United States Department of Agriculture

Minnesota Forests 2013
Statistics, Methods, and Quality Assurance

Forest Service

Northern Research Station

This document supplements Resource Bulletin NRS-104

FOREST INVENTORY METHODS

Strategic Model

The Forest Inventory and Analysis 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):[1]

- 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 six objectives are achieved, 10 strategic approaches have been prescribed:

- A national set of prescribed core variables with a national field manual that describes 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 with 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 detection monitoring by the USDA Forest Service's Forest Health Monitoring (FHM) program.

[1] Citations are available in "Minnesota Forests 2013" located at http://dx.doi.org/10.2737/NRS-RB-104.

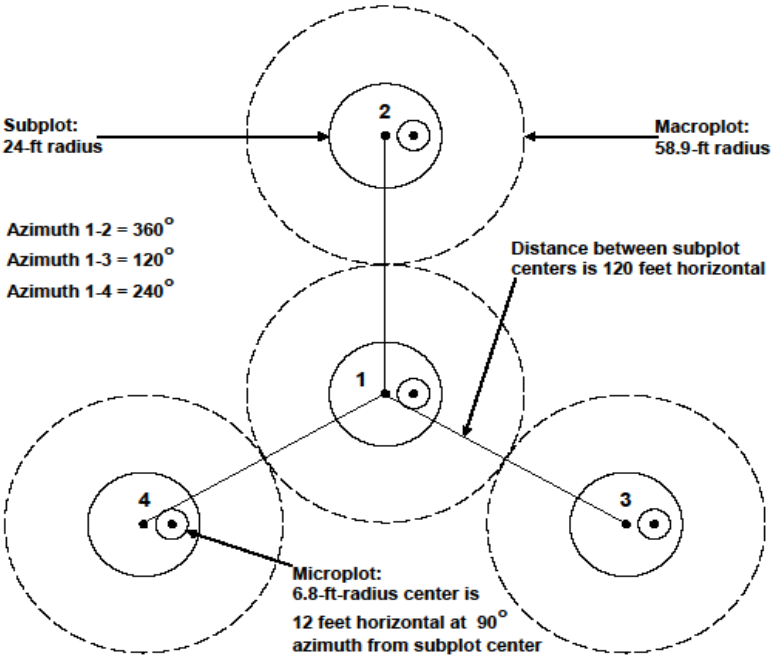

Figure 83.—National FIA plot design (adapted from Bechtold and Patterson 2005).

Plot Configuration

The national FIA plot design (Fig. 83) consists of four 24-foot-radius subplots configured as a central subplot and three peripheral subplots. Centers of the peripheral subplots are located 120 feet from the central subplot and at azimuths of 0°, 120°, and 240° from the center of the central subplot. Every live and dead tree with a diameter at breast height (d.b.h.) of 5.0 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 live tree with a d.b.h. from 1.0 to 4.9 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. Macroplots are not used by the Northern Research Station. They have a radius of 58.9 feet and are used for sampling intensification or sampling relatively rare events. Rocky Mountain and Pacific Northwest Research Stations use these larger sample areas for sampling very large trees.

Sample Design

Historical sampling errors indicate that a sampling intensity of about one plot per 6,000 acres is required to satisfy national FIA precision guidelines. Therefore, FIA divided the area of the United States into nonoverlapping, 5,937-acre hexagons and established a plot in each hexagon as follows: (1) if an existing FHM plot was located in a hexagon, it was selected; (2) if there was no FHM plot in the hexagon, the existing FIA plot from the previous periodic inventory nearest the hexagon center was selected; and (3) if neither an FHM nor an FIA plot was located in the hexagon, a new FIA plot was established at a random location in the hexagon (Brand et al. 2000, McRoberts 1999). This array of field plots is designated the Federal base sample and is considered an equal probability sample. Sampling conducted on these field plots is funded by the Federal government.

The Federal base sample is divided into five interpenetrating, nonoverlapping 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). For estimation purposes, the measurement of each panel of plots is considered an independent, equal probability sample of all lands in a state.

Multi-phase Inventory

FIA conducts inventories in multiple 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 forested permanent field plots to measure traditional inventory variables such as tree species, diameter, and height. 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. 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. P3 has been replaced by Phase 2-plus (P2+), in which less data are collected per plot but more plots are sampled. Otherwise, P2+ and P3 follow the same paradigm, focusing on forest and ecosystem health. Normally, the P2 and P3 or P2+ variables are acquired in the same visit. The three phases of the enhanced FIA program as implemented in this inventory are discussed in greater detail in the sections that follow.

Phase 1

Aerial photographs, digital orthophoto quadrangles (DOQs: digitally scanned aerial photograph), and satellite imagery are used for initial plot measurement via remotely sensed data and stratification. P1 plot measurement consists of observations of conditions at the plot locations using aerial photographs or DOQs. A human interpreter assigns the plot a land cover/use with primary focus on identifying forest land. 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. NRS-FIA uses canopy density classes to derive strata. Canopy density information was obtained from the 2001 National Land Cover Database (NLCD) (Homer et al. 2007). The NLCD 2001 canopy density layer for the United States was produced through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium (http://www.mrlc.gov/). The layer characterizes subtle variations of forest canopy density as a percentage estimate of forest canopy cover (0 to 100) within every 30-m pixel over the United States. The method employed to map canopy density for NLCD 2001 is described in detail in Huang et al. (2001).

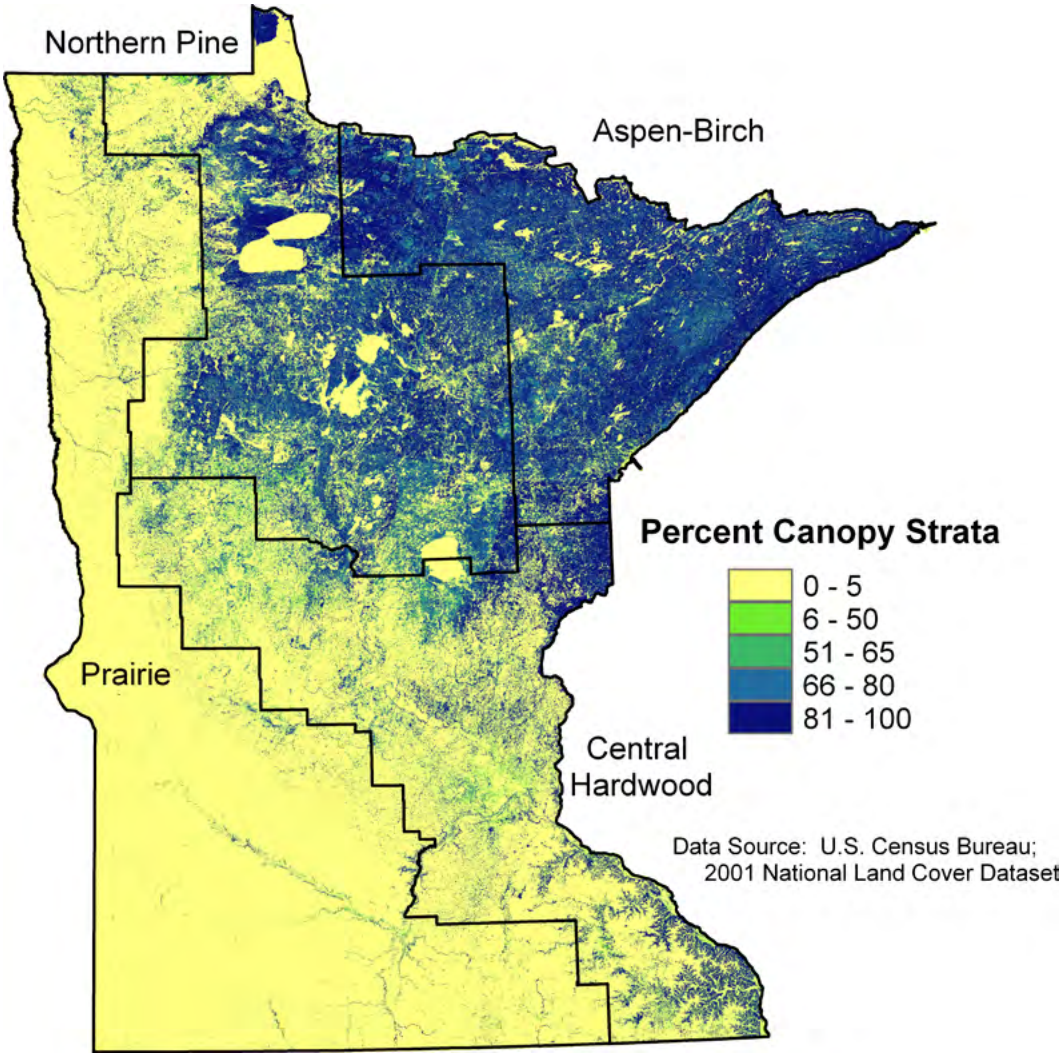

Figure 84.—Percent canopy strata groupings, Minnesota.

