due to the lack of comparable data gathered consistently over time for recreation and tourism. Forecasts can be made with the spreadsheet tools presented above by entering projections or assumed changes in any of the data or model parameters. The spreadsheet models can simulate changes in recreation activity and spending associated with changes in populations, age structure, seasonal homes, lodging capacity, occupancy rates, propensities to travel, per visitor spending averages, and selected indicators of resource availability and quality.

Even if quantitative trends could be established, they are only useful if accompanied by a clear understanding of the factors that are causing the changes. The future is rarely a simple extension of past trends. The future depends a great deal on the policy and management decisions that will be made over the next 10 years. The most significant changes tend to be those that involve a change in direction or deviation from recent trends. These rarely are predictable by quantitative models.

Regional and national trends may or may not apply to any specific local area. Recreation and tourism is growing in some areas of the Lake States and declining in others, depending on the mix of activities offered, local marketing efforts, and regional comparative advantages and disadvantages. In many northern forested areas seasonal homes are contributing substantially to growth; in other areas it may be motel and resort development. Unfortunately most local areas have not adequately measured recreation and tourism activity to be able to clearly document these changes or their causes.

We can, however, glean a number of trends for the Lake States Forest Assessment from the literature. These include well documented social trends and broad national and regional trends in recreation and tourism. Following Letterman *et al.*, we conclude with our "Top 10 trends".

Ten Broad Recreation and Tourism Trends

1. Aging population

The changing age structure of the population is well known. The large group of baby boomers continues to drive a great deal of the changes in the market. The needs and wants of baby boomers continue to be the focus of a great deal of marketing effort. Baby boomers are near the age at which people tend to buy seasonal homes, boats, and recreational vehicles. The leading edge of the baby boom is now 50 years old. Generally this suggests growth in more passive outdoor recreation pursuits like hiking, golf, and fishing. On the other hand, older people tend to be healthier and more active than their counterparts of 20 years ago. People are downhill skiing into their 50's and even 60's. Other older adults are taking up or returning to bicycling, kayaking, roller blading, and backpacking. Murdock *et al.* (1990) document the effects of a changing age structure on recreation participation.

2. Customer diversity

Racial and ethnic minorities are accounting for an increasing share of the population, particularly around urban areas. Although participation rates for minorities in outdoor recreation activities continue to be well below that of the general population, minorities are representing an increasing percentage of visitors in many areas. See Dwyer (1994) for further details and implications for forest management.

Another aspect of customer diversity is the dramatic change in the family over the past 20 years. The typical visitor is no longer the traditional family with a male wage earner, a female homemaker and their two to four children. Customer diversity also means single parents, extended families, retired couples, two income households, and a variety of other kinds of "families" and groups. Changes in the family have dramatically affected the amount and spacing of blocks of leisure time. These changes partly explain the trends to shorter lengths of stays and smaller party sizes, as well as customer preferences for more and higher quality services. Some are seeking to get away and relax, others the peak experiences that give meaning to their lives. Overall, people are attributing higher values to their leisure time and, in most cases, are willing to pay more, but with higher expectations of service and quality.

3. Economic trends

The past 10 years have witnessed a fairly stable economy with little real growth in disposable income and a widening gap between the have and have nots. The costs to consumers of recreation and tourism have increased, but not beyond most customer's willingness or ability to pay. Opportunities for lower income families have likely declined with both increases in fees and charges on public lands as well as a redirection of attention by many public providers to "revenue generating" activities. Outdoor recreation on federal and state lands continues to be largely a middle class pursuit with the poor often excluded by distance, transportation, knowledge or income and the wealthiest often choosing private provision of recreation opportunities.

4. Amenity migration

Populations have increased significantly in high amenity areas due to elderly migration (retirement), growth in seasonal homes, and relocations of small businesses. Increases in populations in amenity rich areas have put increasing pressures on public lands and recreation facilities and in many cases increased conflicts—between development and preservation interests, and between permanent residents, seasonal residents, and tourists. Retirees, seasonal home owners and other amenity migrants often do not depend on the local community for income, preferring amenity uses of nearby public lands over commodities like timber or grazing. These groups also often want to "shut the door" to further growth (Stynes and Zheng 1994).

5. Recreation recruitment

There are a number of indicators of a lack of recruitment into several traditional outdoor recreation markets, e.g., camping, boating, downhill skiing, and hunting. While levels of participation in these activities have been stable or only modestly declining, these activities are being sustained primarily by loyal participants who adopted the activity during the 1960's and 1970's. The long range future of these types of activities will rest on rates of recruitment of younger participants, as older participants will eventually drop out. In some cases increasing frequency of participation by loyal participants and retirees with more leisure time may be masking a long range decline. Changing consumer tastes and preferences, a wider array of leisure choices, leisure time constraints, and in some cases increasing costs, make recruitment more difficult for some activities in the current environment. Free days are one example of efforts to recruit new anglers, campers, park visitors, and downhill skiers.

Examples of relatively new activities that have significant implications for forest recreation and tourism management include mountain biking, use of personal watercraft (jet skis), casino gaming and factory outlet/shopping malls. The latter two are examples of indoor activities that are bringing large numbers of visitors to tourist/forest areas.

6. Trip patterns

For several years, recreation and tourism research has pointed to shorter lengths of stay and closer to home trips. The time crunch has resulted in households taking more shorter trips and fewer extended vacations. Long weekends and day trips account for an increasing portion of leisure travel. Longer trips depend quite a bit on continually changing airfares.

7. Leisure time crunch

Some suggest leisure time is increasing, while others see a decline. Most American's have experienced a decline in available leisure time and are experiencing increasing difficulty in balancing the many demands of work, family, and community responsibilities. The growth in leisure time has fallen largely to the unemployed and retired. American's are retiring earlier and living longer, many with substantial pensions. Retirees constitute increasing shares of park visitors, campers, boaters, anglers, and hikers. As baby boomers begin retiring within the next decade, even higher percentages of elderly and retired people can be expected among outdoor recreationists. Senior discounts will need to be reconsidered and programs to encourage greater off-peak period use expanded.

8. Close to home recreation

Many people are choosing to stay closer to home for their recreation. At the extreme are "cacooners", who hole up in their own homes with an increasing array of recreation and leisure gadgets and facilities. The number of neighborhood and community events is also increasing, providing greater opportunities for recreation close to home. Indoor recreation opportunities are growing more rapidly than outdoor. There is a trend toward greater programming and packaging of events relative to less structured leisure time. All of these trends run counter to the traditional methods of providing outdoor recreation on public lands.

9. Amenity vs. Commodity uses of natural resources

The long range trend in use of natural resources continues to be away from traditional commodity uses and toward amenity and nonconsumptive uses. Local residents, seasonal home owners and tourists value forest resources primarily as settings for outdoor recreation and other activities. Various publics increasingly object to the use of public forest resources for the benefit of a

small number of commodity interests. This is particularly the case for members of the community with no direct economic stake in either timber or tourism. Locals increasingly see public forests as "their forests", demanding a greater say in forest management and policy.

10. Changing roles of public and private sectors

Most of the growth in recreation and tourism over the past ten years has taken place in the private sector. The private sector has targeted specialized markets that can be served at a profit and has focused on quality and service. While public resource management agencies have attempted to innovate and increase service and quality, many are constrained by legal mandates, declining budgets and bureaucratic problems. Partnerships and privatization are two approaches that public agencies have used to either offer higher quality services or improve efficiency. These trends are likely to continue.

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Table 1a.—*Outdoor recreation participation rates by State*

Activity	Michigan	Minnesota	Wisconsin	Region
	Rate of participation (percent participating one or more times)			
Backpack	4.5	6.5	5.9	5.3
Bicycle	31.6	38.2	34.5	33.9
Camping	29.6	32.8	29.0	30.2
Fish (Freshwater)	25.4	38.0	36.5	31.2
Fish (Saltwater)	2.1	1.5	1.9	1.9
Golf	15.4	14.5	17.0	15.6
Hiking	8.1	14.1	15.7	11.5
Hunting (Firearm)	9.8	16.1	17.6	13.3
Ski (Alpine)	6.2	7.9	5.8	6.5
Ski (Cross Country)	2.3	2.3	2.3	2.3
Swimming	33.0	33.3	37.8	34.3
Tennis	8.8	7.0	8.6	8.3
Boardsailing	0.4	0.4	0.4	0.4
Boating (Motor)	21.9	23.8	22.3	22.4
Canoeing	8.3	10.5	9.8	9.2
Ice Skating	3.0	3.0	3.0	3.0
Sailing	2.2	2.2	2.2	2.2
Water Skiing	7.5	6.8	5.8	6.9

Table 1b.—*Outdoor recreation participation frequency by State*

Activity	Michigan	Minnesota	Wisconsin	Region
	Frequency of participation (Days per participant per year)			
Backpack	7.4	8.6	8.5	8.0
Bicycle	50.9	46.4	50.9	49.8
Camping	12.8	11.9	13.4	12.7
Fish (Freshwater)	14.1	13.6	16.0	14.5
Fish (Saltwater)	6.8	9.3	6.4	7.3
Golf	20.0	18.3	16.4	18.6
Hiking	12.6	16.1	15.5	14.2
Hunting (Firearm)	12.1	11.6	11.1	11.8
Ski (Alpine)	8.9	7.1	6.9	8.0
Ski (Cross Country)	7.3	7.2	7.3	7.3
Swimming	36.9	33.1	36.1	35.8
Tennis	21.0	15.5	14.8	18.1
Boardsailing	9.0	9.0	8.8	9.0
Boating (Motor)	12.5	9.8	12.5	11.9
Canoeing	4.8	5.4	6.3	5.3
Ice Skating	5.7	5.7	5.7	5.7
Sailing	9.6	9.6	9.6	9.6
Water Skiing	6.8	5.3	10.0	7.3

a. Participation rate = the percentage of population in an age group participating in the activitiy one or more times in 1990. Rates estimated from NSGA survey.

b. Frequency of participation = number of occasions (days) per year of participation for those who do participate at least once. Rates estimated from NSGA survey.

Table 2.—*Age specific participaton rates for Lakes States Region, 1990*

MI-MN-WI	Age Group							
Activity	7-11	12-17	18-24	25-34	35-44	45-54	55-64	65+
				RATE OF PARTICIPATION (percent participating one or more times)				
Backpack	7.2	7.1	7.0	9.1	5.9	3.5	2.9	0.4
Bicycle	90.9	61.9	33.0	35.8	28.0	20.6	18.7	10.8
Camping	54.4	39.7	29.4	37.4	34.5	23.0	19.1	8.4
Fish (Freshwater)	49.4	38.7	34.7	40.2	33.8	30.6	23.9	15.6
Fish (Saltwater)	1.0	2.2	2.1	2.2	2.0	1.8	1.9	1.2
Golf	5.1	11.4	15.8	20.3	17.7	15.3	14.8	10.7
Hiking	16.2	12.0	10.7	16.9	16.0	11.6	9.6	4.9
Hunting (Firearm)	4.1	18.5	19.3	21.0	16.0	14.3	11.5	4.9
Ski (Alpine)	4.4	13.2	13.1	9.2	6.2	3.8	1.7	0.2
Ski (Cross Country)	1.7	2.5	2.1	3.1	2.9	2.5	2.8	0.3
Swimming	69.2	59.6	42.0	36.6	29.9	22.2	19.6	12.3
Tennis	7.2	17.9	14.7	10.8	6.3	4.5	3.5	0.9
Boardsailing	0.1	0.5	0.7	0.9	0.4	0.2	0.2	0.0
Boating (Motor)	20.0	27.0	24.4	32.7	26.3	20.5	15.6	6.8
Canoeing	8.1	14.4	11.0	13.5	10.8	9.0	3.9	2.6
Ice Skating	9.2	7.3	3.2	2.9	2.3	1.1	0.4	0.1
Sailing	1.4	2.5	2.4	3.2	2.4	2.6	1.5	0.9
Water Skiing	4.9	12.9	12.1	12.2	5.1	2.4	1.2	0.2
				FREQUENCY OF PARTICIPATION (Days per participant per year)				
Backpack	6.63	10.12	10.03	6.81	8.66	8.84	8.18	8.26
Bicycle	77.85	61.46	46.90	41.43	38.90	47.38	66.66	64.79
Camping	9.71	11.06	11.42	9.81	11.68	13.91	16.61	18.27
Fish (Freshwater)	10.39	13.15	15.20	15.60	14.75	16.21	19.02	18.76
Fish (Saltwater)	5.59	5.93	11.67	7.13	6.12	9.33	11.95	9.57
Golf	9.17	17.47	12.72	11.81	15.41	24.24	25.28	38.91
Hiking	9.47	11.06	12.92	10.96	14.31	15.80	18.32	23.36
Hunting (Firearm)	4.19	9.75	13.02	12.97	14.49	9.52	14.12	18.17
Ski (Alpine)	7.91	7.81	10.43	6.75	6.95	8.61	10.38	4.43
Ski (Cross Country)	6.15	9.50	8.95	6.55	7.55	6.45	5.80	7.20
Swimming	37.01	35.14	29.51	27.02	30.97	34.12	44.73	51.12
Tennis	13.76	18.67	14.16	12.64	15.76	24.13	26.64	34.82
Boardsailing	1.50	3.25	10.50	8.25	5.15	15.00	10.80	16.00
Boating (Motor)	11.35	10.90	10.67	10.81	12.31	13.44	13.08	12.22
Canoeing	4.31	4.81	5.14	5.36	5.78	4.95	5.27	6.42
Ice Skating	7.95	7.25	5.20	5.30	6.10	4.70	4.70	5.45
Sailing	10.60	9.10	7.50	8.00	9.95	9.75	11.40	11.75
Water Skiing	6.04	6.81	7.81	6.93	7.50	7.74	4.46	8.81

Table 3.—*Outdoor recreation participation estimates by State*

Activity	Michigan	Minnesota	Wisconsin	Region
	- - - - - - - - Person days of participation at destinations (000's) - - - - - - - - - -			
Backpack	113	62	99	273
Bicycle	134,173	63,373	70,995	268,541
Camping	8,777	5,366	10,085	24,228
Fish (Freshwater)	28,656	13,941	20,696	63,293
Fish (Saltwater)	127	59	64	250
Golf	20,917	9,832	11,339	42,089
Hiking	23,070	11,547	19,137	53,754
Hunting (Firearm)	6,770	3,032	5,323	15,124
Ski (Alpine)	2,215	1,059	1,832	5,106
Ski (Cross Country)	1,281	511	865	2,657
Swimming	93,627	44,459	53,503	191,588
Tennis	9,943	4,615	5,438	19,996
Boardsailing	861	464	669	1,994
Boating (Motor)	19,277	8,761	12,545	40,583
Canoeing	5,344	2,664	3,516	11,524
Ice Skating	1,513	713	819	3,045
Sailing	1,303	578	829	2,710
Water Skiing	1,888	1,246	1,532	4,666
All Activities	359,856	172,280	219,287	751,423
Excluded Activities[a]	258,661	122,278	141,276	522,215
Total Resource-Based	101,196	50,001	78,011	229,208

[a] Bicycling, golf, tennis, and swimming are omitted as only marginally related to forest resources.

Forest-based and city versions of these activities cannot be separated.

Table 3A.—*Person days of participation by activity, Michigan circa 1990 (000's of person days)*

Michigan totals Activity	Person days generated at origins			
	Days generated	Local participation	Day trips outside county	Overnight trips outside county
Backpack	2,085	-	-	2,085
Bicycle	136,090	129,286	1,361	5,444
Camping	17,762	-	-	17,762
Fish (Freshwater)	25,023	15,014	8,007	2,002
Fish (Saltwater)	1,077	-	108	969
Golf	19,250	18,287	481	481
Hiking	11,908	10,717	357	834
Hunting (Firearm)	8,776	4,849	1,566	1,044
Ski (Alpine)	2,427	485	777	1,165
Ski (Cross Country)	757	605	76	76
Swimming	81,945	80,306	1,475	164
Tennis	9,402	9,307	47	47
Boardsailing	215	118	10	87
Boating (Motor)	19,395	10,667	873	7,855
Canoeing	3,419	1,880	769	769
Ice Skating	1,358	1,290	34	34
Sailing	1,512	831	68	612
Water Skiing	2,462	1,354	111	997
All Activities	344,861	284,998	16,120	42,427
Excluded Activities[a]	246,686	237,186	3,364	6,136
Total Resource-Based	98,175	47,812	12,756	36,291

Michigan totals Activity	Person days at destinations						Ratio
	Seasonal homes	Motels	Campers	Over-night total	Day trips from outside	Total days at dest.	Days generated/ days received
Backpack	-	-	113	113	-	113	18.53
Bicycle	2,112	471	704	3,286	1,601	134,173	1.01
Camping	-	-	8,777	8,777	-	8,777	2.02
Fish (Freshwater)	2,590	1,353	553	4,495	9,147	28,656	0.87
Fish (Saltwater)	-	-	-	-	127	127	8.50
Golf	1,452	565	47	2,064	566	20,917	0.92
Hiking	4,409	4,710	2,815	11,933	420	23,070	0.52
Hunting (Firearm)	70	136	8	215	1,707	6,770	1.30
Ski (Alpine)	561	409	-	970	760	2,215	1.10
Ski (Cross Country)	547	55	-	602	74	1,281	0.59
Swimming	6,416	2,355	2,815	11,586	1,735	93,627	0.88
Tennis	293	283	5	581	55	9,943	0.95
Boardsailing	540	169	23	732	11	861	0.25
Boating (Motor)	6,294	1,353	115	7,763	847	19,277	1.01
Canoeing	1,748	717	91	2,556	907	5,344	0.64
Ice Skating	183	-	-	183	40	1,513	0.90
Sailing	315	68	23	405	66	1,303	1.16
Water Skiing	314	73	23	410	124	1,888	1.30
All Activities	27,844	12,716	16,110	56,670	18,189	359,856	0.96
Excluded Activities[a]	10,273	3,674	3,570	17,516	3,958	258,661	0.95
Total Resource-Based	17,571	9,042	12,540	39,153	14,231	101,196	0.97

[a] Bicycling, golf, tennis, and swimming are omitted as only marginally related to forest resources.

Table 3B.—*Person days of participation by activity, Minnesota circa 1990 (000's of person days)*

Minnesota totals	Person days generated at origins			
Activity	Days generated	Local participation	Day trips outside county	Overnight trips outside county
Backpack	811	-	-	811
Bicycle	64,141	60,934	641	2,566
Camping	10,073	-	-	10,073
Fish (Freshwater)	11,744	7,035	3,767	942
Fish (Saltwater)	499	-	50	449
Golf	9,009	8,558	225	225
Hiking	5,588	5,029	168	391
Hunting (Firearm)	3,739	2,066	667	445
Ski (Alpine)	933	187	298	448
Ski (Cross Country)	292	232	30	30
Swimming	38,385	37,618	691	77
Tennis	4,343	4,300	22	22
Boardsailing	101	56	5	41
Boating (Motor)	7,746	4,257	349	3,140
Canoeing	1,729	951	389	389
Ice Skating	640	608	16	16
Sailing	603	331	27	244
Water Skiing	1,705	938	77	691
All Activities	162,080	133,099	7,422	20,998
Excluded Activities[a]	115,879	111,410	1,579	2,889
Total Resource-Based	46,201	21,689	5,843	18,109

Minnesota totals	Person days at destinations						Ratio
Activity	Seasonal homes	Motels	Campers	Over-night total	Day trips from outside	Total days at dest.	Days generated/ days received
Backpack	-	-	62	62	-	62	13.11
Bicycle	993	247	444	1,684	755	63,373	1.01
Camping	-	-	5,366	5,366	-	5,366	1.88
Fish (Freshwater)	1,210	1,098	340	2,647	4,259	13,941	0.84
Fish (Saltwater)	-	-	-	-	59	59	8.50
Golf	683	297	30	1,009	265	9,832	0.92
Hiking	2,073	2,472	1,775	6,320	197	11,547	0.48
Hunting (Firearm)	26	96	5	127	839	3,032	1.23
Ski (Alpine)	209	288	-	497	375	1,059	0.88
Ski (Cross Country)	204	38	-	242	37	511	0.57
Swimming	3,017	1,236	1,775	6,028	813	44,459	0.86
Tennis	138	148	3	289	26	4,615	0.94
Boardsailing	252	137	14	403	5	464	0.22
Boating (Motor)	2,940	1,098	71	4,109	395	8,761	0.88
Canoeing	797	385	57	1,239	474	2,664	0.65
Ice Skating	86	-	-	86	19	713	0.90
Sailing	147	55	14	216	31	578	1.04
Water Skiing	165	31	15	211	97	1,246	1.37
All Activities	12,941	7,626	9,970	30,537	8,645	172,280	0.94
Excluded Activities[a]	4,831	1,928	2,251	9,010	1,858	122,278	0.95
Total Resource-Based	8,110	5,698	7,718	21,526	6,787	50,001	0.92

[a] Bicycling, golf, tennis, and swimming are omitted as only marginally related to forest resources.

Table 3C.—*Person days of participation by activity, Wisconsin circa 1990 (000's of person days)*

Wisconsin totals Activity	Person days generated at origins			
	Days generated	Local participation	Day trips outside county	Overnight trips outside county
Backpack	1,414	-	-	1,414
Bicycle	70,716	67,180	707	2,829
Camping	8,047	-	-	8,047
Fish (Freshwater)	16,333	9,800	5,226	1,307
Fish (Saltwater)	548	-	55	493
Golf	9,657	9,174	241	241
Hiking	6,087	5,479	183	426
Hunting (Firearm)	5,567	3,619	1,169	779
Ski (Alpine)	1,632	326	522	784
Ski (Cross Country)	513	410	52	52
Swimming	42,184	41,340	759	84
Tennis	4,832	4,783	24	24
Boardsailing	142	78	6	57
Boating (Motor)	10,805	5,943	486	4,376
Canoeing	1,613	887	363	363
Ice Skating	710	674	18	18
Sailing	837	461	38	339
Water Skiing	2,039	1,121	92	826
All Activities	183,677	151,276	9,942	22,459
Excluded Activities[a]	127,389	122,478	1,732	3,179
Total Resource-Based	56,288	28,798	8,210	19,281

Wisconsin totals Activity	Person days at destinations						Ratio
	Seasonal homes	Motels	Campers	Overnight total	Day trips from outside	Total days at dest.	Days generated/ days received
Backpack	-	-	99	99	-	99	14.28
Bicycle	1,423	705	855	2,983	832	70,995	1.00
Camping	-	-	10,085	10,085	-	10,085	0.80
Fish (Freshwater)	1,798	1,443	659	3,900	6,996	20,696	0.79
Fish (Saltwater)	-	-	-	-	64	64	8.50
Golf	978	846	57	1,882	284	11,339	0.85
Hiking	2,970	7,054	3,420	13,444	215	19,137	0.32
Hunting (Firearm)	41	172	7	220	1,484	5,323	1.05
Ski (Alpine)	329	515	-	844	662	1,832	0.89
Ski (Cross Country)	321	69	-	390	65	865	0.59
Swimming	4,322	3,527	3,420	11,269	893	53,503	0.79
Tennis	198	423	6	627	28	5,438	0.89
Boardsailing	375	180	27	582	9	669	0.21
Boating (Motor)	4,371	1,443	137	5,951	651	12,545	0.86
Canoeing	1,209	896	111	2,217	412	3,516	0.46
Ice Skating	123	-	-	123	21	819	0.87
Sailing	219	72	27	318	50	829	1.01
Water Skiing	207	43	26	276	134	1,532	1.33
All Activities	18,884	17,388	18,937	55,209	12,802	219,287	0.84
Excluded Activities[a]	6,921	5,502	4,338	16,760	2,038	141,276	0.90
Total Resource-Based	11,964	11,886	14,599	38,449	10,764	78,011	0.72

[a] Bicycling, golf, tennis, and swimming are omitted as only marginally related to forest resources.

Table 4.—*Tourism spending by state and market segment ($millions)*

Segment	Michigan	Minnesota	Wisconsin	Total	Percent
Motel	1,696	961	1,230	3,888	43%
Campers	221	94	171	486	5%
Seasonal Homes	917	368	527	1,812	20%
Visiting Friends & Relatives	850	385	450	1,685	19%
Day Trips	550	250	300	1,100	12%
Total Tourism Spending[a]	4,234	2,059	2,678	8,971	100%

[a] Excludes airfares, spending en route and all day trips within the county of residence (50 miles or less).

Table 4A.—*Tourism spending estimates by county, Michigan 1990 ($000's)*

County	Motel	Camp	Seasonal home	Visit F&R	Day trips	Total	PCT of TIO[1]
Michigan	1,696,196 29%	220,536 4%	917,160 16%	850,000 15%	550,000 10%	4,233,893 73%	1.5%
County	**Motel**	**Camp**	**Seasonal home**	**Visit F&R**	**Day trips**	**Total**	**PCT of TIO**
Alcona	1,173	2,098	23,541	928	418	28,158	22.3%
Alger	12,814	918	6,503	820	3,063	24,118	9.5%
Allegan	9,478	9,802	9,555	8,277	3,506	40,617	1.4%
Alpena	7,724	882	7,602	2,799	2,219	21,226	2.4%
Antrim	31,639	1,241	23,006	1,663	7,504	65,052	15.3%
Arenac	1,220	2,427	10,135	1,365	500	15,647	5.3%
Baraga	3,016	304	3,997	727	807	8,852	5.0%
Barry	842	4,414	8,019	4,577	933	18,784	2.0%
Bay	7,630	1,121	1,373	10,216	3,561	23,901	0.8%
Benzie	4,820	1,505	15,411	1,116	1,283	24,133	9.5%
Berrien	29,870	4,722	18,682	14,757	9,858	77,889	1.3%
Branch	6,404	5,354	9,041	3,795	2,078	26,673	2.5%
Calhoun	18,855	4,426	1,617	12,435	6,323	43,655	1.0%
Cass	603	3,833	11,022	4,524	870	20,852	2.4%
Charlevoix	25,251	1,118	18,978	1,963	6,092	53,402	7.1%
Cheboygan	13,029	4,551	20,290	1,957	3,296	43,123	10.2%
Chippewa	15,891	2,381	16,755	3,164	4,146	42,336	7.7%
Clare	1,420	3,437	40,597	2,282	694	48,429	10.8%
Clinton	1,082	557	161	5,293	1,104	8,197	0.8%
Crawford	15,705	2,932	16,430	1,121	3,773	39,962	17.9%
Delta	16,358	569	8,442	3,455	4,299	33,123	3.1%
Dickinson	8,527	509	5,912	2,454	2,347	19,748	1.6%
Eaton	17,051	1,789	617	8,493	5,639	33,589	1.9%
Emmet	54,259	2,047	21,472	2,290	12,778	92,846	10.8%
Genesee	39,023	4,742	3,314	39,363	16,128	102,570	0.6%
Gladwin	892	812	23,066	2,002	528	27,300	7.9%
Gogebic	9,751	995	8,855	1,651	2,497	23,749	7.6%
Grand Traverse	118,042	2,706	16,150	5,877	30,474	173,250	7.1%
Gratiot	7,641	998	371	3,565	2,324	14,899	1.1%
Hillsdale	1,897	2,251	6,349	3,972	1,076	15,545	1.1%
Houghton	8,445	346	8,460	3,241	2,455	22,947	3.8%
Huron	3,670	1,781	17,850	3,196	1,356	27,853	2.6%
Ingham	45,975	2,518	1,453	25,779	15,669	91,394	0.7%
Ionia	1,318	1,963	1,365	5,215	1,145	11,005	0.9%
Iosco	14,270	2,956	27,901	2,762	3,710	51,599	4.9%
Iron	2,318	811	9,044	1,205	725	14,103	4.8%
Isabella	19,650	444	3,266	4,995	5,301	33,655	2.2%
Jackson	13,384	10,898	7,745	13,694	5,563	51,284	1.1%
Kalamazoo	12,536	2,332	2,579	20,430	6,440	44,316	0.7%
Kalkaska	1,471	684	16,983	1,234	536	20,909	4.7%
Kent	110,218	3,611	5,716	45,780	34,972	200,297	1.2%
Keweenaw	2,118	612	4,494	156	510	7,889	31.1%
Lake	1,067	1,946	26,114	785	371	30,283	31.0%
Lapeer	2,592	3,041	2,601	6,837	1,699	16,769	1.0%
Leelanau	18,703	2,126	20,443	1,511	4,521	47,305	16.4%
Lenawee	3,499	8,393	7,620	8,365	2,153	30,030	1.0%
Livingston	7,110	2,970	6,901	10,575	3,489	31,045	1.2%
Luce	2,057	838	3,892	527	556	7,869	4.5%

[1] PCT of TIO = percent of total industrial output

Table 4A (continued)

County	Motel	Camp	Seasonal home	Visit F&R	Day trips	Total	PCT of TIO
Mackinac	47,241	1,684	14,137	976	10,960	74,998	34.5%
Macomb	50,154	952	2,213	65,602	23,156	142,077	0.4%
Manistee	7,963	2,491	15,660	1,945	2,135	30,194	5.3%
Marquette	17,132	1,167	19,987	6,482	5,333	50,102	2.6%
Mason	10,297	4,440	14,921	2,335	2,732	34,725	4.1%
Mecosta	4,958	4,219	11,456	3,412	1,686	25,729	3.7%
Menominee	2,129	562	6,045	2,279	855	11,869	1.5%
Midland	20,163	1,036	1,751	6,918	6,162	36,030	0.5%
Missaukee	993	1,147	11,824	1,111	407	15,481	6.5%
Monroe	14,984	3,740	1,226	12,217	5,724	37,890	1.0%
Montcalm	883	2,431	10,049	4,852	987	19,202	1.4%
Montmorency	2,622	981	20,467	817	732	25,618	16.3%
Muskegon	10,348	5,667	4,914	14,538	4,940	40,406	0.9%
Newaygo	1,041	5,107	17,700	3,493	803	28,144	2.9%
Oakland	195,758	12,221	10,735	99,088	64,989	382,791	0.7%
Oceana	2,620	5,724	12,264	2,053	931	23,593	4.6%
Ogemaw	1,594	1,863	23,848	1,708	641	29,654	8.2%
Ontonagon	10,734	442	4,277	810	2,585	18,847	3.6%
Osceola	419	1,942	16,307	1,842	394	20,904	4.0%
Oscoda	955	1,049	18,984	717	334	22,039	17.7%
Otsego	22,933	1,247	15,586	1,642	5,510	46,918	6.9%
Ottawa	37,057	7,283	7,258	17,170	12,046	80,814	1.1%
Presque Isle	1,786	858	12,785	1,257	612	17,297	6.4%
Roscommon	9,399	2,433	44,436	1,808	2,442	60,518	18.9%
Saginaw	38,198	1,573	848	19,381	12,689	72,690	1.3%
St. Clair	1,374	5,947	8,068	759	4,926	21,075	0.5%
St. Joseph	11,959	3,922	5,184	6,380	2,762	30,207	1.4%
Sanilac	3,614	1,762	12,177	13,315	2,498	33,364	2.4%
Schoolcraft	21,005	1,000	6,237	5,387	3,606	37,235	18.2%
Shiawassee	7,566	463	410	3,651	1,417	13,506	0.9%
Tuscola	962	442	2,601	5,075	1,041	10,120	0.9%
Van Buren	9,414	2,813	12,289	6,407	3,189	34,111	1.9%
Washtenaw	84,351	3,075	3,927	25,873	25,282	142,507	1.0%
Wayne	278,744	1,590	4,297	193,101	100,952	578,684	1.9%
Wexford	12,537	3,559	10,613	2,410	3,257	32,376	4.0%

Table 4B.—*Tourism spending estimates by county, Minnesota 1990 ($000's)*

State	Motel	Camp	Seasonal home	Visit F&R	Day trips	Total	PCT of TIO
Minnesota	961,168 47%	94,450 5%	367,927 18%	385,000 19%	250,000 12%	2,058,545 100%	1.20%

County	Motel	Camp	Seasonal home	Visit F&R	Day trips	Total	PCT of TIO
Aitkin	1,944	1,747	23,454	1,093	520	28,758	12.46%
Anoka	5,561	394	1,302	21,440	4,496	33,192	0.53%
Becker	12,865	3,266	14,532	2,453	2,748	35,864	5.68%
Beltrami	8,561	2,640	6,013	3,026	2,055	22,294	2.75%
Benton	2,708	422	522	2,656	908	7,216	1.05%
Big Stone	264	300	1,407	553	134	2,658	1.76%
Blue Earth	7,209	1,404	903	4,756	2,089	16,361	0.77%
Brown	6,322	900	102	2,375	1,540	11,239	0.84%
Carlton	2,769	1,522	3,430	2,575	906	11,201	1.28%
Carver	2,585	259	277	4,216	1,140	8,477	0.47%
Cass	30,792	5,753	33,569	1,918	5,936	77,966	20.56%
Chippewa	1,263	43	168	1,164	400	3,039	0.81%
Chisago	1,358	1,190	3,129	2,686	663	9,026	1.24%
Clay	5,968	562	249	4,437	1,810	13,025	1.15%
Clearwater	480	420	1,848	731	199	3,678	2.23%
Cook	17,794	1,757	7,186	340	3,305	30,382	29.96%
Cottonwood	494	0	56	1,117	264	1,931	0.41%
Crow Wing	34,950	3,931	38,486	3,894	7,016	88,277	6.88%
Dakota	27,121	574	770	24,219	8,885	61,569	0.70%
Dodge	113	113	53	1,384	244	1,906	0.47%
Douglas	22,649	2,441	9,783	2,523	4,547	41,942	4.70%
Faribault	615	552	214	1,490	345	3,216	0.59%
Fillmore	1,449	2,309	382	1,828	552	6,520	1.15%
Freeborn	5,818	754	252	2,909	1,535	11,267	1.06%
Goodhue	11,952	1,615	882	3,581	2,764	20,794	1.28%
Grant	351	602	1,337	550	148	2,988	1.87%
Hennepin	354,813	1,745	4,914	90,852	92,238	544,562	0.93%
Houston	947	1,411	294	1,628	423	4,702	1.27%
Hubbard	7,888	2,158	12,243	1,315	1,654	25,258	8.48%
Isanti	983	936	2,037	2,281	535	6,771	1.28%
Itasca	14,186	3,377	18,557	3,596	3,175	42,890	3.89%
Jackson	2,552	797	350	1,028	617	5,343	1.72%
Kanabec	455	1,003	3,409	1,127	259	6,252	2.17%
Kandiyohi	8,213	1,572	5,940	3,411	2,054	21,189	1.81%
Kittson	294	526	602	507	132	2,061	1.32%
Koochiching	8,148	550	4,673	1,434	1,721	16,526	2.27%
Lac Qui Parle	1,347	158	161	785	353	2,805	0.81%
Lake	8,044	1,702	6,559	916	1,618	18,839	7.44%
Lake of the Woods	8,975	1,169	4,298	359	1,698	16,498	12.74%
Le Sueur	3,166	1,406	2,947	2,045	890	10,455	1.48%
Lincoln	219	240	214	606	135	1,414	0.90%
Lyon	4,804	331	49	2,181	1,201	8,566	0.76%
Mahnomen	1,334	348	123	444	260	2,508	2.27%
Marshall	1,124	310	1,652	967	180	4,232	1.55%
Martin	135	86	714	2,016	1,357	4,309	0.52%

Table 4B (continued)

County	Motel	Camp	Seasonal home	Visit F&R	Day trips	Total	PCT of TIO
Mc Leod	5,638	845	336	2,819	681	10,318	0.56%
Meeker	572	511	3,570	1,834	393	6,881	1.13%
Mille Lacs	7,006	2,158	5,747	1,643	1,546	18,099	3.29%
Morrison	2,708	1,116	5,324	2,605	900	12,652	1.79%
Mower	2,375	1,039	105	3,290	953	7,762	0.64%
Murray	230	492	1,817	850	176	3,564	1.13%
Nicollet	992	310	525	2,471	567	4,864	0.59%
Nobles	4,051	384	88	1,769	1,001	7,292	0.89%
Norman	375	5	98	702	177	1,356	0.68%
Olmsted	75,840	1,133	480	9,369	15,374	102,195	1.99%
Otter Tail	7,557	3,557	28,046	4,463	2,105	45,727	3.03%
Pennington	3,927	38	126	1,171	882	6,145	1.31%
Pine	3,156	3,281	15,337	1,871	860	24,505	6.33%
Pipestone	1,361	230	56	923	378	2,948	1.08%
Polk	3,172	691	3,101	2,860	1,023	10,847	1.04%
Pope	1,751	1,164	4,365	946	462	8,688	3.38%
Ramsey	64,037	34	1,705	42,746	18,636	127,157	0.50%
Red Lake	750	269	74	398	190	1,681	1.60%
Redwood	2,461	281	133	1,518	680	5,073	1.10%
Renville	2,016	48	231	1,555	608	4,458	0.79%
Rice	4,432	1,157	2,013	4,328	1,484	13,413	0.86%
Rock	263	199	32	863	184	1,540	0.52%
Roseau	2,572	569	1,621	1,322	668	6,752	0.97%
Saint Louis	56,070	4,898	38,661	17,442	13,073	130,145	2.06%
Scott	5,541	1,757	518	5,090	1,839	14,745	0.89%
Sherburne	2,078	1,123	2,783	3,691	965	10,640	1.17%
Sibley	300	48	42	1,264	255	1,910	0.54%
Stearns	22,272	3,118	8,323	10,453	5,765	49,931	1.25%
Steele	1,593	660	354	2,704	720	6,031	0.40%
Stevens	1,494	0	168	936	402	3,000	1.21%
Swift	356	180	245	944	213	1,937	0.71%
Todd	1,843	929	6,762	2,056	658	12,248	1.77%
Traverse	165	24	644	393	91	1,317	1.03%
Wabasha	789	1,682	1,932	1,737	414	6,555	1.40%
Wadena	1,205	336	1,372	1,158	390	4,460	1.32%
Waseca	960	816	280	1,591	419	4,066	0.50%
Washington	17,886	1,030	1,855	12,839	5,351	38,960	1.05%
Watonwan	255	101	179	1,028	210	1,772	0.37%
Wilkin	225	36	77	661	145	1,144	0.61%
Winona	6,003	953	312	4,209	1,780	13,256	0.80%
Wright	3,007	1,570	8,414	6,046	1,511	20,548	1.38%
Yellow Medicine	315	386	49	1,028	220	1,998	0.59%

Table 4C.—*Tourism sales estimates by county, Wisconsin 1990 ($000's)*

State	Motel	Camp	Seasonal home	Visit F&R	Day trips	Total	PCT of TIO
Wisconsin	1,230,260 31%	171,000 4%	527,104 13%	450,000 12%	300,000 8%	2,678,364 100%	2.09%

County	Motel	Camp	Seasonal home	Visit F&R	Day trips	Total	PCT of TIO
Adams	11,997	5,102	20,822	1,478	2,440	41,839	18.23%
Ashland	7,195	1,049	5,047	1,500	1,566	16,357	4.63%
Barron	19,144	3,403	10,133	3,753	4,127	40,558	4.13%
Bayfield	28,426	2,366	15,505	1,297	5,415	53,009	35.39%
Brown	32,811	840	1,211	17,820	8,971	61,653	1.01%
Buffalo	1,767	674	721	1,251	532	4,944	1.55%
Burnett	12,639	2,182	20,545	1,220	2,515	39,101	16.72%
Calumet	1,622	156	1,089	3,113	815	6,795	0.69%
Chippewa	8,881	3,247	3,983	4,806	2,425	23,342	2.00%
Clark	1,638	1,166	3,528	2,893	782	10,007	1.19%
Columbia	25,118	5,359	5,450	4,169	5,289	45,384	4.44%
Crawford	3,035	1,394	2,916	1,465	799	9,610	2.64%
Dand	74,374	2,774	2,888	33,980	19,265	133,281	1.41%
Dodge	7,163	912	3,325	7,056	2,486	20,942	1.04%
Door	72,591	7,726	22,372	2,381	13,673	118,743	25.47%
Douglas	13,523	1,937	10,738	3,870	3,118	33,185	3.88%
Dunn	2,907	929	1,309	3,335	1,087	9,567	1.42%
Eau Claire	20,750	1,361	1,271	7,869	5,106	36,356	2.07%
Florence	2,425	442	6,510	425	514	10,316	16.62%
Fond du Lac	16,381	3,516	3,007	8,310	4,381	35,594	1.35%
Forest	6,585	1,478	12,516	806	1,339	22,723	21.09%
Grant	5,476	1,805	1,509	4,556	1,761	15,106	1.63%
Green	4,031	1,066	539	2,796	1,203	9,635	1.18%
Green Lake	13,908	2,222	5,380	1,733	2,832	26,075	7.17%
Iowa	3,084	1,733	1,586	1,841	871	9,114	2.17%
Iron	20,380	643	6,808	583	3,824	32,238	50.13%
Jackson	4,417	2,114	3,126	1,532	1,063	12,251	3.98%
Jefferson	7,034	4,620	3,290	6,270	2,332	23,546	1.15%
Juneau	9,700	5,899	8,526	1,997	2,107	28,229	5.35%
Kenosha	14,229	694	7,963	11,725	4,557	39,167	1.59%
Kewaunee	3,710	1,502	1,134	1,740	968	9,055	2.23%
La Crosse	26,242	2,035	798	9,044	6,307	44,425	1.84%
Lafayette	562	1,082	249	1,473	348	3,714	0.96%
Langlade	6,408	1,042	9,079	1,808	1,473	19,809	5.27%
Lincoln	10,166	1,382	8,824	2,505	2,277	25,154	4.07%
Manitowoc	12,623	1,337	1,950	7,425	3,546	26,881	1.38%
Marathon	16,879	1,382	2,538	10,597	4,853	36,249	1.14%
Marinette	13,073	3,005	29,862	3,748	3,016	52,703	4.59%
Marquette	6,809	5,419	9,706	1,153	1,438	24,525	9.88%
Menominee	0	0	1,848	334	56	2,237	0.46%
Milwaukee	134,535	394	2,118	87,833	39,244	264,122	0.97%
Monroe	6,649	2,822	1,124	3,343	1,773	15,711	1.99%
Oconto	7,002	2,186	23,331	2,786	1,745	37,050	4.97%
Oneida	58,266	3,864	39,421	2,953	11,148	115,651	19.85%
Outagamie	17,040	0	623	12,798	5,249	35,710	0.82%
Ozaukee	3,951	252	781	6,700	1,839	13,522	0.70%

Table 4C (continued)

County	Motel	Camp	Seasonal home	Visit F&R	Day trips	Total	PCT of TIO
Pepin	787	194	581	654	253	2,469	1.59%
Pierce	1,638	718	508	3,015	802	6,681	1.12%
Polk	7,661	2,285	16,219	3,195	1,933	31,292	4.25%
Portage	14,679	1,483	2,398	5,676	3,631	27,867	2.15%
Price	9,379	689	8,323	1,447	1,957	21,795	5.17%
Racine	13,474	1,277	3,329	16,010	5,133	39,223	0.81%
Richland	1,317	682	1,029	1,616	510	5,154	1.32%
Rock	21,071	4,140	1,740	12,782	5,984	45,717	1.05%
Rusk	5,220	984	5,828	1,390	1,186	14,607	4.08%
Saint Croix	6,456	2,609	945	4,566	1,942	16,518	1.65%
Sauk	55,792	10,109	6,713	4,314	10,923	87,851	7.67%
Sawyer	46,237	4,049	23,884	1,309	8,674	84,153	48.84%
Shawano	8,014	2,218	6,902	3,431	2,037	22,602	3.45%
Sheboygan	16,542	3,962	2,608	9,580	4,622	37,314	1.20%
Taylor	1,269	530	2,359	1,721	519	6,398	1.13%
Trempealeau	2,778	1,073	613	2,335	897	7,696	1.23%
Vernon	3,389	811	1,467	2,357	1,013	9,036	1.89%
Vilas	83,319	5,434	40,712	1,658	15,514	146,637	64.68%
Walworth	51,633	3,120	26,971	6,970	10,605	99,298	6.49%
Washburn	17,923	2,107	13,314	1,278	3,491	38,113	18.17%
Washington	7,725	1,942	2,457	8,738	2,869	23,731	0.99%
Waukesha	30,241	1,085	4,298	28,096	10,213	73,933	0.76%
Waupaca	8,094	5,820	7,914	4,259	2,190	28,277	2.26%
Waushara	6,167	4,090	13,601	1,805	1,429	27,091	8.82%
Winnebago	19,465	11,328	4,008	12,977	5,723	53,500	1.01%
Wood	12,848	1,747	1,400	6,752	3,475	26,222	1.10%

Table 5.—*Tourism economic impacts by State*

Impact Measure	Michigan	Minnesota	Wisconsin	Total
Direct Effects				
Sales ($MM)	$2,709	$1,470	$1,771	$5,950
Income ($MM)	$1,475	$795	$934	$3,204
Jobs[a]	94,442	50,787	69,090	214,319
Total Effects				
Sales ($MM)	$6,200	$4,448	$5,431	$16,079
Income ($MM)	$3,348	$2,430	$2,876	$8,654
Jobs[a]	155,839	103,565	138,462	397,866

[a] Jobs are not full time equivalents.

Table 6.—*Tourism job impacts by sector and State*

Sector Group	Michigan	Minnesota	Wisconsin
	---------- Percent of all jobs, 1990 ----------		
Manf/Prod	1	1	1
Trans and Services	2	3	4
Recreation	45	15	22
Hotel	55	52	60
Eating & Drinking Estab.	15	14	19
Retail	6	6	7
Government	0	0	0
Total	4	4	5

Demographic Trends and Forest Resource Implications for the Lake States

Katy S. Weiler and Joseph T. O'Leary[1]

INTRODUCTION

Forests and forest resources are intricately linked to the human populations that surround them. They are an important natural resource for a variety of industrial and nonindustrial uses. Their importance goes far beyond their relationship with industry and into the realm of ecology, aesthetics, and recreation.

Loss of forestland is a concern. Although much attention has been aimed at the high rate of deforestation in tropical and developing countries, it is an important issue in developed nations as well. The relationship between developing countries' population and deforestation is currently a major area of research. Research of this kind can serve as a foundation for investigating the relationship between developed nations' forest resources and population.

The relationship between population demographics and forest resources is complicated. Population migration is a demographic phenomenon that affects forestlands in the United States, but which is not investigated in developing nations. This study is designed to investigate the relationship between population demographics and forest area in the Lake States region of the United States. We are specifically interested in the relationship between population density, growth, urbanization, and migration on forest and timberland in Michigan, Minnesota, and Wisconsin.

LITERATURE REVIEWED

There are two kinds of changes in tree cover—clearance and change of condition (Myer and Turner 1992). For the purposes of this study we are concerned with the clearance and conversion of forest cover. Deforestation can be defined as the complete clearing of tree formations and their replacement by some other use of the land (Ooi Jin Bee 1987). Clearance and conversion of forest cover can be either reversible or irreversible. Changes in forestland acreage are attributable to two processes: shifts between agriculture and forestry and permanent loss to development (Alig and Wear 1992). Deforestation through conversion for cultivation purposes is often indirectly related to population growth (Ooi Jin Bee 1987, Castro 1988, Ehui and Hertel 1989, Harrison 1991, Prassad 1992).

Deforestation is a global issue and several broad generalizations have been made about the relationship between population growth and the removal of forests. The highest rates of population growth and deforestation are occurring in Latin America, Africa, and Asia and, therefore, most of the concern and research has been focused on these regions (Ehui and Hertel 1989, U.N 1990, Myer and Turner 1992, Shaw 1992). It is a generally accepted in this literature that population growth affects land use (Bilsborrow and Ogenda 1992, Boyden and Dovers 1992, Myers 1992, Myer and Turner 1992, Reid *et al.* 1993). There is a strong global correlation between modem population growth and annual change in land cover (Myer and Turner 1992, Shaw 1992). Specifically, there is significant statistical evidence suggesting that population growth strongly contributes to forest clearing (Myer and Turner 1992, World Watch Institute 1988).

Although it is clear that population growth is related to deforestation, the relationship is intricate and often ambiguous. Several studies at a national level can help tease out the intricacies of this relationship. In India, a significant effect of population growth is the increased demand for agricultural lands. Between the 1950's and the late 1970's, there was a net increase of 25 million ha of agricultural lands. This increase was accompanied by a 22.4 million ha loss of forestland. It is estimated that in the next 10 years, the amount of land in cultivation will increase by 21 million ha. It is postulated that this increase will be at the expense of forestland (Prassad 1992). Research in the Philippines had similar findings. Deforestation is attributed to two primary factors—large scale commercial exploitation and the demand for the land. The underlying factor of forest loss is attributed to population growth and is manifested in its increased demand for cultivatable land (Ooi Jin Bee 1987). Both

[1] The authors are Graduate Research Assistant and Professor, respectively, Department of Forestry and Natural Resources, Purdue University, W. Lafayette, IN 47907.

of these studies expressed population growth as the number of people and largely ignored a measure of population density. Susan Harrison's (1991) research in Costa Rica measured both the effects of population growth and population density on the clearing of land. She found that the connection between population growth and deforestation is closely related to factors of land use. Deforestation is linked to land clearing for farm and range land.

The connection between population density and loss of forestland is less clear. In some regions of the country there was a strong negative correlation between the amount of forestland and population density; in other regions of the country there was no correlation. In southern Kenya, historical records gave evidence that as population density increased, people moved in search of farmland. The subsequent result of this movement was the clearing of forestland for cultivation (Castro 1988).

These studies suggest that there is a relationship between population growth and deforestation. Growing populations indirectly cause deforestation as their need for cultivatable land increases. The relationship between population density and loss of forest cover is more ambiguous. In some cases, as populations become more dense there is an increase in deforestation; in other cases this relationship does not appear to be true. A factor not considered directly in any of these studies is the loss of forest cover due to development and urbanization. This is an important variable because loss of forestland to development is essentially permanent (Alig and Wear 1991).

The history of forests and deforestation in the United States is rich and complex. The majority of deforestation took place in this country between the years 1850 and 1900. Mostly, forests were timbered for industrial uses such as energy, shipbuilding, buildings, fuel, and firewood. A substantial amount of land was also converted for agricultural purposes. Forests in the Lake States were essentially cleared between 1860 and 1890. The early 1900's was a period of reversion for much of the land. Agricultural lands were abandoned and subsequently reverted to their original cover type. However, not all land was allowed to revert. Much of the land stayed in cultivated forms and much of it was taken up by other uses such as development and urbanization. An analysis of the timber situation in the United States shows that the number of acres of commercial timberland increased until the early 1960's and then it began dropping off again (Maxwell *et al.* 1985, Williams 1989). The relationship between population and forestland has not been well studied in this country.

In order to investigate the relationship between forestland and population in the United States, recent population trends should be understood. The relationship between land use and population growth is a complicated one. Population demographics and migration patterns in the United States are very different from those in developing nations. Population growth rates are not as high and migration is more pronounced.

Throughout most of the twentieth century and before the 1970's, population growth was generally higher in metropolitan areas than in rural or nonmetropolitan areas (Beale and Fuguitt 1978, Johnson 1989). Nonmetropolitan America typically grew slowly because gains from natural increases were offset by substantial emigration (Fuguitt *et al.* 1989). During this time period migration was predominantly from nonmetropolitan areas to metropolitan ones (Beale and Fuguitt 1978, Beale 1975, Engels and Forstall1985, Fuguitt *et al.* 1989). In the 1970's, this trend changed and suddenly nonmetropolitan areas had widespread increases in population growth rates (Johnson 1989; Long and DeAre 1982, 1988; Beale and Fuguitt 1978). Population gains in nonmetropolitan counties exceeded those of metropolitan areas and were largely the result of changes in migration patterns (Beale 1975). Nonmetropolitan and rural areas experienced increases in population growth rates due to immigration (Beale 1975). An important feature of this "population turn-around" is that nonmetropolitan counties that are not contiguous to metropolitan ones also showed increases in population growth rates. These counties had growth rates that surpassed those of metropolitan areas for the first time (Fisher and Mitchelson 1981). This phenomenon suggests that nonmetropolitan population increases were not only the result of a continued decentralization of cites into adjacent counties. Changes in the settlement process seem to embody a component that is independent of large urbanized areas (Fisher and Mitchelson 1981).

In the 1980's, the magnitude of nonmetropolitan population increases diminished from those of the 1970's. Between 1980 and 1987, metropolitan growth rates again exceeded those of nonmetropolitan counties. However, nonmetropolitan counties still had growth rates that were higher than those seen historically. Nonmetropolitan counties that are adjacent to metropolitan areas had population gains that were greater than nonmetropolitan counties not adjacent to metropolitan centers (Johnson 1989). Several authors believe that the "population turn-around" was over in the 1980's (Engels and Forstall 1985, Long and DeAre 1988). However, Johnson (1989) does not believe this is true. The population growth trends of the 1980's do not suggest a reversion to substantial migration losses characteristic of nonmetropolitan counties (Johnson 1989). Viewing the demographic trends of the 1980's in a historical context reveals that growth trends continued to run contrary to long term patterns (Johnson 1989). Although nonmetropolitan counties had slower growth rates in the 1980's

than in the 1970's, these counties had growth rates higher than typically found in the historical trends.

Several factors are attributed to the atypical nonmetropolitan population growth trends of the 1970's and 1980's (Johnson 1989, Fisher and Mitchelson 1981). Two of the factors cited are particularly pertinent to the effects of population movement on land use and land cover conversion. (1) Counties on the periphery of metropolitan areas experienced an increase in growth. There was a spill-over of population from metropolitan counties into adjacent nonmetropolitan ones. This trend of population growth affects the amount of land that is converted as it is developed. (2) There seemed to be a shift in the relative value placed on economic and non-economic factors used in migration decisions (Johnson 1989, Fisher and Mitchelson 1981). This shift in values manifested itself in a search for a better quality of life obtained from resource amenities (Johnson 1989, Fisher and Mitchelson 1981) and is an important component to understanding the relationship between population growth and forest resources.

The search for a better quality of life as a factor in migration was established by several researchers and has important implications for resource management. Edward Ullman (1954) was one of the first researchers to draw attention to environmental preference in interregional migration. He theorized that migration could be explained by preferences for a "pleasant" climate and a desirable natural environment (Ullman 1954). Since this perspective was presented, research on specific environmental preferences supports the hypothesis that the natural environment is important to individuals when making migration decisions (Svart 1976). There is little disagreement that amenities add to the value of property (Gillard 1981). Several researchers have been able to show this (Gillard 1981, Rudzitis *et al.* 1981, Diamond 1980, Harrison and Rubenfiel 1978). An amenity can be defined as a nontradable, location-specific good (Tolley 1974, Graves and Linneman 1979, Rudzitis n.d.). Examples of amenities are clean air, climate, parks, low pollution levels, scenery, and recreation opportunities (Rudzitis n.d.). Rudzitis (n.d.) examined factors responsible for growth in counties adjacent to a federally designated wilderness. These counties are among the fastest growing in the United States. Presently there are a total of 277 wilderness counties in 38 states and the majority of these counties are not within 50 miles of a metropolitan area. In addition, these areas grew at a rate double that of nonmetropolitan areas as a whole (Rudzitis n.d.). This fast rate of growth appeared in the 1970's and continued into the 1980's despite the slower rate of growth seen in other nonmetropolitan counties in this time period (Rudzitis n.d.). It was clear that non-economic variables were as important in explaining migration to wilderness counties as economic variables (Rudzitis n.d.).

Looking at the Issue of Values

As we are challenged by a search for new perspectives in forestry, we recognize that society's views and valuing of natural resources is dynamic and that will have a profound effect on the way in which land and resources are viewed. The literature would suggest that values associated with natural resources have been changing, often dramatically, over the last 20 years. The changes have become so important as to suggest a movement toward new paradigms that better describe the relationships between changing values and natural resources (Catton and Dunlap 1978, Dunlap and Van Liere 1978, Albrecht 1982, Lyden 1988). Lyden (1988) describes this well:

> "In the natural resource field, some commentators feel that even those values which nearly everyone has agreed to in the past are changing. What might be termed as the Dominant Social paradigm (DSP) applicable to this field consists of a belief in abundance and progress, devotion to growth and prosperity, faith in science and technology, commitment to a laissez-faire economy and limited governmental planning, and private property rights . . . . This perspective is now being challenged by a New Environmental Paradigm (NEP) stressing limits to growth, the balance of nature, and the finite nature of natural resources . . . In some parts of the country the NEP may have replaced the DSP as the dominant frame of reference in natural resource public policy decision making. Whether or not this has occurred, it is clear that society no longer brings a uniform set of values to the decision making process. As a result we not only see disagreement and conflict occurring in public decision-making, but also confusion about the sources of the disagreement."[2]

Kluckhohn and Strodbeck (1961) note that values that influence people's behavior stem from different ways of thinking about life and the world around us. They can be influenced by both experience and information, but tend to exist in terms of a relatively stable and continuous foundation upon which opinions are based. They tend to be difficult to change, and are relatively persistent over time.

