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FOREST INVENTORY METHODS

Strategic Model

The Forest Inventory and Analysis (FIA) program of the Northern Research Station (NRS-FIA) is part of the national enhanced FIA program that focuses on a set of six strategic objectives (McRoberts 2005):

- A standard set of variables with nationally consistent meanings and measurements
- Field inventories of all forested lands
- Nationally consistent estimation
- Adherence to national precision standards
- Consistent reporting and data distribution
- Credibility with users and stakeholders

To ensure that these objectives are achieved, 10 strategic approaches have been prescribed:

- A national set of prescribed core variables with a national field manual that prescribes measurement procedures and protocols for each variable
- A nationally consistent plot configuration
- A nationally consistent sampling design
- Estimation using standardized formulas for sample-based estimators
- A national database of FIA data with core standards and user-friendly public access
- A national information management system
- A nationally consistent set of tables of estimates of prescribed core variables
- Publication of statewide tables with estimates of prescribed core variables at 5-year intervals
- Documentation of the technical aspects of the FIA program including procedures, protocols, and techniques
- Peer review and publication of the technical documentation for general access

The result of the strategic objectives and approaches is an inventory program with identifiably new features and a nationally consistent plot configuration, a nationally consistent sampling design for all lands, annual measurement of a proportion of plots in each state, nationally consistent estimation techniques and algorithms, and integration of the ground sampling components of the FIA inventory and the detection monitoring by the U.S. Forest Service's Forest Health Monitoring (FHM) program.

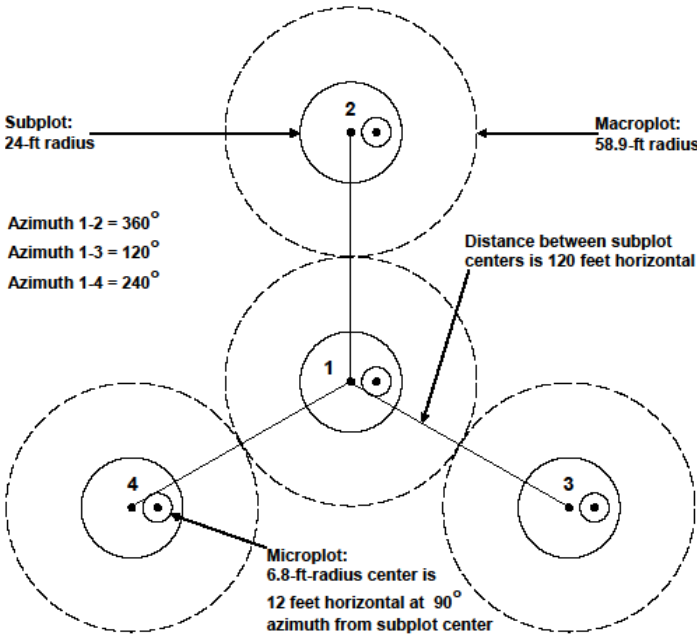

Figure 104.—National Forest Inventory and Analysis plot design (adapted from Bechtold and Patterson 2005).

Plot Configuration

The national FIA plot design consists of four 24-foot-radius subplots (1/24th acre) configured as a central subplot and three peripheral subplots (Fig. 104). Centers of the peripheral subplots are located at distances of 120 feet from the central subplot at azimuths of 0˚, 120˚, and 240˚ from the center of the central subplot. Each tree with a diameter at breast height (d.b.h.) of 5 inches or greater is measured on these subplots. Each subplot contains a 6.8-foot-radius microplot with center located 12 feet east of the subplot center on which each tree with d.b.h. between 1 and 5 inches is measured. Forest conditions that occur on any of the four subplots are identified and recorded. If the area of the condition is 1 acre or greater, the condition is mapped on the subplot. Factors that differentiate forest conditions include forest type, stand-size class, stand origin, land use, ownership, and density.

Sample Design

Based on historic sampling errors, a sampling intensity of approximately one plot per 6,000 acres is necessary to satisfy national FIA precision guidelines. Therefore, FIA divided the area of the United States into nonoverlapping, 5,937-acre hexagons and has established a sample plot location in each hexagon. This array of field plots is designated the federal base sample and is considered an equal probability sample; its measurement is funded by the Federal government.

The federal base sample is divided into five interpenetrating panels, or subsamples, each of which provides complete, systematic coverage of a state. Each year, plots in a single panel are measured and panels are selected on a 5-year, rotating basis (McRoberts 1999)—that is, the plots measured in 2008 were measured again in 2013 and the plots measured in 2004 were measured again in 2009. For estimation purposes, the measurement of each panel of plots is considered an independent, equal probability sample of all lands in a state and the remeasurement of a panel is considered an equal probability sample of change occurring on all lands in a state.

Three-phase Inventory

FIA conducts inventories in three phases. Phase 1 (P1) uses remotely sensed data to obtain initial plot land cover observations and to stratify land area in the population of interest to increase the precision of estimates. In Phase 2 (P2), field crews visit the physical locations of permanent field plots to measure traditional inventory variables such as tree species, diameter, and height. In Phase 3 (P3), field crews visit a subset of P2 plots to obtain measurements for an additional suite of variables associated with forest and ecosystem health. The three phases of the enhanced FIA program are discussed in greater detail in the following sections.

Phase 1

Aerial photographs, digital orthoquads (DOQs: digitally scanned aerial photographs), and satellite imagery are used for initial plot measurement and stratification. P1 plot measurement consists of observations of conditions at the plot locations using aerial photographs or DOQs. Analysts determine a digitized geographic location for each field plot, and a human interpreter assigns the plot a land cover/ use. Lands satisfying FIA's definition of forest land include commercial timberland, some pastured land with trees, forest plantations, unproductive forested land, and reserved, noncommercial forested land. In addition, forest land requires minimum stocking levels, a 1-acre minimum area, and a minimum bole-to-bole width of 120 feet with continuous canopy. Forest land excludes wooded strips and windbreaks less than 120 feet wide and idle farmland or other previously nonforest land that currently is below minimum stocking levels. All plot locations that could possibly contain forest land, plus any additional plots that contained forest land at the previous measurement, are selected for further measurement via field-crew visits in P2.

The combination of natural variability among plots and budgetary constraints prohibits measurement of a sufficient number of plots to satisfy national precision standards for most inventory variables unless the estimation process is enhanced using ancillary data. Thus, the land area is stratified by using remotely sensed data to facilitate stratified estimation.

Currently, NRS-FIA uses canopy density classes to derive strata. Canopy density data are derived from the 2011 National Land Cover Database (NLCD 2011) (Homer et al. 2015), U.S. Forest Service Tree Canopy cartographic dataset (TCC 2011) that was produced through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium (www.mrlc.gov). TCC 2011 is the NLCD tree canopy cover product that covers the CONUS at a medium spatial resolution (30 m). It was produced by the U.S. Forest Service Remote Sensing Applications Center (RSAC) using a Random Forests™ regression algorithm (Breiman 2001). The layer consists of a single raster layer, percent tree canopy cover with file pixels that characterize subtle variations of forest canopy density as a percentage estimate of forest canopy cover (0 - 100 percent) within every 30 m pixel over the United States; i.e., each individual value represents the area or proportion of that 30m cell covered by tree canopy. All data are projected to the USGS Albers Conical Equal Area using the NAD83 Datum, GRS 1980 Spheroid.

The overall NLCD 2011 database philosophy and methodology is presented in Homer et al. (2015). Coulston et al. (2012) describe the methodology used to map canopy density for TCC 2011. Data are free to download and are available at: http://www.mrlc.gov/nlcd2011.php. Additional information about this product is found in the metadata file provided as part of the download package.

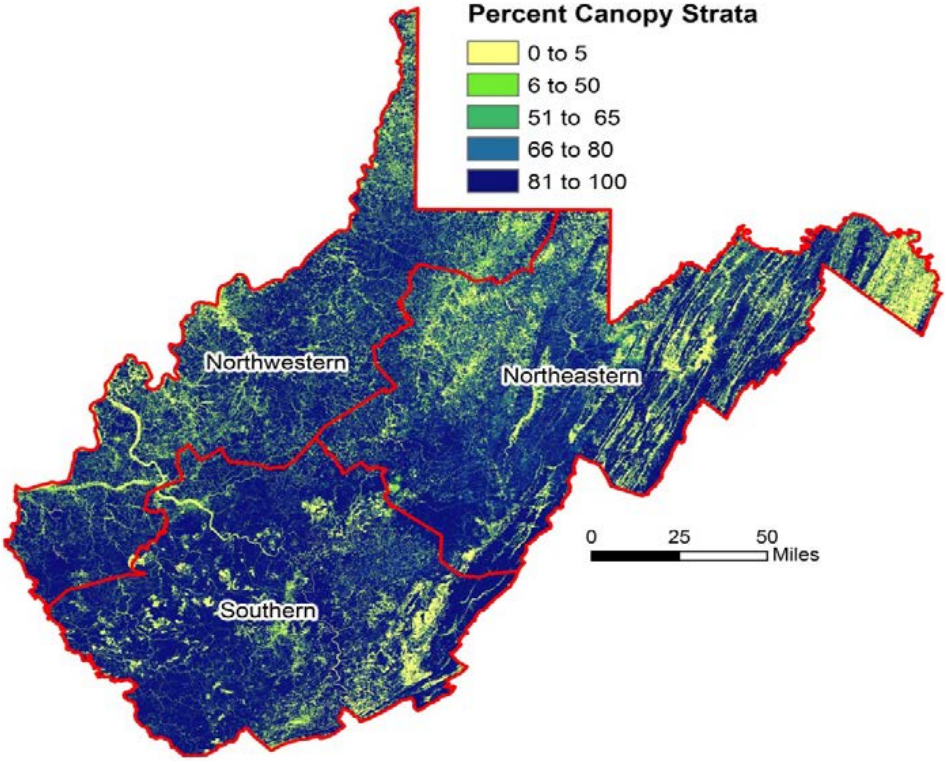

Figure 105.—West Virginia percent canopy strata groupings.

