3 The Forest Inventory and Analysis Plot Design

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This chapter describes the **prescribed core plot**[2] design currently used by Forest Inventory and Analysis (FIA) for **Phase 2** and **Phase 3** ground sampling. FIA ground plots relate to the sampling frame discussed in the previous chapter as follows:

- One plot has been randomly located within each 6,000-acre hexagon.
- Each plot has been assigned to one of five **panels** as described in section 2.2.2.
- Each plot has been designated Phase 2 or Phase 3 based on the rules outlined in section 2.2.3.
- The center point of each plot constitutes the primary **sampling unit** (PSU) described in section 2.2.5.
- The area and vegetation data gathered on each plot serve to support and quantify the information associated with each PSU.

The plot design characteristics, field protocols, and calculations discussed in this chapter are intended to provide additional background to the estimation procedures outlined in chapter 4; some explanation of the most important derived values produced by FIA; and discussion of sampling and estimation issues associated with the plot design. More detail is provided in the referenced supplementary documentation, and a complete description of all field measurements can be found in the FIA Phase 2 field guide[3] available on the Web site http://fia.fs.fed.us/library.htm#manuals.

All of the measurements described herein likewise apply to Phase 3, because Phase 3 plots are a subset of Phase 2. Additional detailed measurements associated with Phase 3 forest health “indicators” (e.g., tree crowns, soils,

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[2] First use of a glossary term in each chapter is in bold face.

[3] U.S. Department of Agriculture Forest Service. 2004. Forest inventory and analysis national core field guide: field data collection procedures for phase 2 plots, Version 2.0. [Not paged]. Vol. 1. Intern. Rep. On file with: USDA Forest Service, Forest Inventory and Analysis, Rosslyn Plaza, 1620 North Kent Street, Arlington, VA 22209.

lichens, downed woody material, and understory vegetation) are described in the Phase 3 field guides, also posted on the above Web site. Some of these indicators have specialized plot designs superimposed over the basic Phase 2 plot design. Specialized designs unique to Phase 3 indicators are beyond the scope of this manuscript but are covered in detail in the field guides. Separate manuscripts that document specialized Phase 3 plot designs and associated estimation procedures have been written and are currently in review.

The prescribed core plot design originated with the Forest Health Monitoring (FHM) Program in 1990 and was selected as the national standard for FIA in 1995. Shortly thereafter, FIA began converting its various regional plot designs to the national standard. Most FIA units had been using 5- or 10-point clusters of prism points arranged in a variety of patterns. While all FIA units change to the national plot design, previously installed plot configurations are being remeasured to provide estimates of change (growth, removals, and mortality). As earlier designs are remeasured to estimate change, the new design is simultaneously installed to yield current inventory estimates and to provide the basis for change estimation upon future remeasurement.

3.1 Overview of the FIA Plot Design

Phase 2 and Phase 3 ground plots are clusters of four points arranged such that point 1 is central, with points 2 through 4 located 120 feet from point 1 at azimuths of 0, 120, and 240 degrees (fig. 3.1). Each point in the cluster is surrounded by a 24-foot fixed-radius **subplot** where trees 5.0 inches diameter at breast height (**d.b.h.**) and larger are measured. All four subplots total approximately 1/6 acre. Each subplot contains a 6.8-foot fixed-radius **microplot** where saplings (1.0 to 4.9 inches d.b.h.) and seedlings are measured. All four microplots total approximately 1/75 acre. Microplots are offset from subplot centers (12.0 feet at an azimuth of 90 degrees) to minimize trampling. Each subplot is surrounded by a **prescribed optional** 58.9-feet fixed-radius **macroplot**, which can be useful for sampling rare occurrences such as large trees (e.g., 40.0 inches d.b.h. and greater) or mortality. Macroplots encompass subplots, as well as the additional area from 24.0 to 58.9 feet beyond the subplot circumference. All four macroplots total approximately 1 acre. When used together, microplots, subplots, and macroplots constitute a **tri-areal plot** design for sampling trees in three different tree-diameter ranges. In regions where the optional macroplots are not used, the plot design is **bi-areal**.

