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South 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 fifth forest inventory of South Dakota in 2001. This initiates a new annual inventory system. This Research Note contains estimates of South 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, South Dakota.

BACKGROUND

The North Central Research Station's Forest Inventory and Analysis (NCFIA) program began fieldwork for the fifth forest inventory of South Dakota in 2001, in partnership with the South Dakota Department of Agriculture, Resource Conservation and Forestry Division. 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 South Dakota's forest resources will not be fully implemented until 2005. However, because each year's sample is a systematic sample of the State's forest and because timely information is needed about South 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 South Dakota are dated 1936, 1962, 1984, and 1996. 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 South Dakota in 1996 (Leatherberry *et al.* 2000). The most important change is the "border-to-border" inventory of forest resources in South Dakota. Prior to 1996, both the NCFIA program and the Interior West FIA program (formerly the Intermountain FIA program) in Ogden, UT, inventoried South Dakota's forest resources. The NCFIA program inventoried that portion of the State that is east of the 103rd meridian. The IWFIA program inventoried western South Dakota (west of the 103rd meridian), including the Black Hills National Forest (BHNF). In 1996, the NCFIA program inventoried forest in South Dakota, except for the BHNF, and in 1999, the IWFIA program inventoried forest in the BHNF (DeBlander 2002). Different designs and methods have been employed in the various South Dakota inventories, making it inappropriate to directly compare portions of the 2001 data with data published earlier. Therefore, few comparisons are made with data from the other South Dakota inventories. Where comparisons are made with published data from past inventories, they are done only to suggest the direction of change.

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RESULTS

In 2001, there were an estimated 1.6 million acres of forest land in South Dakota, accounting for about 3 percent of the State's land area. Most of South Dakota's forests are found west of the Missouri River and mainly in the Black Hills, but also in the limestone covered buttes of the northwest corner, the pine ridge of the southwest, or along streams and rivers. The majority of forested land in central and eastern South Dakota is located along the slopes of the Missouri River, its major tributaries, and in riparian areas. Other areas of forested land are found along the eastern slopes of the Coteau Des Prairie of northeastern South Dakota. Throughout most of the 20th century, the area of forest land in South Dakota remained relatively stable (fig. 1). Between 1996 and 2001, the State's timberland[1] area appears to have increased. The prospective increase, although slight, may be due to a definitional change. Previously, forest lands that were being grazed or providing 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. The 2001 estimate of timberland area is based on a partial inventory, and the estimate is likely to change as more data are collected in ensuing annual inventories. However, the relative stability of timberland area over time, coupled with its scarcity, makes forests a valuable component of South Dakota's landscape.

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

Nearly 70 percent of timberland area in South Dakota is publicly owned. The USDA Forest Service, through the Black Hills and Custer National Forests, holds the majority of public timberland. Owners who have fewer than 100 acres of timberland hold most of the privately owned timberland (Leatherberry *et al.* 2000). Those holdings are generally associated with farm or ranch operations. Native American tribal groups own an estimated 93 thousand acres of timberland held as tribal trust land within the boundaries of reservations in South Dakota (Haugen and Hansen 2002).

Virtually all of the timberland area in South Dakota is of natural origin. South Dakota residents have a long history of planting trees, but most of those plantings were associated with windbreaks, shelterbelts, or farmstead plantings. Most of the strips planted were not considered timberland. Many of the earlier efforts to establish tree plantations failed or were later abandoned.