Strata Construction

The current strata categorizations we employ are applied consistently across the entire Northern FIA region. Using plot location information (center of the center subplot), a percent canopy density value is assigned to each plot. Plots are then aggregated into one of five strata based on the center of the center subplot. The percent canopy cover stratification scheme consists of five groupings: (1) 0-5 percent, (2) 6-50 percent, (3) 51-65 percent, (4) 66-80 percent, and (5) 81-100 percent (Fig. 105). These groupings were based on observed natural clumping of pixel values.

In addition to the classification of every pixel into one of the five canopy cover classes, every pixel was also assigned to an ownership class. The Protected Areas Database (Conservation Biology Institute 2010) was initially used and then state-specific data were added. The largest ownership class, based on pixel counts, was private ownership at nearly 13.8 million acres in West Virginia. Every pixel was also assigned to a county based on the location of the pixel center. If there were not a sufficient number of plots within a canopy cover class/ownership class/county for valid estimation purposes then specific collapsing rules were used to combine classes until sufficient sample sizes were obtained. These collapsed classes defined the strata used in the estimation. NRS-FIA required a minimum of 10 plots per stratum. Stratified estimation requires that two tasks be accomplished. First, each plot must be assigned to a stratum. Next, the proportion of the total area in each stratum must be calculated. The first task is accomplished by assigning each plot to the stratum assigned for the pixel containing the center of the center subplot. The second task is accomplished by calculating the proportion of pixels in each stratum. The population estimate for a variable is calculated as the sum across all strata of the product of each stratum's observed proportion (from P1) and the variable's estimated mean per unit area for the stratum (from P2). Details of the stratum assignments used are presented in the estimation section of this report that follows the P2 and P3 descriptions.

Phase 2

In P2, field crews record a variety of data for plot locations determined in P1 to determine whether a field visit is required, i.e., forested plots last time regardless of current forest land use. Before visiting plot locations, field crews consult county land records to determine the ownership of plots and then seek permission from private landowners to measure plots on their lands. At the plot field crews determine the location of the geographic center of the center subplot using global positioning system (GPS) receivers. They record condition-level observations that include land cover, forest type, stand origin, stand age, stand-size class, site-productivity class, history of forest disturbance, and land use for every condition (major land use of forest stand at least 1 acre in size) that occurs on the plot. They also record information on condition boundaries when multiple conditions are found on a plot. For each tree, field crews record a variety of observations and measurements, including condition, species, live/dead status, lean, diameter, height, crown ratio (percent of tree height represented by crown), crown class (dominant, codominant, suppressed), damage, and decay status. All trees measured in the previous measurement of the plot are remeasured or otherwise accounted for and any new trees that have grown onto the plot are measured. Office staff use statistical models based on field-crew measurements to calculate values for additional variables, including individual-tree volume, volume, and biomass by plot, condition, species group, and live/dead status. The remeasurement of every tree enables the calculation of components of change including growth, mortality, and removals. See U.S. Forest Service (2013) for details on the P2 data collection procedures.

Phase 3 (2004-2010) and Phase 2+ (2012-ongoing)

The third phase of the enhanced FIA program focuses on forest health. P3 is administered cooperatively by the FIA program, other Forest Service programs, other Federal agencies, state natural resource agencies, and universities, and it is partially integrated with the Forest Health Monitoring (FHM) program. The FHM program consists of four interrelated and complementary activities: detection monitoring, evaluation monitoring, intensive site ecosystem monitoring, and research on monitoring techniques. Detection monitoring consists of systematic aerial and ground surveys designed to collect baseline information on the current condition of forest ecosystems and to detect changes from those baselines over time. Evaluation monitoring studies examine the extent, severity, and probable causes of changes in forest health identified through the detection monitoring surveys. The intensive site ecosystem monitoring program conducts research into regionally specific ecological processes at a network of sites located in representative forested ecosystems. Research on monitoring techniques focuses on developing and refining indicator measurements to improve the efficiency and reliability of data collection and analysis at all levels of the program.

The ground survey portion of the FHM detection monitoring program was integrated into the FIA program as P3 in 1999. The P3 sample consists of a 1:16 subset of the P2 plots with one P3 plot for approximately every 96,000 acres. P3 measurements are obtained by field crews during the growing season and include an extended suite of ecological data: soil quality (erosion, compaction, and chemistry), vegetation diversity and structure, and down woody material. The incidence and severity of ozone injury for selected bioindicator species also are monitored as part of an associated sampling scheme. All P2 measurements are collected on each P3 plot at the same time as the P3 measurements. See U.S Forest Service (2016) for additional information on the P3 collection procedures.

P3 variables are selected to address specific criteria outlined for the conservation and sustainable management of temperate and boreal forests (Montreal Process Working Group 1995) and are based on the concept of indicator variables. Observations of an indicator variable represent an index of ecosystem functions that can be monitored over time to assess trends. Indicator variables are used in conjunction with each other, P2 data, data from FHM evaluation monitoring studies, and ancillary data to address ecological issues such as vegetation diversity, fuel loading, regional air-quality gradients, and carbon storage. The P2 and P3 data of the enhanced FIA program are a primary source of reporting data for the Montreal Process Criteria and Indicators (for more information, see Woodall et al. 2011).

For most forest health indicators, P2+ is a more refined and statistically powerful version of P3, collecting only the more important attributes and sampling a greater number of plots. The P3 sample included approximately 6.3 percent of the P2 plots. Since 2012, P2+ protocols have been completed on approximately 12.5 percent of the P2 plots (including the historical P3 plots) and may be completed on up to approximately 25 percent of the plots depending upon future funding. The soils indicator is the one exception which will remain with the 6.3 percent sample intensity using the historical P3 plots and sampling protocol. The field guide for collecting attributes on P2+ plots (U.S. For. Serv. 2016) includes details on sampling sapling length, advance tree seedling regeneration (ATSR), vegetation profiles, invasive plants, down woody materials (DWM), soils, and tree crowns. Besides an invasive plants inventory, P3 and P2+ were not implemented in 2011.

Advance Tree Seedling Regeneration. The tree seedling sample is designed to inventory and monitor the forest's regenerative capacity (McWilliams et al. 2015). Tree seedling counts are used along with the sapling tally to estimate ATSR. Information on ATSR, specifically lengths (heights), is required for estimating regeneration success. ATSR data are used with estimates of competing vegetation derived from the vegetation profile and data on the abundance and character of invasive plants. These three components form the basis for analysis of regeneration adequacy and hence, the ability of native forests to regenerate and an indication of the expected future forest composition.

Vegetation Profile. Vegetation data are collected to describe vegetation structure for vascular plants. The data collected provide a horizontal and vertical estimation of vegetation located within the sample area. Information on the abundance and structure of understory plant communities has many uses. It can be used to assess wildlife habitat, biomass, forage availability, grazing potential, vegetation competition with tree growth, fuel loadings from understory vegetation, and potential site productivity.

Invasive Plants. The invasive plants protocol documents abundance and monitors change in abundance of selected species over time. Combined with other plot data and other datasets, these data can be used to predict the future spread of selected species. Invasive plant species are having tremendous economic and ecological impacts on our nation's forests, and the impacts are increasing over time. Providing accurate, statistically valid estimates of the distribution and abundance of some of the most damaging species will give managers and policy-makers a better understanding of the problem. Each FIA unit, in collaboration with vegetation experts, has developed lists of the most important invasive species to monitor on forested lands. The invasive plants protocol was implemented on approximately 20 percent of plots from 2009 through 2011 but changed to the P2+ sample (12.5 percent) since 2012.

Down Woody Materials. DWM are important components of forest ecosystems across the country. DWM are dead material on the ground in various stages of decay. Down wood components and fuels estimated by the FIA program are coarse wood, slash, fine wood, and litter and duff depth. DWM help describe the following:

- Quality and status of wildlife habitats
- Structural diversity within a forest
- Fuel loading and fire behavior
- Carbon sequestration (amount of carbon tied up in dead wood)
- Storage and cycling of nutrients and water (important for site productivity)

Soils. The soils indicator is used to assess forest ecosystem health in terms of the physical and chemical properties of the soils. The soil resource is a primary component of all terrestrial ecosystems, and any environmental stressor that alters the natural function of the soil has the potential to influence the vitality, species composition, and hydrology of forest ecosystems. Specifically, soils data are collected to assess the following:

- Potential for erosion of nutrient-rich top soils and forest floors
- Factors relating to the storage and cycling of nutrients and water
- Availability of nutrients and water to plants (dependent upon soil structure and texture)
- Carbon sequestration (the amount of carbon tied up in soil organic matter)
- Deposition of toxic metals from pollution
- Acidification of the soil from deposition of pollutants

Crowns. The condition of tree crowns is an important indicator of tree and forest health. The crowns indicator is used to assess the health and vigor of trees based on two metrics, crown dieback and uncompacted live crown ratio. Crown dieback is recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk. Uncompacted live crown ratio is the percentage of live crown length divided by the total tree length.