Potter and Norville (1981:179) in a broad based investigation of the literature tend to support the position above and suggest the following:

[2] Lyden 1988:844

> ". . . (T)he consensus appears to be that values are conceptions of the desirable that help to guide decision making, and they usually contain criteria for preferences by providing codes or standards for conduct. They are believed to be general and abstract concepts, and thus they, themselves, are not directly observable but must be inferred from the behavior they elicit. They are also thought to be enduring, stable, and teamed."

An important theme in trying to understand possible value differences in forestry and natural resources has been the comparison between urban and rural background. Fortmann and Kusel (1990) note that conflicts over natural resource issues and management are argued to be related to the "environmentalism of new residents of urban origin and long standing residents." These studies appear to favor the NEP paradigm noted earlier in that urban origin people have urban environmental attitudes that translate to support for land preservation in a natural state and in limitations or prevention of commodity use on rural lands. Rural residents are said to support commodity use on wildlands, and conflicts emerge when these views are brought together for resolution. Other research has also linked stronger concern toward environmental issues with urban residence and higher levels of education. Fortmann and Kusel (1990) provide a concise summary of this discussion, but also take issue with the more classic findings about urban and rural differences. Dunlap (1987, 1991) has noted a growing concern in the United States with environmental issues that appears to transcend measures like urban and rural. Fortmann and Kusel note that their data points toward more agreement than difference in forest environmental attitudes, with greater support for pro-environmentalist positions. The suggestion is that many long-standing rural residents had these views in the first place and that the arrival of people who had lived in urban areas before, but who were willing to be outspoken against pro-commodity issues, gave a platform for these people to express their views. The argument is that organizations like the Forest Service gave greater attention to the pro-commodity interests through informal contacts and more recently in a formal manner through the public participation process.

Potter and Norville's (1981) examination of social values indicate that there could be a broad range that might be identified. However, in terms of concern about natural resources, there appear to be six that are of greatest interest. These social values are classified (Stankey and Clark 1992) into at least six different categories:

- Commodity values (timber, range, minerals, water);
- Amenity values (nature, scenery, life style);
- Environmental quality values (air, water quality);
- Ecological values (biodiversity, endangered species);
- Public use values (recreation, tourism);
- Spiritual values.

Commodity Values

In the context of Potter and Norville's (1981) research on social values, commodity values may reflect several areas including material comfort, economic benefit, and progress and growth. MacCleery (1991) indicates that the history and development of the nation were highly interdependent with products that came from the forest—fuel, lumber, timber, building materials for houses, barns, and fences, and even wildlife habitat. The emphasis on the commodities that could be taken from the forest is underscored by training in forest management that emphasized business. Davis (1966:1) quoted the Society of American Foresters 1958 definition of forest management:

> "The application of business methods and technical forestry principles to the operation of a forest property."

While he did suggest other opportunities that could be pursued on a forest property, these often were presented in the context of being auxiliary to timber production. Emphasis on concepts like community stability in the early twentieth century underscored a social welfare role for forests. Sufficient timber could be made available for local industry on a sustaining basis to be sure that an area would be able to maintain its economic and social stability. Hence, the early emphasis on timber production was viewed as a vehicle for progress and growth.

The literature on Americans' views toward commodity values would not suggest that material interest has declined. In fact, the country has gone through a recent well-documented period of interest in "me." However, as Machlis (1991) points out, the view about forests and their historical uses appears to be affected by a proximity to population growth on non-metropolitan areas and proximity to forest areas (aesthetic values), lack of support for Forest Service management objectives, shifting values within the forestry profession, greater interest in quality of life, more public involvement, and greater scientific intervention. Although the population changes that Machlis identified were in the western part of the United States, the same patterns are also evident in the East and South, and have been described in various studies of forest land change. Following Potter and Norville's (1981) description of values that include conceptions about what is desirable, the changes noted above broaden the audiences and the variety of views about desirable outcomes, thus placing more value orientations on the table for consideration.

Environmental Quality

Awareness by the public about the environment grew during the 1960's, and appeared to peak around the 1970 Earth Day celebration. Dunlap (1987) notes that while public support for environmental concerns appeared to decline somewhat, it remained strong through energy crises, economic discontinuities, and tax revolts. In fact, several authors have noted that environment has emerged to become one of the persisting concerns of the American public with even some signs of growth (Anthony 1982, Mitchell 1980, Ladd 1982, Dunlap 1991). Some concern was expressed about the impacts of the Reagan presidency on environmental concern, but research appears to indicate that (1) support was strengthened rather than diminished, (2) polls documenting this support could be used to support environmental legislation (e.g., Clean Water Act and Clean Air Act), and (3) failure to provide support for this area could be politically dangerous (Dunlap 1987).

Dunlap (1991) followed up his observations about environmental concern polls noting that the trends continued to support the findings he reported in 1987 with support appearing to grow stronger. He reports:

> "Used intermittently in New York Times/CBS polls since 1981, the fourth item asks respondents to agree or disagree with a very strongly worded statement: 'Protecting the environment is so important that the requirements and standards cannot be too high, and continuing environmental improvements must be made regardless of cost.' Agreement with this statement rose steadily over the past decade, with the result that in 1990 three-fourths of the public was expressing agreement and only one-fifth was expressing disagreement."[3]

Ecological Values

The growth in concern about ecological values, on the one hand, is related to issues about environmental quality and, on the other, the changing role of science. Concerns about biodiversity, ancient forests, endangered species, and a host of other resource-related questions are all tied into a web of both public and professional values. The National Research Council (1990) has called for a greater role for scientists in communicating knowledge for use by policy makers. Machlis (1991) describes an explicit attempt in the New Perspectives program of the U.S. Forest Service to include scientists in management based decisions.

[3] Dunlap 1991:12

In a recent article in *Science*, Brown (1992:200) notes:

> ". . . U.S. government support for basic research has reflected a widespread but weakly held sentiment that the pursuit of knowledge is a cultural activity intrinsically worthy of public support . . . Politicians—always on the lookout for miracle cures to sell to the public—have enthusiastically embraced research as the key to a brighter future . . . Today . . . the uneasy alliance between scientists and politicians is beginning to come unglued."
>
> "An excessive cultural reverence for the objective lessons of science has the effect of stifling political discourse, which is necessarily subjective and value laden."[4]

Dealing with biodiversity issues, Raven and Wilson (1992) also reporting in *Science*, outlined a 50-year plan in 10-year increments to conduct biodiversity surveys that aim at the ultimate full identification and biogeography of all species. Placed in the context of concern for economic well-being and stagnation, it is challenging to think that ecological values and science would rank higher than economic values in the political arena. This is underscored by Brown's (1992) observation that despite 50 years of increasing government support for research, the standard of living in the United States is declining.

The value of science and its contribution to ecological values will continue to be under pressure as skepticism about scientific programs (basic vs. applied; time frame; cost; outcome expectations, etc.) continues to be an issue.

Public-Use Values

In the post-World War II era, outdoor recreation participation grew exponentially, at rates that far exceeded those in the prewar period (O'Leary *et al.* 1990). For many citizens, the ability to get outside and be involved in outdoor activities was growing in importance, and the access to automobiles, greater income, growing populations, and vacation time fueled the growth. National commissions were formed to address these changes and resources were made available to improve access and use of public resources. Agency reports and the Statistical Abstract of the United States underscore the continued growth in all, federal land management agency recreation visitation from the 1950's through the 1980's. All the analysis that has been done about future projections tend to suggest that participation is expected to grow, although the basis for change could be different from what we've seen in the past (Dwyer 1993).

[4] Brown 1992:201

Although one of the values associated with recreation use of public lands is associated with "re-creation" and refreshment of the spirit (often linked to preparation for work), the participation levels have also reflected significant economic value. In addition, while tourist activities have always had a close interdependency with resource areas, increased attention to economic impacts and revitalization of communities and regions appears to have refocused attention again on the value of recreation and travel. In fact, agencies such as the U.S. Forest Service, Bureau of Land Management, and National Park Service have explicitly begun to develop their roles not only in terms of domestic participants, but also in terms of international travelers. This same pattern is also apparent for state agencies such as the Department or Divisions of Tourism. However, while decisions are made to increase the visitors to a state, there is often little discussion that includes resources agencies in how this might affect their actions.

In addition, there are some national studies (President's Commission on Americans Outdoors 1986) that suggest the emergence of citizens that value leisure as their highest pursuit, and work is pursued to support that direction. Although the literature suggested 30 years ago that this would happen because of an increase in leisure time and a decrease in work, other factors appear to be influencing this phenomenon.

Amenity Values

Perhaps one of the key influences of public uses such as recreation and tourism has been a growing interest in the amenity values of the forest and associated resources. As more people had the opportunity to visit resource areas, interest also grew in making areas more attractive and improving scenery. In fact, the area has become so important that it has lead to a growing area of investigation called "Visual Resource Management." Although much of the early work in this area tended to focus on streams and road corridors, the effort has broadened to include timber harvest areas, important and v valued environmental attributes in different settings, landscape views, scenic beauty, etc. This is a growing area of concern, and as Schroeder (1992) indicates amenity values include not only quantitative components, but also qualitative meanings that involve perception, judgment, thought, emotion, imagination, and intuition. These themes appear to also have growing legal standing as environmental and aesthetic quality are receiving greater protection (Smardon and Karp 1993).

In a meeting held in 1991 addressing amenity resources and rural economic opportunities (Shafer and Siehl 1990), the concepts associated with amenities were identified as including natural, historic, and wildlife cultural resources. In the context of rural areas, amenity resources were identified as those aspects of the rural environment that provide beauty and pleasure (Shafer and Siehl 1990). The outcome of these activities were successful enough to influence the final version of the Farm Bill in Congress where amenity resources and rural development were linked and included. The emphasis on beauty and pleasure further underscores the rise of amenity values either viewed as being complementary or in competition with commodity values.

Spiritual Values

An emerging and prominent demand for public wildlands is defined by the spiritual values associated with the on- and off-site use of forests and other natural areas. In a workshop designed to explore the emerging role of spiritual values in wildland management, Driver *et al.* (1992:5) note:

> "While the spirituality-related values of natural areas might not be any more important today than they always have been, interests in and concerns about these values are now being articulated more clearly and stronger and by a broader array of interest groups than in the past. It is a type of resource 'use' that pro-active, creative, and responsible resource managers must attend to more than they have to date."

Of greatest interest is that the issue of spiritual values and forests continues to emerge in a variety of sources. Schroeder (1992) identifies spiritual values showing up as legitimate multiple uses in the *Journal of Forestry* (Salwasser 1990), the National Research Council (1990) report on forestry research, and in the technical dendrology text of Harlowe and Harrar (1958) describing the sense of reverence and awe when entering the outdoor cathedral of a giant sequoia grove. However, he also notes one of the emerging challenges for the resource professional in dealing with the growth in spiritual values.

> ". . . (T)he arguments for a land ethic are mostly abstract and intellectual, and are often justified solely of material human benefits . . . But the educational process for natural resource professionals ignores the intuitive/feeling aspects of human experience, and focuses almost exclusively on a rational/thinking approach."[5]

This issue is underscored in the "Workshop on Spiritual Values of Forests and Other Natural Areas" held in Santa

[5] Schroeder 1992:5

Fe, New Mexico, in 1992 where concerns were expressed both about the growth and emergence of this area and the challenge in measurement and understanding. The concern with this growth is how managers will manage or policy makers make policy with so little known about the interface between values and management

SUMMARY

Nonmetropolitan population growth is an important source of land conversion and loss of natural resources (Dunphy 1988). In fact, population deconcentration has been the primary force shaping changes in urban land use in the United States in the last 50 years (Long and DeAre 1983). Urban land consumption in metropolitan counties occurred at half the rate of urban land consumption in nonmetropolitan counties (Vesterby and Heimlich 1991). Nonmetropolitan growth consumes almost two times the amount of metropolitan land consumption (Zeimetz *et al.* 1976, Vesterby and Heimlich 1991). Forestlands contributed more than one-quarter of the land converted for urban purposes in the 1980's (Vesterby and Heimlich 1991).

Can this broad ranging literature be integrated to formulate a comprehensive understanding of the effects of population growth on forest resources and provide a foundation for research? Population growth and deforestation are causally related on a global scale. This relationship is prominent in developing nations because population growth rates are higher than in developed nations. Population growth is indirectly related to deforestation through land conversion. Forest lands are converted for agricultural crops and pastures. Land conversion for urban uses is not well studied in developing nations. The relationship between population density and land clearing is ambiguous. In some studies there appeared to be a correlation and in others there didn't. Research in developing nations can serve as a foundation for research on the relationship between forest cover and population in developed nations. However, demographic and land conversion dynamics are drastically different in these two types of countries. Growth rates in the United States are not nearly as rapid as they are in developing nations and migration and its effects on urbanization and development appears to play a more prominent role in deforestation. Urbanization is an important source of forest conversion. Migration from metropolitan localities to nonmetropolitan areas is an important phenomenon because nonmetropolitan growth consumes more land than metropolitan growth. Forest resources may be a source of attraction in migration decisions putting pressures on these resources.

PRELIMINARY INVESTIGATIONS

Methods

We analyzed Michigan, Minnesota, and Wisconsin separately to better understand the varying demographic patterns between these states. We performed the analysis on a county-by-county basis. The Forest Statistics publications published by the North Central Forest Experiment Station were used as a source of information on forest land (Raile and Smith 1983, Raile 1985, Miles and Chen 1992). Forest land was calculated as the percentage of kilometers squared per county. The Forest Statistics used were taken from the most recent forest inventory for that state. Michigan's forest statistics (Raile and Smith 1980) were taken from its fourth forest inventory completed in 1980 and published in 1983. Wisconsin's forest statistics (Raile 1985) were taken from its fourth inventory completed in 1983 and published in 1985. Minnesota's forest statistics (Miles and Chen 1992) were taken from its fifth forest inventory completed in 1990 and published in 1992. Census data was gathered from the Census Bureau's summary tape files, 3a (Bureau of Census 1990).

We analyzed several demographic factors in relation to percent forest area to investigate how movements in population interact with forest cover. The first variable we investigated was population density. Population density was measured as the number of persons per kilometer squared per county. It was not clear from the literature how population density affects forest cover. However, we expect that as density increases forest area should decrease. We did a Pearson's correlation on population density and percent forest area to investigate this relationship.

The second population parameter we investigated was the number of people living in urban and rural settings. County population can be divided into three categories: urban, rural, and rural-not-farm. Urban is defined as places with 2,500 or more persons in incorporated areas, census designated places of 2,500 or more persons, and other territory included in urbanized areas. Rural farm comprises of rural households on farms. Farms are defined as places in which $1,000 or more of agricultural products are sold per year. Rural-not-farm comprises the remaining rural residences (Bureau of Census 1990). We expect that as the number of people living in an urban setting increases, forest area will decrease. Similarly, we expect that as the rural farm population increases, forest area will decrease. However, we expect that as the population of rural-not-farm residents increases that forest area would also increase. The literature shows that

urbanization and cultivation are sources of forest conversion. Rural populations not living on farms are not expected to be a source of land conversion. We did a Pearson's correlation to investigate these parameters.

The third population parameter we investigated was a measure of population change. We measured population growth as the percent change from 1980 to 1990. This parameter investigates disparate county growth. The literature defines fast-growth counties as those that grew by 25% and 25,000 people (Vesterby and Heimlich 1991). Very few counties qualify as fast-growing by this definition. Due to a disparity between states' county population growth and percent forest area, we used different category divisions for each state. For Michigan, we divided percent change into three categories: a decrease, no change to a 15% increase, and above 15% increase. We divided percent forest cover into two categories: below 50% forest land and above 50%forest land. For Minnesota, we divided percent population change in the same manner as Michigan, but we changed the percent forest area categories. Mean percent forest area for Minnesota was 19%. Therefore, we considered percent forest area high if it was above 30%. For Wisconsin, we used the same forest categories but changed the population categories. The mean percent county change in Wisconsin was 3% and the fastest growing county grew at 17%. We divided population change into three categories: decrease, between a 0 and 8% increase, and above an 8% increase. We did a chi-square test for each state on percent forest land and percent change to investigate this relationship. We created tables for all three states using the same categories as Michigan to facilitate comparison between states.

To understand the relationship between population growth and percent forest land, we examined the population growth of counties with a high percentage of forest land. We looked at both counties that had above 50% forest area and counties that had above 75% forest area. We also examined the population growth of counties with national forest lands. We divided the counties into those with or without national forest land. If national forest is an attracting amenity, then the presence of national forest in a county could serve as an attraction in migration decisions.

RESULTS

Michigan

Michigan's population in 1990 was 9,295,000 (United States Bureau of Census 1990). This was an increase of 107,000 people and a 1.1% change from the 1980 population (United States Bureau of Census 1980). The mean county change was a 4% increase with a range between 29% and -13%. There were no fast growing counties by definition, although Ottawa County was close. It grew by 30,000 people and a 19% increase. There were 18.4 million acres of forest land in Michigan in 1980 that accounted for 51% of the state's land in 1980. This was a slight decrease from the 1966 forest inventory in which there were 19.4 million acres of forest area that accounted for 53% of the state's land.

The Pearson's correlation on percent forest area showed that as population density increased percent forest cover decreased ($R = -0.3588$; $p = 0.0009$). This was not a particularly strong correlation and looking at the scatterplot of these variables it is noticeable that the relationship is not linear but curvilinear (Figure 1.1).

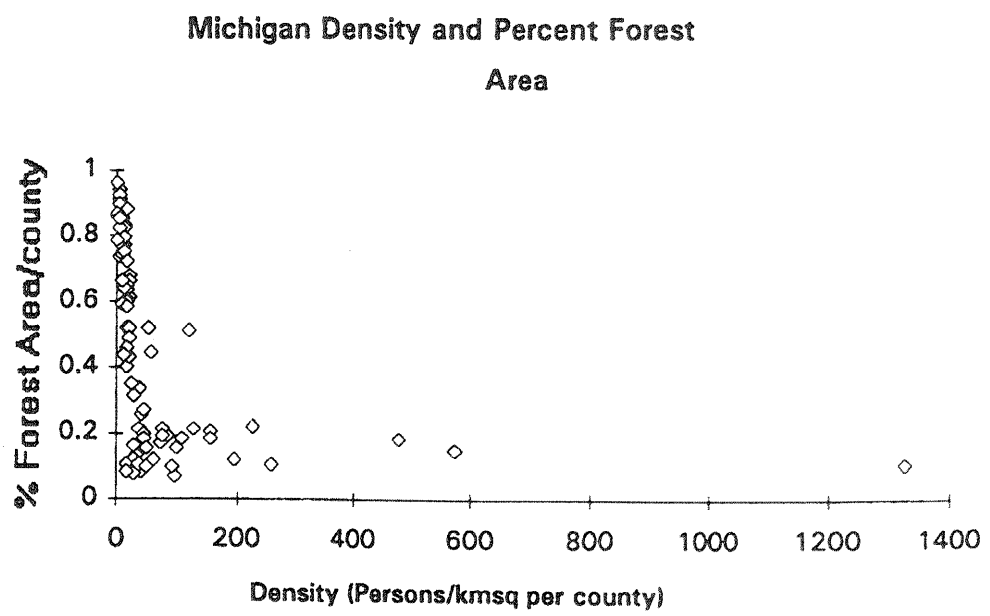

Figure 1.1.—*Michigan density and percent forest area.*

The Pearson's correlation between percent forest land and urban, rural farm, and rural-not-farm parameters revealed interesting results. The strongest negative correlation was between the rural farm population and percent forest land ($R = -0.85$; $p = 0.0001$). However, there was also a strong negative correlation between the rural-not-farm population and percent forest land as well ($R = -0.70$; $p = 0.0001$). There was a negative correlation between the urban population and percent forest land ($R = -0.28$; $p = 0.009$), but it was not as strong as the other variables.

A contingency table for percent forest area and percent growth revealed that eight counties fell into the high growth and high percentage of forest land category. A chi-square test failed to reject the independence of these variables ($\chi^2 = 2.423$; $p = 0.298$). In order to investigate this relationship further, it was important to look at the eight counties that had a large percent change between 1980 and 1990 as well as a large proportion of forest land (Table 1.1). None of these counties were standard metropolitan statistical areas, five had a population change greater than 20%, five had greater than 75% forest land, and four had national forest land present. None of these counties were fast growth counties by definition.

We investigated counties with a very high percentage of forest land (greater than 75%) and national forest land to get an understanding of the population trends in these counties. Overall, counties that had a greater than 75% forest land in the state had an average 2% growth. This was lower than the state average of 4%. However, several of these counties had greater than 15% increase. These counties were Chippewa, Crawford, Kalkaska, Montmorency, Otsego, and Roscommon. None of them were standard metropolitan statistical areas. Crawford and Otsego counties had national forest lands. Several of the counties with greater than 75% forest area had a negative percent change. Keweenaw, Luce, and Ontonagon had a substantial negative change that was greater than 10%.

Counties that had national forest land present had a 4% increase which was equal to the state average. Four of these counties had above 15% increase: Chippewa, Crawford, Grand Traverse, and Otsego. While an increase occurred in some of these counties, many of them had a negative population change. However, Ontonagon is the only county that had a substantial population loss.

Minnesota

Minnesota's 1990 population was 4,375,000, a 7% increase from the 1980 population of 4,105,000. There were 269,000 more people in Minnesota in 1990 than 1980. However, the mean percent county change between 1980 and 1990 was a 1% decrease. The maximum percent county change was an increase of 41% and the minimum percent change was a decrease of 205 (Bureau of Census 1990). In 1990, Minnesota had 16.7 million acres of forest land which was 335 of the 51 million acres of the state's area. Forest area in this state increased by 0.7% since the last forest inventory in 1977 (Miles and Chen 1992).

The Pearson's correlation on population density and percent forest area is plotted in Figure 2.1. The plot looks similar to the plot of these variables for Michigan but not as pronounced. In fact, the correlation coefficient for Minnesota was -0.14 with a p-value of 0.21. This suggests that there was not a relationship between population density and percent forest area in this state.

The Pearson's correlation that we computed for the urban, rural farm, and rural not farm population parameters gave us different trends than the Michigan data. The correlation between urban population numbers and

Table 1.1.—*Michigan counties with greater than 15% growth and 50% forest area*

County	Standard metro. stat. area	Percent change	Population change	Percent forest	National forest
Chippewa	no	19%	5,575	74%	yes
Crawford	no	30%	2,795	85%	yes
Grand Traverse	no	17%	9,374	52%	yes
Kalkaska	no	23%	2,545	76%	no
Missaukee	no	21%	2,138	59%	no
Montmorency	no	19%	1,444	86%	no
Otsego	no	20%	2,964	80%	yes
Roscommon	no	21%	3,402	75%	no

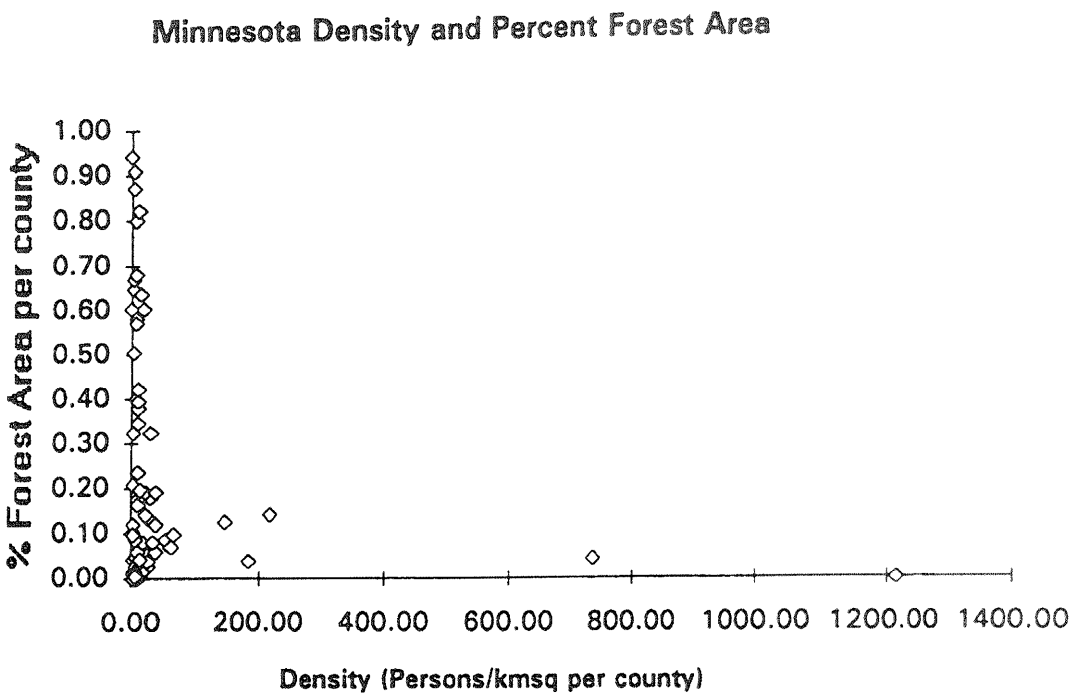

Figure 2.1.—*Minnesota density and percent forest area.*

forest area was very small (R = -0.09; p = 0.37) suggesting that there was no relationship between these variables. There was a relatively strong negative correlation between rural farm populations and percent forest area (R = 0.43; p = 0.0001). There was a moderately positive correlation between the rural not farm population and percent forest area (R = 0.28; p = 0.008).

A contingency table using the categories defined showed that no counties fell into the high growth, high percentage of forest land category. Subsequently, a chi-square test rejected the independence of these variables (chi-square = 6.5; p = 0.03). Minnesota had 11 counties that had a growth of greater than 15%. All were standard metropolitan statistical areas except one and they all had less than 20% forest area except one. Roseau county was the exception. None of these counties had national forest lands and three were truly fast-growing counties by the definition given in the literature. These counties were Anoka, Dakota, and Washington. These three counties had less than 15% forest land.

Looking closer at the counties that had a high percentage of forest land and national forest lands, we see that generally there was a decrease in population in these counties. Fourteen counties had greater than 50% forest land and their average percent population change was a decrease of 2%. The fastest growing county was Beltrami that had a 10% increase. This was a relatively high increase considering the average for the state was a 1% decline. St. Louis County was the only one of these counties that was a standard metropolitan statistical area and its population decreased by 10%. Half of these counties had national forest lands and they were the only counties in the state that had national forest land. These counties had an even greater population decrease of 5%. Beltrami and St. Louis Counties both had national forest land within their borders.

Counties with greater than 75% forest area had an even greater population decrease. These five counties—Cook, Itasca, Koochiching, Lake, and St. Louis—had an average 9% decrease.

Wisconsin

Wisconsin's population in 1990 was 4,892,000 which was an increase from 4,709,000 in the 1980 census. This was a 4% increase. The average county percent change between 1980 and 1990 was 3%. The maximum growth was an increase of 17% and the minimum change was a decrease of 9%. There were no fast growing counties by definition in Wisconsin and only three counties had a greater than 15% change. There were 15.4 million acres of forest land in 1983 which was 44% of the land area. This was a 3% increase from the 1968 estimate of 14.9 million acres of forest land.

As population density increased, forest land decreased (R = -0.33; p = 0.005). The plot of these two variables revealed the same trend as in Michigan and Minnesota. The relationship appears to be curvilinear rather than linear (Figure 3. 1).

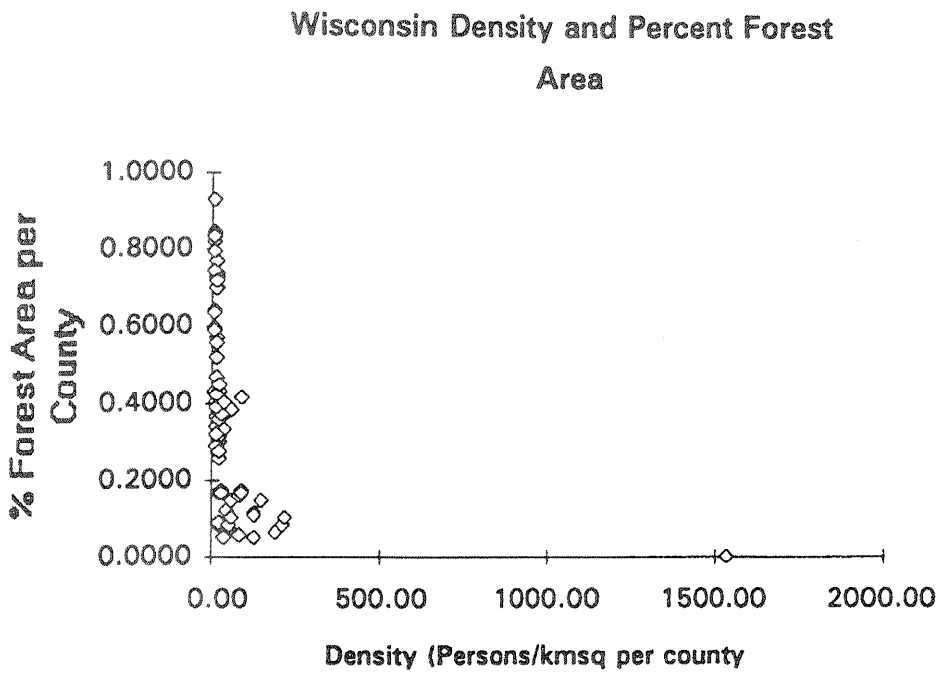

Figure 3.1.—*Wisconsin density and percent forest.*

The relationship between percent forest land and urban, rural farm, and rural not farm populations was more similar to Michigan than Minnesota. As the number of people living in an urban setting increased, the percent forest land decreased ($R = -0.33$; $p = 0.004$). This same relationship was true for the rural farm and rural not farm variables ($R = -0.52$; $p = 0.0001$; and $R = -0.51$; $p = 0.0001$, respectively).

A contingency table of percent forest land by percent change revealed that there were four counties that have above 50% forest land and above 8% population change. The chi-square test failed to reject the independence of these variables (chi-square = 1.66; $p = 0.435$). We created a table with the same parameters as the Michigan contingency table for the purposes of comparison. There were two counties that had a greater than 15% growth and greater than 50% forest area—Adams and Menominee. Neither of these counties were standard metropolitan statistical areas and neither had national forest lands. Menomonee County had 92% forest land. There were no fast growing counties as defined by the literature.

Investigating counties that had a high percentage of forest land and national forest land we see that these counties grew at a rate slower than the state average. Counties with greater than 50% forest land averaged a 2% increase. The state average was 3%. Counties with national forest land also had a 2% increase. There were four counties that had greater than 50% forest land and a greater than 10% increase in population (Table 3.1). These counties were Adams, Florence, Menomonee, and Sawyer.

Table 3.1.—*Wisconsin counties with greater than 10% growth and 50% forest area*

County	Standard metro. stat area	Percent change	Population change	Percent forest	National forest
Adams	no	17%	2,225	57%	no
Florence	no	10%	418	81%	yes
Menomonee	no	*15%*	517	92%	no
Sawyer	no	10%	1,338	80%	yes

FUTURE INVESTIGATIONS

The pattern of metropolitan and nonmetropolitan county growth has been an important area of demographic investigation in the past two decades. These growth trends will continue to be of interest in the 1990's. Population movement between metropolitan and nonmetropolitan counties has repercussions for natural resources, especially forest resources. We will examine the metropolitan and nonmetropolitan growth trends for these states. It would appear from the preliminary investigations that each state will have different trends.

It is evident in the literature that there is a relationship between population movement and resource amenities. Environmental amenities are an important factor in migration decisions. The above results vary between states, but forest land and national forest land in particular do not appear to correlate with high county growth rates. Although, there are several counties that do have a high growth rate and a high percentage of forest land. We will investigate these counties further. Recreation amenities can also be a source of attraction when people are making migration decisions. Future investigations of these data will involve examining migration parameters in relation to recreation resources.

Population movements and forest resources are location dependent. We will be examining the spatial and locational relationship of these variables. It will be helpful to display this information on state maps to view the locational relationship of these counties.

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Updated Estimates of Jobs and Payrolls in Tourism and Forest Products Industries in The Lake States

Larry D. Pedersen and Daniel E. Chappelle[1]

INTRODUCTION

A major effort was made to estimate employment and income associated with forest-related sectors in the Lake States at the time of the regional Governors' conference at which the Lake States Forestry Alliance was formed. Results of that effort are reported in Pedersen and Chappelle (1988).

These estimates are shown in Table 1. They include measures of employment and income in 1982 and 1985, and a projection to 1995, for the forest products sector. Estimates for the forest-related tourism sector are limited (by available data) to measures for 1985. Quality of data available at the time precluded any projections.

Updated estimates using somewhat improved data and methods have now been completed. Methods used are discussed in Pedersen *et al.* (1989), Pedersen and Chappelle (1990), and Chappelle and Pedersen (1991).

Projections for both the forest-related part of the tourism sector and the forest products sector are now feasible. Updated estimates are shown in Table 2. The analysis has been pushed forward from 1995 to 2000.

MAJOR FINDINGS

At least three points are apparent from these measures of employment and income:

1. Numbers of jobs and dollars of sales and income in the two sectors combined are very substantial (e.g., 280,000 jobs considering only direct employment in the two sectors; wages and salaries of some $7.6 billion; and sales and direct expenditures of approximately $26 billion, all as measured in 1990 dollars).

2. Forest products is currently the larger of the two sectors as shown by essentially all of these measures. Specifics of size comparison between the two sectors range from 4 to 1 for employment to 8 1/2 to 1 for wages and salaries with sales and expenditures at approximately 7 to 1.

3. Between 1985 and 1990, employment and income increased more in a proportionate sense in the forest products sector than in the forest recreation sector. The comparison is quite similar for employment, for wages and salaries, and for sales and expenditures when measures for 1985 and 1990 are compared. Each of these measures rose from 1985 to 1990 approximately 15% in the case of forest products. The comparable increases in forest-related tourism were in the range of 3% for expenditures to 6% for employment.

4. Average wage levels are appreciably higher in the forest products sector than in the recreation sectors (specifically about $30 thousand a year contrasted with $14 thousand). This difference is a resources application of a widely made point concerning higher wages in manufacturing compared with wages in service industries.

RELATED WORK

Recent publications on the forest product sectors in each of the three states contributed to major progress on this study element. The first of these is an analysis of progress during the 1980's in economic contributions of forests in Michigan. Economic activity associated with both forest recreation and forest products was analyzed (Chappelle and Pedersen 1991). The second is employment and income estimates for the Wisconsin forest products sector (Martin and Stier 1992). The third is a description of the forest products sector in Minnesota (J. Neil Thomas 1992).

A critical analysis of a number of demographic, social, and economic trends influencing demand for outdoor recreation also contributed to this study element. This analysis suggests a distinct slowing of growth in demand

[1] The authors are Resource economist, Forest Management Division, Michigan Department of Natural Resources, Lansing, Michigan and Professor Emeritus, Departments of Resource Development and Forestry, Michigan State University, East Lansing, Michigan, respectively.

Table 1.—*Forest-based employment and income, Lake States region (Michigan, Wisconsin, Minnesota)*

Forest Products Industries	Measured in 1982	Measured in 1985	Expected by 1995
Sales by wood product industries	$15.3 billion	$16.8 billion	$22 to $24 billion
Additional sales by related industries	$11 billion	$12 billion	$17.6 to $19.2 billion
Direct employment in wood product industries	152,000	170,000	228,000
Additional indirect & induced employment	147,000	164,000	220,000
Wages and salaries in wood product industries	$3.5 billion	$3.85 billion	$5 billion
Average yearly wage or salary (1982 dollars)	$23,036		
Forest Recreation	**Measured in 1985**		
Direct expenditures by recreationists in forested areas	$2 billion	No projections made to 1995 due to relatively low quality of available data.	
Additional indirect & induced expenditures	$2.25 billion		
Employment based on direct, indirect, and induced expenditures (many jobs part-time)	approximately 80,000		
Personal income based on these expenditures and employment	$1.2 billion		
Proportion from nonresidents (new dollars and economic activity)	25 to 35 percent		
Average yearly wage or salary (1982 dollars)	$10,800		

Source: Pedersen and Chappelle (1993).

for quite a range of activities, as well as quite limited usefulness of RPA projections at the national level in estimating levels of outdoor recreation activity (and associated economic contributions) in the Lake States (Pedersen 1992).

CONCLUDING OBSERVATION

Both published work for the three individual states and work now being done for the Lake States as a whole, relate an important observation concerning Lake States forest-products industries as compared with their national counterparts. It is that employment trends in the economic sectors most closely tied to forest resources exceeded both employment trends in the same industries at the national level and employment trends for all manufacturing at the State level. This has been true for several years from the mid-1980's onward for each of the major standard industrial classifications making up forest products industries: lumber and wood products (SIC 24), wood furniture wood part of (SIC 25), and pulp and paper products (SIC 26). Thus, both the absolute and relative economic contributions of these industries have grown over the past decade and this trend appears to be continuing for the foreseeable future.

Table 2.—*Forest-based employment and income (1990 $), Lake States region (Michigan, Wisconsin, Minnesota)*

Forest Products Industries	Estimated for 1985	Estimated for 1990	Projected* for 2000
Sales by wood product industries	$20 billion	$23 billion	$27 billion
Additional sales by related industries	$14 billion	$16 billion	$20 billion
Direct employment in wood product industries	193,000	223,000	234,000
Additional indirect & induced employment	186,000	215,000	225,000
Wages and salaries in wood product industries	$5.9 billion	$6.8 billion	$7.4 billion
Average yearly wage or salary (1990 dollars)	$30,500	$30,500	$31,500
Forest Recreation	**Estimated for 1985**	**Estimated for 1990**	**Projected** for 2000**
Direct expenditures by recreationists in forested areas	$2.9 billion	$3 billion	$3.3 billion
Additional indirect & induced expenditures	$2.7 billion	$2.9 billion	$3.1 billion
Direct employment based on recreation expenditures	54,00	57,000	63,000
Additional indirect & induced employment	31,000	32,000	36,000
Wages and salaries from recreation expenditures	$775 million	$815 million	$900 million
Nonresident share of recreation activity (new dollars and economic activity)	25 to 25 percent		
Average yearly wage or salary (1990 dollars)	$14,300		

Source: Pedersen and Chappelle (1993).

* based on State, federal, and private forecasts.

** based on 1985 to 1990 trend.

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Community and Social Effects of Future Forest-Based Economic Development in the Lake States

Jan J. Hacker and Stephen C. Andrews[1]

INTRODUCTION

This paper discusses the community and social impacts of the three alternative, development scenarios described by the Lake States Forest Resources Assessment. Each of these scenarios starts from the status quo (which in effect is scenario one). The four plausible alternative futures are described as follows:

Future 1: Forest resource-based industrial expansions of the 1980s have carried the region to a new plateau on which the region will rest for some time. There will be few, if any, additional expansions of primary users of Lake States timber resources in the foreseeable future, and only a very modest level of effort to foster them.

Future 2: Forest resource-based efforts toward regional employment and economic growth are concentrated primarily on the tourism/recreation industry. Efforts to attract additional visitors and to provide improved and attractive facilities for them are the core of resource-based economic development efforts in the region.

Future 3: Forest resource-based industrial expansions continue to be assisted by state and community efforts as in the 1980s. These efforts center on effectively packaged information, principal factors affecting plant expansion, and plant location decisions for intrastate regions, e.g., labor supply, potential building sites, transportation facilities, etc.

Future 4: New and more fully synchronized efforts are made to encourage expansion in both tourism/recreation and forest products industries. The two industries are treated as linked in a unified, resource-based development effort. Existing cooperation among the three states is further strengthened and unified in support of this effort.

Three primary methods of analysis are used to describe probable impacts: interpolation from published literature, analysis of case studies, and qualitative assessment based on long experience in rural areas economically dependant on forest products and natural resource-based recreational industries.

Qualitative description dominates the analysis. This emphasis is the result of the broad and non-project specific focus of the various scenarios and the fact that the location of future industry expansions under each scenario cannot be specified with any degree of accuracy. An additional consideration was the target audience of the project—state-level policy makers and elected officials.

For the purposes of this analysis, community is defined as a fabric of social interaction among individuals with somewhat similar sets of values and culture. Community impacts are defined as changes to the fabric of interaction, shared sets of values or community culture. Such impacts can vary in desirability, scale, duration, and intensity. Many factors can result in community impacts, including patterns of in- and out-migration, land-use change, change in resident and non-resident characteristics, and structural economic change, to name a few. These and other social impact assessment variables generally fall into five, broad categories: population characteristics; community and institutional structures; political and social resources; individual and family characteristics; and community resources (Interorganizational Committee on Guidelines and Principals 1994). Several different variables within these broad groupings are examined in this paper and used to describe communities and the impact different types of economic change has on them.

It may also be helpful to define what is meant by forest products and natural resource-based recreational industries. Forest products industries are those industries which create direct jobs in companies classified as 08, 24, 25, and 26 (Standard Industrial Classification). Agricultural services and metal furniture (included under SIC 08 and 25, respectively) are not considered part of the forest products industry in this paper.

[1] The authors are Forest Resource Specialist and Senior Advisor, respectively, Northwest Regional Planning Commission, Spooner, WI.

Natural resource-based recreational industries are more difficult to describe because there is not one or more SIC codes that neatly defines the industry. For the purposes of this analysis, natural resource-based recreational industries are those industries which create direct jobs as a result of people recreating where some type of natural resource is an integral part of the experience. This is a much narrower definition than what is often defined as tourism. Business travel, visits to places like Disneyland, and services associated with conventions are frequently included in the definition of tourism.

Direct job creation in each of these industrial sectors leads to the creation of indirect and induced jobs in other industrial sectors. All three types of jobs are considered important contributors to the economy of a community or region.

HISTORIC DISTRIBUTIONS OF NATURAL RESOURCE-BASED INDUSTRIES IN THE LAKE STATES AND COMMUNITY CHARACTERISTICS RESULTING FROM THESE DISTRIBUTIONS

While the historic distributions of natural resource-based industries may seem irrelevant today, they have influenced current industry distributions especially for recreation industries. Community characteristics of this early distribution are also relevant as they varied with the type of industry dominant in local economies. The community characteristics resulting from different industrial mixes in this time period provide simplified examples of relationships between resources, people, and the jobs at which they worked.

The three Lake States share many similarities regarding the historic distribution of resource-based industries with some important intrastate differences. The first major region-wide focus on forest resources occurred in the period 1880-1910. Within this period, major lumber companies entered the region to cut the virgin forest prompted by reduced supply in the Northeast and South, and strong lumber markets in the Central and Western U.S. This harvest first began in Michigan and gradually expanded westward—first to Wisconsin and then to Minnesota.

Primitive transportation systems and the unsustainable nature of this first harvest strongly influenced community structure and development. Communities in the more remote regions (where the harvest actually occurred) were dominated by mobile and temporary forms of logging camps. At the terminus of major river systems (where sawmills were located), more permanent communities developed. More permanent communities also developed along major rail lines and at ports on the Great Lakes at "service points" (train, ship, and passenger) on the rail lines and at ports.

All three types of communities did share one common characteristic—each had a somewhat different, but very cohesive, set of shared values. The logging camps were the most cohesive, from a community sense, although the turnover of individual residents was often high. These communities were bound by their almost universal, transitory nature and the fact that virtually all community structures, resources, and residents were determined by a single, primary production industry. "Sawmill" communities, while also dominated by a single, primary production industry, developed more diverse economies, including a strong merchant class. This economic mix allowed for a more diverse, community and cultural environment, although economic and class stratification was more pronounced. Northern Michigan, Minnesota, and Wisconsin had centers of similar community structure, at the time, which revolved around iron ore production and associated transportation.

Railroad-centered and port communities were more egalitarian (in terms of income distribution) and the most service-oriented of the three. Their existence was based on servicing the trains and ships that passed through the region and the passengers transported by those trains and ships. As the major modes of transport at the time, these communities were the first rural service centers, although their existence was rarely based on serving recreational visitors.

For the most part, the profits from this resource-based economic development did not remain in the regions from which they originated. The regions' urban centers (Duluth/Superior, Detroit, Chicago, Milwaukee, and Minneapolis-St. Paul) benefitted handsomely from this type of resource development. This fact and the strength of urban economies, based primarily on trade in agricultural products, created the wealth upon which early development of rural, recreational-based economies were built.

Depletion of the forest resource, a poor agricultural land base in the northern Lake States, and, eventually, the Depression caused severe decline in northern, rural areas of the Lake States. The forest products industry virtually collapsed after 1900. The only remnant that remained was pulp and paper industries in the Fox River Valley of Wisconsin. Prior to the depression, railroad-centered and port communities fared better during this period (in a relative sense) as fledgling recreation-based economies developed from previous transport service-based economies. Again, this economic development followed the rail lines in the period 1900-1930, radiating out from the major metropolitan trade centers of Duluth/Superior, Detroit, Chicago, Milwaukee, and Minneapolis/St. Paul and was also centered on major Great Lakes ports. The prosperity of individual service based economies was dependant almost exclusively on their location relative to these major transportation routes.

It was in this era that the foundation for recreation-based economies at such places as Mackinac City, along the Lake Michigan coast of Michigan's lower peninsula, and at select locations in northern Wisconsin and Minnesota, was established. This early, natural resource-based (primarily water-based), recreational development was made possible by the wealth of the region's urban centers. In Michigan, the quality of the resultant recreational developments reflected this wealth.

Recreational developments serving this clientele in Michigan tended to be opulent and self-contained, the ownership and management of which originated from the urban centers. Similar developments in Minnesota and Wisconsin tended to be more modest. Local residents provided the service in these enterprises almost exclusively during the summer months at the peak of the short, summer season. As such, local communities were positively impacted, but the jobs resulting from this form of economic development did not provide year-round employment or a strong base for stable community development. The advent of the Depression which reduced urban to rural travel for recreation, even by the wealthiest individuals and families, greatly impacted communities dependant on this industry. It was not until the end of World War II, widespread ownership of automobiles, and development of the interstate highway system that rural areas unconnected to rail line or port service centers had an opportunity for recreation-based economic development. This more recent development is described in section 3.4.

The strong resurgence of the forest products industry would have to wait until regrowth of the forest base. This more recent development is described in section 4.3.

DESCRIPTION OF THE TYPES OF JOBS ASSOCIATED WITH FOREST PRODUCTS AND RECREATION INDUSTRIES

The types of jobs created by each type of industry are important as they directly impact community structure.

Direct jobs in the natural resource-based recreation industry and forest products industry are fundamentally different. Direct recreation jobs are exclusively service jobs while direct forest products jobs are more likely to be manufacturing jobs. Indirect and induced jobs created by both sectors can be manufacturing or service; however, these jobs also can have distinct differences based on the structure of the primary industry and the prevailing wages they pay.

Indirect jobs in the forest products industry include a high component of other jobs designated as manufacturing or transportation jobs primarily in supplier industries. Jobs in logging and trucking which supply raw material are the primary local indirect jobs created. Manufacturers of equipment, other raw materials and manufacturing users of the intermediate products produced by primary industries are other sectors in which jobs are created, frequently located outside local areas. High quality, service jobs are also created by primary manufacturing industries, which is discussed in Manufacturing Jobs vs. Service Jobs Generally.

Both direct and indirect jobs in the recreation industry are dominantly service type jobs. Retail sales establishments are the primary source of both direct and indirect recreation-based jobs. Jobs in fast food establishments, retail stores and motels/hotels provide the majority of direct and indirect jobs.

Manufacturing Jobs vs. Service Jobs Generally

There is long and ongoing debate about the desirability of manufacturing vs. service types of jobs. It is clear that on a national scale, service jobs make up an increasing percentage of jobs in the economy (General Accounting Office 1994). "Falling manufacturing is a fact. In 1970 the manufacturing sector employed 27% of American workers, falling to 16% by 1993" (Economic Development Digest 1994). It should be noted that Minnesota and Wisconsin did not follow this national pattern to the same degree as other states. Manufacturing employment in each state continued to increase in the 1970's and 1980's along with increased service sector employment. The net result was smaller relative change in the proportion of the economy attributable to manufacturing industries.

One strong trend, however, may mask what is a less dramatic decline on the national level. It is increasingly common for manufacturing enterprises to hire services previously done in-house. When this is done, the same jobs previously classified as occurring in the manufacturing sector are reclassified as occurring in the services sector. Janitorial, accounting, advertising, and engineering services are more frequently done by separate, service businesses. The existence of these service businesses, however, is still dependant on manufacturing. In fact, manufacturing enterprises create local demand for these types of services and other residentiary employment dependant on growth of the economic base (Schallau, 1994). In a recent article, the Economist (1994) notes that while Midwestern cities have had stronger growth in service jobs compared to manufacturing jobs in the last decade, "Gains in manufacturing productivity have paved the way for the Midwest's recovery." This fact is especially important to rural communities.

Rural economies have always had a higher percentage of manufacturing type jobs compared to urban areas.

"The Economic Research Service estimated that by 1989, rural manufacturing employment was slightly lower than it had been in 1979. Nevertheless, as of 1990, rural manufacturing accounted for nearly 21% of all rural jobs, or more than twice the level employed in agriculture and mining combined" (General Accounting Office 1994).

This concentration did not work to the disadvantage of rural counties in the 1980's according to Sears *et al.* (1992) who found that: "Counties specializing in manufacturing generally performed substantially better than average in terms of both growth and stability." Summers *et al.* (1984) found that most case studies involving new manufacturing industry cite positive impacts on per capita or family income. To the extent rural communities can capitalize on concentrations of manufacturing enterprises, they can diversify their economies with high quality, service jobs directly tied to these manufacturing enterprises.

There is little debate that manufacturing industries pay higher wages to their workers and, in the last decade, have had higher productivity growth. The highest quality service jobs pay wages nearly comparable to manufacturing jobs but have higher educational requirements and are frequently directly dependant on the existence of manufacturing enterprises to serve. This is succinctly summarized by Cohen and Zysman (1987) when they write:

"...if we lose mastery and control of manufacturing, the high-paying service jobs that are directly linked to manufacturing will, in a few short rounds of product and process innovation, seem to wither away (only to spout up offshore, where the manufacturing went)."

"It is the high-value-added service roles tied directly to manufacturing (whether they are located in service or manufacturing categories) that we must hold and develop if we are to remain a powerful economy. It is not manufacturing jobs per se. In brief, in order for the shift of employment to services to be developmental and not become a shift to poverty, we must maintain mastery and control of manufacturing production."

These points are further supported by Milewski (1993):

"Yet there is considerable evidence world-wide that natural resources continue to stimulate domestic economic growth and development. A goods-based industry, on average, still generates twice as much additional output for each dollar spent than does a service-based industry. In the US, the Congressional Office of Technological Assessment reports that this multiplier effect has been growing in the manufacturing sector but has been flat in the service sector. While the concept of a "Post-industrial" society continues to be attractive to some futurists, the reality is that Canada, like all other nations, finds itself part of an increasingly complex, industrial society where, as Bennett Garrison puts it "[t]he linkages between the manufacturing and non-manufacturing sectors, between high-tech and low-tech and between what is 'domestic' and what is 'foreign' are becoming more and more intricate."

In addition to higher wages for less skilled workers and the direct support of high paying service jobs, local and regional economies benefit from another characteristic of many manufacturing enterprises compared to service enterprises—their greater contribution to the economic base and their greater productivity. Manufactured products are shipped outside the local or regional economy producing a net influx of revenue to the area. Those service jobs which can also attract clients outside the local or regional economy are part of the economic base and produce similar benefits. In urban areas, a relatively large number of service jobs (but a smaller percentage than that characteristic of manufacturing jobs) may be part of the economic base. This is generally not true of service jobs in rural economies.

Manufacturing, while not producing as high job growth as service industries in the last decade, have had much higher levels of productivity gains compared to service industries. These productivity gains are the basis upon which wages can increase. The combination of higher productivity improvement and higher contributions to economic-base activity make manufacturing more attractive as a basis for community economies. By focusing on manufacturing, greater improvement in a region's economic base can be achieved and local firms that produce a product for export will create stronger local demand for services.

Manufacturing vs. Services as Strategies for Economic Development

For the reasons outlined in the previous section, attraction of manufacturing industries is superior to attraction of service jobs from the perspective of local communities and economic development specialists. How local officials have gone about implementing this focus, however, has changed over the last 10 years. Smokestack industry chasing and exclusive attempts to lure industry from nearby regions has given way to a home-grown approach and focus.

The need to contribute to local economic-base activity and the remote possibility of attracting a large, outside industry has made this approach the most successful. Schallau (1988) echoes this theme when he writes: "Traditionally, most new jobs are created by small, usually existing businesses. Few communities stand a chance of attracting a new, large employer. Consequently, retention of existing firms is of prime importance." Muench (1989) concurs noting that: "Most new jobs in an area generally are created by expansion of existing industry, not location of new industry."

Community Characteristics Resulting From This Focus

Three primary benefits accrue from focusing on retention and expansion of existing businesses and local start-up: (1) more manageable, attainable, and sustainable economic growth; (2) greater likelihood that this growth will be retained on the local level and; (3) more efficient use of available time, personnel, and money. A bias towards manufacturing more quickly leads to a build up of demand for service industries and the greater likelihood that those service industries will ultimately be successful.

Gradual, orderly, and predictable economic growth leads to less disruption in local governance structures and finances, although such growth is often contrary to political goals for any and all types of development. The need for major and immediate improvements in public infrastructure to accommodate large greenfield developments (and the eventual population increase which results) is reduced as is the chance that local tax revenues will have to be sacrificed to achieve economic development. The existing, local labor market is more likely to be positively impacted by such development compared to establishment of a major new employer which, at least initially, will hire a large percentage of current non-residents who may relocate or commute from distant areas. Land use change is also more easily planned and guided.

This is not to say that all major developments are detrimental to community structure and cohesion. Each community has differing ability to absorb new industry given its existing public infrastructure, labor force, and private resources. The establishment of a major, new employer in an area where the skills of the existing labor force and existing infrastructure or planned new infrastructure can be utilized will have positive community impacts. Communities which do not have the capacity to handle major impacts of high intensity or long duration may suffer negative impacts on community cohesion, land use patterns, and local public finance.

All businesses experience peaks and troughs in demand for their products or services. In the long-term, market forces often necessitate a change in operations—be it expansion, retrenchment, or entrance into new product lines. Those firms with strong, local ties are more likely to factor potential community impacts into their business decisions than owners who are not invested in the community. This can lead to longer-term community stability even in periods of retrenchment or a business downturn.

MODEL OF RECREATION INDUSTRY DEVELOPMENT

Many states and local communities are touting recreation and tourism development as major focuses of current economic development efforts. Unfortunately, this is often done without a strategic focus or a realistic assessment of an area's positive and negative attributes to attract specific types of industry. An attitude of "build it and they will come" seems to pervade local efforts to develop this industry—often with disastrous results. Such an orientation ignores the fact that it is the needs, wants, and desires of the tourists themselves which determine the success of recreational industry developments. Failure to match facilities to desired experiences can lead to wast as well as missed opportunity. Communities can benefit from natural resource-based recreational industries if they plan with three predominate considerations in mind:

1. Economic-base industries produce net economic benefits to local communities and create demand for residentiary services;

2. Recreation industry development can be characterized as occurring in different stages, each of which involves different community impacts, different types of visitors, and differing needs for specific types of natural resources; and

3. The types of development with the greatest potential to generate economic-base activity are also the types of development that most impact community character.

STAGES OF RECREATION AREA DEVELOPMENT

The concept of a cycle of recreational area development is discussed in depth by Butler (1980). Citing numerous other studies, this author suggests there is strong evidence in support of a general pattern of recreational area development and change. This section draws heavily from this source. It should be noted that the desirability

of each stage of recreational area development is dependant on individual perceptions and the relative value individuals place on the positive and negative effects each stage creates in communities.

The first stage is the exploration stage. In this stage, small numbers of recreationists are attracted to an area primarily by the areas natural and cultural attributes—clean waters, scenic vistas, opportunities for solitude, historic sites, small town feel, etc. As visitation increases and becomes more regular or predictable, the involvement stage begins. At this stage, local residents recognize the value of these visitors and begin providing services and constructing facilities specifically aimed at visitors often based on an emerging recreational season. Up to this point, local community culture and character remain little changed. Other industries are the backbone of the economy with the incomes generated from recreation serving as a supplement to other sources of income.

In stage three of the cycle—the development stage—promotion and advertising of specific area attributes accelerates. This attracts not only more visitors but can also attract outside investors and competitors. Locally-owned facilities and service providers to visitors are increasingly supplanted by more elaborate facilities connected by regional or national franchises and chains, especially hotels and motels. This stage of development increasingly relies less on an area's natural attributes and more on artificial or man-made attractions for the entertainment of visitors, including such things as indoor entertainment facilities, water parks, golf courses, etc. It seems clear that for this type of development to succeed, a certain amount or critical mass of such entertainment facilities is needed. Stand-alone facilities of this type rarely succeed. The large number of water slide and bumper car type of developments (which seemed a favorite type of investment in the 1980's) in largely rural areas attests to this fact.

The development associated with this third stage attracts different types of visitors and as development accelerates the number of visitors does as well. Changes in the physical appearance of the recreation market area are apparent and local communities may, at this point, face some of the undesirable aspects of such development—increased traffic, the need for greatly improved public infrastructure, etc.