Strata Construction

Strata categorizations were optimized for the entire NRS-FIA region. Using plot location information (center of the center subplot), a percent canopy density value was assigned to each plot. Plots were then aggregated into one of the five strata based on the center of the center subplot. The percent canopy cover stratification scheme consists of five groupings: (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. These groupings were based on observed natural clumping of pixel values and are presented in Figure 84.

In addition to the classification of every pixel into one of the five canopy strata, every pixel was also assigned to an ownership stratum in order to reduce the effects of nonresponse bias that typically varies by owner. In Minnesota, ownership layers derived from the Minnesota Department of Natural Resources (2015a) Data Deli and the Conservation Biology Institute (2012) Protected Areas Database were used to classify

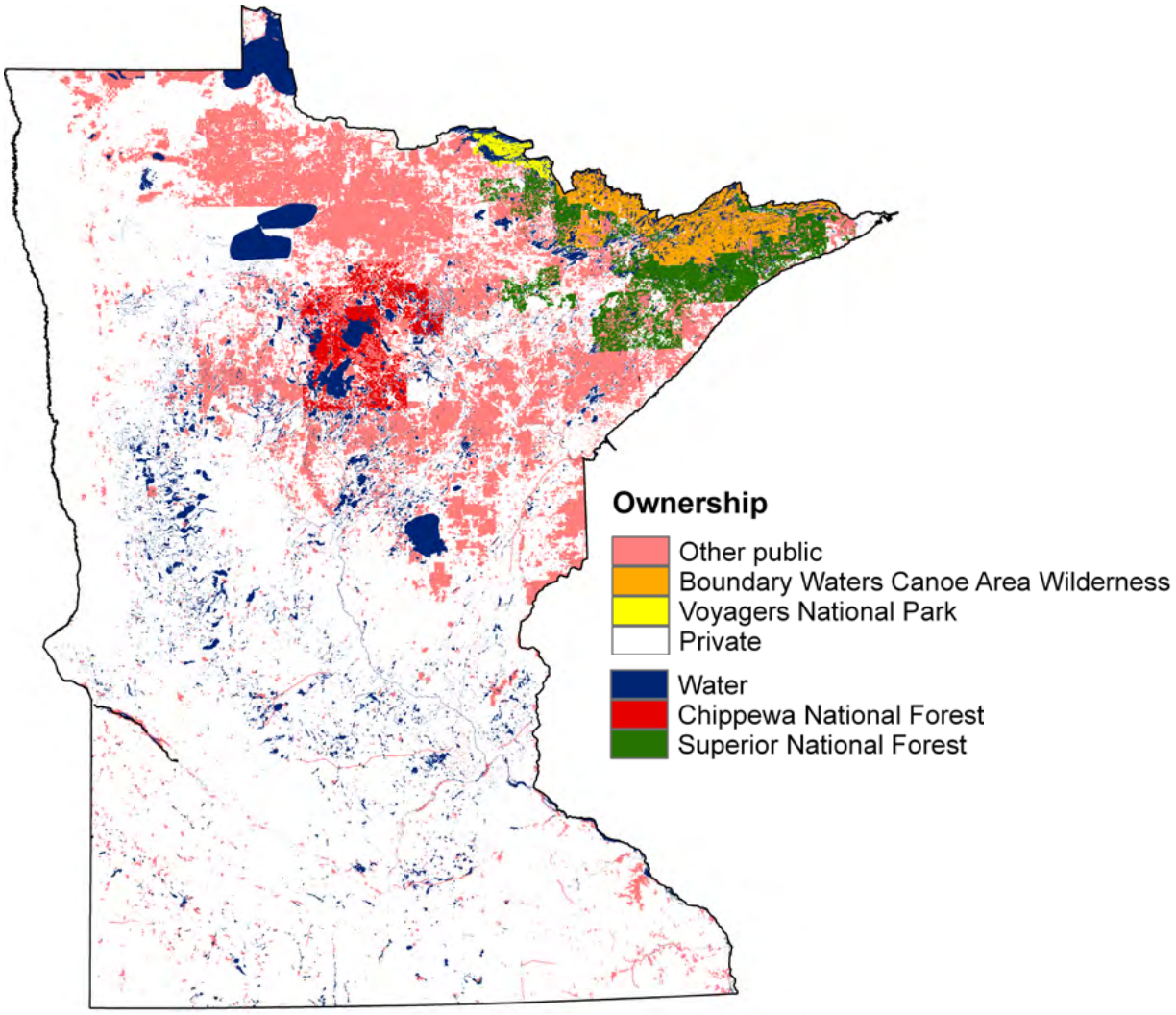

Figure 85.—Forest ownership, Minnesota.

pixels into ownership classes (Fig. 85). Every pixel was also assigned to a county based on the location of the pixel center. The seven ownership classes include the following, with the largest ownership class, based on pixel counts, being private ownership at over 39 million acres:

Ownership class	Acres based on pixel counts
Other Public	8,871,601.8
Boundary Waters Canoe Area	766,334.2
Voyagers National Park	121,087.7
Private	39,219,809.5
Census water (inland)	3,059,985.3
Chippewa National Forest	641,491.2
Superior National Forest	1,328,213.8

If there were enough plots in each of these classes to create strata, then the strata were defined by the class boundaries. If there were insufficient numbers of plots for some classes, collapsing rules were used to combine classes until sufficient sample sizes were obtained. NRS-FIA requires a minimum of 10 plots per stratum. There are two exemptions from the 10 plots per stratum rule. Any stand-alone estimation unit, such as a National Forest, will not be collapsed with another estimation unit regardless of the plot count. Also, the inland census water estimation units use an alternative minimum of two plots per stratum.

Stratified estimation requires that two tasks be accomplished. First, each plot must be assigned to a single stratum. Next, the proportion of each detailed stratum must be calculated (TM land-cover classification, ownership, and county group delineation). 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 in Minnesota are presented in the estimation section of this report.

Phase 2

In P2, field crews record a variety of data for plot locations determined in P1 to include accessible forest land. 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. In most cases permission is not required to visit plots on public lands, but there are exceptions (e.g., military bases). At the plot, field crews determine the location of the geographic center of the central subplot using global positioning system receivers, maps, and notes from previous visits if available. Crews delineate a condition as a unique combination of reserved status, owner group, forest type, stand-size class, stand origin, and tree density. For every condition (at least 1 acre in size) on the plot, they record the delineating attributes and other information such as land cover, stand age, site-productivity class, history of forest disturbance, and land use. The crews 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, per unit area estimates of number of trees and 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. U.S. Forest Service (2012) covers P2 data collection procedures and O'Connell et al. (2014) describe the P2 database.