Trees with vigorous, healthy crowns tend to have higher growth rates. By contrast, trees with damaged or degraded crowns have a reduced capacity for photosynthesis and slower growth rates. Many stressors have been correlated with crown degradation including insects, disease, weather events, senescence, competition, and atmospheric deposition. Additionally, trees with unhealthy crowns are more susceptible to mortality.

Estimation

The FIA sample includes 2,808 plots located across West Virginia. These plots are located within 30 unique strata (Table A) defined by combinations of the five P1 canopy cover classes: (1) 0 to 5 percent, (2) 6 to 50 percent, (3) 51 to 65 percent, (4) 66 to 80 percent, and (5) 81 to 100 percent, a land ownership classification created from the Protected Areas Database, and county groups (FIA units). Nationally consistent algorithms were used to assign forest type and stand-size class to each condition observed on a plot. For NRS-FIA, panels are measured on an annual basis so that five panel estimates are equivalent to 5-year moving average estimates. Field plot measurements are combined

with P1 estimates in the compilation process and table production. Procedures described in Bechtold and Patterson (2005) for stratified estimation with observed stratum areas were used in conjunction with the strata presented in Table A to produce all estimates. Table A shows the total area and number of plots within each stratum.

Integration with Previous Inventories

In 2013, FIA completed the second full annual inventory of plots within West Virginia. The 2013 panels, along with those surveyed in 2009, 2010, 2011, and 2012, comprise the dataset for the second annual inventory referred to as the 2013 annual inventory of West Virginia. Previous forest inventories in West Virginia were completed in 1949 (Wray 1952), 1961 (Ferguson 1964), 1975 (Bones 1978, DiGiovanni 1990), 1989 (DiGiovanni 1990, Griffith and Widmann 2003), 2000 (Griffith and Widmann 2003), and 2008 (Widmann et al. 2012).

Data from new inventories often are 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. Identical classification procedures were used for the 2008 and 2013 inventories, therefore comparisons made between these inventories are relatively uncomplicated.

Comparisons with the earlier inventories are more problematic as there were changes in plot design, measurements taken, and classification methods between each of these inventories. For the sake of consistency, a new, national plot design was implemented by all five regional FIA units in 1999. The new design uses fixed-radius subplots exclusively. In West Virginia, this design was used in the 2000 and 2008 inventories. Prior to this new plot design, fixed and variable-radius subplots were used. Both designs have strong points, but they often produce different classifications for individual plot characteristics. Procedures for assigning condition attributes such as forest type, stand age, and stocking changed significantly with the introduction of the new annual plot design. Unpublished FIA research comparing these plot designs, however, showed no noticeable difference in volume and tree-count estimates.

For additional information on the sample protocols and estimation procedures for the first two phases of the FIA program, see Bechtold and Patterson (2005). See U.S. Forest Service (2016) for additional information on P3 indicator sampling protocols.

Quality of the Estimates

The four primary sources of error common to all sample-based estimates are sampling, measurement, prediction, and nonresponse error. For each of these sources of error, a definition within the context of the FIA inventory is provided along with a discussion of methods used to quantify and reduce this error.

Sampling Error

The process of sampling (selecting a random subset of a population and calculating estimates from this subset) causes estimates to contain error they would not have if every member of the population had been observed. The 2013 FIA inventory of West Virginia is based on a sample of 2,808 plots across the State (a total area of 15,507,057 acres), a sampling rate of about one plot for every 5,522 acres.

The procedures for statistical estimation outlined in the previous section and described in detail in Bechtold and Patterson (2005) provide the estimates of the population totals and means presented in this report. Along with every estimate is an associated sampling error that is typically expressed as a percentage of the estimated value but that can also be expressed in the same units as the estimate or as a confidence interval (the estimated value plus or minus the sampling error). This sampling error is the primary measure of the reliability of an estimate. A sampling error can be interpreted to mean that had a 100-percent inventory been taken using these methods, the chances are two out of three that the results would have been within the limits indicated (i.e., 68 percent confidence interval).

The sampling errors for State-level estimates of the major attributes presented in this report are shown in Table B. Table WV-65[1] presents sampling errors for these estimates at the inventory unit and county levels.

Estimates for classifications smaller than the state totals presented in Table B will have larger sampling errors. For example, Table WV-65 shows that the sampling error for timberland area in any county is higher than that for total timberland area in the State. To compute an approximate sampling error for an estimate that is smaller than a State total, use the following formula:

$$E = \frac{(SE)\sqrt{(State\,total\,estimate)}}{\sqrt{(Smaller\,estimate)}} \qquad (1)$$

where:

E = approximate sampling error for smaller estimate

SE = sampling error for State total estimate (percent)

For example, to compute the approximate error on the area of National Forest System forest land in the State, proceed as follows:

The total National Forest System forest land area in the State from Table WV-2 is estimated at 1,043,600 acres.

The total area of all forest land in the State from Table WV-2 is 12,185,700 acres.

The State total error for forest land area from Table B is 0.58 percent.

Using formula (1):

$$Sampling\ error = E = \frac{(0.58)\sqrt{(12{,}185{,}700)}}{\sqrt{(1{,}043{,}600)}} = 2.0\ percent$$

This approximation works well for estimates of area, volume, number of trees, and biomass. It is less effective for estimates of growth, removals, or mortality. Individuals seeking more accurate sampling errors should use the estimation tools available at http://www.fia.fs.fed.us/tools-data/.

[1] Tables labeled with the State abbreviation (WV) followed by a number (e.g., Table WV-1) are located in a supplementary file titled "Maine forest inventory summary tables" located at http://dx.doi.org/10.2737/NRS-RB-105. Tables labeled with letters (e.g., Table A) are located on pages xx-xx.

The estimators used by FIA are unbiased under the assumptions that the sample plots are a random sample of the total population and the observed value for any plot is the true value for that plot. Deviations from these basic assumptions are not reflected in the computation of sampling errors. The following sections on measurement, prediction, and nonresponse error address possible departures from these basic assumptions.

Measurement Error

Errors associated with the methods and instruments used to observe and record the sample attributes are called measurement errors. On FIA plots, attributes such as the diameter and height of a tree are measured with different instruments, and other attributes such as species and crown class are observed without the aid of an instrument. On a typical FIA plot, 30 to 70 trees are observed with 15 to 20 attributes recorded on each tree. In addition, many attributes that describe the plot and conditions on the plot are observed. Errors in any of these observations affect the quality of the estimates. If a measurement is biased (such as tree diameter consistently taken at an incorrect place on the tree), then the estimates that use this observation (such as volume) will reflect this bias. Even if measurements are unbiased, high levels of random error in the measurements will add to the total random error of the estimation process.

To ensure that all FIA observations are made to the highest standards possible, a regular program of quality assurance and quality control is an integral part of all FIA data collection efforts. This program begins with the documentation of protocols and procedures used in the inventory followed by intensive crew training. To assess the quality of the data collected by these trained crews, a random sample of at least 4 percent of all plots are measured independently by a different expert crew. These independent measurements are referred to as blind checks. The purpose of these blind checks is to assess the quality of field measurements. The second measurement on these blind check plots is done by a Quality Assurance (QA) crew. In all cases, QA crews have as much or more experience and training in FIA field measurements than standard FIA crews.

The quality of field measurements is assessed nationally through a set of measurement quality objectives (MQOs) that are set for every data item we collect. Each MQO consists of two parts: a tolerance or acceptable level of measurement error, and an objective in terms of the percent of measurements within tolerance. The blind check measurements are used to observe how often individual field crews are meeting these objectives and to assess the overall compliance among all crews. Table C shows the compliance rates for various measurements used to compute the estimates included in this report and in other NRS-FIA reports. The column labeled West Virginia comes from blind check measurements of plots used in this report, and the columns labeled All NRS-FIA States come from all measurements made by FIA crews within the entire 24-state area where the Northern Research Station implemented the FIA program from 2009 to 2013. Training and supervision of crews is a regional effort and crews often work in more than one state. Regional data quality observations reflect the overall measurement quality of all data collected by FIA in the NRS region.

In addition to the percent compliance to measurement quality objectives, the blind check observations were used to test for relative bias in the field crew measurements. Relative bias is defined here as a tendency for the standard field crew measurements to be higher or lower than those measurements taken by the QA crews. The estimated relative bias and

limits of 95 percent confidence intervals (based on parametric bootstrap estimates) for the relative bias are presented in Table D.

The blind check measurements do not provide direct observations of true bias in field measurements (average difference between field measurements and true values) because they are paired observations of two field measurements. The QA crew in these blind checks typically has more training and experience with FIA field measurements than the first crew, but both crews use the same methods and instruments to obtain the measurements. These methods were the best available and were selected for use nationwide by FIA; they are commonly used by other similar natural resource inventories. A basic assumption is that the methods, when correctly applied, provide unbiased observations of the attribute they are designed to measure. Under this assumption, relative bias observations in Table D provide observations of bias due to the difference in experience and training between the field and QA crews. In most cases there is no significant bias.

Prediction Error

Errors associated with using mathematical models (such as volume models) to provide observations of the attributes of interest based on sample attributes are referred to as prediction errors. Area, volume, biomass, growth, removals, and mortality are the primary attributes of interest presented in this report. Area and number of trees estimates are based on direct observation and do not involve the use of prediction models; however, FIA estimates of volume, biomass, growth, removals, and mortality use model-based predictions in the estimation process. Models are used to predict volume and biomass estimates of individual trees. Change estimates such as growth, mortality, and removals are based on these model-based predictions of volume from both the current plot measurements and the measurements taken in the previous inventory.