In the consolidation stage (stage 5), development of new facilities will taper off and visitor numbers will stabilize. Marketing and advertising of the area will be far reaching and attempts will be made to extend the seasonality of the recreation in the area, transforming it to a "year-round recreation destination". The economy of the area is more reliant at this stage on the recreational industry. It is within this stage that visitor numbers peak.

The next stage in recreational area development is the stagnation state. At this stage visitor numbers begin to decline and attendant social, economic, and environmental problems associated with aging public and private infrastructure become more apparent. The area may no longer be trendy and marketing will begin to focus on other forms of traffic or visitors, such as conventions and business travel. A second wave of new attractions may be built specifically to maintain visitation levels and attract new types of visitors. Depending on the success of these strategies, an area can enter either a decline stage or a rejuvenation stage.

Not all areas will go through each of these stages. The attributes of particular areas and their location in respect to major travel routes from urban sources of visitors are two major factors which contribute to an area's potential to go through each stage. The length of time an area can spend in any one stage is also highly variable. This model does, however, provide a valuable framework within which community impacts can be analyzed.

COMMUNITY IMPACTS OF EACH STAGE OF RECREATION AREA DEVELOPMENT

Community and social impacts vary greatly for each stage of recreation industry development as does the importance of natural resources in each stage. The first two stages are the most natural resource dependant because visitors are attracted to an area specifically because of the natural resources which exist there.

From a land use perspective, large areas may be devoted to attraction of the small number of visitors characteristic of the exploration stage of development. Extensive trails, remote and dispersed campsites, and the scenic vistas desired by visitors in the exploratory stage all require significant land areas. Such dedication can be costly to local economies if it does not quickly lead to further recreation-based development. A case in point is Orick, California, surrounded by Redwood National Park. In the late 1970's, after a bitter battle, 78,000 acres of commercial forest land surrounding Orick was added to Redwood National Park. The flood of tourists to the park never materialized and the loss of jobs in the sawmilling industry caused an over 50% reduction in the population and huge jumps in unemployment and welfare dependency (Kiestor 1993).

At another extreme, the sheer crush of visitors to some well-known natural resource-based recreation areas can cause a different set of problems. The popularity of many national and some state parks has created problems

and questions of how to manage the popularity while still preserving the resource base upon which such visitation depends (Byrne 1989). Deteriorating public facilities in parks and unregulated and uncontrolled land use and development just outside park boundaries has, in many cases, created sprawling, visually unappealing types of development (Schallau 1994).

Visitors to recreation areas which can be characterized as exploratory often provide little local benefit because of their low numbers and thrifty habits. Again, as described for Redwood National Park:

"People stop, look up at the trees, go to the bathroom and drive on. Visitation is not helped by the park's lack of facilities. It has no tourist lodging and no drive-in campgrounds. Campsites can be reached only by strenuous backpacking." "... most North Coast visitors are budget-minded, outdoors-loving families who camp in the state and county parks or head for the beaches." (Kiester 1993).

To the extent a community can attract such visitors **without** substantial cost to other sectors of the economy, it will be to local benefit. However, this rarely happens and when it does, local benefits are not high. In Maine:

"Vacation land is the proud tag on Maine's license plates. But the holiday season is short. Two or three months, and the summer houses strung along the rocky coast are closed again. The largesse of visitors neither lasts the winter nor reaches the interior of this most north-eastern state" (Economist 1992).

Significant community benefits usually appear when recreation in an area enters the involvement stage. Within the involvement stage of development the economic benefits of area recreation are almost wholly captured on the local level. To the extent, again, areas can function in this stage **without** reservation of natural resources which contribute to other local natural resource dependant industries, this type of recreational development can produce substantial local benefits without excessive cost to community cohesion or social patterns.

In this stage, facilities to serve visitors are often family owned and operated. There is close cooperation between facility owners born largely as a result of previously established social interactions. Workers in the industry are almost entirely local and frequently work only part of the year during seasonal peak periods. The local population does not increase substantially and land and housing prices tend to remain fairly stable. Out-migration may slow as jobs in the industry allow some family members to remain.

Community cooperation in promoting visitation at this stage is high and often takes the form of sponsorship of community festivals or sporting competitions at various times of the year. The largest and most successful of these, such as Grandma's Marathon in Duluth, MN, Alice in Dairyland held throughout Wisconsin, and the Tulip Festival in Holland, MI, make much higher contributions to the economic base of local communities than events which appeal to more local crowds. Huge, short-term influxes of people on color tours, deer hunting or snowmobiling trips can also produce economic base activity.

At this stage of development, these visitors provide economic benefit at very little cost in terms of community finances, stability, cohesion, or character. Public infrastructure needs to accommodate any growth are usually moderate primarily because local populations do not increase dramatically. Except for hotels and motels, other components of the recreation industry are likely to be as dependant on serving resident recreationists as they are on serving visitors from outside the local area. A key concern for communities at this stage is how to attract more distant visitors and reduce the seasonality of recreational visits. Burch (1992) aptly describes this type of development, and the visitors it caters to:

"However, such disappointments [referring to unsuccessful development of a large resort catering to high income urbanites in Greenville, Vermont] should not deter us from considering our more traditional forms of tourism that complement traditional, primary forest production activities. Rather than free spending, swinging singles, our clients are more likely to be steady, married with children. Their interests tend toward more prosaic activities such as ice fishing, snowmobiling, mountain biking, wading, swimming and boating. These recreational activities and those customers who engage in them provide a steady, incremental growth that will produce long-term economic benefits of a type that is less likely to upset the traditional community life of places like Greenville. Such customers are not likely to fulfill the dreams of cargo-cult tourism with its vision of quick riches. However, serving their needs and expanding activities likely to appeal to them will insure a core, low key, solid economic base from which to launch other ventures."

In advancing through the next stages, communities reap added benefits but also incur increasingly high costs. As the development stage progresses communities are increasingly beset by problems related to rapid development at the exact same time their area, as a destination for more distant travelers, becomes more attractive. The initial entrance of regional and national franchises and

chains in an area does provide local economic stimulus in the form of service jobs for local residents although it introduces an element of competition that can be disadvantageous in the long run. These chains and franchises, with more sophisticated marketing and advertising networks, offer stiff competition to local enterprises. They frequently raise the stakes to the point that locally owned enterprises are put out of business by a combination of two factors: (1) the chain's ability to attract visitors which demand more man-made amenities than local industry is accustomed to providing, and (2) alteration of the community in a way that discourages long time visitors interested in the areas natural and cultural resources. Local community culture is changed if outside owners and managers are brought in to operate new facilities, job holders in these facilities are increasingly non-residents, and visitor numbers increase. Smith (1989) described the impacts of this type of development in the Southeastern U.S.:

"While successful development generates much-needed local and state revenue, it also places costly demands on a community's infrastructure, raises the cost of living, degrades the environment which first attracted tourists, dilutes often fragile local cultures, and generates principally marginal, seasonal jobs."

"In the process of expanding tourism development, the Appalachian communities of Sevier County (Tennessee) have sacrificed the simplicity and the slow pace of the culture that originally attracted visitors to the area."

It is often at the development stage that local, public financial resources and land use control policies are severely strained. Large influxes of visitors and seasonal workers require high front-end investments in public infrastructure, such as improved water, sewer, and road systems, before increased property tax revenue is available to pay for it.

This financial burden, the difficulties experienced by local owners, and change in the "look" of local communities can lead to resentment by long-time residents and emergence of growth vs. no-growth factions. At the extreme, community character can be destroyed and local long-time residents can be driven out of the community by the combination of increasing property values and the types of jobs created by such development. In Jackson, Wyoming, currently experiencing a tourism boom:

". . . what Jackson now lacks are homes for teachers, firefighters, waiters, police officers, and assorted others who earn their living serving people who go there to play or live on a grand ranch."

"At the Antler Motel, Clarene Law puts her 40 employees up in trailers and small cabins. It is the only way, she said, to hold onto the bed-changers, clerks, and laundry cleaners who keep the motel running." "While the boom has been good for some ... it has raised property assessments and taxes to the point where many long-time residents have no choice but to sell" (Egan 1994).

The development stage is a wrenching one for local communities. Having gone through it, the consolidation stage is reached. At this point, the economy and the community are heavily dependant on the recreation industry. Most of the recreation will be only marginally related to the natural resources of the area. The appearance of an area will have been permanently altered. From a state-wide perspective, development up to and including this stage is all to the good as it has the ability to draw in large numbers of out-of-state visitors. The local community, however, is frequently disillusioned by this stage. This disillusion stems from disappointment with the types of jobs created for local residents and a vague sense of loss of local control. On the matter of jobs and local economic benefit, Rajender *et al.* (1967) note the leakage of funds from local areas which often results from major tourist attractions or resorts:

"In Teton County there is a complicating factor in that many of the summer residents are seasonal workers who have a permanent residence elsewhere. These people are inclined to spend relatively little money during their residence in the County; the bulk of their earnings go into expenditures at their regular place of residence. This situation is responsible for a large part of the fund leakage and has very serious results."

The sense of loss of local control is often less easy to quantify but is nevertheless a very real fact.

"In north country sprawl it is this loss of the ability to sustain, the sense that a productive landscape has been swapped for greater access to Hagen-Daz ice cream and Big Macs. This is confirmed by the emergence of no trespassing signs blocking access to traditional hunting and fishing areas. Slowly there is an awareness that one and one's hometown are dependent upon persons and institutions far from the reach of the locality. Like urban graffiti that signals the loss of order and authority in one's community, the rural town soon learns that the local leadership is equally dependent upon the whims of outsiders."

"It is this sense of dependency, this sense of loss of local control that has local politicians and citizens look for someone to blame" (Burch 1992).

Whether recreation areas stagnate, decline or are rejuvenated at this point matters little to community structure and social patterns. The major benefits and costs to the previously existing community have already occurred.

Decline, of course, will have negative impacts but not as severe as those incurred up to this point.

Recreation is and can be an important industry in various regions of the Lake States but its development is not without cost. Except in the case of a recreation area in decline, those costs are largely borne by local communities while benefits are more widely dispersed.

THE SPECIAL CASE OF RETIREMENT/REGIONAL VACATION CENTERS

Discussion of recreation-based communities up to this point has focused on recreation designed to attract and cater to visitors—people who do not own property in the area and visit specifically for a recreation experience. Another type of "visitor" some areas of the Lake States are heavily dependant on are second home owners who eventually may turn into retired homeowners. For the most part, owners of these homes spend only part of the year at these locations and their primary residence is in one of the region's major metropolitan areas. The dominant settlement pattern in areas heavily impacted by this type of development is highly dispersed and overwhelmingly centered on lakes or rivers. Pleasant forested settings and water access are very important natural resource components of this type of development. This type of development has very different impacts on local economies and community structure compared to recreation-based development.

From a community perspective, there are both advantages and disadvantages of being in such an area. The highly dispersed nature of this type of development makes provision of public services expensive. For the most part, however, communities choose not to incur the highest of these expenses (provision of centralized sewer and water). This rarely causes problems except where settlement densities are very high around lakes—especially when the primary period of settlement occurred decades ago. In this case, septic systems and wells frequently have substandard designs and spacing and the current density of housing makes provision of centralized water and sewer very expensive. Other public services are not discretionary. Road construction and maintenance costs can be very high as can fire protection in areas of very flammable forest types. Community and county burdens for other types of expenses, such as schools and welfare payments, are little affected by the direct impact of this type of development because of the nature of the new "residents".

Conversion of second homes into retirement homes increases the need for some public services. In general, these service needs remain manageable. A conversion of second homes or retirement homes into full-time family dwelling structures, however, can create major impacts on local government finances. This is especially true in communities which have practiced deferred maintenance on and construction of public infrastructure—an all to common pattern.

Development of second and retirement homes does produce rising property tax revenues and rising property values both of which are usually welcomed in the initial stages by local residents and governments. At some point, however, this can begin to adversely affect local communities and long-time residents as Hoffman (1976) pointed out about Bull Shoals, Arkansas:

"As people and capital started coming in from the outside, and some of the natives prospered in their business and professional ventures, land ownership began drifting more and more into the hands of the well-to-do."

"As recently as fifteen years ago, farm land in the area was selling for $30 to $40 an acre; now it sells for five or ten times that and is still rising."

As alluded to in the preceding quote, communities with high numbers of seasonal homes or retirees who moved in from outside the area do have positive impacts on local economies (General Accounting Office 1994). In a study of 2,360 rural counties across the country, Sears *et al.* (1992) found that: ". . . retirement counties substantially outperformed other counties in terms of stability and growth. The stronger counties were more than three times as likely as the weaker counties to be retirement counties."

This performance is linked to the fact that these inmigrants often bring with them money from urban jobs or pension benefits earned elsewhere which they spend on services. Thus, from the perspective of the local economy, such spending is entirely economic base activity. Unlike major recreational attractions, however, such spending is often not part of a state's or region's economic base since these homes are frequently owned by a state's or region's urban residents within a day's drive. The need for these services results in the creation of more permanent local jobs, jobs in the construction trades, home services and health care, as opposed to jobs serving recreationists which tend to be part-time and in the hospitality trades. This phenomenon is also described by Hoffman (1976):

"Most of the people migrating to Bull Shoals are oldsters from up North. But quite a number of younger people are also coming and bringing their needed skills—plumbers, shopkeepers, even professional people."

The major disadvantages for local communities as they develop into second home or retirement centers, are fragmented land use patterns, declining support for public services, and increasing community conflict. Many communities take great pride in their physical appearance. For communities in forested areas this pride is extended to the surrounding landscape. The concentration of second homes on lakes is thought to detract from the beauty of the local setting. As one participant in a recent Wisconsin Department of Natural Resources strategic planning project said (a retired inmigrant himself): "People have to realize that every lake in the north should not be surrounded by 100 foot lots." The report from that same planning project also discusses the need to maintain big-block, contiguous forests in order to protect the character of the north. This perception is an important part of the culture of communities in forested areas. In areas strongly influenced by second home development, this type of landscape can rarely be maintained.

Long-term support for community services also deteriorates in areas of strong second home development. This is particularly true of retirement areas (Weeks 1989). Part-time residents or those retired and on fixed incomes (who do not receive public services via schools, water, sewer, community parks, or libraries) are rarely willing to vote for increased public monies for improvements.

In addition to conflicts over support of public services, the differing characteristics of immigrants and local residents can also lead to conflict over development and the environment. Many retired immigrants move to forested areas precisely to enjoy the forested environment. Their income is not dependant on the condition of the local economy. In fact, many perceive that any additional development (after they arrive) will be bad if it impacts the natural, uncrowded conditions that attracted them in the first place (Blahna 1989). They also may object to resource management practices which residents find entirely acceptable. These attitudes and orientations can negatively impact future growth by constraining a communities fiscal and physical capacity to provide for future economic development and by creating a perception that additional growth is not supported by community residents.

EXAMPLES OF EACH STAGE IN THE LAKE STATES AND THEIR CURRENT DISTRIBUTION

Current distribution of recreational industries in the Lake States was strongly influenced by historic patterns which gives some regions distinct advantages in attracting future development. Also important to appreciate is the different nature of recreational enterprises in different parts of the Lake States. Recreational markets and the industries they will support are highly variable within inter- and intra-state regions.

The three Lake States currently exhibit very different patterns of recreational industry distribution. In addition to the strong influence of historic distributions, all three Lake States have been influenced by changes in patterns of recreational travel, purposes of recreational travel, and the amount of second home and retirement home construction.

Following World War II, greater mobility of average people favored development of smaller and more forest-based types of resorts to which families would drive and spend a week or more recreating in the immediate vicinity. The differing character of recreational development catering to this clientele (compared to earlier recreational development based on wealthy urbanites traveling by train or boat) allowed for more local ownership and, consequently, greater capture of the benefits on the local level. The season, however, was still primarily summer-based, and consequently provided important but limited benefits to service workers in local communities. Unlike earlier recreational developments, these types of developments tended to be more dependant on the natural resource attributes of the recreational area due to the increased activity of participants in such things as hiking, camping, hunting, and fishing.

This type of development is best characterized as the involvement stage of recreational development and has associated with it all the community advantages and disadvantages described in section 3.2.

All three states seemed to benefit equally from the emergence of this new pattern of recreational development—at least initially. Wisconsin, clearly, has been able to sustain longer the predominant form of recreational enterprise of the post World War period—small, often family-owned resorts centered on northern lakes. The Rhinelander area, in particular, is noted for this type of enterprise. These industries appear vibrant despite the fact that recreational visitor patterns have changed.

Development of small, forest-based resorts was also strong in Minnesota in the Post War Era and they remain an important part of the northern Minnesota economy. The resorts that remain today are strongly oriented toward fishing. The Brainerd area is clearly the center of this type of recreation in the state. The distribution of small, forest-based resorts is more concentrated in Minnesota compared to Wisconsin. Another concentration of industries characteristic of the involvement stage of recreational development exists in areas bordering the Boundary Waters Canoe Area. These businesses serve the needs of visitors to this wilderness area.

In Michigan such resorts were concentrated along the Great Lakes and, as prices for shore land property rose, were displaced by other types of development. Stronger patterns of change in recreational activities also more severely impacted Michigan resorts compared to those in Minnesota and Wisconsin. Sheer distance from major population centers seems to have prevented establishment of similar resorts in Michigan's Upper Peninsula. Recreation-based industry in much of Michigan's Upper Peninsula is dominated by summer-based types of activity and is highly dependant on travelers passing through the area although winter-based recreational activity is becoming more important.

Travel patterns again influenced by greater mobility changed in the 1970's and 1980's from week long stays at resorts to two or three night stays in a number of resorts or motels with travel in between. This forced management modifications at traditional resorts.

The activities people engage in while recreating and the season of the year they choose to recreate have also changed over time. More active and equipment dependant activities have become a larger component of the recreational industry. Snowmobiling, power boating, ATV riding, cross-country and downhill skiing, and mountain bike riding have necessitated increased facilities to accommodate their use. The growth in winter sports in particular has aided many areas dependant on forest-based recreation in reducing the seasonality of recreation-based industry from its previous heavy reliance on the summer trade. The relative strength of rural areas where recreation businesses are a major part of the economy is due, in large part, to more year-round activities focusing on fishing and camping in the summer, hunting in the fall, and skiing and snowmobiling in the winter. This has led to many stable recreation-based industries. It is still common to have industries catering to recreationists open only spring, summer, and fall in the northern Lake States (especially non-winterized resorts), but it is less common than it was once.

The development stage of recreational development was historically most strongly represented in Michigan along the Lake Michigan shoreline as described in Historic Distributions of Natural Resource-Based Industries in the Lake States and Community Characteristics Resulting from These Distributions. More recently, this stage was most strongly evident in the Wisconsin Dells area of Wisconsin. The most recent evidence of forested areas entering the development stage include the triangle area between Petoskey, Gaylord, and Rapid City in Michigan, the St. Croix/Mississippi Valley between Wisconsin and Minnesota, and portions of the Door County Peninsula in Wisconsin. Many businesses in these areas which serve recreationists are also seasonal despite being fairly close to major urban centers. Development in the Gaylord/Petoskey area is more dominantly based on resorts often catering to golfers.

Areas presently in the consolidation stage of recreational development include Traverse City, Petoskey, Charlevoix and Mackinac City in Michigan and Wisconsin Dells in Wisconsin. In Minnesota such areas are closely located south of the two cities of Minneapolis and St. Paul (Chaska and Shakopee) but are only remotely related to an original natural resource base. In all these areas, existing recreational areas have highly developed man-made attractions of long standing intended to satisfy the recreational and retail shopping needs of visitors. All of this recreational development is less rustic than other forms of development and is less dependant on the presence of forests or other natural resources. Community characteristics of these areas are described in section 3.2.

Forested areas most strongly influenced by second home construction in Wisconsin include the area north of USH 8 and west of STH 27 in northwest Wisconsin and the Rhinelander area. Forested areas most influenced by second and retirement home development in Minnesota include the Brainerd area and the area east and south of Brainerd. In Michigan, second and recreational home development has occurred in the northern Lower Peninsula and has been concentrated in areas close to I-75 and along the Lake Huron shoreline, south of Alpena.

DESCRIPTION OF TYPE AND LOCATION OF JOB GROWTH FOR THIS SCENARIO AND EXAMPLES OF APPLICATION AND IMPACT

Future scenario 2 of the assessment is described by Chappelle (1994) as follows:

"Forest resource-based efforts toward regional employment and economic growth are concentrated primarily on the tourism/recreational industry. Efforts to attract additional visitors and to provide improved and attractive facilities for them are the core of resource-based economic development efforts in the region."

Under this scenario, an addition of 10,000 total jobs in the recreational sector are estimated in the 10-year period 1990 to 2000. The **direct portion** of these jobs will result in increases of $85 million in wages and salaries and $300 million in sales and direct expenditures. This represents a 10% increase over estimated 1990 employment wages and salaries and sales and direct expenditures sector. Average annual wages for directly generated recreational jobs were estimated at $14,000.

Due to the strong influence of historical distribution and travel patterns on recreational industries, these natural resource-based recreational jobs are likely to be located in areas where they currently make up a substantial part of local economies. The dominant form of enterprise which will cause the least disruption in local rural communities and yield the most economic benefits are developments characteristic of the involvement stage of recreational development. By building on existing strengths of well developed trail systems, highly cooperative relationships between local owners, and extensive water resources still available for public use, rural areas can incrementally add to their economic base while creating jobs for local residents who desire such employment or those residents who desire only part-time employment.

The encouragement and promotion of further recreational development in areas already past the involvement stage can also be beneficial if it is accompanied by strong, local direction and influence to maintain desirable land-use patterns and encourage local ownership wherever possible. Less rural areas have stronger and more receptive local government structures needed to provide strong local direction in the face of promises of quick riches based on tourism. Recognition of the type of development most appropriate to a given area can go a long way to avoiding community disruption and the waste of private and public financial resources.

Capture of the benefits of second home and retirement communities, while minimizing substantial local costs, is more problematic. While areas characterized by this type of development (and the local jobs which result from it) are not included in the previously mentioned job estimates, their influence on recreational industry development warrants some discussion. Areas of strong second home development can lose their capacity to provide natural resource amenities designed to attract visitors desiring an experience based on a natural landscape. Second home development may be a precursor to more intensive development designed to satisfy an area's retail shopping needs.

It is also, almost inevitable, that areas of strong second home growth result in fragmentation of large areas of forest land into small privately-owned parcels. While second home growth areas generally perform better economically, this economic benefit comes at the cost of the loss of extensive areas of working forests. This can have severe impacts on other local natural resource dependant industries as productive land is subdivided and lost to forest industry use. It seems certain that second home development in the areas currently impacted by this type of development will continue with accruing benefits to local economies and costs in terms of community character, cohesion, and future infrastructure needs.

A MODEL OF FOREST PRODUCTS INDUSTRY DEVELOPMENT

Two distinct types of development patterns are characteristic of forest products industries. Primary, forest products industry development patterns are highly dependant on sub-state and local timber supply characteristics, national and international market conditions, and, in the case of pulp and paper industries, access to large quantities of water for processing. Historic distributions of primary, forest products industries has some influence but not nearly as much as is characteristic of recreational industries. Secondary forest products industry development patterns are influenced to a greater degree by distance to major regional consumer markets and historic distributions.

Sawmills and plants based on composite board technology are established in a widely dispersed, regional pattern based on local timber supply characteristics, given national and international markets which will absorb resultant products. Unlike more advanced types of recreational developments, there appear to be no advantages to sawmills or composite board industries producing the same products to locate close to one another. For these industries, no critical mass is needed for success as individual firms. In fact, local concentrations of such industries which compete for the same raw material supply are often counter productive. There are advantages, however, for industries which further process one another's products or that utilize different raw materials to locate together. Such associations can save on transportation costs and utilize pooled facilities such as wood yards or power sources.

Typically, sawmill and composite board production industries are established in rural areas without intensive local competition for wood supply. Such establishments, especially composite board industries, are increasingly owned by corporations not endemic to the local community. Sawmills are still more frequently locally-owned and operated but that is changing as the size of mills increases to capture greater economies of scale and higher productivity rates.

Once initially established, sawmills often spawn additional forest products expansions or enterprises focusing on increasing levels of investment in various secondary forest products sectors. The first stage of such investment beyond sawmills is often in pallet production operations and dry kilns. Dry kiln investment can lead to

additional investments designed for entrance into more specialized markets for flooring, dimension parts, panelling and moldings. To the extent there is vertical integration and critical mass in the forest products industry, it is in the relationship between these different industries catering to different markets. Fully integrated forest products firms producing green lumber through to finished products such as furniture are rare. More commonly, separate firms produce intermediate products for use by other firms further down the production line to final consumer products. Many communities have attempted to attract various industries that are compatible and can utilize each other's intermediate products through creation of forest industry industrial parks.

Unlike sawmills, composite board industries rarely spawn additional forest products expansions or enterprises in different sectors. These types of plants also rarely expand capacity at existing sites. The more common pattern is wholly new, greenfield developments at new locations where similar plants do not exist. Pulp and paper mills also rarely spawn additional forest products enterprises in different sectors; however, capacity expansions frequently occur at the sites of existing mills. The primary reason for this type of pattern are the large capital expenditures needed in pollution control technologies, particularly water treatment facilities. Needs for large amounts of power and water limit the number of locations where these types of facilities can be built.

As stated previously, primary production (conversion of logs into lumber or composite materials) is concentrated in areas close to raw log supply while final product production (furniture, fixtures, cabinets, etc.) is concentrated in major sales (market) areas which tend to be more urban in nature. There are many stages between primary production and final product production of solid wood products, all of which are affected by transportation costs, local labor markets, and other factors. Reduced transportation costs and more favorable labor markets in rural areas can affect the general pattern of secondary industries being located close to final markets by favoring development of secondary industries in rural areas. While rural areas have a virtual lock on primary production sawmill and composite board industries, the extent to which they can develop beyond this into secondary industries is dependant on local demand for final products, transportation costs for final products to more distant markets, and the relationship between labor markets in rural areas vis-a-vis labor markets in urban areas.

Development of many secondary forest industries (which characteristically locate in urban and suburban areas) is the direct result of local markets for products produced by these industries. The growth of cabinet makers, industrial pattern makers, and other producers of products for direct consumer consumption are frequently dependant on local urban and suburban markets. Other types of secondary forest products industries serve more regional markets for such products as pallets, furniture and millwork. These industries tend to locate in more urban areas but they are less tied to such areas. For many of these industries, there is no pattern of development independant of general economic growth. There are some exceptions in the Lake States region, notably window manufacturers and furniture makers, but for secondary forest products industries in general, location near major population centers is the norm.

HISTORY OF INNOVATION IN THE INDUSTRY AND REGIONAL COMPARATIVE ADVANTAGES IN THIS SECTOR

It is not possible to fully appreciate the dynamic nature of the forest products industry in the Lake States without reviewing the history of innovation in the various sectors and the industries' national and international market positions.

Following unsustainable harvest of the virgin forest in the Lake Sates in the period 1880 to 1910, communities dependant on this industry collapsed across the northern Lake States. In only one intra-state region was some semblance of a stable forest products industry maintained—the Fox River Valley in Wisconsin. This location has remained the center of the pulp and paper industry in the region. Mills here and in Kalamazoo and Muskegon, Michigan were established before 1900 and relied exclusively on the pine resource as a raw material supply. In the 1920's and 1930's, kraft pulping made it possible to utilize hardwoods as a raw material supply and Lake States paper industries immediately took advantage of the abundant regional supply.

Continual technical innovation, increased automation, improved pollution control, and emergence of new markets (for example the invention of the Xerox machine in 1954-1956) have allowed this industry to grow in the Lake States. Pulp and paper industries expansions in the 1970's and 1980's were particularly strong, when worldwide demand for high-grade types of paper made from hardwoods expanded. Contrast this growth and manufacturing strength with that of the steel and automobile industries. International competition and loss of market share shocked these industries into making the kind of technological and quality advances that have been made on a continuous basis in the pulp and paper sector.

In the 1970's, one technologic innovation in particular had profound effect on the forest products industry in the

Lake States. In the 1970's, technology to make composite building products from hardwood fibers and chips advanced to a commercially applicable point. The unused supply of available hardwood resources in the region resulted in rapid expansion of forest products industries based on this technology. Continuing advances in composite board technology have had a profound impact on forest industry in the region. This technology created markets for low value hardwoods and a product that could compete with more conventional building materials. The innovation is continuing with developments of such products as composite I-beams and wood/plastic composites.

Regional expansion of sawmills began in the 1950's coinciding with regrowth of the forest. The impact of technology in the sawmilling industry has been less spectacular than that in pulp and paper and composite board industries but has been significant. Adoption of mills to saw smaller logs, thin kerf saw blades, computerized sawyer operations, and more careful log and lumber sorting and sales have increased productivity and levels of utilization.

In short, all sectors of the primary forest products industry in the Lake States have a strong history of innovation, driven by changes in markets, raw material supply characteristics, and competition. In a national comparison of 13 key U.S. industries with their competitors in Europe and Japan, forest products and pharmaceuticals were the only two industries given top grades (Kupfer 1992). Examining profit levels, Bush (1989) found that:

" . . wood-based industries are more competitive than the average U.S. manufacturing industry. Solid-wood primary product industries are particularly competitive due, in part, to low entry barriers, low industry concentration, and pressure from substitute products."

The Lake States Region is fortunate to have a strong existing and growing forest products industrial sector. In the 1980's, for example, the three Lake States shared nearly equally in $4.5 billion in new investment in forest products plants. In Michigan in particular, investment in this sector may have produced the largest increase in employment of any industrial sector in the Michigan economy (Webster 1990). These levels of growth have come about for a variety of reasons, some of which have already been discussed. Available hardwood timber resources are one key reason as are supply disruptions in other parts of the country which positively impact markets within which Lake States industries compete. Targeted marketing and development efforts have also played a role.

The primary conclusion to be drawn from this section is that given the history and current competitiveness of this industrial sector in the Lake States, such industry has and likely will continue to provide high quality, permanent jobs for regional residents.

TYPES OF DEVELOPMENT AND ASSOCIATED COMMUNITY CHARACTERISTICS

Types of forest industry development are less easy to describe than types of recreational industries. Two primary types of development are typical for the industry—on site expansion of existing operations and greenfield developments in areas where little comparable industry currently exists. Expansion of existing industry is a common pattern in the pulp and paper industry and in the sawmilling industry. Paper industry expansions often involve additions of a new paper machine, expansion of pulping facilities, or addition of equipment to affect a process change. These types of expansions occur primarily in cities with sufficient labor force and public infrastructure to accommodate such expansions. Net community impacts are increases in per capita and family incomes and local tax revenues.

Expansion of existing sawmills and other wood products firms generally produce more regionally wide-spread effects due to the generally smaller nature of the capital investments involved and their application to smaller firms compared to pulp and paper expansions. Examples of such expansion were announced in 1994 in Ashland County, Wisconsin. One firm is undertaking a $1.7 million expansion to upgrade sawmill equipment, add kiln capacity, and enter the dimension lumber or cut stock market. Another is undertaking a $1.0 million expansion of its veneer operation, increasing production space, and adding additional equipment. The net result will be addition of 50-75 direct jobs, 35-60 indirect jobs and annual payroll increases of $1.4 million in the county. At the high end, if all jobs went to Ashland County residents, these expansions could result in employment of a full 2% of the Ashland County workforce and reduction of the unemployment rate nearly two full percentage points.

Addition of kiln capacity, entrance into new product lines, and expansion into new product lines are all characteristic responses to market change in the sawmill industry. Sawmill operations are becoming increasingly diversified and capital intensive primarily because of the need to invest in the latest technology. Such diversification positively impacts community stability. The increase in the level of capital investment results in productivity improvement and an increase in the ability of such industries to raise relative salaries of their

workers. Consequently, positive impacts on the family incomes of those holding existing and newly-created jobs result.

Similar increased capital expenditures have occurred in other primary and first stage secondary production industries in the region, such as veneer, flooring, and dimension parts operations. Secondary production has the greatest potential to increase positive community and state effects because of the greater value that is added to the raw material feed stock during manufacturing (Mater 1989, Jones 1989). Not all communities, however, have the ability to successfully compete for secondary industry. For those communities, primary industry development can be an attractive alternative. Unlike additions and expansion of existing industry, the types of forest products industry developments that command the most attention are wholly new, greenfield developments. These types of development on a large scale are most commonly associated with establishment of composite board facilities in the Lake States although, in recent years, pulp and paper manufacturers have also established a number of such facilities. Such establishments involve high amounts of capital investment and are highly coveted by local communities.

These facilities tend to locate in areas where similar industries do not exist, primarily to avoid intense competition for wood supply. Because of the desirable nature of such industry and the areas they tend to locate, such developments can involve considerable local expense in improved public infrastructure and/or property tax incentives. The location of such developments are also highly dependant on rail and/or port access which gives some locations distinct advantages for attracting such development.

Not all, but in fact most, such developments result in substantial local benefit. In Menominee, MI, a newly formed company announced the construction of a $200 million paper recycling plant that would create 100 new jobs in the actual manufacturing operation and an additional 100 jobs in trucking and warehousing as a direct result of the new operation (Timber Producer 1994). In Luce County, MI, the location of a composite board facility resulted in 150 new jobs in the plant, 80 new jobs harvesting wood for the facility, increased tax revenues of $210,000 annually, and a decrease in the county unemployment rate from 21% to 9.7%. The local community donated 120 acres to establish this facility and was assisted by the previously established local Economic Development Council (Thomas *et al.* 1990).

In Minnesota, construction of a new paper mill in Duluth employs 280 people at full production levels and an additional 19 at a renovated steam plant. Two major Duluth attractions for the paper company involved were a readily available site and unused capacity in the municipal sewer system which the new plant could utilize (Irland 1990a).

In 1987, a furniture manufacturer opened a plant in Hoyt Lakes, MN, which employs 34 and has an annual payroll of $350,000. This firm became the town's second-highest taxpayer. An important factor which brought this company to Hoyt Lakes was the availability of a school building damaged by fire which was remodeled on spec by the regional economic development agency (Irland 1990b).

In Wisconsin, an international veneer company established a plant in Stanley (1988 population 2,198). This plant became the city's largest employer (130 employees) with an annual payroll of $1 million. Establishment of this firm was aided by state assistance, a vacant manufacturing facility, and a local revolving loan fund (Irland 1990c).

Other examples of the benefits of such greenfield projects around the country could be cited. Maximum positive effects from these types of developments, as well as major factors in attracting these types of developments, are ready access to rail, port, and/or highway transport, access to raw material supply, state and/or local financing for capital improvements or job training, adequate public infrastructure to accommodate development, and existing available manufacturing space. This is especially true in the establishment of smaller firms.

Both types of forest products industry development (expansion of existing firms and establishment of new greenfield operations) occur in areas with a strong history of acceptance of this type of industry. Such industries generally "fit" in a local area conception of desirable development. Disruption in the community character of such places is minimal as a result of such development. Community character can actually be strengthened as a result of such development because of the nature of the work force affected by it.

Workers in the forest products industry, especially loggers, often belong to what, in sociology, are called occupational communities. Members of occupational communities attach special social significance to their jobs often socializing with fellow members and drawing on fellow members to define their sense of identity (Carroll *et al.* 1989).

Especially for loggers, such jobs are not simply a means of earning wages but represent a way of life complete with a shared sense of values and traditions (Lee 1992, Stevens 1979). The life and social structure of commercial fisherman, specialized oil rig workers, and ranchers

demonstrate similar occupational communities. Even with in forest products manufacturing plants, especially in rural areas, it is not unusual for young people to aspire to life-long employment in the local forest products firm. This loyalty and commitment to the local community and the jobs it provides lease to stable and cohesive social structure.

EXAMPLES OF EACH TYPE IN THE LAKE STATES AND THEIR CURRENT DISTRIBUTION

Forest products industries are not evenly distributed across the Lake States. Comparing 1989 employment in SIC codes 24, 25 (excluding metal furniture) and 26, regional employment in these sectors is concentrated in Wisconsin. A full 48% of direct, regional forest products employment occurs in Wisconsin. This represents 3.4% of all Wisconsin employment. The strong representation of the pulp and paper sector in Wisconsin is largely responsible for this concentration. Both historically and currently, pulp and paper facilities are concentrated in the Fox River Valley. Expansion of existing facilities was largely responsible for growth in this sector of Wisconsin in the 1990's.

In Michigan and Minnesota, long established pulp and paper mills in Cloquet, International Falls, Muskegon, Alpena, and Escanaba have been upgraded and/or expanded and been supplemented by wholly new facilities at Duluth and Quinnesec. An upgrade of an existing mill at Sault Ste. Marie, Ontario has also improved wood supply markets and produced economic benefits on both sides of the international boundary.

Michigan has the second highest level of regional forest products industry employment, at 29%, of the regional total. Due to a larger labor force in Michigan, this represents only 1.2% of total state employment. The center of the forest products industry in Michigan has historically been Grand Rapids—a nationally renowned furniture manufacturing center. Employment within this sector has remained strong despite considerable competition from southern states—particularly North Carolina. There is a degree of market segmentation among furniture manufacturers. The southern furniture industry produced large quantities of relatively low-cost furniture based on standardized designs. Grand Rapids produces a larger share of top-of-the-line furniture and has a higher concentration of furniture design industries.

Michigan and Minnesota have benefitted greatly from the commercialization of composite board technology. This technology created markets for low value hardwoods and products that could compete with more conventional building materials. The abundance of hardwood resources in the Lake States and their low level of utilization immediately attracted high levels of investment in these types of plants. Establishment of plants in such places as Grayling, Newberry and Sagola have strengthened previously weak timber markets and provided high quality employment opportunities. Several plants in the Duluth/Superior area have been built which manufacture new types of building materials (notably floor joist) based on new composite technologies.

Sawmills across the Lake States are fairly evenly distributed. Concentration of other types of forest products industries also occur in the Lake States. Northcentral and northeast Wisconsin, as well as the western Upper Peninsula of Michigan are home to a high number of veneer mills. Both Wisconsin and Minnesota have an unusually high concentration of two types of secondary industries. The wreathing, cone, and potpourri industry is strongly represented in each state, as are window manufacturing companies.

The combination of a diverse forest products industry and constant upgrading and adoption of new technology has made this industry one of the most vibrant in the Lake States. All sectors of the industry are well positioned for expansion in the next 10 years. Ample raw material supply, a trained workforce, strong national and international markets for the region's products, and raw material supply restrictions in other parts of the country are all factors favoring further expansion in the Lake States.

DESCRIPTION OF TYPE AND LOCATION OF JOB GROWTH FOR THIS SCENARIO AND EXAMPLES OF APPLICATION AND IMPACT

Future scenario 3 of the assessment is described by Chappelle (1994) as follows:

"Forest resource-based industrial expansions continue to be assisted by state and community efforts as in the 1980's. These efforts center on effectively packaged information on principal factors affecting plant expansion and plant location decisions for instate regions, e.g., labor supply, potential building sites, transportation facilities for both market access and assembling inputs. These efforts may also involve efforts to assure stable and sustainable timber supply and ready availability of competent labor and other inputs. Efforts to foster expansion of value-added secondary forest products industries are also part of both this future and the next."

Under this scenario, an addition of 21,000 jobs in total in the forest products industry sector are estimated in the 10-year period from 1990 to 2000. The **direct portion**

of these jobs will result in increases of $600 million in wages and salaries and $4 billion in sales by wood products industries and another $4 billion in sales by related industries. This represents increases of 5% for employment, 9% for wages and salaries, and 17 to 25% for sales by different kinds of industries compared to 1990 levels. Average annual wages for directly generated forest products industry jobs were estimated at $30,000.

Two factors will likely strongly influence location of predicted job growth in the forest products sector—raw material supply and location of existing industry. These factors will have differential impact on each segment of the industry. The high capital investments characteristic of the pulp and paper industry and their need for large amounts of water, power, and waste treatment facilities suggest that most growth in this sector will be where existing facilities currently exist.

Capacity expansions at existing composite board facilities is also likely for similar reasons. The maturity of this industry sector in the Lake States, however, is not as advanced as that of the pulp and paper sector and, as such, additional greenfield developments are also likely. The location of each greenfield developments will be strongly influenced by raw material supply markets. New plants are likely in areas where the differential between growth and removal rates are highest.

The location of wholly new sawmills will also be strongly influenced by raw material supply characteristics. Expansion of existing mills and their diversification into more value-added production will be a more common pattern. The sawmilling industry in the Lake States is well positioned to expand value-added production based on ready access to expanding national markets.

Such developments will have multiple, positive impacts on communities. These impacts will vary, based on the characteristics of existing communities likely to benefit. As examples of the types of impacts that can be anticipated, projected job growth was allocated to a number of multi-county areas in the Lake States based on the amount of the industry represented in those areas in 1989.

Outagamie and Winnebago Counties in Wisconsin have highly diverse economies with extensive urban and suburban development. The forest products industry is strongly represented in these counties, employing 12.5% of all county workers. Under scenario 3, an additional 1,076 direct jobs would be created in these counties increasing forest industry employment from 16,181 to 17,257. An additional 987 indirect jobs would also be created for a total impact of 2,054 jobs. These increases would represent a total increase in county employment of 1.6%. If all these jobs went to unemployed workers in these counties, the number of unemployed in 1989 would have been reduced by one-third.

Delta, Dickinson, and Marquette Counties in Michigan are less urban than Outagamie and Winnebago Counties and have a job base in which 9.5% of all jobs in the county are directly attributable to the forest products industry. Under scenario 3, an additional 245 direct jobs would be created in these counties increasing forest industry employment from 3,688 to 3,933. An additional 223 indirect jobs would also be created for a total impact of 468 jobs. These increases represent a total increase in county employment of 1.2%. Approximately 10% of unemployed in 1989 would have been impacted by job growth of this magnitude.

Carlton and Kouchiching Counties in Minnesota are largely rural in character. Forest product industries employ 15.6% of all county workers. Under scenario 3, 121 direct and 110 indirect jobs would be created in these counties for a total of 230 jobs. These increases would represent a total increase in county employment of 2%. Job growth of this magnitude would impact approximately 14% of the unemployed in 1989 if all jobs created went to currently unemployed, county residents.

In areas such as Outagamie County, where unemployment rates are low and extensive industrial and residential development currently exist, labor to fill new jobs will largely be imported from adjacent areas of lower unemployment or supplied by new residents from outside the region. In such areas, new forest product jobs will pay wages comparable to existing median household incomes. As such, only one wage earner per family will be needed to match existing median household income levels. Forest product jobs will result in net population increases in these communities because of traditionally low unemployment rates. Adequate infrastructure, however, will minimize any negative community effects associated with population growth.

For counties more rural in nature, primary positive effects are realized through net job increase, impacts on household incomes and reduction in unemployment rates, impacts on household incomes, and reduction in unemployment rates. In Delta County, Michigan and Carlton County, Minnesota unemployment rates in 1989 were 9.5 and 8.7%, respectively. In such areas, a greater proportion of labor needed for industrial expansion is likely to come from existing residents with positive impacts on an area's unemployment rate and minimal increases in resident population levels. Significant impacts will be realized in household income levels and

economic base activities in such areas. In Delta and Carlton Counties, median household income was $22,800 and $24,900, respectively, in 1989. At average wage levels of $30,000 for forest products industry jobs, net household income levels with increase considerably under this scenario for those households which benefit from these job increases.

COMBINED INDUSTRY DEVELOPMENT CENTERS

Throughout the Lake States there are many examples of communities and counties with strong representation of both forest products and recreation industries within their economy. In fact, this pattern seems to be the norm for the most part, except in areas of highly concentrated forest products industry in developed areas (e.g., Fox River Valley in WI and Grand Rapids in MI) or intensively developed recreation areas (e.g., Wisconsin Dells in WI or parts of the St. Croix Valley between WI and MN). Despite evidence to the contrary, many communities and even some economic development specialists, often believe that recreation and forest products industry development are not compatible. This belief seems to have developed as a result of isolated incidents where harvesting (primarily clearcutting) occurred adjacent to or in sight of heavily used recreational trails. Such incidents, which create temporary conflicts, are not representative of the general relationship between these two sectors of industry.

Compatibility is a function of the needs each industry has from a land use perspective, the economic relationship between each industry type, and the specific types of industry which occur in a given place. The forest products industry is heavily dependant on access to managed forests to provide raw material for their operations. Many types of recreational activities are also dependant on access to large or continuous blocks of managed forest land. Virtually all types of trail use for snowmobiling, mountain bike riding, hiking, and skiing require access comparable to that required by forest products industries. In fact, most existing trails in the Lake States were initially created as logging access roads or skid trails. Many not formally designated as recreation trails are still used as such on the "off-season". The vast majority of trail users find trail use and harvesting entirely compatible. Especially in the winter, many users may not even be aware that such activity has taken place unless they are regular users of the trail and know something about timber harvesting. Careful timber sale design minimizes conflict with adjacent recreational trails.

Access for hunting and fishing is also provided by logging roads. Where such roads are frequent, concentration of hunters can be lessened. Harvesting activity is also essential in improving wildlife habitat for most game species.

Hunters, trail users, and other recreationists depend on the same physical landscape as forest products firms. Other types of recreational activity do not rely on the same physical landscape and, as such, create few instances of conflict. Resorts, usually centered on lakes, cater to visitors whose interests are usually satisfied in small geographic areas surrounding such resorts. Festivals held to attract recreational visitors are dominated by man made attractions with few people venturing out in the woods as part of the experience. Water-based activity, such as canoeing or fishing, occurs in a narrow zone of forest land within which harvesting activity is restricted on public ownerships and is rarely evident on private ownerships. For industry dependant on these types of activities, a recreational industry concentration and a forest products industry concentration are entirely compatible.

An additional aspect of compatibility involves the linkage between recreational industries and other sectors of the local economy. Most recreation industry is service oriented and, therefore, dependant on the economic strength of other local industry sectors or visitors from outside the region (Schallau 1994). Where residentiary activity constitutes a large portion of local recreation business, an improvement in the incomes of local residents via forest industry development will translate into improved business for such recreation industries.

The necessity for access to large, contiguous blocks of forest land for some types of recreation industries and the forest products industry, as well as the fact that a large component of industries dependant on serving recreational visitors do not require such access, partially explain why concentrations of each industry often occur in the same places. Such combined development centers occur near Brainerd, Cloquet, and Bemidji in Minnesota; near Rhinelander, Ashland, and Hayward in Wisconsin; and near Cadillac and Gaylord in Michigan. The advantages of these types of arrangements are discussed in the next section.

ADVANTAGES OF COMBINED EFFORTS

Evidence suggests that diverse local economies are more stable over time and lead to more predictable change as national and regional economies vary. Diversity leads to more stability because different sectors of local industry are more likely to compete in different markets and

therefore be subjected to different cyclical variations. This enables workers displaced by one industry which is undergoing retrenchment to gain employment in other industries which may be growing.

Diverse local economies also create a diversity of jobs which is more likely to match the varying skill levels and interests of the existing workforce. Attractive full-time job opportunities for both husbands and wives and part-time or summer job opportunities for children are becoming increasingly important in the maintenance of family income levels.

Community economic stability is also important in maintaining support for community institutions and public services. Weeks (1989) found that ". . . community economic instability is often accompanied by a lessening of support for community institutions and public services and public services." "The lack of support for government services is not characteristic of small communities per se . . .".

The types of jobs existent in local economies also impact area stability. Sears *et al.* (1992) found that differing economic growth rates and earnings growth rates impacted the economic strength of non-metro counties in the 1980s. Counties which were able to maintain or increase earnings per job (with or without employment growth) were better off than counties in which earnings per job declined.

Specifically focusing on recreation and forest products industry jobs, the forest products component of these jobs has greater potential to maintain or increase earnings per job and create year-round employment compared to recreation jobs. The undesirability of focusing too strongly on recreation is discussed by Burch (1992):

"I suspect that when tourism exceeds 35-40 percent of the gross local product some threshold of disutility is being reached. Instability in jobs, property values, tax receipts and population characteristics is a daily pattern."

Solely focusing on forest products, however, also has its disadvantages. The availability of diverse recreational opportunities is one component which determines an areas quality of life. Such availability also results in the capture of higher proportions of the income generated by primary forest products industry jobs.

In mixed economies, recreation ". . . supplements core economic activities and can serve as a balance for market fluctuations in demand for primary products and thereby is a stabilizing influence . . ." (Burch 1992). The fact that the combination of recreation and forest products industries produce different types of jobs which may be suitable for different members of the same family suggests family or household income levels will be more positively impacted in mixed economies. Unemployment levels also appear to be more positively impacted by mixed economies.

"It seems that development of either a significant local concentration of forest products industry, or of tourism and associated recreation, can help to reduce unemployment. There is also some indication that an industrial concentration can help to reduce unemployment further than can a tourism concentration—a point that would likely be emphasized further if we also compared wage rates in the two sectors. The best situation would be to develop a significant local concentration both in the forest products industry and in tourism and associated recreation" (Webster 1990).

All these factors—differing types of jobs, differing markets served by each type of industry, joint reliance on access to managed forest landscapes for forest products industries and some recreation industries, and the nature of recreation industries not reliant on access to managed forest landscapes—contribute to the desirability of combined recreation and forest products industry development centers.

DESCRIPTION OF TYPE AND LOCATION OF JOB GROWTH FOR THIS SCENARIO AND EXAMPLES OF APPLICATION AND IMPACT

Minimum economic effects of future scenario four of the assessment are described by Chappelle (1994) as an addition of the effects predicted for scenarios 2 and 3. This assumes no synergistic effects between joint development of both industries in the same location—an unlikely possibility. Chappelle goes on to note that 10 to 20% greater economic effects are likely to be realized by joint efforts compared to separate initiatives.

The types and location of job growth resulting from a joint focus can be determined by review of sections 3.5 and 4.4. Predicted development as described in these sections can be expected to proceed in parallel. Focus on both sectors simultaneously will allow for more coherent and targeted state and local efforts at specific localities. From an economic development perspective, local development opportunities which present themselves are frequently **not** evaluated in terms of the effect such developments may have on future development opportunities. Initiatives which explicitly include interconnected, multiple economic sectors have the potential for more logical decision making regarding infrastructure investment and community development.

SUMMARY OF COMMUNITY AND SOCIAL EFFECTS

While it is recognized that the majority of effects resulting from the development strategy will be experienced in the more rural, northern and forested portion of the three state area, some general comments about population, job and per capita income growth in the three states for the last 10 years are warranted for perspective.

The region experienced an absolute growth in population of nearly 450,000 persons. At the same time the labor force increased nearly 790,000 persons with the greatest growth in absolute number and as a percentage of the labor force in female participants while the percentage of male participants in the labor force declined. The region had an absolute growth of 776,000 jobs resulting in a minor net reduction of .23% in unemployment. It is a common pattern that unemployment rates in rural, forested areas tend to be higher than in urban areas. A positive result also was an absolute increase in real per capita income over the 10 years of approximately $1,250.00.

Given these general growth trends in the Lake States region, projected industry growth under the various scenarios would constitute only a minor part of anticipated future growth when viewed from a regional perspective. The fact that anticipated growth in the two targeted sectors is expected in the more rural, northern and forested portion of the region suggests that areas of concentrated development will experience more than minor effects. The nature of the jobs created under each scenario and existing labor force trends as described above will also influence community effects—reducing the negative effects and increasing the positive effects, especially in combined industry growth centers.

FACTORS INFLUENCING LIKELY COMMUNITY AND SOCIAL EFFECTS

Several factors are important in determining community and social effects of the three scenarios. Three of the most important are discussed below.

Type of Industrial Development

Economic base industries, regionally or nationally competitive industries, locally owned and operated industries, and manufacturing industries are preferred from a community development perspective because such industries bring new wealth into an area, generally pay high relative wages, are more likely to stay and expand in a community over time, and have greater positive impact on a communities tax base. There is less opportunity for such development in the recreation sector compared to the forest products sector. Natural resource-based recreation industry growth under these scenarios should consist of additional expansion of hotels, eating establishments, and other types of hospitality services catering to regional markets and a mobile type of visitor. Community efforts will focus on extending local stays and completion of development of four-season tourism. Some expansion of full service types of resorts can be expected but only in areas where they currently exist.

Forest products industry development will continue to be influenced by national and international market, technology, and wood supply trends. Expansion of primary production industries will continue as a result of more efficient use of existing raw material supply and increasing use of recycled material as feed stock. Secondary manufacturing will also expand. New business formations should increase as well as additional job creation within existing businesses on existing product lines. The greatest opportunity for business formation/growth depends upon a new set of technological advances in products and spin-off opportunities for new products and services.

Location of Industrial Expansion

Industrial expansion in areas with adequate public infrastructure and labor force surplus are ideal from a community perspective. In both cases of forest products and forest-based recreation industries, the location for new growth is expected to be near existing, like goods production and service provision given the location factors of each sector and the basic theory of efficiency of critical mass. In the case of recreational development, enterprises catering to the same types of visitors and competing in the same types of markets can be expected to locate together. In the case of forest products industries, enterprises which complement existing business but compete in different markets can be expected to locate together. If this occurs, and expansion is near existing infrastructure adequate to service the activity, the combination of negative and positive community effects will be optimal.

Population Growth Associated with Industrial Expansion

Industrial expansion which contributes significantly to community population growth, especially in a short period of time, will have more negative effects compared to more incremental growth which may create the same number of jobs. Population growth will certainly occur to some extent, but the magnitude of that growth due to this strategy will likely be small. The level of growth will be dependant upon several circumstances. The first, and probably most important, will be the availability of

appropriately skilled workers and/or the existence of adequate training for low-skilled or under-employed persons. If these conditions are not present, labor from outside the region will certainly fill the vacuum. While skill levels across the region are relatively equal, higher relative unemployment rates in Michigan will allow more labor force absorption than in Wisconsin and Minnesota. Within Wisconsin and Minnesota, however, the existence of strong training programs will satisfy any labor needs utilizing existing residents or recent immigrants in either sector. Consequently, unemployment rates should drop somewhat in areas where forest products or recreation industries expand, especially in Michigan.

ESTIMATED COMMUNITY AND SOCIAL EFFECTS

Community and social effects resulting from industry development under the three scenarios within the general parameters discussed above are dependant on the intricate relationship between existing income levels, family structure, local government infrastructure and finance, land use, and community character. Across the region, there is great variability in combinations of these factors in individual communities.

Family and Per Capita Income

Increases in family and per capita income improve the welfare of community residents, improve the stability of family units and increase the demand for residentiary services. It is anticipated that a majority of the forest products sector jobs will be filled by male labor force participants, while a good portion of the indirect and recreation jobs will be filled by female participants. Secondary forest products industries will employ more women compared to primary forest products industries. Under scenario 4, the net effect should be a significant net improvement in family or household income as well as per capita income. This will occur in two fashions: first by incremental employment improvements where an employed person moves up the job ladder due to new job opportunities; and, second through gross improvements to the number of persons employed and their relative salaries. Opportunities to increase the number of workers per family will be greater under scenario 4 since three types of jobs will be created—manufacturing, recreation service and indirect service—each of which have associated with them differing skill requirements. Under scenario 3, family wage jobs will be created but opportunities for a second family wage earner in full or part-time work will be lessened. Strategies focusing exclusively on natural resource-based recreation industries will result in small increases in family or per capita incomes.

Family Cohesion and Welfare

Employment and a shared sense of values are the basis of family cohesion and welfare. Where stable employment opportunities are lacking, family cohesion and welfare suffer as spouses are forced to work at distant locations and children have to leave the community to get work. This strategy will improve family cohesion and welfare primarily through stabilization of the employment base and increased wage and salary income. Creation of full-time, high wage jobs for primary family providers and other, often part-time, jobs for spouses and children will produce the highest level of benefits.

Government Finance

On a state level, any improvement in job opportunities accompanied by a reduction in the unemployment rate, or improvement in per capita income will positively impact state government finances. On the local level, increases in locally generated, government operating funds can only occur through increases in property tax collections. Careful planning is needed to ensure that development which increases property tax revenue occurs in a way that will minimize increases in long-term, public infrastructure development and maintenance costs. Establishment and expansion of forest products manufacturers will have major positive effects on local government finance, if infrastructure development costs are minimized and population increase is minimized. Manufacturing establishments traditionally pay a higher relative proportion of property taxes compared to service or residential properties.

More dispersed geographic development implies higher public service costs in the long-term for provision of such things as roads, sewer, water, and electricity. Increases in population lead to higher costs for these services and such things as schools, libraries, public parks and other government services. School services and the impact of local population increases on their provision will be less of a concern in Michigan and Wisconsin compared to Minnesota. In Michigan, funding for schools was largely removed from the property tax system in 1994. This will also occur in Wisconsin in 1996.

Matching existing or planned infrastructure improvements, surplus labor and industrial expansion is key in creating maximum local advantage from economic development. This can be done within each scenario but will be easier to accomplish in forested areas within scenarios 3 and 4 given the tendency of manufacturing to locate near existing available infrastructure. Many rural areas in the three Lake States are currently being severely

impacted by second home development. Those areas so impacted are also considered prime forest-based recreation areas. Over the last 10 to 15 years, many communities and counties in these areas have deferred construction and/or maintenance on vital infrastructure, such as streets, sewage treatment and water supply facilities, and other important support services to residents and businesses. The dispersed nature of this type of development will make future infrastructure investment extremely costly when densities rise to the point where such investment is needed.

