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Michigan's Forest Resources in 2000

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ABSTRACT.—The North Central Research Station's Forest Inventory and Analysis program began fieldwork for the sixth forest inventory of Michigan in 2000. This initiates a new annual inventory system. This Research Note contains estimates of Michigan's forest resources derived from data gathered during the first year of the inventory.

KEY WORDS: Annual inventory, forest land, forest type, growing-stock volume, Michigan.

BACKGROUND

The North Central Research Station's Forest Inventory and Analysis (NCFIA) program began fieldwork for the sixth forest inventory of Michigan in 2000, in partnership with the Michigan Department of Natural Resources. This inventory initiates a new annual inventory system in the State. One-fifth of the field plots in the State are measured each year under this system. As a result, the current inventory of Michigan's forest resources will not be fully implemented until 2004. However, because each year's sample is a systematic sample of the State's forest and because timely information is needed about Michigan's forest resources, estimates have been prepared from data gathered during the first year of the inventory. Due to the limited number of field plots measured, future estimates using data from this report are subject to change when ensuing annual inventories are completed and data complied. The results presented are estimates based on sampling techniques. As additional inventories are completed, the precision of the estimates will increase and additional data will be released.

Reports of previous inventories of Michigan are dated 1935, 1955, 1966, 1980, and 1993. Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. However, for the comparison 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 inventory of Michigan in 1993 (Leatherberry and Spencer 1996). Some of these changes make it inappropriate to directly compare portions of the 2000 data with data published for 1993.

RESULTS

Before Euro-Americans settled the region that is Michigan, forests occupied an estimated 33.1 million acres, or slightly more than 90 percent of the land area (Smith *et al*. 2001). From the early 1800s to the 1935 inventory, forest land area in Michigan declined to 19.1 million acres, about half of the State's total land area. During the 1935 inventory, approximately one-fifth of the forest land area (3.6 million acres) in Michigan was considered "deforested" (Cunningham and Moser 1938). Deforested lands were lands that had once been forest but that were now in grass, brush and marsh, or lightly wooded pasture. Deforested lands were viewed as acreage needing planting (Cunningham and Moser 1938). The conventional wisdom was that with proper management deforested lands could be reforested.

Between 1935 and 1966, timberland[1] area in Michigan hovered around 19 million acres (fig. 1). The general stability in timberland area during the middle third of the 20th century can be attributed to forest management activities dedicated to reforestation. For example, between

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[1] Timberland is forest land that is capable of growing trees at a minimum level (20 cubic feet per acre per year) and that is not restricted from harvest.

1933 and the start of World War II, the Civilian Conservation Corps (CCC) planted about 500 million trees in Michigan. Also, the significant amount of public ownership of forest in Michigan helped maintain a stable base of timberland area. However, between 1966 and 1980, the area of timberland in Michigan declined to a historical low of 17.5 million acres. Much of the decline in timberland area was related to increased tillage and the pasturing of livestock on marginal timberland. During the 1980s and early 1990s, the area of timberland rebounded to 18.6 million acres. The increase came predominantly from abandoned cropland and pasture and marginal forest land that were productive enough to be reclassified as timberland (Schmidt et al. 1997). Between 1993 and 2000, Michigan's timberland area increased by an estimated 442 thousand acres to an estimated 19.1 million acres. The increase in timberland area between 1993 and 2000 should be viewed with the caveat that the 2000 estimate of timberland area is based on a partial inventory and therefore has a higher sampling error than inventories since 1955 (fig. 1). The 2000 estimate indicates that timberland area is at least holding steady. A stable timberland base is noteworthy considering that suburban and second-home developments continue to expand into rural areas. Also, resort communities or enclaves, including golf courses, continue to expand into timberland areas. Timberland that converted to other land uses is apparently supplanted by land, some of it agricultural land, that reverted back to forest. However, land that converted to timberland may be different from timberland that was converted to other land uses. Differences may be associated with species composition, productivity, and ownership. Subsequent inventory data will allow for a more in-depth analysis of regional changes in Michigan's timberland area.