For attributes such as large trees that are always measured within subplots, whether or not macroplots are utilized, it is sometimes useful to describe

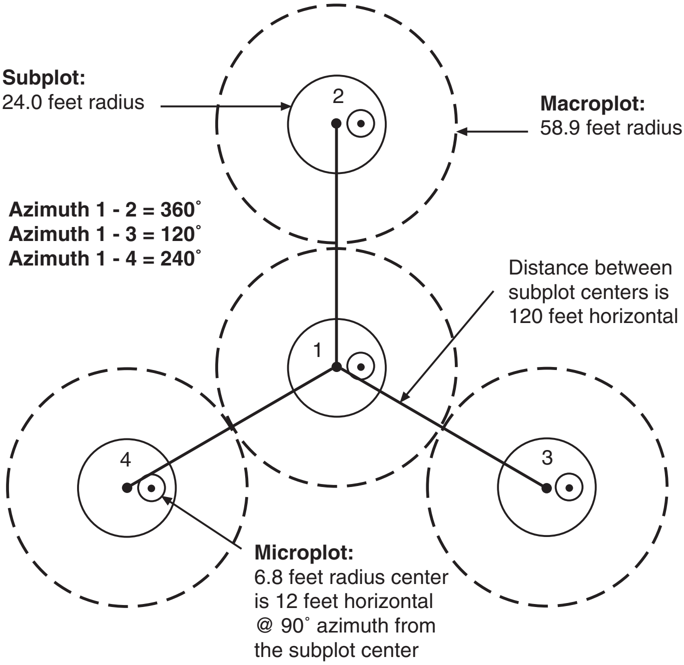

Figure 3.1—FIA plot design.

the trees between 24.0 and 58.9 feet on tri-areal plots as being located in an annular ring. For example, this description avoids the need to redefine the range of diameters sampled on the subplot if the diameter threshold for sampling large trees is changed. Theoretically, distinctions between macroplot trees in the annular and inner portions of the macroplot do not have any implications for the estimation procedures described in chapter 4.

In addition to the trees measured on FIA plots, data are also gathered about the area or setting in which the trees are located. Area classifications are particularly useful for partitioning the **forest** into meaningful categories (i.e., **domains**) for analysis. Some of these area **attributes** are measured (e.g., percent slope), some are assigned by definition (e.g., ownership group), and some are computed from tree data (e.g., percent **stocking**).

To enable division of the forest into various domains of interest for analytical purposes, it is important that the tree data recorded on these plots are properly associated with the area classifications. To accomplish this, plots are mapped by **condition class**. Field crews assign an arbitrary number to the first condition class encountered on a plot. This number is then defined by a series of predetermined discrete variables attached to it (i.e., land use, forest type, stand size, regeneration status, tree density, stand origin, ownership group, and disturbance history). Additional conditions are identified if there is a distinct change in any of the condition-class variables on the plot. Further details are provided in section 3.2.

Sometimes a plot straddles two or more distinct condition classes. **Boundaries** of condition classes can bisect the subplots, or may occur between subplots. When they bisect a subplot, condition boundaries are mapped using two or three azimuths as described in section 3.1.2. Similarly, microplots and macroplots, if used, also are mapped. So for each ground plot, the microplot, subplot, and macroplot area in each condition class are known, as is the location and condition class of every tree tallied. Because FIA primarily is concerned with the classification and monitoring of **forest land**, no tree data are recorded for **nonforest land** uses.

At first glance, an unwieldy number of condition-class permutations seems likely at the regional scale, especially because condition classes from the same dataset must be processed in different combinations from one inventory summary table to the next depending on the domain of interest. However, most plots have only one or two condition classes and data summarizations are easily managed with **indicator functions** as described in chapter 4.