Land Use

Land use patterns help define community character and the need for public infrastructure. Primary forest products industries (and secondary forest products industries as a result) require access to an actively managed forest resource base. Low intensity types of recreational industries, such as those catering to snowmobilers, hikers, cross country skiers, etc., also require access to a forest resource base less intensively managed. More concentrated recreational enterprises centered on unique natural resources of limited geographic extent and/or including modest development of man-made attractions are the most compatible with forest products industry development and will produce the greatest net community benefit.

Focus on recruitment and development of forest industry first and compatible recreation industry development second will have positive effects on land use patterns by concentrating industry where it can be more easily served by public infrastructure and creating value for well managed and fairly contiguous blocks of forest. Pursuit of scenario 4 has the greatest potential to achieve positive benefits regarding future land use patterns. Hard headed and realistic analysis of individual properties suitability for each use (recreation or forest products industries) and future infrastructure service costs will allow intelligent planning to accommodate both in a mutually reinforcing land use pattern. The single, most destructive type of development presently occurring in the Lake States, from a land use perspective, is continued, essentially uncontrolled, second home development in the north. This rural sprawl rings lakes and fragments larger blocks of forest reducing their usefulness for recreation and raw material supply.

Community Character

Community character and cohesion is a real but hard to define concept. Maintenance of community character implies creation of jobs for local residents, manageable growth which does not tax local ability to provide needed infrastructure, and maintenance of desirable land use patterns. Community character and cohesion is damaged by heavy reliance on industries which import temporary labor on a seasonal basis, involve dispersed development which exceeds local ability to pay for needed infrastructure investment, and which result in land use changes that displace existing uses important to the local economy or residents. Evidence of disruption of community cohesion is polarization, often between long-time working residents and new or retired residents, over differing visions of the future and goals and policies necessary to arrive at a chosen future. Such polarization is most characteristic in areas experiencing strong second or retirement home development or in communities dependent on a recreation-based economy.

In general, communities that have reasonable tax revenues, adequate jobs for local residents, sufficient personal income, and experience modest, managed growth are less stressful places to live with a higher quality of life than are turbulent communities with a feast or famine development regime. In addition, those communities that experience more managed development also develop a political stability and continuity which will carry the community over the turbulent times. Stability and continuity are also highly important attributes to demonstrate when recruiting new business of any type. Focus on expansion of existing recreation and forest products industries and recruitment of new industry based on forest products manufacturing will contribute most to maintenance of community cohesion.

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Interaction of Tourism and Forest Products Sectors on Community Employment/Unemployment in the Lake States Region

Daniel E. Chappelle[1]

EXECUTIVE SUMMARY

This study investigated possible relationships of a small region's economic base to its unemployment rate (seasonally unadjusted). Many types of regions (i.e., single or multi-county regions) within each state were delineated by a panel approach, although emphasis was on tourism and forest products sectors. Monthly data on labor force and unemployment were provided by employment security agencies in Michigan, Minnesota and Wisconsin. The data series for this study covered August 1989 through July 1992. Monthly unemployment data for the regions delineated in this study have been examined on a more informal on-going basis since completion of the formal study.

The most important finding was that forest industry development centers are characterized by higher unemployment rates than general urbania regions, but lower than tourism and relatively undeveloped regions and are generally more stable and less influenced by seasonality. For most months, regions that have an economic base in both the forest products industry and travel/tourism have lower unemployment rates than regions relying primarily on one or the other. And regions that are one or the other are characteristically better off than those that are neither, in the sense of being relatively undeveloped. As discussed in this report, although not analyzed in the study, it was evident that regional historical development trends, state economic structure and institutional framework influenced regional unemployment rates.

PURPOSE OF THE STUDY

The purpose of this study was to examine the relationship between economic base and unemployment rate for regions within the Lake States (i.e., Michigan, Minnesota, and Wisconsin) to discover if a region's economic structure has a predictable unemployment rate in relative terms. The unemployment rate is measured as the percentage of the civilian labor force (nonagricultural labor only) that is out of a job at a particular time.

[1] The author is a Professor Emeritus of Resource Development and Forestry, Michigan State University, East Lansing, Michigan 48824.

INTRODUCTORY CONCEPTS AND CONTEXT

There are a number of concepts and aspects of context that are essential to understanding implications of the data analysis. Accordingly, these aspects are discussed at this point. Why are we concerned with unemployment? We are concerned about employment because it is an indication of societal welfare, probably the most important one in today's economic climate. Persistent levels of unemployment, underemployment, and discouraged workers constitute one of society's most serious problems, not only in the United States, but in virtually all countries, both developed and underdeveloped. In fact, the problem is worldwide. The seriousness of the current situation has been noted with alarm by McCracken (1994): "Those entering the work forces in Western Europe and even in the U.S. confront labor market conditions more nearly resembling those of the late 1930s than those prevailing during the four decades or so following World War II."

The situation is so desperate that recently some European countries (e.g., France) are considering implementing a job sharing policy to alleviate social hardships imposed by high unemployment rates. This waste of human beings (or human capital) is finally beginning to be focused upon by policy-makers, even some of those concerned with natural resources. It is generally recognized (although not necessarily established in quantitative terms) that high unemployment contributes to diverse factors of anomie in society, including high crime rates. The major implication of the situation seems to be that in order to properly manage the environment and natural resources, one must consider impacts on human resources, as well as vice versa.

Trends in unemployment undoubtedly vary greatly from one country to another and from one time period to another. Juhn, Murphy and Topel (1991) studied unemployment and nonparticipation among U.S. men since 1967. They were able to show that (Juhn, Murphy, and Topel 1991): ". . . virtually all of the trend toward rising joblessness in the United States is accounted for by rising unemployment and nonparticipation of less skilled persons. And for these groups, increases in nonemployed weeks are mainly attributable to an increase in the

incidence of very long spells. In a reduced form sense, there is little doubt that rising unemployment and nonparticipation are demand driven. Wages fell substantially among the skill categories in which employment declined, while groups with stable wages also had relatively stable employment rates." Katz (1992/1993) notes a similar trend: "Inside almost all sectors of the [U.S.] economy, firms are substituting more-educated for less-educated workers and are increasing their use of professional, managerial, and technical workers relative to production workers."

It is becoming clearly apparent that jobs for the less skilled members of society are disappearing as mechanization and automation take over tasks once completed by individuals. This can be taken as a benefit to society because it is the essence of productivity increases. However, from the viewpoint of the less-educated and/or less-skilled individual member of that society, this trend amounts to a catastrophe, which is the driving force of labor union resistance to changes in negotiated work rules and introduction of new equipment. In a sense this trend is the flip side of the trend of protectionism by firms and industries.

Juliet Schor, in her 1991 book entitled *The Overworked American*, provides a comprehensive analysis of national labor force trends over the long term. She points to increases in overtime required of those working at the same time as unemployment and underemployment grew (Schor 1991): "Declining industries provide poignant illustrations of the coexistence of long hours and unemployment. The manufacturing sector lost over a million jobs in the 1980's. At the same time (from 1980 to 1987), overtime hours rose by 50 per year. Many of those on permanent layoff watch their former co-workers put in steady overtime, week after week, year after year. Outside manufacturing, unemployment also rose steadily. At the height of each business expansion (1969, 1973, 1979, and 1987), the proportion of the labor force without a job was higher—rising from only 3.4% in 1969 to almost twice that—6.1%—in 1987."

"Enforced idleness is not just confined to those who have been laid off. Underemployment is also growing. The fraction of the labor force working part-time but desiring full-time work increased more than seven times. The fraction employed only part of the year, but wanting a job year-round, nearly doubled. Those who had neither full-time nor full-year work, but wanted both, rose four times. All told, in the first year of my study, 7% of the labor force were unable to obtain the work they wanted or needed. Twenty years later, this category had more than doubled—and stood at almost 17% (. . .)."

Schor (1991, p. 39) reaches a most disturbing conclusion from her analysis: "The trend toward underemployment and unemployment signals a disturbing failure of the labor market: the U.S. economy is increasingly unable to provide work for its population. It is all the more noticeable that growing idleness is occurring at a time when those who are fully employed are at their workplaces for ever longer hours."

Schor (1991, p. 66) identifies the role of the "bias of fringe benefits" in contributing to this alarming trend: "For both salaried and hourly workers, in the second half of the twentieth century, pensions, health and life insurance, paid vacations, and other fringe benefits have become a powerful incentive for the perpetuation of long hours. Since most of these additions to basic earnings are paid on a per-person basis, rather than by the hour, they create a strong discontinuity in cost structures. It becomes far more profitable for a company to hire a smaller number of people for long hours than to extend those hours over more workers (who would also be paid benefits). The long hours of the postwar period owe a lot to the "bias of fringe benefits."

"This bias has grown in recent years, as the value of fringes relative to wages and salaries has mushroomed. The standard figure of 15% (fringes as a percentage of pay) which prevailed in the 1950's has risen sharply. By 1987, total benefit payments as a percent of wages and salaries stood at 36.2%; at some firms, the figure reaches as high as 60%."

"Tax structures for government-administered programs have added to this effect, even when paid on an earnings rather than a per-capita basis. Employers' contributions to social security, unemployment insurance, and other programs are capped, so that no taxes are levied after a certain level of earnings. This creates a further bias toward requiring extra hours for existing workers, because no additional tax liability is incurred. If a new employee is added instead, the tax bill rises."

Finally, Schor (1991, p. 151) pinpoints the interdependence of the unemployment problem and the overworked employee problem, as well as a possible role of government in alleviating the crisis: ". . ., the problem of worktime cannot be solved without an equalization of the distribution of work itself. This means we must find a durable solution for the crisis of unemployment and underemployment plaguing this economy. Such a solution will require an ongoing commitment from the federal government to ensure a more equal allocation of total work hours."

Urgency in solving the unemployment problem is reflected in a recent article by William Vickrey (1993, p. 14): "There is no reason inherent in the real resources available to us why we cannot move rapidly within the next 2 or 3 years to a state of genuinely full employment, and then continue indefinitely at that level, with the concomitant reduction in the ills of poverty, homelessness, sickness, and crime, together with a reduction in the resistance to reductions in military expenditure to more rational levels, to liberalization of trade and immigration policy, and to conservation and environmental protection programs."

"We simply cannot continue on as we have been doing without falling apart as a community and losing what is left of our status of world leadership."

Most economists would take this as an appropriate goal, but one very difficult to accomplish. Cornwall (1993, p. 9), in an article contrasting unemployment rate trends in the United States and Canada to those of seven low unemployment OECD countries, points to the need to make basic institutional changes in labor policy (and income policies) if the unemployment situation is to be improved: "Events of the 1980s provide a clear warning. An aggregate demand policy that merely reduced unemployment to 5-6% levels generated serious and politically unacceptable inflation. The implementation of a social bargain policy to reduce inflationary forces at low unemployment is an absolutely essential part of any recovery efforts in the 1990s, yet it has received little attention. What is to be done? For countries like the United States and Canada, trapped by history with a most unfortunate set of institutions, achieving the twin goals of low inflation and low unemployment will first require policy-induced changes in institutions that lead to arrangements consistent with a social bargain strategy. This means that there is no 'quick fix' cure of the present ills."

THE REGIONAL APPROACH

The unit of analysis in this study was the region within the Lake States of Michigan, Minnesota, and Wisconsin. Each region consists of one or more counties. The focus was on the intra-state region because we were interested in the relationship of the regional economic base to the unemployment rate.

This unit of analysis has both disadvantages and advantages. A disadvantage of this level in contrast to the community level is that there is much more heterogeneity in economic base from one part of a specific region to another. A disadvantage compared to the state level is that data are not available at the county level for many variables related to those used in this study. Unavailability of data on these variables blocked expanding the analysis beyond the limits observed in this report.

A major advantage is that data are available at the county level for several important variables (i.e., size of civilian labor force, number of unemployed workers, etc.) that can be aggregated into regions that make sense from the standpoint of economic base, infrastructure, governance, commuting patterns, etc. All of these considerations are important in explaining regional economic growth and development within a state.

DELINEATION OF REGIONS

Delineation of regions is always somewhat arbitrary. In general, there are three basic regionalization principles that might be used (either singly or in combination):

(a) functional integration (e.g., the Metropolitan Statistical Area).

(b) homogeneity (e.g., a watershed).

(c) planning and policy regions (e.g., a National Forest).

In the United States, relevant data for this study are recorded at the county level. Therefore, it was necessary to build our regions using counties as components. The county is an example of a policy region. In addition to the county, relevant data for this study are recorded for Metropolitan Statistical Areas (MSAs), therefore the functional integration principle is used as well. Finally, within the constraint of county boundaries, contiguous areas having similar economic base are aggregated. This is an application of the homogenity principle.

Selection of multi-county regions and MSAs as regions was carried out in this study using an informal panel approach. That is, a small panel of experts designated regions of the three Lake States that could be identified with a certain type of economic base. After regions were suggested, subsequent investigation was carried out to confirm them using a multitude of information sources. Of course, considerable aggregation error can be generated because different parts of a given county may have different economic bases. Even where regional economic bases are the same, there may be important differences in economic structure that may derive from different development trends over time in the various regions. Also, institutional frameworks of the states represented in the study differ somewhat from one another and these differences may be reflected in study results.

Markusen (1990, p. 28) emphasizes the importance of recognizing the institutional framework and international trade: "The individual regions cannot be understood on their own—by studying their resources and industrial mix as has been the recent tradition in the economic development field. Nor can their fortunes be simply derived from the mechanics of national trade and growth patterns. Resources, environment, industrial mix, and economic base are the key characteristics of each region, but it is increasingly useless to study these without a fine-grained appreciation of the international dynamics of the industries involved and the postures of the key players in each."

The focus in this study is on regional economic base. Among the many factors related to economic development, only the unemployment rate is investigated.

The Concept of Regional Economic Base

In this paper, I focus on the relationship between regional unemployment and economic base. This important concept of economic base is relatively simple and refers to those economic sectors that export products (i.e., goods and services) outside of the region and bring new money in from outside regional boundaries. New money generates respending rounds that expands the total amount of economic activity so it will be greater than export revenue. Although regional growth can be based on other factors, the export base is generally viewed by economists as useful for measuring economic growth potentials.

Natural Resource Sectors That are Part of the Regional Economic Base

Given the definition of economic base, it follows that any sector exporting goods or services beyond the regional boundary is part of the economic base. Manufacturing enterprises generally export the majority of their outputs outside the region, whereas retail establishments export very little. For example, almost all production of a pulp and paper plant is exported, whereas many recreational sites have a minority of visitors from outside of the region. However, most sectors supply both outside and inside markets. Also, we need to be concerned with imports of inputs to regional enterprises and substitution of regional products for exported products when evaluating the regional economic base (e.g., a regional resident selecting a recreational experience in the region rather than one outside the region).

There is another set of linkages to consider as well if we are to properly quantify employment or any other economic variable (e.g., personal income). Those are linkages between our region and the rest of the nation and the rest of the world. Some of these linkages already have been mentioned, e.g., goods and services exported from our region. However, we also must be concerned with inputs that come from outside our region. These imports may be either consumer or producer goods and services. For the most part we do not import labor, but we import goods that have embedded labor inputs and this substitutes for regional labor.

It turns out, therefore, that although the economic base concept is rather straightforward and clearcut, its measurement rarely is. A serious measurement concern is to account for flows, both into and out of the region. For any region below the national level (with a few exceptions), this requires primary data collection.

Roles of Natural Resource Sectors in the Regional Economy

Natural resource sectors traditionally have been viewed in economics as suppliers of industrial raw materials. However, the scope and importance of these sectors are greater today than ever before because of society's emphasis on amenities, biodiversity, environmental quality, assimilation of residuals, recreation/tourism, natural values, and preservation of natural areas. We need to view our forests as sources of a wide range of commodities and services. We must manage them to sustain product flows as well as for biodiversity. At the same time, we need to manage with a view toward human development and a sound, vital economy. That means natural resource areas must continue to provide commodities, and therefore continue to provide industrial jobs.

It is difficult to measure employment in natural resources because sectors are involved that we normally do not consider involved with natural resources, especially in recreation and tourism. Unfortunately, the economic accounts (i.e., income and product accounts and input output accounts) do not include many of the sectors important to regional economic analysis (those cases where goods and services are not priced) and aggregate others inappropriately (e.g., recreational enterprises).

Natural resource sectors include all those directly related to the natural resource base; e.g., the forest products industry (including many sectors), forest-based recreation, minerals, water, wildlife, etc. Note that many products of these sectors are not priced by organized markets, which makes economic analysis difficult (and very controversial).

Although certainly natural resources can be important in economic growth and development, one should recognize that they may have no effect in isolation of other economic activities. Many undeveloped countries have a

rich stock of natural resources. In contrast, many rich, highly developed countries have few natural resources. It stands to reason, however, that if a region has the other necessities for generating economic growth and development, then natural resources can play an important part in the process. One thing for certain, if a country does not possess natural resources that provide raw materials required for production of the multitude of goods and services demanded by its people, those inputs must be imported, adding to a deficit in the balance of trade.

The various forest-based sectors of the regional economy vary a great deal from one another. From the standpoint of this study, the major differences to illuminate are economic—particularly relating to employment and income. Also, it is pertinent to differentiate sectors in terms of the extent to which they contribute to the economic base.

For example, Chappelle *et al.* (1986, Table 8, p. 12) reported 1980 exports and inputs as a percentage of total sales for Michigan forest products sectors to be shown in Table 1:

Those sectors exporting their products outside the region bring revenues back to the region, thereby resulting in net gains to regional economic prosperity. Of course, as indicated in the table above, the imported factors of production must be considered in evaluating a sector's potentials to increase regional economic prosperity. The less mobile factors of production generally are not exported or imported. Very little labor is generally exported or imported between regions, and land never is, except for a minor amount through erosion processes. Even within the forest products economy, there are many differences between sectors. For example, the wood furniture and fixtures sector exports about the same proportion of output as the integrated pulp and paper and particleboard sector, but imports significantly more of its inputs (37.5% vs. 26.9%). Of course, from an economic development standpoint, imported production inputs, although a leakage out of the regional economy, often do represent an opportunity to substitute regional goods and services for those that are imported.

As indicated, the major concern of this study was employment/unemployment. The various forest products sectors vary greatly in regards to employment potentials.

Table 1.—*Imports, exports, employment/output, and number of employees per establishment, Michigan, 1980*

Sector	Exports[1]	Imports[2]	E/O[3]	Jobs/Est.[4]
Sawmills & planing mills	50.0	5.7	0.02004	9.2
Millwork, flooring, structural members	51.6	51.2	.01526	22.0
Wood furniture and fixtures	85.0	37.5	.02229	40.5
Wood pallets, boxes and skids	22.0	17.5	.02277	12.7
Veneer and plywood; other wood products	55.3	37.0	.02138	22.5
Integrated pulp and paper; particleboard	86.0	26.9	.00848	517.8
Paper mills; building paper and board mills	66.9	52.0	.00573	215.2
Paperboard containers & boxes	21.6	44.7	.01111	57.3
Other paper, converted paper and paperboard	79.2	64.3	.00977	47.0

[1] Exports as a percentage of total sales (Chappelle *et al.* 1986, Table 8, p. 12)
[2] Imports as a percentage of total expenditures (Chappelle *et al.* 1986, Table 8, p. 12)
[3] Employment/Output (full time jobs/ $1,000 of sales) (Chappelle *et al.* (1986, Table 11, p. 13)
[4] Number of employees in average establishment (Chappelle *et al.* (1986, Table 4, p. 7)

For example, in Table 1, employment/output ratios are taken from Chappelle *et al.* (1986, Table 11, p. 13). Note that solid wood sectors are, for the most part, much more labor intensive than those involved with fiber products (average is 0.0203 for solid wood sectors vs. 0.0088 for those based on fiber; i.e., about 2 1/2 times more labor intensive). Therefore, for a million dollars of output, the solid wood manufacturing industries are likely to hire many more workers than will those producing fiber products. However, counteracting this may be scale of manufacturing. It is evident that, on the average, if a new integrated pulp and paper plant is built within the state about 56 times the number of employees at a sawmill or planing mill will be hired. Even though the employment/output ratio is low for the integrated pulp and paper sector, the employment and income impacts on the region will be much larger than if a sawmill is added to the region's economic structure.

Backward and Forward Linkages in a Regional Economy

It is useful to look at linkages involved going from the environment (e.g., the woods) to eventually final consumer goods and services. These linkages are a set of input-output relationships that, with the exception of both extreme ends of the continuum, represent intermediate industries. Most natural resource sectors are found here, with a few exceptions, such as firewood and wilderness recreation. This is a consequence that most goods and services that use inputs from the environment are cases of derived demand. In many cases the number of intermediate industries are numerous and complex. In order to trace impacts of any proposed strategy, it is necessary to locate the unit of analysis along this continuum. Forward linkages go towards the final consumer (i.e., final demand orientation), whereas backward linkages go to the environment (i.e., supply oriented). To properly account for employment impacts of any particular industry or resource, it is necessary to consider these linkages.

These linkages are quantified as multiplier effects. Normally when considering economic development we are not just focusing on direct jobs created by a project, but rather the total of direct, indirect and induced jobs. Generally multipliers are based on demand-driven input-output models. This means that demands for all goods and services in the economy are taken as data rather than explained by the model. Another way of looking at it is that the amount of timber required by society will depend on the amount of goods and services demanded by society. A supply-driven model, in contrast, calculates the amount of production required to exactly exhaust resource stocks (in fact, all inputs). Since materials become more specialized in terms of use as they proceed through the marketing chain (e.g., contrast a 2x4 wood member to a standing tree), the demand-driven modeling approach makes the most sense for our purposes.

There can be considerable differences in the amount of indirect and induced employment effects, depending on the sector involved. For example, for Michigan using a 1980 data base of primary data for forest product industries and secondary for all other sectors, Chappelle *et al.* (1986) developed the following Type II employment multipliers and rankings (Table 2). This multiplier is the ratio of the total jobs and direct jobs.

Table 2.—*Type II employment multipliers, Michigan, 1980*

Sector	Multiplier	Rank
Sawmills & planing mills	2.048	5
Millwork, flooring, structural members	1.998	6
Wood furniture and fixtures	1.826	9
Wood pallets, boxes and skids	2.069	4
Veneer and plywood; other wood products	1.937	8
Integrated pulp and paper; particleboard	3.537	1
Paper mills; building paper and board bills	3.106	2
Paperboard containers & boxes	2.387	3
Other paper, converted paper & paperboard	1.992	7

For example, using these estimates, one could say that a new particleboard plant employing 200 direct workers likely would create a total of about 707 jobs (i.e., 200 X 3.537).

The Type II multiplier assumes a fixed consumption function. Therefore, there is a bias towards high multipliers because normally people change their consumption function as their income changes. For example, as family income rises the marginal propensity to consume decreases (i.e., savings increases). A Type III multiplier has been devised to at least partially remedy this situation.

Pedersen *et al.* (1989) estimated the following selected Type III employment multipliers for forest products sectors in the Lake States (the States of Michigan, Minnesota, and Wisconsin) based on the 1982 IMPLAN data base (Table 3). One should note that sectors are not identical to those used in Chappelle *et al.* (1986).

In addition, it was found in this study that the multiplier for wood energy was 1.499, outdoor recreation (including both regional residents and non-residents) 1.567, and recreation (non-residents only) 1.550. All of these are lower than multipliers for forest product sectors. These multipliers were developed by tracing expenditure patterns for the activities involved and dividing total employment effects by direct effects, since such sectors do not exist in the input-output accounting system. Hence, these sectors are not represented as sectors in the IMPLAN data base and model because that data base utilizes national accounts. These multipliers reflect, therefore, transactions involved among linked sectors in the regional economy when economic activities are pursued, given leakages involved (e.g., imported inputs to recreational enterprises).

Employment multipliers can be very useful in evaluating changes in total employment that might be expected if new jobs are created in specific sectors of the regional economy. For example, if a new paperboard container plant is to be constructed that will employ 60 production employees, we might expect that total Lake States employment will increase by about 130 jobs (60 x 2.164 = 129.84). Also, input-output models can be used to indicate the distribution of jobs (e.g., see Diamond and Chappelle 1981). Of course, impacts of the plant construction phase would have to be evaluated separately.

One can see that the demand-driven input-output model can be very useful in quantifying expected impacts of new plant capacity. However, these estimates are developed under the assumption that sufficient inputs of all types are available (at the same relative prices as expressed in the transactions data) to produce all goods and services demanded by the population.

Unemployment (i.e., number of workers unemployed) is the measure we use to quantify unused inputs of labor available within the region. Unfortunately, unemployment estimates used in this study are too gross to be used in plant feasibility studies because they do not differentiate labor by occupation and skill levels. However, these unemployment statistics can be taken as a measure of excess labor inputs which may indicate favorable prospective investment opportunities for entry of new production capacity into the region, as well as an indication of human distress, as emphasized above. Of course, labor is not the only input to any good or service production. Therefore, data must be collected on all inputs before an investment decision can be made. And, of course, added demands for the goods and services (expressed in the final demand sectors of the input output model, which are exogenous) must be realistic.

Table 3.—*Type III employment multipliers, Lake States, 1982*

Sector	Multiplier	Rank
Sawmills and planing mills	1.619	7
Millwork	1.843	3
Wood & lumber products including pallets	1.706	6
Veneer, plywood, structural members	1.753	4
Wood furniture & fixtures (SIC 25 weighted average)	1.750	5
Paper mills	2.072	2
Paperboard containers & boxes	2.164	1

Natural Resources as a Base for Increased Economic Growth and Development

Natural resources can serve as a base for increased economic growth and development to the extent that they provide inputs to economic activities exhibiting increasing demand. Although for the most part commodities have been declining in real price worldwide, timber is one of a few exceptions[2] and is likely to become more so over time, as we continue to reserve timberlands for wilderness and other naturalistic purposes, both here and in other countries.

Also, forested environments are likely to become increasingly scarce as sites for recreation as our populations grows and urbanization continues. It appears, therefore, that forested environments have many characteristics likely to provide opportunities for favorable future economic growth and development, if properly managed. Of course, it is necessary that strategies be implemented and necessary investments made to fully take advantage of these opportunities.

Land Use Trends and Influences on Economic Growth and Development

In order to produce timber, recreation, water, amenity values, and other goods and services, adequate land must be available. The status of land development must be considered both from the perspective of resource availability and location of consumers for the array of goods and services. Hence, both rural and urban land development are pertinent when we consider contributions of natural resources to regional economic prosperity.

Regional Urban Economic Development

We need to consider the pattern of urban economic development when analyzing employment patterns because most Americans live in urban areas. Urban land uses are superior economic uses because normally they can bid away land from rural uses. However, an important factor to consider when tracing unemployment trends is the dramatic spatial reconfiguration that our cities have endured since the 1930's as industrial plants moved to suburban, ex-urban, and even rural areas. This movement occurred to take advantage of new technology (i.e., single level industrial plants powered by electrical belts instead of gravity), substitution of cheaper land for other inputs, and to provision of improved transportation (this was especially facilitated by the railroad system early in the nation's history and later by the Interstate Highway System and introduction of larger and more powerful trucks, as well as improvements in packaging technology). Among other effects, this caused movement of manufacturing jobs out of central cities, stranding poorer laborers (particularly blacks), whose jobs had not been taken away already by improved technology. This reconfiguration provided impetus for development of zones outside the central city, but it also meant that more and more commuting would be required to keep the system functioning.

During the same period, retailing largely moved to suburban shopping centers to serve the expanded residential zones. This trend accelerated during the 1960's to the present with the development of ever-larger regional malls; the larger of which include theme parks that act as magnets to draw tourists from beyond the usual service areas. Commonly central cities have come to be devoted to offices and retailing to service the population working in those offices (particularly restaurants). These trends transformed the labor market spatially and intensified spatial linkages between urban areas (e.g., consider the conurbations (i.e., continuous urbanizations) on both the East and West coasts).

Groshen and Robertson (1993, p. 5) " . . . suggest that the Midwest's principal cities are becoming service centers for manufacturing establishments and other customers located within their boundaries."

Regional Rural Economic Development

Rural economic development is directly linked to developments in urban areas. That is, urban and suburban areas are markets for primary production occurring for the most part in rural areas (of course, many of these commodities are shipped on to other areas, even to other countries). Towns in rural areas are retailing centers, selling to relatively large service areas, in contrast to the more densely packed urban service areas. Also, however, many towns in rural areas have declined (or even disappeared) as retailing centers because of declines in commuting time for rural residents over high-speed highways to urban shopping malls. Rural jobs, therefore tend to be concentrated in primary commodity production, tourism-related retailing, and government. In

[2]*The Economist* magazine noted (in the issue of January 16, 1993, p. 107) that: "Timber is one of the few commodities enjoying a boom. The price of timber in Chicago has soared by around a third over the past year." *The Economist* worldwide commodity-price indices of selected commodities (various industrial raw materials and foods), measured as percentage change over the period December 31, 1991, to January 12, 1993 (SDR terms) indicates that by far the largest increase was for timber (almost 50% compared to its nearest competitor, tea, at 35% and its closest industrial raw material, rubber, at about 15%) (Jan. 16, 1993 issue, p. 69). Although this particular price boom subsequently moderated, it indicates the potentials of market responses relative to supply restrictions.

contrast, consumption patterns for rural residents, even farmers and forest workers, have become similar to those of urban residents in the same cohorts, and indeed purchases are often made in urban centers rather than where they live and work.

Uneven Development

A region can be described by the mix of sectors included in its economy. Regions generally have specialized functions developed over time and sectors necessary to participate in these specialized functions will be located there. The concept of industrial complex explains the composition of sectors found in the region to a certain extent. These consist of agglomerations of establishments at a single location that are linked to one another (e.g., technical, production, or marketing linkages) in terms of input-output relationships, i.e., the output of one firm is an input of another firm, which may generate significant economies. Industrial complexes are important in that they provide for a specialized industrial base which may be a generator of regional economic growth if demand for the complex's consumer products are strong (e.g., California's Silicon Valley in the 1980's), but can be a source of serious problems if demand for the complex's products are lagging (e.g., U.S. automobile industrial complexes in the 1980's). Nevertheless, this concept can be applied to develop useful descriptors of the regional economic base.

Possibilities of agglomerations of various types may be important in decision-making of firms interested in locating establishments in a particular area. Agglomeration may be fueled by economies of various types, including: (a) transportation economies, (b) economies of scale within firm, (c) economies of scale external to the firm, but to the industry (termed "urbanization economies"). Of course, disagglomeration is the opposite force and it is fueled by analogous dis-economies.

Another phenomenon relevant to this section is that of product life cycle. In a dynamic economy new products are constantly being developed, competing with other products that serve the same or similar functions (i.e., provide the same service), and eventually are dislodged by products that are either higher quality, less expensive or both. An exception is the disappearance of products made of raw materials that are degraded, exhausted, or prohibited by society for some reason. In the private sector of the economy this process is tracked by a profit cycle. Eventually profits decrease to the point that industries cease to produce the good (or service) and substitutes take their place. In the public sector of the economy, actions of the political system result in decisions to change product mix, albeit usually more slowly than in the private sector.

When we look at any sector of the economy (i.e., an industry), we are really looking at a mix of products that changes over time. These products involve various production functions. Therefore, the sector production function is essentially a weighted function of the individual product production functions included in that aggregate. Even more important from the standpoint of the present study, an area's unemployment rate is a weighted rate of the unemployment rates for the sectors included in the area's economic structure. Because of this dynamic situation in product mix, it is difficult to trace economic development by economic sector. However, these considerations go far towards explaining what is termed "uneven development" in economics.

Harris (1989, p. 334) describes "uneven development" as follows: "By this is meant specifically that the process [of capitalist development] is marked by persistent differences in levels and rates of economic development between different sectors of the economy."

Further, Harris (1989, p. 337) outlines the sequential process in the evolution of the economy: " . . . we can map out the dynamic evolution of the economy in terms of a **sequential process**, where the overall growth is accountable for on the basis of (1) the individual growth of particular new sectors, (2) the growth of pre-existing sectors, each of which is growing at a different rate depending on the particular phase reached in its life-cycle, and (3) the constant accretion of new sectors into the economy owing to the introduction of new products. In this context also, the relative position of any region or country on a relevant index of development could be seen as a matter of the particular products or industries it has managed to capture as a result of the previous pattern of accumulation and the ongoing activity of firms operating within it and the particular timing of their entry into the life—cycle of new products."

It follows from the above that in order to comprehensively explain trends discussed in the results section of this report, it would be necessary to track all previously discussed variables over time as well as the variables that are measured in this study (i.e., unemployment rate, civilian labor force, etc.). Unfortunately, such comprehensive analysis was not possible given available data. However, it is important to keep the above considerations in mind when interpreting study results.

Changes in the sectoral structure of the regional economy raise serious questions regarding adaptability of the labor force to change. Can employees of failing firms and perhaps entire sectors be retrained to serve as human resources for new enterprises? Experiences with traditional extractive resource industries in the United States do not provide an optimistic view of this situation.

Consider, for example, the situation of the coal miners in the Cumberland plateau region of Kentucky. Caudill (1963) provides the context and the enormity of the problem in effecting this adaptation to regional structural change during the post World War II period and through the 1950's. Very few of any but the youngest workers displaced by the coal mining industry's technological change (and enforcement of more stringent safety standards) found employment elsewhere, providing a context for and illustrating the enormity of the problem in adapting to regional structural change. According to Caudill (1963, p. 278): "The young men on whom the mines had not yet set their ineradicable stamp could go to Detroit or other industrial cities with reasonable prospects of finding employment. But their older colleague, once his employment in the mines was ended, was generally helpless. The personnel directors concluded that he lacked the ability to be trained which the companies required. Another factor operating against him was the growing importance of industry-supported retirement plans."

In contrast, the older men faced a more dismal future (Caudill, 1963, p. 278): "The upshot was that the older sort of unemployed miners were driven into an increasingly desperate trap. Technology in the mines had made them obsolete, rendering unsalable the only skill they possessed. The factories and mills in distant cities would not employ them. While the young men and their families drained out of the plateau, the older miners—those in their early 40s and upward—were stranded, and, as automation gathered momentum in other industries, those who had 'made the break' began to return to the mountains."

The tragic sequence noted by Caudill has been moderated somewhat in recent decades. Generally education has improved (e.g., a much higher percentage of students graduate from high school and attend college). Geographic isolation has been overcome with more advanced (and faster and cheaper) transportation and, especially, communication networks. However, adaptation of labor continues to be a major problem in this age of high technology. There is serious question whether most students have the skills necessary to thrive. in the economy they will face. Bluestone and Harrison (1982, p. 97) provide some research findings for New England that indicate the size of the adaptation problem: "What has happened to those workers who eventually left (or were displaced from) the old mill industries? How many were able to find jobs in the new high-tech companies or in the highly unionized, high-paying engineering industries? How many were forced to accept jobs in the predominantly low-wage and more unstable services, where they probably had to take wage cuts? And finally, from what industries and from where do the new high-tech industries recruit their new work forces?"

"Consider the 833,200 people in the New England LEED [Social Security Administration's Longitudinal Employer-Employee Data file] sample whose principal activity in 1958 was to work in the mill industries. In the period after 1958, as continuing de-industrialization swept through the sector, 674,000 of them left the mills. By 1975, only 18,000 of this group—fewer than 3%—were employed in the high-tech industries of the region. (Another 2,000 had migrated to high-tech jobs outside New England.) More than five times as many ended up in trade and service jobs, either inside or outside of the region. A huge number dropped out of the labor force (or went into jobs not covered by Social Security). In essence, . . ., losing one's job as a result of de-industrialization tends to propel one downward in the industry hierarchy toward lower productivity jobs—not upward."

Although this study was not designed to trace changes in employment with de-industrialization, the above findings can provide explanations useful in interpreting study results (and going beyond them).

Seasonal and part-time employment in natural resource sectors is very common (e.g., in logging and tourism establishments). Duerr (1949, p. 78) noted the supplemental nature of much rural employment of the Appalachian region during the period 1940 to 1950: "Woods work, mining, work in small mills, service employment, and farm work are alternative occupations for many individuals. The really significant consideration is the balance between the rural working force as a whole and the employment opportunities, as a whole, open to these workers."

Although the economy of the United States has changed a great deal since Duerr wrote this, and the Lake States differs much from his region, the substitutability of occupations to rural people continue to be a major consideration in national labor policies. The entry of travel/tourism as a major economic activity in rural areas enhances this force, rather than diminishing it.

Also, Duerr (1949, p. 90) points out advantages of decentralized industry from the standpoint of wages: "The manufacture of forest products appears to be one of the few outstanding examples of an industry where great decentralization has been generally successful, in the sense that small rural plants have survived and, indeed, continually risen in importance up to the present. The existence of such plants, in itself, is desirable; and through the agency of education, and with gradual improvement in technology and the conditions of ownership and management, it may be shaped into a powerful instrument for allowing forests to contribute their optimum to employment and income."

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Although the economy of the United States has changed a great deal since Duerr wrote this, and the Lake States differs much from his region, the substitutability of occupations to rural people continue to be a major consideration in national labor policies. The entry of travel/tourism as a major economic activity in rural areas enhances this force, rather than diminishing it.

Also, Duerr (1949, p. 90) points out advantages of decentralized industry from the standpoint of wages: "The manufacture of forest products appears to be one of the few outstanding examples of an industry where great decentralization has been generally successful, in the sense that small rural plants have survived and, indeed, continually risen in importance up to the present. The existence of such plants, in itself, is desirable; and through the agency of education, and with gradual improvement in technology and the conditions of ownership and management, it may be shaped into a powerful instrument for allowing forests to contribute their optimum to employment and income."

There are many differences between the conditions noted by Duerr for the Appalachian region in 1949 and those found in the Lake States nowadays. For example, after being harvested almost out of existence in the Lake States (especially Michigan at the beginning of this century, the region's forests have come back, reflecting both the resilience and recuperative powers of Nature and efforts of thousands of landowners, managers and foresters in the region. There has been a shift from small mills (primarily lumber mills) to large mills and even industrial complexes. The pulp and paper sector, particleboard sector, and composite board sectors have increased in importance. Technology has advanced greatly, even in the lumber industry, thereby requiring fewer workers per unit of product. Regardless of all these changes, there are some parallels to the picture related by Duerr. The truth of the matter is that often rural labor must sacrifice greatly in order to maintain a rural lifestyle.

Private-sector wages in rural areas are generally lower than in urban areas for the identical job. However, a mitigating factor is that living costs are generally lower in rural areas, particularly housing costs. For highly skilled workers, the sacrifice likely will be a job below workers' capacities and lower incomes than could be earned in an urban labor market. For the less skilled, the outcome is more questionable. The biggest sacrifice may be in continuity of employment in rural areas, since they are characterized by higher unemployment levels, more persistent unemployment, more seasonality, and more instability than urban areas (mainly because the labor market is much smaller, less diversified, and concentrated on primary production of goods).

Diversification of the Regional Economy Through Expansions of Natural Resource Sectors

Natural resource sectors can often serve as target industries in those economies that have comparative advantage in those lines of production. For example, Michigan's economy, which has for long been overdependent on automobile manufacturing, has become 25% less dependent on this industry in recent years in part because of a target industry program that included both the forest products and travel/tourism industries as targets for expansion.[3]

Recent research indicates that significant diversification resulted from this program, although it is not possible to isolate contributions of the forest products industry (Vega 1992). Thus, forest products and tourism industries can provide for increasing diversification of regional economies, particularly in rural areas. Effects of such diversification may be to widen regional labor markets, increase incomes, and decrease unemployment.

William R. Burch, Jr., a recognized social scientist in the area of forest-based recreation research, recently provided some expert guidance regarding the matter of best mix of economic activities from the standpoint of community economy, vitality and stability (Burch 1992, p. 15): "Nature-based or rural tourism as an industry is best when it is an adjunct to primary production rather than the primary source of a community's survival. I suspect that when tourism exceeds 35-40% of the gross local product some threshold of disutility is being reached. Instability in jobs, property values, tax receipts and population characteristics is a daily pattern. . . . Unlike a mixed economy where tourism supplements core economic activities and can serve as a balance for market fluctuations in demand for primary products and thereby is a stabilizing influence, tourism as the dominant industry lacks sustainability."

During the past few decades, particularly since Earth Day in 1970, it has been popular in American society to oppose extraction of resource commodities. Preservation is much favored, but commodity production is not by many segments of the United States public. At the same time, public opinion seems to have embraced the idea that forested regions which have been heavily dependent economically on resource commodities (i.e., timber, forage and minerals) generally could be better off (especially in terms of numbers of jobs) if resources were left unharvested and natural resource assets provide the base of a travel/tourism industry (e.g., see Knize 1991, regarding the National Forests). In fact, many economic consultants have predicted economic booms based on recreation in such regions.

There is evidence that heavy reliance on tourism, especially based on forests lacking adequate infrastructure and resort development, is unlikely to live up to such expectations. For example, Kiester (1993) discusses impacts of the establishment of the Redwood National Park in California 25 years ago and its expansion 15 years ago. He documents poor performance of tourism in substituting for an economic base previously provided by the logging industry for communities in Del Norte and Humboldt counties. He provides a stark contrast between rosy expectations and realities based on history, an analysis not often attempted (Kiester 1993, pp. 48 - 49): "Tourism has been the biggest disappointment, however. In the rosy scenario of the 1970's, the timber industry cutbacks were only to be a period of adjustment ushering in a new flood of tourism prosperity. Park advocates insisted that waves of tourists attracted to the

[3]For a discussion of this program with an emphasis on the forest products industry, see Chappelle and Webster (1987).

newer, bigger park would more than compensate for the lost jobs in the woods and mills. Arthur D. Little, a management consulting firm, predicted a gain of 1.6 million visitors by 1983, and a total of 950,000 visitor-days above the numbers recorded by the state parks [which were the basis of the original national park, before expansion]."

"In fact, tourists have never arrived in anything like the promised numbers. Far from the projected million-and-a-half tree lovers a year, tourist visits last year were estimated at 388,000 in a year when Yosemite, about 700 miles to the south, was overrun by well over 3 million.

"The average visitor spends less than 50 minutes in the park. . . .Visitation is not helped by the park's lack of facilities. It has no tourist lodging and no drive-in campgrounds. Campsites can be reached only by strenuous backpacking."

Ironically, the National Park has not been the major recreational attraction of the area. Rather, the major tourism lure was fostered by the logging industry. According to Kiester 1993, p. 49): "Although Humboldt County tourism has gradually inched upward and is now the county's fifth largest industry, the park is not the primary lure. The big tourism draw is Eureka's restored Old Town and the gingerbread mansions of the timber barons, souvenirs of the conservation-be-damned, cut-and-run logging days of a hundred years ago."

Kiester (1993, p. 49) maintained that tourism created few jobs in the Redwood National Park area and those created are largely low paying, especially in contrast to the forest products industry: "The average Humboldt County timber worker last year earned $21,300. The average motel employee received $11,500. Even then, most North Coast visitors are budget-minded, outdoors-loving families who camp in the state and county parks or head for the beaches."

In contrast, Pedersen and Chappelle (1993) estimated that the 1985 annual wage or salary levels (in 1990 dollars) in the Lake States region (Michigan, Minnesota, and Wisconsin) averaged $30,500 for the forest products industry and $14,300 for recreation sectors in the forested areas of the region.

Some important economic conditions in the nation during the study period[4]:

- The United States was in recession from mid-1990 through the first quarter, 1991
- The national unemployment rate reached its highest level since 1984 during the study period.
- Since the March 1991 trough of the recession, annual GDP growth has averaged, as of March 1993, only 2.3%, versus a 4.3% average rate following the troughs of the previous four recoveries. About 98% of the labor growth was in average weekly hours rather than new jobs. "Weak employment growth reflects a combination of factors: First a large amount of sectoral re-allocation is occurring in this recovery—for example, as displaced defense workers are being retrained for other jobs. Second, increased medical costs, along with new regulations surrounding disabilities, civil rights, and family leaves, have increased the costs of hiring new workers" (Economic Trends, March, 1993, p. 9).
- Average foreign exchange rate of the dollar (trade-weighted) reached its lowest level since 1979-1981.
- Inflation rates ranged from low to moderate, about the same prevailing during 1982-1984 (averaging 4.4% Dec. 1986 through December 1991).
- Foreign trade account balances were negative for the entire study period (highest in 1989). Trade balances for the U.S. were positive only with the E.C. and Mexico for 1991 and 1992, with the largest negatives with Japan.
- Change in average monthly nonfarm employment was positive in 1989, but negative for the rest of the study period.
- From 1979 through 1989, service employment increased by 30%, while employment levels in goods-producing industries actually declined slightly.
- Total compensation by service-producing industries exceeded goods-producing industries in 1989 and 1990, but goods-producing took the lead for the rest of the period.
- After a secular declining trend in housing starts that began in 1976, there was a revival in early 1991 that then weakened. New home prices largely leveled off after peaking in early 1990. In contrast, the housing affordability index, which measures cost of home ownership relative to personal income, was at its most favorable level since the early 1970's at the end of the study period.
- After peaking at about 63% in 1989, the employment/population ratio declined. Very likely, family income in the future will not grow by increasing the number of workers per household, as was true during the 1980s.

[4]Source: various issues of *Economic Trends* issued by the Federal Reserve Bank of Cleveland.

- Manufacturing capacity utilization was below the 1967-1991 average of 81% during most of the study period, beginning November 1990.

- In contrast to 3.4% in 1980, the average commercial office vacancy rate in 1992 was 18.8%. It is anticipated that excess space will inhibit commercial building activity for many years to come. Suburban vacancy rates were higher in 1991 (19.7%) than those downtown (18.1%).

- National GDP per worker in 1990 (about $44,000) was highest of the developed industrial nations (including Canada, Japan, France, U.K., and Germany) , but manufacturing productivity growth during 1973-1990 was only 2 1/2% per year, among the lowest of the world's advanced economies (of those listed, only Canada was lower).

- Per capita health care spending in 1989 was about $2,400, the largest of any of the world's developed countries (also highest in terms of share, of GDP), over 40% of which is paid by government. From 1973 through 1991 these costs have risen about 2.6% more per year than the cost of living.

- At the national level over the period 1986 to 1993, the percentage of the labor force (seasonally adjusted) unemployed for less than 5 weeks has been fairly flat at about 3%. Those persons unemployed for less than 14 weeks averaged a little less than 5% since 1991. Approximately another 1% was made up of those unemployed less than 26 weeks, but more than 14 weeks. Since 1991, the percentage unemployed more than 26 weeks averaged about 1% of the labor force ("Economic Trends," Federal Reserve Bank of Cleveland, August, 1993, p. 9).

Some important economic conditions in the region during the study period[5]:

Trade with Canada (1990): from list of top 12 importing and exporting states. Michigan is the top importing and exporting state:

	Imports (billions of U.S. $)	Exports (billions of U.S. $)
Michigan	(85.0% transp., 3.4% paper and lumber)	(69.2% transp., 0.8% paper and lumber)
Minnesota	1.654	
Wisconsin		2.102

State manufacturing employment shares, 1990 (to nearest percent): Michigan—24%, Minnesota—19%, Wisconsin—25%.

State distribution of auto production, 1990: Michigan—32.0%, Wisconsin—3.4%.

State export activity, 1989-1991:

	Manufactured exports growth (% change)	State share of exports (%)	
		All exports	Export growth
Michigan	35.9	5.1	9.1
Minnesota	22.7	1.3	1.6
Wisconsin	41.6	1.3	2.5
Midwest	35.7		
U.S.	18.2		

Markusen (1990, pp. 8 & 10) provides a succinct summary of conditions in the industrial heartland during the period immediately prior to this study: "The Great Lakes core of this region [i.e., of the industrial heartland] experienced an absolute decline in total numbers of jobs from 1979 to 1986, at a time when the Pacific, New England, and South Atlantic regions added jobs at rates of 14.7%, 15.4%, and 20.8%, respectively (. . .). Manufacturing job losses were the dominant component of this disparity. The Great Lakes states lost 19.3% [of its] net manufacturing jobs over the period, almost double the national loss of 10%, while the South Atlantic, Pacific, and Mountain regions actually posted increases (. . .). Almost half of the 2 million jobs lost in the nation were found in the five East North Central states. In their wake, manufacturing shutdowns depressed the region's service sectors, so that in states like Illinois and Michigan, services grew at only one-half to two-thirds of the national rate. Despite no job expansion, labor force supply pressures grew in the heavy industrial states, resulting in dramatic rates of outmigration. In the first half of the decade, the Great Lakes States lost 3.6% of their population through net outmigration (. . .)."

It appears that Markusen is using standard U.S. Census divisions and regions and "the Great Lakes core" refers

[5]Source: various issues of *Economic Trends* issued by the Federal Reserve Bank of Cleveland.

to the East North Central Region (which includes the states of Indiana, Illinois, Michigan, Ohio, and Wisconsin). Minnesota is in the West North Central Region. Further, she notes that (Markusen 1990, p. 10, fn. 9): "Disparities have ameliorated somewhat since 1985, as the dollar has weakened. In 1987, the outlying states of Minnesota, Wisconsin, and Iowa grew by more than the national manufacturing growth rate, but Illinois, Michigan, and Ohio still lagged behind the national rate (Robbins 1988). From the trough of the 1983 recession to early 1989, the Midwest barely outpaced the nation, but since the Midwestern slump was more than twice as severe as the nation's, it should have doubled the nation's recovery rate just to stay even (Schnorbus and Israilevich 1989)."

This apparent geographic difference within the Midwest appears to be a proxy for differences in economic potentials among different kinds of manufacturing industries. Trends and prospects for Midwest manufacturing other than automobiles and related industries are quite good (Bilek and Stier 1993, also Borchert 1987), whereas the future appears much less favorable for automobiles and related industries.

Types of Regions Taken as Entities in the Study

A number of types of regions were developed for each state, depending on the state's economic structure (or lack of economic structure in the case of relatively undeveloped areas). All regions considered in the preliminary study (Chappelle and Webster 1990) were retained, but additional regions were added. It is unlikely that a long time series could be used in this type of study because of relatively rapid changes in economic structures, especially for rural regions with a relatively small number of establishments.

The specific regions considered in this study are indicated by state below:

Michigan

1. Primary Auto Corridor (PAC): Detroit (city), Pontiac (city), Flint (city), Saginaw (city)
2. General Urbania (GU): Grand Rapids (city), Kalamazoo (MSA)
3. Forest Industry Development Center 1 (FIDCl): Marquette, Delta, Dickinson
4. Forest Industry Development Center 2 (FIDC2): Crawford, Roscommon
5. Tourism Development Center (TDC): Grand Traverse, Leelanau, Charlevoix, Emmet
6. Relatively Undeveloped 1 (RUDl): Chippewa, Mackinac, Luce
7. Relatively Undeveloped 2 (RUD2): Alpena, Cheboygan, Montmorency, Presque Isle
8. Combined Forest Industry/Tourism Development Center (COM): Otsego
9. University Center (UC): Ann Arbor
10. Mining Center (MC): Ontonagon
11. Agricultural Area (AA): Huron, Ottawa, Allegan

Minnesota

1. General Urbania (GU): Minneapolis-St. Paul (MSA)
2. Forest Industry Development Center 1 (FIDCL): Carlton, Koochiching
3. Forest Industry Development Center 2 (FIDC2): Duluth (city)
4. Tourism Development Center (TDC): Cass, Crow Wing
5. Combined Forest Industry/Tourism Development Center (COM): Beltrami
6. Relatively Undeveloped 1 (RUDl): Aitkin, Hubbard, Lake of the Woods, Wadena
7. Relatively Undeveloped 2 (RUD2): Red Lake, Clearwater, Kanabec, Mahnomen
8. Mining Center (MC): St. Louis (minus Duluth), Itasca
9. Agricultural Area (AA): Stearns, Polk, Otter Trail

Wisconsin

1. General Urbania (GU): Milwaukee (MSA), Madison (MSA)
2. Forest Industry Development Center (FIDC): Green Bay (MSA), Outagamie, Winnebago
3. Tourism Development Center (TDC): Vilas, Door
4. Combined Forest Industry and Tourism Development Center (COM): Oneida
5. Relatively Undeveloped 1 (RUDl): Rusk, Sawyer, Price

6. Relatively Undeveloped 2 (RUD2): Calumet, Oconto, Marinette, Clark

7. Indian Reservation (IR): Menominee

8. University Center (UC): Madison (MSA)

9. Agricultural Area (AA): Marathon, Grant, Dodge

In this paper the focus primarily is on FIDC, TDC, COM, and RUD regions, although the data base developed in this study includes all the above study regions[6]. The range of economic bases can be viewed as distinct types along a continuum and that any actual place will not be a pure case. Unfortunately, there appears to be no robust measurement of a place's economic base from readily available secondary data.

In those cases where there are multiple regions of a given type within a state, the second one was added after the 1990 paper by Chappelle and Webster, which included a preliminary analysis of the relationship of economic base to unemployment. Also, Agricultural Areas and Mining Centers were added at that time.

Time period considered in the study:

August 1989 through July 1992.

Hypotheses of the 1990 paper

As noted above, a preliminary analysis was carried out by Chappelle and Webster (1990). Hypotheses tested in that paper were taken as starting hypotheses in this analysis, which expanded the data set from a 6-month period to a 3-year period. The hypotheses were:

1. The relative magnitude of regional unemployment is related to regional characteristics, primarily the economic base, and that employment patterns exhibited by the predominant industry is reflected in regional unemployment patterns, with influences flowing through both backward and forward linkages.

2. FIDC and TDC centers have lower unemployment rates than RUD areas.

3. Forest industry development centers have generally lower unemployment rates and less seasonal variation than do TDC areas.

4. There is a systematic difference between unemployment rates in which Michigan contrasts with Wisconsin and Minnesota.

Data sources

1. Michigan: Michigan Employment Security Commission, Bureau of Research and Statistics, Labor Market Analysis Section.

2. Minnesota: Minnesota Department of Jobs and Training, Research and Statistics Office.

3. Wisconsin: Wisconsin Department of Industry, Labor and Human Relations, Bureau of Labor Market Information.

Only final estimates were used each month in the series. However, even these sometimes were later revised. To the extent possible, we revised our data set in response to these changes.

Readers interested only in major study conclusions rather than detailed results may turn directly to the conclusions section on page 53.

MAJOR STUDY RESULTS

Major aggregated results are summarized in Table 4, where means and ranges over the entire study period are shown for the unemployment rate for each type of region in each state. Although this table is much less detailed than the data base and figures (a few of which appear in the body of this report), many major study findings can be deduced from it. These statistics are aggregative for the entire study period, hence they indicate in a sense "long-term misery" in the various study regions for the entire study period. Of course, seasonality and secular trend (if any) are reflected in the ranges. In most cases, the lowest part of the range occurred near the beginning of the study period.

[6]This data base was developed by Dylan Cole, Graduate Research Assistant, Department of Forestry, Michigan State University and is included as an appendix to this report. Also, graphs displaying trends are included in an appendix to this report.

Table 4.—*Arithmetic means and ranges of monthly regional unemployment rates (percent of nonagricultural civilian labor force) by state, August 1989 through July 1992)*

Type of Region	Michigan	Minnesota	Wisconsin
PAC	12.5	(10.0-15.9)	
GU	6.9	4.4	4.0
	5.5-8.3	3.3-5.4	3.0-5.0
FIDC1	9.0	7.2	4.3
	5.6-12.1	4.9-10.1	3.1-5.5
FIDC2	7.9	5.5	
	5.4-11.9	3.5-7.1	
TDC	8.7	7.2	6.6
	5.7-12.7	4.4-10.8	3.1-12.3
COM	9.1	6.1	4.7
	5.5-14.3	4.5-8.5	2.7-7.1
RUD1	12.7	8.1	7.2
	7.0-19.7	5.6-11.6	4.3-13.0
RUD2	15.3	11.7	7.6
	9.4-23.2	7.5-18.1	5.6-11.4
UC	3.1		2.9
	2.2-4.2		2.1-4.3
MC	8.0	7.5	
	5.5-14.3	5.5-10.6	
IR			21.6
			14.7-33.6
AA	6.5	5.7	5.4
4.9-8.9	3.8-8.3	3.8-7.3	
State	8.4	4.9	4.8
	6.7-11.0	3.9-6.5	3.7-6.9

Note: The U.S. mean during the study period was 6.3, with a range of 5.0 to 8.1.

The rankings of mean unemployment rates and ranges (from lowest to highest) are shown in Table 5.

