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Minnesota's Forest Resources in 2002

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The North Central Research Station's Forest Inventory and Analysis (NCFIA) program began fieldwork for the sixth forest inventory of Minnesota's forest resources in 1999. This inventory initiated the new annual inventory system in which one-fifth of the field plots (considered one panel) in the State are measured each year. A complete inventory consists of measuring and compiling the data for all plots (or five panels). Once all panels have been measured, each will be remeasured approximately every 5 years. For example, in Minnesota, the field plots measured in 1999 will be remeasured in 2004.

In 2002, NCFIA continued the annual inventory effort with the fourth panel of the sixth forest inventory. Reports of previous inventories of Minnesota are dated 1936, 1953, 1962, 1977, and 1990. This sixth inventory of Minnesota's forest resources will be completed in 2003. However, because each year's sample is a systematic sample of the State's forest and because timely information is needed about Minnesota's forest resources, estimates have been prepared from data gathered during the first 4 years of the inventory. Data presented in this report represent 80 percent of the field plots (or four panels) for a complete inventory and are a combination of the first year's panel from 1999, the second year's panel from 2000, the third year's panel from 2001, and the fourth year's panel from 2002. Earlier reports for the 1999 panel (Schmidt 2000), the combined 1999 and 2000 panels (Haugen *et al.* 2002), and the combined 1999 through 2001 panels (Miles *et al.* 2003) have also been published. Results presented are estimates based on sampling techniques—estimates were compiled assuming the 1999, 2000, 2001, and 2002 data represent one large sample. The precision of the estimates will increase and additional data will be released when the final annual inventory is completed in year 5.

Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. However, for the comparisons to be valid, the procedures used in the two inventories must be similar. As a result of our ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have occurred since the last Minnesota inventory in 1990 (Miles *et al.* 1995) (see appendix). While these changes will have little impact on statewide estimates of forest area, timber volume, and tree biomass they may have significant impacts on plot classification variables such as forest type and stand-size class. Some of these changes make it inappropriate to directly compare 2002 data tables with those published for 1990.

RESULTS

Area

The total land area of Minnesota is 50.9 million acres of which 32 percent or 16.3 million acres are forest land (table 1). There are three components to forest land: 1) Timberland[1] — forest land that is not restricted from harvesting by statute, administrative regulation, or

[1] Timberland may not be equivalent to the area actually available for commercial timber harvesting or other access. The actual availability of land for various uses depends upon owner decisions that consider economic, environment, and social factors.

designation and is capable of growing trees at a rate of 20 cubic feet per acre per year; 2) Reserved forest land—land that is restricted from harvesting by statute, administrative regulation, or designation (i.e., national parks, wilderness areas, etc.); and 3) Other forest land—low-productivity forest land that is not capable of growing trees at a rate of 20 cubic feet per acre per year.

The estimated area of forest land declined from 16.7 million acres in 1990 to 16.3 million acres in 2002. During the same period timberland showed a slight increase from 14.7 million acres in 1990 to 15.0 million acres in 2002 (fig. 1)[2]. The decrease in forest land and the increase in timberland are due largely to changes in the reserved and other forest land components. The estimate of reserved forest land decreased from 1,117 thousand acres in 1990 to 938 thousand acres in 2002, and the area estimate of other forest land decreased from 840 thousand acres to 375 thousand acres. Nearly half of this acreage decrease was due to conversion to non-forest land and the other half was due to conversion to timberland. The net effect was a decrease in the area estimate for forest land and an increase in the area estimate for timberland.

The estimate of forest land in public ownership remained relatively unchanged over the period (fig. 2). The public timberland estimate, however, increased from 7.6 million acres in 1990 to 8.1 million acres in 2002 with a corresponding decline in the area of other and reserved forest land (table 2).

Private ownership declined from 7.1 million acres to 6.9 million acres over the period. Over four-fifths of all private timberland is in the hardwood forest types. Nearly four-fifths of all conifer forest types are found on publicly owned land.

The aspen-birch forest type, with 6.5 million acres of timberland (table 3), is the dominant forest type in the State (fig. 3) and is an important resource for Minnesota's forest industries. Three-fourths of all the coniferous timberland in the State is in the spruce-fir forest type (3.2 million acres). Between inventories, the estimate of hardwood forest

[2] *The error bar atop each bar in figure 1 provides a measure of reliability of these figures. In 2002 there was a two out of three chance that if a 100-percent inventory had been taken, using the same methods, the result would have been within the limits indicated by the bar—15,029.7 thousand acres plus or minus 120.2 thousand acres.*

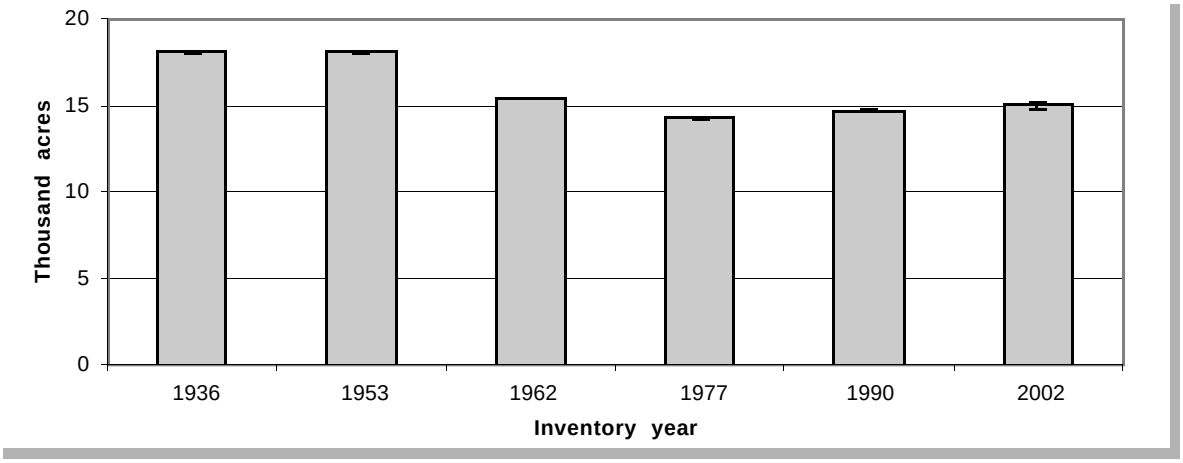

Figure 1. — Area of timberland in Minnesota by inventory year.

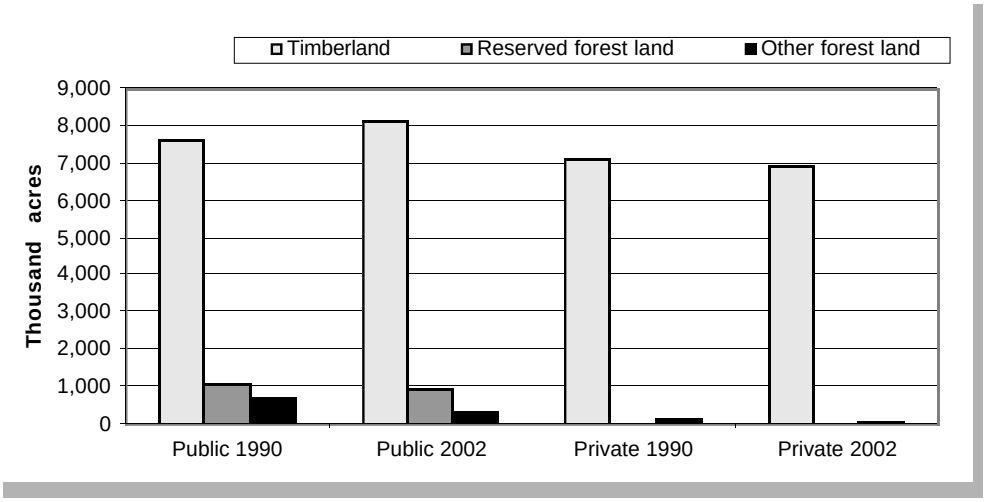

Figure 2. — *Area of forest land in Minnesota by forest land component, owner category, and inventory year.*

types increased from 10.2 million acres in 1990 to 10.8 million acres in 2002, while the estimate for conifer forest types decreased from 4.4 million acres in 1990 to 4.1 million acres in 2002. This appears to be the result of new stocking and forest typing algorithms used in conjunction with a new plot design rather than a change in species composition because roughly 31 percent of the State's growing-stock volume was in softwood tree species in both 1990 and 2002.

The stand-size class algorithm used in the 1990 inventory placed greater emphasis on large trees than the algorithm used in the 2002 inventory. This partially explains the increase in the area estimate of timberland in small- and medium-diameter stands (fig. 4) and the decrease in the area of large diameter stands (stands where a plurality of the stocking is in trees at least 9 inches d.b.h. for conifers and 11 inches d.b.h. for hardwoods).

