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North Dakota's Forest Resources in 2001

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ABSTRACT.—The North Central Research Station's Forest Inventory and Analysis program began fieldwork for the fourth forest inventory of North Dakota in 2001. This initiates a new annual inventory system. This Research Note contains estimates of North Dakota'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, North Dakota.

BACKGROUND

The North Central Research Station's Forest Inventory and Analysis (NCFIA) program began fieldwork for the fourth forest inventory of North Dakota in 2001, in partnership with the North Dakota Forest Service. 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 North Dakota's forest resources will not be fully implemented until 2005. However, because each year's sample is a systematic sample of the entire State and because timely information is needed about North Dakota'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 compiled. 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 North Dakota are dated 1954, 1980, and 1994. 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 been made since the last inventory of North Dakota in 1994 (Haugen *et al.* 1999). Some of these changes make it inappropriate to directly compare portions of the 2001 data with those published for earlier inventories.

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RESULTS

North Dakota is best known as a Prairie State with an agricultural-based economy. Although forest lands cover only a small portion of the State's land area, they are an important component of the landscape. Forests, wooded strips, shelterbelts, and windbreaks all play a crucial role in protecting riparian areas, farmsteads, crops, livestock, and wildlife (Haugen *et al*. 1999).

The first settlers in North Dakota found about 700 thousand acres of forest land (Jakes and Smith 1982). Most of the forest at that time was in the Turtle Mountains, Killdeer Mountains, Pembina Hills, the Devil's Lake area, and along major rivers and their tributaries (Haugen *et al.* 1999). In 2001, forest land in North Dakota totaled more than 893 thousand acres—an increase of 32 percent from the 1994 total of 673 thousand acres. The increase continues a trend established with the 1994 inventory. However, the magnitude of the increase was mostly due to a definitional change. Previously, forest lands that were being grazed or that provided shelter from the wind were classed as nonforest with trees; now such lands are classed as forest land if they meet the definitional standards for size, width, and stocking.

Timberland, a subset of forest land, has followed the same trend in North Dakota (fig. 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 harvesting. The estimated area of timberland increased by nearly 29 percent between the 1980 and 1994 inventories. The increase of 70 percent between 1994 and 2001 may be due in part to sampling error and definitional changes. As additional years of inventory data are collected, a clearer picture of total timberland area for the State should unfold.

In North Dakota, hardwoods dominate the native forest landscape—93 percent of all forest land area is in hardwood forest types (fig. 2). The exception, the pinyon-juniper forest type, constitutes 4 percent of forest lands and is found primarily in western North Dakota.

Over 78 percent of forest land is privately owned in North Dakota. These owners include farmers, ranchers, business people, retirees, and persons from nearly every walk of life (Haugen *et al*. 1999). Native American tribal groups own an estimated 47.8 thousand acres of forest land held as tribal trust land within the boundaries of reservations in North Dakota (Haugen and Hansen 2002). Privately owned forest lands are important because they are a major source of wildlife habitat, outdoor recreation, riparian protection, and other social and environmental benefits. The State of North Dakota is the single largest owner of publicly held forest lands in the State.

Between 1994 and 2001, the area of timberland in all stand-size classes increased, but, the percentage of timberland area in the sapling-seedling stand-size class decreased (fig. 3). The percentage of timberland area in poletimber-size stands did not change significantly between inventories, but sawtimber-size stands increased by 4 percent. Nonstocked timberland (timberland less than 10 percent stocked with all live trees) increased from 1 percent of total timberland area in 1994 to 3 percent in 2001. With over three-quarters of all timberland area classified as saw- and pole-size stands, the forests in the State are maturing.

Growing-stock volume is the amount of solid wood on timberland in trees 5 inches d.b.h. and over in trees meeting quality standards, from 1 foot above ground to a minimum 4-inch top diameter with deductions made for poor form or defect. Along with increases in timberland area, especially in the saw- and pole-stand-size classes, growing-stock volume also increased between inventories (fig. 4).

In 2001, 40 percent of the growing-stock volume in North Dakota was in the white oak species group, followed by the cottonwood and aspen species group (30 percent), and the ash species group (23 percent). Hardwoods dominate in North Dakota, with 99 percent of the total growing-stock volume.