In comparing FIA estimates to other data sources, users need to be aware of the prediction models used in both estimates. If both estimates are based on the same prediction models with matching fitted parameter values, then the prediction bias of one estimate should cancel out that of the other estimate. If the estimates are based on different prediction models, then the user should be aware of the prediction error of both models.

Nonresponse Error

Nonresponse error refers to the error caused by not being able to observe some of the elements in the sample. In FIA, nonresponse occurs when crews are unable to measure a plot (or a portion of a plot) at a selected location. Nonresponse falls into the following three classes:

Denied access—Entire plots or portions of plots where the field crew is unable to obtain permission from the landowner and is therefore unable to measure the trees on the plot.

Hazardous/inaccessible—Entire plots or portions of plots where the conditions present prevent a crew from safely getting to the plot or measuring the trees on the plot.

Other—Plots where the field crew is unable to obtain a valid measurement for a variety of reasons other than those stated above.

Nonresponse has two effects on the sample. First, it reduces the sample size. The reduced sample size is reflected in the sampling errors discussed in that section. Second, nonresponse can bias the estimates if the portion of the population not being sampled differs from the portion being sampled. In FIA, unlike many survey samples, nonresponse rates are relatively low.

In the 2013 West Virginia inventory, a total of 2,552 sample plots were selected to be field visited while the other 256 were deemed to be nonforest based on aerial photography. Of the total sample plots selected for field visit there were 437 plots where crews were unable to obtain owner permission to measure the plot or where hazardous conditions prevented the crew from measuring the plot.

Even though an overall response rate of 83 percent is high, it can cause considerable bias if not properly accounted for. The major source of nonresponse is denied access to plots. Denied access plots primarily occur on lands in private ownership. Also, the observations needed for plots on nonforest and water land classes do not usually require crews to physically enter the land and permission is not needed to obtain the observation because it can be obtained from aerial photos or other remotely sensed information sources.

The stratified estimation process used by FIA with strata defined by three ownership classes (inland census water, public, and private) and five canopy cover classes reduces the possible effects of bias caused by nonresponse. Under the stratified estimation process used by FIA, nonresponses are removed from the sample, and stratum estimates are obtained from only those plots with valid observations. The nonresponse rate in one stratum does not affect the estimate in other strata. The response rate within each stratum is presented in Table E for the West Virginia 2013 inventory and for all FIA inventories conducted by the Northern Research Station over the same period.

The nonresponse plots in this inventory were not permanently removed from the FIA system of plots. In future inventories, we will again attempt to measure these plots. At that time we may be able to obtain permission to access these plots, the hazardous conditions may have changed, or other circumstances that caused us to drop plots from estimation for a specific inventory cycle will probably be different.

GLOSSARY

Accretion: The estimated net growth on trees that were measured during the previous inventory (divided by the number of growing seasons between surveys to produce average annual accretion). It does not include growth on trees cut during the period or those trees that died. This component uses the incremental change in volume between two inventories.

Average annual mortality of growing stock: The average annual change in cubic-foot volume of sound wood in growing-stock trees that died over a defined measurement cycle.

Average annual mortality of sawtimber: The average annual change in board-foot volume of sound wood in sawtimber trees that died over a defined measurement cycle.

Average annual net growth of growing stock: The average annual change in cubic-foot volume of sound wood in live growing-stock trees, and the total volume of trees entering diameter classes greater than 5.0 inches d.b.h., through ingrowth, less volume losses resulting from natural causes. Natural causes include mortality except that due to logging damage, timber stand improvement, or conversion to a nonforest land use.

Average annual net growth of sawtimber: The average annual change in the board-foot volume of live sawtimber trees, and the total volume of trees reaching sawtimber size, less volume losses resulting from natural causes. Natural causes include mortality except that due to logging damage, timber stand improvement, or conversion to a nonforest land use.

Average annual removals from growing stock: The average cubic-foot volume of wood in live growing- stock trees removed annually for roundwood forest products, in addition to the volume in logging residues or mortality due to logging damage (harvest removals). This component of change also includes the volumes of growing-stock trees removed due to land use changes (other removals).

Average annual removals from sawtimber: The average board-foot volume of wood in live sawtimber trees removed annually for roundwood forest products, in addition to the volume of logging residues or mortality due to logging damage (harvest removals). This component of change also includes the volumes of sawtimber trees removed due to land use changes (other removals).

Basal area: Tree area in square feet of the cross section at breast height of a single tree. When the basal areas of all trees in a stand are summed, the result is usually expressed as square feet of basal area per acre.

Bioindicator species: A tree, woody shrub, or nonwoody herb species that responds to ambient levels of ozone pollution with distinct visible foliar symptoms that is easy to diagnose.

Board foot: A unit of lumber measuring 1-foot long, 1-foot wide, and 1-inch thick, or its equivalent. International ¼-inch rule is used as the U.S. Forest Service standard log rule in the eastern United States.

Bulk density: The mass of soil per unit of volume. A measure of the ratio of pore space to solid materials in a given soil. It is expressed in units of grams per cubic centimeter of oven-dry soil.

Census water: Lakes, reservoirs, ponds, and similar bodies of water 4.5 acres in size or larger; and rivers or canals more than 200 feet wide (U.S. Census definition).

Coarse woody debris (CWD): Dead branches, twigs, and wood splinters 3.0 inches in diameter and larger measured at the smallest end.

Commercial species: Tree species currently or prospectively suitable for industrial wood products; excludes species of typically small size, poor form, or inferior quality, e.g., hawthorn and sumac.

Compacted live crown ratio: The percent of the total length of the tree that supports a full, live crown. To determine compacted live crown ratio for trees that have uneven length crowns, lower branches are visually transferred to fill holes in the upper portions of the crown, until a full, even crown is created.

Condition: A delineation of a land area based upon land use, forest type, stand size, regeneration status, reserved status, tree density, and owner class.

Corporate: An ownership class of private lands owned by corporations.

County and municipal: A class of public lands owned by counties or local public agencies, or lands leased by these governmental units for more than 50 years.

Cropland: Land under cultivation within the last 24 months, including cropland harvested, crop failures, cultivated summer fallow, idle cropland used only for pasture, orchards, active Christmas tree plantations indicated by annual shearing, nurseries, and land in soil improvement crops, but excluding land cultivated in developing improved pasture.

Crown: The part of a tree or woody plant bearing live branches or foliage.

Crown dieback: Recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk. Dieback is considered only when it occurs in the upper and outer portions of the tree. When whole branches are dead in the upper crown, without obvious signs of damage such as breaks or animal injury, it is assumed the branches died from the terminal portion of the branch. Dead branches in the lower portion of the live crown are assumed to have died from competition and shading.

Cull decrement: The net volume of rough and rotten cull trees in the previous inventory that are classified as growing-stock trees in the current inventory (divided by the number of growing seasons between inventories to compute average annual cull decrement).

Cull increment: The net volume of growing-stock trees in the previous inventory that are classified as rough and rotten cull trees in the current inventory (divided by the number of growing seasons between inventories to compute average annual cull increment).

Cull tree: A live tree, 5.0 inches in d.b.h. or larger, that is unmerchantable for saw logs now or prospectively because of rot, roughness, or species. (See definitions for rotten and rough trees.)

Decay class: Qualitative assessment of stage of decay (five classes) of coarse woody debris based on visual assessments of color of wood, presence/absence of twigs and branches, texture of rotten portions, and structural integrity.

Diameter at breast height (d.b.h.): The diameter outside bark of a standing tree measured 4.5 feet above the ground.

Diameter at root collar (d.r.c.): The diameter outside bark of a bole measured at the root collar of a shrub or tree. Also called basal diameter.

Diameter class: A classification of trees based on diameter outside bark measured at breast height (4.5 feet above ground). With 2-inch diameter classes, the 6-inch class, for example, includes trees 5.0 through 6.9 inches diameter at breast height (d.b.h).

Dry ton: A unit of measure of dry weight equivalent to 2,000 pounds or 907.1848 Kg.

Dry weight: The weight of wood and bark as it would be if it had been oven dried; usually expressed in pounds or tons.

Down woody material (DWM): Woody pieces of trees and shrubs that have been uprooted (no longer supporting growth) or severed from their root system, not self-supporting, and lying on the ground.

Duff: A soil layer dominated by organic material derived from the decomposition of plant and animal litter and deposited on either an organic or a mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material (e.g., individual plant parts) can no longer be identified.

Effective cation exchange capacity (ECEC): The sum of cations that a soil can adsorb in its natural pH. Expressed in units of centimoles of positive charge per kilogram of soil.

Federal: An ownership class of public lands owned by the U.S. Government.

Fiber products: Products derived from wood and bark residues, such as pulp, composition board products, and wood chips.

Fine materials: Wood residues not suitable for chipping, such as planer shavings and sawdust.

Fine woody debris (FWD): Dead branches, twigs, and wood splinters 0.1 to 2.9 inches in diameter.

Forest industry: An ownership class of private lands owned by companies or individuals operating wood- using plants.

Forest land: Accessible land that has at least 10 percent crown cover by live trees or formerly had such tree cover and is not currently developed for a nonforest use. In general, the minimum area for classification as forest land is 1 acre and 120 feet wide measured stem-to-stem from the outer-most edge. The components that make up forest land are timberland and all noncommercial forest land.