Phase 3 (1999 - 2010)

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, universities, and 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. Intensive site ecosystem monitoring studies 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 detection monitoring program was integrated into the FIA program as P3 in 1999. The NRS-FIA P3 sample consists of a 1:16 subset of the P2 plots with one P3 plot for approximately every 95,000 acres. P3 measurements are obtained by field crews during the growing season and include an extended suite of ecological data for Minnesota:

- Lichen diversity and abundance (data collected in inventory years 2002 through 2005)
- Soil quality–erosion, compaction, and chemistry (data collected 2000 through 2005)
- Vegetation diversity and structure (data collected in inventory years 2001 through 2003 and 2007 through 2010)
- Down woody material (data collected in inventory years 2001 through 2010)
- Incidence and severity of ozone injury for selected bioindicator species that are also monitored as part of an associated sampling scheme (data collected in inventory years 1999 through 2010)
- Crown indicators (data collected in inventory years 2000 through 2010)

All P2 measurements are collected on each P3 plot at the same time as the P3 measurements (U.S. Forest Service 2007). Additional information on the collection procedures used in P3 is available at http://www.nrs.fs.fed.us/fia/topics/. Woodall et al. (2010) describe the P3 database.

P3 variables were selected to address specific criteria outlined by the Montreal Process Working Group for the conservation and sustainable management of temperate and boreal forests (Montreal Process 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.

Phase 2-plus

For most forest health indicators, P2+ is a more refined and 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. Forest Service 2014b) includes details on sampling sapling length, advance tree seedling regeneration (ATSR), vegetation profiles, invasive plants, down woody materials (DWM), soils, and tree crowns.

Advance Tree Seedling Regeneration

The tree seedling sample is designed to inventory and monitor the forest's regenerative capacity. Tree seedling counts are used along with the sapling tally to estimate ATSR. Information on ATSR, specifically lengths, 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 provide 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.

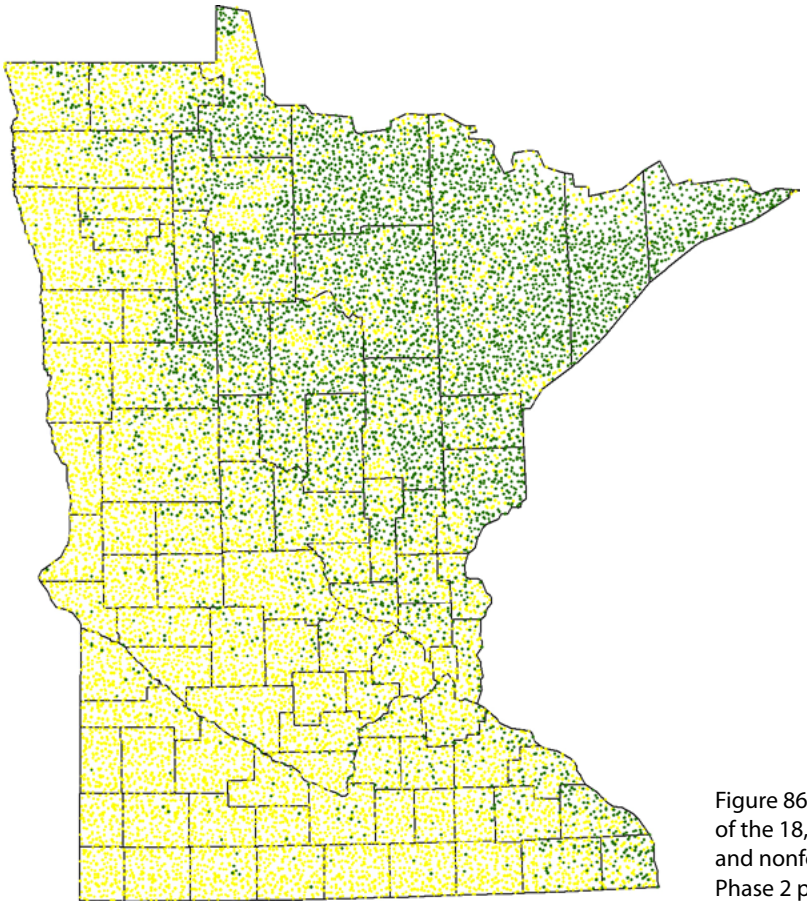

Figure 86.—Approximate locations of the 18,087 forest (green dots) and nonforest (yellow dots) land Phase 2 plots, Minnesota, 2013.

Estimation

Most of the estimates and analysis of forest resources presented in this report (including estimates in Tables MN-1 through MN-65[2]) are based on data observed on the 18,087 Phase 2 plots located across Minnesota (Fig. 86). The analysis of forest health issues that relate to down woody materials, soils, ozone damage, and crown condition are based on data observed on the 555 Phase 3 plots. (Fig 87).

Approximately 20 percent of the Phase 2 observations were acquired each year from October 1, 2008 through September 30, 2013 (the last plot was actually measured on November 26, 2013). These observations are collectively called the 2013 inventory. These plots are located on 53 strata located within 16 estimation units (Table A; Tables labeled with letters begin on page 26) defined by five Phase 1 canopy cover classes (0 to 5 percent, 6 to 50 percent, 51 to 65 percent, 66 to 80 percent, and 81 to 100 percent) or collapsed canopy cover classes, a land ownership classification (based on information obtained from the Minnesota DNR [2015] Data Deli), and four inventory units (where an inventory unit is a grouping of counties based on ecological similarities). Procedures described in Scott et al. (2005) for stratified estimation with observed stratum areas were used in conjunction with the strata in Table A to produce all estimates. Table A shows the total area and number of plots within each stratum.

[2] Tables labeled with the State abbreviation followed by a number (e.g., Table MN-1) are located in a supplemental file titled "Summary Tables for Minnesota Forests 2013: Statistics, Methods, and Quality Assurance" found at http://dx.doi.org/10.2737/NRS-RB-104. Tables labeled with letters (e.g., Table A) begin on page 26.

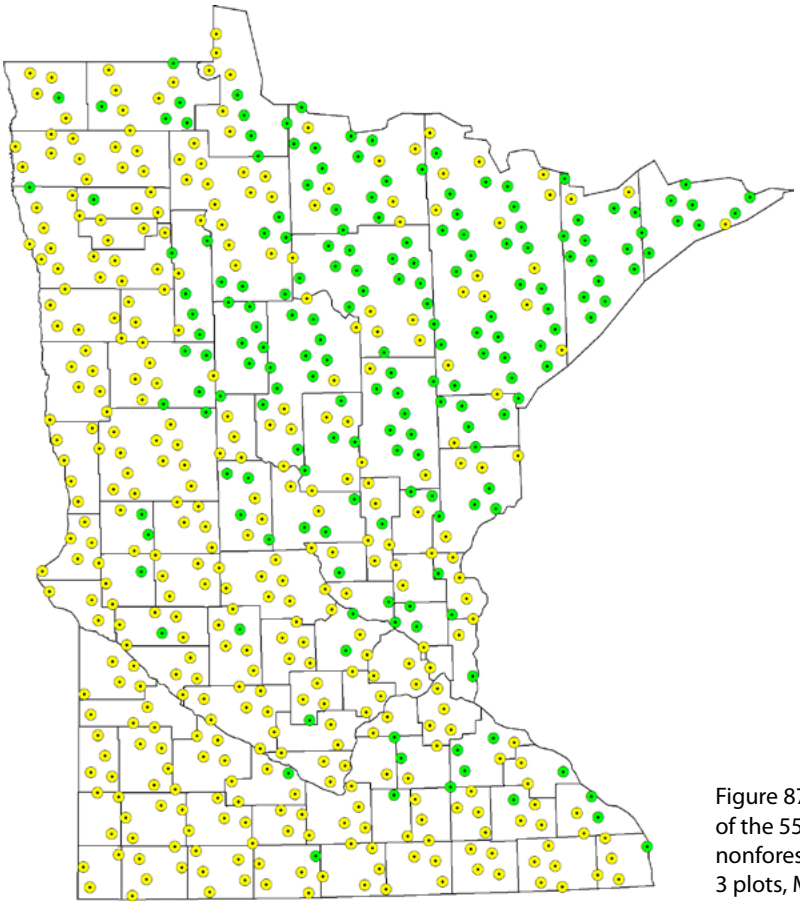

Figure 87.—Approximate locations of the 555 forest (green dots) and nonforest (yellow dots) land Phase 3 plots, Minnesota, 2013.