Volume

Historically, volume has been reported as either growing stock or sawtimber. However, volumes in noncommercial trees, rough trees, and rotten trees do not qualify as growing

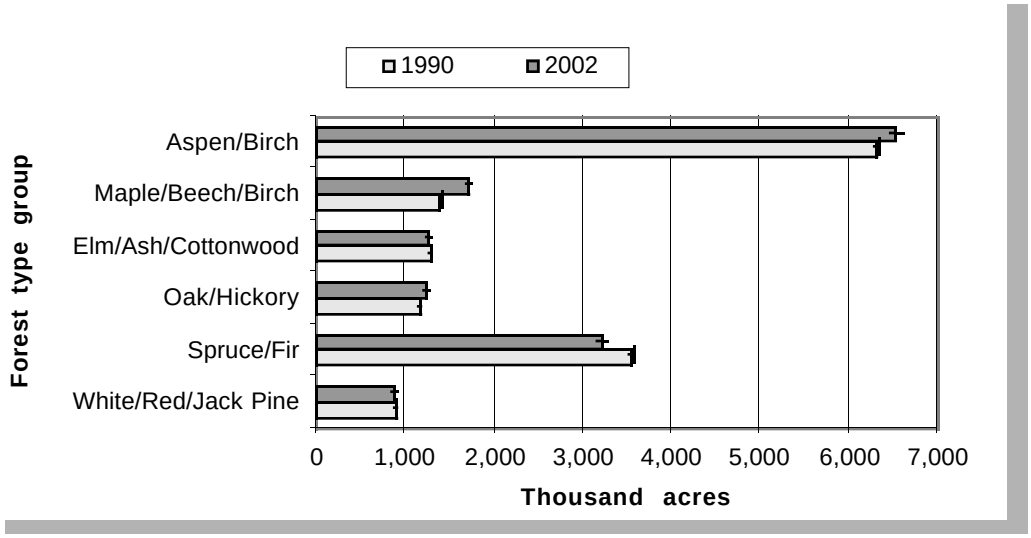

Figure 3. — Area of timberland in Minnesota in 1990 and 2002 by forest type.

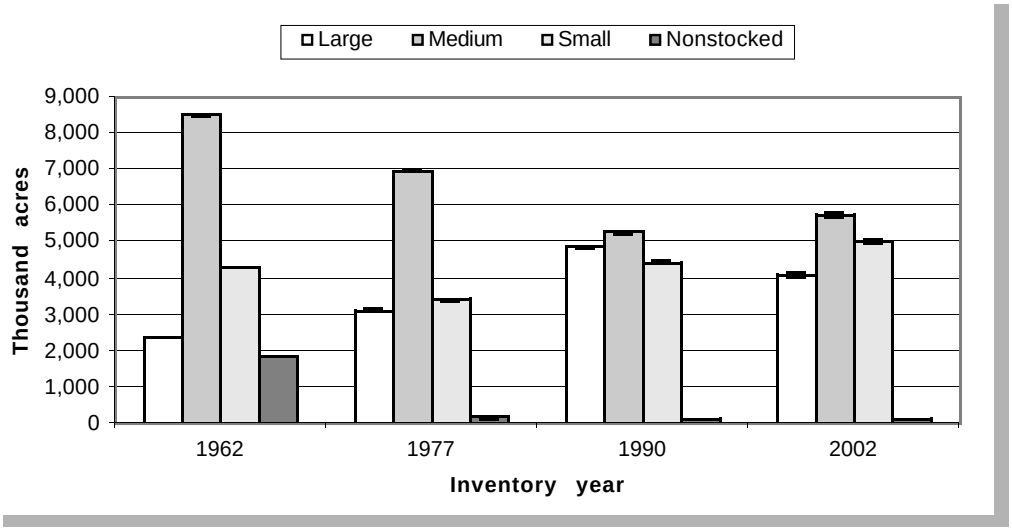

Figure 4. — Area of timberland in Minnesota by stand-size class and inventory year.

stock but are utilized for wood fiber and fuelwood. Such trees also make important ecological contributions (such as for wildlife habitat, and soil and water protection). With the annualized inventory system and increased interest in FIA data from an ecological perspective, a greater focus has been placed on all live volume. In 2002, Minnesota had 17.6 billion cubic feet of all live volume on its 16.3 million acres of forest land (table 4). This equates to an average of 1,080 cubic feet of all live volume for each forest land acre in Minnesota.

The net volume of growing stock on timberland in Minnesota was estimated at 15.4 billion cubic feet on 15.0 million acres in 2002 (table 5), or 1,024 cubic feet of growing stock per acre (fig. 5). The 1990 inventory estimates were 15.1 billion cubic feet of growing stock on 14.7 million acres of timberland, or 1,028 cubic feet of growing stock per acre. While growing-stock volume increased, all live volume on timberland decreased from 17.1 billion cubic feet in 1990 to 16.5 billion cubic feet in 2002 due in part to a decrease in the volume of rough and rotten cull trees from 1.6 billion cubic feet in 1990 to 1.1 billion cubic feet in 2002.

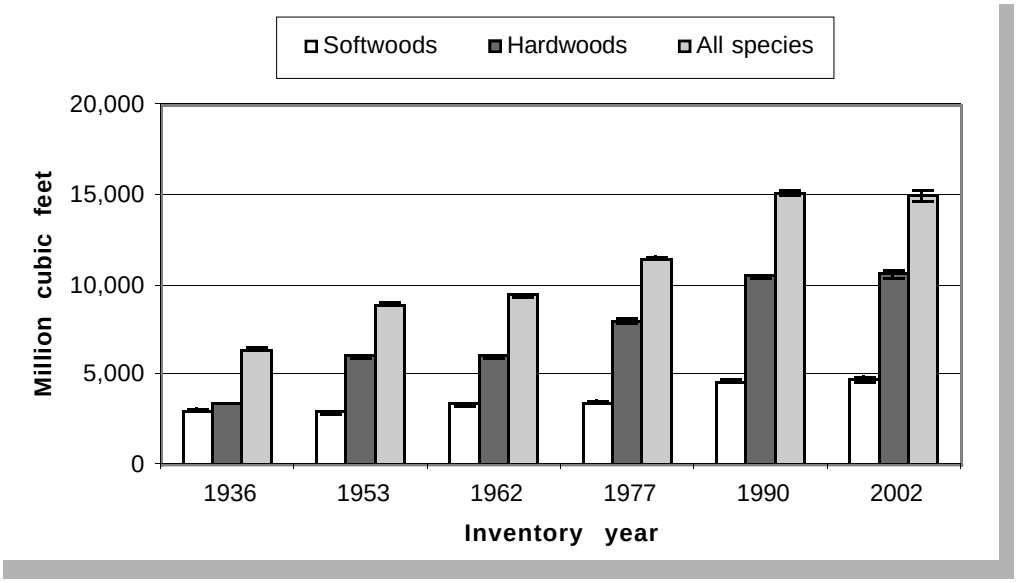

Figure 5. — *Growing-stock volume in Minnesota by inventory year.*

In 2002 hardwoods made up 69 percent of the growing-stock volume and 68 percent of the sawtimber volume in the State (figs. 5, 6, and table 6). The cottonwood-aspen species group accounted for 40 percent of the hardwood volume, followed by other eastern soft hardwoods (15 percent), ash (10 percent), basswood (8 percent), select red oaks (7 percent), select white oaks (7 percent), soft maple (6 percent), and hard maple (5 percent) (table 7).

Softwood growing-stock volume was estimated at 4.8 billion cubic feet in 2002. The spruce and balsam fir species group accounted for 36 percent of the softwood volume, followed by other eastern softwoods (32 percent), eastern white and red pines (23 percent), and jack pine (9 percent).

The growing-stock volume of poletimber-size trees decreased from 7.8 billion cubic feet in 1990 to 7.1 billion cubic feet in 2002 (table 7) while the growing-stock volume of sawtimber-size trees increased from 7.4 billion cubic feet to 8.3 billion cubic feet (table 8).

Biomass

Biomass, measured as all live aboveground tree biomass on timberlands, was estimated at 435 million dry tons in 2002 (an average of 29 dry tons per acre) (table 9). Biomass estimates are increasing in importance for analyses on carbon sequestration, wood fiber availability for fuel, and other issues. In 2002, 78 percent of the total biomass was in growing-stock trees, an additional 14 percent was in trees less than 5 inches d.b.h., and the remaining 8 percent was in non-growing-stock trees. Three-quarters of the total biomass was composed of hardwood species. Although total biomass was almost evenly split on private (215 million dry tons) and public (220 million dry tons) timberlands, softwoods made up 34 percent of the total biomass on public lands but only 15 percent on private lands.

Growth, Removals, and Mortality

The three components of change (growth, removals, and mortality) provide trend information that helps to describe forest changes between inventories.

Net average annual growth between the current and previous inventories is equal to gross growth over the period less mortality over the period divided by the number of growing seasons in the period. The net average annual growth of growing stock on timberland from 1990 to 2002 was 421.5 million cubic feet (table 10), or approximately 2.7 percent of the current growing-stock inventory on timberland.

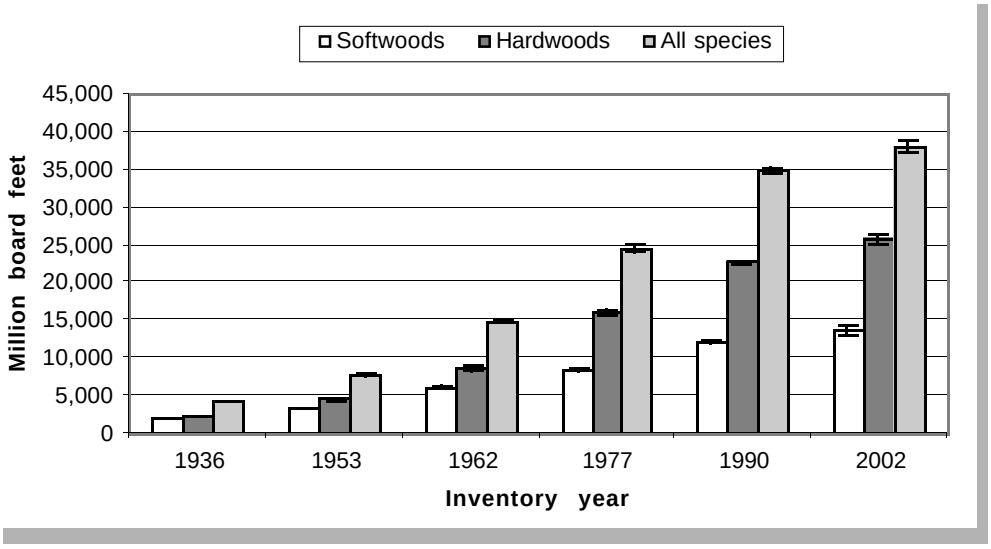

Figure 6. — *Sawtimber volume in Minnesota by inventory year.*

Average annual removals includes both trees cut or killed as a result of harvesting and trees removed from the timberland base as a result of land use change. Average annual removals of growing stock on timberland from 1990 to 2002 were 240.5 million cubic feet (table 11), or approximately 1.6 percent of the current growing-stock inventory on timberland.