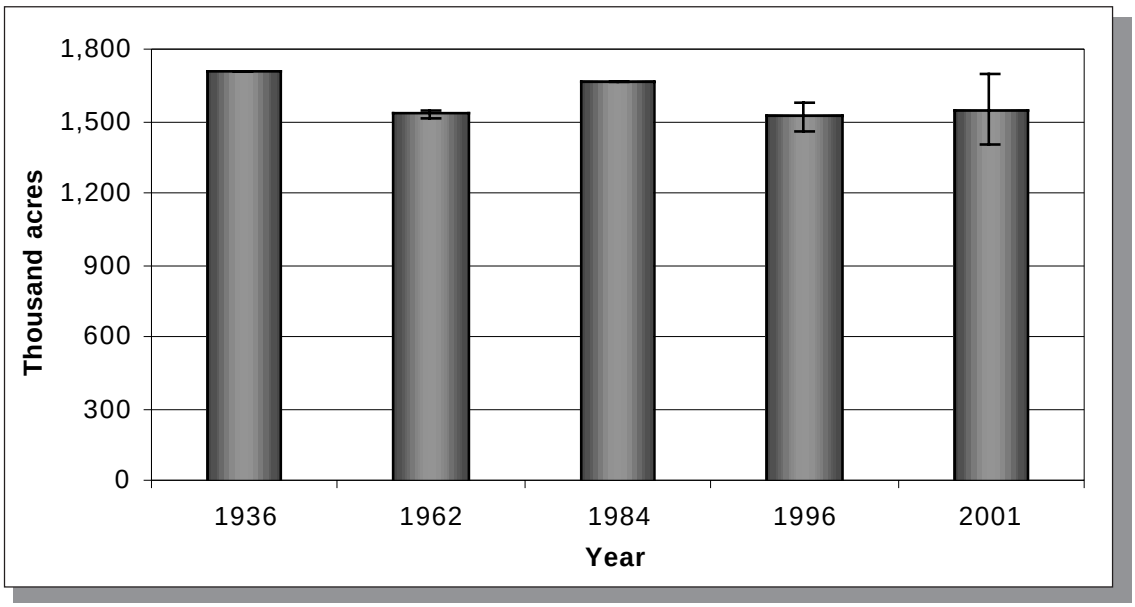

Figure 1.—*Area of timberland, South Dakota 1936-2001. (Note: Sample errors are not provided for the 1936 and 1984 inventories because no single statewide sample error is available for those inventories. The 1962 and 2001 estimates are for total timberland area; the sample error associated with the 1996 estimate is calculated for timberland area outside of the BHNF. Sample error is represented by the vetical line at the top of each bar.)*

Softwood forest types occupy 80 percent of the State's forest land area. The ponderosa pine forest type occupies slightly more than three-quarters of the forest land area in the State (fig. 2). Ponderosa pine is found exclusively in the western part of the State, most of it in the Black Hills region. The pinyon/juniper forest type group—eastern redcedar in the east and Rocky Mountain juniper in the west—makes up nearly all the remaining area of softwood forest, or about 4 percent of the State's forest land area. It appears that eastern redcedar is expanding in South Dakota. In 1996, the eastern redcedar, eastern redcedar-hardwood, and Rocky Mountain juniper forest type groups combined occupied an estimated 28 thousand acres in South Dakota outside the BHNF. Between 1996 and 2001, the corresponding pinyon/juniper forest type group occupied 67 thousand acres, which equates to an increase of 141 percent. The hardwood forest in South Dakota occupies 17 percent of the State's forest land area. Although only a small portion of total forest land area, the hardwood resource is dispersed throughout the State and is ecologically diverse.

As South Dakota'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 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. Sawtimber-size stands predominate in South Dakota, occupying 61 percent of timberland area (fig. 3). Seedling/sapling-size stands account for 25 percent of timberland area, followed by poletimber-size stands on 11 percent of timberland area. About 3 percent of timberland area is classed as nonstocked.

The predominance of sawtimber-size stands reflects the presence of larger diameter ponderosa pine in the Black Hills National Forest, and older, large-diameter hardwood stands (i.e., green ash, cottonwood, bur oaks). The significant presence of seedling/sapling stands is partly related to the presence of overstocked “doghair” ponderosa pine stands and the expansion of eastern redcedar. The somewhat bipolar size class distribution of timberland stands in South Dakota will probably smooth out as older hardwood