Private ownership controls 62 percent of the timberland area in Michigan. These include individual, as well as partnership, corporate, and other group ownerships (Leatherberry *et al.*1998). Michigan's timberland owners provide an array of goods and services. For example, Michigan's timberland owners provide wildlife habitat, watershed protection, timber and non-timber products, recreation opportunities, and environmental benefits such as biodiversity. Further, some private owners have had their forest formally certified by an independent authority as ecologically sustainable. Managers of public timberland, such as national and state forests, have more of an explicit responsibility to foster societal benefits through forestry. The conservation and

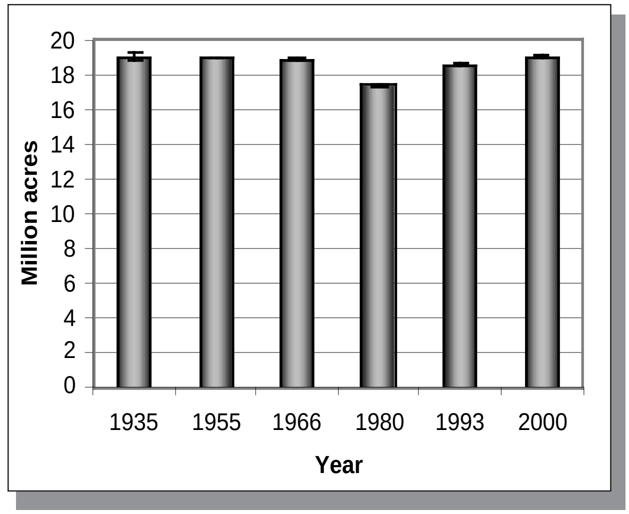

Figure 1.—*Area of timberland, Michigan, 1935-2000 (Note: the sample error associated with each inventory is represented by the vetical line at the top of each bar).*

restoration of the pine resource in Michigan is an illustration of how public ownership provides societal benefits. Before the period of extensive logging in the late 1800s and early 1900s, pines were an important component of the State's forests. Logging largely decimated the pine resource. However, some pockets where pines survived logging were placed in public ownership. Places such as Hartwick Pines State Park and Estivant Pines are remnant old-growth pine forest. Extensive pine restoration programs were carried out on public land. About one-fourth of the timberland area now in the softwood type groups was planted, and nearly 60 percent of that was planted on public land.

Hardwood forest types occupy about three-fourths of the State's timberland area. The maple-beech-birch forest type group is the most extensive forest type in Michigan, occupying an estimated 36 percent of the State's timberland area (fig. 2). The aspen-birch type occurs on about 19 percent of timberland area. The oak-hickory group, and the elm-ash-cottonwood type group, when combined occupy about 20 percent of Michigan timberland area. The white pine-red pine-jack pine group and the spruce-fir type group cover about one-fourth of the timberland area, accounting for virtually all the area in the softwood forest type groups.

As Michigan's forests mature and are affected by natural and human-caused events, they take on certain stand-size characteristics. Stand-size class is a measure of the average diameter of the dominant trees in a stand. There are three stand-size classes: sawtimber—large trees, softwoods at least