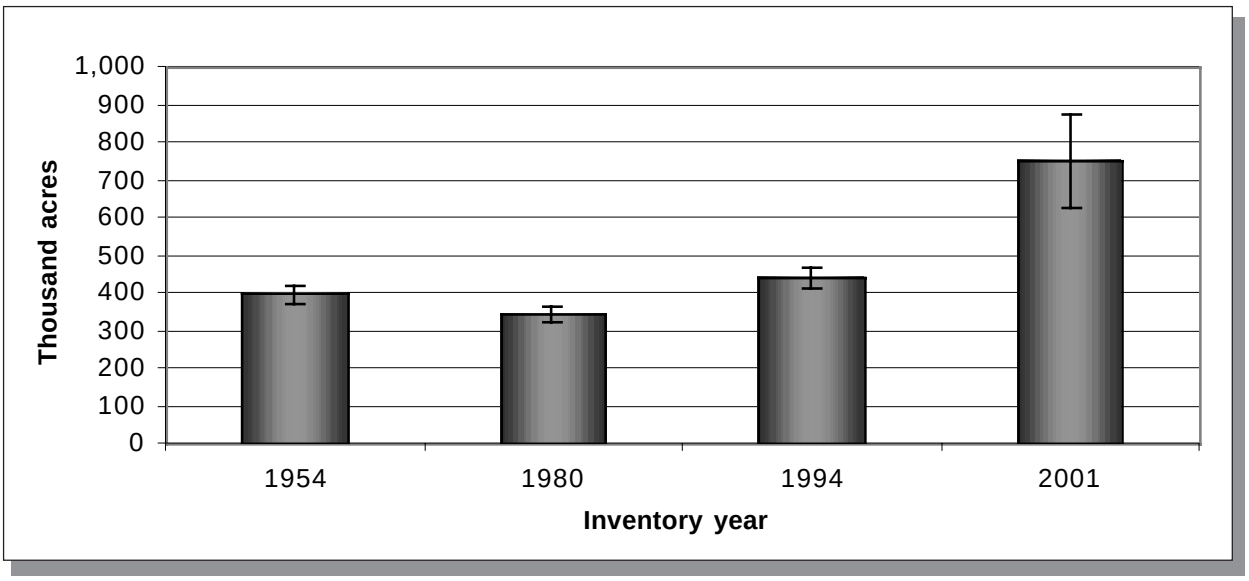

Figure 1.—*Area of timberland, North Dakota, 1954-2001 (Note: the sample error associated with each inventory is represented by the vertical line at the top of each bar).*