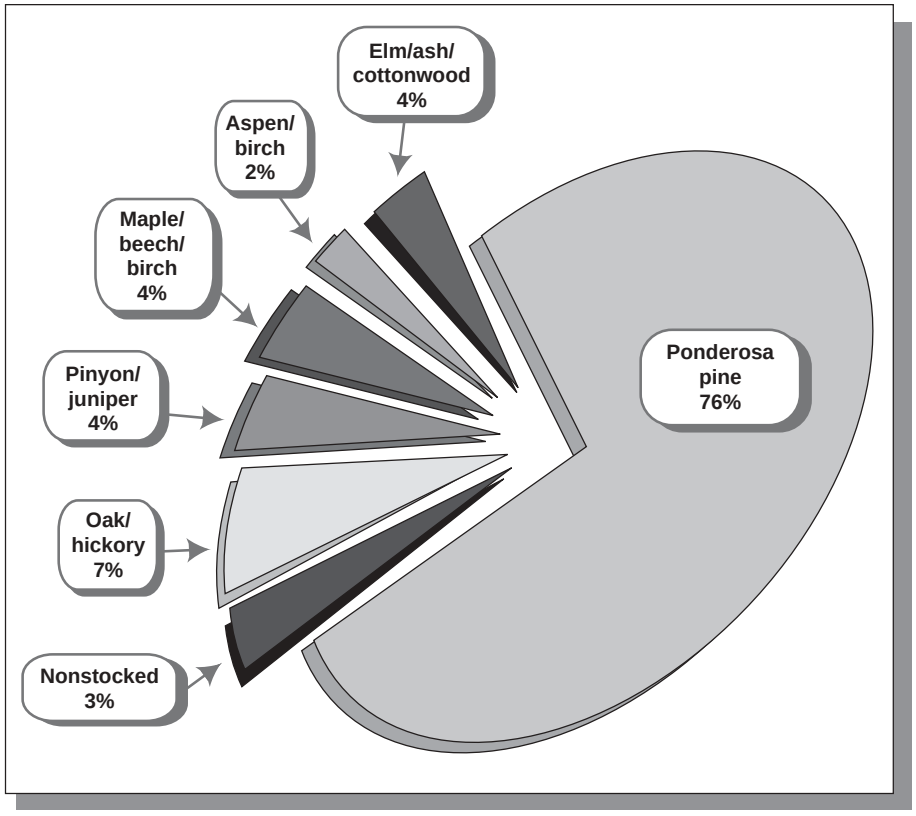

Figure 2.—*Area of forest land by forest type, South Dakota, 2001.*

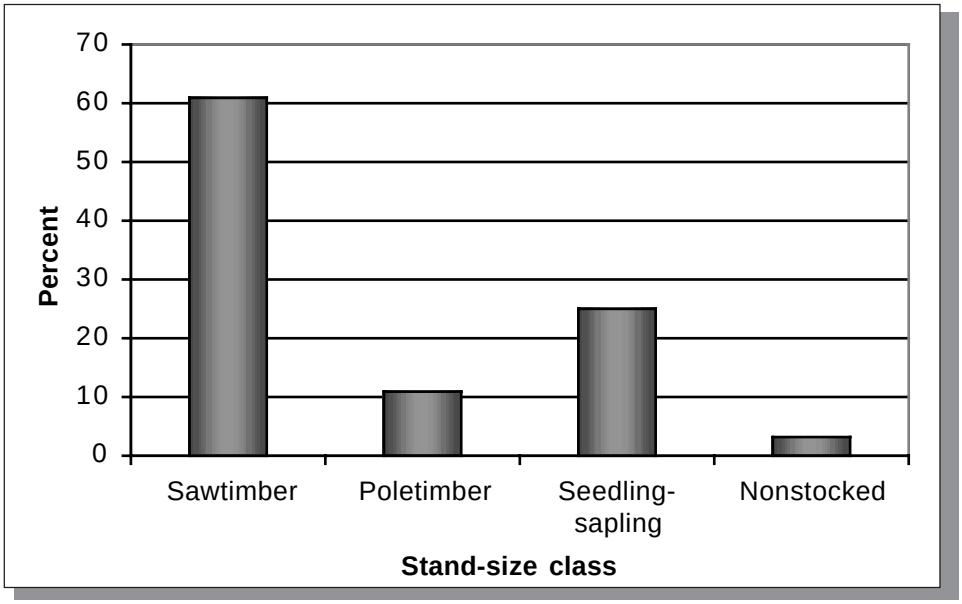

Figure 3.—*Stand-size class as a percentage of total timberland area, South Dakota, 2001.*

stands are replaced, and as more area of seedlings/saplings move into the poletimber-size class. Ensuing panels of the fifth South Dakota inventory will provide information for more definitive conclusions about forces driving the changes in stand-size class.

South Dakota's growing-stock volume totals 1.4 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. Over the years, growing-stock volume has increased from the estimated 757.7 million cubic feet present in 1936, to 1.1 billion cubic feet in 1962, to 1.4 billion cubic feet in 2001.