Average annual mortality includes trees that died over the period but did not die as a result of timber harvesting (trees that died as a result of timber harvesting are included in removals). Average annual mortality of growing stock on timberland from 1990 to 2002 was 259.2 million cubic feet (table 12), or approximately 1.7 percent of the current growing-stock inventory on timberland. Average annual mortality is not presented in figure 7 because it has already been removed from gross growth to compute the average net growth number.

Forest Health

Insects, pathogens, weather events, fire, and other factors cause damage and losses on forests throughout Minnesota every year. Since 1954 the eastern spruce budworm (*Choristoneura fumiferana*) has defoliated spruce/fir forests annually, establishing itself as the most consistent damaging agent in the State. The prevalence of spruce budworm had been declining over the past decade but increased significantly in 2002 (table 13). Another defoliator, the forest tent caterpillar (*Malacosoma disstria*), has been active on a large scale throughout aspen and birch forests for the fourth consecutive year (fig. 8), culminating in 7.8 million acres of defoliation in 2001 and 7.4 million acres in 2002. Populations are expected to continue to be at damaging levels in 2003. Other significant damage agents that have been active between inventories are the large aspen tortrix (*Choristoneura conflictana*) affecting the aspen and birch forest types; the jack pine budworm (*Choristoneura pinus*) defoliating and killing older, open-growing jack pine; and the introduced larch casebearer (*Coleophora laricella*) defoliating larch.

Since 1997, all of these and other defoliating agents have been active, sometimes on some of the same acreages at the same time. Many trees that are repeatedly defoliated sustain measurable growth loss, which, in turn, sometimes results in mortality. Figure 9 shows areas of the State where, since 1998, forested lands have been defoliated between one and five times.

Larch beetles have been a part of the Minnesota landscape for decades, but they usually attack tamaracks weakened by stress from drought, flooding, or defoliation. Mortality is usually confined to individual trees or small pockets of trees. In the last 2 years, both the amount of

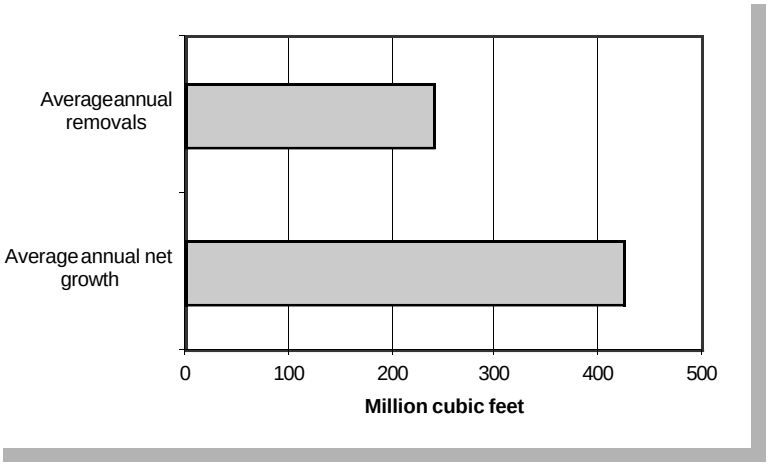

Figure 7. — *Average annual net growth and average annual removals, Minnesota, 1990-2002.*

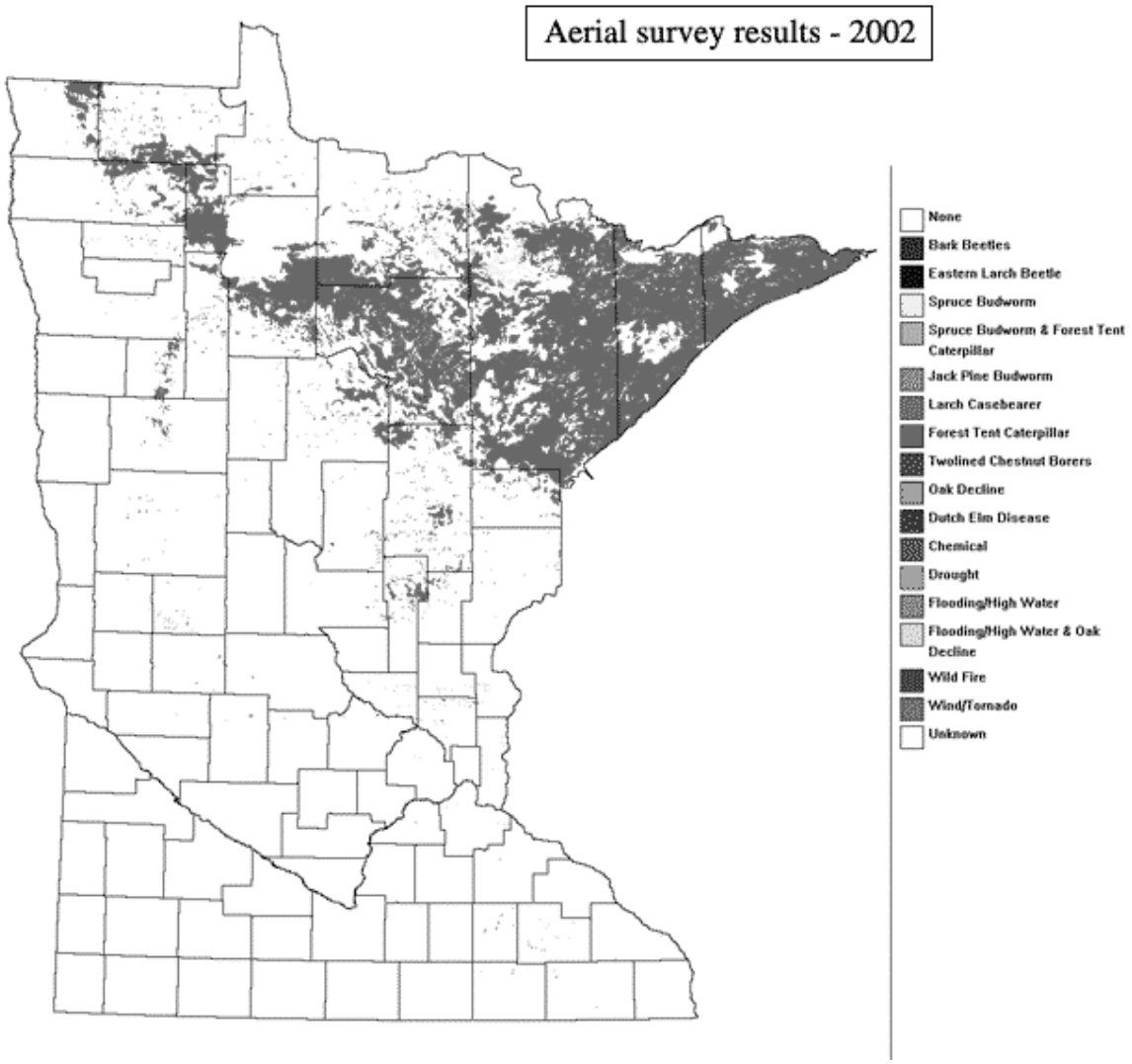

Figure 8. — *Aerial survey results for 2002 (Forest Health Protection, St. Paul Field Office).*