3.1.1 Motivation Behind the FIA Plot Design

FIA has historically used cluster plots, primarily because they reduce between-plot variance and, therefore, the total number of plots necessary to achieve a given accuracy standard (Scott 1993). The 4-point cluster was chosen because experience with FHM and FIA pilot studies showed that on average, crews can complete one 4-point cluster plot per day. It is conceivable that the number of points comprising the national standard may be revised in the future if the field workload changes such that a different number of cluster points is more efficient.

The **mapped-plot** feature of the design arose from the need to correctly match tree data with area classifications when plots straddle multiple conditions. Before the advent of mapped plots, some FIA units moved plots into a single, uniform condition. This generated a bias by altering the selection probabilities of trees, especially those near condition edges (Williams and others 1996). Other FIA units addressed the problem by prohibiting the movement of plots, but then blended area data from distinctly different conditions. Although unbiased for area and volume totals, this procedure resulted in domain misclassifications. For example, a plot that straddled a pure oak forest type and a pure pine forest type might be classified as a mixed oak/pine forest type.

In 1991, FIA project leaders and inventory specialists met with a panel of university and forest industry biometricians to discuss the problem and explore a variety of potential alternatives. A committee was subsequently appointed by the FIA project leaders to review the alternatives and recommend a solution (Hahn and others 1995). The tri-areal, fixed-radius mapped design was ultimately selected because it solved both the bias and classification problems, it had the flexibility needed to satisfy a growing FIA customer base, and it permitted greater use of the data for such nontraditional purposes as forest health monitoring.

The tri-areal design is a departure from the polyareal plot sampling (pps) approach (Husch and others 1982) originally implemented by FIA in the early 1960s. The pps design is more efficient for sampling timber and estimating volume, but fixed-radius plots add versatility by preserving information about the spatial relationships among trees. Fixed-sized plots also are more compatible with mapped-plot designs, because the area that must be mapped is constant. In addition, pps sampling in conjunction with mapped plots often leads to a situation where the full range of tree sizes is not sampled in all conditions (Scott and Bechtold 1995). This has negative consequences that are difficult to correct when area attributes such as forest type and stand size are computed from the tree data. This problem rarely occurs with the tri-areal design and is much easier to manage when it does occur.

3.1.2 Field Protocols for Mapping Plots

Field crews specify and define (if not previously defined) the condition class at each subplot center, as described in section 3.2. If a subplot straddles two or more conditions, they then specify the condition class that contrasts with the condition at subplot center. Standing at subplot center and facing the **contrasting condition**, they record the two azimuths where the condition-class boundary crosses the subplot perimeter. A third azimuth (with a distance) is permissible if the boundary contains a sharp curve or a corner (fig. 3.2). All trees tallied are then assigned to the condition class in which they occur. Horizontal distance and azimuth to the center of each tree are recorded for remeasurement purposes and to establish spatial relationships among the sampled trees. Microplots (and macroplots, if used) are mapped in a similar fashion. It is not necessary to match boundaries at the edge of each plot type, so microplots, subplots, and macroplots all are mapped independently. Microplot, subplot, and macroplot areas in each condition class are computed from field measurements when the data are processed (sec. 3.3.3).

Field crews are trained to recognize and map only those boundaries that are distinct and obvious. A variety of logic checks are programmed into field

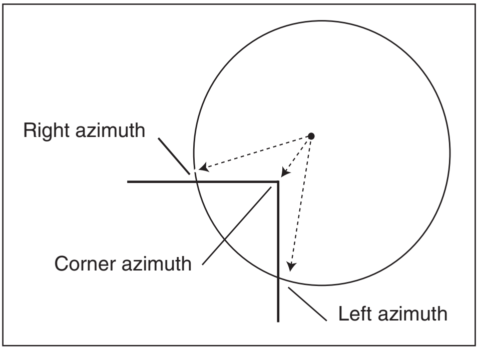

Figure 3.2—Using azimuths to reference a boundary to a subplot center.

data recorders to check boundary data for errors and to verify that the tree location and condition observations are consistent with condition-class and boundary observations (Scott and Bechtold 1995). Most condition-class boundaries do not require mapping because they occur between subplots, or are indistinct. The frequency of mapped subplots depends on the homogeneity of the landscape, but is typically < 5 percent of the total number of subplots in a region. There is some concern over the level of detail to which plots are mapped, as well as the repeatability of boundary recognition and placement. We expect that mapping protocols will be evaluated as part of the FIA quality control program and adjusted as necessary.