Forest type: A classification of forest land based on the species presently forming a plurality of the live-tree stocking.

Forest-type group: A combination of forest types that share closely associated species or site requirements and are generally combined for brevity of reporting. The major forest-type groups for the eastern United States are:

> ***White-red-jack pine:*** Forests in which eastern white pine, red pine, or jack pine, singly or in combination, comprise a plurality of the stocking. Common associates include hemlock, aspen, birch, and maple.
>
> ***Oak-pine:*** Forests in which hardwoods (usually upland oaks) comprise a plurality of the stocking, but in which pine or eastern redcedar comprises 25 to 50 percent of the stocking. Common associates include gum, hickory, and yellow-poplar.
>
> ***Oak-hickory:*** Forests in which upland oaks or hickory, singly or in combination, comprise a plurality of the stocking except where pines comprise 25 to 50 percent, in which case the stand is classified as oak-pine. Common associates include yellow-poplar, elm, maple, and black walnut.
>
> ***Oak-gum-cypress:*** Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, comprise a plurality of the stocking except where pines comprise 25 to 50 percent, in which case the stand is classified as oak-pine. Common associates include cottonwood, willow, ash, elm, hackberry, and maple.
>
> ***Elm-ash-cottonwood:*** Forests in which elm, ash, or cottonwood, singly or in combination, comprise a plurality of the stocking. Common associates include willow, sycamore, beech, and maple.
>
> ***Maple-beech-birch:*** Forests in which maple, beech, or yellow birch, singly or in combination, comprise a plurality of the stocking. Common associates include hemlock, elm, basswood, and white pine.
>
> ***Aspen-birch:*** Forests in which aspen, balsam poplar, paper birch, or gray birch, singly or in combination, comprise a plurality of the stocking. Common associates include maple and balsam fir.

Fuel class: Categories of forest fire fuels defined by the approximate amount of time it takes for moisture conditions to fluctuate. Large coarse woody debris pieces take longer to dry out than smaller fine woody pieces.

> *1,000-hour fuels*: Coarse woody debris with a transect diameter ≥ 3.0 inches and ≥ 3.0 feet long.
>
> *100-hour fuels*: Fine woody debris with a transect diameter between 1.0 and 2.9 inches.

10-hour fuels: Fine woody debris with a transect diameter between 0.25 and 0.9 inches.

1-hour fuels: Fine woody debris with a transect diameter < 0.24 inches.

Gross growth: The sum of accretion and ingrowth.

Growing stock: A classification of timber inventory that includes live trees of commercial species meeting specified standards of quality or vigor. Cull trees are excluded. When associated with volume, this includes only trees 5.0 inches d.b.h. and larger.

Growing-stock volume: Net or gross volume in cubic feet of growing-stock trees 5.0 inches and larger d.b.h. measured from the 1-foot stump to a minimum 4.0- inch top diameter outside bark on the central stem, or to the point where the central stem splits into limbs. Net volume equals gross volume minus deduction for cull defects.

Hardwood: A dicotyledonous tree, usually broad-leaved and deciduous.

Soft hardwoods: A category of hardwood species with wood generally of low specific gravity (less than 0.5). Notable examples include red maple, paper birch, quaking aspen, and American elm.

Hard hardwoods: A category of hardwood species with wood generally of high specific gravity (greater than 0.5). Notable examples include sugar maple, yellow birch, black walnut, and oaks.

Industrial wood: All commercial roundwood products except fuelwood.

Ingrowth: The estimated net volume of trees that became 5.0 inches and larger d.b.h. during the period between inventories (divided by the number of growing seasons between surveys to produce average annual ingrowth). Also, the estimated net volume of trees 5.0 inches and larger d.b.h. that are growing on land that was reclassified from noncommercial forest land or nonforest land to timberland.

Introduction: The intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity. "Introduced" is not synonymous and should not be confused with the term "invasive" (USDA definition).

Invasive species: Those species whose introduction does, or is likely to, cause economic or environmental harm or harm to human health. For the purpose of this policy only, a plant species is considered "invasive" only when it occurs on the Federal or State-specific noxious weed list or a list developed by the State-specific Department of Agriculture with their partners and approved by the State Technical Committee that prohibits or cautions its use due to invasive qualities (USDA definition).

Land area: The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river flood plains; streams, sloughs, estuaries, and canals less than 200 feet wide; and lakes, reservoirs, and ponds less than 4.5 acres in area.

Land use: A classification of land that indicates the primary use at the time of the inventory. Major categories are forest land and nonforest land.

Litter: Undecomposed or only partially decomposed organic material that can be readily identified (e.g., plant leaves, twigs).

Live aboveground biomass: The aboveground volume of live trees (including bark but excluding foliage) reported in dry tons (dry weight). Biomass has four components:

> *Bole:* Biomass of a tree from 1 foot above the ground to a 4-inch top outside bark or to a point where the central stem breaks into limbs.
>
> *Tops and limbs:* Total biomass of a tree from a 1-foot stump minus the bole.
>
> *Saplings:* Total aboveground biomass of a tree from 1.0 to 4.9 inches d.b.h.
>
> *Stump:* Biomass of a tree 5 inches d.b.h. and larger from the ground to a height of 1 foot.

Live cull: A classification that includes live, cull trees. When associated with volume, it is the net volume in live, cull trees that are 5.0 inches d.b.h. and larger.

Logging residues: The unused portions of growing- stock and non-growing-stock trees cut or killed by logging and left in the woods.

Merchantable: Refers to a pulpwood or saw log section that meets pulpwood or saw log specifications, respectively.

National Forest: An ownership class of Federal lands, designated by Executive order or statute as National Forests or purchase units, and other lands under the administration of the Forest Service including experimental areas.

Net cubic-foot volume: The gross volume in cubic feet less deductions for rot, roughness, and poor form. Volume is computed for the central stem from a 1-foot stump to a minimum 4.0-inch top diameter outside bark, or to the point where the central stem breaks into limbs.

Net board-foot volume: The gross volume in board feet less the deductions for rot, roughness, and poor form. Volume is computed from the 1-foot stump to a minimum 7.0-inch diameter outside bark for softwoods and a minimum 9.0-inch outside bark for hardwoods on the central stem. This estimate includes all softwoods 9.0 inches d.b.h. and larger, and all hardwoods 11.0 inches d.b.h. and larger.

Noncensus water: Streams/rivers 120 to 200 feet wide and bodies of water 1 to 4.5 acres in size, where the U.S. Bureau of the Census (1990) classifies such water as land.

Noncommercial species: Tree species of typically small size, poor form, or inferior quality, which normally do not develop into trees suitable for industrial wood products.

Nonforest land: Land that has never supported forests and lands formerly forested where use of timber management is precluded by development for other uses. (Note: Includes area used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining clearings, powerline clearings of any width, and 1- to 4.5-acre areas of water classified by the U.S. Bureau of the Census as land. If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet wide, and clearings, etc., must be more than 1 acre in area to qualify as nonforest land.)

Nonindustrial private: An ownership class of private lands where the owner does not operate wood-using plants.

Nonnative species: Within a particular ecosystem, any species (including its seeds, eggs, spores, or other biological material capable of propagating that species;) that is not native to that ecosystem (USDA definition).

Nonstocked areas: Timberland less than 10 percent stocked with all live trees.

Ownership unit: A classification of ownership encompassing all types of legal entities having an ownership interest in land, regardless of the number of people involved. A unit may be an individual; a combination of persons; a legal entity such as a corporation, partnership, club, or trust; or a public agency. An ownership unit has control of a parcel or group of parcels of land.

Owner class: A classification of land into categories of ownership.

Forest industry: Land owned by private companies that operate primary wood-using mills.

Nonindustrial private: Land owned by other corporate, individuals, or trusts (NGOs) that do not operate primary wood-using mills.

Other corporate: Land owned by timber investment or real estate companies.

Public: Land owned by federal, state, county, or municipal government.

Ozone: A regional, gaseous air pollutant produced primarily through sunlight-driven chemical reactions of nitrogen dioxide and hydrocarbons in the atmosphere and causing foliar injury to deciduous trees, conifers, shrubs, and herbaceous species.

Ozone bioindicator site: An open area used for ozone injury evaluations on ozone-sensitive species. The area must meet certain site selection guidelines on size, condition, and plant counts to be used for ozone injury evaluations in FIA.

Physiographic class: A measure of soil and water conditions that affect tree growth on a site. The physiographic classes are:

Xeric: Very dry soils where excessive drainage seriously limits both growth and species occurrence. These sites are usually on upland and upper half slopes.

Xeromesic: Moderately dry soils where excessive drainage limits growth and species occurrence to some extent. These sites are usually on the lower half slopes.

Mesic: Deep, well-drained soils. Growth and species occurrence are limited only by climate. These include all cove sites and bottomlands along intermittent streams.

Hydromesic: Moderately wet soils where insufficient drainage or infrequent flooding limits growth and species occurrence to some extent.

Hydric: Very wet sites where excess water seriously limits both growth and species occurrence.

Poletimber trees: Live trees at least 5.0 inches d.b.h. but smaller than sawtimber trees.

Primary wood-using mill: A mill that converts roundwood products into other wood products. Common examples are sawmills that convert saw logs into lumber and pulp mills that convert pulpwood into paper.

Productivity class: A classification of forest land in terms of potential annual cubic-foot volume growth per acre at culmination of mean annual increment in fully stocked natural stands.