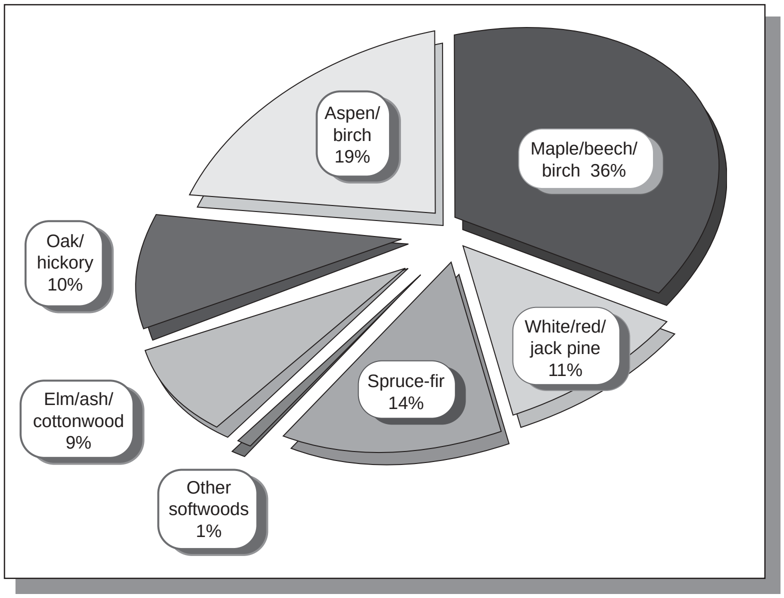

Figure 2.—*Area of forest land by forest type, Michigan, 2000.*

9 inches in diameter at breast height (d.b.h.) and hardwoods at least 11 inches d.b.h.; poletimber—medium trees, trees 5 inches in d.b.h. to sawtimber size; and sapling/seedling—small trees, trees 1 to 5 inches in d.b.h. Between 1993 and 2000, the area of larger trees—sawtimber-size trees—declined while the area in poletimber-size stands increased. The proportion of area in sapling-seedling size stands stayed about the same (fig. 3). Ensuing annual inventories of the sixth Michigan inventory will provide information for more definitive conclusions about forces driving the changes in stand-size class.

Michigan's growing-stock volume totals 27.3 billion cubic feet. Growing-stock volume is the amount of solid wood in trees greater than 5 inches d.b.h., from 1 foot above the ground to a minimum 4-inch top diameter. Growing-stock volume increased between 1993 and 2000, from 26.6 to 27.3 billion cubic feet. Total growing-stock volume has increased in every inventory since 1955. However, between 1993 and 2000 hardwood growing stock declined from 19.1 to 18.3 billion cubic feet (fig. 4). Fully two-thirds of total growing-stock volume is now in hardwood species. The apparent decrease in hardwood growing-stock volume is probably associated with the decline of area in sawtimber-size stands. Some of the sawtimber-size stands may have been harvested or otherwise removed, resulting in declining hardwood volume. In addition, the higher sampling error associated with the 2000 estimate may distort actual change (Hansen *et al*. 2000).

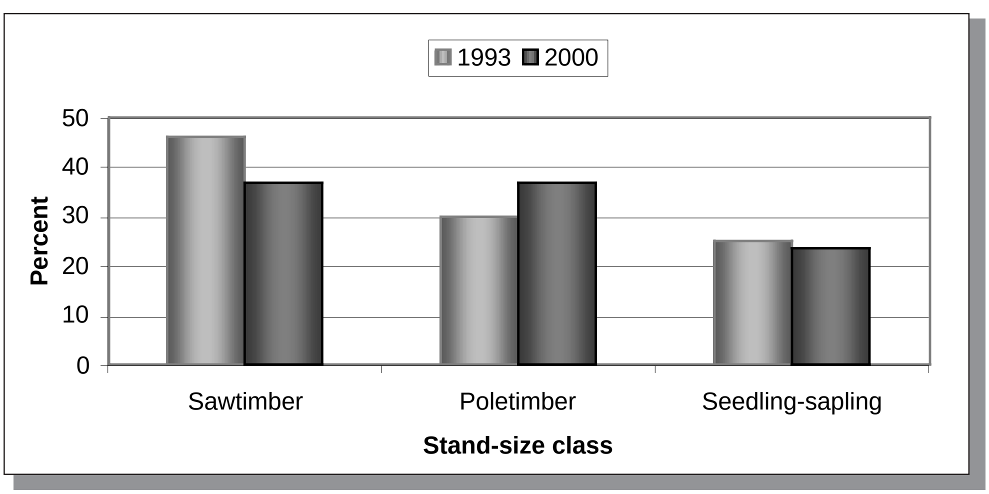

Figure 3.—*Stand-size class as a percentage of total timberland area, Michigan, 1993 and 2000.*