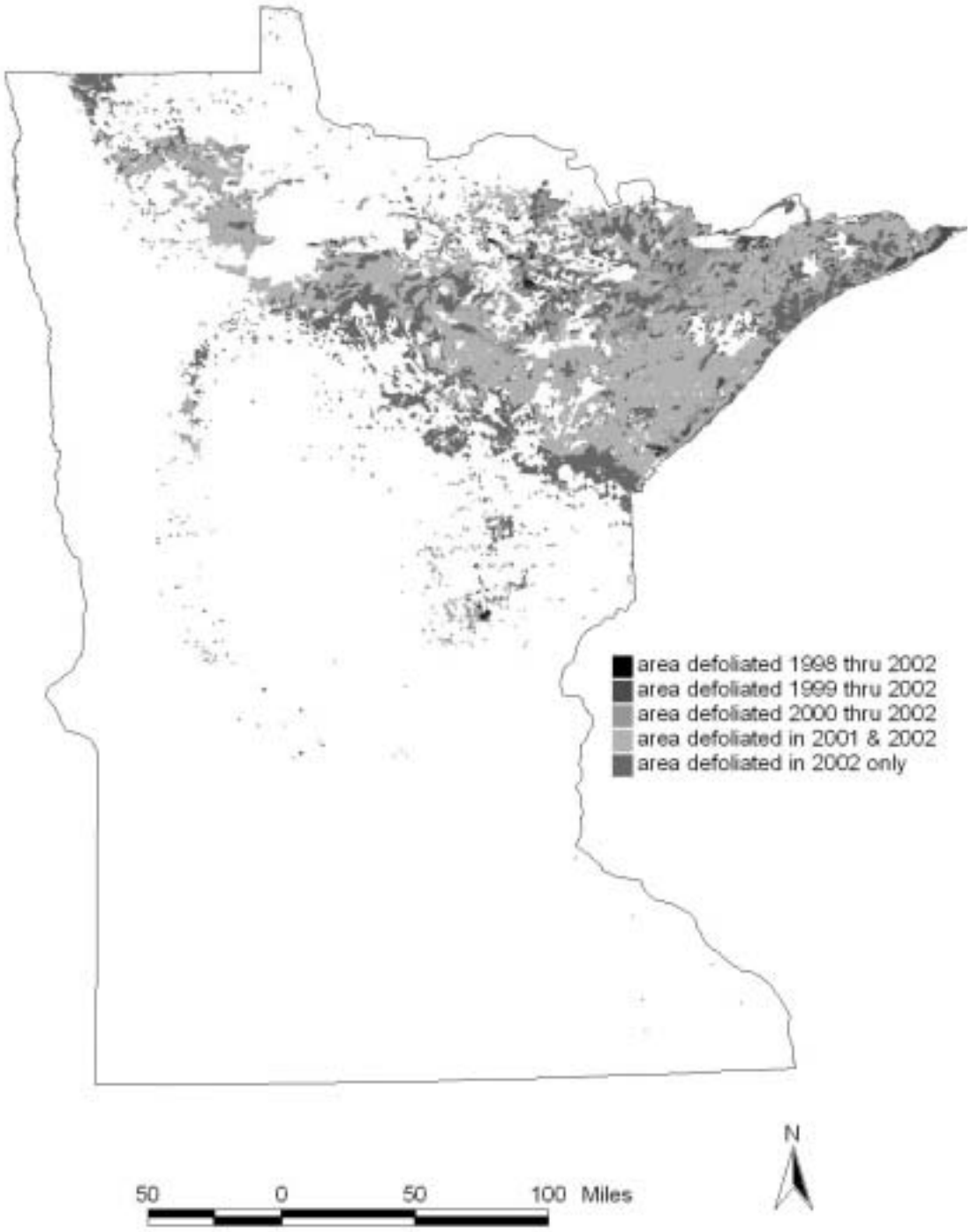

Figure 9. — *Areas with high incidence of damage mapped by aerial survey, 1998-2002 (Forest Health Protection, St. Paul Field Office).*

mortality and the size of the areas affected have increased. Much of the mortality has still been confined to small pockets. However, some stands of 30 acres and larger have experienced over 75 percent mortality.

Mortality has been found in stands ranging from 40 to 160 years in age, on lowland and upland sites, and in pure stands as well as mixed component stands. As the beetles feast on the trees, woodpeckers feast on the beetles, leaving behind telltale signs that include mounds of bark chips at the base of trees and reddish or white boles, depending on how much bark a woodpecker flakes off as it searches for food. In late summer, needles of the affected trees begin to turn yellow, then brown, before falling off. The dieback begins at the bottom of the crown and works upward, leaving the green tops for last.

In mid-August of 2002, twolined chestnut borer (TLCB) damage began to show up in Itasca County. By late August, dieback, topkill, and whole tree mortality were widespread in northern and southern Minnesota. Some oaks that did not appear to have been attacked by TLCB in 2001 were entirely brown and looked dead by the end of August 2002. Borer galleries could be found in the trunks of these trees down to the soil line.

In the northern counties, a few pockets of TLCB were seen in the fall of 2001, but the amount of topkill and mortality seen in 2002 was unexpected. A very dry April, May, and June just as the trees were leafing out, coupled with two or more years of forest tent caterpillar defoliation, were likely the stress factors contributing to the success of the borers. Aerial survey was flown in late August over about 84 townships in parts of Clearwater, Beltrami, Cass, Itasca, Mille Lacs, Aitkin, and Crow Wing Counties. Approximately 10,000 acres with oak mortality and top kill were mapped. Scattered damage occurred throughout northern Minnesota, but the worst damage was in Itasca County. Approximately 7,000 acres of stands with mortality were mapped within a 10-mile radius of Grand Rapids. Additional damage continued to become evident through September. In some stands over 75 percent of the oaks suffered top kill or mortality. Severe damage occurred in stands that had been recently thinned or in areas where road construction or building construction had recently occurred. However, damage was not restricted to these types of stands.

As of spring 2002, oak wilt was of most concern in central Minnesota. Sherburne and Anoka Counties had the largest number of active infection pockets and the most acreage affected (fig. 10).

The number of infection pockets dramatically increased in those areas affected by storms in 1997 and 1998. As a result, the oak wilt epicenter shifted northwestward into Sherburne County, where storm damage and increased development have put a large number of oaks at risk. The spread increases the risk of oak wilt moving into heavily forested counties further north that do not yet have oak wilt. If oak wilt is allowed to spread into these counties, the loss of trees and the cost of disease control could be substantial.

For the first time, scattered pockets of oaks in Stearns and Morrison Counties had symptoms of oak tatters. Much of the area in southern Minnesota that was affected in 2001 was free of tatters symptoms in 2002. Tatters primarily affects bur oak but was also observed on swamp white oak, eastern white oak, a few red oaks, and hackberries. The long-term impact remains low. The causal agent remains unknown.

Across southern Minnesota, a late season leaf disease can be seen on bur oak, usually after August 1. The causal fungus, *Actinopelte dryina*, was recently renamed *Tubakia dryina*. The appearance can be very dramatic as the entire crown turns brown except a few leaves at the very top. Defoliation can reach 90 percent in a few short weeks, and affected trees

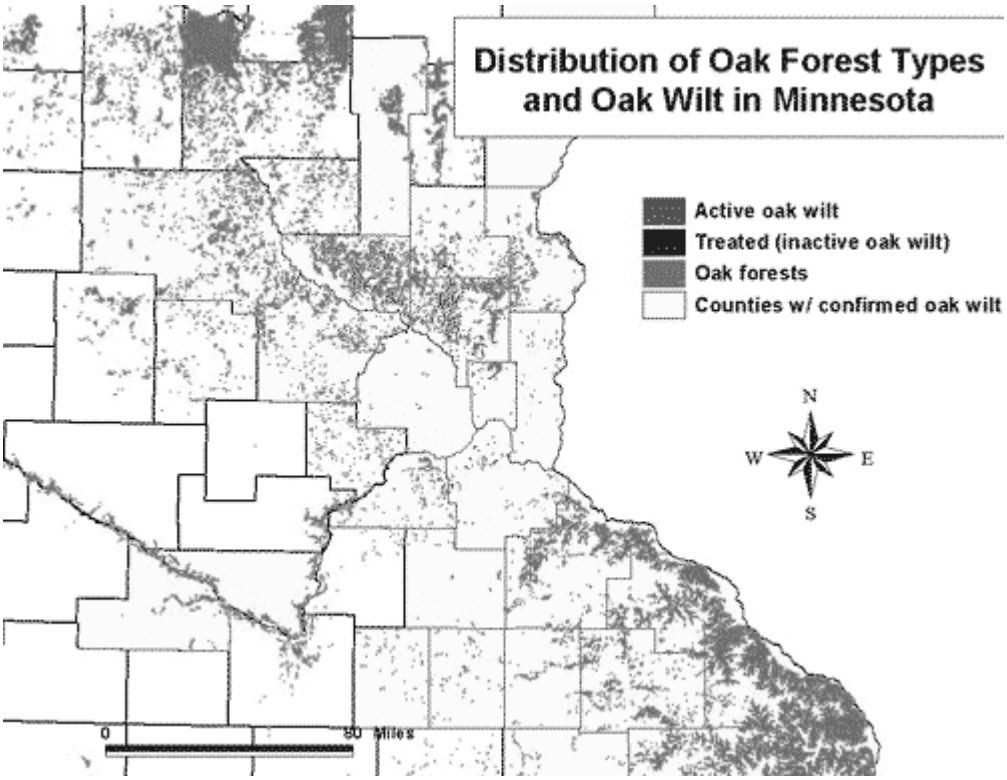

Figure 10. — Distribution of Oak Forest Types and Oak Wilt in Minnesota, 2002 (Forest Health Protection, St. Paul Field Office).

look nearly dead. Late season defoliation has minimal impact on the tree's health. However, several consecutive years of defoliation of this nature may have long-term impacts. Stored food reserves could be depleted resulting in dieback by insect and diseases of secondary action. This has not been observed to date on infected trees.

Arguably, agents completely beyond human control, namely the weather, cause the most significant damage. Periods of drought and flooding, snow, ice, cold, and wind damage are an integral component of the State's forest dynamics. The single most significant event occurred in 1999 when about 465,000 acres of northern forests were blown down by straight-line winds (fig. 11). This caused varying degrees of breakage and mortality, that in turn has had longer term impacts on subsequent insect and pathogen activity and fire. The annual current mortality resulting from all of these damage agents, exceeding 10 percent of standing trees, is displayed in figure 12.

For Further Information

Additional data related to the most recent three inventories of Minnesota (1977, 1990, 2002) are available at: www.ncrs.fs.fed.us/4801/fiadb/index.htm.