Integration with Previous Inventories

The first five inventories of Minnesota were completed in 1935, 1953, 1962, 1977, and 1990 (Zon 1935, Cunningham et al. 1958, Stone 1966, Jakes 1980, Leatherberry et al. 1995, respectively). Inventories 6 through 11 involved a special study that helped in the development of the current annual inventory system. Minnesota's 12th inventory (the first conducted under the annual inventory system) was completed in 2003 and consisted of data collected in five panels over 5 years (1999, 2000, 2001, 2002, and 2003) (Miles et al. 2007). The 13th inventory (the first complete remeasurement of an annual inventory) was completed in 2008 (Miles et al. 2011) and consisted of data collected in 2004, 2005, 2006, 2007, and 2008. The 14th inventory (the second complete remeasurement of an annual inventory) was completed in 2013 and includes the five panels of data collected in 2009, 2010, 2011, 2012, and 2013.

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 inventories must be similar. Identical classification procedures for assigning condition-level variables such as forest type and stand-size were used for the 2003, 2008, and 2013 annual inventories, therefore comparisons made between these inventories are relatively uncomplicated. Because these identical classification procedures were applied nationwide to data collected under the annual inventory design, comparisons using forest type and stand size across state boundaries are also possible. Different classification procedures for forest type and stand size were used for Minnesota

periodic inventories (1990, 1977, 1962, 1953, and 1935) because they were collected using different plot designs. Comparisons with these earlier period inventories are more problematic as there were major changes in plot design between the periodic inventories conducted prior to 1998 and annual inventories conducted after 1998.

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. Prior to this new plot design, fixed and variable-radius subplots were used in the 1990 and 1977 inventories. 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, for example, 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). For additional information on Phase 3 indicator sampling protocols, see Woodall and Monleon (2008).

Reserved Status Changes

In an effort to increase consistency among states and across inventory years, a refined set of procedures determining reserve status have been implemented with version 6.0 of the FIA field manual which took effect with the 2013 inventory year (beginning in October 2012). Furthermore, all previously collected annual inventory data (1999 to present) have been updated using the new standardized interpretation.

Starting with this report, timberland estimates generated for earlier annual inventories will differ from previously published estimates. The 2012 inventory was the last inventory in which all data were available under the previous and improved implementations. Small but significant changes are associated with timberland acreage (-2 percent), number of trees (-2 percent), volume (-2 percent), and biomass (-2 percent). The impact on harvest removals was quite small (-0.2 percent), but the impact on the estimate of annual other removals of growing stock trees on timberland was very large (-69 percent). This large decrease in other removals is the result of improved consistency in reserved status determination.

The improved implementation of the reserve status definition increases the spatial and temporal precision of timberland estimates, allowing for higher quality trend analyses and potentially better forest management decisions.

Common Sources of Error

Two general types of error—random variability (precision) and estimation bias (accuracy)—are of general interest to all users. Random variability refers to the precision of the estimate, which would occur if the entire sampling and estimation process were to be repeated many times. Estimation bias refers to the difference between the estimate and the "true value" in the absence of this random variability and refers to the overestimation or underestimation inherent in the entire estimation process.

Errors in the estimates presented in this report (both random variability and estimation bias) are affected by various sources. The four primary sources of error common to all sample-based estimates are sampling, measurement, prediction, and nonresponse error. A section is devoted to each of these sources of error. Included in each section is a definition of the source of error in the context of the FIA inventory as well as a discussion of methods used to quantify and/or reduce that source of error. Measures of sampling, measurement, and prediction errors associated with various attributes are presented. Issues of possible bias related to nonresponse also are addressed.

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 (e.g., every tree in the State) had been observed and included in the sample. The 2013 inventory of Minnesota is based on a sample of 18,087 plots located randomly across the State (total area of 54.0 million acres), or a sampling rate of about one plot for every 2,986 acres.

The procedures for statistical estimation outlined in the previous section and described in detail in Scott et al. (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 (the estimated value plus or minus the sampling error). This sampling error is the primary measure of the reliability of an estimate. This report utilizes a sampling error based on one standard error which can be interpreted to mean that the chances are two out of three that if a 100-percent inventory had been taken using these methods, 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 listed in Table B. Table MN-65 presents sampling errors for these estimates at the county level.

Estimates for classifications smaller than the State totals in Table B will have larger sampling errors. For example, Table MN-65 shows 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:

$$E = \frac{(SE)\sqrt{(\text{State total estimate})}}{\sqrt{(\text{Smaller estimate})}}$$

Where

E = approximate sampling error for smaller estimate

SE = sampling error for State total estimate (percent)

For example, to compute the error on the estimate of area of forest land in the spruce/fir forest-type group for the State, proceed as follows:

Total area of the spruce/fir group in the State (see Table MN-3) = 4,004,825 acres

Total area of all forest land in the State (see Table MN-3) = 17,378,345 acres

State total error for forest land area (see Table B) = 0.52 percent

Sampling error = $E = \frac{(0.52)\sqrt{(17{,}378{,}345)}}{\sqrt{(4{,}004{,}825)}}$ = 1.08 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/default.asp.

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, 15 to 50 trees are observed with 15 to 20 attributes recorded on each tree. Also, 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), 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 control and quality assurance 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 extensive 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 is measured independently by a different qualified crew. These independent measurements are referred to as blind checks, the purpose of which is to assess the quality of field measurements. A second measurement on blind check plots is made by a quality assurance (QA) crew. QA crews have as much or more experience and training in FIA field measurements as that of 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 collected. 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. 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. Columns labeled Minnesota are based on blind check measurements of plots used in this report. The columns labeled All NRS States come from all measurements made by NRS-FIA crews within the entire 24-state area (Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Vermont, West Virginia, and Wisconsin). 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 Minnesota many variables, such as diameter at breast height, have a low tolerance (± 0.1 in.) and a high percentage of data within the tolerance (95.5 percent). Measurements for determining tree-size class are precise. In contrast, a few variables, such as stand age, have a larger tolerance (± 10 years) and less data within the tolerance (85.7 percent). The estimate of stand age is based on the composition of all age classes within a stand. Often, stands are heterogeneous by age, but a single value must be assigned to them. Sometimes this confounds analysis of stand age over time.

In addition to percent compliance to MQOs, 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 standard field crew measurements to be higher or lower than 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.

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 measurements. These methods have been identified as the best available and were selected for nationwide use by FIA, and are commonly used by similar natural resource inventories. A basic assumption is that when applied correctly, these methods 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.

More than 98 percent of the remeasured trees were given the same species codes by the field crews in both the current and previous inventories. Notable exceptions were Bebb willow, where according to the current field crew, only 10 percent of the Bebb willow trees were correctly identified during the previous inventory (most of the trees were previously identified as black willow, peachleaf willow, or willow spp.); and, northern pin oak, where only 43 percent had been correctly identified as northern pin oak (56 percent had been incorrectly identified as northern red oak). There was also minor confusion between the elm species, hickory species, and cherries (black cherry, pin cherry, and chokecherry).

Prediction Error

Errors associated with mathematical models (such as volume models) aimed at providing observations of the attributes of interest based on sample attributes are called prediction errors. Area, number of trees, volume, biomass, growth, removals, and mortality are the primary attributes of interest presented in this report. Estimates of area and number of trees are based on direct observation and do not rely on prediction models. Models are used to predict volume and biomass estimates of individual tree volumes. 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.

Estimates of prediction errors associated with the volume models in this report were presented by Hahn (1984), along with model forms, methods used in model development, and model-parameter estimates. The estimated prediction errors are based on observations of 101,642 trees measured in the forest inventories of Michigan (1980), Minnesota (1977), and Wisconsin (1968). For gross cubic-foot volume of a live tree, standard errors ranged from 1.47 to 28.13 cubic feet. For board-foot volume of a live tree, standard errors ranged from 14.49 to 189.95 board feet.

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, the prediction bias of one estimate should cancel out that of the other estimate. If the estimates are based on different prediction models, the prediction error of both models must be considered.

Nonresponse Error

Nonresponse error 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 to measure trees on the plot.
- Hazardous/inaccessible—Entire plots or portions of plots where conditions prevent a crew from safely accessing the plot or measuring trees on the plot.
- Other—Plots where the field crew is unable to obtain a valid measurement for 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. Second, nonresponse can bias the estimates if the portion of the population not being sampled differs from the portion being sampled.