3.1.3 Differences in Mapping Forest and Nonforest Plots

Any plot that intersects with a forest land use is designated as a forest plot. Otherwise, the plot is classified as **nonforest**, **census water**, **noncensus water**, or (if inaccessible) nonsampled. In order to reduce the field costs associated with nonforest plots, mapping is initiated only in the presence of accessible forest. For those plots that contain no accessible forest, only the condition status (e.g., nonforest, census water) at the center of subplot 1 is recorded, and that condition is assigned to the entire plot.

Similarly, forest plots may include individual subplots or macroplots where no accessible forest is present. There, only the condition status at subplot center is recorded and that condition is assigned to the entire subplot. Thus, when two or more condition classes occur within a subplot or macroplot, boundaries between them are mapped only when one or both conditions are classified as accessible forest. Boundaries between adjacent nonforest, census water, and nonsampled conditions are mapped only on subplots containing some accessible forest.

3.2 Condition Classification Based on Direct Field Observation

Some condition-class variables trigger the mandatory identification of a distinct condition class in the field; others are ancillary, recorded only after a new condition class is recognized. Both mandatory and ancillary condition-class variables typically are used to specify the domains of interest (e.g., a specific forest type and physiographic class) for which **population** estimates are generated for some attribute of interest (e.g., acres or volume).

3.2.1 Discrete Variables That Trigger Recognition of a Unique Condition Class

There are seven discrete condition-class variables that require recognition of a unique condition in the field: condition status (land use), reserve status, owner group, regeneration status, tree density, forest type, and stand size. If one of these variables changes during plot measurement, a new condition is defined and mapped if necessary. All are subjective field calls, some of which have guidelines and/or subsampling protocols to assist crews make a determination.

3.2.2 Ancillary Condition-Class Variables

Ancillary condition-class variables are recorded in the field whenever unique conditions are defined, but these variables do not trigger the recognition of new condition classes. These ancillary variables, obtained for all forested conditions include detailed owner class, private owner industrial status, artificial regeneration species, stand age, disturbance history, treatment history, and physiographic class.

3.2.2.1 Site Index Equations and Site Productivity Classes

In addition to ancillary condition-class variables, one or more site trees are measured in each unique condition class if qualified trees are available. If there is no reason to suspect a difference in site quality among condition classes, the same site tree(s) may be used for multiple conditions on a plot. Site trees are used in determining site quality (i.e., the capacity of forest land to grow trees). A **site index** or **site productivity class** is thus associated with each forested condition class.

Site index is the average total height that the dominant and codominant trees in fully stocked, even-aged stands will obtain at key ages (Husch and others 1982). Site productivity class, also known as site class or yield capacity, is the maximum mean annual increment in cubic feet per acre that can be expected in fully stocked, natural, even-aged stands. Using regionally specific equations, site index is computed as a function of the stand age and the average height of dominant or codominant trees as determined from the species, d.b.h., and total height of qualifying site trees on or near the plot. The following selection criteria are preferred for site trees: acceptable species, free of damage, dominant or codominant crown position, between 15 and 120 years old, and at least 5.0 inches d.b.h. Resulting site-index values are then applied to site-productivity equations, or look-up tables, to determine the maximum mean annual increment for a given condition class. The site index and site class equation references used by the various FIA units are Brickel (1970), Clendenen (1977), and Edminster and others (1985) in the Interior West; Carmean and others (1989) in the North Central region;[4] Scott and Voorhis (1986) in the Northeast; Hanson and others (2002) in the Pacific Northwest; and Vissage and Greer in the South.[5]