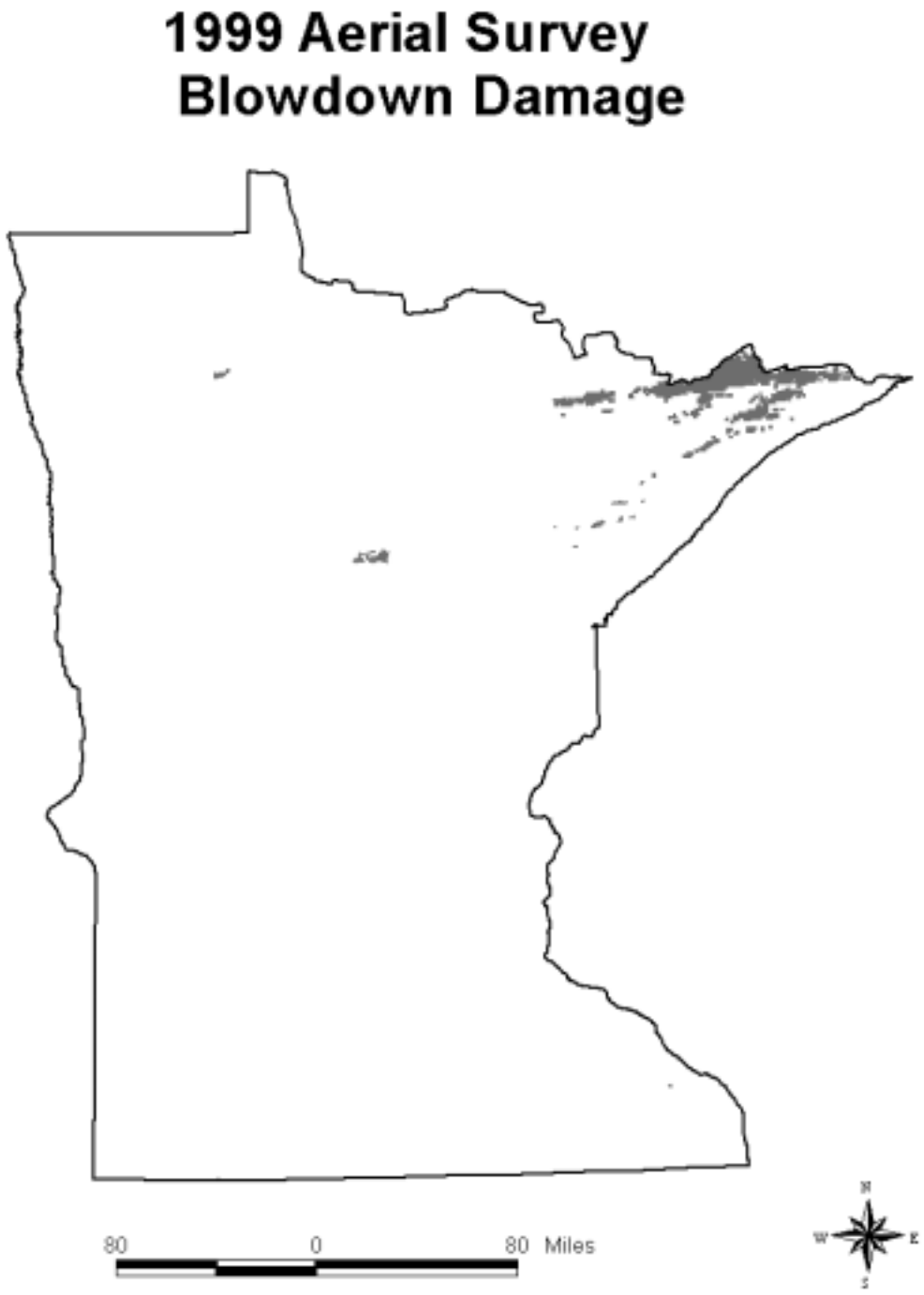

Figure 11. — Storm damage resulting from July 4, 1999, straight-line winds includes dead trees as well as broken, up-rooted, and still alive trees (Forest Health Protection, St. Paul Field Office).

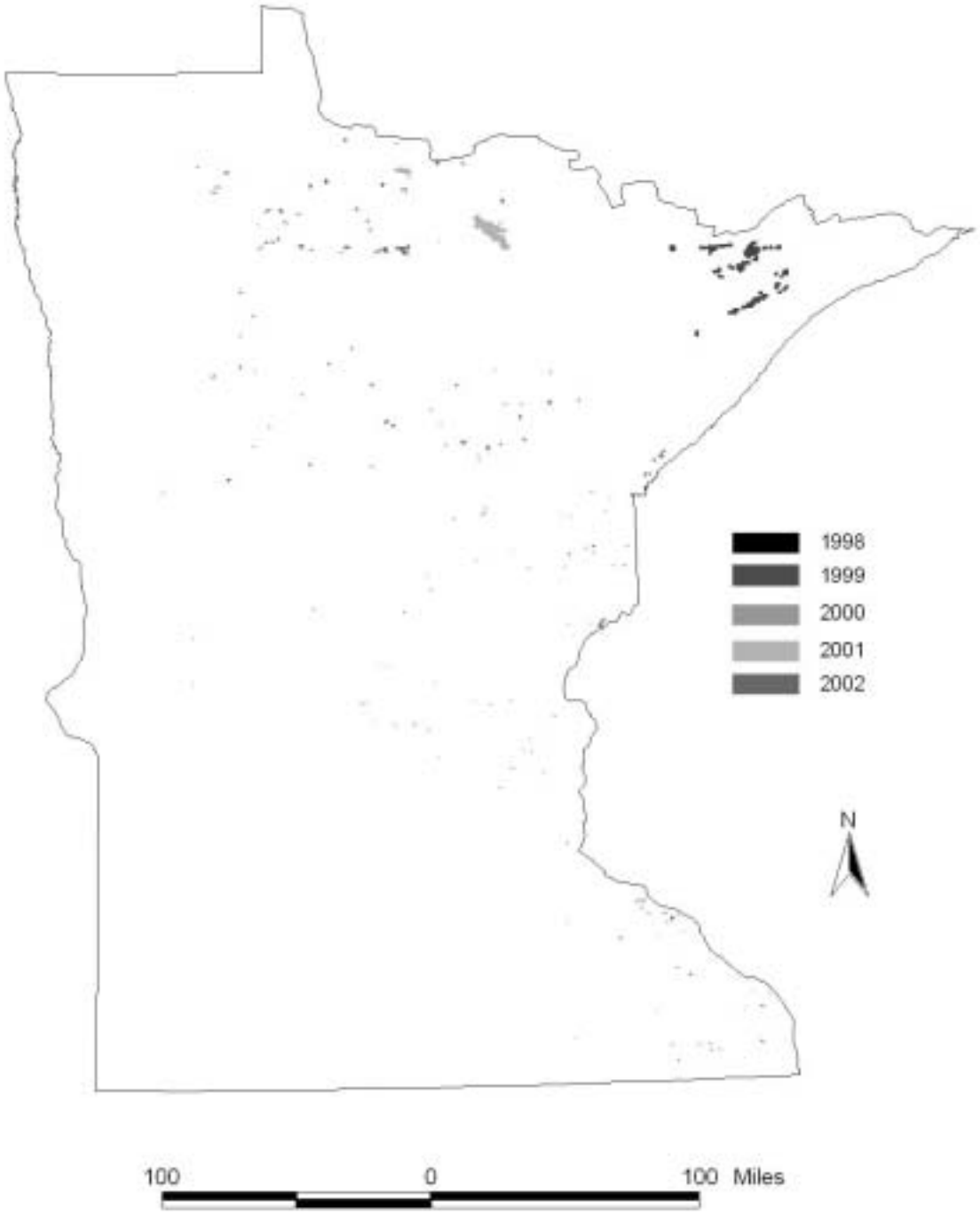

Figure 12. — *Areas of >10 percent mortality mapped by aerial survey (not including 1999 storm damage—see figure 11), 1998-2002 (Forest Health Protection, St. Paul Field Office).*

APPENDIX

Inventory Methods

Since the 1990 inventory of Minnesota, several changes have been made in NCFIA inventory methods to improve the quality of the inventory as well as meet increasing demands for timely forest resource information. The most significant difference between inventories is the change from periodic inventories to annual inventories. Historically, NCFIA periodically inventoried each State on a cycle that averaged about 12 years for recent inventories. However, the need for timely and consistent data across large geographical regions, combined with national legislative mandates, resulted in NCFIA's implementation of an annual inventory system. Minnesota was one of the first States in the North Central region, and one of the first States in the Nation, to be inventoried with this new system, beginning with the 1999 panel of measurements.

With an annual inventory system, about one-fifth of all field plots are measured in any one year. After 5 years, an entire inventory cycle will be completed. After the first 5 years, NCFIA will report and analyze results as a moving 5-year average. For example, NCFIA will be able to generate a report based on inventory results for 1999 through 2003 or for 2000 through 2004. While there are great advantages for an annual inventory, one difficulty is reporting on results in the first 4 years. With the 2002 annual measurements, only 80 percent of all field plots have been measured. Sampling error estimates for the 2002 inventory results are area of forest land, 0.71 percent; area of timberland, 0.80 percent; number of growing-stock trees on timberland, 1.72 percent; volume of growing stock on timberland, 1.58 percent; volume of sawtimber on timberland, 2.26 percent; average annual net growth of growing stock on timberland, 5.09 percent; average annual removals of growing-stock on timberland, 6.75 percent; and average annual mortality of growing stock on timberland, 3.91 percent. These sampling error estimates are considerably higher than those for the last periodic inventory completed in 1990 (i.e., 0.36 percent for timberland area and 0.71 percent for growing-stock volume) because of the smaller sample sizes. Thus, caution should be used when drawing conclusions based on this limited data set. As we complete ensuing measurements, we will have additional confidence in our results due to the increased number of field plots measured. As each measurement year is completed, the precision of estimates will improve.