In FIA, nonresponse rates are relatively low. In the 2013 Minnesota inventory, 18,087 sample plots were selected for observation. More than 97 percent of these are included in the sample used to estimate current resources. There were 378 plots where crews were unable to obtain owner permission to measure all or part of the plot. Hazardous conditions on another 66 plots prevented the crew from measuring all or part of the plot.

Even an overall nonresponse rate of 1 percent can cause considerable bias if not properly accounted for. The major source of nonresponse is denied access to plots, which occurs primarily on lands in private ownership. Also, observations for plots on nonforest and water land classes rarely require crews to physically enter the land. Nor is permission needed because the observation can be obtained from aerial photos or other sources of remotely sensed information. Therefore, nonresponse is of most concern for observations of forest land in private ownership.

The stratified estimation process used by NRS-FIA with strata defined by ownership classes and canopy cover class reduces the possible effects of bias caused by nonresponse. Under the stratified estimation process used by NRS-FIA, nonresponses are removed from the sample, and stratum estimates (means, totals, and sampling errors) are obtained only from plots with valid observations. The net effect in the estimates of means and totals is that the average of the observed plots within the stratum (ownership and canopy cover class) becomes the estimate for all nonresponses within that stratum. 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 Minnesota 2013 inventory.

In Table MN-1 of this report we acknowledge denied access and hazardous as two land classes in Minnesota within which we are unable to provide estimates on variables such as forest area and timber volume. However, we do report the total estimated area in each of these classes. In all other tables of this report, we do not acknowledge either of these classes, and in the estimation process we treat the sample where we do have observations as a random sample of the entire State.

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, hazardous conditions may have changed, and other circumstances that caused us to drop plots from a specific inventory cycle may be different.

GLOSSARY

Average annual mortality: The average annual mortality of trees during the period between inventories. This estimate can be provided in cubic feet for live and growing-stock trees that died or in board feet for sawtimber trees that died.

Average annual net growth: The average annual change in the volume of trees during the period between inventories. Components include the change in volume of trees that have met the minimum size requirements over the inventory period, plus the volume of trees reaching the minimum size during the period (ingrowth), minus the volume of trees that died during the period, minus the volume of cull during the period. Mortality removals (trees killed in the harvesting process and left on site) and diversion removals (trees removed from the forest land base due to a change from forest to nonforest land) are not included. This estimate can be provided in cubic feet for live and growing-stock trees or in board feet for sawtimber trees.

Average annual removals: The average annual removals of trees during the period between inventories. The estimate includes harvest removals, mortality removals (trees killed in the harvesting process and left on site), and diversion removals (trees removed from the forest land base due to a change from forest to nonforest land). This estimate can be provided in cubic feet for live and growing-stock trees or in board feet for sawtimber trees.

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 usually is expressed as square feet of basal area per acre.

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

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

Bulk density: The mass of soil per unit 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.

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 suitable for industrial wood products.

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.

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

County and municipal: An ownership class of public lands owned by counties or local public agencies, or lands leased by these governmental units for more than 50 years. Also known as local government.

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 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 class: A classification of trees based on diameter outside bark measured at breast height (4.5 feet above ground). With 2-inch diameter classes, for example, the 6-inch class includes trees 5.0 through 6.9 inches diameter at breast height (d.b.h). A diameter at root collar (d.r.c.) measurement is acquired for multi-stemmed woodland species (e.g., Rocky Mountain juniper).

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) no longer can be identified.

Effective cation exchange capacity (ECEC): The sum of cations that a soil can adsorb in its natural pH. It is 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 land: Land that has at least 10 percent canopy cover by live tally trees of any size or has had at least 10 percent canopy cover of live tally species in the past, based on the presence of stumps, snags, or other evidence. To qualify, the area must be at least 1.0 acre in size and 120.0 feet wide. Forest land includes transition zones, such as areas between forest and nonforest lands that meet the minimal tree stocking/cover and forest areas adjacent to urban and built-up lands. Roadside, streamside, and shelterbelt strips of trees must have a width of at least 120 feet and be at least 1.0 acres in size to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if they are less than 120 feet wide or less than an acre in size. Tree-covered areas in agricultural production settings, such as fruit orchards, or tree-covered areas in urban settings, such as city parks, are not considered forest land.

Forest type: A classification of forest land based on the species presently forming a plurality of the live-tree stocking. If softwoods predominate (50 percent or more), then the forest type will be one of the softwood types and vice versa for hardwoods. For the Eastern United States, there are mixed hardwood-pine forest types when the pine and/or redcedar (either eastern or southern) component is between 25 and 49 percent of the stocking. If the pine/redcedar component is less than 25 percent of the stocking, then one of the hardwood forest types is assigned.

Forest-type group: Combinations of forest types that share closely associated species or site requirements and are generally combined for brevity of reporting. See forest type for examples of forest-type group members.

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

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.

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.

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

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.

Local government: An ownership class of public lands owned by counties or local public agencies, or lands leased by these governmental units for more than 50 years. Also known as county and municipal.

Logging residues: The unused portions of growing-stock and nongrowing-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.

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.

Noncorporate private: Nongovernmental conservation and natural resource organizations; unincorporated local partnerships, associations, and clubs; and Native American communities.

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 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.)

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

Other red oaks: A group of species in the genus *Quercus* that includes scarlet oak, northern pin oak, southern red oak, bear oak, shingle oak, laurel oak, blackjack oak, water oak, pin oak, willow oak, and black oak.

Other white oaks: A group of species in the genus *Quercus* that includes overcup oak, chestnut oak, and post oak.

Ownership: The property owned by one ownership unit.

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.

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 (small sheltered bays) and bottomlands (low land) 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 in 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.

Residues: Bark and woody materials that are generated in primary wood-using mills when roundwood products are converted to other products. Examples include 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.

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 d.b.h.

Sawtimber volume: Net volume of the saw log portion of live sawtimber in board feet, International 1/4-inch rule (unless specified otherwise), from stump to a minimum 7.0 inches top d.o.b. for softwoods and a minimum 9.0 inches top d.o.b. for hardwoods.

Seedlings: Live trees less than 1.0 inch d.b.h. and at least 1 foot in height.

Select red oaks: A group of species in the genus *Quercus* that includes cherrybark oak, northern red oak, and Shumard oak.

Select white oaks: A group of species in the genus *Quercus* that includes white oak, swamp white oak, bur oak, swamp chestnut oak, and chinkapin oak.

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.

Soil order: The broadest category or class of soil based largely on the processes that formed the soil as indicated by the presence or absence of diagnostic horizons or layers. Several dominant soil orders in Minnesota are:

> ***Alfisols*:** Moist mineral soils that form mostly in cool to hot humid areas. These soils usually form under deciduous forests and are usually quite productive. These soils are more weathered than Inceptisols but less than Spodosols.
>
> ***Entisols*:** Mineral soils with no horizons or only the beginning of horizons. These soils are basically unaltered from their parent material. Soils of this order vary widely in productivity.
>
> ***Histisols*:** Organic soils that form in saturated wet conditions. These can occur in any wet area and can be very productive when drained.
>
> ***Inceptisols*:** Soils with few diagnostic features that have formed quickly from the parent material. They form under a wide variety of climates. These soils are more advanced than Entisols but less than other orders. They vary widely in productivity.
>
> ***Mollisols*:** Organic soils that form in semiarid to semihumid areas mostly under prairie vegetation. These are some of the most productive soils.
>
> ***Spodosols*:** Mineral soils that form in humid climates usually where it is cold and temperate. Most of these soils develop naturally under forests. They are not naturally very fertile but can be productive with fertilizer.

Sound dead: The net volume in salvable dead trees.

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

Stand-size class: A condition classification of accessible forest land based upon the size class of stocking; that is, small-diameter stands (less than 5.0 inches d.b.h.), medium-diameter stands (5.0 to 8.9 inches d.b.h. for softwoods and 5.0 to 10.9 inches d.b.h. for hardwoods), or large-diameter stands (≥ 9.0 inches d.b.h. for softwoods and 11.0 inches d.b.h. for hardwoods), of live trees in the selected area.