Table 5.—*Rankings of mean unemployment rates and ranges (from lowest to highest)*

Rank	Michigan		Minnesota		Wisconsin	
	Mean	Range	Mean	Range	Mean	Range
1	UC	UC	GU	GU	UC	GU
2	AA	GU	state	state	GU	UC
3	GU	AA	FIDC2	FIDC2	FIDC1	FIDC1
4	FIDC2	state	AA	COM	COM	state
5	MC	PAC	COM	AA	state	AA
6	state	FIDC1&2	FIDC1&TDC	MC	AA	COM
7	TDC	TDC	MC	FIDC1	TDC	RUD2
8	FIDC1	COM & MC	RUD1	RUD1	RUD1	RUD1
9	COM	RUD1	RUD2	TDC	RUD2	TDC
10	PAC	RUD2		RUD2	IR	IR
11	RUD1					
12	RUD2					

The following conclusions can be drawn within an individual state analysis:

Michigan

1. AA and GU regions are similar, except that AA has a larger range.

2. Means of FIDC2 and MC are nearly identical although the MC region's range is larger.

3. Means and ranges of FIDC1, FIDC2, TDC and COM are nearly the same.

4. Means of PAC and RUD1 are nearly the same, but the range of RUD1 is much greater.

5. Mean and range of RUD2 is much larger than the rest of the regions.

Minnesota

1. Means of FIDC2 and AA are nearly identical, but the range of AA is larger.

2. Means of FIDC1 and TDC are identical, but range of TDC is slightly larger.

3. FIDC1 and MC have means and ranges almost the same.

4. Both the mean and range of RUD2 are much larger than those for RUD1.

Wisconsin

1. The range of GU is almost the same as FIDCl, but the mean of FIDC1 is slightly larger.

2. The mean of TDC is almost as large as RUD1, but the range of the latter is much larger.

3. The mean of RUD2 is only slightly larger than that for RUD1, but its range is much narrower.

Contrasts between states for the same type of region are also illuminating:

1. GU regions in MN and WI have about the same means and ranges.

2. UC regions in MI and WI have almost identical means and ranges.

3. The MC regions' means and ranges are similar, although the range is greater in MI than in MN.

4. The means for the AA regions in MN and WI are similar, but the range was wider in MN.

5. The state means and ranges were about the same in MN and WI.

When monthly data are plotted for a given type of region and contrasted between states, it is possible to perceive relationships that cannot be revealed in the aggregative data in Table 4. In the study analysis a large number of graphs were produced to trace relationships. Only a few of the graphs are included in this report, but the findings below are based on the large number of plots.[7]

One effect that requires plotting monthly data to quantify is seasonality, which was merely reflected in the range in the aggregative data in Table 1. More importantly, this plotting was required to trace secular trends. Changes in ranking of regions according to unemployment rate occurred in some cases during the study period. The major findings of these analyses were:

1. Michigan unemployment rates have been consistently higher than in Minnesota, Wisconsin, and the nation. However, in February 1993, it was announced that in January 1993 the Michigan UR tied the national UR for the first time since 1978 (at 7.1%). Examination of unemployment rates since completion of the formal study suggests that rates for Michigan areas other than the auto production corridor are becoming somewhat more like those for comparable areas in the other two states. It would appear that parts of Michigan are partially escaping the negative influence of the auto corridor.

2. The Primary Auto Corridor (PAC) has the highest sustained rates of unemployment, except for the IR.

3. In general, the unemployment rate in all three states increases as one proceeds from GU to FIDC to TDC to RUD regions.

4. Except for the PAC and IR, RUD regions always have the largest UR throughout the year.

5. GU regions in all three states had an UR below state average for every month for all 3 years.

6. Michigan's GU rate has exceeded the other two states GU rates for every month of the study.

7. GU and FIDC rates in Wisconsin are similar.

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[7]Much of this section is based on a study progress report dated January 7, 1993, by Dylan Cole, Graduate Research Assistant, Department of Forestry, Michigan State University.

8. FIDCs in Michigan had higher URs than those in the other two states, with the exception of a few months.

9. The RUD and GU regional to state ratios are similar in the three states, both in terms of means and ranges.

10. URs for UCs have been consistently lower and more stable than national URs and are lower than all other state or regional rates for every month.

11. In general, labor force instability ordering is that RUD has been the most unstable, followed by TDC, FIDC, GU, with UC being the most stable.

12. In most regions labor force size has increased over time. There is some evidence that regional unemployment rates have increased because of increases in the civilian labor force (CLF) size. Consider the following contrast for Minnesota and Wisconsin of change in seasonally unadjusted unemployment rates (UR) and change in CLF from May 1992 to May 1993 (note that these data are more recent than those included in the data base for this study):

	Minnesota		Wisconsin	
Region	UR	CLF	UR	CLF
	annual percentage change			
GU	+0.4	+2.16	+0.6	+3.36
FIDC1	+0.4	+3.43	+0.9	+3.34
FIDC2	+0.8	-1.21		
MC	+0.2	-1.67		
TDC	+1.1	+3.39	+2.7	+6.16
COM	+0.3	+2.05	+2.6	+2.84
RUD1	+0.8	+1.88	+4.9	+6.70
RUD2	+0.8	+2.35	+2.7	+0.77
IR			+7.7	+26.32

13. In Michigan and Minnesota, trends of FIDC, TDC and RUD are similar, with RUD with highest URs and with TDC and FIDC at lower and more stable levels (usually with FIDC somewhat lower). Wisconsin, however, shows URs for TDC and RUD1 very similar (even seasonality), with FIDC usually lower (much lower during winter months, with little seasonality).

14. Taking the regional to state ratio, Minnesota FIDC1 always ranked highest, followed by Michigan and finally Wisconsin (with the exception of a few months in 1989).

15. Although peaks and troughs occurred at about the same time, the trend in unemployment rate for Michigan FIDCI differs greatly from FIDC2, which usually had the higher unemployment rate. With the exception of one month, unemployment rates for both regions have been higher than the national unemployment rate. During summers, however, the unemployment rate for FIDC2 were lower than the state rate,[8] whereas FIDC1 rates were higher than the state averages, excepting a few months.

16. For every month in the data series for Minnesota, the unemployment rate in FIDC1 were higher than in FIDC2.

17. In Wisconsin, the unemployment rate in the FIDC, with the exception of a few months, was below the state rate.

18. The Michigan RUD1 unemployment rate was higher every month than RUD1 for Minnesota and Wisconsin, which trended at about the same levels.

19. The Michigan RUD2 unemployment rate, with the exception of 2 months early in the series, was higher than RUDs in the other two states. RUD2 in Minnesota, except for 1 month when equal, was higher than Wisconsin's RUD2 throughout the data series, with the greatest differences occurring in the winter months.

20. Trends in unemployment rates in UCs in Michigan and Wisconsin were about the same level for the entire series, fluctuating between 2.25 to 4%.

21. The Michigan MC unemployment rates stayed about equal to Minnesota's MC rates until August 1991, at which time they grew higher, sometimes by as much as 3 percentage points.

22. Unemployment rates for AAs cluster together for the three states, sometimes with one state leading and then another. From December 1992 to the end of the data series, the unemployment rates in these areas were below the national rate. Before that date, one state or another fell above the national rate. The reader should again be cautioned, however, that agricultural labor is not included in the civilian labor force and unemployment rates reported here.

23. Peak unemployment rates for the IR occurred in January and February throughout the data series, with troughs occurring in September or October.

24. In Minnesota, the ratio of regional to state unemployment rates for the COM region, with an exception of a few months at the beginning of the data series, was lower than those for FIDC1. FIDC2

[8]The fact that FIDC2 has a significant tourism aspect somewhat confounds the matter, but helps to explain this specific pattern.

ratios, however, were generally lower than COM ratios except during August and September.

25. In Wisconsin, regional-state unemployment rate ratios for FIDCI have been lower than COM ratios, except for June and July.

26. In Wisconsin, RUD2 ratios of regional unemployment rates to state rates fluctuated over a narrow range (1.40-1.85), whereas RUD1 fluctuated much more widely (0.9-2.0).

CONCLUSIONS

It is evident that none of the regions perfectly match their labels and they vary somewhat within a class within a state. It is even possible that regional compositions changed enough during the study period that labels should have been changed in some cases. It appears impossible to isolate a "pure" region in the Lake States classified by economic base. Very likely this would be a general truth applicable to all parts of the world except perhaps in a stagnant or primitive economy.

In relative terms, economic base does have a fairly predictable effect on unemployment rates. Generally forest industry development centers are characterized by higher unemployment rates than general urbania regions, but lower than tourism and relatively undeveloped regions and are generally more stable and less influenced by seasonality.

Regions that have an economic base in both the forest products industry and travel/tourism sectors usually (but not always!) have lower unemployment rates than regions characterized by a single sector. Over all states, the unemployment rate was lower for the COM region (i.e., the region having an economic base in both tourism and forest products) than the FIDC and TDC regions combined for 51.8% of the months in the data base. However, the frequency differed a great deal from state to state and among FIDCS, as shown below (in percent):

Region	Michigan	Minnesota	Wisconsin	All States
FIDC1	42.9	91.4	33.3	
				39.8
FIDC2	5.7	25.7		
TDC	42.9	80.0	91.7	71.7

From the above statistics, one can maintain with some confidence that the unemployment rate is likely to be lower if the region has an economic base including **both** forest products and tourism industries, rather than just one or the other, particularly tourism. The above statistics illustrate how difficult it is to delineate regions with any degree of homogeneity in respect to economic base. Also, it is evident that other variables are important.

Source of tourism visitors showed itself to be an important factor in terms of effects on employment/unemployment. This has occurred by accident in terms of observations in one of the states, namely Michigan. During the last 2 years of the data series, monthly unemployment rates have been generally higher for the locality that is a center for both tourism and forest products, than for localities that are one or the other. That the regional economic base was misidentified may be possible. But additional thought, comparing particularly the tourism development center and the combined development center, suggests something more complicated. The tourism development center focuses on Traverse City and several associated communities on the east shore of Lake Michigan. This area is linked quite strongly to Chicago and several other major communities in several states by airline links, configuration of the highway system, and a long-standing pattern of tourism (including substantial numbers of seasonal residences). The combined development center focuses on Gaylord, a much newer center with links primarily to Detroit and associated communities essentially completely by highway. Tourism linked to economically strong sources of visitors, particularly multiple sources, appears to have greater beneficial effects than tourism linked primarily to a single, less economically strong source.

For most regions there was a secular increase in the civilian labor force. CLF size was greater at the end of the data series than at the beginning for most regions (exceptions: MI—PAC and GU; WI—TDC, RU-2). However, real incomes have not kept up with inflation, and there has been very little job growth nationally. If the same forces held for the regions (and data are not uniformly available to examine this) then it was inevitable that unemployment rates increased over time. Also, new jobs tend to pay lower wages than lost industrial jobs, thereby leading to lower incomes. During this period family incomes rose only because additional family members (usually married women with children) entered the labor force and gained employment outside the home. This trend peaked recently and now has been decreasing nationally.

It is to be recognized that this analysis covers a relatively short time period. There are longer time trends that also influence employment. Serious loss of international competitiveness (and then only partial and uneven recovery) in major heavy industries dominant in parts of the region is an important example. These longer-term trends mean that month-to-month data do not necessarily prove or disprove cause and effect. However, patterns

are quite striking as noted, and worthy of serious consideration in relation to regional development strategy.

This analysis tells us something quite simple but important concerning efforts (particularly state efforts) to foster economic and community development based in major part on forests and related resources. It suggests that such efforts will be most successful if actions to foster the tourism and forest products sectors are parts of the same package of state initiatives, not separate efforts and least of all efforts that deliberately compete with each other (State of Michigan 1987).

This analysis also suggests that development efforts may be more successful in terms of employment effects some places than others in a definable pattern. Other things equal, they are more likely to be successful in places that have the assets (both natural and cultural) to be both tourism and forest products development centers, not simply tourism. Also, it is evident that the development trend for the region is very influential. Very likely differences in infrastructure development over time is at the foundation of many of the differences in observed unemployment rates. Both of these points are likely to be matters of considerable potential interest to state governments trying to tailor their regional and community development efforts to make them effective.

Another aspect that could not be investigated as a part of this study was the effect of agglomerations and industrial complexes on unemployment rates. Regional economic theory would lead one to expect some significant differences depending on agglomeration and development of industrial complexes.

Implications

From a social welfare standpoint, and to the extent that markets exist for products, siting forest products manufacturing plants in relatively undeveloped regions likely will lead to reduced unemployment rates (assuming availability of raw materials). Also, siting tourism developments in such regions also likely will lead to reduced unemployment rates, but high rates likely will continue to occur during winter months, if more year-round resorts are not developed. A combination of forest industry development and tourism development likely will lead to both lower rates and less seasonality.

However, one should not assume that a high unemployment rate means that labor appropriate for the forest products sectors is necessarily in over supply. For example, Granskog and Manthy (1970, p. 5) found that during 1965 and 1966 there were problems of woods labor supply even with " . . . surplus manpower levels in the very areas experiencing woods labor shortages. For example, in Michigan's Upper Peninsula unemployment levels were so high that surplus manpower was leaving the area (. . .). The generally acknowledged explanation is that alternative opportunities have been more attractive than woods work."

It is true that not all jobs would be so unattractive, but given that all forest products sectors depend on this type of labor **somewhere** (i.e., the primary production), all such activities could be affected by woods labor force trends.

It seems inevitable that higher unemployment rates will exist in some states (e.g., Michigan) than in others (e.g., Minnesota and Wisconsin). This follows from the contextual factors that were discussed in the introductory section of the report. Very likely such rates are structural and change only slightly over time. To a certain extent, the high rates in Michigan are probably related to high dependence of the state's economy on automobile manufacture and suppliers to this industry, a matter that is decreasing to some extent over time, as previously discussed.

Recommendations for Further Study

There needs to be increased efforts at developing regionalizations based on types of economic bases. This will undoubtedly be difficult because data collected by the federal government are not adequate to the task (Vega 1992). The panel approach of delineating economic bases used in this study is probably the best approach that could be used given the status of data resources, but panel size and composition needs to be increased.

The time series needs to be increased and more time series analysis needs to be completed. Our data set, for example, was the minimal time series to even carry out moving average calculations to adjust for seasonality (which we concluded had little value, given our research objectives).

Most of all, this type of analysis needs to be broadened by linking to a demographic analysis (focusing particularly on migration) on the one hand and to a regional economic model on the other. In this way it should be possible to trace the effect of migration on the labor force and the level of economic activity in the region. A regional model that takes this approach was developed by Olson *et al.* (1984). Ideally, one would develop an interregional model.

In terms of industrial targeting, it would be desirable to define FIDCs by four digit SIC (Standard Industrial Classification) sector, rather than according to forest

products industry as a whole. State-level unemployment compensation records (commonly known as ES202 data) may have great potential for improving future analysis. For an example, see White *et al.* (1990). However, costs of correcting data records for many sub-state areas likely would be very high. Also, interstate comparisons are difficult to make because " . . . state bureaus of employment services control how firm-level data are gathered, processed, and publicized" (Lin *et al.* 1990, p. 255).

There is a need to link regional development trends with industrial trends in the four digit sectors. In particular, sectoral market analyses, considering estimates of both domestic and foreign sales, can be used to forecast regional development trends by inputting such forecasts into the final demand vector of an input-output model.

There needs to be a comprehensive analysis of labor potentials in any given area targeted for expansion of industries considered in this report. An early example of this within the Lake States region is Blyth and Gronseth (1963) and Blyth (1964) for the Duluth, Minnesota area. Labor potentials for unemployed workers in this case were classified in terms of occupational group and educational level for cohorts defined by age class and gender.

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A Detailed Examination of Economic Effects of Growth in Tourism and Forest Products Sectors in the Lake States

Daniel E. Chappelle[1]

INTRODUCTION

This detailed examination of economic effects is the first part of identification and evaluation of plausible alternative futures concerning the tourism and forest products sectors in the Lake States. Four different futures have been defined in terms that may appeal to governors and their advisors as a range of policy choices concerning forest resources.

Evaluation of economic effects will give a sense of the scale of growth likely in these sectors, both singly and combined. It will then be possible to more readily identify and evaluate community effects and environmental effects likely to be associated with economic effects at this identified scale.

The first step is to consider the four plausible alternative futures, and some major dimensions of their evaluation. Next, economic effects related to the forest products sector are examined in detail. This is followed by a parallel examination of economic effect related to the tourism sector.

Each of these parallel examinations finally tries to give a sense of where in the Lake States growth in employment and income associated with the two sectors is most likely to occur. This is done essentially to aid subsequent evaluation of associated community effects. Multi-county areas previously analyzed in terms of effects of various economic sectors on local employment and unemployment are used in this effort to give a sense of the geography of likely effects.

DISCUSSION OF ALTERNATIVE FUTURES AND THEIR EVALUATION

Future 1.—Forest resource-based industrial expansions of the 1980s have carried the region to a new plateau on which the region will rest for some time. (Translation: Few if any additional expansions of primary users of Lake States timber resources in the foreseeable future, and only a very modest level of effort to foster them.)

Future 2.—Forest resource-based efforts toward regional employment and economic growth are concentrated primarily on the tourism/recreation industry. (Efforts to attract additional visitors, and to provide improved and attractive facilities for them are the core of resource-based economic development efforts in the region.)

Future 3.—Forest resource-based industrial expansions continue to be assisted by state and community efforts as in the 1980s. (These efforts center on effectively packaged information on principal factors affecting plant expansion and plant location decisions for instate regions, e.g., labor supply, potential building sites, transportation facilities for both market access and assembling inputs. These efforts may also involve efforts to assure stable and sustainable timber supply and ready availability of competent labor and other inputs. Efforts to foster expansion of value-added secondary forest products industries are also part of both this future and the next.

Future 4.—New and more fully synchronized efforts are made to encourage expansion in both the tourism/recreation and forest industries. (The two industries are treated as linked in a unified resource-based development effort; existing cooperation among the three states is further strengthened and unified in support of this effort.)

A. Relating Pedersen and Chappelle (P&C) estimates of future employment and income to the proposed futures:

   1. The estimates are based on a demand-driven input-output model, hence they relate to production levels required (at current relative prices) to satisfy expected final demands of all types (including exports) and it is assumed that all inputs (including wood) will be available to meet these final demands. In view of this, the estimates probably relate best to a combination of Futures 2 and 3.

   2. The model assumed that all prices (both of inputs and outputs) will remain fixed in a relative sense (i.e., in real terms). Therefore, to the extent that actual regional wood prices increase beyond relative prices in the model, estimates will be off

[1] The author is Professor Emeritus of Resource Development and Forestry, Michigan State University, East Lansing, Michigan 48824.

somewhat. This might occur because of reduced harvest levels on federal lands in the Pacific Northwest, growth reductions of Southern pines, trends in the Canadian forest products industry, etc.

3. P&C projections may be applied to the proposed futures as indicated below, where the principal assumption being made is that there is little transactions linkage (in dollar terms) between the forest products industry and the tourism/recreation industry:

   a. Future 1 might be taken as a situation where there is no job or income growth in the regional forest products sectors. For this future, the levels of employment and income would be taken as the 1990 P&C estimates. However, this future still would involve a modest increase in production because of expected continued productivity gains in the forest products industry. [Question—What about growth in the tourism/recreation industry?]

   b. In the case of Future 2, we could assume the tourism/recreation sector expands as indicated in the year 2000 P&C projections. Levels of employment and income for the forest products industry would be set at 1990 P&C estimates.

   c. Future 3 might be taken as a situation where 2000 P&C projections apply for the forest products industry, but increases do not occur in the tourism/recreation sector (i.e., 1990 P&C levels would be used).

   d. Future 4 would then be a situation where 2000 P&C projections for both the forest products and tourism/recreation sectors would hold.

4. Given the way employment and income estimates were derived, a major effort must be to estimate whether resource and other inputs are adequate at unchanged relative prices to meet final demands. Capital inputs are extremely mobile and probably readily available for promising investment opportunities given current interest rates. Therefore, this input is judged not to be a problem that must be addressed in this analysis. It does not appear that land is scarce (e.g., much agricultural land in the region has been released) nor is labor scarce overall (i.e., unemployment rates are relatively high and real incomes have been decreasing). Therefore, the main concern regarding input availability relates to timber.

B. Adequacy of future regional timber supplies:

1. It appears that estimates derived by the NCFES and interpreted by Stone will be adequate in terms of physical supply.

2. Hagenstein's analysis indicates that regional real prices may be increasing fairly steeply if the worst case scenarios for the Pacific Northwest and Southern regions, as well as for Canada, were to occur in the future, particularly if all three were to occur simultaneously. Smyth (1993), focusing on softwood supplies in the U.S. South and Pacific Northwest and Canada, is particularly pessimistic regarding the future (p. 10):

   ". . . a large shortfall [in softwood lumber production] in 1994 will force adjustments in consumption, including a reversal of the trend of the last decade toward much larger new houses. It will also speed up the adoption of non-wood substitute products by the nonresidential construction industry, which has shown less resistance to such changes. And it will greatly expand the role of wood-based composite products, particularly those that are not dependent on the harvesting of old-growth species. Given the potential demand which is now in place and the slowness with which many supply side adjustments will occur, high levels of unsatisfied consumer demand will assure the continuance of record lumber prices in 1994."

3. We may have to develop alternative futures that will reflect alternative scenarios in these three major wood producing regions. This might take the form of estimating share of the timber market likely to be gained by the Lake States given what may happen in the major wood producing regions. This could be done by making estimates of real price increases (hence decreasing demands) given effects of supply situations in the other regions. We do not have to consider the effects of this region's production on the supply-demand situation in the other regions.

4. Technological changes described by Skog will provide the basis for analysis of adequacy of regional timber supply in meeting raw material demands. Because of technological change we can likely anticipate that the amount of wood embodied in a unit of final product will continue to decrease. Technological changes could be summarized in estimates of timber inputs to produce one unit of product.

5. In a detailed comprehensive analysis one would want to have input demands by species and size for each sector within the forest products industry. However, data does not exist to carry out such an analysis. Also, currently there is no model really adequate to the task that would retain the spatial delineation required in this project. Therefore, I propose we assume (perhaps with some modifications) that all species can substitute for one another without change in the production function. Essentially we would be assuming that industry can readily modify production processes to use available wood supplies, which appears to be what generally occurred during the history of the industry in the United States as well as the world as a whole. Also, one must remember that many forest products sectors have been making even more radical changes in production processes over the last few decades to meet environmental regulations than we would be implicitly assuming.

C. Analysis of demand for goods and services[2]:

1. A more difficult area in evaluating futures relates to expected demands for the diverse goods and services supplied by the region's forests. Much depends on population size and composition, which in the United States depends greatly on immigration trends. See Marcin (1993) for a brief review of the situation.

Effects of population change on wood use—

a. Fast growing areas that are rural likely will have a decreasing availability of timber for harvest.

b. Increases in population size will result in increased demands for wood products, although not likely directly proportional to population increase.

c. Increased demands in pulp and paper sector likely will be met partly by recycled fiber.

d. The most binding situation will be for solid wood products, both to meet regional demands resulting from population increases, but more importantly because of the need to substitute for drastically decreased harvests of coniferous sawtimber from federal lands in the Pacific Northwest. Even though we are likely to see considerable substitution of non-wood products (e.g., steel studs), the pressure will be great to increase harvests in the region to meet demands in this region and other regions (particularly the East).

Effects of population change on recreational use of regional forests—

Population growth will lead to more recreationists but probably not proportional to population increase because of:

a. Available family leisure time has been generally decreasing in recent years;

b. Aging of the population has the effect of decreasing demand for strenuous recreational activities requiring forest land (e.g., downhill skiing, hunting);

2. Changes in intergenerational skill transfer have had the effect of decreasing certain recreation activities (e.g., hunting);

3. Many increasingly attractive substitute recreational activities do not require forest land (e.g., urban parks, television, video games);

4. Also, final demands for all goods and services depend on future consumption patterns, which are very difficult to estimate, especially for the far future. In the case of forest products, substitution of non-wood materials for wood in construction (e.g., steel, aluminum, straw, etc.) is usually the first to come to mind. Likewise there are many substitutable materials for wood in paper manufacture (e.g., kenaf, hemp and straw).

Generally we think that people in the future will require about the same quantity and quality of goods and services as they have in the past. However, life styles may change (and have changed) significantly. Consider, for example, impacts in housing markets as settlement patterns have changed since the Second World War. Urban recreational activities have substituted for wildland recreation to some extent. A much larger proportion of our population reside in urban areas now. Aging of the population by itself means that significant changes in population distribution, type of housing, density of housing, and price of housing will likely occur. Consumption patterns depend much on demographic trends (e.g., immigration patterns for various ethnic groups),

[2] Note that the economic impact model (FS-USDA's IMPLAN) on which the Pedersen - Chappelle estimates are based calculates production required to meet final demands in dollars. Raw material levels in physical units are not considered in such an analysis. However, remember the model assumes that all inputs will be available to meet the calculated production schedule.

and distribution of real income. Also, technological changes can be very significant, including such timely and esoteric trends as spread of the information superhighway (that can substitute for publications printed on paper), as well as theme parks (and in the future, virtual reality gaming centers) that can often substitute for some forest-based recreational activities, etc.

5. Another aspect of demand analysis that will be difficult to estimate is future redistribution of real disposable income. The gap between rich and poor has been increasing and some trends (e.g., increasing requirements for higher education and training among entrants to the job market) are likely to increase it even further. It appears that the lowest two-fifths of the income classes are unlikely to be able to afford consumption at previous levels, especially for housing. It is likely, therefore, that products containing wood will be impacted more than most other goods and services.

6. Changes in the structure of labor markets also will likely have significant impacts on real incomes and hence on major purchases (such as housing and furniture) and on lifestyles (which will have significant impacts on recreation).

D. Estimating economic impacts:

1. Major variables of concern in the economic impact analysis will be employment and income likely under the alternative futures.

2. Employment and income changes in both the forest products industry and the tourism/recreation industry will be considered for each alternative future.

3. It seems reasonable to assume that future growth in both industries will occur in areas where the industries already are important to the regional economy. That is, expansions of current centers are more likely than the establishment of new centers of these economic activities. (See "Assembling Some of the Information for Identifying and Evaluating Plausible Alternative Futures," 3/7/94 for a discussion of potential expansions).

4. There is difficulty in spatially allocating changes in employment and income. It does not seem very useful to attribute changes to the three-state region as a whole. Therefore, the following procedures are proposed:

   a. Take regions used by Chappelle (1994) in the analysis of unemployment as units of analysis. These regions are delineated according to major economic base. Only three types of regions in the three states would be used: (a) forest products development centers, (b) tourism/recreation centers, and (c) combined forest products and tourism/ recreation centers.

   b. Assume that changes in the industry (i.e., either forest products industry or tourism/ recreation industry) will occur only in regions bearing these designations within each state.

   c. Allocate growth in employment and income to existing forest products and tourism/recreation centers in proportion to their existing employment size. This will require using the most recent labor force data for the economic base regions in the three states.

   d. Take available unused wood capacity into consideration as a constraint and reallocate expansions to other areas if the needed supply appears not to be available. It would seem that forest survey units would adequately provide spatial delineation to achieve this appraisal, considering likely timbershed sizes.

   e. Assume that excess labor supply will be adequate to handle future growth in both the forest products and tourism/recreation industries. This assumption is not very critical because additional labor supply is available in areas within commuting distance from designated labor markets.

5. Economic growth of the regions would be calculated on the basis of growth of either the forest products industry, the tourism/recreation industry or both.

6. Essentially by the above procedures we will be allocating the growth indicated in the Pedersen and Chappelle estimates to regions within the three-state region in terms of direct, indirect and induced economic impacts. At this point we will have determined scale effects. After that we can explore community economic effects and then proceed to social and environmental impacts of the expansions indicated in the alternative futures. In contrast to the three-state region, at the small area level, some modifications will have to be made to avoid double-counting when aggregating sector estimates of indirect and induced employment.

DETERMINING IMPACTS OF FOREST PRODUCTS INDUSTRY EMPLOYMENT GROWTH ON TIMBER DEMAND IN THE LAKE STATES

The Pedersen and Chappelle (1994) estimates of employment growth (from 1990 to 2000) are taken as a base in this analysis. The question to be answered here is what timber volumes are implied by these employment levels, which are expected to be required to meet 2000 final demands? A simple way to approach the question is to develop coefficients representing roundwood receipts per job in the various forest products sectors. This was done by using data from Hackett and Pilon (1993) for Michigan, Hackett and Dahlman (1993) for Minnesota, and Hackett and Whipple (1993) for Wisconsin (see Tables 1 - 5, below). Unfortunately, in this process it was necessary to aggregate to the two-digit SIC level (see Table 6 for 1990). Forecasted distribution of direct employment to sectors for 2000 is initially done on the basis of no change in technology (Table 7).

Table 1.—*Number of active primary wood-using mills, 1990*

Kind of mill	Michigan*	Minnesota**	Wisconsin***	Region
Sawmills[1]				
Large[2]	26	12	27	65
Medium[3]	103	52	102	257
Small[4]	171	457	139	767
Subtotal	300	521	268	1,089
Pulp mills[5]	12	15	22	49
Veneer mills	8	1	17	26
Other mills	35	35	16	86
Total	355	572	323	1,250

[1] Mills persistently sawing 50 mbf or more annually.
[2] Annual lumber production in excess of 5 million bd. ft.
[3] Annual lumber production from 1 million to 5 million bd. ft.
[4] Annual lumber production from 50 thousand to 1 million bd. ft.
[5] Includes flakeboard plants.
* Hackett and Pilon (1993), Table 1, p. 12.
** Hackett and Dahlman (1993), Table 1, p. 13.
*** Hackett and Whipple (1993), Table 1, p. 12.

Table 2.—*Industrial roundwood receipts by type of mill, 1990 (in million cu. ft.)*

Kind of mill	Michigan*		Minnesota**		Wisconsin***		Region	
	S	H	S	H	S	H	S	H
Pulp mills[1]	41.2	173.2	41.1	138.0	72.9	162.8	155.2	474.0
Saw mills	23.3	64.1	14.8	32.5	13.8	84.0	51.9	200.6
Other mills[2]	0.7	6.4	2.5	5.4	2.3	11.7	5.5	23.5
Total	65.2	263.7	56.4	175.9	89.0	258.5	212.6	698.1

[1] Includes flakeboard plants.
[2] Does not include treating plants or fuelwood receipts.
S=softwoods
H=hardwoods
* Hackett and Pilon (1993), Table 2, p. 12.
** Hackett and Dahlman (1993) Table 2, p. 13.
*** Hackett and Whipple (1993), Table 2, p. 12.

Table 3.—*Industrial roundwood receipts per primary wood-using mill by kind of mill, 1990 (million cubic feet per mill) all species*[1]

Kind of mill	Michigan	Minnesota	Wisconsin	Region
Pulp mills	17.87	11.94	10.71	12.84
Saw mills	.36	.09	.36	.23
Other mills[2]	.16	.22	.42	.26
Industry average	.93	.41	1.08	.73

[1] Developed from information in Tables 1 and 2.
[2] Includes veneer mills.

Table 4.—*Estimated number of jobs in the primary wood-using industry of the Lake States, 1990**

Kind of mill	Jobs in sector	Jobs per mill
Pulp mills	49,588	1012.0
Saw mills	8,976	8.2
Other mills**	24,266	150.7
Total	82,830	66.3

* Interpolation of estimates in Table 5, p. 21 of Pedersen, Chappelle and Lothner (1989).
** Includes veneer mills.

Table 5.—*Estimated industrial roundwood receipts per job in primary wood-using mill, all species, Lake States, 1990**

Kind of mill	Million cubic feet
Pulp mills	.0127
Saw mills	.0281
Other mills	.0012
Industry average	.0110

*Using information from Tables 2 and 4.

Table 6.—*Distribution of forest-based direct employment and industrial roundwood receipts in the Lake States, all species, 1990*

SIC	Direct employment*	Roundwood receipts**	Roundwood receipts/job
	# jobs	million cubic feet	
24 & 25	104,364	281.5	0.002697
26	118,636	692.2	.005304
Total	223,000	910.7	.004084

* From Pedersen and Chappelle (1993). Division of SICs 24, 25, and 26 made on the basis of 1990 estimated employment in Pedersen, Chappelle and Lothner (1989). SICs 24 & 25 accounted for 46.8% of jobs and SIC 26, 53.2% of jobs.
** From Table 2 taking Pulpmills for SIC 26 and total of Sawmills and Other mills for SICs 24 and 25.

Table 7.—*Distribution of forest-based direct employment and industrial roundwood receipts in the Lake States, all species, 2000 (assuming 1990 roundwood receipts per job)*

SIC	2000 Direct employment*	1990 Roundwood receipts/jobs**	2000 Estimated roundwood receipts
	# jobs	million cubic feet	
24 & 25	109,512	0.002697	295.35
26	124,488	.005304	660.28
Total	234,000	.004084	955.63***

* From Pedersen and Chappelle (1993). Division of SICs 24, 25, and 26 made on the basis of 1990 estimated employment in Pedersen, Chappelle and Lothner (1989).

** From Table 6, assuming no change in technology (or productivity) from 1990 to 2000.

*** Estimated roundwood receipts for 2000 are 4.9% higher than for 1990.

However, it seems reasonable to assume a 10% decrease in roundwood receipts per job be introduced to account for prospective gains in wood utilization over the period 1990 to 2000. Although no direct evidence for this assumption has been found, this forecast is based on the following indicative points drawn from recent literature:

1. Note the following indexes of output per hour for all employees (national level):*

SIC	Industry	Average annual percent change 1975-1991	Average annual percent change 1985-1991
2421	Sawmills, planing mills	2.6	1.7
2431	Millwork	0.0	2.6
251	Household furniture	1.5	1.6
2611, 21, 31	Pulp, paper & paperboard mills	3.2	2.5

* Source: Table 663, p. 422. U.S. Bureau of the Census. 1993. Statistical Abstract of the United States: 1993 (113th ed.), Washington, DC.

Weighting the above indexes with estimated 1985 jobs in the Lake States (Pedersen *et al.* 1989, p. 21) indicates an average annual industry index of 2.2%.

2. The USDA Forest Service projects softwood lumber per square foot of floor area in residential construction will decline by 24% between 1986 and 2040." (Skog 1993, p. 12). [This implies a rate of decrease of about 4% per year.]

3. The rate at which recycled paper is utilized in making paper in the U.S. (tons of recycled paper input per ton of paper output) has increased from 24% in 1985 to 29% in 1991 and is projected to increase to 41% by 2010." (Skog, 1993, p. 9). [This implies a rate of increase of about 6% per year.]

Pulpwood roundwood and recycled paper use in the U.S. North (from Figure 2, Skog, 1993):

1990	Pulpwood roundwood	1.1 billion cu. ft.
	Recycled paper use	13.4 million tons
2000	Pulpwood roundwood	1.1 x 1.18 = 1.3 billion cu. ft.
	Recycled paper use	13.4 x 1.68 = 22.5 million tons

[This implies a rate of increase of 1.7% per year or 18.2% for 10 years.]

4. "Overall, hardwood lumber use per unit of furniture production is expected to fall over the next 50 years even though use may increase for high value furniture." (Skog, 1993, p. 14).

5. Hardwood lumber use in shipping per unit of manufacturing output is expected to decrease over the next 50 years. Softwood lumber and plywood use are also expected to decline with the rapidly declining use of wooden containers in favor of paper and plastic, and the virtual elimination of wood use for dunnage, blocking, and bracing during transportation." (Skog 1993, p. 15).

6. Expectations are for "Modest growth in recycled paperboard production, but substantial growth in use of recycled fiber in traditionally virgin fiber grades, such as kraft linerboard, semichemical corrugating medium, newsprint, and tissue." (Skog 1993, Table 4).

7. "New technologies being applied in primary processing such as in the softwood lumber segment of the industry have as a side effect lasting elimination of employment in the industry as capital is substituted for labor. In 2040 [for the U.S.], employment in the lumber and wood products portion of the industry will only be 72% of the employment in 1985, despite a 44% increase in lumber production and a 60% increase in production of structural panels." (Haynes, 1990, p. 5). [This implies an increase of about 22% in P/E.]

8. "During the 1980s, most [U.S. forest products] industries experienced reductions in employees and constant dollar value of shipments. The only increases were in the number of employees in the woodpulp industry. The solid-wood industries [lumber and structural panels] were most severely impacted. These declines cannot be completely blamed on the 1982 economic recession. Long-term trends in the primary timber processing industries have been towards larger mills with fewer employees producing goods with increasing real total value and value per employee. These long-term trends are evident in 1986 as total employment remained near the 1982 low, but constant dollar shipments and shipments per employee rose to record levels." (Haynes 1990, p. 67).

9. Nonwood processing costs in the United States by sector and region (1982 dollars).

	1985	1986		2000	
Sector	**South**	**North**	**South**	**North**	**South**
Softwood lumber[1]	89				78
Softwood plywood[2]	82				81
Oriented strandboard & waferboard[3]		90	87	84	84

[1] per thousand board feet. Source: Haynes 1990, Table 82, p. 125.

[2] per thousand sq. ft., 3/8" basis. Source: Haynes 1990, Table 83, p. 125.

[3] per thousand sq. ft., 3/8" basis. Source: Haynes 1990, Table 84, p. 126.

10. Nonwood processing costs at integrated pulp and paper facilities in the United States, by product (Haynes 1990, Table 85, p. 126):

Sector	1986	2000	% Change
	- - - - 1982 dollars per ton - - - -		
Newsprint	363	359	-1.1
Unbleached kraft bd.	177	162	-8.5
Semichemical bd.	206	202	-1.9
Recycled bd.	235	235	0
Solid bleached bd.	460	398	-13.5

11. "Competitive firms in the forest products industry have generally been those that utilize technology in place of labor and raw material as modernization takes place. The historical trend that we expect to continue is increased productivity of labor in new mills that more than offsets increases in employment that might have resulted from higher levels of production. Expected increases in labor productivity are clear when total employment (. . .) is compared to production (. . .)" (Haynes 1990, p. 155).

    For example, for the softwood lumber sector in the South, the production per employee was 0.313 million board feet compared to a projected 0.328 million board feet in 2000, a 4.8% increase (production data from table 97, p. 133 and employment data from table 122, p. 156).

12. Expected production given expected increased solidwood recovery (Haynes 1990, Table 124, pp. 160-163):

    Softwood lumber production (U.S.)
    1986 33,889 million board feet
    2000 39,285 million board feet
    + 15.9 %

    Softwood North harvest
    1986 879 million cu. ft.
    2000 1,142 million cu. ft.
    +29.9%

    Hardwood North Harvest
    1986 3,355 million cu. ft.
    2000 4,091 million cu. ft.
    +21.9 %

13. "Between 1952 and 1976, the residue left unused at mills declined from 13% to 4% and declined to 2% in 1986. By 1986, virtually all roundwood was made into products or converted to energy. The percentage of roundwood and mill residue converted to solid products or delivered to pulpmills increased from 68% to 90% between 1952 and 1976 due to increased sawmill and plywood/veneer mill product recovery, an increased use of mill residue for pulp, [sic] and panels. But the proportion declined to 88% in 1986 partially as a consequence of increased demand for fuelwood" (Haynes 1990, p. 196).

In view of this trend, virtually all productivity gains arise from the substitution of capital for labor rather than increased use of roundwood material. Applying this 10% gain in labor productivity to the information in Table 7 provides Table 8.

Table 8.—*Distribution of forest-based direct employment and industrial roundwood receipts in the Lake States, all species, 2000 (assuming a 10% increase in labor productivity; i.e., a 10% decrease in wood use per direct job)*

SIC	2000 Direct employment*	2000 Roundwood receipts/jobs	2000 Estimated roundwood receipts
	# jobs	- - - - - million cubic feet - - - - -	
24 & 25	109,512	0.002427	265.82
26	124,488	.004774	594.25
Total	234,000	.003676	860.07**

*From Pedersen and Chappelle (1993). Division of SICs 24, 25, and 26 made on the basis of 1990 estimated employment in Pedersen, Chappelle and Lothner (1989).
**Estimated roundwood receipts for 2000 are 5.6% lower than for 1990.

Summary of estimated roundwood receipts:

1990	910.7 million cu. ft.
2000	without labor productivity gains +4.9% (955.63 million cu. ft.)
	with labor productivity gains -5.6% (860.07 million cu. ft.)

I propose that we use the estimated roundwood receipts in Table 8 as the basis of our analysis (i.e., 860 million cu. ft.). This contrasts with an estimated 911 million cu. ft. of roundwood receipts in 1990. Therefore, at this stage of the analysis there appears that there will be an estimated reduction of about 51 million cu. ft. The 860 million cu. ft. represents the estimated total amount of roundwood required for the region's mills to meet final demands (i.e., it appears consistent to employment and income estimates for 2000 by Pedersen and Chappelle).

Note that this estimate disregards roundwood trade into and out of the region. However, as illustrated by the information in Table 9, this assumption does not diverge seriously from the 1990 trend, with the exception of softwood plywood residuals, which is not crucial to our analysis.

It is not likely that we will see a reduction in roundwood receipts in 2000 in the Lake States for a reason mentioned earlier, namely the tightening of timber supplies in other regions, particularly the Pacific Northwest.

The recent Clinton administration plan for the federal forests in the Pacific Northwest indicates a reduction in harvest to one-half of the 1990-1992 level (from 2.4 billion bd. ft. to 1.2 billion bd. ft.), a harvest level that is one quarter of the 1980-1989 level (FEMAT 1993, Figure 16. p. 55).

There is no way to precisely forecast the extent to which deficits in timber supplies will be filled by Lake States forests. The PNW supply is mainly softwoods for solid wood products, whereas the majority of Lake States production is hardwoods for fiber production. Nevertheless, we can expect that continual technological change will permit the substitution of Lake States timber for a certain amount of the PNW timber supply deficit. Also, it is apparent that some of the deficit will be met by Lake States forests because movement of new capacity into the region is anticipated in reaction to the drama in the Pacific Northwest. The upper limit will be set, of course, by the sustained yield level of the region's forests. Perhaps year 2000 is distant enough that we should assume that the sustained yield level will be reached. This means then that we would have a significant increase in roundwood receipts and increased employment, even assuming technological change, as noted above.

Earlier in this report the suggestion was made that roundwood receipts (and hence jobs and income) be allocated to the existing recognized forest products development centers (including those in combination with tourism). If this suggestion is accepted, that means that the areas that would be impacted by increases in employment in the forest products industry would be as follows (from Chappelle, 1994):

Michigan

a. Forest Industry Development Center 1 (FIDC1): Marquette, Delta, Dickinson
b. Forest Industry Development Center 2 (FIDC2): Crawford, Roscommon.
c. Combined Forest Industry/Tourism Development Center (COM): Otsego

Minnesota

a. Forest Industry Development Center 1 (FIDC1): Carlton, Koochiching
b. Forest Industry Development Center 2 (FIDC2): Duluth (city)
c. Combined Forest Industry/Tourism Development Center (COM): Beltrami

Wisconsin

a. Forest Industry Development Center (FIDC): Green Bay (MSA), Outagamie, Winnebago
b. Combined Forest Industry and Tourism Development Center (COM): Oneida

Results from the study by Chappelle (1994) indicates that there is likely to be adequate labor supply to support expansions of the forest products industry in the above areas. Results from Chappelle (1994, Table 4) are listed in Table 10, below, for the forest product development centers in the Lake States.

As shown in Table 12, the percentage distribution of employment within the forest products industry has been fairly stable over the 1980 to 1991 period for Michigan, Minnesota, and Wisconsin. In fact, the distributions for 1991 closely resemble arithmetic means over the period.

There are some important differences between states, however. Employment is more concentrated in the furniture industry in Michigan, whereas Wisconsin has a greater concentration in the paper and allied products sector.

Table 9.—*Percentage distribution of receipts by species group and area of origin to Lake States region[1] 1990[2]*

Origin of material	Type of material							
	Pulpwood roundwood		Pulpwood residuals		Saw logs		Veneer	
	SW[3]	HW[4]	SW	HW	SW	HW	SW	HW
	percentage of total volume							
Lake States Region	100	99.95	55.59	94.78	99.996	99.52	100	95.28
Other U.S.	0	0.00	37.76	4.76	0.004	0.48	0	4.16
Canada	0	0.05	6.64	0.45	0.000	0.00	0	0.57

[1] Includes Michigan, Minnesota and Wisconsin.

[2] Data sources are Hackett and Pilon (1993) for Michigan, Hackett and Dahlmann (1993) for Minnesota, and Hackett and Whipple (1993) for Wisconsin.

[3] SW = softwoods.

[4] HW = hardwoods.

Table 10.—*Arithmetic means and ranges of monthly regional unemployment rates (percent of nonagricultural civilian labor force) in the forest development areas by state, August 1989 through July 1992)**

Type of region	Michigan	Minnesota	Wisconsin
FIDC1	9.0	7.2	4.3
	5.6-12.1	4.9-10.1	3.1-5.5
FIDC2	7.9	5.5	
	5.4-11.9	3.5-7.1	
COM	9.1	6.1	4.7
	5.5-14.3	4.5-8.5	2.7-7.1
STATE	8.4	4.9	4.8
	6.7-11.0	3.9-6.5	3.7-6.9

* Note: The U.S. mean during the study period was 6.3 with a range of 5.0 to 8.1. Source—Chappelle (1994)

Table 11.—*Employment levels in the Lake States forest products industry (SIC 24, 25 wood only, and 26), 1980-1991**

Year	Lake States	Michigan	Minnesota	Wisconsin
1980	150,847	49,301	32,379	69,167
1981	143,413	45,646	30,380	67,387
1982	129,400	39,899	25,674	63,827
1983	128,150	37,899	25,762	64,489
1984	139,090	42,021	28,461	68,608
1985	137,743	41,480	29,052	67,211
1986	140,079	43,314	29,119	67,646
1987	151,121	47,412	31,292	72,417
1988	145,245	43,834	28,602	72,809
1989	158,019	45,502	34,111	78,406
1990	159,138	45,448	34,148	79,542
1991	152,039	43,234	32,661	76,144

* Source: County Business Patterns (data collected on March 12 of each year). A study of the Michigan forest products industry found that CBP undercounted annual employment by about 15%, largely because of failure to count smallest establishments (James *et al.* 1982, pp. 17-18). In this analysis only proportions based on the information in this table will be used.

Table 12.—*Percentage distribution of employment within the forest products industry of the Lake States, 1980-1991*

	Michigan			Minnesota			Wisconsin		
Year|SIC	24*	25**	26***	24*	25**	26***	24*	25**	26***
1980	27.7	26.4	45.9	42.3	6.8	50.9	31.7	8.7	59.6
1981	26.5	26.8	46.7	40.7	6.6	52.7	29.5	8.3	62.2
1982	25.8	23.8	50.4	42.4	7.6	50.0	26.7	7.9	65.3
1983	28.7	18.9	52.5	44.6	7.2	48.2	27.2	7.6	65.1
1984	30.4	19.2	50.4	45.8	7.6	46.6	30.1	8.4	61.5
1985	31.9	18.8	49.3	43.9	7.6	48.5	29.4	8.8	61.8
1986	31.8	18.8	49.3	44.7	9.1	46.2	29.8	8.4	61.8
1987	33.8	18.6	47.6	47.1	8.8	44.1	31.6	9.0	59.3
1988	34.0	19.3	46.7	48.3	10.3	41.4	31.5	10.1	58.4
1989	33.4	22.5	44.1	49.0	8.9	42.1	33.7	10.0	56.3
1990	32.6	22.2	45.2	49.1	8.7	42.2	33.6	9.7	56.7
1991	31.6	20.8	47.5	46.2	7.8	46.0	31.1	9.6	59.2
Arith. mean	30.7	21.3	48.0	45.3	8.1	46.6	30.5	8.9	60.6
Range low	25.8	18.6	44.1	40.7	6.6	41.4	26.7	7.6	56.3
Range high	34.0	26.8	52.5	49.1	10.3	52.7	33.7	10.1	65.3

* Lumber and wood products

** Furniture and fixtures (wood only)

*** Paper and allied products

Source: Derived from County Business Patterns information (data reported for March 12 of each year).

Table 13.—Percentage of Lake States total employment in the forest products industry in the three states (SIC 24, 25 wood only, and 26)*

Year	Michigan	Minnesota	Wisconsin
1980	32.68	21.46	45.85
1981	31.83	21.18	46.98
1982	30.83	19.84	49.32
1983	29.57	20.10	50.32
1984	30.21	20.46	49.33
1985	30.11	21.09	48.79
1986	30.92	20.79	48.29
1987	31.37	20.71	47.92
1988	30.18	19.69	50.13
1989	28.80	21.59	49.62
1990	28.56	21.46	49.98
1991	28.44	21.48	50.08

* Based on data in Table 11.

Based on the time trend shown in Table 13, we will assume that 30% of job changes will occur in Michigan, 20% in Minnesota, and 50% in Wisconsin. As shown in the above table, the percentage distribution of jobs between the three states has been very stable over the past decade. It is assumed that this pattern will continue over the forecast period.

Next, it is necessary to forecast where the job changes will occur within each of the states in the region. As noted earlier, it appears reasonable to assume that the changes will occur in existing centers having their economic base in the forest products industry within each of the states. It is suggested that the regions identified in Chappelle (1994) be used for this purpose (i.e., FIDC and COM regions). The rationalization for this assumption is that agglomeration and disagglomeration (e.g., economies and diseconomies of scale both internal and external to the industry) favor changes in employment occurring in those areas. Because it is believed that economies (and diseconomies) external to the industry are important, it seems reasonable to scale job changes to total civilian labor force size in the areas rather than employment only in the forest products industry. Accordingly, information in Table 14 is used to determine the distribution of job changes within each state.

Table 14.—*Labor market regional employment levels (total civilian labor force), April, 1994*

	CLF	% of state	% of 3-state region
	Michigan*		
FIDC1	58,400	72.18	12.45
FIDC2	12,475	15.42	2.66
COM	10,025	12.39	2.14
Subtotal	80,900		
	Minnesota**		
FIDC1	20,377	26.58	4.34
FIDC2	40,397	52.69	8.61
COM	15,898	20.74	3.39
Subtotal	76,672		
	Wisconsin***		
FIDC	294,736	94.60	62.83
COM	16,818	5.40	3.58
Subtotal	311,554		
Lake States Total	469,126		

* Michigan Employment Security Commission
** Minnesota Labor Market Review
*** U.S. Dept. of Labor-BLS/Wisconsin DILHR-LMI

Table 15.—*Percentage allocation of job changes in the forest products industry to regional labor markets*

Michigan					
FIDC1	0.7218		0.30	=	0.2165
FIDC2	.1542	x	.30	=	.0463
COM	.1239	x	.30	=	.0372
Minnesota					
FIDC1	0.2658	x	0.20	=	0.0532
FIDC2	.5269	x	.20	=	.1054
COM	.2074	x	.20	=	.0415
Wisconsin					
FIDC	0.9460	x	0.50	=	0.4730
COM	.0540	x	.50	=	.0270

Application of the above distribution is straightforward. Say that we expect an increase of 1000 direct jobs in the 3-state region in the future. According to the information in Table 15, the distribution of the jobs will be as follows:

Michigan	
FIDC	1,217
FIDC2	46
COM	37
State total	300
Minnesota	
FIDC1	53
FIDC2	105
COM	42
State total	200
Wisconsin	
FIDC	473
COM	27
State total	500
Regional total	1,000

Pedersen *et al.* (1989) estimated the following selected Type III employment multipliers for forest products sectors in the Lake States (the states of Michigan, Minnesota, and Wisconsin) based on the 1982 IMPLAN data base (Table 3).

Table 16.—*Type III employment multipliers, Lake States, 1982*

Sector	Multiplier	Rank
Sawmills and planing mills	1.619	7
Millwork	1.843	3
Wood & lumber products (including pallets)	1.706	6
Veneer, plywood, structural members	1.753	4
Wood furniture & fixtures (SIC 25 weighted average)	1.750	5
Paper mills	2.072	2
Paperboard containers & boxes	2.164	1

In addition, it was found in this study that the multiplier for wood energy was 1.499, outdoor recreation (including both regional residents and non-residents) 1.567, and recreation (non-residents only) 1.550. All of these are lower than multipliers for forest product sectors. These multipliers were developed by tracing expenditure patterns for the activities involved and dividing total employment effects by direct effects, since such sectors do not exist in the input-output accounting system. Hence, these sectors are not represented as sectors in the IMPLAN data base and model because that data base utilizes national accounts. These multipliers reflect, therefore, transactions involved among linked sectors in the regional economy when economic activities are pursued, given leakages involved (e.g., imported inputs to recreational enterprises).

Employment multipliers can be very useful in evaluating changes in total employment that might be expected if new jobs are created in specific sectors of the regional economy. For example, if a new paperboard container plant is to be constructed that will employ 60 production employees, we might expect that total Lake States employment will increase by about 130 jobs (60 x 2.164 = 129.84). Also, input-output models can be used to indicate the distribution of jobs (e.g., see Diamond and Chappelle 1981). Of course, impacts of the plant construction phase would have to be evaluated separately.

One can see that the demand-driven input-output model can be very useful in quantifying expected impacts of new plant capacity. However, these estimates are developed under the assumption that sufficient inputs of all types are available (at the same relative prices as expressed in the transactions data) to produce all goods and services demanded by the population.

DETERMINING IMPACTS OF RECREATION/ TOURISM INDUSTRY

Determining impacts of the recreation/tourism industry is completed in a fashion similar to that used for the forest products industry. However, analysis for this industry is always more difficult because the federal industrial classification system (SIC) does not explicitly define this industry as a sector or a group of sectors as in the case of the forest products industry.

The first step in allocating jobs indicated in the P&C analysis is to determine the distribution of added jobs in the tourism/recreation industry to various SIC sectors representing tourism expenditures. This can be accomplished by making use of prior work by Pedersen *et al.* (1989). Table 17 indicates the percentage distribution of direct and total employment in the Lake States for 1985.

Table 17.—*Estimated percentage distribution of direct and total employment impacts by sector for outdoor recreation in Lake States forested areas, 1985**

Industry sector	Direct	Total
Food and tobacco products	2.411	4.812
Textiles and apparel	1.337	1.357
Petroleum production	0.701	2.566
Misc. manufacturing	1.799	1.898
Wholesale trade	4.042	4.193
Retail trade	19.610	17.515
Hotels and lodging	32.509	30.910
Misc. services	3.805	3.777
Restaurants and bars	20.294	19.630
Amusement & recreational services	6.827	6.534
Other	6.665	6.807
Total	100.000	100.000

* Source: Derived from Pedersen *et al.* 1989, p. 30.

Since Pedersen and Chappelle (1993) forecasted direct employment in tourism in year 2000 to be 63,000 (an increase of 6,000 jobs), information in Table 17 can be used to derive forecasted distribution of new jobs (Table 18), if we assume no relative changes since 1985. Likewise, total estimated employment of 99,000 (i.e., including 36,000 indirect and induced jobs to the direct, an increase of 4,000 new indirect and induced jobs) can be used to derive tourism/recreation total employment in year 2000. Similarly, the estimated distribution of jobs by sector in year 2000 can be developed (Table 19).

Table 18.—*Estimated distribution of growth in direct (6000) jobs and total (10,000) jobs, 1990 to 2000 in the Lake States tourism/recreation industry*

Industry sector	Direct	Total
Food and tobacco products	145	481
Textiles and apparel	80	136
Petroleum production	42	257
Misc. manufacturing	108	190
Wholesale trade	242	419
Retail trade	1,177	1,751
Hotels and lodging	1,950	3,091
Misc. services	228	378
Restaurants and bars	1,218	1,963
Amusement & recreational services	410	653
Other	400	681
Total	6,000	10,000

Table 19.—*Estimated distribution of direct and total jobs by sector for outdoor recreation in Lake States forested areas, 2000*

Industry sector	Direct	Total
Food and tobacco products	1,519	4,764
Textiles and apparel	842	1,343
Petroleum production	442	2,540
Misc. manufacturing	1,133	1,879
Wholesale trade	2,546	4,151
Retail trade	12,354	17,340
Hotels and lodging	20,481	30,601
Misc. services	2,397	3,739
Restaurants and bars	12,785	19,434
Amusement & recreational services	4,301	6,469
Other	4,199	6,739
Total	63,000	99,000

There is some question as to the output level implied by the above employment levels. It is assumed in the P&C estimates that productivity is unchanged from 1985. The question arises whether some adjustments should be factored into the analysis to account for possible productivity changes from 1985 to 2000. Information on productivity directly appropriate to forest-oriented tourism/recreation is not available. However, national level indexes of output per hour in Table 20 are at least indicative of levels appropriate to our analysis.

Table 20.—*Indexes of output per hour, all employees, national level (average annual percent change)*

SIC	Industry	1975-1991	1985-1991
5311	Department stores	2.8	1.2
5331	Variety stores	-0.5	0.5
54	Food stores	-0.6	-1.0
5541	Gasoline service stations	3.1	0.4
56	Apparel and accessory stores	2.0	-0.3
58	Eating, drinking places	-0.2	1.5
5912	Drug and proprietary stores	1.2	1.2
5921	Liquor stores	0.1	-1.7
7011	Hotels and motels	-0.7	-2.0
753	Automotive repair shops	-0.4	0.1

* Source: Table 663, p. 422, U.S. Bureau of the Census. 1993. Statistical Abstract of the United States: 1993 (113th ed.), Washington, DC.

As can be noted by comparing the last two columns of Table 20, with the exceptions of SIC 58 (eating and drinking places) and SIC 753 (automotive repair shops), output per hour has been level or declining in recent years.