Other significant changes between inventories include the implementation of new remote sensing technology, the implementation of a new field plot design, and the gathering of additional remotely sensed and field data. The advent of remote sensing technology since the previous inventory in 1990 has allowed NCFIA to use computer-assisted classifications of Multi-Resolution Land Characterization (MRLC) data and other available remote sensing products to stratify the total area of the State and to improve estimates. Inventories in Minnesota before 1999 used manual interpretation of aerial photos to stratify the sample 1936, 1953, 1962, 1977, and 1990.

New algorithms were used in 1999-2002 to assign forest type and stand-size class to each condition observed on a plot. These algorithms are being used nationwide by FIA to provide consistency among States and will be used to reassign the forest type and stand-size class of every plot measured in the 1990 inventory when it is updated. This will be done so that changes in forest type and stand-size class will more accurately reflect actual changes in the forest and not changes in how values are computed. The list of recognized forest types, grouping of these forest types for reporting purposes, equations used to assign

stocking values to individual trees, definition of nonstocked, and names given to the forest types changed with the new algorithms. As a result, comparisons between the published 1999-2002 measurement results and those published for the 1990 inventory results may not be valid. For additional details regarding algorithms used in both inventories, please contact NCFIA.

Sampling Phases

The 2002 Minnesota survey used a two-phase sample for stratification that included remeasuring inventory plots from the 1990 inventory and measuring new field plots. Two-phase sampling, also called double sampling, consists of a phase 1 sample to estimate area by strata and a phase 2 sample to estimate the average value of parameters of interest within these strata. The estimated population total for a parameter is the sum across all strata of the product of each stratum's estimated area and the parameter's estimated mean per unit area.

The only land that could not be sampled was private land where field personnel could not obtain permission from the owner to measure the field plot and plots that could not be accessed because of a hazard or danger to field personnel. The methods used in the preparation of this report make the necessary adjustments to account for sites where access was denied or hazardous. Fortunately, there were only 23 denied access or hazardous plots in 1999, 59 in 2000, 66 in 2001, and 61 in 2002.

Phase 1

In this first phase the Minnesota inventory used a computer-assisted classification of satellite imagery. FIA used the imagery to form two initial strata—forest and nonforest. Pixels within 60 m (2 pixel widths) of a forest-nonforest boundary formed two additional strata—forest-edge and nonforest-edge. Forest pixels within 60 m on the forest side of a forest-nonforest boundary were classified into forest-edge strata. Pixels within 60 m of the boundary on the nonforest side were classified into nonforest-edge strata. An overlay of all national forest land was used to identify all lands owned by national forests. These national forest lands were treated separately but were also put into one of the above four strata. Stratification and estimation were conducted at the State level for national forest lands and at the FIA Inventory Unit level for other lands. In the national forest stratum, forest and forest-edge strata were combined.

Phase 2

Phase 2 of the inventory consisted of the measurement of the annual sample of field plots in Minnesota. Current FIA precision standards for annual inventories require a sampling intensity of one plot for approximately every 6,000 acres. FIA has established a grid that divides the entire area of the United States into non-overlapping hexagons, each of which contains approximately 5,937 acres (McRoberts 1999). A grid of field plots was established by selecting one plot from each hexagon based on the following rules: (1) if a Forest Health Monitoring (FHM) plot (Mangold 1998) fell within a hexagon, it was selected as the grid plot; (2) if no FHM plot fell within a hexagon, the existing NCFIA plot from the 1990 inventory nearest the hexagon center was selected as the grid plot; and (3) if neither FHM nor existing NCFIA plots fell within the hexagon, a new NCFIA plot was established in the hexagon (McRoberts 1999). This grid of plots is designated the Federal base sample and is considered an equal probability sample; its measurement in Minnesota is funded by the Federal government.

The total Federal base sample was systematically divided into five interpenetrating, non-overlapping subsamples or panels. Each year the plots in a single panel are measured, and panels are selected on a 5-year, rotating basis (McRoberts 1999). For estimation purposes, the measurement of each panel of plots may be considered an independent systematic sample of all land in a State. Field crews measure vegetation on plots forested at the

time of the last inventory and on plots currently classified as forest by trained photointerpreters using aerial photos or digital ortho-quads.

Phase 3

NCFIA has two categories of field plot measurements—phase 2 field plots and phase 3 plots (FHM plots)—to optimize our ability to collect data when available for measurement. Both types of plot are systematically distributed both geographically and temporally. Phase 3 plots are measured with the full suite of FHM vegetative and health variables collected as well as the full suite of measures associated with phase 2 plots. Phase 3 plots must be measured between June 1 and August 30 to accommodate the additional measurement of non-woody understory vegetation, ground cover, soils, and other variables. We anticipate that in Minnesota the complete 5-year annual inventory will involve about 465 phase 3 plots. On the remaining plots, referred to as phase 2 plots, only variables that can be measured throughout the entire year are collected. In Minnesota, the complete 5-year annual inventory is expected to involve about 5,200 phase 2 forested plots. The 1999-2002 annual inventory results represent field measures on 3,350 timberland, 243 other forest land, and 8,141 non-forest land plots. The above number of field plots represents a single intensification for the standard base Federal sample in 1999 and a double intensification for 2000, 2001, and 2002. This double intensification was made possible by additional resources provided by the State of Minnesota..

The new national FIA 4-point cluster plot design (fig. 13) was first used for data collection during the 1999 measurement of Minnesota. This design was also used in the 2000, 2001, and 2002 measurements and will be used in subsequent years. The national plot design requires mapping forest conditions on each plot. Due to the small

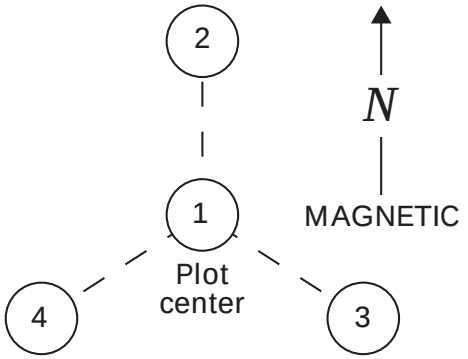

Figure 13. — Current NCFIA field plot design.

sample size (20 percent) each year, precision associated with change factors such as mortality will be relatively low. Consequently, change estimates were not reported in the 1999, 2000, or 2001 reports. Estimates of change are reported for 2002 but are limited in detail. When all five annual panels are completed in 2004, the full range of change data will be available.

The overall plot layout for the new design consists of four subplots. The centers of subplots 2, 3, and 4 are located 120 feet from the center of subplot 1. The azimuths to subplots 2, 3, and 4 are 0, 120, and 240 degrees, respectively. The center of the new plot is located at the same point as the center of the previous plot if a previous plot existed within the sample unit. Trees with a d.b.h. of 5 inches and larger are measured on a 24-foot-radius (1/24 acre) circular subplot. All trees less than 5 inches d.b.h. are measured on a 6.8-foot-radius (1/300 acre) circular microplot located 12 feet east of the center of each of the four subplots. Forest conditions that occur on any of the four subplots are recorded. Factors that differentiate forest conditions are changes in forest type, stand-size class, land use, ownership, and density. Each condition that occurs anywhere on any of the subplots is identified, described, and mapped if the area of the condition meets or exceeds 1 acre in size and 120 feet in width. Field plot measurements are combined with phase 1 estimates in the compilation process and table

production. The number of tables generated from less than five panels of data is limited. However, as additional annual inventories are completed, the number of tables will increase until year 5, when all statewide inventory summary tables will be available in both printed and electronic formats. For additional information, contact:

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TABLE TITLES

TABLES

Table 1. -- Area of forest land by forest type group and owner category, Minnesota, 1999 - 2002

(In thousand acres)

Forest type group	Owner category			
	All owners	Public	Private	Unidentified owner
Softwood type groups				
White / red / jack pine	1,024.1	690.4	333.7	--
Spruce / fir	3,777.3	3,015.7	761.6	--
Pinyon / juniper	9.2	--	9.2	--
Exotic softwood	3.2	--	3.2	--
All softwood types	4,813.8	3,706.1	1,107.7	--
Hardwood type groups				
Oak / pine	85.9	24.7	61.2	--
Oak / hickory	1,272.1	310.9	961.2	--
Elm / ash / cottonwood	1,313.7	554.6	759.2	--
Maple / beech / birch	1,759.1	671.9	1,087.1	--
Aspen / birch	6,964.2	4,002.5	2,961.7	--
All hardwood types	11,394.9	5,564.6	5,830.3	--
Nonstocked	134.0	78.8	55.2	--
All forest types	16,342.8	9,349.5	6,993.3	--

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their total due to rounding.