State: An ownership class of public lands owned by states or lands leased by states for more than 50 years. Also a general reference to one of the political and geographic subdivisions of the United States.

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.

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 pulpmills 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 3.0 inches, a more or less definitely formed crown of foliage, and a height of at least 15 feet at maturity.

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.

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 MN-1) report estimates of forest characteristics collected during this inventory period, including estimates of forested area, number of trees, volume, and growth. These tables can be found in a supplemental file "Summary Tables for Minnesota Forests 2013: Statistics, Methods, and Quality Assurance" found at http://dx.doi.org/10.2737/NRS-RB-XXX.

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, Minnesota, 2013

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

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

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

Table E.—FIA nonresponse by ownership and strata, Minnesota, 2013

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

Unit [a]	Estimation unit [b]	Strata [c]	Area [d] (acres)	Selected [e]	Nonforest office plots [f]	Field check plots [g]	Field check plots measured [h]	Forest plots measured [i]	Plots measured for change [j]	Field measured for change [k]	Plots not measured [l]
1	BWCA	Canopy cover 0 - 80	281,404	42	1	41	39	39	39	38	2
1	BWCA	Canopy cover 81 - 100	484,931	69	-	69	67	67	64	64	2
1	Inland Census Water Unit 1	Canopy cover 0 - 5	534,524	177	157	20	20	20	174	20	-
1	Inland Census Water Unit 1	Canopy cover 6 - 100	64,228	14	4	10	10	10	12	9	-
1	Private Unit 1	Canopy cover 0 - 5	536,064	202	133	69	62	46	198	65	7
1	Private Unit 1	Canopy cover 51 - 65	140,400	47	15	32	30	30	45	30	2
1	Private Unit 1	Canopy cover 6 - 50	96,290	30	16	14	14	12	29	13	-
1	Private Unit 1	Canopy cover 66 - 80	847,136	287	13	274	248	243	271	258	26
1	Private Unit 1	Canopy cover 81 - 100	1,382,242	477	13	464	424	423	447	434	40
1	Public Unit 1	Canopy cover 0 - 5	207,641	65	28	37	35	33	64	36	2
1	Public Unit 1	Canopy cover 6 - 65	148,249	42	11	31	30	30	41	30	1
1	Public Unit 1	Canopy cover 66 - 80	1,167,327	405	23	382	369	366	397	374	13
1	Public Unit 1	Canopy cover 81 - 100	2,050,174	659	23	636	603	603	642	620	33
1	Superior NF	Canopy cover 0 - 65	75,001	21	3	18	17	16	21	18	1
1	Superior NF	Canopy cover 66 - 80	418,763	131	2	129	128	127	128	126	1
1	Superior NF	Canopy cover 81 - 100	834,449	289	4	285	282	282	288	284	3
1	Voyagers NP	Canopy cover 0 - 100	121,088	42	2	40	40	40	40	38	-
2	Chippewa NF	Canopy cover 0 - 65	76,479	18	9	9	7	7	18	9	2
2	Chippewa NF	Canopy cover 66 - 80	243,438	81	4	77	77	76	81	77	-
2	Chippewa NF	Canopy cover 81 - 100	321,574	101	1	100	99	99	101	100	1
2	Inland Census Water Unit 2	Canopy cover 0 - 5	1,429,083	478	474	4	4	4	478	4	-
2	Inland Census Water Unit 2	Canopy cover 6 - 100	56,370	15	7	8	8	8	15	8	-
2	Private Unit 2	Canopy cover 0 - 5	2,784,653	938	775	163	148	124	924	149	15
2	Private Unit 2	Canopy cover 51 - 65	370,309	118	36	82	74	69	110	74	8
2	Private Unit 2	Canopy cover 6 - 50	329,592	116	60	56	50	45	116	56	6
2	Private Unit 2	Canopy cover 66 - 80	1,410,005	480	59	421	389	381	454	395	32
2	Private Unit 2	Canopy cover 81 - 100	1,563,704	573	25	548	508	501	536	511	40
2	Public Unit 2	Canopy cover 0 - 5	626,515	200	143	57	56	49	200	57	1
2	Public Unit 2	Canopy cover 51 - 65	192,265	70	20	50	50	48	70	50	-
2	Public Unit 2	Canopy cover 6 - 50	98,677	27	10	17	17	17	26	16	-
2	Public Unit 2	Canopy cover 66 - 80	1,310,510	436	41	395	390	388	433	392	5
2	Public Unit 2	Canopy cover 81 - 100	1,732,104	596	37	559	554	545	591	554	5

continued

Table A.—continued

Unit [a]	Estimation unit [b]	Strata [c]	Area [d] (acres)	Selected [e]	Nonforest office plots [f]	Field check plots [g]	Field check plots measured [h]	Forest plots measured [i]	Plots measured for change [j]	Field measured for change [k]	Plots not measured [l]
3	Inland Census Water Unit 3	Canopy cover 0 - 5	586,179	201	197	4	4	2	201	4	-
3	Inland Census Water Unit 3	Canopy cover 6 - 100	39,226	10	6	4	4	3	10	4	-
3	Private Unit 3	Canopy cover 0 - 5	7,886,765	2,703	2,407	296	282	238	2,691	284	14
3	Private Unit 3	Canopy cover 51 - 65	457,799	164	49	115	100	86	158	109	15
3	Private Unit 3	Canopy cover 6 - 50	609,400	195	126	69	61	49	189	63	8
3	Private Unit 3	Canopy cover 66 - 80	879,399	281	45	236	213	205	258	213	23
3	Private Unit 3	Canopy cover 81 - 100	1,327,035	439	15	424	380	372	390	375	44
3	Public Unit 3	Canopy cover 0 - 5	227,484	77	62	15	15	13	76	14	-
3	Public Unit 3	Canopy cover 51 - 65	44,565	14	6	8	8	8	14	8	-
3	Public Unit 3	Canopy cover 6 - 50	39,419	13	6	7	6	6	11	5	1
3	Public Unit 3	Canopy cover 66 - 80	119,148	38	7	31	31	31	38	31	-
3	Public Unit 3	Canopy cover 81 - 100	336,528	116	4	112	111	111	115	111	1
4	Inland Census Water Unit 4	Canopy cover 0 - 100	350,376	111	108	3	3	3	111	3	-
4	Private Unit 4	Canopy cover 0 - 5	17,703,307	5,986	5,819	167	156	123	5,975	157	11
4	Private Unit 4	Canopy cover 51 - 65	155,302	66	24	42	40	38	63	39	2
4	Private Unit 4	Canopy cover 6 - 50	284,613	91	45	46	34	31	88	43	12
4	Private Unit 4	Canopy cover 66 - 80	192,981	58	9	49	41	41	55	46	8
4	Private Unit 4	Canopy cover 81 - 100	262,816	84	7	77	67	66	77	70	10
4	Public Unit 4	Canopy cover 0 - 5	435,726	148	129	19	19	14	148	19	-
4	Public Unit 4	Canopy cover 6 - 80	79,679	21	8	13	13	12	21	13	-
4	Public Unit 4	Canopy cover 81 - 100	55,590	25	2	23	21	21	24	22	2
Total			54,008,526	18,087	11,230	6,857	6,458	6,221	17,766	6,542	399

[a] Survey unit code: 1 = Aspen-Birch; 2 = Northern Pine; 3 = Central Hardwood; 4 = Prairie.

[b] Classification based on Minnesota DNR Data Deli ownership layers (http://deli.dnr.state.mn.us/); BWCA=Boundary Waters Canoe Area Wilderness.
Note: This ownership call is used for stratification purposes only. Ownership stored in the FIA Database is based on field crew information.

[c] Canopy cover class; obtained from the Multi-Resolution Land Characteristics (MRLC) Consortium (http://www.mrlc.gov/).

[d] Total area based on pixel counts.

[e] Total number of plots selected to be sampled.

[f] Selected plots whose observed classification is nonforest based on examination of aerial photographs and/or digital orthoquads.