3.3 Computed Attributes

In contrast to attributes that are observed and classified directly in the field such as the condition-class variables in the previous sections; others are computed. Some attributes are computed at the tree level; some are computed at the condition-class or plot level. Computed attributes can be the measures upon which population estimates are based (e.g., acres, numbers of individuals, and volume) or they might be used to specify domains. An example of the latter would be placement of continuous variables into discrete classes (e.g., volume-per-acre class) in order to estimate the area in each class. Some attributes are computed in addition to being observed directly (i.e., forest type and stand size), so these have both field-assigned and computed values.

3.3.1 Computed Tree-Level Attributes

Tree-level attributes are variables associated with the individual trees tallied on FIA ground plots. Expressions of tree volume and weight are among the most basic statistics reported by FIA. The functions used to compute these values are typically statistical models developed or calibrated by State or region. The most commonly reported volume and weight statistics are described in the supplementary document “FIA Volume Calculations” at http://srsfia2.fs.fed.us/publicweb/statistics_band/stat_documents.htm.

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[4] For site-index to site-class conversions used by the North Central FIA unit see the supplementary document “Site Productivity Assignment for the North Central FIA unit” at http://srsfia2.fs.fed.us/publicweb/statistics_band/stat_documents.htm. [Date accessed: December 9, 2004].

[5] Vissage, John S.; Greer, Travis R., Jr. Site class and site index – two estimates of site quality for the Southern Research Station Forest Inventory and Analysis unit. 12 p. Internal document. On file with: J.S. Vissage, USDA Forest Service, North Central Forest Experiment Station, 1992 Folwell Ave., St. Paul, MN 55105.

3.3.2 Condition Classification Based on Computed Attributes

Computed condition-class attributes further describe condition classes and the domains they represent. These attributes usually are derived from tree-level (vegetation) data. They can be discrete (e.g., forest type) or continuous (e.g., percent stocking).

3.3.2.1 Condition-Level Per-Acre Ratios

For modeling, or for summarizations of area data by discrete per-acre classes, tree-level statistics (e.g., volume or basal area) can be used to compute per-acre ratios for individual plots, or per-acre ratios for specific condition classes within a plot. Condition-level ratios are computed by summing the tree-level attribute of interest (e.g., basal area) for all trees in the condition class and then dividing by the area of the plot in that condition:

$$y_{ik} = \frac{\sum_{j}^{4} \sum_{t} y_{ijkt}}{\sum_{j}^{4} a_{oijk}} \qquad (3.1)$$

where

y_{ijkt} = the attribute of interest associated with tree t on microplot, subplot, or macroplot j covering condition k on plot i

a_{oijk} = area used to observe the attribute of interest (microplot, subplot, or macroplot j) covering condition k on plot i

When combining subplot and microplot values, condition-level ratios are:

$$y_{ik} = \frac{\sum_{j}^{4} \sum_{t} y_{ijkt}}{\sum_{j}^{4} a_{oijk}} + \frac{\sum_{j}^{4} \sum_{t} y'_{ijkt}}{\sum_{j}^{4} a'_{oijk}} \qquad (3.2)$$

where

y'_{ijkt} = the attribute of interest associated with tree t on microplot j covering condition k on plot i

a'_{oijk} = area of condition k on microplot j on plot i

3.3.2.2 Condition-Level Attributes Based on Stocking

Stocking class, stand-size class, and forest type are important condition-level attributes of interest that are calculated from the stocking contributions of individual trees. Although forest type and stand-size class are assigned in the field, these attributes are also computed from the tree tally when the field data are processed. The primary purpose of the field assignments is to delineate the unique condition classes encountered on each plot, and to supply an alternative value in case the area sampled is too small to derive a calculated value (i.e., calculated values for forest type and stand size are not produced for conditions that occupy < 25 percent of a plot).