Pulpwood: Roundwood, whole-tree chips, or wood residues used for the production of wood pulp.

Reserved forest land: Forest land withdrawn from timber utilization through statute, administrative regulation, or designation without regard to productive status. Examples include national forest wilderness areas, national parks, and national monuments.

Residues: Bark and woody materials that are generated in primary wood-using mills when roundwood products are converted to other products. Examples are slabs, edgings, trimmings, miscuts, sawdust, shavings, veneer cores and clippings, and pulp screenings. Includes bark residues and wood residues (both coarse and fine materials) but excludes logging residues.

Rotten tree: A live tree of commercial species that does not contain a saw log now or prospectively primarily because of rot (that is, when rot accounts for more than 50 percent of the total cull volume).

Rough tree: (a) A live tree of commercial species that does not contain a saw log now or prospectively primarily because of roughness (that is, when sound cull due to such factors as poor form, splits, or cracks accounts for more than 50 percent of the total cull volume); or (b) a live tree of noncommercial species.

Roundwood products: Logs, bolts, and other round timber generated from harvesting trees for industrial or consumer use. Roundwood products include saw logs, veneer, cooperage logs, bolts, pulpwood logs, fuelwood, pilings, poles posts, ties, mine timbers, and various other round or split products.

Salvable dead tree: A downed or standing dead tree considered currently or potentially merchantable by regional standards.

Saplings: Live trees 1.0 inch through 4.9 inches d.b.h.

Saw log: A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight, and with a minimum diameter inside bark of 6 inches for softwoods and 8 inches for hardwoods, or meeting other combinations of size and defect specified by regional standards.

Sawtimber tree: A live tree of commercial species containing at least a 12-foot saw log or two noncontiguous saw logs 8 feet or longer, and meeting regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d.b.h. Hardwoods must be at least 11.0 inches diameter outside bark (d.o.b.).

Sawtimber volume: Net or gross volume in board-foot (International ¼-inch rule) or cubic-foot of the saw log portion of live sawtimber trees measured from the 1-foot stump to a minimum 7.0-inch top diameter outside bark (for softwoods) or a 9.0-inch top diameter outside bark (for hardwoods), on the central stem, or to the point where the central stem splits into smaller limbs. Net volume equals gross volume minus deduction for rough and rotten cull.

Seedling: Live tree smaller than 1.0 inch d.b.h./d.r.c. and at least 6.0 inches in height for softwoods and 12.0 inches in height for hardwoods.

Site index: An expression of forest site quality based on the height of a free-growing dominant or codominant tree of a representative species in the forest type at age 50.

Snag: A standing dead tree. In the current inventory, a snag must be 5.0 inches d.b.h./d.r.c. and 4.5 feet tall, and have a lean angle less than 45 degrees from vertical. A snag may be either self-supported by its roots or supported by another tree or snag.

Softwood: A coniferous tree, usually evergreen, having needles or scale-like leaves.

Sound dead: The net volume in salvable dead trees.

Species group: A combination of tree species that share closely associated understory plants or site requirements.

Stand: A group of trees on a minimum of 1 acre of forest land that is stocked by forest trees of any size.

Standing dead tree: A standing dead tree must be at least 5 inches d.b.h. or larger, at least 4.5 feet in height, and have a lean of less than 45 degrees from the vertical. A snag should be self-supported or supported by another tree.

Stand-size class: A classification of forest land based on the size class of live trees in the area. The classes are:

> *Nonstocked:* Forest land stocked with less than 10 percent of full stocking with live trees. Examples are recently cutover areas or recently reverted agricultural fields.
>
> *Sapling-seedling:* Forest land stocked with at least 10 percent of full stocking with live trees with half or more of such stocking in seedlings or saplings or both.
>
> *Poletimber:* Forest land stocked with at least 10 percent of full stocking with live trees with half or more of such stocking in poletimber or sawtimber trees or both, and in which the stocking of poletimber exceeds that of sawtimber.
>
> *Sawtimber:* Forest land stocked with at least 10 percent of full stocking with live trees with half or more of such stocking in poletimber or sawtimber trees or both, and in which the stocking of sawtimber is at least equal to that of poletimber.

State: An ownership class of public lands owned by states or lands leased by states for more than 50 years.

Stocking: The degree of occupancy of land by trees, measured by basal area or number of trees by size and spacing, or both, compared to a stocking standard; that is, the basal area or number of trees, or both, required to fully utilize the growth potential of the land.

Stocking class: At the tree level, stocking is the density expressed as a percent of total tree density required to fully utilize the growth potential of the land. At the stand level it is expressed as the sum of the stocking values of all trees sampled. The classes include:

Overstocked: Forest stand with stocking ≥100 percent.

Fully stocked: Forest stand that contains 60 to 99 percent of full stocking.

Moderately stocked: Forest stand that contains 35 to 59 percent of full stocking.

Poorly stocked: Forest stand that contains only 10 to 34 percent of full stocking.

Nonstocked: Forest stand with less than 10 percent of full stocking.

Sum06: The sum of all hourly average ozone concentrations greater than or equal to 0.06 ppm that occur between June 1 and August 31. It is a widely recognized threshold for ozone injury to sensitive plants.

Timberland: Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland are capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.)

Timber products output: All timber products cut from roundwood and byproducts of wood manufacturing plants. Roundwood products include logs, bolts, or other round sections cut from growing-stock trees, cull trees, salvable dead trees, trees on nonforest land, noncommercial species, sapling-size trees, and limbwood. Byproducts from primary manufacturing plants include slabs, edging, trimmings, miscuts, sawdust, shavings, veneer cores and clippings, and screenings of pulp mills that are used as pulpwood chips or other products.

Tree: A woody plant usually having one or more erect perennial stems, a stem diameter at breast height of at least 3 inches, a more or less definitely formed crown of foliage, and a height of at least 15 feet at maturity.

Tree class: A classification of tree quality or condition of the tree for saw log production. Tree class for sawtimber- size trees is based on current conditions. Tree class for poletimber-size trees is based on the prospected determination or forecast of the potential tree quality when the tree reaches sawtimber size.

Tree size class: A classification of trees based on diameter at breast height, including sawtimber trees, poletimber trees, saplings, and seedlings.

Tops: The wood of a tree above the merchantable height (or above the point on the stem 4.0 inches diameter outside bark (d.o.b.) or to the point where the central stem breaks into limbs). It includes the usable material in the uppermost stem.

Total live tree biomass: The total mass of live trees and associated saplings expressed in pounds or tons (dry weight) per unit area. The total tree and sapling biomass (excluding foliage) has five components:

Bole: Biomass of a tree from 1 foot above the ground to a 4-inch top outside bark or to a point where the central stem splits into smaller limbs. This includes protruding twigs from the central stem.

Tops and limbs: Total biomass of a tree from the 12-inch stump minus the bole. This does not include any twigs protruding from the central stem below the 4-inch top.

Sapling trees: Total biomass of a tree from 1 to 4.9 inches diameter measured at the root collar (d.r.c.) or at breast height (d.b.h.)

Stump: Total biomass of a tree 5 inches d.b.h. and larger from the ground to a height of 1 foot.

Belowground: Total biomass of the belowground portion of the stump and the coarse roots of all trees and saplings.

Urban forest land: Land that would otherwise meet the criteria for timberland but is in an urban-suburban area surrounded by commercial, industrial, or residential development and not likely to be managed for the production of industrial wood products on a continuing basis. Wood removed would be for land clearing, fuelwood, or esthetic purposes. Such forest land may be associated with industrial, commercial, residential subdivision, industrial parks, golf course perimeters, airport buffer strips, and public urban parks that qualify as forest land.

Unreserved forest land: Forest land not withdrawn from harvest by statute or administrative regulation. Includes forest lands that are not capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands.

Veneer log: A roundwood product from which veneer is sliced or sawn and that usually meets certain standards of minimum diameter and length and maximum defect.

Weight: The weight of wood and bark, oven-dry basis (approximately 12 percent moisture content).

TABLES

Tables labeled with the State abbreviation followed by a number (e.g., Table WV-1) report estimates of forest characteristics collected during this inventory period, including estimates of forested area, number of trees, volume, growth, etc. These tables can be found in a supplemental file labeled "West Virginia forest inventory summary tables" at http://dx.doi.org/10.2737/NRS-RB-105.

Tables A through E referenced in this report are published in this document on subsequent pages. These tables report data related to sampling, measurement variables, and measurement quality objectives.