[g] Selected plots that required field measurement.

[h] Field check plots where measurement was completed successfully. Excludes plots that were denied access, hazardous, or lost and measurement was not possible.

[i] Field check plots where forest condition was present on plot and measurement was completed in 2004 inventory. These plots are used to estimate current conditions (e.g., area, volume, number of trees, and biomass).

[j] Plots measured for change in both 2008 inventory and 2013 inventory.

[k] Field check plots measured in both 2008 inventory and 2013 inventory where a forest condition was found on plot and measurement was completed. These plots are used to estimate change between inventories (e.g., growth, removals, mortality, and area change).

[l] Plots selected for field measurement but not measured due to denied access, hazardous condition, or other complications.

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

Item	State total	Sampling error
Growing stock on timberland:	*million cubic feet*	percent
Volume	14,985	1.27
Average annual net growth	375	2.61
Average annual removals	178	6.65
Average annual mortality	237	2.70
Sawtimber on timberland:	*million board feet* [a]	
Volume	38,617	1.89
Average annual net growth	1,151	3.34
Average annual removals	472	8.02
Average annual mortality	567	4.15
Area:	*thousand acres*	
Forest land	17,378	0.52
Timberland	15,648	0.62
Biomass (aboveground live trees and saplings):	*million dry tons*	
Forest land	484	1.02
Timberland	443	1.07

[a] International ¼-inch rule.

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

Variable	Tolerance	Objective	Minnesota		All NRS states	
			Data within tolerance	Observations	Data within tolerance	Observations
Plot Level		*percent*		*number*	*percent*	*number*
Distance to Road	No Tolerance	90.0	76.6	548	81.7	2,420
Water on Plot	No Tolerance	90.0	80.7	548	86.7	2,420
Elevation	±50 feet	99.0	89.6	556	87.9	2,204
Latitude - decimal degrees	±0.0001 degree	99.0	99.8	557	100.0	2,208
Longitude - decimal degrees	±0.0001 degree	99.0	89.9	557	87.4	2,208
Number of plots				559		2,532
Condition Level						
Condition Status	No Tolerance	99.0	98.1	1,236	98.5	6,552
Reserve Status	No Tolerance	99.0	99.4	1,236	99.7	6,552
Owner Group	No Tolerance	99.0	97.4	899	97.6	3,690
Forest Type (Type)	No Tolerance	95.0	89.8	899	90.8	3,690
Forest Type (Group)	No Tolerance	99.0	92.4	899	94.5	3,690
Stand Size	No Tolerance	99.0	88.5	899	91.4	3,690
Regeneration Status	No Tolerance	99.0	97.3	899	98.6	3,690
Tree Density	No Tolerance	99.0	95.0	899	96.7	3,690
Owner Class	No Tolerance	99.0	93.9	899	95.4	3,690
Owner Status	No Tolerance	99.0	99.4	899	99.3	3,690
Regeneration Species	No Tolerance	99.0	97.3	899	98.6	3,690
Stand Age	±10 percent	95.0	85.7	899	88.0	3,690
Disturbance 1	No Tolerance	99.0	91.7	884	92.1	3,620
Disturbance Year 1	±1 year	99.0	89.3	75	90.4	436
Disturbance 2	No Tolerance	99.0	89.6	134	91.2	678
Disturbance Year 2	±1 year	99.0	100.0	6	80.0	40
Disturbance 3	No Tolerance	99.0	100.0	19	97.8	90
Disturbance Year 3	±1 year	99.0	.	.	50.0	2
Treatment 1	No Tolerance	99.0	97.7	884	98.0	3,620
Treatment Year 1	±1 year	99.0	97.6	42	96.4	220
Treatment 2	No Tolerance	99.0	76.3	59	86.9	289
Treatment Year 2	±1 year	99.0	100.0	19	98.4	64
Treatment 3	No Tolerance	99.0	96.9	32	96.0	99
Treatment Year 3	±1 year	99.0	100.0	3	83.3	6
Physiographic Class	No Tolerance	80.0	77.6	899	86.7	3,690
Present Nonforest Use	No Tolerance	99.0	89.5	1,236	90.0	6,552
Number of conditions				1,236		6,552
Boundary Level						
Boundary Change	No Tolerance	99.0	70.7	157	81.9	875
Constrasting Condition	No Tolerance	99.0	93.6	157	95.5	875
Left Azimuth	±10 degrees	90.0	82.2	157	87.2	875
Corner Mapped	No Tolerance	90.0	94.9	157	94.9	875
Corner Azimuth	±10 degrees	90.0	100.0	10	92.8	83
Corner Distance	±1 foot	90.0	90.0	10	91.6	83
Right Azimuth	±10 degrees	90.0	82.8	157	87.2	875
Number of boundaries				157		875
Subplot Level						
Subplot Center Condition	No Tolerance	99.0	97.3	2,236	98.3	10,128
Microplot Center Condition	No Tolerance	99.0	96.9	2,236	98.1	10,128
Slope	±10 percent	90.0	99.3	1,995	98.8	8,565
Aspect	±10 degrees	90.0	94.8	1,931	94.7	8,360
Snow/Water Depth	±0.5 foot		44.8	2,027	67.7	8,604
Number of subplots				2,236		10,128

continued

Table C.—continued

Variable	Tolerance	Objective	Minnesota		All NRS states	
			Data within tolerance	Observations	Data within tolerance	Observations
Tree Level						
DBH	±0.1 inch per 20 inches	95.0	95.5	8,283	95.6	37,648
DRC	±0.1 inch per 20 inches	95.0	.	.	73.9	69
Azimuth	±10 degrees	90.0	99.0	9,368	99.3	42,187
Horizontal Distance	±0.2 foot per 1.0 foot	90.0	98.2	9,368	98.7	42,187
Species	No Tolerance	95.0	98.0	9,423	98.4	42,472
Tree Genus	No Tolerance	99.0	99.5	9,421	99.6	42,430
Tree Status	No Tolerance	95.0	98.9	9,423	98.9	42,495
Rotten/Missing Cull	±10 percent	90.0	98.5	5,357	98.4	27,677
Total Length	±10 percent	90.0	81.5	5,312	79.7	27,382
Actual Length	±10 percent	90.0	71.2	761	74.0	3,340
Compacted Crown Ratio	±10 percent	80.0	79.9	7,673	83.0	35,077
Uncompacted Crown Ratio (P3)	±10 percent	90.0	.	.	100.0	19
Crown Class	No Tolerance	85.0	79.6	7,673	81.8	35,077
Decay Class	±1 class	90.0	94.0	1,523	96.0	6,218
Cause of Death	No Tolerance	80.0	77.8	1,523	83.6	6,218
Condition	No Tolerance	99.0	97.0	9,423	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	92.6	8,378	92.4	38,038
Damage Agent 1	No Tolerance	90.0	89.9	7,673	90.2	35,077
Damage Agent 2	No Tolerance	90.0	69.1	1,416	78.2	6,759
Tree Grade	No Tolerance	90.0	70.7	1,169	74.8	8,257
DBH-Live & Trees with Decay Code 1 or 2	±0.1 inch per 20 inches	95.0	95.3	7,918	95.4	35,911
DBH-Trees with Decay Codes 3, 4 or 5	±1 inch per 20 inches	95.0	99.5	365	99.5	1,732
Total Length-trees 40 feet and greater	±10 percent	90.0	82.7	4,244	81.4	21,666
Total Length-trees less than 40 feet	±10 percent	90.0	76.4	1,068	73.1	5,716
Total Length-trees less than 5 inches DBH	±10 percent	90.0	82.5	40	70.8	349
Number of trees				9,423		42,472
Seedling Level						
Species	No Tolerance	85.0	92.3	1,768	92.5	8,648
Genus	No Tolerance	90.0	96.5	1,768	96.8	8,648
Seedling Count	±20 percent	90.0	57.7	1,768	63.1	8,648
Seedling Count (coded)	No Tolerance	90.0	65.1	1,768	69.3	8,648
Number of microplots				824		3,535
Site Tree Level						
Condition List	No Tolerance	99.0	89.1	941	93.1	2,775
Diameter	±0.1 inch per 20 inches	95.0	97.2	941	98.0	2,775
Species	No Tolerance	95.0	99.1	941	99.3	2,775
Genus	No Tolerance	99.0	99.9	941	100.0	2,775
Azimuth	±10 degrees	90.0	98.1	941	99.1	2,775
Distance	±5 feet	90.0	98.8	941	99.3	2,775
Total Length	±10 percent	90.0	97.9	941	98.5	2,775
Diameter Age	±5 years	95.0	98.4	941	98.0	2,775
Number of site trees				941		2,775