3.3.2.2.1 Algorithm to Assign Stocking Values to Individual Trees

FIA uses a complicated algorithm to assign stocking percentages to individual trees, the details of which are provided in the supplementary document "National Algorithms for Stocking Class, Stand-Size Class, and Forest Type" at http://srsfia2.fs.fed.us/publicweb/statistics_band/stat_documents.htm. A simplified explanation follows to summarize the concept. The algorithm is based on "A-line" values, which are described by Gingrich (1967) as the number of trees per acre where average maximum stocking occurs in undisturbed stands. A-line values are negatively correlated with mean stand diameter, so they vary by diameter class as well as by species. The formula used to assign percent-stocking values to individual tally trees is:

$$s_{ijkt} = (100)\frac{1}{A_{\max}} \tag{3.3}$$

where

s_{ijkt} = the percent stocking assigned to tree *t* on (microplot, subplot, or macroplot *j*) covering condition *k* on plot *i*

A_{max} = the A-line value (trees per acre) associated with the species and diameter class of tree *t*

Once s_{ijkt} is assigned, division by a_{oijk} adjusts the sample tree to a per-acre basis as shown in equation 3.1 when s_{ijkt} is substituted for y_{ijkt}. Equation 3.1 then yields the total percent stocking for condition class *k* on plot *i*. For reporting purposes, condition-level stocking percentages commonly are grouped into the classes listed below:

Stocking class	Class stocking range
	percent
Nonstocked	0 – < 10
Poorly stocked	10 – < 35
Moderately stocked	35 – < 60
Fully stocked	60 – ≤ 100
Overstocked	> 100

3.3.2.2.2 Stand-Size Class of Each Condition Class Based on Stocking Algorithm

Tree-level stocking values also are used to categorize each condition by stand-size class. Each tree is first assigned to one of the following size classes based on its d.b.h.:

Stand-size class	Stand-size class d.b.h. range
Seedling-sapling	d.b.h. < 5.0 inches
Poletimber	5.0 inches ≤ d.b.h. < 9.0 inches for softwoods
	5.0 inches ≤ d.b.h. < 11.0 inches for hardwoods
Sawtimber	9.0 inches ≤ d.b.h. for softwoods
	11.0 inches ≤ d.b.h. for hardwoods

For a given condition class, stocking values for each tree (i.e., s_{ijkt} / a_{oijk}) are then summed across all trees in each stand-size class, and for all stand-size classes combined. Stand-size class is then assigned on the basis of which of the following stocking requirements is satisfied first:

Stand-size class	Stocking requirement
Nonstocked	Total stocking across all size classes < 10 percent
Seedling-sapling	Seedling-sapling stocking > 50 percent of total stocking
Poletimber	Poletimber stocking > sawtimber stocking
Sawtimber	Poletimber stocking ≤ sawtimber stocking

3.3.2.2.3 Forest Type of Each Condition Class Based on Stocking Algorithm

Tree-level stocking values also are used to categorize each condition by forest type. The forest type assignment algorithm is quite complicated and still undergoing evaluation. Details are provided in the supplementary document “National Algorithms for Stocking Class, Stand-Size Class, and Forest Type” at http://srsfia2.fs.fed.us/publicweb/statistics_band/stat_documents.htm.

3.3.3 Calculations of Area in Each Condition Class

3.3.3.1 Mathematical Functions

Geometric and trigonometric functions can be used to calculate the area within each condition class as specified by Scott and Bechtold (1995).

3.3.3.2 Computer Simulation

Mathematical functions are useful for calculating areas at any one time, or when performing data recorder logic checks; but they can be unwieldy for some applications—particularly the calculation of **area change matrices** between inventories. Change matrices are necessary to quantify land-use and condition-class change and to enable the partitioning of growth, removals, and mortality by condition-class attributes at either the initial or terminal inventory of a measurement **cycle**.