Productivity information for sectors shown in Table 19 could not be found. Instead, the 1985-1991 average annual percent changes in output per hour in Table 20 were weighted by year 2000 direct employment in Table 19 for sectors indicated in Table 21. The average annual change in output per hour for the tourism/recreation industry developed in this way was -0.4%. This implies that for the period 1985-2000, a change of -6% in output per hour might be expected. Therefore, it would be expected that in year 2000, 6% more employees would be needed to meet requirements indicated in the P&C estimates. This is surprising, especially since growth of direct jobs was expected to be only 10% in the P&C analysis. If this drop in productivity is added to the P&C estimate, a total of 16% of new direct jobs would be needed to meet expected demands for tourism/recreation services.

Table 21.—*SICs of industry productivity indexes used in analysis*

Industry sector	SIC
Food and tobacco products	54
Retail trade	5311,5331,5541, 56,5912,5921
Hotels and lodging	7011
Misc. services	753
Restaurants and bars	58

Another consideration is possible changes in consumption in services related to forest-oriented tourism/recreation. Presumably these changes are already reflected in P&C estimates of employment insofar as they were correctly reflected in the final demands used to forecast production levels. It is interesting to note recent forecasts for the most important forest-oriented recreational activities in the North region (the source unfortunately does not separate out individual states or smaller regions). These activities are shown in Table 22 (note: the source includes a total of 33 activities).

Table 22.—*Forecasted year 2000 consumption index of recreation trips away from home, if recent past trends in resource availability continue, North region (1987 = 100)*

Resource category & activity	Percent change from 1987 base
Land	
Wildlife observation	106
Primitive camping	105
Backpacking	125
Nature study	97
Offroad vehicle driving	100
Driving for pleasure	107
Sightseeing	115
Picnicking	105
Developed camping	115
Water	
Canoeing/kayaking	111
Stream/lake swimming	105
Rafting/tubing	116
Rowing/paddling, etc.	107
Snow and ice	
Cross-country skiing	112
Snowmobiling	123

Source: Table 15 (pages 24 -27), English *et al.* (1993).

The most popular outdoor recreation activities in volume of trips consumed in the North region in 1987 are shown in Table 23 (English *et al.* 1993, Table 16, page 27). Unfortunately only six of the activities shown in Table 22 are included.

Table 23.—*Most popular outdoor recreation activities in volume of trips consumed by North region, 1987*

Activity	Rank
Driving for pleasure	1
Sightseeing	2
Walking for pleasure	3
Picnicking	4
Non-pool swimming	5
Motorboating	6
Pool swimming	7

If activities in Table 22 are equally weighted, the mean index is 111 (i.e., indicating an increase of 11% over the 1987 level). If weighted inversely by rank (i.e., the activity ranked first is given a weight of 7), the mean index is 111. It appears that the 10% increase in direct jobs noted in P&C is rather directly related to expected increases in consumption.

In order to proceed in the analysis it is evident that a decision on assumed productivity changes must be made. Note that nearly a third of the direct jobs in year 2000 are likely to be in the Hotels and Lodging industry (Table 19) and this industry experienced a large decline in productivity over the recent past (Table 20). In fact, excepting this industry, the weighted mean productivity would be +0.708 for the period 1985-1991. It would appear, therefore, that the estimate of weighted productivity is very sensitive to assumptions regarding the Hotels and Lodging industry. Note also that productivity loss during the longer period (1975-1991) is only a third of that for the 1985-1991 period. If this industry were to regain its long run level (-0.7) and the others remain constant at the level for the most recent period, the weighted mean productivity for 1985-1991 would be +0.126. That is, if we assume that the Hotels and Lodging industry reverts to its long term level (and all others at their 1985-1991 levels), there would be a productivity gain. Finally, if one takes the longer period (1975-1991) productivity changes as more likely, the weighted mean is +0.017. In view of the productivity situation, it would seem most prudent to assume no productivity change to the year 2000 for the tourism/recreation industry.

Distribution of forest-oriented tourism between the three states within the region is difficult to ascertain from existing information. However, there is some fragmentary information that might help in making reasonable assumptions in this matter. National forest recreation use in 1991 is indicated in Table 24 in terms of visitor-days. Recreation use of state parks and recreation areas in 1991 is shown in Table 25 in terms of visitor numbers. Table 26 indicates 1989 Canadian travel to the three states in the region. Finally, Table 27 provides 1985 information on hunting, fishing and boating.

Table 24.—*National Forest recreation use, 1991*

State	Visitor-days (1000)*	Percentage of regional total
Michigan	8,153	53.20
Minnesota	4,956	32.34
Wisconsin	2,215	14.45
Total	15,324	100.00

* Source: Table 395, page 245. Statistical Abstract of the United States, 1993.

Table 25.—*State parks and recreation areas use, 1991*

State	Visitors (1000)*	Percentage of regional total
Michigan	25,260	55.52
Minnesota	7,981	17.54
Wisconsin	12,252	26.93
Total	45,493	100.00

* Source: Table 397, page 246, Statistical Abstract of the United States, 1993.

Table 26.—*Canadian travel to the region, 1989 (thousands) (percentages shown in parentheses)*

State	Person visits	Person nights	Total spending
Michigan	1,333.3 (67.1)	3,216.2 (66.0)	$126,084.0 (62.8)
Minnesota	456.4 (23.0)	1,182.6 (24.3)	54,749.2 (27.2)
Wisconsin	198.0 (10.0)	471.1 (09.7)	20,092.7 (10.0)

Original Sources: United States Department of Commerce, United States Travel and Tourism Administration. Cited in Thorp and Smith (1991, Table 1, p. 119).

Table 27.—*Hunting, fishing and recreational boats in the region (thousands) (percentages shown in parentheses)*

	Michigan	Minnesota	Wisconsin
Hunting			
Total hunters	943	545	723
	(42.6)	(24.6)	(32.7)
Hunting related expenditures, 1985	$440,311	$216,158	$303,415
	(45.9)	(22.5)	(31.6)
Fishing			
Total anglers	2,444	1,793	1,827
	(40.3)	(29.6)	(30.1)
Fishing related expenditures, 1985	$1,403,429	$778,268	$640,800
	(49.7)	(27.6)	(22.7)
Total Great Lakes anglers	1,300	86	495
	(69.1)	(4.6)	(26.3)
Great Lakes days of fishing	15,430	705	3,260
	(79.6)	(3.6)	(16.8)
Boating			
Total registered boats	788	693	480
U.S. rank	1	3	6

Original sources: U.S. Dept. of the Interior, Fish and Wildlife Service, National Survey of Hunting and Wildlife, Associated Recreation (1985); and National Marine Manufacturers Association, Boating 1989. Cited in Thorp and Smith (1991, Table 2, page 123).

Note: Total anglers, hunters and Great Lakes days of fishing are indicated by state where activity took place. Total expenditure data are indicated for hunters' and anglers' state of residence. Anglers and hunters are 16 years old and older.

For Table 27, if hunting and fishing are aggregated, distribution of participants by states is as follows: Michigan 40.9%, Minnesota 28.2%, and Wisconsin 30.8%. Similarly, hunting and fishing related expenditures are distributed as follows: Michigan 48.7%, Minnesota 26.3%, and Wisconsin 25.0%.

Given the fragmentary information in Tables 24-27, it will be assumed that job growth indicated in the P&C analysis will be distributed to states within the region as follows: Michigan 50%, Minnesota 25%, and Wisconsin 25%.

After determining the number of additional jobs expected in the tourism/recreation industry in the year 2000, it is necessary to distribute them to places within the three-state region. As noted earlier, one possible strategy would be to distribute new jobs to economic base areas within each state recognized in the Chappelle (1994) analysis. Relevant employment data for areas within each state are shown in Table 28. As noted in the forest products industry section above, it seems reasonable to assume that job growth will occur primarily in existing economic base areas within each state, as discussed in Chappelle (1994). These areas in the case of the tourism/recreation industry are the tourism development centers (TDC) and the combined forest products industry-tourism development centers (COM), as noted in Table 28 from Chappelle (1994).

Table 28 for tourism/recreation is comparable to Table 14 for the forest products industry. As before, it seems reasonable to scale job changes to total civilian labor force size in the areas. Accordingly, information in Table 28 is used to determine the distribution of job changes within each state (Table 29).

Application of the above distribution is straightforward. Say that we expect an increase of 6,000 new direct jobs in sectors related to tourism/recreation (as indicated in Pedersen and Chappelle 1993). According to the information in Table 29, distribution of jobs would be as shown in Table 30.

Table 28.—*Labor market regional employment levels (total civilian labor force), April, 1994*

	CLF employed	% of state	% of three state region
		Michigan*	
TDC	71,250	87.66	42.58
COM	10,025	12.33	5.99
Subtotal	81,275	100	48.57
		Minnesota**	
TDC	32,858	67.40	19.64
COM	15,898	32.61	9.50
Subtotal	48,756	100	29.14
		Wisconsin***	
TDC	20,479	54.90	12.24
COM	16,818	45.09	10.05
Subtotal	37,297	100	22.29
Lake States Total	167,328		100.00

* Michigan Employment Security Commission
** Minnesota Labor Market Review
*** U.S. Dept. of Labor - BLS/Wisconsin DILHR-LMI

Table 29.—*Proportional allocation of job changes in the tourism/recreation industry to regional labor markets (decimal)*

State	Proportion of state	x	Proportion of region	=	Proportion of area
			Michigan		
TDC	0.8766	x	0.50	=	0.43830
COM	.1233	x	.50	=	.06165
			Minnesota		
TDC	.6740	x	.25	=	.16850
COM	.3261	x	.25	=	.08152
			Wisconsin		
TDC	.5490	x	.25	=	.13725
COM	.4509	x	.25	=	.11272

Table 30.—*Forecasted distribution of new direct jobs to areas within states*

Economic Base Area	No. of Direct Jobs
Michigan	
TDC	2,630
COM	370
State total	3,000
Minnesota	
TDC	1,011
COM	489
State total	1,500
Wisconsin	
TDC	824
COM	676
State total	1,500
Regional Total	6,000

SUMMARY

Likely economic effects of growth in the tourism and forest products sectors are quite substantial. Specific estimates of increases in employment and income from details of this paper have already been incorporated in simplified form into a draft of the major report for the overall regional resources assessment. Increases range upward to those for the most ambitious altemative future (i.e., unified development effort for tourism and forest products sectors). For this alternative future increases over a 10-year period are estimated to amount to approximately 6% for direct and total employment, 9% for wages and salaries, and slightly over 19% for sales and expenditures in connection with various kinds of enterprises and industries.

Where these effects will primarily occur can be considered first by focusing on a continuation of historic patterns. Some possible or probable departures from historic patterns can then be taken into account to some degree.

Historic patterns in the tourism and forest products sectors in the Lake States reflect two major patterns. One reflects location of human population with Michigan having population about equal to the combined population of Wisconsin and Minnesota. The other reflects location of forest products industry particular pulp and paper disproportionately in Wisconsin (specifically the Fox and Wisconsin River Valleys).

Direct continuation of these patterns would infer the following distribution of economic effects of growth among the three states.

	Growth in tourism employment and income	Growth in forest products employment and income
	- - - - - - - % of total growth - - - - - - -	
Minnesota	25	20
Wisconsin	25	50
Michigan	50	30

This pattern of differences in likely economic effects among the states is probably an exaggeration to some degree. Actual distribution of economic effects seems to a degree likely to be more equal than direct continuation of these historic patterns would suggest. This is for three reasons:

1. Differential growth rates in human population are gradually changing the relationship among the states. Between 1980 and 1990, Minnesota's population increased 7.3%, Wisconsin's about 4%, and Michigan's less than 1%. This differential is likely with time to somewhat affect location of tourism effects in particular.

2. A factor operating in the same direction is the *very* strong link between the very large tourism market in Chicago and environs, and the particularly widespread resort industry in Wisconsin and historic travel patterns linking the two.

3. Growth in forest products industries in the three states during the 1980's was approximately equal when they shared equally in some $4.5 billion in new industrial investment. Minnesota and Michigan appear to be advancing on a path initially forged primarily by Wisconsin. Changes in timber harvests during the 1980's reflect this more rapid advance in the two states, as compared with Wisconsin which started from a higher base. Tabulation below illustrates this pattern (units:million cu. ft.).

	Total removals		Absolute	Percent
	1981	1990	increase	increase
Michigan	231	324	93	40
Wisconsin	270	324	54	20
Minnesota	165	250	85	51

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Geopolitical Events: Some Possible Effects on Resource Sectors in the Lake States

Henry H. Webster[1]

INTRODUCTION

Some remarkably large changes in the world are occurring that perhaps can be called geopolitical for want of any notably better terms. Several may ultimately have effects so large as to indirectly affect the tourism and forest products sectors (as well as much else) in the Lake States and elsewhere.

This is an attempt to identify and evaluate several kinds of such changes. It consists of three or four steps: first to identify several geopolitical events to be considered; second (closely linked to first) to make some brief but hopefully penetrating observations on the nature and background of these events; third to note that evaluation can best distinguish between at least two rather different kinds of effects; and fourth to set down one person's best judgment on likely effects on Lake States resource sectors.

This might be termed an effort in reasonably well-informed speculation. This may be useful. This regional resources assessment will be more useful if vaguely right on effects of geopolitical forces (rather than precisely wrong through neglecting them entirely).

GEOPOLITICAL EVENTS TO BE CONSIDERED

- Political change and contention in several parts of the world on a truly remarkable scale;
- continuing emergence of the Pacific Rim as a center of expanding economic activity and rising stands of living;
- formation of regional trading blocs in several parts of the world with uncertainty as to relationships among these blocs;
- ongoing efforts to harmonize trading relationships between countries at quite different stages of development; and
- renewed and substantial uncertainty concerning energy costs.

SOME OBSERVATIONS CONCERNING THESE EVENTS

Political change and contention on a truly remarkable scale is occurring particularly in eastern and southeastern Europe, and along the southern fringe of the former Soviet Union, areas approaching what was once called Asia Minor as well as the volatile Middle East. (Potential and impending political change in South Africa is very large, but geographically more discrete with little connection to other areas of instability.) The relatively contiguous areas mentioned are areas that were historically contended over for centuries by empires as diverse as the Russian, the Ottoman, the Austrian, and the British. Contentions based on oil resources, including the various Iran, Iraq, and Kuwait wars are more recent. Current Balkan upheavals are essentially a more local rerun with variations of much earlier contention. Instability and flaming nationalism in a place with such a history certainly has potential for large and unforeseen disturbance with wide-ranging effects. (References: Ferdinand Schevill, *A History of the Balkans* and Peter Hopkirk, *The Great Game*.)

Continuing emergence of the Pacific Rim can be viewed as a process of modernization and economic advancement spreading in a series of tiers or ranks. Japan is first; South Korea, Taiwan, and the city-states of Singapore and Houghoug would seem to be a second tier; Malaysia, Thailand, and Indonesia are perhaps a third. One major uncertainty concerns China. Will this huge country finally, and to what extent, overcome the cultural forces/frictions that caused it to rather spectacularly fail to parallel or accompany Japan's course on a path toward modernization? Other uncertainties relate to countries that currently do not seem to fit anywhere on this series of tiers or ranks (except perhaps on a base level below the tiers or ranks). Examples include the Philippines for one set of reasons, Cambodia for another, and Vietnam, for the moment at least.

[1] The author is Project Director, Lake States Regional Forest Resources Assessment, Department of Forest Resources, University of Minnesota, St. Paul, MN.

This tiered process of advance has its cyclical flows and ebbs. That is only to say that it is not a straight-line, unfluctuating, continuous process. A degree of recession in Japan currently is an example of a cyclical ebb. But even in its short-run effects, this ebb may be of more consequence for finance (as in the Tokyo stock exchange) than for the underlying real economy.

In terms of longer-term developments, the tiered pattern of modernization and advancement seems an accurate representation. There may also be some tendency over an extended period for the size of steps between successive tiers to become somewhat less in a partial catching-up process. (That would parallel to a degree historic patterns in North America. A century ago nearly all real societal wealth was north of the Potomac and Ohio Rivers, and east of the Mississippi. It is now more widespread due to this sort of partial catching-up.)

Work by John King Fairbank in *A New History of China*, plus several articles in *The Economist* and *The Atlantic Monthly* (the latter primarily by James Fallows) is very helpful in understanding these matters. One of these articles was a lengthy survey of Japan in The Economist.

Formation of regional trading blocs is occurring in several parts of the world via another flow-and-ebb process. Enlargement of the European Economic Community is one example. Over a period this has involved both broadening to include additional countries, and deepening via removal of additional trade restraints among the core members (including proposals for a common currency). Substantial pulling and hauling following signature of the Maastricht Treaty illustrates flow-and-ebb.

Creation of the North American Free Trade Area is a second example. Its proposed enlargement from Canada and the United States to also include Mexico is a major step attempting to join together economies and societies at very different stages of development. Eventual inclusion of additional Latin American countries has been suggested in a very preliminary sense. Here again there are flows and ebbs as illustrated by experience under the existing agreement linking Canada and the U.S. This agreement has been blamed in some quarters for adverse economic trends caused primarily by entirely different factors. (E.g., high unemployment and considerable loss of industrial jobs in parts of Canada brought on more by extremely stringent monetary policy, and resultant high real interest rates, than by the FTA.) Second, trade disputes between the two countries have not diminished, indeed they may have increased. Having improved dispute settlement arrangements may have made it safer to dispute (by lessening unpredictable consequences of disputes).

Some form of Pacific bloc focusing to some degree and in some form on Japan would also seem an eventual possibility. Perhaps this is more likely to be informal than formal. The history of the Japanese "co-prosperity sphere" of 50 to 60 years ago still makes neighbors nervous. Memories of Asian-on-Asian colonialism seem to endure. But economic links are very considerable, and likely to become more so.

Ongoing efforts to harmonize trading relationships, including those at quite different stages of development, are centered in GATT negotiations. The General Agreement on Tariffs and Trade (GATT) is perhaps more a forum for ongoing negotiations, and an organization for facilitating them, than an agreement at any one point in time. GATT, in concept at least, seeks to foster equitable trading relationships among all countries. Thus it is in some contrast with regional trading blocs. Blocs by their nature have some entities inside and others outside. But it seems at least possible that the two approaches will eventually be brought together. GATT dealing with relationships between regional blocs, that themselves attend to relationships within, would be such a pattern.

GATT negotiations have gone through several rounds of multiple-year negotiations. It seems apparent that a very substantial liberalization of world trade has occurred in the course of these negotiations. This has fostered an expansion of economic activity worldwide. Links between the economies of various countries have become much stronger and more important. One measure specific to the United States illustrates the matter. Over a period of several decades the formerly insular U.S. economy changed so much that the share of economic growth attributable to international trade increased from 4 to 26% (this observation was made by the ambassador of the European Economic Community to the U.S. at a trade conference recently in St. Paul).

This progress, like that in other areas, has not been continuous and without difficulties and costs. The current Uruguay Round illustrates some of the difficulties. This is especially so in terms of arguments over the arrangements under which agricultural commodities are to be exported. Western Europe and the United States each contend—with some justice—that their own practices are justified by their social conditions, and that the other's are not. The so-called CAIRNS Group involving Australia, Canada, Argentina, Brazil, and several other countries is squeezed in the middle in terms of its agricultural exports.[2] Nevertheless, considerable progress is being made. It is progress made as an old phase put it "... steady-by-jerks, like a frog a-walking."

[2] The CAIRNS Group is named after the city in Queensland in northeastern Australia where delegates of these countries first met to discuss these matters.

One significant cost of this increased globalization concerns use of fiscal policy by nations. It has become substantially harder for any given nation to use fiscal policy purposefully and effectively to foster low unemployment, low inflation, and substantial economic growth simultaneously. Rather high unemployment rates nearly worldwide in part reflect this cost (as well as other factors).

Renewed and substantial uncertainty concerning energy costs is reflected in quite different forecasts of future price levels particularly for oil. Periods of potential stress seem to lead to forecasts that simply do not match each other at all. This most recently occurred during the hostilities in the Persian Gulf. Relatively well-reasoned analyses of the possible aftermath suggested either a large decrease or a substantial increase in oil prices. (One such analysis, symptomatic of many others, was reported in the issue of *The New York Times* for February 11, 1991.)

Neither increases nor decreases on the scale foreseen by some of these forecasts have occurred to this point. The triggering event for any large, sustained increase would probably have to be a very large and protracted conflict in some part of the Middle East. (Foregoing references plus Shipler 1986 and Friedman 1989.)

KINDS OF EFFECTS TO BE EVALUATED TO EXTENT FEASIBLE

Possible effects of major geopolitical forces on major resource sectors in the Lake States will be evaluated in two different dimensions. One dimension can be termed growth effects. These are effects that change the size of the overall pie either positively or negatively. An increase or decrease in societal prosperity, with consequent effects on demands for various resource outputs, is a rather obvious but certainly important example.

The other dimension is competitive effects. These are effects that significantly change the position of this resource region as compared with other resource regions. What effect might geopolitical events (notably in Japanese-Russian relations) have on where resource-commodity demands go when displaced by reduced outputs in the U.S. Pacific Northwest? This would be an example of a competitive effect.

SOME POSSIBLE EFFECTS

These possible events (if they in fact occur) could combined in quite a number of different ways. Any claim that a person or persons can actually predict outcome would be a serious exaggeration.

Nevertheless, some glimmerings of possible effects can be noted. There would seem to be four. They are: (1) a potential growth effect that might be a major plus for this region and others; (2) a second potential growth effect that might be a modest plus; (3) a third potential growth effect that could be a substantial minus if two different uncertainties were to interact in a particular way; and (4) a positive competitive effect that may be moderately substantial despite considerable political uncertainty.

Ongoing efforts to harmonize trading relationships. If successful, this may have major growth effect on many sectors at global scale. Perhaps the matter was most succinctly put by the EEC's ambassador to the U.S. at a recent conference in downtown St. Paul. He stated that "The Uruguay Round [of the GATT negotiations] is the most powerful growth-stimulus available." The "if" contains considerable uncertainty at this point but progress is being made as noted earlier.

Formation of regional trading blocs may, by itself, have some growth effect, but only very limited competitive effect. This will be for a simple but important reason pointed out by Ron Aurell and Jaakko Pöyry (1988). They noted that "What is called international trade is mostly intraregional trade. The three big geographical market areas—North America, Western Europe—are largely self-sufficient" in terms of paper (the authors assigned subject). While less true in terms of building products, the primary competitiveness matter is more a matter of continued emergence of the Pacific Rim than of formation regional trading blocs.

The only possible exception in terms of positive competitive effect for the Lake States would be better combination of Canadian and U.S. strengths regarding forest resources in overall Great Lakes region. (Specifics were discussed by the director of this regional resources assessment at a meeting of Central Ontario Section, Canadian Institute of Forestry, and Michigan Society of American Foresters in May 1990. Specifics deal with margin of growth over harvest in U.S. portion of Great Lakes region, Canadian arrangements for financing targeted industries and stabilizing raw material supply for them, stability for U.S. arrangements for managing public land, particularly at state and county levels, and Canadian leadership on improved transportation arrangements for exports from this region [Webster 1991].)

The possible negative growth effect, if it occurred, would involve a notably bad combination of the political and energy cost uncertainties previously discussed. These two uncertainties likely have only small probability of thus interacting directly. But should they do so, effects could be very major. The triggering event, if this were to occur, would very likely be a major Middle East dust-up beyond the scale of events of the past decade.

Should this occur, there would be economic effects squeezing many sectors many places. The tourism and forest products would be among those affected in this overall squeeze. In addition, there might be even more direct effects on human use of forests and related resources. This would occur in some part through a major increase in costs of recreational travel. A probably still greater effect would occur via a major increase in costs of scattered settlement patterns. The costs to both individuals and society of the 50- or 60-mile or more commute to work would be greatly increased. (If long continued, some change in settlement patterns might occur. The process that is creating additional wildland/urban interface would be slowed.)

Probability may be low, but the fact that many of these areas of instability have strong historic links to each other (via the Ottoman Empire and otherwise) is somewhat unsettling.

Continuing emergency of Pacific Rim will substantially increase demand for a wide range of specific forest products. This will occur at some time that there is a major supply contraction from one part of the Pacific Rim (i.e., Pacific Northwest in U.S.). Demand-up, supply-down will obviously cause price increases in a generic sense. More fundamentally, it is likely to improve competitive positions of several other regions including the Lake States. The degree of such improvement for the Lake States depends on the degree of supply response in places far away. Supply response to increasing Pacific Rim demand, by New Zealand and Chile with their maturing radiata pine plantations is a fairly straightforward economic matter, and reasonably certain. (This is part of an emerging region as characterized by Sedjo and Lyon in their analyses of the adequacy of world timber supply.) Degree of response (if any) from Siberia likely depends primarily on a political matter of large scope, and is highly uncertain. Resources are there in apparently large amount—creation of infrastructure to access resource would require very large investment—Japan is likely the only potential source of investment on the necessary scale. Large Japanese investment in Siberia undoubtedly depends on solution of a dispute of nearly 50 years over islands at northern end of Japan. Solution has eluded the efforts of governments led by several different leaders in each country.

CONCLUDING OBSERVATIONS

Attempting to add these observations together is probably all right and somewhat useful if done with sufficient humility and sense of humor. It amounts to adding several maybes together to obtain something. But that said, there is perhaps something of a pattern.

There would appear to be both an overall growth effect and a competitive effect of geopolitical developments that will likely work to the benefit of resource sectors in the Lake States. Thus geopolitical developments beyond North America may further reenforce the effects of some matters within North America (as analyzed by Perry Hagenstein in study elements 4.3).

The major uncertainty relates to a possible adverse interaction or intersection between political uncertainty and energy-cost uncertainty centering in the Middle East. Probability may be low, but uncertain. With a major and lengthy blow-up this could throw many things into reverse in a major way.

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Institutions for Managing Lake States Forests

Henry H. Webster[1]

INTRODUCTION

This is a moderately brief discussion of a rather large topic, namely institutions for managing Lake States forests. It is, first, an attempt to describe the major categories of individuals and organizations that own and manage forests in the region. Then an attempt is made to appraise the adequacy of these institutions in a fairly simple, but potentially useful, sense. Finally, there is an effort to identify some areas affecting many organizations where some degree of institutional improvement may be both possible and useful.

Who manages forests and is obviously influenced by landownership patterns. A look at such patterns is, therefore, a logical starting point. Discussion, in turn, of each of the four primary forest ownership categories follows: nonindustrial private forests and their owners; industrial forests; state- and county-managed public forests; and federally-managed public forests. (Note that nonindustrial private forests and state- and county-managed public forests, taken together, constitute 80 percent of the forest land in the Lake States.) Several types of organizations that influence management of forest resources are then discussed in categories that simplify greatly for sake of pattern.

Adequacy of institutions in a collective sense is appraised in relation to sustainable development. This appraisal uses criteria adapted from a recent book titled *Managing the World's Forests*, by authors associated with the World Bank.

All the foregoing material is then drawn on to suggest several possible institutional improvements.

LANDOWNERSHIP PATTERNS, A FACTOR INFLUENCING INSTITUTIONS

Patterns of forest landownership in the Lake States can be examined using a single, consistent data source. That source is forest inventory and analysis (FIA) carried out for the Lake States and for a number of additional states west and south by the North Central Forest Experiment Station. The specific data source is Lake States forest resource: Forest inventory and analysis work tables (1992). Data on many aspects of Lake States forest resources have been pulled together there from inventories for individual states at various dates over a 40-year period. Estimates of forest ownership by major categories are shown for the Lake States as a whole, and for individual states, from 1952 to 1992, with four intermediate dates: 1962, 1970, 1977, and 1987 (ownership data is presented in table A-2).

The total area of forest land in the Lake States is approximately 50.5 million acres (18.3 in Michigan, 16.7 in Minnesota, and 15.5 in Wisconsin). This area has been essentially stable during the last 15 years. Earlier there was a decrease of slightly over 4.5 million acres during the 25 years from early 1950s to mid-1970s. A major part of this decrease was associated with expansion of agricultural land, particularly at the prairie edge. This is mirrored by the fact that nearly 60% of the decrease occurred in Minnesota where the forested portion of the Lake States meets the prairies of the Great Plains. About half of the decrease occurred in the early 1970s, an era of substantial efforts to expand grain production at a time of substantial apparent world food shortage.

Of this 50.5 million acres, 47.1 million acres have sufficient inherent productivity to be considered productive forest land (growth of 20 or more cubic feet per acre per year). It is also not in legal or administrative classifications that severely restrict forms of resource management allowed (e.g., timber harvest). The other 3.4 million acres do not meet one or the other of these criteria.

Two million acres are labelled "reserved forest land," and are subject to legal and administrative classifications just noted. Two of the largest examples are Voyageurs National Park and the Boundary Waters Canoe Area Wilderness. Another 1.4 million acres are labelled "other forest land," predominantly for reasons of very low inherent productivity. A good bit of this latter land has considerable usefulness as wetland. A substantial amount of it is in public ownership via either reversion from private ownership for failure to pay real estate taxes, or simply having never been in private ownership.

[1] The author is Project Director, Lake States Regional Forest Resources Assessment, Department of Forest Resources, University of Minnesota, St. Paul, MN.

This 3.4 million acres is located rather unequally among the Lake States. A bit over 1.9 million acres are in Minnesota, a figure approaching 0.9 million acres are in Michigan, with slightly less than 0.6 million acres in Wisconsin.

Our attention can now turn to the 47.1 million acres of productive forest land. Table 1 gives acreage figures in somewhat simplified form for 1992. Discussion of ownership patterns that follows is based on these figures, and on close examination of trends in them since 1952. (Acreage figures for the previous five observation dates are not reproduced here for reasons of space. They will, however, be sent to any readers who wish to see them, and do not have ready access to the volume of FIA work tables.)

Several observations concerning current ownership of forest land in the Lake States are readily apparent:

- nonindustrial private owners hold substantially more forest land than owners in any other category;

- states and counties hold the next largest amount (approximately half that held by nonindustrial private owners). As noted earlier, these two categories together constitute 80% of all forest land in the region.

- A large amount of state- and county-managed public forest land is a feature that makes the region considerably different than many parts of the country. The only regions partially similar in this regard are the region composed of Oregon, Washington, and Alaska; and another part of the Great Lakes region, namely Pennsylvania and New York. The extent of the matter can be best illustrated with calculations from forest survey data of some time ago. They show that a bit over 6% of all productive forest land in the United States is owned and managed by states and counties. Twenty-one of 30 million acres of state and county owned and managed forest land is in 20 northeastern states. Some 17 million of these 21 million acres are in five states: Minnesota, Wisconsin, Michigan, Pennsylvania, and New York with 12.6 million in the three Lake States alone. The remainder of the 30 million acres is concentrated to significant extent in Oregon, Washington, and Alaska (particularly the latter two). More recent shifts in land ownership in Alaska from federal to state and native control have doubtless affected specific numbers—increasing the total of state and county public land, for example. But the regional pattern has remained substantially the same (Webster 1988). Abandonment of land relatively poor for agricultural purposes during first the agricultural depression of the 1920s, and general depression of the 1930s, is a core reason for these large acreages of state- and county-managed public forests.

- Federally-managed land in national forests is the third largest category. It is appreciably smaller being somewhat less than half the area of state- and county-managed land, and being approximately 22% as large as the aggregate holdings of nonindustrial private forest owners.

- Firms in the forest products industries own and manage a bit less than 4 million acres (specifically 3.9). These areas represent one important trend occurring over the past 40 years.

Table 1.—*Forest landownership in the Lake States, 1992*

(In millions of acres)

	Lake States Region	Minnesota	Wisconsin	Michigan
Total	47.1	14.8	14.9	17.4
Nonindustrial private	25.2	6.4	9.5	9.3
Industry	3.9	0.75	1.2	2.0
State and county	12.5	5.8	3.0	3.8
Federal	5.5	1.8	1.25	2.4

Note: All land included in this table is capable of growing 20 cubic feet or more per acre per year, and is not in a category where harvest is barred by statue, administrative regulation, or designation.

Ownership trends over the past 40 years can be usefully summarized in five dimensions:

1. While the total area of productive forest land has decreased somewhat over 40 years (though essentially stable during the past 15 years), the aggregate area owned and managed by forest products industries has increased appreciably. Absolute increase has amounted to nearly 860 thousand acres, which is a 28% increase in proportionate terms. This increase took place from early 1950s to 1970 with some reversal during the 1970s and with essential stability since.

2. Aggregate acreages in other ownership categories decreased somewhat over 40 years. In each case, decrease occurred primarily from early 1950s to late 1970s, with stability or modest increase from the latter date onward.

3. A decrease of 16% over 40 years in aggregate acreage held by nonindustrial private owners is likely a result of two factors. The first is fluctuations in the margin between agricultural land and forest land (a back and forth process that by specific choice of dates, 1952 and 1992, may have shown a particularly sizeable decrease). The second factor is conversion of some amount of forest land to urban uses.

4. A decrease of 8% over 40 years in federally-managed productive forest land would appear to result largely from assignment of national forest land to land use categories where timber harvest is prescribed. Enlargement of the Boundary Waters Canoe Area Wilderness, and creation of Voyageurs National Park, may have been the major element. The fact that federally-managed productive forest land decreased substantially more in Minnesota than in Wisconsin, or in Michigan (where it remained essentially stable) would seem to mirror this explanation of overall change.

5. A decrease of 12% in state- and county-managed production forest land has less apparent explanation. A minor element may have been a state equivalent of federal land use reservations discussed in the preceding item. Another, larger element may be transfer to private ownership of areas of previously county owned and managed land in Minnesota. Eighty percent of the regional reduction in state- and county-managed land occurred in this one state.

The three Lake States share many common characteristics, including primary landownership patterns. There is also some more detailed variation within overall patterns.

- the predominant importance of nonindustrial private forests decreases somewhat from Wisconsin (64%), to Michigan (53%), to Minnesota (43%). The region as a whole matches the middle figure (53%). Minnesota is the only state of 20 in the northeastern part of the country where nonindustrial private owners do not hold half or more of the productive forest land. (Public land ownership in three combined categories—state, county, and federal—is somewhat greater proportionally in Minnesota than in the other states.)

- Ownership and management of forest land by states and counties differs appreciably among the three states. Constitutional differences among the states in terms of the level of government to which tax delinquent agricultural land reverted is at the core of this matter. Wisconsin and Michigan illustrate the matter most neatly. In Wisconsin, tax reverted land went to counties, giving it the largest county forest system in any state. In Michigan, tax reverted land went to the state, giving it the largest directly managed state forest system in the contiguous 48 states. The situation is more mixed in Minnesota for a variety of historic reasons. As a result, Minnesota has the largest amount of combined state- and county-managed forest land in the contiguous 48 states. Working relationships between state and county agencies concerning management of forest resources also appear most settled, stable, and harmonious in Wisconsin.

- Forest ownership by forest products industries is proportionately a somewhat greater factor in Michigan (11.5%) than in the other two states; Wisconsin (8%) and Minnesota (5%). Federally-managed national forests are proportionately a modestly larger share of the total in both Michigan and Minnesota, than in Wisconsin (14, 12, and 8%, respectively).

NONINDUSTRIAL PRIVATE FORESTS AND THEIR OWNERS: MANY GOALS AND ROLES

Nonindustrial private forests and their owners in the Lake States can be best examined by first considering some characteristics of these forests themselves.

Nonindustrial private forests are the smallest ownership class individually, the largest in aggregate. Individual ownerships range from just a few acres to multiple hundreds of acres, and in a small number of cases to thousands of acres (maximum 5,000). Owners of the total of 25.2 million acres in the Lake States number in the multiple hundreds of thousands.

Numbers of owners is much reduced as we focus on properties larger than an arbitrary threshold. This is illustrated by readily available data for one of the states (specifically Michigan). Some 380 thousand owners hold the 9.3 million acres of nonindustrial private forests. Some 363 thousand of them own tracts of less than 100

acres. Just 16.7 thousand of them with 100 acres or more, in aggregate own an acreage of forest equal (by odd statistical quirk) to that of the state forest system, the largest in the contiguous 48 states. They own 3.8 million acres. This amounts to an average of slightly under 230 acres per 100+ acre property. This is well beyond known diseconomies of small-scale for principal resource management activities. This same pattern occurs in the other two states also, although the numbers obviously are not identical.

Nonindustrial private forests characteristically have higher average inherent productivity than publicly owned and managed forests for a very simple historic reason. Much public land became such by being only very poor farmland and subsequently going through reversion to public owners for failure of private owners to pay real estate taxes. Much nonindustrial private forest land stayed on the tax rolls, in part via inherent productivity high enough to earn its keep in agriculture and other uses.

Next, let us consider some characteristics of owners of these forests. Owners of these forests have historically been older and poorer than averages for U.S. population. Quite recently, partial information suggests this pattern may be changing. This information seems to show that an increasing acreage of these forests is being shifted into ownership of people both younger and with higher incomes than the previous owners. This may be one result of ongoing shifts from ownership by farmers to ownership by essentially urban people (broadly defined). In some modest number of cases, this shift may be among different generations of the same family.

Owners of these forests acquired and hold them for a wide range of purposes. In many cases, these purposes cut across, rather than match, conventionally-defined outputs of goods and services that come from forest land. For example, there is reason to think that direct personal satisfaction from ownership is a significant factor toward the lower end of the acreage size-range. Similarly, there is reason to think that a role in individual or family financial estate building is a significant factor toward the upper end.

There would also seem to be another important matter that differs diametrically at the two ends of the acreage size-range. It concerns fragmentation and consolidation of nonindustrial private forests. A considerable amount of fragmentation seems to be occurring toward the lower end (e.g., below the 100 acre threshold). At the same time, appreciable consolidation has occurred during some periods toward the upper end (Yoho 1983).

Some aspects of performance by these forests and their owners are apparent from both experience and analysis. These forests frequently provide more than their proportionate share of important outputs from forests. A broadly-applicable example taken from one state (again, Michigan) is illustrative. Just a bit over half of the productive forest land in that state is in nonindustrial private forests. Two-thirds of total timber harvest comes from these forests. (Note: correspondence of this fact to "... higher average inherent productivity..." mentioned previously.)

Detailed analysis elsewhere in this overall project shows that a high proportion of physical resource inventory on these forests comes on the market (Kingsley 1991). This seems to occur irrespective of the stated reasons of owners for acquiring and holding the land. Having mature forest, and being offered reasonable prices, are keys. The same analysis notes that readily available and effectively integrated assistance and incentives to owners is crucial if effective resource management—beyond timber harvest—is to be widely practiced. Both of these points have been confirmed numerous times by other analysts in several parts of the country (e.g., Fesco *et al.* 1982, Kaiser and Royer 1983, Kaiser 1985).

Assistance and incentives are available via a considerable network of organizations at several levels of government and in the private sector. Coordination/integration concerning who does what, and how the pieces fit together, is characteristically provided by one or a series of interorganization agreements. A body chaired by the state forester characteristically oversees these efforts. Thus, assistance and incentives are available, and are effectively coordinated/integrated at large-scale and at conceptual level. Having enough skilled people to do the job, and achieving integration on the ground, in many particular places are more real issues.

INDUSTRIAL FORESTS: INSURANCE POLICY AND EVOLVING ASSETS

Forests owned and managed by firms in the forest products industries (while the smallest in aggregate of the four major ownership classes) are the one that has increased in size over the past 40 years by some 860 thousand acres. It seems likely that land acquisitions by two major pulp and paper firms with major plants in the Wisconsin/Michigan boundary area are a major element in this increase. Both have taken a quite active approach to land acquisition and management.

Industrial ownership and management of forest land rests on several interrelated but differing motives. The mix of these motives may differ considerably from one firm to

another. A first motive at a rather basic level is essentially an insurance policy for raw material for the firm's processing facilities. When raw material supplies from land in other ownerships are tight or unavailable, for whatever reason, the firm's own land can be drawn upon for an increasing share. Firms often differ, one from another, in the amount of such insurance they chose to obtain (by holding progressively more land). The range is perhaps from essentially none, up to approximately one-third of normal raw material requirements.

A second motive is a variant of the first, involving ability to soften the impact of increased prices on raw material purchased (directly or indirectly) from other major landownership categories. This again amounts to increased reliance on company-owned land during periods when prices for purchase from nonindustrial private forests, or publicly owned and managed forests, are unusually high for whatever reason. Thus, an asset normally supplying say, 15 to 20% of raw material may be able to moderate the impact of price increases on the other 80 to 85% of usual supply.

Third, company-owned lands may be a profit center in its own right, growing where favorable conditions exist high value raw material that goes to processing plants other than those in the firm's own core business. In some cases, these may be a separate division of the firm involved in this (as in a division dealing predominately with saw logs and veneer logs in one of the two major pulp and paper firms mentioned above). Finally, company-owned lands may provide opportunity for the firm to publicly demonstrate in very visible form its concern for effective and sustainable management of the resource on which it ultimately depends.

Industrially owned and managed forests have strong potential for clear goals, and for technically effective management to reach those goals. This will occur (obviously) to greatest degree in a well-organized, competent, and competently led firm (with actual results varying a good bit from one firm to another).[2] But potential is there, given that firms answer to relatively unified direction and relatively clear overall purposes. This is some contrast to the conflicting publics and conflicting overall purposes that are affecting particular public agencies to varying, and possibly increasing, degree.

[2] Absence of excessive pressure of debt repayments is also an important condition. Mergers that resemble leveraged buyouts have created excessive pressure of debt repayment for some firms in some parts of the country. Fortunately, there seems to be few or none such situations directly affecting the Lake States.

Particular firms also may have ability to demonstrate new methods of resource management in a publicly useful way. A single example may help illustrate this. One of the major pulp and paper firms previously referred to is directly involved with a national environmental organization in a special project. This project is intended to demonstrate practical methods for protecting biological diversity of forests in the western Lake Superior basin while managing them for pragmatic purposes.

STATE- AND COUNTY-MANAGED PUBLIC FORESTS: A DISTINCTIVE FEATURE OF THE LAKE STATES

State- and county-managed public forests are a distinctive feature of the Lake States. They have their primary origins in agriculture land abandonment during the 1920s and 1930s. And which levels of government have predominant ownership and primary responsibility for resource management differs systematically among the three states for constitutional reasons, as previously discussed. State- and county-managed forests are managed overall for multiple outputs of goods, services, and conditions valued for their own sake. This is multiple use management in a large pattern sense. There is some tendency for commodity outputs to be emphasized more strongly the closer to local level management is located. This is perhaps most clearly and significantly the case in the Lake States with large amounts of both state- and county-managed forests, namely Minnesota; somewhat less clearly so in the other two states, where it's one or the other level of government that manages by far the largest system. (The principle of "more emphasis on commodities closest to local" also contrasts both state- and county-managed forests with federally-managed forests.) The link to economic values and development is for some reason much more apparent at state and county levels than at the national level where many people apparently see virtually no link.

State- and county-managed public forest at times have an apparent strategic role in state and in-state regional economic development efforts. This is in addition to these other roles and values. This apparent strategic role can be specifically illustrated via events in Michigan during the past 12 to 14 years. Much the same pattern of events is thought to have also occurred in Wisconsin and Minnesota.

In Michigan, part of the Governor's Target Industry Program was a deliberate effort by two successive governors of opposing political parties to foster expansion of forest products industries as part of a comprehensive initiative to diversify a vulnerable, recession-prone economy. Forest products expansion during the 1980s

did, in fact, contribute to a diversified state economy. During the first two-thirds of the 1980s, national firms invested $1.5 billion in new and expanded plants in Michigan. (This was Michigan's share of a regional expansion that affected each of the Lake States in essentially equal measure. More recent expansions of pulp and paper facilities at both Cloquet and International Falls in Minnesota are a continuing aspect of this regional expansion.) Due to this and other efforts, the Michigan economy became 25% less dependent on the automobile industry.

A pattern emerged during this time. In the first few years, state forests were a particularly important source of raw materials for adjacent new plants. State forests regularly offered professionally prepared timber sales under straightforward terms, making them relatively easy sources of raw material for any firm willing to pay prices established through competitive bidding. As a new plant's procurement organization matured, a partial shift to timber from nonindustrial private forest (NIPF) owners usually occurred. The state forests could then provide the initial supply for another new or expanded plant. This strategy enabled the state to supply raw materials several times at critical points. It cannot be proven that this role for state-managed public land led directly to plant locations. However, questions asked of the state forester by a major national firm in the process of locating an oriented strandboard plant at Grayling certainly indicated a positive effect. The state forester was asked three questions:

1. What are your future intentions concerning state forest timber sales?
2. What are your future intentions concerning silvicultural management on state forests?
3. What are your future intentions concerning assistance and incentives to NIPF owners?

Assured that the state forest system would grow and sell its proportionate share of the total timber supply, and that the state would support NIPF owners to the best of its ability, the firm located in Grayling.

Significant efforts to improve and strengthen management of state- and county-managed land have been made in each of the three states during the past two decades or thereabouts. Over that period, Minnesota markedly raised the professional level of resource managers in its forest resources agency. Wisconsin developed further a pattern of strong state assistance to counties in management of county-managed public forests (a pattern further discussed below). And Michigan undertook two interrelated initiatives to improve management of its state forest system. The first involved improved management planning for state forests that focussed on partial separation of uses and users to the degree necessary to reduce unnecessary conflict. This amounted to an application of important suggestions made earlier at national level by Marion Clawson (1974, 1975). The second initiative is designed to create a more adequate, and explicitly investment-oriented, funding arrangement for management of that part of the state forest system where intensive vegetation management is the designated "key value," or primary purpose. This arrangement will involve sale of state revenue bonds with the proceeds invested in more intensive management of very carefully selected parts of the system, and future repayment from increased receipts from sale of more and better timber. The two initiatives are linked in that management planning helps determine where to invest. They are also linked in that investment in more intensive management in particular places will grow the state forest system's share of total timber supply on fewer acres than otherwise needed. More area can thus be assigned to other "key values," specifically developed forms of recreation and naturalistic values.

Links between state and county management of forests are valuable. It seems apparent that county management of forests can be aided quite sustainably by state assistance in terms of both technical matters and funding. The major example is in Wisconsin. The forest resources agency in Wisconsin Department of Natural Resources works directly with counties, supplying technical expertise and a portion of the funding for resource management. The forest resources agency also guides adjacent counties toward reasonably similar resource management policies and some related matters. Leading members of the forest resources agency regularly take part in meetings of the Association of County Forest Administrators at invitation of its officers. The issue in Michigan is of such scale (only one county manages a significant area of forest land) that it can be successfully treated as an exception requiring no general widely-applicable arrangements. Arrangements for positive state/county interaction appear less than fully settled in Minnesota. A recent lawsuit by particular counties against the state concerning certain specifics of sharing of revenues is perhaps illustrative. It would seem that (whatever present or past reasons for difficulties) it is particularly important to achieve fully-settled arrangements in a place where both state- and county-managed forests are very extensive and important. It seems quite possible (indeed perhaps quite likely) that management will be improved—via strengthened state aid to counties. Clarity of arrangements in any of several possible patterns will help a lot in working together.

FEDERALLY-MANAGED PUBLIC FORESTS: NATIONAL ASSETS WITH ATTACHED CONTROVERSIES

There are seven national forests in the Lake States. They comprise slightly under 12% of productive forest land in the region (14, 12, and 8% in individual states).

Origins of these national forests lies partially in deliberate acquisition under the Weeks Law which authorized land acquisition for creation of national forests east of the Great Plains. Origins also lie partially in something resembling a more guided version of the land abandonment process that created state- and county-managed public forests. This amounted to purposeful acquisition by purchase in 1930s of farms and associated land that seemed unlikely to provide a decent family living. This in effect anticipated eventual abandonment. It was tied, at least in concept, to efforts of Farm Resettlement Administration, Wisconsin rural zoning, and Michigan land economic survey. All of these efforts sought to shift settlement from places not affording a decent living to those where prospects were significantly better.

Management goals for federally-managed public forests are of several kinds. They are managed overall for multiple outputs of goods, services, conditions sought from forests in same overall sense as other public forests. Management is influenced to considerable degree by legislation applying only to federally-managed land, e.g., Wilderness Act, National Forest Management Act. The latter act specified a legally mandated planning process of substantial complexity. It also specifies (or at least provides) numerous opportunities for participation by public/citizen groups.

One form, when others do not achieve agreement, is participation by lawsuit. Such participation that has been used with some considerable frequency in various parts of the country. The legal issue is frequently related to specified procedures called for in NFMA. Substance is often disagreement concerning management direction and emphasis.

It seems apparent that management trends on federally-managed public forests are away from commodity outputs and toward recreation and natural conditions. The extent of parts of this trend is illustrated at national level by a drop in national forest timber sales from 11.9 billion board feet in 1989 to 7.3 billion board feet in 1992. At the same time, officially accounted for net revenues fell from approximately $796 million to approximately $255 million (Public Land Review, March 18, 1993). (These specific figures at national level heavily reflect events of very major size in the Pacific Northwest. As such, they exaggerate downward trends, as compared with other regions, including the Lake States. But basic direction is the same—although degree is considerably different from one region to another.)

The Forest Service has historically been the lead agency for all of U.S. forest resource management and protection. A great deal of its activity over decades served as a model for states and other entities, both public and private. In part, this role as model was simply by example. In another major part, it was by aid (both technical and financial) to states and other entities. As historian William G. Robbins (1985) put it, "... [cooperative efforts and support of state activities came to encompass] virtually every arena of interest to forest owners and industrial processors."

All principal branches of the Forest Service took part in this role as model. The state and private forestry branch was and is the direct link for most technical and funding assistance to states and other entities. The research branch provides much essential information of many types. Management of national forests long provided a useful model by example. Being frequently better staffed and equipped than state and county forest management agencies, national forests provided a model or goal or target of aspiration.

This pattern of model by example for national forests has in the past decade been a good bit obscured. Controversies appear to attach to national forests almost nationwide, that may or may not have strong connection to particular locations. Two from many possible examples may be usefully illustrative.

To my understanding, people in one northeastern state some time ago arrived at relatively good agreement on how a particular national forest was to be managed. This agreement was then blown apart by national interest groups who transferred to this state an ongoing argument among themselves. Signs of this tendency can be observed at times in the Lake States (although we fortunately have not to this point had an incident in such striking and consensus-breaking form. The specific state was New Hampshire, the national forest the White Mountain, source Allen and Gould 1986).

The so-called below cost timber sales issue would seem to be legitimately a primarily Rocky Mountain issue—this rooted in very steep slopes and consequently very high costs. This issue is, however, being transferred to many other regions, including the Lake States. An accounting system that allows comparisons of timber revenues with aggregate costs for many outputs appears to have a role in this. Very complex procedures rooted substantially in the NFMA may also have a role. In comparison, several states and counties have disaggregated costs in a way that permitted comparing timber sale

receipts directly with costs of these sales. The effects have generally been to demonstrate substantial net resources, and to essentially end discussion of below cost timber sales.

In conclusion, the historic leadership role of the Forest Service continues in some dimensions, much less so in others. This is due to essentially national controversies attaching to national forests despite best efforts of their managers to focus on matters more germane to their particular situation.

RELATED INSTITUTIONS THAT INFLUENCE RESOURCE MANAGEMENT

The people and organizations that directly own and manage the forest resources of the Lake States are influenced in a variety of ways by many other organizations and groups. There are too many and too varied (including variation from one state to another) to describe them all. This section is an attempt at deliberately simplified description for the purpose of bringing out major patterns.

The roles of the upper reaches of executive and legislative branches at several levels of government is a first, obvious source of influence. Roles of these branches at both state and federal levels have been described essentially until the cows come home. Hence, these roles, important as they are, can be left at that. County boards of supervisors often combine executive and legislative roles in one body at more nearly local level.

Our real topic is the several kinds of institutions that influence management of forest resources from vantage points in essence between the owners and managers, and the general policy level of governments. Following is one simplified way to characterize and illustrate these institutions. (Illustrations are deliberately selective, and in no way whatsoever comprehensive. In addition to not trying to enumerate every kind of organization, some illustrations taken from one or another of the three states are deliberately not repeated from the other two for sake of brevity.)

Four major kinds of institutions fitting here influence resource management in a considerable way. The first is interagency alliances for economic and community development, particularly at state level. One form of such alliances is direct joint work by the business development unit, and the forest resources unit, of the governments of each of the three states. This goes beyond coordination. While the units are in different departments, individuals in both frequently work together so jointly and closely as to resemble a single unit in themselves. Principal efforts commonly include: packaging for in-state regions information needed by forest products firms for informed plant location decisions; systematic efforts to call this information to attention of firms at national and international levels; direct work with firms expressing interest; and advice to communities as kinds of plants that might constitute realistic possibilities for development efforts by particular communities. (This latter is based on both characteristics of particular industry sectors, and assets of particular communities.)

These kinds of efforts in each of the three states have been strongly associated with the substantial expansion of forest products industries that has occurred in the Lake States since 1980. These expansions have led to a considerable increase in amount of timber harvested—and have by that means influenced resource management.

The governor's cabinet council for jobs and economic development in one of the three states, Michigan, was a higher level, and more encompassing example of such an alliance. A primary role in relation to forest resources and industries was to encourage joint work of the sort just described.

Quasi-governmental organizations that foster effective resource management and use at several geographic scales are a second type. These are organizations attached in a variety of ways to various levels of government, and consisting of appointed citizens (civilians), not agency members. They characteristically help chart sense of direction and encourage efforts by many organizations to effectively pursue that direction. The Wisconsin Council on Forest Productivity is an example. Appointed by the governor, the council has helped substantially to foster the state's efforts toward effective management and use of its forest resources.

Resource conservation and development units (RC and D) have historically played a useful role at both state and more nearly local levels in Michigan. At multicounty local level, individual RC and D units are frequently the most effective voice for well-considered community development efforts. The state council of RC and D units is one of the most effective voices for such efforts statewide outside the major cities. (RC and D units are fostered in an organizational sense by the Soil Conservation Service, with support by the Forest Service in forest resource matters.)

The Arrowhead Regional Development Commission in Minnesota was an early example of efforts toward effective resource management and use in a multicounty sense. Indeed, its efforts to package information needed by forest products firms for effective plant location

decisions were in a sense important regionwide. For example, its efforts served as a model for at least one of the other states at very early stages of that state's work just described under interagency alliances. (Insert re sponsorship of Arrowhead Regional Development Commission.)

Advocacy groups of several different persuasions are a third type. Citizen environmental organizations, industrial groups, and sportsmen's groups are three examples of advocacy groups. All attempt to influence management of forest resources in a variety of ways. (These are just three of an enormous number of advocacy groups in U.S. society, a society that has organized interest groups on virtually every side of every issue.)

Attempts to characterize the principal positions and influence of these three kinds of groups are inherently difficult, and not particularly valuable. Each consists of numerous individual organizations that differ from one another.

Within this sort of broad variation, citizen environmental groups generally favor very cautious resource management and naturalistic values, and at best a modest level of resource commodity outputs. Industrial groups are characteristically concerned about a wide range of diverse public policies and other factors influencing their members' business prospects. Resource industry groups quite naturally favor a substantial level of resource commodity outputs. Sportsmen's groups are characteristically most concerned about factors influencing populations, habitats, and regulations affecting their particular favored line of activity. Specific to forest resources, they often favor rather vigorous forms of vegetation management that create favored habitat for a considerable range of game species.

There also is (to a degree) a difference between reasonably local interactions among advocacy groups, and national interactions. It has been observed that at local (and in some cases, state) levels advocacy groups of differing persuasions can often find ways to get along amicably, and reach reasonable compromise or consensus. This is considerably more easily done (if not exactly easy) than is the case at national level. It appears that getting along with reasonably close neighbors, or agreeing to amicably disagree, is one thing. Matches in which national groups shout past each other are another. Resource matters in the Pacific Northwest, where personal intervention by the president of the United States is apparently necessary, is the extreme end of the scale.

A fourth type consists of organizations and activities that attempt to form consensus among diverse interests, and across the region. A 5-foot library shelf on efforts to foster improved consensus on matters affecting resource management could easily be filled several times over. Following are simply those efforts that relate in various ways to the Lake States.

The Minnesota generic environment impact statement is a one-state attempt to form a consensus concerning some of the effects of an increasing level of timber harvest. Improved information of a highly detailed kind is the primary ingredient. Two primary interpretations seem to be that foreseeable levels of harvest are well within sustainable growth capacity of the state's forests, and that impacts on wildlife, water, and recreational activities are quite modest at those levels.

The Lake States Forestry Alliance itself is a regional effort at consensus formation. It is most strongly this in a geographic sense. A major success has been to foster and institutionalize a common sense of direction among a considerable group of people in the three states. This is giving common thrust to efforts to effectively protect, manage, and use forest resources among the three states. The alliance has also made more limited efforts to bring together individuals and groups of varying, and to a degree opposed, interests.

The Duluth Manifesto is a national effort that happened to get its start at a location in the Lake States. The manifesto is an attempt to state principles for effective management and use of forest resources in simple, direct language. It is also an attempt to contribute toward more rational discourse at a national level. It draws at root on the central point of the Bruntland Commission, namely that economic development and environmental quality are complementary, and we need both, not one or the other (World Commission on Environment and Development 1990).