Table A.—Area and number of plots in each stratum used for stratification and estimation, West Virginia, 2013

Table B.—State-level estimates of major forest resource attributes and their sampling errors, West Virginia, 2013

Table C.—Compliance to measurement quality objectives (MQO) tolerances of variables based on blind check plots, West Virginia, 2013

Table D.—Observed relative bias values (Average [field crew—QA crew]) for measurement variables, blind check plots, West Virginia, 2013

Table E.—FIA nonresponse by strata, West Virginia, 2013

Table A.—Area and number of plots in each stratum used for stratification and estimation, West Virginia, 2013

Unit code	Estimation unit description[a]	Canopy cover stratum[b]	Area (acres)	Selected[c]	Office selected[d]	Field selected[e]	Field sampled[f]	Field sampled forested[g]	Total plots sampled for change[h]	Field sampled plots for change[i]	Not measured[j]
2	George Washington NF	Canopy cover 0 - 100		30	0	30	29	29	21	21	1
2	Inland Census Water Unit 2	Canopy cover 0 - 100	22000	6	3	3	3	2	6	3	0
2	Monongahela NF	Canopy cover 81 - 100	626,000	216	0	216	214	214	102	102	2
2	Monongahela NF	Canopy cover 0 - 65	22000	13	1	12	12	11	6	5	0
2	Monongahela NF	Canopy cover 66 - 80	138000	64	0	64	61	61	29	29	3
2	Private Unit 2	Canopy cover 66 - 80	957000	166	1	165	134	132	139	138	31
2	Private Unit 2	Canopy cover 0 - 5	742000	133	90	43	42	22	130	41	1
2	Private Unit 2	Canopy cover 51 - 65	248000	29	2	27	25	23	27	25	2
2	Private Unit 2	Canopy cover 6 - 50	536000	96	23	73	62	53	92	69	11
2	Private Unit 2	Canopy cover 81 - 100	2346000	384	0	384	326	325	360	360	58
2	Public Unit 2	Canopy cover 81 - 100	156000	20	0	20	20	20	20	20	0
2	Public Unit 2	Canopy cover 0 - 80	60000	11	2	9	8	8	11	9	1
3	Inland Census Water Unit 3	Canopy cover 0 - 100	23000	2	1	1	1	1	2	1	0
3	Jefferson NF	Canopy cover 0 - 100	19000	5	0	5	5	5	3	3	0
3	Monongahela NF	Canopy cover 66 - 80	6000	3	0	3	3	3	2	2	0
3	Monongahela NF	Canopy cover 0 - 65	3000	2	0	2	2	2	0	0	0
3	Monongahela NF	Canopy cover 81 - 100	119000	41	0	41	39	39	18	18	2
3	Private Unit 3	Canopy cover 51 - 65	109000	25	5	20	13	13	22	17	7
3	Private Unit 3	Canopy cover 6 - 50	371000	57	8	49	34	29	50	42	15
3	Private Unit 3	Canopy cover 81 - 100	3349000	540	2	538	389	388	492	490	149
3	Private Unit 3	Canopy cover 0 - 5	411000	67	41	26	23	14	63	22	3
3	Private Unit 3	Canopy cover 66 - 80	417000	90	1	89	63	60	85	84	26
3	Public Unit 3	Canopy cover 0 - 100	221000	41	0	41	38	38	38	38	3
4	Inland Census Water Unit 4	Canopy cover 0 - 100	52000	11	7	4	4	4	10	3	0
4	Private Unit 4	Canopy cover 6 - 50	535000	96	20	76	65	54	94	74	11
4	Private Unit 4	Canopy cover 51 - 65	210000	33	1	32	28	27	32	31	4
4	Private Unit 4	Canopy cover 66 - 80	559000	100	0	100	74	69	93	93	26
4	Private Unit 4	Canopy cover 0 - 5	383000	66	48	18	13	4	64	16	5
4	Private Unit 4	Canopy cover 81 - 100	2612000	437	0	437	360	360	415	415	77
4	Public Unit 4	Canopy cover 0 - 100	149000	24	0	24	24	23	24	24	0

[a] Estimation unit description: Description of the sub-population undergoing post-stratification. County groups are defined by one or more contiguous counties used for population estimation.
[b] Canopy cover stratum: A stratum within each estimation unit defined by partitioning the full range of percent canopy (0 - 100%) into five strata.
[c] Selected: The number of plots selected when the sample was drawn.
[d] Office selected: The number of plots determined to have no chance of being forested during a prefield interpretation procedure. These plots are withheld from field sampling and considered remotely sampled.
[e] Field selected: The number of plots determined to have some chance of being forested or that were forested or nonsampled on a previous visit.
[f] Field sampled: The number of field selected plots that were successfully sampled in the field.
[g] Field sampled forested: The number of field selected plots that were successfully sampled in the field and found to intersect forest land.
[h] Total plots sampled for change: The number of plots included in the sample that were successfully sampled in the previous cycle.
[i] Field sampled plots for change: The number of plots included in the sample that were successfully sampled in the previous cycle and that were sent to the field for sampling.
[j] Not measured: The number of plots that were selected as part of the sample but were completely nonsampled.

Table B.—State-level estimates of major forest resource attributes and their sampling errors, West Virginia, 2013

Item	State Total	Sampling Error
Growing stock on timberland	*million cubic feet*	*percent*
Volume	25,043.5	1.29
Average annual net growth	518.7	3.47
Average annual removals	241.3	10.94
Average annual mortality	190.5	5.78
Sawtimber on timberland	*million board feet* [a]	
Volume	92,200.7	1.70
Average annual net growth	2,607.5	3.31
Average annual removals	991.9	11.82
Average annual mortality	656.1	8.57
Area	*thousand acres*	
Forest land	12,185.7	0.58
Timberland	11,807.3	0.67
Biomass (aboveground live trees)	*million dry tons*	
Forest land	823.8	1.06
Timberland	793.6	1.15

[a] International ¼-inch Rule.

Table C.—Compliance to measurement quality objectives (MQO) tolerances of variables based on blind check plots, West Virginia, 2013

Variable	Tolerance	Objective	West Virginia		All NRS States	
			Data within tolerance	Observations	Data within tolerance	Observations
Plot Level		-------- *percent* --------		*numbers*	*percent*	*numbers*
Distance to Road	No Tolerance	90.0	66.4	122	81.7	2,420
Water on Plot	No Tolerance	90.0	82.8	122	86.7	2,420
Elevation	±50 feet	99.0	79.4	63	87.9	2,204
Latitude - decimal degrees	±0.0001 degree	99.0	100.0	63	100.0	2,208
Longitude - decimal degrees	±0.0001 degree	99.0	82.5	63	87.4	2,208
Number of plots				128		2,532
Condition Level						
Condition status	No Tolerance	99.0	97.2	248	98.5	6,552
Reserve status	No Tolerance	99.0	99.6	248	99.7	6,552
Owner group	No Tolerance	99.0	96.4	197	97.6	3,690
Forest type (type)	No Tolerance	95.0	87.3	197	90.8	3,690
Forest type (group)	No Tolerance	99.0	94.4	197	94.5	3,690
Stand size	No Tolerance	99.0	91.4	197	91.4	3,690
Regeneration status	No Tolerance	99.0	99.0	197	98.6	3,690
Tree density	No Tolerance	99.0	95.9	197	96.7	3,690
Owner class	No Tolerance	99.0	95.4	197	95.4	3,690
Owner status	No Tolerance	99.0	98.5	197	99.3	3,690
Regeneration species	No Tolerance	99.0	99.0	197	98.6	3,690
Stand age	±10 percent	95.0	91.9	197	88.0	3,690
Disturbance 1	No Tolerance	99.0	87.9	190	92.1	3,620
Disturbance year 1	±1 year	99.0	95.5	22	90.4	436
Disturbance 2	No Tolerance	99.0	90.9	44	91.2	678
Disturbance year 2	±1 year	99.0	100.0	2	80.0	40
Disturbance 3	No Tolerance	99.0	100.0	6	97.8	90
Disturbance year 3	±1 year	99.0	.	.	50.0	2
Treatment 1	No Tolerance	99.0	100.0	190	98.0	3,620
Treatment year 1	±1 year	99.0	75.0	4	96.4	220
Treatment 2	No Tolerance	99.0	100.0	4	86.9	289
Treatment year 2	±1 year	99.0	.	.	98.4	64
Treatment 3	No Tolerance	99.0	.	.	96.0	99
Treatment year 3	±1 year	99.0	.	.	83.3	6
Physiographic class	No Tolerance	80.0	90.4	197	86.7	3,690
Present nonforest use	No Tolerance	99.0	95.6	248	90.0	6,552
Number of conditions				248		6,552
Boundary Level						
Boundary Change	No Tolerance	99.0	79.5	44	81.9	875
Constrasting Condition	No Tolerance	99.0	97.7	44	95.5	875
Left Azimuth	±10 degrees	90.0	88.6	44	87.2	875
Corner Mapped	No Tolerance	90.0	100.0	44	94.9	875
Corner Azimuth	±10 degrees	90.0	33.3	3	92.8	83
Corner Distance	±1 foot	90.0	33.3	3	91.6	83
Right Azimuth	±10 degrees	90.0	86.4	44	87.2	875
Number of boundaries				44		875
Subplot Level						
Subplot Center Condition	No Tolerance	99.0	98.4	512	98.3	10,128
Microplot Center Condition	No Tolerance	99.0	98.2	512	98.1	10,128
Slope	±10 percent	90.0	95.7	461	98.8	8,565
Aspect	±10 degrees	90.0	89.8	453	94.7	8,360
Snow/Water Depth	±0.5 foot		85.2	461	67.7	8,604
Number of subplots				512		10,128