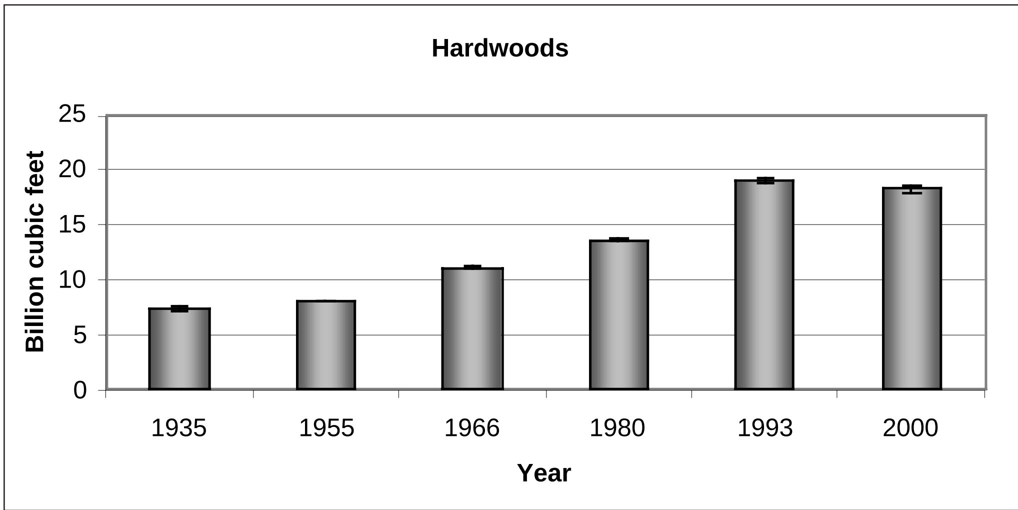

Figure 4.—*Hardwood growing-stock volume, Michigan, 1935-2000 (Note: the sampling error associated with each inventory is represented by a vertical line at the top of each bar.)*

Softwood growing-stock volume has increased during every inventory since 1955 (fig. 5). Between 1993 and 2000, the volume of softwood growing stock increased from 7.5 billion cubic feet to 9 billion cubic feet.

Maples account for the largest part of growing-stock volume at 28 percent of total growing-stock volume. Other species with significant growing-stock volume are eastern white and red pines (13 percent), followed by aspen and cottonwood (11 percent), oaks (10 percent), and other eastern softwoods (10 percent).

In summary, data from the 2000 inventory of Michigan forest resources indicate the directions of change in the State's forest resources. Timberland area increased slightly between 1993 and 2000. Although total growing-stock volume increased, hardwood growing-stock volume appears to have decreased during the same time. These findings are presented with the caveat that data are not yet sufficient to make definitive statements about how Michigan's forest resources have changed since the 1993 inventory. As additional data become available under the annual inventory system, a clearer picture of the direction of Michigan's forests will emerge.