ADEQUACY OF THESE INSTITUTIONS FOR SUSTAINABLE DEVELOPMENT

Sustainable development as a concept, and as applied to forests, was discussed in a previous paper (or previous section if both are incorporated in some form into regional resource assessment documents [Webster 1993]). To summarize extremely briefly:

1. sustainable development as described by the Bruntland Commission amounts to meeting the needs of the present without impairing the future (World Commission on Environment and Development 1990). Equal attention is given to human needs and resource base/national environment, and to both economic development and environmental protection. Equity among human generations is emphasized.

2. Sustainable development as applied to forests can best focus on maintenance (and hopefully enhancement) of the productivity of the resource base over areas of some substantial size. Productivity for outputs ranging from clean water, to wildlife of many different species, to recreational opportunities of various kinds, to timber products is involved.

3. Sustainability is related in a very positive way to new technology, effectively applied research, and investment in forest resource management.

A fairly simplified appraisal of the collective adequacy of institutions for managing Lake States forests will be useful, and can be fairly readily made. Potential improvements in the adequacy and effectiveness of this overall group of institutions will then be briefly listed.

Criteria for simplified appraisal can be usefully taken from a chapter on "The management of natural forests" in a recent book by a sizeable group of authors associated in various ways with the World Bank (Palmer and Synott 1992). The book is titled *Managing the World's Forests: Looking for Balance Between Conservation and Development* (Sharma 1992).

Four major conditions for sustainable management of natural forests are listed. The detailed content and specifics of some will be modified in application to appropriate reflect an important difference: the authors of the chapter were discussing tropical forests predominantly in developing countries, while we are concerned with temperate forests in a rather highly developed part of a developed county. The overall categories are nevertheless useful.

* Long-term security of operations and tenure. This basically concerns stability of landownership and ability of owners to substantially control what goes on in their lands. (The latter in the sense of preventing others from moving on their land and using it for purposes that seriously undercut the owner's management.) Forest land ownership is fundamentally quite stable in the Lake States. It is wholly so for industrial and public ownerships. It is substantially so for the larger (and hence more important) nonindustrial private forests. Ownership turnover at fairly short intervals on smaller nonindustrial private forests is the only partial exception.

  Landowners ability to substantially control is also relatively good, having a basis in the legal system. Modest exceptions include various forms of illegal trespass that can be prevented by appropriate enforcement, and the effect of an increasing amount of dispersed human settlement. The latter may bring neighbors, some of whom may object in a variety of ways to owners management actions. (Another study element is addressing both the extent of this matter and possible steps to contain its negative effects.)

* Security for forest operations. This basically concerns effective control of harvesting and other resource management operations to make them conform to technically suitable methods decided upon by the owner.

  Lake States forest owners and managers largely have the ability to do this. Ability to select and carry out technically suitable methods is strongest on industrial and public forests. On nonindustrial private forests it covers some range from quite good to less so. Ability here depends considerably on ready availability of reasonably integrated assistance and incentives to landowners from a network of organizations, some public and some private.

* Suitable financial environment. In North American context, this topic relates primarily to adequacy of funding for forest resource management, and to financial arrangements that adequately distinguish between current expenditures (related to current benefits) and investment to secure and enhance future benefits.

  Adequacy of funding is quite variable among institutions managing Lake States forests. Adequacy of distinguishing between current expenditure and investment is also quite variable. And differences are substantial among institutions within some of the four major forest ownership categories. For example, a recent history of state economic and fiscal difficulties has affected some parts of the region substantially more than others (although each state has felt some degree of pinch, as compared with its own historic standards). Therefore, generalization is difficult if it is to be meaningful.

  One area of some apparent partial deficiency concerns the form of funding for management of state- and county-managed public forests. These are forests managed in considerable (but certainly not exclusive) part with an eye to economic benefits including those from commodity outputs. Yet, management of these forests is commonly funded via annual (or biennial) appropriations that can easily resemble solely current expenditures from the viewpoint of budget agencies and legislators. Further, management is often funded very largely from current receipts from timber sales and other current revenues. The combined effect is underinvestment, with past low-intensity management (and hence modest current receipts) overly influences the future.

* Adequate information. Here the chapter on "The management of natural forests" directly provides categories useful in simplifying matters. It identifies three primary information needs: concerning forest resources themselves (in the sense exemplified by FIA information); concerning likely values of various outputs; and information for effective management (for example, in the simplest case, practical silvicultural information).

  Institutions for managing Lake States forests are basically adequate in terms of available information. A long history of substantial research in both a high-quality Forest Service experiment station and several nationally and internationally recognized institutions of learning are contributors. Effective distribution and effective application of this information may be variable from extremely good to less so.

  Major elements of less than universal effectiveness may include continuing education for resource professionals in many organizations, and variable availability of assistance and incentives for nonindustrial private forest owners in parts of the region. In addition, consensus-forming organizations and arrangements may to date be relatively rudimentary though distinctly useful.

Overall, institutions for managing Lake States forests appear to measure up relatively well in relation to major requirements for sustainable development. They do so, however, somewhat variably and with opportunities for further improvement.

SOME AREAS FOR POSSIBLE IMPROVEMENT

Following are several areas where there appears room for appreciable and useful improvement in institutions for managing Lake States forests. (These points draw upon essentially all observations made earlier, not simply the section immediately preceding this one.)

- Make integrated assistance for nonindustrial private forest owners more uniformly and readily available across the region. (At present availability of such assistance is quite variable. To a surprising degree, the two states with the most forest land in this ownership category are at opposite ends of the scale. A difference in state economic and fiscal condition is one major factor. A long-term difference in orientation of the parent department in which the state forest resources agency is located may also be a factor.)

- Partially disentangle use and uses of forest resources, and attempt to make the major forms of funding more investment-oriented, particularly for state- and county-managed forests. (The first portion involves more consistent application of ideas originating with Marion Clawson [1974, 1975] for separating uses and users that would otherwise conflict—this in order to make management for all major values more effective, primarily where a given use is primary. The second portion involves establishment of capital accounts to support resource investments and fund sources for those accounts that are themselves investment-oriented. Such sources key on prospective returns [and associated risks], not artificial capital-rationing.)

Potentially useful examples include key-value management, and the authorized forest development fund, both affecting Michigan's state forest system.

- Resolve any remaining impediments to state-county cooperation in management of forest resources. (Wisconsin's arrangement for cooperation appears particularly effective and harmonious.)

- Reduce, if possible (or alternatively confine) the effects of litigiousness and controversy concerning federally-managed public forests. (A first question is can litigiousness and controversy actually be reduced with very polarized interest groups, and a very open legal system? Specifically, how? Or is it more realistic to focus efforts on attempting to confine nationally-generated controversy to federally-managed land? It is at present substantially, though not entirely, so confined.

- Create stronger consensus-forming organizations and situations concerning forests and related resources in the Lake States. (One potentially useful model may be high-level roundtables on environment and economy now operating in each province and at federal level in Canada. A state sustainable development initiative in Minnesota is currently drawing on this model to some extent.)

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Some Thoughts on Sustainable Development as a Concept and as Applied to Forests

Henry H. Webster[1]

INTRODUCTION

This is a relatively brief discussion of sustainable development as it applies to forest resources. It is intended to give a sense of direction for a useful way of looking at such development. It was prepared initially as a background paper in connection with an analysis of trends and opportunities associated with forest resources in the Lake States.

Three major topics are discussed. The first is some central ideas involved in the overall concept of sustainable development as it is being discussed at international levels. The second is the application of sustainable development to forest resources in several important dimensions. And the third is some examples of published but distinctly **un**helpful applications of overly narrow definitions of sustainable development of forest resources.

All three major topics are needed to arrive at, and to apply, widely understandable and useful approaches to sustainable development. All three are needed to be sure of avoiding overly narrow, and eventually self-defeating definitions and approaches to sustainable development.

SUSTAINABLE DEVELOPMENT: SOME CENTRAL IDEAS

Sustainable development has been discussed in a particularly encompassing and useful way by the Bruntland Commission (United Nations World Commission on Environment and Development 1990). The work of this commission chaired by Gro Harlem Bruntland, prime minister of Norway, provided major underpinning for the recent "earth summit" in Rio de Janeiro. That is one measure of the international dimensions of sustainable development. Another is the fact that work of the Bruntland Commission involved major discussions and hearings at 14 locations worldwide in places as diverse as Sydney, Jakarta, Nairobi, and Rio de Janeiro, and also six Canadian cities.

The emphasis of the Bruntland Commission is on *meeting the needs of the present without impairing the future.* Human needs and resource base/natural environment were given equal emphasis. There was also emphasis on equity among human generations.

The Bruntland Commission strongly made the point that *both* economic development and environmental protection are needed, *not* one or the other. Indeed, they were mutually interdependent, with each providing an essential basis for the other.

Economic growth will eventually be inhibited, and effectively cut off, in any location with *seriously* degraded natural environment. A first effect will be that people who have a choice will in significant number choose to live and work somewhere else. A further effect will eventually be a lack of resources needed for a substantial level of economic activity.

And effective protection of environmental quality requires substantial and continuing societal prosperity. Simple ability to pay for relatively expensive environmental protection measures is one aspect of this essential point. A more penetrating aspect concerns poverty. Poverty understandably leads to short-term views—everyone does have to eat *today*, and at reasonably regular intervals. Short-term views can, in turn, lead to harsh treatment of resources and natural environment. Alleviation of poverty is the single most important step worldwide in alleviating harsh treatment of resources and natural environment. Interdependence between economic growth and environmental quality is mutual.

Discussion in particular parts of the United States seems to be evolving toward this international orientation. One example is the Minnesota sustainable development initiative which directly mentions both economic development and protection of environmental quality. Elsewhere, however, there has been a tone that suggests that it's *either* one *or* the other, often with human needs largely ignored in efforts to protect environmental quality (e.g., Robert G. Lee 1992). This either-or orientation is distinctly unhelpful.

Indeed there may be reason to think that emphasis on both economic development and environmental protection *by themselves* is still too narrow—though a great

[1] The author is Project Director, Lake States Regional Forest Resources Assessment, Department of Forest Resources, University of Minnesota, St. Paul, MN

improvement over *one or the other*. Let's think briefly in an unconstrained way about the range of things to be sustained or enhanced if we are literally to provide for present needs without impairing the future—indeed attempting to provide for a better future to the extent possible.

Following would seem to be minimum list of things to be sustained to meet needs of the present without impairing the future.

- society as a whole;
- sense of community (at several different levels);
- capacity for innovation (in both technical and institutional senses);
- education and skills for an effective work force;
- developed physical infrastructure;
- effective governmental and political institutions;
- national, regional, state economies and associated employment; and
- productivity of the earth's resource base.

The two ends of the scale—society as a whole and productivity of the resource base—are in a particular order. They are in a particular order for reasons discussed fairly recently by Alston Chase (author of among other things *Playing God in the Yellowstone Region*). In a newspaper piece just before Christmas, Chase reflected on what is relatively resilient, and what is fragile and difficult to restore once broken down (The Detroit News 12/24/92). His central point is that *civilization* is fragile, while *nature* is resilient. His examples come from the further end of current breakdowns of civilization (Bosnia and Somalia). But his central point is extremely important if we are truly serious about meeting human needs of the present without impairing the future.

Much the same point is made in a book recently reviewed in *The Economist* (a British published international newsmagazine). Robert Putnam and associated authors discuss *Making Democracy Work: Civic Traditions in Modern Italy* (1992). At first glance, this would seem to have little to do with resource management and sustainable development. But at a more penetrating level it says a great deal. The authors examine where in Italy regional government now works well, where it works at mediocre level, and where it works poorly. Several conventional factors explain little of the variation in effectiveness. What it does explain is the fact that regional government "...works best in regions with high levels of 'civic community'—patterns of social cooperation based on tolerance, trust, and widespread norms of active citizen participation." The review goes on to observe that "...social capital is far harder to accumulate than physical capital." Biological capital could be interpreted to be an adjunct or aspect of physical capital.

APPLYING SUSTAINABLE DEVELOPMENT TO FOREST RESOURCES

These central ideas taken as a whole help to sort out how the concept of sustainable development can best be applied to forest resources. Several matters are particularly important in defining a consistent and useful approach to sustainable development of forest resources. Following are four that are particularly germane:

1. the objects, conditions and values that are to be sustained;
2. the range of forestry activities that contribute to sustainable development;
3. the geographic scale at which sustainable development can most usefully be applied; and
4. the *relationship* of sustainable development for forest resources *to* new technology, effectively applied research, and investment in resource management.

It will be helpful to separately consider each of these topics, and to then note interrelationships among them, particularly the objects, etc., to be sustained, and the geographic scale.

Objects, conditions and values to be sustained can be defined in many different ways—indeed too many different ways for the full range to result in much other than confusion. For example, one of the *simpler* published discussions of alternative definitions lists *five* revolving around sustainability of timber volume, quality, habitat, environmental quality, and the forest estate (Baskerville 1990). Other published discussions go further up the scale of complexity and multiple alternative definitions.

Fortunately, meaningful simplification is possible. A good place to start is a simpler version of Gordon Baskerville's presentation. He gave such a version as a talk at the annual meeting of the Canadian Institute of Forestry in Alberta in 1989. He discussed three definitions that illustrate a scale of possibilities, with two being closely related at one end, and the third being at the other end. The two closely-related definitions are, namely, maintenance of overall productivity of forest resources in a region, or province or state, or other sizeable area; and long-term maintenance and hopefully enhancement of levels of outputs of a variety of products and services from these resources. Outputs would, for example, range from clean water to wildlife of many different species, to recreational opportunities of various kinds, to timber products. These are definitions that are fundamentally in harmony with meeting human needs.

A third possible definition noted by Baskerville is applicable on particular relatively small areas, namely,

maintenance essentially unchanged except by natural process of all ecologic features on specific sites. Wide-scale use of such a definition is not in harmony with meeting human needs. Ecological features certainly can be and are maintained undisturbed on limited and selected areas. But maintenance of these features undisturbed except by natural processes on all areas is simply not feasible if society is to meet human needs for a substantial range of values from forest resources.

A definition that focuses on continuing productivity of the resource base is strongly suggested. Such a definition can help to guide patterns of resource management that pay careful attention to human needs over an extended future. A definition that focuses indiscriminately on undisturbed ecologic features is *not* suggested. The latter will only encourage the appearance of a false choice between meeting human needs of several generations and sustainability. That leads entirely toward ideological gridlock.

The *range of forestry activities that contribute to sustainable development* can be illustrated. A good place to start is a major statement by the Canadian Council of Forest Ministers (1992), titled *Sustainable Forests: A Canadian Commitment*. The statement is very explicit on need for a strong economic base both nationally and in major regions, supported in part by forest products and by recreation and tourism. The statement is also very explicit on need for "...a full range of uses and values including timber production, habitat for wildlife, and areas allocated for parks and wilderness." Nine areas of emphasis quite familiar to members of The Canadian Institute of Forestry illustrate the range of forestry activities that contribute to sustainable development. Several deal quite directly with societal and institutional underpinnings for sustainable development.

The *geographic scale at which sustainable development can be most usefully applied* has already been discussed in an initial and rudimentary manner. The point was made that the concept of sustainable development can be best applied to areas of some substantial size. If applied in a literal-minded way to quite small areas, it would be quite easy to fall into a definition close to the idea of sustaining undisturbed (except by natural processes) all ecological features on all specific sites. This is simply not consistent with meeting human needs for a substantial range of values from forest resources, as previously discussed.

How can "areas of some substantial size" be defined in a more specific and less all-encompassing way? Perhaps a useful illustration can be constructed for a large state forest system quite familiar to this writer. This state forest system encompasses 3.8 million acres (1.54 million hectares) of state-owned and managed land spread over a substantially larger area with considerable intermingled land in other ownerships. Major planning and management for the system is focused on six sizeable state forests which average 633 thousand acres (255.1 thousand hectares) of public land. *Much* more specific planning and on-ground management practices are focused on individual compartments which average 2,500 to 3,000 acres (1,012 to 1,210 hectares). Compartments are laid out in such a way as to make site conditions reasonably homogeneous within any given compartment. Specific management steps are considered and discussed in "compartment reviews" that in any given case may deal with from one to three or four adjacent compartments. Representatives of local government (townships), and people in several divisions of the managing agency take part in compartment reviews.

It may be reasonable to think of sustainable development in a particular sense in terms of a grouping of compartments considered in several compartment reviews. For example, forest stands at all stages ranging from newly-regenerated to approaching some reasonable definition of maturity might be regularly found on units of some 12 to 20 adjacent compartments. That perhaps gives us some sense of what sustainable development might look like on the ground.

One additional topic can usefully be considered: the ***relationship** of sustainable development for forest resources **to** new technology, effectively applied research, and investment in forest management.* New technology based in research has quite apparently expanded the ability of forest resources to provide for continuation of particular uses in a stable or expanding manner. The waferboard industry (under a variety of specific names) in the Lake States and adjacent areas both sides of the international boundary is a case much in point. This industry is now producing building products at relatively low cost from raw material that was considered essentially worthless only 3 or 4 decades ago (i.e., aspen). There is also evidence in parts of the region that additional very low value species (notably several different hardwoods in relatively small trees) become valued parts of raw material supply as strong demand for aspen raises prices and costs.

This whole process of an expanding supply of useful material from previously essentially worthless material also has a worldwide dimension. This is a point strongly made by Roger Sedjo and Kenneth Lyon in discussing *The Long-Term Adequacy of World Timber Supply* (1990). They make the point that technologic developments rooted in effectively applied research are both making actual use of wood more efficient (demand effect), and making previously unusable/low-value species useful (supply effect).

The *level* of use at which forest resources are sustainable is also quite directly influenced by effectiveness and intensity of management of those resources. Investment in more effective management can raise the level of sustainable outputs (Charles E. Little in Sampson and Hair 1990). Investment in management of some areas can also increase commodity outputs there, making it easier (in relation to overall demand) to leave other areas essentially undisturbed for their natural values.

Much the same point is made at world level by Sedjo and Lyon in discussing the contribution to world timber supply of rapidly growing plantations in what they term an *emerging region* (namely, New Zealand, Australia, Chile, Brazil, South Africa, and the Iberian peninsula).

EXAMPLES OF UNHELPFUL APPLICATION

Sustainable development as visualized here is entirely consistent with meeting human needs for a wide range of values that come from forest resources. And the evidence is that in major parts of the world forest resources are improving in their ability to provide for these uses and values in an ongoing manner (e.g., Sedjo and Lyon 1990, Frederick and Sedjo 1991, MacCleery 1992).

At the same time, there are published discussions that suggest (or could be quite easily interpreted to suggest) that much, or most or nearly all, use of forest resources is not sustainable. One such interpretation occurs in a chapter by Botkin and Talbot (1992). In discussing primarily tropical forests, they implicitly adopt a definition of sustainable development that focuses on leaving essentially unchanged all ecologic features of most or all specific sites. Not surprisingly, this leads to the conclusion that nondisturbance by humans is essentially the only sustainable form of development for tropical forests. How human needs are to be met both at present and in the future goes largely undiscussed. They further suggest via a very odd historical—and misinterpreted—example that much temperate forest management is also unsustainable.

CONCLUSION

Unhelpful applications heighten need for careful attention to a particular focus for sustainable development. We *do* need focus on an approach that recognizes simultaneous need for both economic development and protection of environmental quality (plus several other attributes of a civilized and liveable society). We *do* need to focus on a definition of sustainable development applied to forest resources that emphasizes continuing productivity of the resource base. And we *do* need to affirmatively avoid definitions and applications that rather directly foster conflict almost by definition between resource sustainability and human needs.

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APPENDIX

Botkin and Talbot (1992) concluded that much management of temperate forests is unsustainable. They based this sweeping conclusion on just one example, the original harvest 100 years ago in the forests of the first-settled of the Lake States (Michigan). That was, as noted earlier, a harvest done without any hint of silvicultural prescriptions, and a harvest followed by a punishing fire history.

Full rebuttal involves first the major increase in volume and vigor of forests over the past several decades. Data from the best resource inventories in existence show that total volume of growing stock increased over the past 40 years (1952 to 1992) by a factor 2.3 times. The volume of large trees (sawtimber) increased by a factor of nearly three times. This occurred during a period of increasing harvest (as can be most readily illustrated via readily available data for 1996, 1980 and 1987). Over these 21 years, harvest increased by 50%. The *margin* by which growth *exceeds* harvest *increased* by 65%. Growth not only increased, it increased a *lot* more than the increasing harvest did.

Perhaps the ultimate rebuttal is that the forest resources and industries of Michigan became one major sector in an effort to develop and diversify the economy of that state. This effort was led in the later 1970s and 1980s by two successive governors of opposite political parties who created by stages a "target industry program" of several specific sectors. Forest resources and industries was one of the designated sectors. The effort was rooted in these rather simple but extremely important facts:

- state unemployment rates in the early 1980s rose to a range of 14 to 17% of the labor force. (The steel-heavy machinery-automobiles sector so important in the Great Lakes region simply went-to-hell-in-a-hand-basket in a near classic case of economic unsustainability.)
- forest growth was three times harvest after 60 to 70 years of progressively more effective fire control, and several very major efforts in improved forest resource management (involving both reforestation and stand management).
- in-state production of paper and building products that was one-third of consumption by the state's citizens.

These three facts defined a simple, robust sense of direction. The target industry program for this sector involved 25 specific measures in three major categories: (1) to improve the business climate for forest products industries; (2) to get public and private actions affecting forest resources and industries into harmony with each other; and (3) to assure a stable and expanding supply of timber as a base for expanding industries.

Major expansions did in fact occur. National firms invested approximately $1.5 billion in new and expanded plants. This was Michigan's share of major growth in the forest products industries in the Lake States. This, together with efforts in other sectors, resulted in a 25% decrease in dependence of the state economy on the automobile industry—a very troubled dependence, as unemployment figures and related measures make clear.

This renaissance at a time of societal need is hardly an example of unsustainable development. Indeed, it is an example of sustainable development, very directly illustrating how the sustainable level of use is directly influenced by effectiveness and intensity of resource management.

Interregional Competition and the Lake States Forest Resources

Perry R. Hagenstein[1]

INTRODUCTION

The purpose of this report is to show possible changes resulting from major forest resource developments in other regions as they may affect the management and use of forest resources in the Lake States—Michigan, Minnesota, and Wisconsin. This perspective recognizes that the Lake States are only part of a broad "national and international" forest economy. The future place of the Lake States' forest resources in this economy will be determined in good part by economic and other forces that are outside of the Lake States and beyond the control of people in this region.

In a parallel sense, what happens in other regions will be determined in some part by what happens in the Lake States. The economies of the world's regions are truly interlocked in various ways. To describe all of these ways accurately is clearly impossible. The task for this report is to focus attention on some of the more important developments in the forest economies of other regions that will affect the management and use of forest resources in the Lake States.

Most of the report is concerned with timber products, although it is evident that these are only one of the forest resources. The report also focuses on current trends in only a few of the regions of the world that are relevant in some way to the future of Lake States forests. These are the Pacific Northwest and the South in the United States and Canada, especially the province of British Columbia. This report was prompted by reports that future timber supplies from these regions could be less than had been expected as recently as a decade ago. The stated reasons varied, but the common conclusion was that national markets for timber products could be affected by such shortages. This clearly would affect the forest economy of the Lake States, an important consuming and producing region.

International trade in timber products is also relevant to what happens in the Lake States, if only indirectly through impacts on other trading regions. Timber and forest products from Scandinavia, Siberia, the tropics, Chile, and New Zealand are having substantial impacts on world markets. Expanding markets along the western Pacific Rim, including China, are drawing timber products from the major suppliers, including those regions of the United States and Canada that will be treated in this report. The full range of these relationships is too great for detailed treatment here, but they will have some impact on the future of the Lake States' forest economy.

This report is concerned with what might be called the "mid-term" future of some 10 to 20 years hence. This is a time far enough in the future that near-term changes in forest resource policies will begin to have some impact on what happens in the forest. Yet it is not so remote as to be of no real interest to those who must make policy and investment decisions today.

In the sections that follow, there is a brief description of the place of the Lake States as a supplier of forest resources to meet its own needs and as an exporter to other regions. The report then describes some of the driving forces that affect and are likely to affect the forest economy of the Lake States and related regions. The next sections provide a descriptive analysis of trends in the forest economies of, in order, the Pacific Northwest, the South, and Canadian provinces as they relate to the future forest economy of the Lake States. This analysis assesses the implications of public policies that may impinge on the operation of the market economies of these regions as suppliers of wood products. The final section draws together the results of the previous sections in summary fashion.

THE PLACE OF THE LAKE STATES

The Lake States region is a consumer of forest resources. It is also a supplier of forest resources and a trading partner with other regions, both North American and elsewhere. There are no direct measures of the Lake States' trade balance in forest resources with other regions. The Forest Service provides estimates of production of some wood products by state, but there are no solid estimates of consumption of these products by state. But consumption for the three-state region can be estimated based on estimated shares of such important indicators as population, income, and manufacturing.

[1] The author is a Forest Policy Specialist, Resource Issues, Inc., Wayland, MA.

In 1990, the three-state region had 7.44% of the nation's population, down from 7.96% in 1980. It also had 7.69% of nation's employment and 7.78% of the payroll. In 1987, the most recent year for which data are available, it accounted for a somewhat higher proportion, 9.87% and 10.64%, of the value added by manufacturing and the value of manufactured shipments. Based on these measures, the region probably accounts for about 8.5% of the nation's consumption of wood products, including woodpulp and paper and lumber and panel products.

The region has some apparent competitive advantages in producing timber products for its own consumption and for shipping to other regions. In 1987, the three Lake States accounted for 5.9% of the US timber removals from growing stock (mainly harvested for timber products) and 3.6% of the sawtimber removals. Of the major species groups, these amounted to 1.6% of the softwood and 15.4% of the hardwood growing stock removals, and 1.0% of the softwood and 13.6% of the hardwood sawtimber removals. From these figures, it is clear that the Lake States region is a net importer of softwood products and a net exporter of hardwood products. The Lake States' share of US total softwood removals has remained about the same since 1952 for both growing stock and sawtimber, but has increased substantially since 1952 for both hardwood growing stock and sawtimber.

From these very general comparisons and a general knowledge of the uses of softwood and hardwood timber, it is evident that the Lake States region is a net importer of softwood lumber and products made from softwood woodpulp. It is also a net importer of softwood plywood, but a net exporter of waferboard and oriented-strand board, which compete with softwood plywood used in construction. It appears to be a net exporter of solid wood products made from hardwood (lumber and veneer) and products made from hardwood woodpulp. It also has an important millwork industry that uses softwood lumber and a modest-sized furniture industry that requires hardwood lumber and veneer.

The position of the Lake States as a net importer of softwood lumber and a producer of oriented-strand board suggests its potential sensitivity to reductions in softwood timber harvests in the Pacific Northwest and possible timber supply problems in the South and Canada as well. These are addressed in the remainder of this report.

Some Forces Driving the Forest-Based Economy

The basic forces driving the forest economy and that drive the national economy are much the same as those that have driven it over the past few decades:

- fiscal and monetary policies that foster more or less steady economic growth;
- social welfare and insurance programs that have shifted much of the burden of risk from individuals to society (the socialization of risk);
- a petroleum-based lifestyle that determines where people live and how they use their leisure time; and
- a vast expansion in both private and public debt.

Along with these have come the emergence of pension funds as a major source of investment capital and new communications technologies that have internationalized markets and severed some of the ties that bind people to regions and to business, civic, and social organizations (Raup 1988).

The results of these forces for the forest economy derive to a large extent from their effects on the overall economy and people's lifestyles. For one thing, the combination of public policies that foster steady economic growth, not always wholly successfully, and that tend to shift individual risk to society as a whole encourage consumption, including consumption of forest resources. Not only does society generally expect that income will grow, but the impetus for saving to provide for unexpected expenses has been significantly reduced.

Over the past several decades, national income and, along with it, consumption have grown. Over the past 20 years (1971 to 1991), median family income went up 1.2% in constant dollars, but this figure by itself hides some other important changes. Over the same period, average hourly earnings in private nonagricultural employment went down 9.3% as labor force participation by females increased 32.0% (labor force participation by males fell 4.4%). At the same time, average hourly compensation in the economy as a whole increased 19.3% (Council of Economic Advisers 1993).

Taken together, these data suggest that although family income has grown somewhat, people are working harder to get it, especially through increased participation of women in the workplace. The growing spread between wage rates in private nonagricultural employment and average compensation in the economy as a whole also has implications for how income will be spent. The data suggest the possibility of a bi-modal distribution of income, with peaks for low income and for high-income earners, and a growing spread between "haves" and "have-nots" among those in the labor force. This, along with the increase in the two-earner family, has implications for use of leisure time—who uses it and who has money to spend on it.

Personal consumption expenditures as a percentage of gross domestic product in the US were between 62.5 and 64.7% from 1960 to 1981. Since that time, they have consistently been above 65% and in the recession years of 1991 and 1992 were over 68%. Personal savings in relation to personal consumption expenditures ranged from 12 to 17% from 1962 through 1986. From 1987 through 1992, they averaged only 10.8%. These relationships are certain to change with changes in fiscal and monetary policies. But the relationships in the last few years suggest that relatively low personal savings and relatively high personal consumption expenditures may have been encouraged by public tax and spending policies.

Consumption of wood products is at or near record highs when adjusted for the performance of the overall economy. But pressure on forests to produce nonwood outputs is also at or near record highs and is expected to grow more rapidly than the demand for wood products. For example, the US Forest Service projects consumption of timber to increase 51% from 1986 to 2040, but projects at least a doubling in various kinds of outdoor recreation use over the same period (US Forest Service 1989). While it might seem that increased recreation use of forest land will compete directly with timber production, this is not really clear from the Forest Service analyses. And the projections themselves, aside from their interpretation, are questionable (Pederson 1992).

The Forest Service recreation use projections focus on activities—hiking, winter sports, and water sports. But these do not fully capture how people use their leisure time and income. A more relevant perspective would focus on how people live in relation to forest land and how their lives are changing. One factor is a recent decline in the average paid time off—vacations, holidays, sick time—that has come with changing work rules and compensation agreements (Schor 1991). This combines with people's ever-increasing mobility and advancing communications technology to affect how people, especially those with above average incomes, can arrange their lives. In addition, a collapse of well-ordered social conditions in some urban areas is causing some residents to flee to what they perceive as more protected rural areas. These various factors are leading toward a recombination of workplace and residence in rural, and often forested, areas (Raup 1988). Simple projections of recreation activities fail to capture the potential impact of these changes in lifestyles that are bringing an increasingly urban-based population to forested regions.

The increase in debt and the growing influence of pension funds in financial markets are also having significant impacts on the forest products economy. Although nominal interest rates on mortgages may now seem low relative to what they were during the general inflation of the late 1970s and early 1980s, real interest rates on corporate borrowing are high. The real interest rate on corporate AAA bonds in 1992 was about 5%, down a bit from real rates of better than 6% from 1981 to 1991. But this compares with real rates generally in the range of 2 to 3% for the three decades from 1952 to 1972 (Council of Economic Advisers 1993).

High real interest rates affect how firms invest their funds. Although data are not readily available, it appears that firms in the forest products industry have set higher goals for returns on investments in recent years than in the decades immediately following World War II. In turn, high interest rates have apparently helped foster a reversal of the trend toward vertical integration from woods to markets that characterized the forest products industry in the years following World War II. In recent years, many forest products industry firms have changed their operations to concentrate either on the solid wood products or the pulp and paper sides of their business. The rationale is that profits will be maximized if firms concentrate on areas they know best or where they have market strength. This has also led to some sales of forest land and a parallel increase in ownership of forest lands by organizations such as insurance companies, limited partnerships, and other institutional investors.

The change in forest land ownership is important for the forest economy not because the new institutional owners are adverse to selling timber to supply mills. In fact, it is just the opposite. But the idea that forest products firms need a supply of their own timber as a reserve to protect their mill investments and that they should manage their lands and timber conservatively has weakened. Pressure from financial markets to get high returns from company timberlands, or to get rid of them, has reportedly led to heavy cutting by some firms.

Basic economic forces also drive the management of nonindustrial private forest lands, although the role of debt markets is not as direct as for corporate lands. Nevertheless, high interest rates, along with high property taxes, discourage intensive management for timber and other forest resource uses. In those cases where private nonindustrial forests are held and managed for timber, it is often only the expectation that real timber prices will rise that justifies investments in land and forestry. This expectation has been borne out in the past to a degree generally for softwood timber and some species of hardwood timber, but timber prices have also had peaks and valleys (Ulrich 1988). Over the fairly short time that many nonindustrial lands are held and managed by a single owner, there is little assurance that timber prices will increase significantly.

Economic forces also affect use of forest resources other than timber. Most important among these are new communication and transportation technologies and the continuing low cost of oil. Together, these have encouraged an increasingly international and even domestic tourism industry. Shorter vacations that provide an "intense experience," such as river rafting, helicopter skiing, and rock climbing, are adding to the more traditional, but less challenging, kinds of recreation. Distance and borders are not very limiting for those who want to be challenged. Pressures for allocating land and resources to these new kinds of recreation do not reduce the pressure for providing traditional recreation opportunities. But they are increasing the kind and level of pressure placed on some forest lands.

Most of the above discussion concerns "demand shifters," which affect how much and what kinds of demands are placed on forests. Environmental concerns, a political rather than economic force, also place demands on forests, as is so evident in the issues involving endangered species. For the timber economy, these environmental concerns can also be viewed as "supply shifters." They affect the capacity of forests to meet the demands of the timber economy.

These factors are to a degree reflected in the basic assumptions used by the Forest Service for projecting timber demand and supply as part of its assessments of the forest and rangeland situation (e.g., Haynes *et al.* 1993). Based on these assumptions, the Forest Service projects increases in the consumption of timber and other forest products. One conclusion of the Forest Service analyses is that real timber prices will rise in the coming years for both softwood and hardwood timber in all regions of the United States.

At the same time, based on the earlier discussion of forces driving the forest-based economy, it seems clear that:

- there will be increased competition for forest land from the expansion of urban-based living into rural areas;
- high real interest rates will continue as a result of growing public and private debt and will limit investments in forest management by forest products industry firms and other private landowners; and
- forest landowners, public and private, will continue to be pressed by environmental concerns that will limit their ability to respond to increased demands for timber.

This latter assessment of driving forces does not really conflict with the Forest Service assessment of factors affecting the future demand for timber. It leads to some questioning, however, of the capacity of the nation's forests to provide timber to meet market demand without significant dislocation. There is considerable uncertainty about this capacity. The following examination of what seems to be happening in the Pacific Northwest, the South, and Canada explores the factors leading to this uncertainty.

THE PACIFIC NORTHWEST

Western softwood timber supplies are an important element in the US timber economy. Among the western regions, the Pacific Northwest is the major timber supplier. Despite its continuing physical and economic potential for supplying wood products, the timber economy of the Pacific Northwest is beset with problems. Most are related in one way or another to the extensive areas of national forests and their substantial timber resources. The issues that have been brought to a head by the current concerns over the spotted owl and biodiversity have their roots in the way in which the western national forests have been managed over several decades.

The National Forests in 1987 had 52% of the timberland in the western regions excluding Alaska and Hawaii. This area was down 14% from 1962, due mainly to designation of wilderness areas, which are reserved from timber harvesting and not included as timberland in the basic statistics. Softwood timber inventories on national forests in the western states fell about 9% from 1962 to 1987. This consisted of a 23% drop in the Pacific Northwest and a 6%increase in the rest of the West. The drop in timber inventories in the Pacific Northwest was only partly due to designation of wilderness areas. Much was the result of timber harvests that exceeded timber growth as old-growth stands were being harvested and converted to second-growth forests. The decline on forest industry lands in the Pacific Northwest over the same period was 33%, which reflected the more rapid conversion of the industry old-growth to second-growth forests than on the national forests (Waddell *et al.* 1989).

Timber harvests on forest industry lands have exceeded those on the national forests in the Pacific Northwest for many years. But it was long evident that the time would come when forest industry harvests would go down, at least for a period of a decade or two (Bruner and Hagenstein 1982; LeMaster and Sample 1992). This time was generally expected around the end of the current century and beginning of the next. The national forests, however, were managed under sustained yield policies that seemed to assure that timber harvests from these lands would, at the very least, not drop. This also was the case for the federal forest land managed by the

Bureau of Land Management, of which the Oregon and California revested railroad grant lands (the O and C lands) in Oregon are significant timber producers (Hagenstein 1992).

It became evident by about 1980 that timber harvests on the federal lands could not be maintained at planned levels because of various environmental constraints. In addition to the growing need to provide for recreation and aesthetic concerns, trying to meet emerging concerns with maintaining ecosystem health led to what were called "minimum management requirements." These were requirements intended to sustain key species of wildlife or protect specific elements of ecosystems. Together with management practices to provide for recreation and aesthetics, these requirements gradually led to reductions in planned timber harvest levels that in total were greater than those caused by wilderness designations. They hit hardest in the Pacific Northwest.

The Pacific Northwest has been providing about two-thirds of the timber harvest of the western regions excluding Alaska and Hawaii, although it has only 34 percent of the timberland area. The Douglas-fir subregion of the Pacific Northwest—the heartland of the northern spotted owl—has only 20% of the timberland area of the West, but 36% of the softwood timber inventory. It also has 46% of the West's timberland in the two highest productivity classes (Waddell *et al.* 1989). But the rest of the western regions, as well as forest land other than that in the national forests, are also important to the nation's timber economy. The following points are especially relevant.

The West is still a major source of softwood timber, although its share of the nation's total softwood harvest fell from 42% 1986 to 38% in 1991. Most of the region's drop in share was in the Pacific Northwest, where the harvest from federal lands (national forests and BLM lands) fell by 40%. The share of timber harvests from private lands in the West, generally in the range of 50 to 60%, was greater than that from federal lands from 1975 to 1991. From 1986 to 1991, the harvest from private lands in the West dropped only 6%.

Although timber harvests from private lands in the West have held up remarkably well as harvests from federal lands have fallen in very recent years, they may not continue to replace withdrawn federal timber over the next decade or so. This conclusion, however, is somewhat speculative because of the many ways in which markets can respond to shifts in supply. This will become clearer below as we review the results of some analyses of the timber situation.

Sample and Le Master (1992) summarized some projections of Pacific Northwest timber harvests made from 1963 to 1982. All showed projected declines in harvests from private lands. A 1963 report by the Forest Service projected that harvests from private lands in the Douglas-fir region (Pacific Northwest, Westside) would be at a low point during the 1980s and 1990s and then rise somewhat in subsequent decades (US Forest Service 1963, p. 100). A later Forest Service report projected that the decline in private timber harvests in the Douglas-fir region would continue well into the next century (US Forest Service 1982).

A report by some faculty members at Oregon State University projected that harvests from forest industry lands in the Douglas-fir region of Oregon would be 14 and 44% below 1968-1973 levels in the 1985-1995 and 1995-2005 decades (Beuter *et al.* 1976). A full-blown economic analysis of the timber economy of the Pacific Northwest in 1981 concluded that harvests from forest industry lands in Douglas-fir region would be 18% and 39% below 1970s levels in the 1980s and 1990s and not recover to the 1970s levels at least until after 2020 (Bruner and Hagenstein 1981).

These rather dismal conclusions for the timber situation in the Douglas-fir region were paralleled in Forest Service reports for Idaho and Montana. These reports, published in 1987, concluded that harvests from forest industry lands in each of the two states could not be sustained at recent levels for more than a decade, at which point they would fall sharply (Flowers *et al.* 1987, LaVere *et al.* 1987). These conclusions were similar to those in the economic analysis mentioned above, which found that forest industry harvests in the interior region made up of Oregon and Washington east of the Cascade Crest and all of Idaho would hit lows in the two decades from 1990 to 2010 (Bruner and Hagenstein 1981).

Along with their conclusions that private timber harvests in these regions would necessarily fall as timber inventories were depleted, the authors of the studies saw a role for timber from the federal lands. It was clear that if timber harvests in the region were to be maintained at something like recent levels, federal timber harvests would have to make up for some of the decline in private timber harvests. Such a role for federal timber would be consistent with the promise inherent in the sustained yield policies for federal lands (Hagenstein 1992). But none of the studies indicated the likelihood of federal timber harvests that would completely offset the expected drops in private harvests.

While all of the indicated studies projected some decrease in overall timber harvests in the Pacific Northwest, the current furor over old-growth forests has

changed the picture dramatically. First of all, a number of national forest plans are being revised with substantially lower planned harvest levels. Second, President Clinton's plan for the forests of the Northwest proposes that harvests from federal lands in the "owl forests"—those forests that are in the preferred range of the northern spotted owl—be lowered to 1.084 billion board feet annually. This is from an average level of 4.524 billion board feet during the 1980-1989 period (Interagency SEIS Team 1993). This is the proposed reduction for the "preferred alternative" in Forest Service and Bureau of Land Management timber harvests in the "owl forests" of both western and eastern Oregon and Washington and northern California. It amounts to a reduction of 3.44 billion board feet annually to a level of about 24% of the 1980-1989 average. Although the plan is a proposal that must be approved by the courts, it is likely that the indicated timber harvest levels are close to what will be adopted.

The proposed timber harvest reductions for federal lands in the Pacific Northwest must be viewed in the context of expected harvests from other forests in the region. The Clinton plan includes estimates of the likely timber harvests on nonfederal lands in the "owl region." These estimates are based on simulations made with the Forest Service's Timber Assessment Market Model (TAMM). They indicate that harvests from nonfederal lands during the next decade will go up by about 110 million board feet annually in response to timber price increases that are projected to be one result of the cutbacks in federal timber harvests. That is, nonfederal timber harvests in the Northwest will replace only about 3 percent of the reduction in federal harvests.

Hardwood harvests in the region are expected to go up substantially—120% in 2000 and 150% in 2010 from a 1986 base. But because hardwood timber is only a small part of the region's total harvest, these increases are only 16% and 18% of the projected drops in softwood harvests by 2000 and 2010 (Haynes *et al.* 1993).

A more inclusive analysis of the effects of federal timber harvest reductions in the Pacific Northwest would include estimates of harvests from nonfederal lands in this region, from federal and other forest lands in other regions of the United States, and from lands elsewhere. This is the subject of a recent report by the Center for International Trade in Forest Products (CINTRAFOR) at the University of Washington. The report estimates the effects on supplies from other regions and on timber use that would result from a roughly 20% drop (4 billion board feet) in federal timber harvests in the West together with a roughly 25% drop (4 billion board feet) in timber harvests in British Columbia (Perez-Garcia 1993). The 4 billion board feet drop in harvests in the West is probably somewhat less than will occur in total in the West if the Clinton proposal for the "owl forests" is adopted. The combined decreases in timber harvests in the West and in British Columbia will:

- lead to a decrease in consumption of timber products nationally that will account for 37.5% of the decrease in timber harvests;
- lead to increases in private timber harvests on private lands in the West that will offset 20.7% of the decrease;
- lead to increased harvests in the rest of North America, of which the increase in timber harvests in the South will be largest;
- lead to increases in timber production in Europe and Japan that together will offset 22.5% of the decrease in timber harvests in western North America (most of this will come from Europe).

A second set of estimates was based on an assumption that timber production from Siberia would offset some of the decline in western North America timber harvests. These estimates resulted in substantial role for Siberian timber at the expense mainly of increases in harvests in Europe and the US South relative to the previous example (Perez-Garcia 1993).

These analyses view softwood timber from the Northwest and other regions as fully substitutable in various uses, but there are some considerable differences in the products that will limit substitution. One effect of the reduction in federal timber harvests will be a significant decrease in the volume of marketable lumber that has old-growth characteristics. The average diameter of softwood logs in the region will drop even more than was expected earlier as private forests are cut more heavily to make up for some of the cutback in federal timber harvests.

Much of this high-grade old-growth lumber now is used in making millwork and specialty products. One likely market reaction to the decreased supplies will be to stretch the supplies of this high-grade lumber through more careful use. Another will be to substitute engineered lumber and related products that are assembled from smaller pieces. The likelihood of substituting ordinary lumber from other regions for this high-grade old-growth lumber in making specialty products is low. There will also be some decrease in the quantity of high-grade sanded plywood now made from Douglas-fir.

Most of the impact of reductions in federal timber harvests in the region will be in the lumber and plywood industries. The Pacific Northwest woodpulp industry,

which supplies about 14% of the nation's woodpulp, relies heavily on wood chips from lumber and plywood mills for its raw material. The expected decline in lumber and plywood production may not, however, cause great problems for woodpulp mills, which are using more wastepaper in their furnish and are likely to be able to divert wood chips that are now exported (Interagency SEIS Team 1993).

Drops in softwood timber harvests similar to those in the Pacific Northwest, and for much the same reasons, are also projected for the rest of the western United States. The place of the Pacific Northwest relative to the rest of the West is projected to fall from providing about 65% of its softwood timber to providing about 60%. But the overall drop of the western share of total US softwood harvests is projected to drop from 44% in 1991 to 33 and 31% in 2000 and 2010. The place of the national forests relative to other ownerships in the West is projected to drop from providing about 38% of the softwood timber in 1986 to providing about 25% in 2000 and 2010. Nonindustrial private ownerships are expected to increase their share from 13 to 28% (Haynes *et al.* 1993, Tables 9, 11, 20, 32).

In sum, softwood timber harvests in the Pacific Northwest will be reduced by some 3 billion board feet annually from the levels of the 1980s for at least the next two decades. Total reductions in the rest of the West will be close to a billion board feet annually. These decreases amount to about 13% of total US softwood harvests. The effects will be felt mainly in the loss of a significant part of the nation's high-grade softwood plywood and, particularly, high-grade softwood lumber production.

THE SOUTH

Among regions of the country, the South has the largest area of timberland, about 40% of the total timberland area in the United States. It accounts for about 50% of the softwood and nearly 60% of the hardwood timber harvests. In 1992, it provided for nearly 30% of the nation's softwood lumber consumption, about equal to the proportion provided by softwood lumber imports from Canada (Irland Group 1993, p. 14). The South now accounts for about 63 percent of the US production of softwood plywood and about 44% of the US production of waferboard and oriented-strand board (Wood Technology 1993). Already in 1984, the South produced 70% of the nation's woodpulp (US Forest Service 1988). All of these proportions have increased in recent years.

Although the place of the South as a timber producer has continued to grow, some concern has been expressed over the past decade about timber growth rates. There seems to have been some slowdown in southern pine growth rates, but the specific cause is unknown. Air pollution (acid rain) has been suggested as a possible cause, but others include drought, competition from hardwoods, changes in stand density, and decline in productivity of old fields that have grown into forests (US Forest Service 1988). One concern is whether this slowdown in growth, which shows up in aggregate timber growth statistics, is persistent enough to affect future timber supplies seriously.

There are other, perhaps more substantial, concerns, too. One is that recent increases in harvests, partly in response to the cutbacks on western federal lands, are putting undue additional pressure on timber inventories in the South. This pressure is not wholly unexpected. A 1988 Forest Service report, *The South's Fourth Forest*, projected that softwood (mainly southern pine) harvests would soon exceed growth, although this trend would be reversed during the first decades of the coming century. The projection was borne out at least for its initial stage in the most recent Forest Service assessment of the US timber situation. Softwood growth for the South as a whole was only 88% of softwood harvests in 1991 (US Forest Service 1993).

At the same time, growth of hardwoods continues to exceed harvests in the South. But hardwood inventories, too, appear to be coming under increased pressure. The proportion of hardwoods used in making woodpulp is increasing relative to softwoods in the South as well as elsewhere in the United States. And there has been a strong market for hardwood chips for export in the last 2 or 3 years. Other concerns are evident in the wide differences in some recent projections of the future timber situation in the region, which will be discussed below. In addition, there are some ambiguities about some of the information needed to make an accurate assessment of the situation.

The timber supply situation in the South is complex, but for quite different reasons than in the Pacific Northwest. In contrast with the Pacific Northwest, public ownership of forest land is not very important in an overall appraisal of the South's timber situation. About 90% of the timberland is private. Of the private forest land in the region, forest products industry firms and farmers each own close to a quarter, nonforest industry corporate owners hold about 10%, and individual owners other than farmers hold about 40% (US Forest Service 1988, p. 13). These owners' goals are diverse.

Pulpwood markets are dominant in some parts of the region and sawtimber markets (for lumber and plywood) in other parts, but both are important throughout the region. Both softwood and hardwood timber are important and they are intertwined in various ways-often

intermixed in the woods and sometimes serving as substitutes for each other at the mill. For this report, discussing softwoods and hardwoods separately makes sense.

The Softwood Situation in the South

Uncertainty about the future situation for softwood timber in the South is shown in comparisons of projections in three major recent Forest Service reports—*The South's Fourth Forest* (published in 1988), the 1989 RPA Assessment, and the draft 1993 RPA Assessment. This comparison was taken from projections assembled by members of the Southern Forest Resource Consortium (Cubbage *et al.* 1993). Differences among the projections start with those of softwood lumber production, softwood pulpwood consumption, and structural panel (softwood plywood and waferboard/OSB) production.

Southern softwood lumber production

billion board feet

Source	1984-86	1990	2000	2010
Fourth Forest	10.1	11.7	13.1	14.4
1989 RPA Assess.	11.3	—	13.1	13.2
1993 RPA Assess.	11.6	12.7	17.1	19.0

Southern softwood pulpwood consumption

million cubic feet

Source	1984-86	1990	2000	2010
Fourth Forest	2.06	2.09	2.21	2.34
1989 RPA Assess.	2.43	—	3.11	3.42
1993 RPA Assess.	—	3.07	3.42	3.50

Southern structural panel production

billion square feet, 3/8"

Source	1984-86	1990	2000	2010
Fourth Forest	9.8	9.3	9.5	9.9
1989 RPA Assess.	12.1	—	12.2	13.2
1993 RPA Assess.	12.0	12.9	14.6	15.8

Projected consumption of softwood pulpwood and production of softwood lumber and structural panels in the South are higher in the two RPA Assessments, and particularly in the draft 1993 Assessment, than in the South's Fourth Forest report. This is probably the result of a more recent evaluation of the federal timber harvest situation in the West, and its potential impacts on the South, and of the strong markets for lumber and structural panels in the late 1980s. At first glance, at any rate, these are plausible explanations.

Cubbage *et al.*, also compared softwood timber removals (harvests) and timber inventories from the three studies.

Southern softwood timber removals

billion cubic feet

Source	1984-86	1990	2000	2010
Fourth Forest	5.36	5.69	6.07	6.36
1989 RPA Assess.	5.37	—	5.99	6.33
1993 RPA Assess.	5.34	5.45	6.20	6.50

Southern softwood timber inventories

billion cubic feet

Source	1984-86	1990	2000	2010
Fourth Forest	102	97	92	93
1989 RPA Assess.	104	—	101	108
1993 RPA Assess.	106	103	103	115

The differences among these analyses, all made within the 6 years from 1987 to 1993, are striking. While projected softwood timber removals in 2000 and 2010 are roughly the same in all three projections, the differences in projected softwood pulpwood consumption, softwood lumber production, and structural panel production from the lowest to highest range from 30 to 60%, in the same direction for all three products. The substantial projected increases in production of softwood lumber and pulpwood in particular suggest the potential for future timber supply problems in the South.

Two of the important assumptions on which these projections are based concern the future area of pine plantations and the level of investment in timber management. In addition, projected timber harvest levels are an important determinant of future timber growth in that

they affect the timber inventories that are the capital on which growth takes place. Each of these is discussed in turn below.

Pine plantations are important for softwood timber supplies in the South because annual timber growth rates are considerably higher than on other timberland. In 1984, pine plantations accounted for 23% of the total softwood growth, even though the area of such plantations, as noted above, was only 11% of the total. By 2010, pine plantations are projected to provide 65% of the net annual softwood growth. Growth rates relative to inventory for pine plantations were 9.6% in 1984 and are projected to increase to 11.0% in 2010, compared to rates of 5.6 and 7.3% for softwood timber overall in the South (US Forest Service 1988). These growth rates are high relative to expected softwood growth rates in other regions of the country or for other species. They reflect, in part, the fact that they are for all timber that is at least 5 inches in diameter, not just sawtimber, and for timber that is on average fairly young and vigorous.

Forest industry lands play a particularly important role in future softwood timber growth because of the high proportion of pine plantations expected on these lands. The proportion of the area owned by forest industry firms that is in pine plantations is expected to grow from 31% in 1985 to 53% in 2010. The proportions of the area now and prospectively in pine plantations for all other ownership classes are much lower, below 10% in 1985 and from 10 to 20% in 2010. Overall, pine plantations are projected to increase from about 11% of the total timberland area in 1985 to 25% in 2010.

The South's Fourth Forest report noted that in 1985 there were 22 million acres of cropland and pasture in the South that would give higher economic returns to the owners if they were in pine plantations. That report also projected a 23 million acre increase in the area of pine plantations from 1985 to 2010. About 12 million acres of this increase is projected to be on forest industry land, where pine plantations are expected to replace about 10 million acres now in natural pine, mixed pine-hardwoods, and upland hardwoods. Most of the other 11 million acres of additional pine plantations is expected to be on private lands other than those owned by forest products industry firms.

The acreage of land planted mainly to softwoods each year has increased substantially since the 1950s. While the trend line has been steadily upward, there are two periods when planting was substantially above the trend line. One was around 1960 when the Soil Bank program about doubled the area planted each year for about 5 years. The other was during the late 1980s when the Conservation Reserve Program (CRP) led to planting of erodible farm land, especially in the South, for several years. In both cases, the area planted each year as part of the government program added substantially to the trend level.

Projections of the area of pine plantations for the South's Fourth Forest study were made based on planting levels during the most recent "planting bubble." But the area planted in the most recent years (1990-1991) has been about 500,000 acres below the average of about 3 million acres during the 1986-1990 bubble (Moulton *et al.* 1993).

Meeting the projected area of pine plantations appears to be a critical element in having future timber growth rates that are at or near the levels that the Forest Service has projected. There are some who doubt that this is being done. One, an independent forest industry analyst, points out that planting following logging in the South has remained roughly constant while softwood removals have continued to climb. His projections indicate that, as a result, there necessarily will be a substantial decline in softwood removals in the South starting in the mid-1990s. This will be the result of a drop in total softwood inventories in the South of about 25% from the mid-1980s to 2000, a result of a roughly 40% drop in annual softwood growth (Decisions Support, Inc. 1992). His projections of future softwood timber supplies in the South are much more pessimistic than those of the Forest Service.

Forest industry lands provided more than their share of softwood timber harvests in 1984, while all other ownership classes provide less than their share relative to area owned. The proportions were roughly the same in 1991. By 2010, the South's Fourth Forest study projected that forest industry lands will provide 43% of the total timber harvests, up from 35% in 1984. At the same time, the shares expected to be provided by farmer and other individually owned lands are expected to drop significantly.

This is partly due to a substantial drop in the expected area of farmer owned land, but individually owned lands are expected to maintain their share of the total area (US Forest Service 1988). If the rate at which pine plantations are established does not meet projections, especially on forest industry lands, there is good reason to question whether overall softwood timber harvests can increase to the projected levels.

Projected softwood growth rates also depend on assumptions about management practices. The Forest Service projections for the South were developed as part of the South's Fourth Forest study and were based on consultations with industry representatives . The projections generally are based on the assumption that private

landowners will use relatively intensive management practices. For example, it was assumed that all pine plantings would be made with genetically improved seedlings after 1995 and that the most intensive site preparation would be used on 50% of the forest industry lands, with only slightly lower management intensity on other corporate lands.

Assumptions about timber management investments and the resulting timber growth rates are subject to dispute. A 1983 study by the congressional Office of Technology Assessment reflected a timber industry view at the time that Forest Service timber growth projections were unduly conservative (Office of Technology Assessment 1983, p. 16-17). It is doubtful that projections in the South's Fourth Forest report were adjusted to respond to this critique. Nevertheless, they appear to be based on some assumed levels of investment by private forest owners that may be more aggressive than now seems warranted, especially in view of the current high real interest rates for investment capital.

The final matter concerns timber harvest projections. The South's Fourth Forest projections that softwood timber removals in the South would exceed net softwood timber growth during the 1990s are, if anything, being met ahead of schedule (US Forest Service 1993). Although 1991 was an economic recession year, softwood removals in the South were somewhat above those projected for that time in the South's Fourth Forest. The most recent projections (1993 draft RPA Assessment) are that softwood harvests will continue to increase at a rate faster than that projected in the South's Fourth Forest (Cubbage *et al.* 1993).

The tight timber situation in the Pacific Northwest is part of the reason for the bigger projected increases in softwood harvests in the South. But markets for southern pine lumber have also been strong in recent years on their own account. Although housing starts nationwide have been lower than during the 1970s, use of softwood lumber in repairs and renovation has grown. A good part of this growth has been in treated southern pine lumber. Even without the tight timber supplies in the Northwest, southern softwood harvests would be projected to increase.