Table 2. -- Area of timberland by major forest type group, stand origin, and owner category, Minnesota, 1999 - 2002

(In thousand acres)

Major forest type group and stand origin	Owner category			
	All owners	Public	Private	Unidentified owner
Softwood type groups				
Natural	3,609.0	2,744.1	864.9	--
Planted	492.6	304.5	188.0	--
All softwood types	4,101.6	3,048.6	1,053.0	--
Hardwood type groups				
Natural	10,607.5	4,921.5	5,686.0	--
Planted	202.3	96.6	105.7	--
All hardwood types	10,809.8	5,018.1	5,791.7	--
Nonstocked	118.3	69.6	48.7	--
All groups	15,029.7	8,136.3	6,893.4	--

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table 3. -- Area of timberland by forest type group and stand-size class, Minnesota, 1999 - 2002

(In thousand acres)

Forest type group	All stands	Stand-size class			
		Sawtimber	Poletimber	Sapling-seedling	Non-stocked
Softwood type groups					
White / red / jack pine	866.5	375.9	318.7	171.9	--
Spruce / fir	3,222.7	466.9	1,081.7	1,674.0	--
Pinyon / juniper	9.2	4.2	--	4.9	--
Exotic softwood	3.2	2.1	--	1.1	--
All softwood types	4,101.6	849.1	1,400.5	1,852.0	--
Hardwood type groups					
Oak / pine	79.6	29.4	36.1	14.1	--
Oak / hickory	1,234.2	723.6	405.6	104.9	--
Elm / ash / cottonwood	1,259.2	327.5	582.7	349.1	--
Maple / beech / birch	1,708.4	871.1	648.2	189.0	--
Aspen / birch	6,528.5	1,320.9	2,675.9	2,531.7	--
All hardwood types	10,809.8	3,272.5	4,348.6	3,188.8	--
Nonstocked	118.3	--	--	--	118.3
All forest types	15,029.7	4,121.6	5,749.0	5,040.8	118.3

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table 4. -- Net volume of all live trees on forest land by species group and owner category, Minnesota, 1999 - 2002

(In thousand cubic feet)

Species group	Owner category			
	All owners	Public	Private	Unidentified owner
Softwoods				
Other yellow pines	4,867	--	4,867	--
Eastern white and red pines	1,310,960	860,780	450,179	--
Jack pine	549,366	385,424	163,942	--
Spruce and balsam fir	1,907,180	1,384,133	523,047	--
Other eastern softwoods	1,689,685	1,239,526	450,159	--
Total softwoods	5,462,058	3,869,864	1,592,194	--
Hardwoods				
Select white oaks	919,143	187,746	731,397	--
Select red oaks	871,470	310,502	560,968	--
Other white oaks	109	--	109	--
Other red oaks	70,807	3,149	67,658	--
Hickory	30,595	816	29,778	--
Yellow birch	56,623	41,417	15,206	--
Hard maple	689,420	357,653	331,767	--
Soft maple	734,118	341,880	392,238	--
Beech	--	--	--	--
Ash	1,187,035	481,503	705,532	--
Cottonwood and aspen	4,753,539	2,655,176	2,098,363	--
Basswood	900,805	301,123	599,682	--
Black walnut	33,554	3,873	29,681	--
Other eastern soft hardwoods	1,881,333	1,021,534	859,798	--
Other eastern hard hardwoods	10,173	2,002	8,171	--
Eastern noncommercial hardwoods	46,730	9,136	37,594	--
Total hardwoods	12,185,456	5,717,512	6,467,944	--
All species groups	17,647,514	9,587,376	8,060,138	--

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

Table 5. – Net volume of all live trees and salvable dead trees on timberland by class of timber and softwood/hardwood categories, Minnesota, 1999 - 2002

(In thousand cubic feet)

Class of timber	All species	Softwood species	Hardwood species
Live trees			
Growing-stock trees			
Sawtimber			
Saw log portion	6,411,610	2,313,826	4,097,785
Upper stem portion	1,840,518	318,519	1,521,999
Total	8,252,128	2,632,345	5,619,783
Poletimber	7,142,077	2,150,873	4,991,204
All growing-stock trees	15,394,205	4,783,218	10,610,987
Cull trees			
Rough trees [1]			
Sawtimber size	685,805	60,513	625,291
Poletimber size	220,884	25,642	195,242
Total	906,689	86,155	820,533
Rotten trees [1]			
Sawtimber size	141,683	20,883	120,799
Poletimber size	29,168	4,048	25,120
Total	170,851	24,932	145,919
All live cull trees	1,077,540	111,087	966,453
All live trees	16,471,744	4,894,305	11,577,440
Salvable dead trees			
Sawtimber size	145,145	53,271	91,874
Poletimber size	144,292	60,050	84,241
All salvable dead trees	289,437	113,321	176,116
All classes	16,761,181	5,007,626	11,753,555

All table cells without observations in the inventory sample are indicated by –. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

[1] Includes noncommercial species.

Table 6. – Net volume of growing stock on timberland by forest group and softwood/hardwood species categories, Minnesota, 1999 - 2002

(In thousand cubic feet)

Forest type group	All species	Softwood species	Hardwood species
Softwood type groups			
White / red / jack pine	1,286,455	1,175,855	110,600
Spruce / fir	2,503,527	2,260,520	243,006
Pinyon / juniper	3,908	3,707	201
Exotic softwood	3,659	3,558	100
All softwood types	3,797,549	3,443,641	353,908
Hardwood type groups			
Oak / pine	108,857	70,237	38,619
Oak / hickory	1,597,019	50,611	1,546,408
Elm / ash / cottonwood	1,417,569	135,054	1,282,515
Maple / beech / birch	2,358,694	138,595	2,220,098
Aspen / birch	6,105,574	938,992	5,166,583
All hardwood types	11,587,713	1,333,489	10,254,223
Nonstocked	8,943	6,087	2,856
All forest types	15,394,205	4,783,218	10,610,987

All table cells without observations in the inventory sample are indicated by –. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

Table 7. -- Net volume of growing stock on timberland by species group and diameter class, Minnesota, 1999 - 2002

(In thousand cubic feet)

Species group	All classes	Diameter class (inches at breast height)									
		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+
Softwoods											
Other yellow pines	3,855	193	960	1,483	1,219	--	--	--	--	--	--
Eastern white and red pines	1,111,174	85,737	149,940	143,162	100,331	88,503	99,014	114,043	112,628	176,586	41,231
Jack pine	442,600	57,491	99,416	117,753	83,796	48,769	21,308	10,082	3,984	--	--
Spruce and balsam fir	1,696,337	597,616	502,006	299,175	147,069	70,178	42,765	18,590	8,460	12,478	--
Other eastern softwoods	1,527,251	297,659	359,854	306,354	214,730	151,573	71,853	57,603	27,915	39,711	--
Total softwoods	4,783,218	1,038,696	1,112,177	867,927	547,146	359,023	234,939	200,318	152,986	228,775	41,231
Hardwoods											
Select white oaks	771,092	54,891	84,415	100,763	104,264	84,025	83,569	69,678	39,199	115,844	34,445
Select red oaks	794,829	23,129	56,556	95,121	122,459	134,319	99,424	85,610	67,911	89,800	20,500
Other white oaks	109	109	--	--	--	--	--	--	--	--	--
Other red oaks	48,537	1,503	3,500	2,731	8,165	6,357	8,655	7,270	2,752	7,604	--
Hickory	30,297	3,696	4,603	5,898	8,353	6,332	1,415	--	--	--	--
Yellow birch	46,435	3,795	3,943	4,555	3,480	7,263	5,129	8,280	3,725	6,265	--
Hard maple	573,613	81,752	115,358	106,081	83,271	57,911	48,514	32,986	11,034	36,707	--
Soft maple	600,755	102,347	128,216	97,402	70,479	46,528	31,759	15,752	12,072	58,604	37,596
Beech	--	--	--	--	--	--	--	--	--	--	--
Ash	1,113,760	181,961	249,293	230,163	155,519	113,068	77,960	35,383	36,565	30,405	3,445
Cottonwood and aspen	4,209,816	490,884	667,955	766,769	760,002	648,188	397,457	209,540	95,272	129,085	44,664
Basswood	812,651	57,012	103,987	127,921	113,987	119,190	94,562	73,406	58,003	47,266	17,317
Black walnut	33,289	1,263	1,902	6,211	5,125	3,479	9,952	1,833	--	3,525	--
Other eastern soft hardwoods	1,565,792	253,018	400,558	366,148	260,288	129,700	82,618	26,297	15,865	23,839	7,462
Other eastern hard hardwoods	10,012	1,896	2,696	1,205	1,333	1,795	1,087	--	--	--	--
Total hardwoods	10,610,987	1,257,256	1,822,981	1,910,967	1,696,725	1,358,155	942,100	566,035	342,398	548,942	165,428
All species	15,394,205	2,296,952	2,935,158	2,778,894	2,243,871	1,717,178	1,177,039	766,353	495,384	777,717	206,659

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

Table 8. -- Net volume of sawtimber on timberland by species group and diameter class, Minnesota, 1999 - 2002

(In thousand board feet)[1]