continued

Table C.—continued

Variable	Tolerance	Objective	West Virginia		All NRS States	
			Data within tolerance	Observations	Data within tolerance	Observations
Tree Level		-------- *percent* --------		*numbers*	*percent*	*numbers*
DBH	±0.1 inch per 20 inches	95.0	94.3	1,975	95.6	37,648
DRC	±0.1 inch per 20 inches	95.0	.	.	73.9	69
Azimuth	±10 degrees	90.0	98.7	2,154	99.3	42,187
Horizontal Distance	±0.2 foot per 1.0 foot	90.0	98.5	2,154	98.7	42,187
Species	No Tolerance	95.0	97.7	2,155	98.4	42,472
Tree Genus	No Tolerance	99.0	99.7	2,149	99.6	42,430
Tree Status	No Tolerance	95.0	99.4	2,155	98.9	42,495
Rotten/Missing Cull	±10 percent	90.0	95.9	1,522	98.4	27,677
Total Length	±10 percent	90.0	69.3	1,512	79.7	27,382
Actual Length	±10 percent	90.0	65.0	143	74.0	3,340
Compacted Crown Ratio	±10 percent	80.0	78.0	1,853	83.0	35,077
Uncompacted Crown Ratio (P3)	±10 percent	90.0	.	.	100.0	19
Crown Class	No Tolerance	85.0	81.6	1,853	81.8	35,077
Decay Class	±1 class	90.0	96.3	243	96.0	6,218
Cause of Death	No Tolerance	80.0	85.6	243	83.6	6,218
Condition	No Tolerance	99.0	99.5	2,155	98.3	42,495
Crown Position	No Tolerance		.	.	100.0	18
Crown Light Exposure	±1 class	85.0	.	.	100.0	19
Sapling Crown Vigor Class	No Tolerance	85.0	.	.	100.0	1
Crown Density	±10 percent	90.0	.	.	100.0	18
Crown Dieback	±10 percent	90.0	.	.	100.0	18
Transparency	±10 percent	90.0	.	.	100.0	18
Tree Class	No Tolerance	90.0	90.1	1,984	92.4	38,038
Damage Agent 1	No Tolerance	90.0	88.7	1,853	90.2	35,077
Damage Agent 2	No Tolerance	90.0	77.1	375	78.2	6,759
Tree Grade	No Tolerance	90.0	66.7	543	74.8	8,257
DBH-Live & Trees with Decay Code 1 or 2	±0.1 inch per 20 inches	95.0	94.0	1,882	95.4	35,911
DBH-Trees with Decay Codes 3, 4 or 5	±1 inch per 20 inches	95.0	100.0	93	99.5	1,732
Total Length-trees 40 feet and greater	±10 percent	90.0	71.1	1,306	81.4	21,666
Total Length-trees less than 40 feet	±10 percent	90.0	57.8	206	73.1	5,716
Total Length-trees less than 5 inches DBH	±10 percent	90.0	53.8	13	70.8	349
Number of trees				2,155		42,472
Seedling Level						
Species	No Tolerance	85.0	88.2	431	92.5	8,648
Genus	No Tolerance	90.0	93.5	431	96.8	8,648
Seedling Count	±20 percent	90.0	58.9	431	63.1	8,648
Seedling Count (coded)	No Tolerance	90.0	62.2	431	69.3	8,648
Number of microplots				173		3,535
Site Tree Level						
Condition List	No Tolerance	99.0	92.1	38	93.1	2,775
Diameter	±0.1 inch per 20 inches	95.0	89.5	38	98.0	2,775
Species	No Tolerance	95.0	97.4	38	99.3	2,775
Genus	No Tolerance	99.0	100.0	38	100.0	2,775
Azimuth	±10 degrees	90.0	94.7	38	99.1	2,775
Distance	±5 feet	90.0	94.7	38	99.3	2,775
Total Length	±10 percent	90.0	94.7	38	98.5	2,775
Diameter Age	±5 years	95.0	86.8	38	98.0	2,775
Number of site trees				38		2,775

Table D.—Observed relative bias values (Average [field crew—QA crew]) for measurement variables, blind check plots, West Virginia, 2013

Variable	Unit of measure	West Virginia				All NRS states			
		Relative bias	95% CI limits		Observations	Relative bias	95% CI limits		Observations
			Lower	Upper			Lower	Upper	
Plot Level					*number*				*number*
Elevation	foot	3.97	-6.93	17.08	63	224.68	46.44	449.35	2,204
Latitude - decimal degrees	degree	0.00	0.00	0.00	63	0.00	0.00	0.00	2,208
Longitude - decimal degrees	degree	-0.01	-0.04	0.00	63	-0.00	-0.01	-0.00	2,208
Number of plots					128				2,532
Boundary Level									
Left azimuth	degree	-3.66	-10.78	1.66	44	0.07	-3.18	3.38	875
Corner azimuth	degree	-1.33	-30.00	26.00	3	6.00	-0.62	18.80	83
Right azimuth	degree	3.02	-2.19	10.43	44	1.61	-1.33	4.35	875
Number of boundaries					44				875
Subplot Level									
Slope	percent	0.46	-0.12	0.97	461	0.04	-0.05	0.13	8,565
Aspect	degree	0.64	-1.86	3.48	453	0.29	-0.33	0.92	8,360
Snow/water depth	foot	-0.43	-0.77	-0.14	461	-0.28	-0.39	-0.17	8,604
Number of subplots					512				10,128
Tree Level									
D.b.h.	inch	0.01	0.00	0.02	1,975	-0.00	-0.00	0.00	37,648
D.r.c.	inch				.	0.06	-0.10	0.23	69
Azimuth	degree	0.04	-0.42	0.48	2,154	-0.03	-0.09	0.05	42,187
Horizontal distance	foot	-0.00	-0.01	0.01	2,154	0.00	-0.00	0.00	42,187
Rotten/missing cull	percent	-0.08	-0.36	0.21	1,522	-0.15	-0.19	-0.11	27,677
Total length	foot	-0.21	-0.81	0.44	1,512	0.21	0.09	0.34	27,382
Actual length	foot	-3.75	-7.79	-0.50	143	-1.46	-2.62	-0.50	3,340
Compacted crown ratio	percent	-0.57	-1.06	-0.17	1,853	0.11	0.01	0.21	35,077
Uncompacted crown ratio (P3)	percent				.	0.63	-0.03	1.37	19
Crown density	percent				.	0.00	0.00	0.00	18
Crown dieback	percent				.	0.00	0.00	0.00	18
Transparency	percent				.	0.00	0.00	0.00	18
D.b.h.—live & trees with decay code 1 or 2	inch	0.01	0.01	0.02	1,882	0.00	-0.00	0.00	35,911
D.b.h.—trees with decay codes 3, 4, or 5	inch	-0.00	-0.04	0.04	93	-0.02	-0.05	-0.01	1,732
Total length—trees 40 feet and greater	foot	0.37	-0.28	0.91	1,306	0.70	0.57	0.83	21,666
Total length—trees less than 40 feet	foot	-3.87	-5.46	-1.91	206	-1.67	-1.97	-1.34	5,716
Total length—trees less than 5 inches d.b.h.	foot	2.10	-2.69	7.23	13	-1.53	-2.82	-0.05	349
Number of trees					2,155				42,472
Seedling Level									
Seedling count	number	-8.69	-14.17	-2.59	431	-12.53	-14.37	-10.94	8,496
Seedling count (coded)	number	0.04	-0.06	0.13	431	-0.00	-0.02	0.02	8,648
Number of microplots					173				3,535
Site tree level									
Diameter	inch	0.00	-0.07	0.09	38	0.00	-0.01	0.01	2,775
Azimuth	degree	-4.21	-10.25	-0.03	38	0.14	-0.18	0.47	2,775
Distance	foot	0.38	-0.36	1.44	38	0.04	-0.00	0.08	2,775
Total length	foot	-0.32	-1.99	1.63	38	-0.04	-0.22	0.13	2,775
Diameter age	year	0.79	-1.22	3.13	38	0.00	-0.09	0.11	2,775
Number of site trees					38				2,775

Table E.—FIA nonresponse by strata, West Virginia, 2013

Owner and strata(um)	Number of plots selected	Sampled	Denied access	Hazardous	Other	Percent response rate
			number of plots			
George Washington NF:						
1, 2, 3, 4, 5	30	28.75	1	0.25	0	95.83
Jefferson NF:						
1, 2, 3, 4, 5	5	5	0	0	0	100
Monongahela NF:						
4	67	64	3	0	0	95.52
5	257	252.5	2.25	2.25	0	98.25
1, 2, 3	15	15	0	0	0	100
Public:						
5	20	20	0	0	0	100
1, 2, 3, 4	11	9	0	2	0	81.82
1, 2, 3, 4, 5	41	37	2	2	0	90.24
1, 2, 3, 4, 5	24	24	0	0	0	100
Private:						
1	133	131.5	1.5	0	0	98.87
2	96	84	11	1	0	87.5
3	29	26.25	2	0.5	0.25	90.52
4	166	132.15	32.35	1.5	0	79.61
5	384	322.56	60.67	0.77	0	84
1	67	64	3	0	0	95.52
2	57	40.64	13.5	2.86	0	71.3
3	25	17.5	6.25	1.25	0	70
4	90	63.13	21.25	5.62	0	70.14
5	540	386.35	134.37	19.27	0	71.55
1	66	60.75	4	1.25	0	92.05
2	96	84.13	11.25	0.62	0	87.63
3	33	28.75	4	0.25	0	87.12
4	100	73.25	25	0.75	1	73.25
5	437	358.24	76.86	1.9	0	81.98
Census Water:						
1, 2, 3, 4, 5	6	6	0	0	0	100
1, 2, 3, 4, 5	2	2	0	0	0	100
1, 2, 3, 4, 5	11	10.25	0.5	0.25	0	93.18
Total	2,808.0	2,346.7	415.8	44.3	1	98.4

Strata codes:
1: Canopy cover 0 - 5
2: Canopy cover 6 - 50
3: Canopy cover 51 - 65
4: Canopy cover 66 - 80
5: Canopy cover 81 - 100