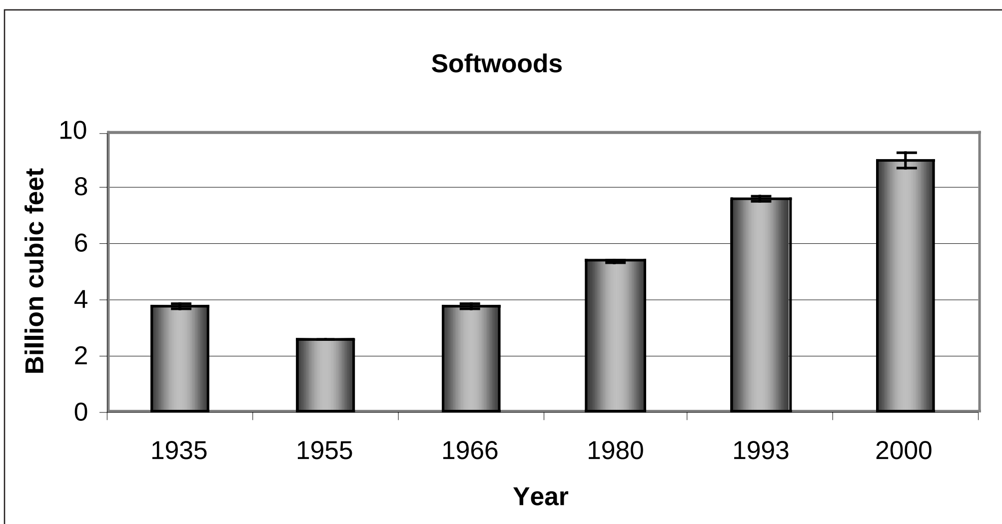

Figure 5.—*Softwood growing-stock volume, Michigan, 1935-2000 (Note: the sampling error associated with each inventory is represented by a vertical line at the top of each bar.)*

INVENTORY METHODS

Changes Between Inventories

Since the 1993 inventory of Michigan, several changes have been made in the NCFIA inventory methods to improve the quality of the inventory as well as meet the increasing demands for timely forest resource information. The most significant change between the inventories has been the change from periodic inventories to annual inventories. Historically, the NCFIA inventoried each State on a cycle that averaged about 15 years. 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. The annual inventory system began in Michigan in 2000.

With an annual inventory system, approximately one-fifth of all field plots are measured in any single year. After 5 years, the entire inventory will be completed. After the initial 5-year period, NCFIA will report and analyze results as a moving 5-year average. For example, NCFIA will be able to generate inventory results for 2000 through 2004 or for 2001 through 2005. While there are great advantages for an annual inventory, one difficulty is reporting on results in the first 4 years. With the 2000 inventory, only 20 percent of all field plots have been measured. Sampling error estimates for the 2000 inventory are 0.89 percent for timberland area and 1.76 percent for growing-stock volume. Thus, caution should be used when drawing conclusions based on this limited data set. As ensuing measurements are completed, we will have additional confidence in our results due to the increased number of field plots measured. As each measurement year is completed, the quantity and quality of the results will expand.

Other significant changes between inventories include the implementation of new remote sensing technology, implementation of a new field plot design, development of new volume equations, and gathering of additional remotely sensed and field data. The use of new remote sensing technology since the previous inventory 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. Previous inventories used manual interpretation of aerial photographs to stratify the sample.

The new volume equations, developed by USDA Forest Service research scientists and cooperative researchers, more accurately estimate the true growing-stock and sawtimber volumes. As additional annual inventories are implemented and comparisons between the current inventory and previous inventory become possible, FIA will update the 1993 inventory using the new volume equations.

New algorithms were used in 2000 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 from State to State and will be used to reassign the forest type and stand-size class of every plot in the 1993 inventory when it is updated. This will be done so that changes in forest type and stand-size class will reflect actual changes in the forest and not changes due to algorithms. The list of recognized forest types, groupings of these forest types for reporting purposes, equations used to assign stocking values to individual trees, definition of nonstocked (stands with a stocking value of less than 10 percent for all live trees), and names given to the forest types changed with the new algorithms.

Another change with the current inventory is the determination of the exact plot location of every ground plot in the new inventory. For plots that are visited in the field, this is done using a global positioning system (GPS) device at plot center. For plots not visited in the field, the plot location is determined by transferring the old plot location from aerial photography to an unclassified, geo-corrected remotely sensed image. Both procedures provide an accurate location that is used to link the ground plots to the classified remotely sensed data used for stratification.