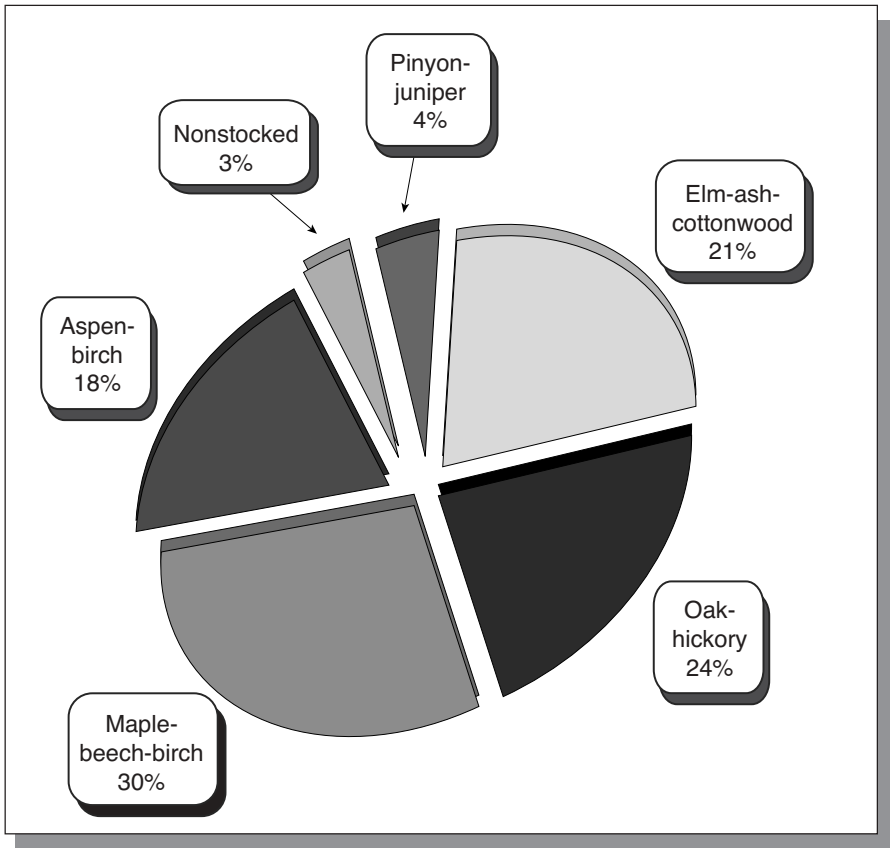

Figure 2.—*Area of forest land by forest type, North Dakota, 2001.*

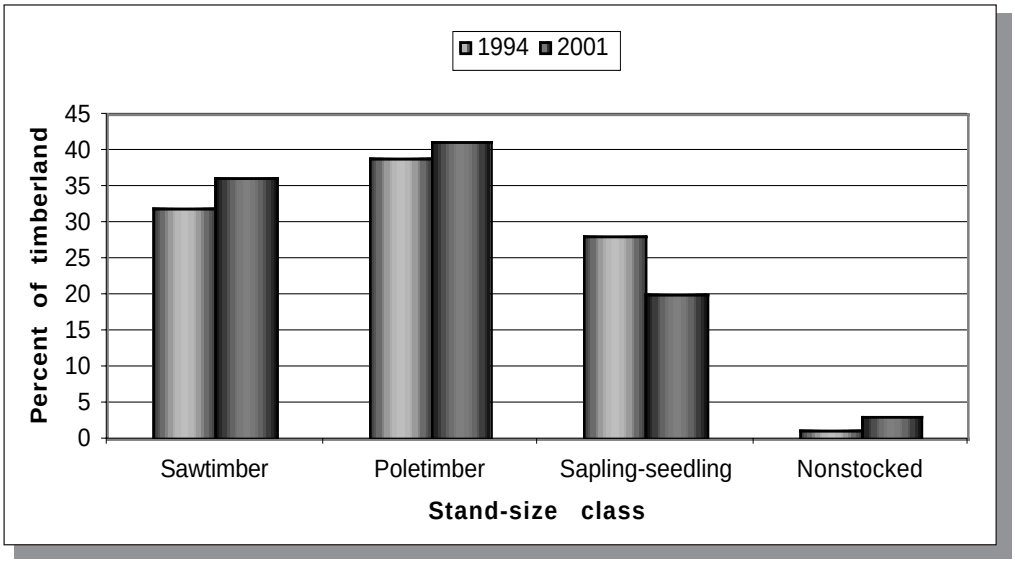

Figure 3.—*Stand-size class as a percentage of total timberland area, North Dakota, 1994 and 2001.*

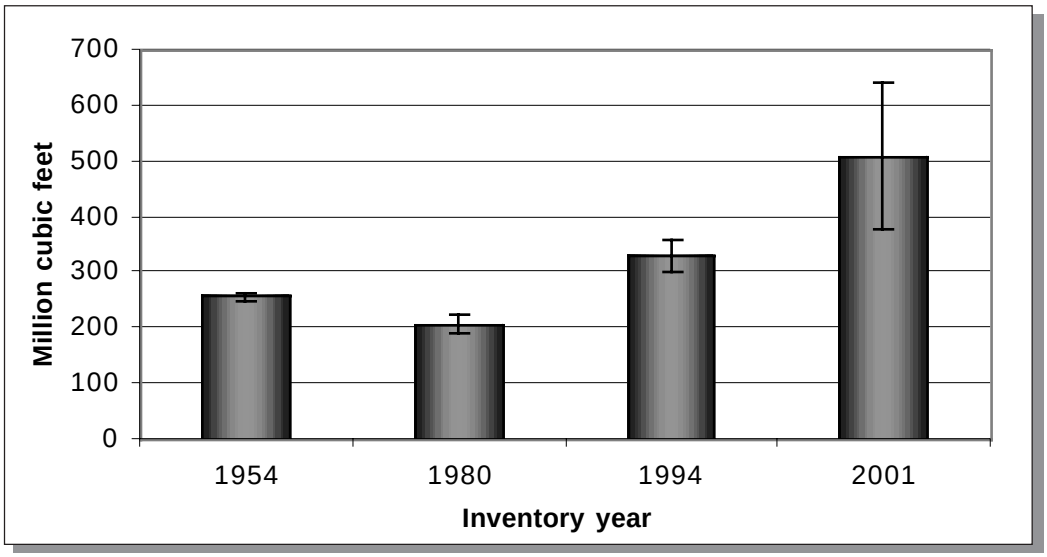

Figure 4.—*Growing-stock volume, North Dakota, 1954-2001 (Note: the sampling error associated with each inventory is represented by the vertical line at the top of each bar).*