In summary, concerns about future softwood supplies from the South are well placed. Planting pine seedlings following logging and on otherwise unused crop and pasture land has slowed from the high rates of the late 1980s, which appear to have been used as the base for projecting future planting levels. In addition, levels of future management on private forests that were assumed in making projections of future softwood timber growth may have been unduly optimistic. Finally, rapid expansion in harvesting softwoods over the past decade in response to rising market demands has put substantial pressure on southern forests.

The Southern Hardwood Situation

The situation for hardwood timber in the South is less clear than that for softwoods. For one thing, the hardwood situation has not received as much attention in Forest Service and other analyses because hardwood supply problems have not been seen as important as have softwood supply problems. In addition, the hardwood situation is more complex. There are many more species with significant differences in their characteristics than among the softwoods. The markets for hardwoods are more varied and management of hardwood forests is less well understood.

For hardwoods as a whole, the growth and drain situation in the South appears favorable. Total hardwood timber growth in the South in 1991 was 10% above that in 1970. The overall growth-drain ratio for hardwoods has been narrowing somewhat, but it was still 1.51 in 1991, about the same as for 1984 (US Forest Service 1988). For the future, some differences in projections from the South's Fourth Forest, the 1989 RPA Assessment, and the draft 1993 RPA Assessment are shown below (Cubbage *et al.* 1993).

Southern hardwood lumber production

billion board feet

Source	1984-86	1990	2000	2010
Fourth Forest	4.3	4.6	4.8	4.9
1989 RPA Assess.	4.6	—	4.0	4.1
1993 RPA Assess.	4.5	5.2	6.2	7.1

Southern hardwood pulpwood consumption

million cubic feet

Source	1984-86	1990	2000	2010
Fourth Forest	0.88	1.04	1.34	1.62
1989 RPA Assess.	1.11	—	1.73	2.27
1993 RPA Assess.	—	1.45	1.98	2.39

Production of hardwood lumber and hardwood pulpwood in the South increased significantly from 1984-1986 to 1990 and is projected to increase as substantially during the next two decades. The projections in the draft 1993 RPA Assessment are also significantly above those in the 1989 RPA Assessment. In the case of hardwood lumber, the higher numbers in the 1993 RPA Assessment may reflect some adjustment from earlier years because recent estimates show that hardwood lumber production was substantially underestimated by the Department of Commerce for a number of years up to the mid-1980s (Haynes 1988).

Southern hardwood removals (harvests)

billion cubic feet

Source	1984-86	1990	2000	2010
Fourth Forest	2.81	3.49	3.69	4.18
1989 RPA Assess.	2.93	—	3.93	3.98
1993 RPA Assess.	2.99	3.15	3.98	4.67

As in the case of southern softwoods, southern hardwood harvests are not projected to rise as quickly relative to hardwood lumber production and hardwood pulpwood consumption in the draft 1993 RPA Assessment projections as in the South's Fourth Forest projections. The differences again are striking—timber harvests in the 1993 Assessment are projected to be 8 and 12% higher in 2000 and 2010 than those in the South's Fourth Forest. But lumber production and pulpwood consumption are projected to be from 30 to 45% higher.

Although the overall growth and drain relationship for hardwood timber in the South appears favorable, it is somewhat less favorable when viewed in its particulars. Many of the hardwood forests have been scoured for years for their best species and most valuable timber. Much of what remains in these forests is suitable only for fuel and pulpwood. While these are the largest markets, and markets that have been expanding at least for pulpwood, they are also the lowest value markets.

Also, hardwood timber may be less available to the market than softwood timber for a variety of reasons. Many of the hardwood forests in the South with high-grade timber of desirable species are in the mountainous areas where logging costs are high and parts of the forest are economically inaccessible (Bechtold 1988, Cubbage *et al.* 1993). Thus, any analyses of the hardwood timber situation must reckon with the fact that some part of the timber inventory and growth may not really be available to the market.

Despite the seeming surplus of hardwood timber in the South, the South's Fourth Forest report projected that hardwood harvests in the South would exceed hardwood growth in the 1990s and continue to do at least through 2030. Although hardwood harvest levels in the South were about the same from 1952 through 1976, they went up some 24% from 1976 to 1984 (U.S. Forest Service 1988).

Markets for hardwood timber in the South have been quite strong since 1984 for a combination of reasons. One is the continuing increase in the proportion of hardwood pulp in the furnish for making paper. Another is the relatively strong export market for hardwood logs, lumber, and chips. A third is the increased use of hardwoods, often yellow poplar, in making oriented-strand board, a substitute for pine plywood. Finally, decreasing availability of western softwoods for lumber and plywood puts upward pressure on softwood timber prices in the South. This in turn makes hardwood timber more attractive as a substitute for softwoods where substitution is technically possible. All of these forces have undoubtedly exerted some upward pressure on the use of southern hardwoods.

The hardwood situation in the South is relevant for the Lake States in several respects:

- some southern hardwoods, especially those from the Appalachian region, compete directly with Lake States hardwoods in some markets, especially those for high-grade and high-value hardwood lumber;
- some southern hardwoods, especially yellow poplar and the gums, are used to make oriented-strand board that competes with the oriented-strand board made in the Lake States;
- southern hardwoods are used increasingly in making woodpulp that is used to make paper and paperboard that compete directly with that made in the Lake States;
- in the latter two cases, southern hardwoods substitute for softwoods and thereby expand the resource base, lessening upward pressure on softwood timber prices in the South and elsewhere.

Despite the various limitations on southern hardwood timber harvests, it does not appear that they are severe enough to affect substantially the ability of the South to compete in those hardwood markets for which its timber

is suited. Hardwood sawtimber prices are projected to rise above recent levels more in the western half of the South than in the eastern half (Haynes *et al.* 1993). Hardwood pulpwood prices have already risen some recently, especially in the southeastern states, as paper mills have increased the proportion of hardwood pulp in the furnish. The increase in hardwood timber prices indicates increasingly tight markets. But the implications of this tightness for the Lake States are not of great significance during the next two decades.

CANADA

The timber situation in Canada is an enigma in terms of its implications for the timber situation in the United States. It is unquestionably of great importance, but basic data for analysis are weak. Concern centers on whether timber harvests can expand sufficiently to satisfy growing US markets for imported softwood lumber, or, indeed, whether harvests may be reduced. Experts and public officials often disagree, between and among themselves, in their analyses. And, to a degree at least, markets for timber in Canada are subject to manipulation to meet political and social objectives.

Canada is an important source of wood products for the United States. Softwood lumber imports from Canada have been meeting about 30% of US consumption for the past dozen years or so. Canada has also long been a major supplier to the US of newsprint, softwood pulp, and paper. Waferboard made from aspen was produced commercially in Canada well before it was produced in the US and the initial supplies for the US market were imported from Canada.

The role of Canada in US forest products markets is changing as US forest products production also changes. The big increase in softwood lumber exports from Canada to the US over the last two decades is one measure of these changes. Two factors that pushed in this direction are investments in sawmilling that have made it possible to turn small softwood logs, of which Canada has many, into lumber profitably and a decline in the value of the Canadian dollar relative to the US dollar.

At the same time, changes in technology have allowed US mills to produce newsprint from southern pine and to use increasing amounts of low-cost hardwood fiber in making various grades of paper. Paper mills in both the US and Canada are expected to increase newsprint exports to the rest-of-the-world, while US mills are expected to gain market share at the expense of Canadian newsprint mills in the big US market (Pulp and Paper 1993). Availability of wastepaper for recycling is also likely to favor US mills. Thus, the theory of comparative advantages appears to favor marketing of Canadian softwood lumber in the US and a relative shift in exporting Canadian pulp and newsprint to markets in the rest of the world.

Forest products trade relations between the United States and Canada have been strained. United States lumber firms have filed countervailing duty suits against Canadian softwood lumber exporters three times in the last decade. They were successful in 1986, the second attempt, in imposing an initial 15% duty for 5 years. The intent of the 1986 decision was that the 15% duty be lifted as the major lumber-producing provinces increased the prices for their timber. The provinces responded in different ways. British Columbia, the biggest lumber exporter, changed its practices to conform more or less to the decision. But the US lumber producers were not satisfied and succeeded in 1992 their third attempt, in getting a 6.51% duty imposed. This is a continuing battle in which an international joint dispute panel recently (July 1993) rejected the 1992 decision pending further analysis.

At the root of the disputes with Canadian forest products producers is the way in which Canadian timber is owned and made available to forest products firms. Nearly all of the softwood timber in Canada is owned by the provinces, with the proportions increasing from the eastern to the western provinces. Cutting rights are assigned to producers in long-term tenure arrangements. At least until 1986, timber prices were arranged rather than determined in competitive auctions as they are for most public timber in the United States.

The volume of provincial timber that will be made available under these arrangements is clouded by economic and environmental factors. Some of the timber included in the provinces' allowable cut determinations is at the edge of economic merchantability. As timber values go up and down in response to changes in market demand, the volume of timber that is plausibly marketable also varies. In recent years, the potential impact of environmental constraints on logging has added to the uncertainty over the volume of timber that will actually be put on the market.

The conditions under which timber is made available in Canada should not be expected to mirror those in the United States. The forms of government are different and Canada is more thinly populated than the United States. Natural resources have a vastly more important role in the Canadian economy (Rugman and D'Cruz 1990). Timber and other resources, which are largely under the direct control of the provinces, are used to promote development of the economy and settlement of the less populated areas. These various factors must be considered in an evaluation of the Canadian timber situation.

Canada has 579 million acres of commercial forest with 903 billion cubic feet of timber (Forestry Canada 1993). This compares with 483 million acres of timberland and 756 billion cubic feet of timber in the United States (Waddell *et al.* 1989). The annual allowable cut of about 8.36 billion cubic feet is about 1.1% of the estimated timber inventory on productive, unreserved forest land. About 75% of the annual allowable cut is softwood timber and the remainder is hardwood timber (Runyon 1991).

At first glance, the annual timber harvest appears to be within the annual allowable cut based on estimates for each of the provinces. The softwood harvest in 1986 was 92.5% of the softwood allowable cut for Canada. A portion of the harvest, some 12% came from timber that was not included in the allowable cut base. The softwood harvest in 1986 in the four major timber provinces of British Columbia, Alberta, Ontario, and Quebec was well under the allowable cut when allowance is made for timber that came from timber not included in the allowable cut base (Runyon 1991).

Although the overall relation between timber harvests and the allowable cut appears to provide a considerable cushion that could allow for expansion of timber harvests, a closer look gives somewhat different results. For one thing, the allowable cut is generally greater than the "long-run sustained-yield" because the allowable cut provides for the drawdown of old-growth during the period of adjustment to the long-run sustained-yield. Second, the allowable cut calculations generally define the limits of economic merchantability based on peak market conditions. Thus, some of the allowable cut base is not economically operable in years that are below peak, at least to the extent that the estimates of merchantability are reliable indicators (Runyon 1991).

At the same time, improvements in logging and processing productivity have been reducing costs and extending the geographic limits of merchantability, as do increases in real timber prices over time. The differences between actual harvests and the biologically possible allowable cuts unrestrained by economics are substantial in all of the major provinces. Significant increases in softwood timber harvests within sustained yield constraints appear to be possible as a result of either decreased logging and silviculture costs or product price increases (Marshall 1990).

The duties placed on exports of Canadian softwood lumber to the United States have not substantially changed the volume of such exports. These exports are expected to continue to provide for about 30% of US softwood lumber consumption over the next two decades (Haynes *et al.* 1993). A portion of the cost of the duties has fallen on US consumers, who pay more for all softwood lumber as a result of the duties. In those provinces where pricing timber in long-term tenures has been adjusted so that the duties can be reduced, a portion is also covered by Canadian lumber producers, who have to pay somewhat more for timber.

A Perspective on Future Timber Supplies From Canada

"We have concluded that the greatest benefit to all British Colombians will not come from significantly reducing commercial activity in our forests, with the resultant loss of jobs, negative community impact and reduced government revenue. Rather, it will come from managing our forests better for all values" (Forest Resources Commission 1991). This statement of A. L. "Sandy" Peel, chairman of a recent British Columbia commission on the future of the province's forest resources, is characteristic of the optimistic view of the ability of the Canadian timber resource to sustain increased harvests.

The opposite view is characterized by a statement by Les Reed, a long-time observer of the timber situation in Canada. He noted that there is wide agreement in British Columbia forestry circles that saw log harvests in the province will be reduced by 20 to 25% by 1996 (Reed 1993). Reed's statement is from a short presentation to the US Forest Service in which he said that its projections of increased Canadian harvests in the 1993 draft RPA Assessment overstate the capacity of Canadian forest to support increased softwood lumber exports to US markets.

Arguments can be made to support either position, Reed's or Peel's, or some position in between. The volume of standing softwood timber in Canada is very large. How much of it will be made available for logging is a matter that will largely be decided in the political process. There are economic limits to the marketability of some of the standing timber, but these are unclear in any case and probably still subject to being adjusted.

The US Forest Service projections are for average annual harvests of softwood sawtimber in Canada that are about 11% higher in 2000 and 19% higher in 2010 than in 1986 (Haynes *et al.* 1993). The increases in Canadian harvests are about 2.8 billion board feet per year to 2000 and 4.8 billion board feet per year to 2010. As projected by the Forest Service, these increased softwood harvests are based on responses to expected increases in timber prices and are proportionately largest in eastern Canada. In effect, the timber price increases expected as a result of tight future timber supply and demand conditions in the US are projected to be large enough to expand the area of Canadian forest that can be logged economically.

Sedjo and Lyon project declining harvests in both eastern and western (British Columbia) Canada over the next two to three decades. The projected declines are greater in western than in eastern Canada as the remaining old-growth timber is depleted. They found that British Columbia, of the seven timber-producing regions of the world that they examined, was the most likely to have declines in timber harvests as competition from other regions intensifies (Sedjo and Lyon 1990).

The case for increased timber harvests in Canada is plausible. There is a considerable forest area in most provinces that is not now included in the base for calculating annual allowable cuts. In addition, current annual allowable cuts in each province appear to be set at conservative levels. Comparisons of the 1986 softwood timber harvests by province with the softwood timber inventory show that annual harvests in the western provinces are less than 1% of inventories. In New Brunswick and Nova Scotia, they are just over 2% of inventories but are about 1.1% of inventories in the other eastern provinces (Runyon 1991). Timber growth rates in managed forests generally are around 3%. For example, net annual growth of all timber in the US in 1986 was 2.98% of the total timber inventory (Waddell *et al.* 1989). In other words, annual allowable cuts in Canada could apparently be increased somewhat without threatening long-term yields, especially if there were some additional investments in timber management (Dellert 1991)

Timber is one of Canada's main natural resources, which have been the "backbone" of the country's wealth. An extension of Sandy Peel's view is that the resource industries, including timber, should be treated as the base for the Canada's industrial growth into the next century and that wealth generated by these industries should be reinvested in them (Rugman and D'Cruz 1990). This viewpoint carries some weight in a country whose unemployment rate is currently over 10% and whose forests are largely publicly owned. Although this has been at the heart of the countervailing duty suits brought by US lumber producers, the provinces have control over their resources and can make more timber available for harvesting if they so choose. The penalties for doing so are continued disputes with US lumber producers and, perhaps, a cutback in far-distant future timber harvests.

The other view, that presented by Reed, is that future timber harvests are likely to be reduced below current levels in any case, especially in British Columbia. Reed lists recent reductions, with effective dates in 1991 to 1993, in annual allowable cuts on a number of British Columbia timber supply areas and tree farm licenses, the two major tenure arrangements for provincial timber. The reductions range from 4 to 37% and average about 22%. Reed also states that parallel reductions to satisfy environmental concerns are likely to be in the same range in the provinces east of British Columbia (Reed. 1993). Forestry Canada's annual report for 1992 provides some support for Reed's view in noting that the timber harvest has reached the allowable cut for softwoods in some parts of the country and that British Columbia expects to reduce its harvests over the next few years (Forestry Canada 1993).

The matter of future harvest levels in Canada involves two main issues. Will investments in timber management be sufficient to sustain current or increased harvests? Will environmental concerns limit the forest area and timber quantities that are available for harvest?

Reed has voiced his concerns with the first of these issues for some years. The provinces, which own most of the forests, have been revising their tenure arrangements and the way in which the forests are managed. Some of this involves a shift in responsibility for specific management actions from leaseholders to the provinces. The recent "Canada Forest Accord," signed in 1992 by the provinces (except Quebec) and a variety of important nongovernment organizations, is a commitment to sustainable forests (Forestry Canada 1993). The Accord shows serious purpose, but it is not clear that the commitment to "sound forest management" will be backed by funds for reforestation and other management actions.

The impacts of environmental concerns on timber harvests, the second issue, are not easily dismissed. The potential reductions in British Columbia harvests cited by Reed would seriously affect that province's ability to export softwood lumber. The concerns appear to be fairly widespread in Canada, as shown by Forestry Canada's 1992 report. It draws attention to the same sort of environmental concerns with forests that are constraining harvests on US national forests—global warming, biological diversity, and ecosystem management (Forestry Canada 1993).

Parallels between the effects of environmental concerns in Canada and the United States should not be drawn too finely. In Canada there is apparently no legal basis for the kind of class-action lawsuits that have brought some federal timber harvests to a halt, nor are there any preemptive wildlife protection laws like the endangered species act (Webster 1991). Whether the kind of concerns noted in Forestry Canada's 1992 report will in the end outweigh concerns with employment and development of a resource-rich country is difficult to predict with any certainty. It seems likely, however, that development of the timber resource will not be halted in the near future.

BRINGING IT TOGETHER

The discussion of timber supplies from three major producing regions—the Pacific Northwest, the South, and Canada—has focused on matters particular to each region. In most cases, the analyses that underlie the discussion were based to some extent on what happens in the other regions and in some cases in other parts of the world, too. The following discussion pulls the information for the three regions together and uses the results of some multi-regional analyses to identify some implications for the Lake States of the timber supply concerns in other regions.

Interregional competition in supplying timber products is driven in the main part by economic forces. The qualification, "in the main part," is necessary because extra-market forces, mainly political, also affect timber supplies and their distribution. In particular, timber supplies from public lands, in the United States and elsewhere, are only partly determined by market forces, and trade and transportation of timber are subject to a bewildering variety of government policies and actions.

Even more bewildering than the variety of relevant government policies and actions is the complexity of the marketplace itself. Economists use some simple descriptions of market decisions—the familiar supply and demand schedules, for example. But they also understand that simulating market decisions, and then imposing on these simulations some constraints meant to describe the effects of government actions, does not begin to describe the full complexity of the marketplace.

Projections made with three models that describe the interplay of the regional timber supplies and product demand that determine timber products consumption are reviewed here. Each of the models was mentioned earlier in this report. The models are probably most useful in analyzing the effects of policy or other changes in elements of the models, but they are also used in forecasting future market conditions. Projections made with these three models are not directly comparable. To a degree, the models are intended to help explain different aspects of the timber situation. In addition, they differ in the scope of the timber-producing and consuming regions that are examined. Together, however, the results highlight several factors relevant to the future for forest resources in the Lake States.

Very recent analyses that used two of the models reflect potential recent cutbacks in timber harvests in the Pacific Northwest. The third analysis, published in 1988, does not. All three of these models find economically efficient regional timber production levels to meet regionally specified demands.

The best known and probably most widely used model is the Timber Assessment Market Model (TAMM, sometimes known as the Haynes-Adams model) developed by Richard Haynes of the Forest Service and Darius Adams, now with the University of Montana. This model was used for the policy simulations in the Forest Service's draft 1993 RPA Assessment, the 1989 Assessment, and the Clinton administration's proposed plan for the "owl forests" in the Pacific Northwest. The main features of the model and its specifications as used in the draft 1993 RPA Assessment (Haynes *et al.* 1993) are:

- timber harvests are modeled for US regions and softwood harvests for Canadian regions, but trade with other regions of the world is estimated separately;
- softwood and hardwood harvests are modeled separately, but linked with assumptions about substitution;
- harvests on federal lands are assumed to be much lower in the next two decades than in the 1980s, but not quite as low as indicated in the Clinton administration's plan for the "owl forests;"
- the level of wastepaper recycling in the US is estimated to reach 45% by 1995 (from 21% in 1986) and then stay at that level.

The resulting timber harvest projections for the next two decades are driven by the expected drop in federal timber harvests in the West and the projected increase in wastepaper recycling. Softwood timber prices are projected to rise sharply, but how much consumption will fall as a result of the price increases is not clear. Projected timber harvests by region are as follows.

Softwood and hardwood timber harvests

million cubic feet

Year		PNW	Other West	South	North	Total
1986	Softwoods	3,239	1,799	5,317	908	11,263
	Hardwoods	145*	57	2,931	3,190	6,323
	Total	3,384	1,856	8,248	4,098	17,586
1991	Softwoods	3,179	1,937	5,117	947	11,181
	Hardwoods	262*	25	2,982	3,560	6,828
	Total	3,441	1,962	8,099	4,507	18,009
2000	Softwoods	2,144	1,483	5,802	1,237	10,666
	Hardwoods	319*	24	3,697	4,034	8,074
	Total	2,463	1,507	9,499	5,271	18,740
2010	Softwoods	2,060	1,501	6,126	1,477	11,164
	Hardwoods	363*	34	4,323	4,428	9,148
	Total	2,423	1,535	10,449	5,905	20,312

*Includes California and Alaska

In addition to increased wastepaper recycling, the projected drop in federal timber harvests in the West is projected to be made up through:

- increased softwood lumber imports from Canada, from 11.3 billion board feet in 1991 to 14.8 billion board feet in 2000 and to 16.4 billion board feet in 2010;
- a big percentage increase in softwood harvests in the North, by 31% from 1991 to 2000 and by 56% from 1991 to 2010;
- some increase in softwood harvests in the South, by 13% from 1991 to 2000 and by 20% from 1991 to 2010;
- a big increase in hardwood harvests, by 18% from 1991 to 2000 and by 34% from 1991 to 2010.

The drop in projected timber harvests from federal lands in the West puts strong upward pressure on timber prices throughout the US and in Canada, too. If softwood timber prices increase to the extent projected in the 1993 draft RPA Assessment, the projections of increased softwood lumber imports from Canada and the sharp increases in hardwood timber harvests may be possible. Some of the projected US regional timber price increases are:

Projected softwood timber price increases

percent increase from 1991 Base

To	North	South	N. Rockies	S. Rockies	PNW West	PNW East	PSW
2000	73	80	274	87	17	93	60
2010	179	101	325	115	38	87	73

Projections of timber price increases in past RPA Assessments have been on the high side for the Rocky Mountain regions and the North. If the new projections are accurate, timber prices in the above tables would mark a distinct departure from the trend lines over the past three decades or so. On the other hand, the drop in projected federal timber harvests is also a distinct departure from the past.

Especially in the case of Canada, sharp increases in timber prices in the US could make additional areas economic for logging. Real timber prices in much of Canada are apparently close enough to the margin of merchantability that a price increase of a few dollars per thousand board feet would make a real difference. The percentage increases in the US represent changes that are also large in absolute dollar terms. This may be what has driven the Assessment model to project the increases in Canadian softwood and US hardwood harvests.

The second model is the CINTRAFOR Global Trade Model (CGTM) developed at the University of Washington. Its most recent relevant use was for a paper that examined the effects of a major drop in Pacific Northwest timber harvests (similar to those in the Clinton administration's proposed plan for the "owl forests") and a parallel drop in British Columbia timber harvests (Perez-Garcia. 1993). The main features of this model and its specifications as used in the indicated analysis are:

- timber harvests are modeled for softwood timber in 5 US, 3 Canadian, and 12 rest-of-the-world regions;
- production, consumption, prices, and trade are projected for 8 forest products in 43 timber supply and 33 final product demand regions around the world;
- a base case used for comparisons reflects the softwood timber situation prior to 1990, which included a modest reduction in harvest levels in the US Pacific Northwest due to then-extant spotted owl rules;
- an "alternative case" based on a 4 billion board feet reduction in western federal timber harvests (about the same as the Clinton administration's plan for the "owl forests") and a 4 billion board feet cutback in British Columbia;
- a second alternative that tests for sensitivity to an increase in log exports from Siberia.

This model is more complex than the TAMM model used by the Forest Service in that it includes more timber supply and product demand regions. Although this is an advantage in some ways, it also places much greater demands on available data that describe the many markets. On the supply side, this model is less detailed than the TAMM model, which has very large data requirements.

In the base case, the CINTRAFOR Global Trade Model projects substantially higher log costs, and presumably proportionately even greater increase in timber prices, in all timber supply regions. Increased log costs in the Pacific Northwest of 20% and in the South of 60% are more or less consistent with the timber price increases in the 1993 RPA Assessment. The CGTM also projects that log costs in British Columbia will increase 90%, which tends to support the idea that increases in US timber prices will be reflected in greater proportionate increases in Canada. Log prices increase even more in the alternative case involving the big cutbacks in western US and British Columbia timber harvests, as one would expect.

One interesting result of this model, which is only implicit in the reported results in the 1993 RPA Assessment, is that the price increases resulting from cutbacks in federal timber harvests, as well as from cutbacks in harvests in British Columbia, will lead to cutbacks in consumption of softwood products. Another interesting result is that softwood log exports from Siberia, if this becomes an economic reality, could moderate the impacts of cutbacks in the Northwest and British Columbia substantially.

The third model was developed by Sedjo and Lyon at Resources for the Future, an independent research organization in Washington, DC. Its main features and specifications for the analyses in this book are (Sedjo and Lyon 1988):

- models specifically the transition from old-growth to second-growth forests;
- models three kinds of forests, unmanaged natural, managed natural, and plantation;
- lumps softwoods and hardwood together as industrial wood (assumes ready substitution among species group);
- models seven market-responsive timber supply regions—South, PNW, western Canada (British Columbia), eastern Canada, Nordic Europe, Asia-Pacific, and the emerging region (Brazil, Chile, Venezuela, New Zealand, Australia, South Africa, Spain, Portugal)—and defines three non-market-responsive timber supply regions—Soviet Union, other Europe, all other;

- assumes a modest rate of increase in demand for industrial wood from current bases by region;

- aims at long-run solutions and implications.

Three results of using this model are particularly interesting. One is that the base case projections of harvests are well below those of the UN Food and Agriculture Organization and the World Bank. Even the harvests forecasted with a high growth demand assumption are below those of the other two organizations. The second is that future timber prices are projected to increase at a rate of only 0.2% in the base case, which is much lower than the rates found in a study by IIASA, the International Institute for Applied Systems Analysis. The third is that over the next two decades or so the South continues as the dominant timber supply region and the "emerging" and Nordic regions increase their roles (Sedjo and Lyon 1988).

The authors note that the slow rate of increase in timber prices in their study can be attributed to: a slower increase in demand for industrial wood than assumed in other studies; greater supply response to increased prices both in investments in silviculture (plantation forestry) and in bringing new regions into the market; and greater response to technological change. One might add that lumping softwoods and hardwoods implicitly assumes that new regions will become economic and that technological change will occur. The assumption that hardwoods can be readily substituted for softwoods is critical.

One other point seems clear in the Sedjo-Lyon analysis. Neither the Pacific Northwest nor western Canada (British Columbia) are major forces in the world timber economy once the effects of the ongoing cutbacks have been absorbed. This is largely the result of a limited area of high-productivity land with good access. The best opportunities for investments are in the "emerging" region and in the US South. Eastern Canada is expected to provide a larger timber harvest in the long run than British Columbia.

The Sedjo and Lyon model is less ambitious in the details of its description of the world timber economy than the CINTRAFOR model. Also, the book was not timely to the extent that it came before the most recent round of cutbacks in federal timber harvests in the West. Nevertheless, the forecasts of slower rates of increase in both timber harvests and timber prices than in the two other reports described here cannot be dismissed. Especially the timber price forecast fits well with past timber price trends.

Implications for the Lake States

Adjustments in the timber economy to the cutbacks in federal softwood timber harvests in the West will take some time. These will take even more time if timber harvests in Canada are limited to meet environmental objectives. The Lake States have, in effect, a window in which to make their own adjustments. The following points appear to be most relevant.

- The place of western federal timber harvests in the US timber economy is big enough that the cutbacks in harvests will push prices up for softwood sawtimber throughout the country. But over the next decade or two, the pressure will be lessened as a result of supply responses, including those created by changes in technology and the substitution of hardwoods for softwoods in various uses. The level at which timber prices will be more or less stable will be higher than in 1991 but not as high as projected by the Forest Service.

- Restrictions on timber harvests in Canada will probably limit softwood lumber exports to the US somewhat, but higher timber prices and the recognition in Canada that its economy is still tied to natural resources will offset the restrictions by expanding the area that is now available for harvesting.

- The timber resource for producing high-grade old-growth softwood lumber and plywood will no longer be available for logging in the US and perhaps in Canada, too. The normal market response, as in the past with waferboard and more efficient sawmills, will be technological adaptations based on wood as a relatively inexpensive raw material.

- Pressure on southern softwood timber supplies as a result of increased harvests will not be severe enough to cause major timber price increases. The South will continue to be the region that competes most directly with the Lake States in markets for waferboard/OSB, woodpulp, and paper.

- Even though the prospects for low-cost wood supplies from what Sedjo and Lyon call the "emerging" region are good, timber from this region is most likely to be used in other regions of the world over the next decade or so. Its effect on the Lake States will be mainly through its impacts on markets for southern pine and western softwoods especially in Pacific Rim markets. Some may also find its directly into US markets where it could substitute for western softwoods in millwork.

These implications for the Lake State are clearly speculative and provisional. They appear to be reasonable based on the studies that were reviewed for this report. Perhaps the appropriate description is that they are "arguable" and proper for a draft report.

They emphasize the importance of technological adaptation to changing markets. They also suggest that some caution be used with respect to projected timber price increases that do not sufficiently reflect the opportunities for technological adaptations.

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Timber Supply and Market Trends in the Lake States

J. Michael Vasievich, Karen Potter-Witter, and Larry A. Leefers[1]

INTRODUCTION

Sustaining timber supply from Lake States forests is important for non-industrial private land owners, forest-products industries, public agencies, and citizens in general. Timber harvesting has long been recognized as an appropriate means of changing ecosystems to provide desired outputs, whether they be timber products, habitat for wildlife, or to achieve a specific desired condition. This paper describes several dimensions of timber supply in the Lake States. Much of the information presented was derived from data compiled in recent surveys conducted by the USDA Forest Service's Forest Inventory and Analysis unit in cooperation with the States.

Several factors that affect timber supply must be examined before long term supply potentials can be fully analyzed. Among the factors to consider are: timberland area by ownership and forest cover type, growing stock volume, recent timber growth and removals, pulpwood and sawlog production trends, price trends, and factors affecting future timber harvests. Analysis of these factors provides an historic and current context for timber supply in the Lake States. It also provides a first step in examining future supply scenarios.

The timber resources of the Lake States are significant in terms of area, volume, and growth. There are concerns, however, about the future management direction of our public and private forests. A more detailed analysis of future supply scenarios is beyond the scope of this paper, but is being completed by the authors. The more detailed analysis considers multiple ownerships and forest types on a subregional basis.

TIMBERLAND AREA AND TIMBER VOLUMES

There are 47.4 million acres of timberland[2] in the Lake States according to the most recent forest inventories: 18.6 million in Michigan, 13.8 million in Minnesota, 14.9 million in Wisconsin (Tables 1-3). Timberland area and volume varies by forest types and ownership across the Lake States.

Forest Types

The most abundant Lake States forest types are maple-beech-birch, aspen, oak-hickory, and elm-ash-soft maple (Figure 1). Together, these four types account for 70% of Lake States timberland. The maple-beech-birch type is the largest, comprising 27% of the timberland. Aspen-birch is 22% of Lake States timberland. Northern white-cedar and black spruce are the most common softwood types, and together they compose just under 10% of the timberland. In Michigan and Wisconsin, the red pine type is more common than black spruce, however. The remaining Lake States timberland is either in one of the six other forest types or is classified as nonstocked. Many of these forests developed after the massive harvesting that occurred near the turn of the century and are now maturing.

Ownership

Timberland ownership is 62% private and 38% public based on the most recent surveys in each State[3] (Figure 2). The largest ownership class, non-industrial private and farms, contains 55% of the region's timberland. This class is composed of land held by farmers and private owners other than forest industry. Regionally, non-industrial private ownership is concentrated in Wisconsin and Michigan which have 19 of the 25 million acres of non-industrial private land in the region.

States are the major public timberland owners, with 15% of the timberland region-wide. State natural resource management agencies administer 7.2 million acres of state forests, game areas and recreation areas. Federal lands, primarily managed by the USDA-Forest Service, comprise 13% of Lake States timberland. The 5.6 million acres of the National Forest System lands make up the majority of this ownership. Minnesota and Wisconsin also have sizable county and municipal forests which, together with Michigan, comprise 10% of the Lakes States forest. Forest industry ownership is 7.2% of timberland, with Michigan and Wisconsin having higher concentrations.

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[1] The authors are Project Leader, USDA Forest Service, North Central Forest Experiment Station, and Associate Professors, Department of Forestry, Michigan State University, East Lansing, MI.

[2] Timberland is defined as forestland capable of producing at least 20 cubic feet of merchantable timber annually and not otherwise legally reserved.

[3] The most recent survey was completed in 1993 for Michigan, in 1990 for Minnesota, and in 1983 in Wisconsin.

Table 1.—*Area of timberland in Michigan by forest owner and cover type in thousands of acres based on 1993 forest survey*

	National Forest	Indian	Other. federal	State	County-Munic.	Forest industry	Farmer	Oth pvt. -corp.	Oth pvt. -indiv.	All owners
	thousand acres									
Jack pine	208	—	15	329	16	7	—	44	112	731
Red pine	323	—	4	240	20	22	5	56	229	897
White pine	42	—	1	63	—	5	12	36	76	234
Scotch pine	—	—	—	4	2	1	5	10	93	115
Balsam fir	91	—	5	113	7	91	5	76	176	563
Black spruce	90	—	—	143	3	67	2	44	117	465
Northern cedar	145	2	—	363	17	196	21	123	484	1,349
Tamarack	20	—	—	41	5	13	—	18	52	149
White spruce	40	—	—	26	—	10	1	20	50	147
Oak-hickory	272	—	—	422	33	10	105	169	972	1,982
Elm-ash-soft maple	109	2	—	226	21	55	146	176	892	1,627
Maple-beech-birch	835	9	12	969	109	868	332	934	3,092	7,161
Aspen	329	1	11	671	23	127	63	291	1,158	2,676
Paper birch	19	1	1	75	—	25	7	50	114	292
Balsam poplar	21	—	—	28	—	18	17	12	94	190
Nonstocked	—	—	—	16	1	—	2	3	17	39
All types	2,542	15	50	3,728	256	1,514	723	2,062	7,726	18,616

Table 2.—*Area of timberland in Minnesota by forest owner and cover type in thousands of acres based on 1990 forest survey*

	National Forest	BLM	Indian	Other federal	State	County-Munic.	Forest industry	Farmer	Oth pvt. -corp.	Oth pvt. -indiv.	All owners
	thousand acres										
Jack pine	74	2	6	5	93	70	51	31	11	98	442
Red pine	108	1	13	5	51	40	28	7	5	45	302
White pine	15		2	1	6	5	6	5	5	19	63
Scotch pine	—	—	—	—	—	—	1	—	2	3	6
Balsam fir	191		13	1	151	156	71	34	36	87	739
Black spruce	249	10	42	9	562	206	63	33	38	111	1,322
Northern cedar	92	2	61	8	288	112	47	11	15	45	681
Tamarack	32	1	44	5	322	123	9	44	18	107	705
White spruce	28	1	3		17	14	12	2	2	16	94
Oak-hickory	11	—	8	42	106	58	7	576	45	332	1,184
Elm-ash-soft maple	59	2	40	19	200	214	66	282	52	359	1,292
Maple-beech-birch	114		42	24	131	187	51	436	60	358	1,403
Aspen	651	6	161	36	880	1,025	283	613	244	1,215	5,114
Paper birch	168	—	32	8	108	195	35	57	55	177	836
Balsam poplar	21	—	16	5	106	76	21	74	22	87	428
Nonstocked	9	1	10	3	57	24	2	28	5	25	164
All types	1,821	26	491	172	3,078	2,506	751	2,232	613	3,084	14,773

Table 3.—*Area of timberland in Wisconsin by forest owner and cover type in thousands of acres based on 1983 forest survey*

	National Forest	Indian	Other. federal	State	County Munic.	Forest industry	Farmer	Oth pvt. -corp.	Oth pvt -indiv.	All owners
	thousand acres									
Jack pine	49	6	16	30	123	66	45	19	140	493
Red pine	86	13	12	43	97	62	46	47	198	603
White pine	15	21	10	7	22	19	42	19	76	231
Scotch pine	—	—	—	—	—	—	—	—	2	2
Balsam fir	40	4	2	26	63	38	19	7	82	282
Black spruce	63	4		27	84	44	43	19	164	447
Northern cedar	74	20		21	58	38	66	16	134	427
Tamarack	14	2	2	22	23	14	41	16	87	222
White spruce	28	—	—	—	4	8	4	2	13	58
Oak-hickory	57	14	49	65	239	84	1,230	141	993	2,872
Elm-ash-soft maple	50	13	28	62	195	91	379	63	474	1,354
Maple-beech-birch	466	181	14	120	512	471	919	167	1,323	4,173
Aspen	256	62	40	127	606	195	434	105	914	2,738
Paper birch	44	6	4	19	132	36	160	44	246	691
Balsam poplar	—	—	—	—	9	—	4	4	6	22
Nonstocked	2	11	7	10	39	14	90	18	113	305
All types	1,245	356	184	580	2,206	1,179	3,522	684	4,965	14,921

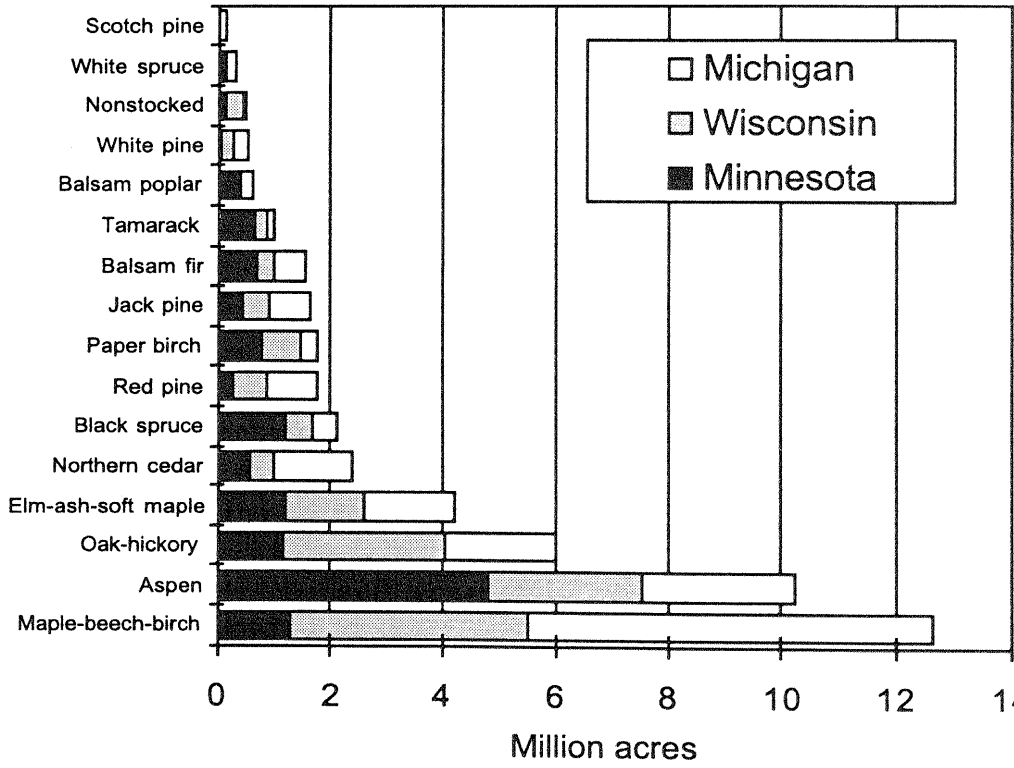

Figure 1.—*Area of timberland in acres by forest type in the Lake States.*

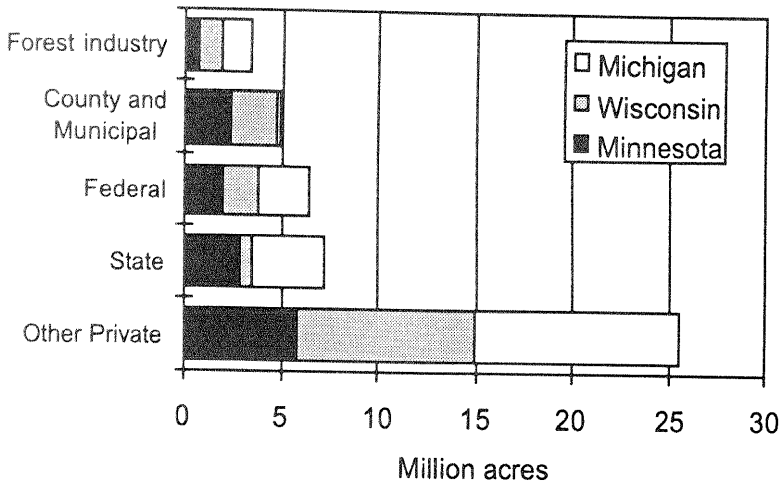

Figure 2.—*Area of timberland in acres by ownership in the Lake States.*

Growing Stock Volume

The Lake States growing stock volume[4], based on the most recent surveys for each state, is 56 billion cubic feet (Table 4). Hardwood types dominate the inventory with 78%) of the total growing stock volume (Figure 3). The maple-beech-birch forest type has 33% of the total growing stock volume. The remaining 22% of the inventory volume in softwood is primarily northern cedar, red pine, and jack pine.

GROWTH AND REMOVALS ON TIMBERLAND

Growth and removals of timber provide a coarse measure of the sustainability of timber production. Average annual gross growth for the Forest Inventory and Analysis (FIA) survey is determined by the difference between the standing timber volume in the previous inventory cycle and the volume in the current cycle divided by the number of years between cycles. Net volume growth, the average annual growth minus mortality, is considered to be available for harvest without depleting the stock of timber. Comparing net growth to removals (or drain) yields a simple measure of the sustainability of a timber resource. A growth/drain ratio less than one indicates depletion over the last period. A ratio greater than one indicates an expansion of timber inventory. Net annual growth, average annual growing stock removals and growth/drain ratios for the past two FIA surveys are presented in Tables 5, 6, and 7, respectively. Overall the total growth to removal ratio in the most recent surveys for the Lake States is 2.1. This is a very favorable ratio; however resource conditions vary by ownership, location, and species. Ratios also represent all growing stock volume and do not fully account for lands that may be withdrawn from timber harvest for management or policy reasons.

Although not reported here, another comparison of growth to removals can be made with current annual growth and current removals. Current annual growth is the growth for the year of the inventory cycle and is an estimate of the present growth rate. Current growth estimates can be compared to current timber production estimates published in the Timber Products Output series published by the USDA Forest Service for each state. The current relationship of growth to removals can be notably different than that of the average annual relationship over the previous inventory cycle.

[4] Growing stock volume includes trees at least 5 inches in diameter at breast height with merchantable volume measured from 1 foot above the ground to a top diameter of 4 inches, net of rot or other defects that reduce the yield for timber products

Table 4.—*Volume of growing stock on timberland by state and total Lake States in million cubic feet*

	Michigan, 1993	Minnesota, 1990	Wisconsin, 1983	Lake States
Maple-beech-birch	11,462	1,561	5,474	18,498
Aspen	3,059	4,917	2,390	10,367
Oak-hickory	2,853	1,292	3,185	7,330
Elm-ash-soft maple	1,985	1,098	1,345	4,428
Northern cedar	1,928	665	589	3,182
Red pine	1,397	471	1,058	2,926
Paper birch	466	965	839	2,270
Jack pine	575	509	454	1,539
Balsam fir	613	681	155	1,449
Black spruce	308	694	440	1,441
White pine	382	109	411	902
Tamarack	94	366	132	591
Balsam poplar	206	350	19	575
White spruce	160	91	108	359
Scotch pine	109	5	2	116
Nonstocked	1	6	4	10
All types	25,598	13,779	16,604	55,981

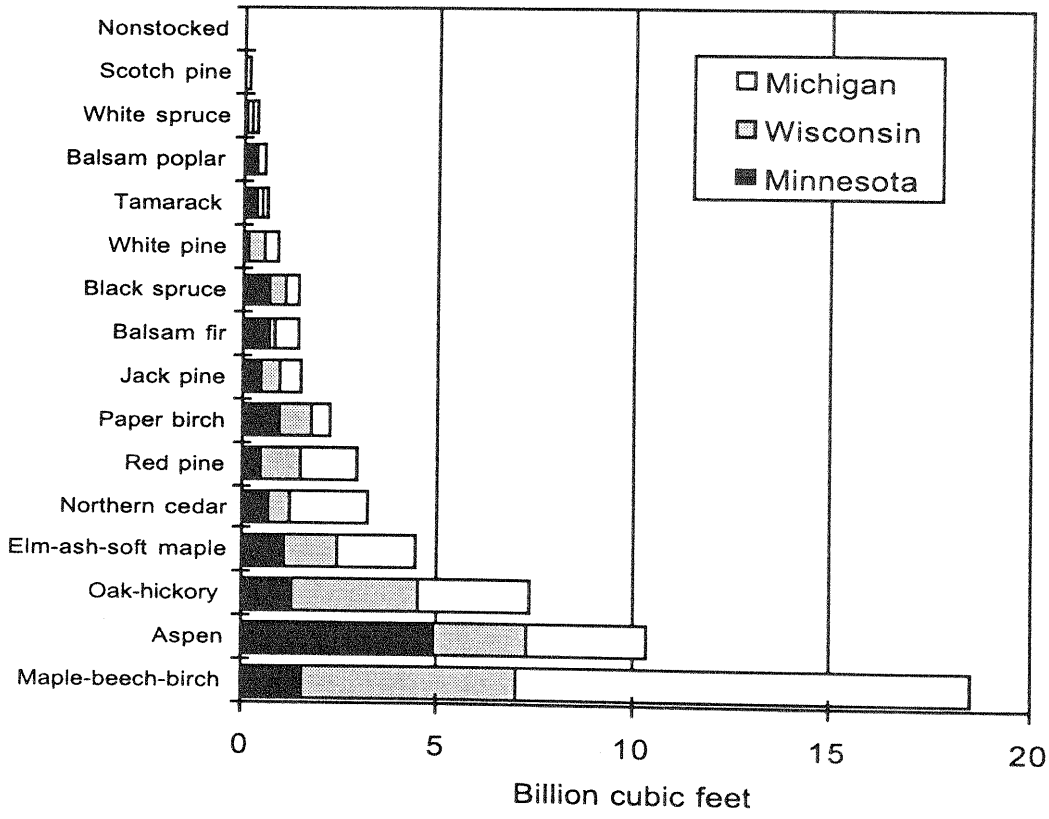

Figure 3.—*Growing stock volume by forest type in the Lake States, 1992.*

Table 5.—*Average net annual growth, all species on timberland, million cubic feet, by ownership*

State	Survey years	National Forest	State	County	Forest industry	NIPF	All owners
Michigan	1966-1979	89.5	133.8	7.8	80.5	364.5	677.8
Michigan	1980-1992	92.8	141.8	11.3	53.1	462.0	763.6
Minnesota	1962-1976	50.9	63.1	54.2	15.9	146.2	330.3
Minnesota	1977-1989	49.9	64.0	67.0	19.0	152.9	369.8
Wisconsin	1956-1967	52.9	NA	NA	49.0	278.6	500.1
Wisconsin	1968-1982	47.9	18.0	74.8	42.1	292.3	491.2

Table 6.—*Average annual growing stock removals, million cubic feet per year, by ownership*

State	Survey years	National Forest	State	County	Forest industry	NIPF	All owners
Michigan	1966-1979	27.2	33.9	1.0	30.9	181.3	274.6
Michigan	1980-1992	39.2	52.5	4.1	36.9	137.8	270.5
Minnesota	1962-1976	16.4	34.1	18.4	15.2	104.3	188.4
Minnesota	1977-1989	36.4	33.0	37.9	18.7	79.3	210.1
Wisconsin	1956-1967	20.7	NA	NA	35.2	145.1	233.2
Wisconsin	1968-1982	17.3	5.4	41.4	29.0	182.7	285.0

Table 7.—*Growth/drain ratios for growing stock volume of all species from two most recent forest surveys*

State	Survey years	National Forest	State	County	Forest industry	NIPF	All owners
Michigan	1966-1979	3.3	3.9	7.6	2.6	2.0	2.5
Michigan	1980-1992	2.4	2.7	2.8	1.4	3.4	2.8
Minnesota	1962-1976	3.1	1.8	3.0	1.0	1.4	1.4
Minnesota	1977-1989	1.4	1.9	1.8	1.0	1.9	1.8
Wisconsin	1956-1967	2.6	NA	NA	1.4	1.9	2.1
Wisconsin	1968-1982	2.8	3.3	1.8	1.5	1.6	1.7

TIMBER REMOVALS AND PRODUCTION TRENDS

A second source of data for timber removals, in addition to the forest survey, is the annual pulpwood production reports and periodic sawtimber production reports from the USDA Forest Service[5]. While not strictly comparable to FIA data, they do provide more frequent trend information on short-term production rates by species and location. Unfortunately, these data cannot be separated by ownership.

Pulpwood Production

Pulpwood production in the Lake States was 8.7 million cords in 1993, with each state producing approximately one-third of the total (Table 8). This production is 2.22 times that of 1970. Total pulpwood production increases among the states have been largely parallel for the past 23 years for which output data are available (Figure 4). These production trends reflect why average figures may be misleading in calculating growth to removal ratios. Current removals are generally higher than average removals for the most recent FIA cycles.

[5] Timber product output reports are published by the North Central Forest Experiment Station and included in the list of references. For example, see Hackett and Piva (1994) and Hackett and Pilon (1993).

Table 8.—*Production of pulpwood in the Lake States, 1993*

	Michigan	Minnesota	Wisconsin	Lake States
	thousand cords			
Aspen	1,142	2,185	1,129	4,455
Jack pine	296	128	393	817
Hard maple	342	1	247	590
Soft maple	289	20	185	493
White birch	177	42	246	465
Balsam fir	101	199	61	361
Red pine	67	26	267	360
Spruce	67	158	34	259
Red oak	114		95	209
Balsam poplar	42	92	4	138
Other hardwoods	206	2	213	421
Other softwoods	66	5	63	134
All species	2,909	2,857	2,937	8,703

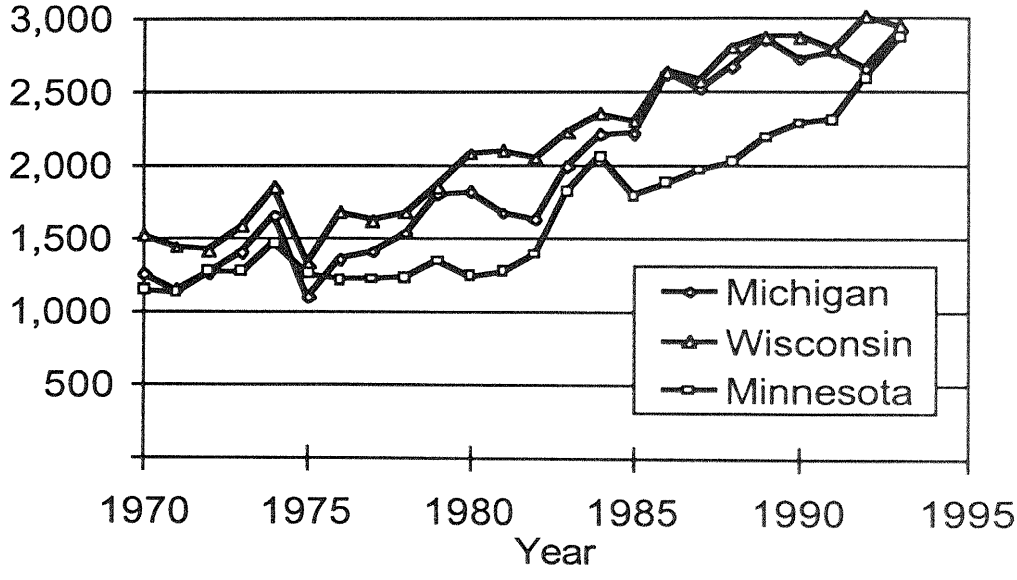

Figure 4.—*Total pulpwood production trends in the Lake States, 1970-1993.*

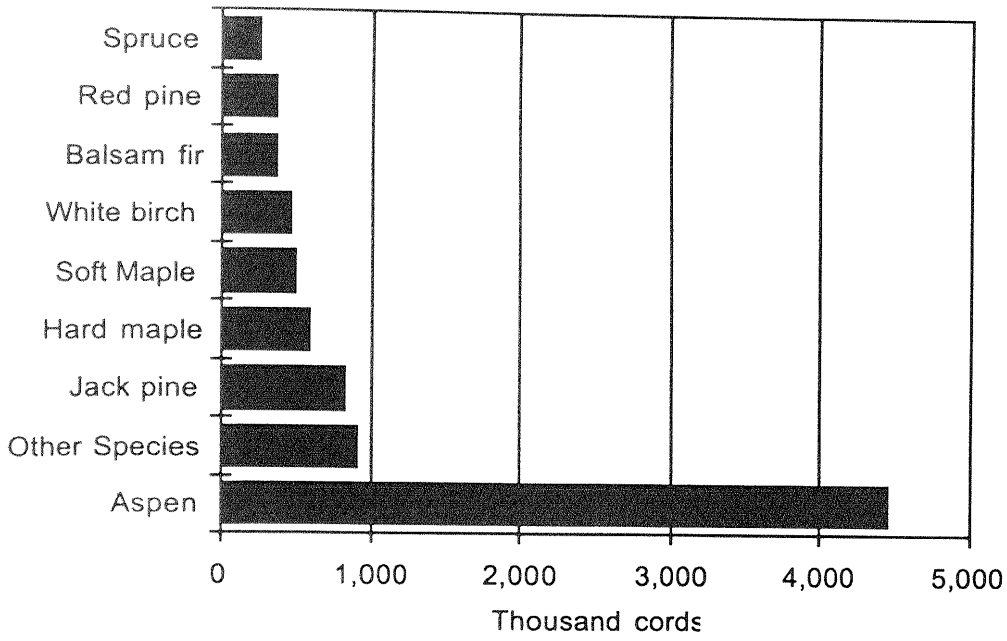

Figure 5.—*Total pulpwood production by species in the Lake States, 1993.*

Hardwoods

Aspen dominates Lake States pulpwood production with 1993 production at 4.45 million cords or about 51% of the total pulpwood produced (Figures 5, 6a). Minnesota's production of 2.2 million cords is twice that of Michigan's and Wisconsin's aspen production. Minnesota's aspen output also increased at a higher rate than did the other states, 5.9% per year from 1970 to 1993, while Wisconsin and Michigan production increased 2.8% and 3.3%, respectively

Hard maple is the second most important hardwood pulpwood species in the Lake States with output of 590 thousand cords in 1993. Michigan production was 344 thousand cords. Output in both Michigan and Minnesota increased steadily since 1973; at 10.0% and 7.0% annually, respectively (Figure 6b). Minnesota hard maple pulpwood production is negligible. Soft maple production also is concentrated in Michigan with 289 thousand cords of the total 473 thousand cords of 1993 Lake States production. Output has risen steadily from Michigan and Wisconsin (Figure 6c).

White birch pulpwood production increased dramatically from 109 thousand cords in 1971 to 465 thousand cords in 1993. Almost half this production was in Wisconsin (Figure 6d). Production of red oak pulpwood fell from a high of 385 thousand cords in 1974 to 209 thousand cords in 1993.

Softwoods

More than twice as much jack pine pulpwood is produced than any other softwood with 1993 output at 817 thousand cords. Wisconsin produces almost 400 thousand cords and Michigan almost 300 thousand cords (Figure 7a). Balsam fir is second in Lake States softwood pulpwood production with 361 thousand cords produced in 1993. Just under 200 thousand cords of this were produced in Minnesota (Figure 7b).

The majority of the red pine production is from Wisconsin which produced 267 thousand cords of the total 360 thousand cords of output. Production showed steady increases from 1974 to 1990 at an annual rate of 7.2%. Output had reached a high of 404 thousand cords in 1991, more than double the 1973 level (Figure 7c). Spruce pulpwood production has remained the most steady of the softwoods. Output in 1993 was 259 thousand cords and 248 thousand cords in 1970. Minnesota is the source for most spruce pulpwood—178 thousand cords in 1993 (Figure 7d).

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Contains 21 technical working papers prepared for the Lake States regional forest resources assessment, Lake States Forestry Alliance 1995. They represent significant contributions from many individuals and organizations and form the technical background for the Assessment.

KEY WORDS: Economic development, forest resource trends, sustainable development, Michigan, Minnesota, Wisconsin, timber supply, employment, tourism, forest products, economic opportunities.

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.

NORTH CENTRAL FOREST EXPERIMENT STATION