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

Variable	Unit of measure	Minnesota				All NRS states			
		Relative bias	95% CI limits		Observations	Relative bias	95% CI limits		Observations
			Lower	Upper			Lower	Upper	
Plot Level					*number*				*number*
Latitude - decimal degrees	degree	0.00	0.00	0.01	557	0.00	0.00	0.00	2,208
Longitude - decimal degrees	degree	-0.00	-0.01	0.01	557	-0.00	-0.01	-0.00	2,208
Number of plots					559				2,532
Boundary Level									
Left Azimuth	degree	-5.29	-13.97	3.31	157	0.07	-3.18	3.38	875
Corner Azimuth	degree	1.00	0.00	3.00	10	6.00	-0.62	18.80	83
Corner Distance	foot	0.20	0.00	0.60	10	-0.10	-0.50	0.19	83
Right Azimuth	degree	5.35	-4.59	14.07	157	1.61	-1.33	4.35	875
Number of boundaries					157				875
Subplot Level									
Slope	percent	-0.18	-0.29	-0.07	1,995	0.04	-0.05	0.13	8,565
Aspect	degree	2.39	1.12	3.98	1,931	0.29	-0.33	0.92	8,360
Snow/Water Depth	foot	-0.58	-0.93	-0.28	2,027	-0.28	-0.39	-0.17	8,604
Number of subplots					2,236				10,128
Tree Level									
DBH	inch	-0.01	-0.02	-0.00	8,283	-0.00	-0.00	0.00	37,648
DRC	inch					0.06	-0.10	0.23	69
Azimuth	degree	-0.03	-0.16	0.12	9,368	-0.03	-0.09	0.05	42,187
Horizontal Distance	foot	-0.00	-0.01	0.01	9,368	0.00	-0.00	0.00	42,187
Rotten/Missing Cull	percent	-0.30	-0.40	-0.21	5,357	-0.15	-0.19	-0.11	27,677
Total Length	foot	1.58	1.35	1.86	5,312	0.21	0.09	0.34	27,382
Actual Length	foot	1.75	-1.30	3.95	761	-1.46	-2.62	-0.50	3,340
Compacted Crown Ratio	percent	0.51	0.24	0.76	7,673	0.11	0.01	0.21	35,077
DBH-Live & Trees with Decay Code 1 or 2	inch	-0.01	-0.02	-0.00	7,918	0.00	-0.00	0.00	35,911
DBH-Trees with Decay Codes 3, 4 or 5	inch	-0.03	-0.05	-0.00	365	-0.02	-0.05	-0.01	1,732
Total Length-trees 40 feet and greater	foot	2.04	1.77	2.26	4,244	0.70	0.57	0.83	21,666
Total Length-trees less than 40 feet	foot	-0.28	-0.85	0.30	1,068	-1.67	-1.97	-1.34	5,716
Total Length-trees less than 5 inches DBH	foot	0.90	-2.18	3.69	40	-1.53	-2.82	-0.05	349
Number of trees					9,423				42,472
Seedling Level									
Seedling Count	number	-15.03	-19.15	-11.37	1,760	-12.53	-14.37	-10.94	8,496
Seedling Count (coded)	number	0.01	-0.04	0.07	1,768	-0.00	-0.02	0.02	8,648
Number of microplots					824				3,535
Site Tree Level									
Diameter	inch	0.01	-0.01	0.04	941	0.00	-0.01	0.01	2,775
Azimuth	degree	0.37	-0.45	1.28	941	0.14	-0.18	0.47	2,775
Distance	foot	0.07	-0.01	0.16	941	0.04	-0.00	0.08	2,775
Total Length	foot	-0.11	-0.59	0.29	941	-0.04	-0.22	0.13	2,775
Diameter Age	year	0.23	0.03	0.46	941	0.00	-0.09	0.11	2,775
Number of site trees					941				2,775

Table E.—FIA nonresponse by ownership and strata, Minnesota, 2013

Owner	Strata(um) Code	Plots selected	Observed	Denied Access	Hazardous	Other	Response rate
			number of plots				percent
Boundary Waters Canoe Area Wilderness	5	69	66.75	0	2	0.25	96.74
Boundary Waters Canoe Area Wilderness	1234	42	39.64	0	2.36	0	94.39
Chippewa NF	4	81	81	0	0	0	100
Chippewa NF	5	101	100	0	0	1	99.01
Chippewa NF	123	18	15.16	0	0.84	2	84.2
Inland Census Water Unit 1	1	177	176.5	0	0.25	0.25	99.72
Inland Census Water Unit 1	2345	14	14	0	0	0	100
Inland Census Water Unit 2	1	478	478	0	0	0	100
Inland Census Water Unit 2	2345	15	15	0	0	0	100
Inland Census Water Unit 3	1	201	201	0	0	0	100
Inland Census Water Unit 3	2345	10	10	0	0	0	100
Inland Census Water Unit 4	12345	111	111	0	0	0	100
Private Unit 1	1	202	194.5	6.5	0	1	96.29
Private Unit 1	2	30	30	0	0	0	100
Private Unit 1	3	47	44.69	2.31	0	0	95.08
Private Unit 1	4	287	259.2	24	0.8	3	90.31
Private Unit 1	5	477	434.25	35.25	2.5	5	91.04
Private Unit 2	1	938	920.72	16.28	1	0	98.16
Private Unit 2	2	116	109.5	6.5	0	0	94.4
Private Unit 2	3	118	109.75	8	0.25	0	93.01
Private Unit 2	4	480	445.84	33.41	0.75	0	92.88
Private Unit 2	5	573	525.46	43.29	2.25	2	91.7
Private Unit 3	1	2703	2683.5	16.81	2.33	0.36	99.28
Private Unit 3	2	195	186.41	8.34	0.25	0	95.6
Private Unit 3	3	164	148.25	15.75	0	0	90.4
Private Unit 3	4	281	253	27	1	0	90.04
Private Unit 3	5	439	389.74	47.26	2	0	88.78
Private Unit 4	1	5986	5974.13	10.87	1	0	99.8
Private Unit 4	2	91	78.75	11	1.25	0	86.54
Private Unit 4	3	66	63	2	1	0	95.45
Private Unit 4	4	58	49.25	8	0.75	0	84.91
Private Unit 4	5	84	73	10.25	0.75	0	86.9
Public Unit 1	1	65	63	0	1	1	96.92
Public Unit 1	4	405	392	0	3	10	96.79
Public Unit 1	5	659	625.44	4.56	2	27	94.91
Public Unit 1	23	42	40.75	0.25	0	1	97.02
Public Unit 2	1	200	198.5	0	1.5	0	99.25
Public Unit 2	2	27	27	0	0	0	100
Public Unit 2	3	70	70	0	0	0	100
Public Unit 2	4	436	429.46	2	1.54	3	98.5
Public Unit 2	5	596	589.25	2	1.75	3	98.87
Public Unit 3	1	77	77	0	0	0	100
Public Unit 3	2	13	12	1	0	0	92.31
Public Unit 3	3	14	14	0	0	0	100
Public Unit 3	4	38	38	0	0	0	100
Public Unit 3	5	116	114.5	0	1.5	0	98.71
Public Unit 4	1	148	148	0	0	0	100
Public Unit 4	5	25	23	1	1	0	92
Public Unit 4	234	21	21	0	0	0	100
Superior NF	4	131	129	0	2	0	98.47
Superior NF	5	289	285.69	0	3.31	0	98.85
Superior NF	123	21	20	0	1	0	95.24
Voyagers NP	12345	42	42	0	0	0	100

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