PROCEDURES

The 2000 Michigan survey used a two-phase sample for stratification that included remeasuring inventory plots from the 1993 inventory and measuring new field plots. Two-phase sampling, also called double sampling, consists of a phase 1 sample used to estimate area by strata and a phase 2 sample used to estimate the average value of parameters of interest within the strata. The estimated population total is the sum across all strata of each stratum's estimated area multiplied by its estimated mean per unit area. The only land that could not be sampled was private land where field personnel could not obtain permission to measure a phase 2 plot. These denied access plots were rare in Michigan (about 2 percent of the total plots statewide), and the methods used in the preparation of this report made the necessary adjustments to account for sites where access was denied.

Phase 1

Phase 1 and phase 2 plots were placed systematically across the entire State without regard to specific land characteristics. All lands have the same probability of being sampled under this inventory system. The 2000 inventory used a computer-assisted classification of satellite imagery for classification. FIA used the imagery to form two initial strata—forest and nonforest. Pixels within 60 m (2 pixel widths) of a forest/nonforest edge formed two additional strata—forest/nonforest and nonforest/forest. Forest pixels within 60 m of the boundary on the forest side were classified as forest/nonforest. Pixels within 60 m of the boundary on the nonforest side were classified into the nonforest/forest strata. An overlay of national forest land ownership was used to identify all lands owned by the Ottawa, Hiawatha, and Huron-Manistee National Forests. These national forest lands where treated separately but were also stratified 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. Final estimation of area by stratum was based on these five strata—national forest, forest, forest/nonforest, nonforest/forest, and nonforest for all lands.

In the 1993 inventory, aerial photographs were assembled into township mosaics and a systematic grid of 121 one-acre photo plots (each plot representing approximately 190.4 acres on the ground) was overlaid on each township mosaic. Each of these photo plots was stereoscopically examined by aerial photo interpretation specialists and classified based on land use, forest type, and stand-size density. From these photo plots, a systematic sample of plots (without regard to their aerial photo classification) was selected as ground plots and further examined by survey crews to verify the classification and to take further measurements. These 1993 ground plots formed the basis for the remeasured ground plots in the 2000 inventory. Additional information related to the procedures for the 1993 inventory can be found in Leatherberry and Spencer (1996).

The move to satellite imagery changed NCFIA's phase 1 sample from being based on one photo plot for every 190.4 acres to a sample based on a classified pixel every 0.22 acres. The increased intensity of the phase 1 sample greatly improved estimates of the area within each stratum, particularly at the county level. Also, because the classification was conducted using a computer-assisted algorithm across the entire State, biases in the photo plot sampling method that resulted from differences in photo quality, age of photography, and experience of the photo interpreter were eliminated and classification was consistent across the entire State.

Phase 2

Phase 2 of the inventory consisted of the measurement of an annual sample of field plots in Michigan. Current FIA precision standards for annual inventories require a sampling intensity of one plot for every 5,937 acres. To satisfy this requirement, the geographical hexagons established for the Forest Health Monitoring (FHM) program were divided into 27 smaller NCFIA hexagons, each of which contained 5,937 acres (McRoberts 1999). A grid of field plots was established by selecting one plot from each of the smaller hexagons based on the following rules: (1) if an FHM plot fell within a hexagon, it was selected as the grid plot; (2) if no FHM plot fell within the hexagon, the existing FIA plot 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 Michigan is funded by the Federal government. The State of Michigan supplemented the Federal base sample and tripled the number of sample plots across the State.

The total Federal base sample of hexagonal grid plots was systematically divided into five interpenetrating, non-overlapping subsamples or panels. Each year the plots in a single panel are measured with panels selected on a 5-year, rotating basis (McRoberts 1999). For estimation purposes, the measurement of each panel of plots may be considered an independent random sample of all lands in a State. Field crews measured vegetation on plots in the forested and straddler (nonforest/forest and forest/nonforest) categories; plots classified as non-forested were checked to ensure correct classification.