Species group	All classes	Diameter class (inches at breast height)							
		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+
Softwoods									
Other yellow pines	13,062	7,101	5,961	--	--	--	--	--	--
Eastern white and red pines	4,724,624	712,789	504,908	457,819	528,125	623,740	630,937	1,019,421	246,886
Jack pine	1,414,126	560,645	412,024	249,696	113,808	55,421	22,532	--	--
Spruce and balsam fir	3,088,199	1,497,660	754,365	372,144	234,420	106,058	49,092	74,461	--
Other eastern softwoods	4,531,969	1,545,406	1,101,938	794,761	386,361	317,683	156,647	229,172	--
Total softwoods	13,771,982	4,323,602	2,779,197	1,874,419	1,262,715	1,102,901	859,208	1,323,054	246,886
Hardwoods									
Select white oaks	2,461,632	--	427,519	368,486	381,498	328,363	189,576	583,189	183,002
Select red oaks	2,848,516	--	500,148	588,613	455,555	405,975	331,533	457,135	109,557
Other red oaks	188,703	--	34,182	28,238	39,743	34,586	13,647	38,307	--
Hickory	64,239	--	31,890	26,201	6,148	--	--	--	--
Yellow birch	169,800	--	15,573	34,637	25,183	41,998	19,258	33,151	--
Hard maple	1,241,174	--	350,006	260,413	228,363	159,714	54,798	187,880	--
Soft maple	1,271,243	--	286,509	204,715	145,712	74,727	59,088	296,869	203,624
Ash	2,092,250	--	671,404	521,670	371,292	172,109	181,272	155,951	18,553
Cottonwood and aspen	10,454,108	--	3,239,184	2,951,316	1,880,059	1,017,682	472,125	651,627	242,115
Basswood	2,459,734	--	486,683	543,034	447,611	357,819	288,506	242,840	93,241
Black walnut	113,284	--	22,195	16,108	48,014	8,966	--	18,001	--
Other eastern soft hardwoods	2,374,466	--	1,068,298	571,108	377,289	122,485	76,185	118,243	40,858
Other eastern hard hardwoods	17,999	--	5,304	7,847	4,849	--	--	--	--
Total hardwoods	25,757,148	--	7,138,894	6,122,385	4,411,316	2,724,424	1,685,988	2,783,193	890,949
All species	39,529,130	4,323,602	9,918,091	7,996,804	5,674,030	3,827,325	2,545,196	4,106,248	1,137,835

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand board feet. Columns and rows may not add to their totals due to rounding.

[1] International 1/4-inch rule.

Table 9. – All live aboveground tree biomass on timberland by owner category, softwood/hardwood species category, and tree biomass component, Minnesota, 1999 - 2002

(In dry tons)

Owner category and softwood/hardwood category	Tree biomass component							
			Growing-stock trees			Non-growing-stock trees		
	All components	All live 1-5 inch trees	Total	Boles	Stumps, tops, and limbs	Total	Boles	Stumps, tops, and limbs
Public								
Softwoods	75,762,691	16,109,645	57,839,868	44,220,789	13,619,078	1,813,178	1,386,209	426,969
Hardwoods	144,513,859	20,686,723	112,655,011	81,913,471	30,741,540	11,172,125	8,327,218	2,844,907
Total	220,276,550	36,796,368	170,494,879	126,134,260	44,360,619	12,985,303	9,713,427	3,271,876
Private								
Softwoods	32,874,952	5,046,431	27,006,695	21,039,734	5,966,961	821,825	629,415	192,411
Hardwoods	182,193,987	20,686,538	141,150,909	102,466,807	38,684,102	20,356,541	15,097,507	5,259,034
Total	215,068,939	25,732,969	168,157,604	123,506,542	44,651,062	21,178,366	15,726,922	5,451,444
All ownerships								
Softwoods	108,637,643	21,156,076	84,846,563	65,260,524	19,586,039	2,635,004	2,015,624	619,379
Hardwoods	326,707,847	41,373,251	253,805,920	184,380,278	69,425,642	31,528,666	23,424,725	8,103,940
Total	435,345,489	62,529,337	338,652,483	249,640,802	89,011,681	34,163,669	25,440,350	8,723,320

All table cells without observations in the inventory sample are indicated by –. Table value of 0 indicates the aboveground tree biomass rounds to less than 1 dry ton. Columns and rows may not add to their totals due to rounding.

Table 10. -- Average annual net growth of growing stock on timberland by species group and owner category, Minnesota, 1990 to 1999 - 2002

(In thousand cubic feet per year)

Species group	Owner category			
	All owners	Public	Private	Unidentified owner
Softwoods				
Other yellow pines	58	--	58	--
Eastern white and red pines	39,323	21,817	17,506	--
Jack pine	7,287	5,658	1,629	--
Spruce and balsam fir	27,551	15,225	12,326	--
Other eastern softwoods	34,590	20,063	14,527	--
Total softwoods	108,809	62,762	46,047	--
Hardwoods				
Select white oaks	39,616	5,816	33,800	--
Select red oaks	21,077	5,400	15,677	--
Other red oaks	3,406	2,028	1,377	--
Hickory	117	--	117	--
Yellow birch	297	-315	612	--
Hard maple	17,395	5,699	11,696	--
Soft maple	30,424	9,669	20,755	--
Ash	39,555	12,125	27,430	--
Cottonwood and aspen	105,280	43,027	62,253	--
Basswood	25,610	6,726	18,884	--
Black walnut	1,618	--	1,618	--
Other eastern soft hardwoods	28,081	2,904	25,177	--
Other eastern hard hardwoods	196	--	196	--
Eastern noncommercial hardwoods	--	--	--	--
Total hardwoods	312,671	93,078	219,593	--
All species groups	421,480	155,840	265,640	--

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

Table 11. -- Average annual removals of growing stock on timberland by species group and owner category, Minnesota, 1990 to 1999 - 2002

(In thousand cubic feet per year)

Species group	Owner category			
	All owners	Public	Private	Unidentified owner
Softwoods				
Other yellow pines	--	--	--	--
Eastern white and red pines	9,833	6,806	3,027	--
Jack pine	16,106	7,886	8,220	--
Spruce and balsam fir	28,029	17,022	11,007	--
Other eastern softwoods	5,960	5,034	926	--
Total softwoods	59,928	36,748	23,180	--
Hardwoods				
Select white oaks	3,943	598	3,345	--
Select red oaks	11,985	3,015	8,970	--
Other red oaks	--	--	--	--
Hickory	198	--	198	--
Yellow birch	106	--	106	--
Hard maple	1,909	948	961	--
Soft maple	4,792	3,291	1,501	--
Ash	5,703	1,929	3,774	--
Cottonwood and aspen	124,160	67,098	57,063	--
Basswood	6,777	1,814	4,963	--
Black walnut	154	--	154	--
Other eastern soft hardwoods	20,818	12,851	7,967	--
Eastern noncommercial hardwoods	--	--	--	--
Total hardwoods	180,546	91,544	89,002	--
All species groups	240,474	128,292	112,182	--

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

Table 12. – Average annual mortality of growing stock on timberland by species group and owner category, Minnesota, 1990 to 1999 - 2002

(In thousand cubic feet per year)

Species group	Owner category			
	All owners	Public	Private	Unidentified owner
Softwoods				
Eastern white and red pines	5,360	2,754	2,606	--
Jack pine	9,424	3,842	5,582	--
Spruce and balsam fir	51,486	38,501	12,986	--
Other eastern softwoods	11,531	8,573	2,957	--
Total softwoods	77,801	53,671	24,131	--
Hardwoods				
Select white oaks	1,272	597	675	--
Select red oaks	5,914	1,687	4,226	--
Other red oaks	994	--	994	--
Hickory	903	--	903	--
Yellow birch	687	687	--	--
Hard maple	2,649	721	1,928	--
Soft maple	4,928	2,864	2,064	--
Ash	4,656	1,408	3,248	--
Cottonwood and aspen	100,523	56,230	44,293	--
Basswood	6,621	3,490	3,131	--
Black walnut	468	--	468	--
Other eastern soft hardwoods	51,784	27,548	24,235	--
Eastern noncommercial hardwoods	--	--	--	--
Total hardwoods	181,399	95,233	86,167	--
All species groups	259,201	148,903	110,297	--

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

Table 13. -- Area of forest land with high incidence of damage as identified by aerial survey, Minnesota, 1994-2002

(In acres)

Damage Agent	2002	2001	2000	1999	1998	1997	1996	1995	1994
Forest tent caterpillar	7,374,057	7,759,807	2,039,919	495,000	9,000	2,064		9,120	
Large aspen tortrix			63,942	340,000	9,000				
Flooding	10,781	17,909	30,697						
Spruce budworm	90,689	18,893	28,481	70,000	240,242	257,000	207,727	500,100	2,704,000
Oak tatters		2,300	20,000						
Frost			7,507						
Two-lined chestnut borer	9,665								
Larch casebearer	2,544	18,816	6,363						
Eastern larch beetle	1,279								
Oak mortality		16,800	6,061						
Dutch elm disease	2,528	1,052	365						
Bark beetles	658	2,122	100						
Winter injury		2,424							
Wind/tornado	1,995			465,000				217,800	
Walking stick				920					
Oak anthracnose				150,000					
Aspen defoliator complex								36,600	599,627
Jack pine budworm	845						74,836	66,501	6,900
Tamarack defoliation -unknown	17,072								
Mortality	15,966	47,358	20,571	7,614	5,776	10,308			
Total	7,528,079	7,887,481	2,224,006	1,528,534	264,018	269,372	282,563	830,121	3,310,527

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Results of the combined 1999, 2000, 2001, and 2002 annual forest inventories of Minnesota show that 16.3 million acres or 32 percent of the total land area is forested. The estimate of total all live tree volume on forest land is 17.6 billion cubic feet or approximately 1,080 cubic feet per acre. Just over 15.0 million acres of forest land in Minnesota is classified as timberland (forest land that is not reserved and is of high productivity). The estimate of growing-stock volume on timberland is 15.4 billion cubic feet or approximately 1,024 cubic feet per acre. All live aboveground tree biomass on timberland is estimated at 435 million dry tons or approximately 29.0 tons per acre. Important pests in Minnesota forests include the forest tent caterpillar and spruce budworm.

KEY WORDS: Annual inventory, forest area, forest type, volume, biomass, Minnesota

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