In summary, although the initial 2001 annual inventory of North Dakota indicates that forest land area and growing-stock volume increased between 1994 and 2001, these trends should be viewed with caution until sufficient data are collected in ensuing years to clearly indicate how North Dakota's forest resources have changed since the 1994 inventory. As additional inventory data become available under the annual inventory system, a clearer picture of North Dakota's forest resources will unfold.

INVENTORY METHODS

Changes Between Inventories

Since the 1994 inventory of North Dakota, several changes have been made in the NCFIA inventory methods to improve the quality of the inventory as well as to 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, 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 North Dakota in 2001.

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 2001 through 2005 or for 2002 through 2006. While there are great advantages for an annual inventory, one difficulty is reporting on results in the first 4 years. With the 2001 inventory, only 20 percent of all field plots have been measured. Sampling error estimates for the 2001 inventory are 16.76 percent for timberland area and 26.07 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, 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.

Volume equations developed by Hahn and Hansen (1991) are used to estimate the 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 1994 inventory.

New algorithms were used in 2001 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 2001 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. In the northern Great Plains States, (Kansas, Nebraska, South Dakota—outside the Black Hills National Forest, and North Dakota), all field plots are newly established. For each newly established field plot, the exact location is determined by using a global positioning system (GPS) device at the plot center. For plots not visited in the field, the plot location is identified on 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 2001 North Dakota survey used a two-phase sample for stratification. 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 North Dakota (less than 5 percent of the total number of 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 2001 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 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 as nonforest/forest. In North Dakota, final estimation of area by stratum was based on three strata—nonforest, nonforest edge, and forest plus forest edge.

In the 1994 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. Additional information related to the procedures for the 1994 inventory can be found in Haugen *et al.* (1999).

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 North Dakota. 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 establishing a new permanent FIA plot in each of the smaller hexagons. This grid of plots is designated the Federal base sample and is considered an equal probability sample; its measurement in North Dakota is funded by the Federal government. Fieldwork for this inventory was expedited through the cooperation and assistance of the North Dakota Forest Service.

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 (formerly 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 North Dakota the complete 5-year annual inventory will involve about 472 phase 3 plots. On the remaining plots, only variables that can be measured throughout the entire year are collected. In North Dakota, the complete 5-year annual inventory is expected to involve about 7,150 phase 2 plots.

The new national 4-point cluster plot design was used for data collection (fig. 5) in 2001 and will be used in subsequent years. In North Dakota, because all plots in the annualized inventory are newly established, remeasurement data will not be available until the sixth year of the annual inventory. Those measurements will form the basis for change estimates between the first five-panel cycle and the second five-panel cycle for characteristics such as average annual net growth, mortality, and removals. 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 in the second five-panel cycle, and even then we anticipate that estimates of change will be limited in detail. When the complete second five-panel cycle of the annual inventory has been implemented in 2010, (if the anticipated 20 percent of the State is sampled each year), the full range of change variables will be available.

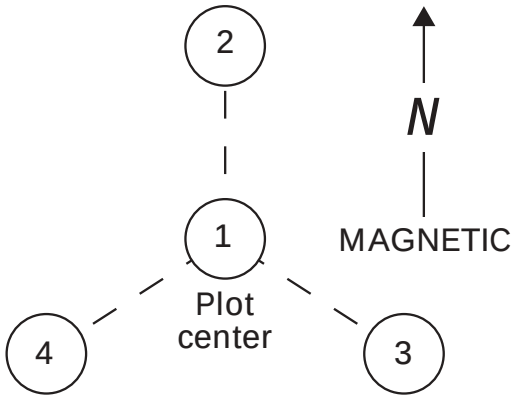

Figure 5.—*Current NCFIA field plot design.*

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, statewide inventory summary tables will be available in both printed and electronic formats. However, change factors such as growth, mortality, and removals will not be reported until at least three annual inventories have been completed in the second five-panel cycle.

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