NCFIA has two categories of field measurements—phase 3 (formally FHM plots) and phase 2 field plots to optimize our ability to collect data when available for measurement. It is imperative that each type of plot be uniformly distributed both geographically and temporally. Phase 3 plots are measured with the full array of vegetative and health variables collected (Mangold 1998) 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 measurement of non-woody understory vegetation, ground cover, and other variables. We anticipate that in Michigan the complete 5-year annual inventory will involve about 400 phase 3 plots. On the remaining plots, only variables that can be measured throughout the entire year are collected. In Michigan, the complete 5-year annual inventory is expected to involve about 3,500 phase 2 forested plots and about 1,380 phase 2 straddler plots. With intensification, the number of field plots will be tripled.

The new national FIA 4-point cluster plot design was used for data collection (fig. 6) in 2000 and will be used in subsequent years. For all remeasured field plots in the Federal base sample, the new 4-point cluster plot was established and measured at the old plot (1993) location. In addition, the first five subplots of the old 10-point (subplot) cluster were remeasured in 2000 to estimate change. All trees previously measured on the five subplots were remeasured or otherwise accounted for. These measurements form the basis for change estimates between the 1993 and 2000 inventories for characteristics such as average annual net growth, mortality, and removals. Thus, until a complete cycle of annual inventories for Michigan has been accomplished, both the new 4-point cluster plots and part of the old 10-point cluster plots will be measured. If the anticipated 20 percent of the State is sampled each year, by the sixth year of annual inventories in Michigan, the new 4-point cluster plots will begin to be remeasured and the former plot design will be abandoned. The national plot design also requires mapping forest conditions on each plot. Due to the small sample size (20 percent) each year, the precision associated with change factors such as mortality will be relatively low. Consequently, change estimates will not be reported until at least three annual inventories have been completed, and even then we anticipate that estimates of change will be limited in detail. When the complete annual inventory has been implemented in 2005, the full range of change variables will be available.

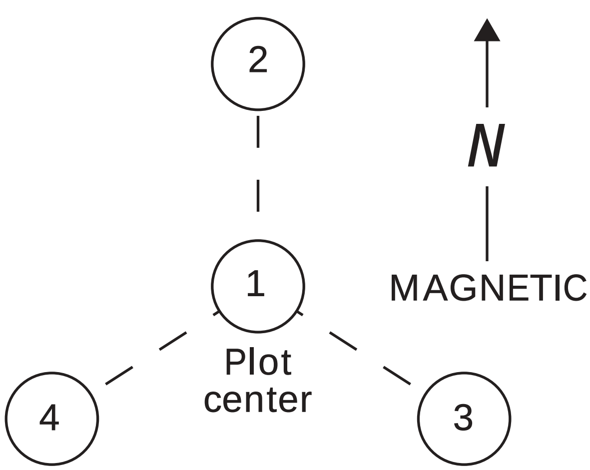

Figure 6.—*Current NCFIA field plot design.*

The overall plot layout for the new design consists of four subplots spaced 120 feet apart in a triangular arrangement. Subplots 2, 3, and 4 are spaced 120 degrees apart. 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. All trees less than 5.0 inches in diameter at breast height (d.b.h., or 4.5 feet above ground level) are measured on a 6.8-foot-radius (1/300 acre) circular microplot located 12.0 feet due east of the center of each of the four subplots. Trees with diameters 5 inches and larger are measured on a 24-foot-radius (1/24 acre) circular subplot. The forest condition of each subplot is recorded. Factors that can determine a change in forest condition from subplot 1 are changes in forest type, stand-size class, land use, ownership, and density. Each condition that occurs anywhere on one of the subplots is identified, described, and mapped if the condition in total meets or exceeds 1 acre in size (the 1-acre minimum size for a condition to be identified could include land off the subplot). Each condition is assigned a condition number, and condition information is recorded.

Field plot measurements are combined with phase 1 estimates in the compilation process. As additional annual inventories are completed, tables will be generated for publication. In year 5, all statewide inventory summary tables will be available in both printed and electronic formats. For additional information, contact:

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