Softwood volume accounts for 91 percent of South Dakota's growing-stock volume, and virtually all softwood volume is in the ponderosa pine forest type group. Although the area of eastern redcedar appears to be expanding in South Dakota, eastern redcedar volume (as reflected in volume in the pinyon/juniper group) is fairly minor at less than 1 percent of total growing-stock volume. The elm/ash/cottonwood group, and the oak/hickory group account for the largest portion of hardwood growing-stock volume, both at 3 percent of total growing-stock volume.

In summary, data from the 2001 inventory of South Dakota's forest resources indicate timberland area has remained relatively stable at about 3 percent of land area. Ponderosa pine, found mostly in the Black Hills region, is the predominant forest type group. It appears that eastern redcedar is expanding in the State. However, eastern redcedar growing-stock volume is a minor portion of total volume. These findings are presented to provide an indication of the current status and possible direction of changes in the State's forest resources. As additional data become available, a clear picture of the direction of South Dakota's forest will emerge. The annual inventory system allows, for the first time since 1936, a basis from which uniform, comprehensive information about the South Dakota's forest can be derived.

INVENTORY METHODS

Changes Between Inventories

Since the 1996 inventory of South Dakota's forest outside the BHNF, 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 South Dakota in 2001. At that time, the NCFIA program assumed responsibility for inventorying all forest lands in South Dakota.

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 9.50 percent for timberland area and 11.70 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 South Dakota 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 BHNF, and North Dakota), all field plots are newly established. (In the BHNF, remeasurement plots are from the 1999 periodic inventory conducted by IWFIA.) 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 South Dakota survey used a two-phase sample for stratification that included remeasuring inventory plots from the 1999 BHNF inventory (DeBrander 2002) 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. In South Dakota denied access plots was not a problem; on only one plot was the field crew denied access. The methods used in the preparation of this report made the necessary adjustments to account for the plot 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 into the nonforest/forest strata. In South Dakota, final estimation of area by stratum was based on three strata—nonforest, nonforest edge, and forest plus forest edge.

In the 1996 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. The Black Hills National Forest have remeasurement ground plots that were last measured in 1999 (DeBrander 2002, USDA Forest Service 2002). Additional information related to the procedures for the 1996 inventory can be found in Leatherberry *et al.* (2000).

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 and annual sample of field plots in South 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 South Dakota is funded by the Federal government. The South Dakota Department of Agriculture, Resource Conservation and Forestry Division contributed personnel and equipment in conducting the inventory.

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 (Mangold 1998) 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 measurement of non-woody understory vegetation, ground cover, and other variables. We anticipate that in South Dakota the complete 5-year annual inventory will involve about 550 phase 3 plots. On the remaining plots, only variables that can be measured throughout the entire year are collected. In South Dakota, the complete 5-year annual inventory is expected to involve about 7,782 phase 2 plots.

The new national 4-point cluster plot design was used for data collection in South Dakota in 2001 (fig. 4) and in BHNF in 1999. The design will be used in subsequent years. On forest land outside the BHNF, all plots in the annualized inventory are newly established; therefore, some remeasurement data will not be available until the sixth year of the annual inventory. These measurements form the basis for change estimates between the first five-panel cycle and the second five-panel cycle for characteristics such as average

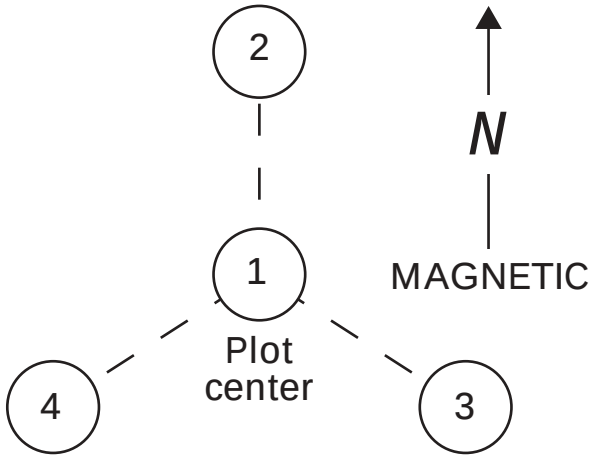

Figure 4.—*Current NCFIA field plot design.*

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 outside the BHNF may 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 annual inventory has been implemented in 2009, the full range of change variables will be available for areas outside the BHNF.

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 and table production. The number of tables generated from a single year's 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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