Change matrices are produced by overlaying a computer-generated map of each subplot at time *t* (the previous inventory) with a similar map of the same subplot at time *t*+1 (the current inventory) (fig. 3.3). The area of the

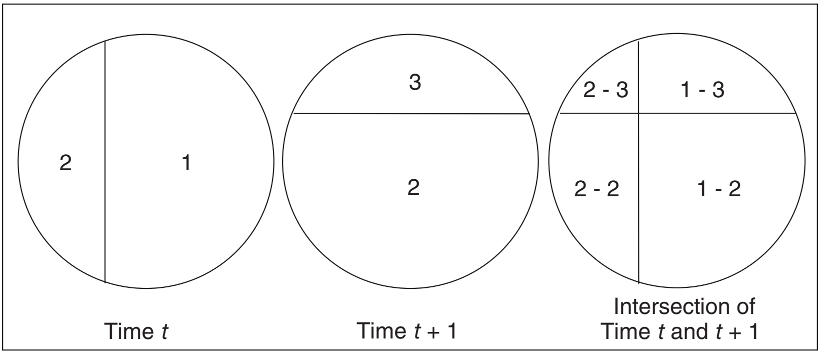

Figure 3.3—Condition-class change matrix between two points in time.

intersection of all combinations of initial and terminal condition classes is then calculated by using a computer to count dots on an electronically generated grid superimposed onto the intersected maps (Bechtold and others 2003). For each cell of the intersection matrix, an observation is created that includes area percent, as well as all of the condition-class variables at both time t and time $t+1$. Subplot-level change data are then combined to produce plot-level matrices. Similar matrices are produced for microplots and macroplots. Note that it is not necessary for field crews to retain specific condition-class numbers over time. Numbers assigned to conditions remain arbitrary and are defined by the series of condition-class variables attached to them.

3.4 Special Cases

3.4.1 Population Boundaries

Plots (and portions of plots) are assigned to the population in which they are located with indicator functions. Plots (and portions of plots) in the population of interest are then pooled to compute population estimates as described in chapter 4.

FIA sampling protocols recognize four types of population boundaries: (1) County, (2) National, (3) Federal agency (e.g., National Forest System, Bureau of Land Management), and (4) Census water.

All except county boundaries are currently mapped in the field. County boundaries are often not observable in the field, so whole plots are assigned to the county in which the center of subplot 1 is located. The inability to recognize population boundaries is not considered a problem because this implies that forest conditions are the same on both sides of the boundary, so no bias is introduced by sampling area outside the population of interest (i.e., the numerators and denominators of **ratio-of-mean** (ROM) estimators are incremented proportionately).

3.4.2 Slivers

Slivers are defined as conditions that occupy less than one full subplot and not encountered on any other subplots of a given plot. Slivers have the potential to create data processing or analysis issues, but in most cases the difficulties are minor. Alternative designs that do not require mapping create different or more serious problems such as classification anomalies and tree selection probabilities that result in biased estimators (Hahn and others 1995).

3.4.2.1 Slivers and Continuous Variables

One concern regarding slivers is that extremely small values in the denominators of per-acre ratios might unreasonably inflate estimates of per-acre values. This is not a problem because the ROM estimators prescribed in chapter 4 avoid the use of plot-level ratios. Slivers are pooled with similar conditions from other plots in the calculation of population means and totals. Although users of FIA data should be aware that a sliver may yield an unrealistic mean per-acre ratio for a rare domain in a small population, that possibility is usually of little consequence for standard FIA estimations. A domain that rarely would not be isolated in any standard output and, for reporting purposes, would be pooled with other domains.

Modeling is the only application where slivers and potentially inflated per-acre values are isolated and used as individual observations. The modeler has a variety of options to deal with this problem, such as accepting the increased variance, pooling slivers with other conditions on the same plot, pooling slivers with similar conditions from different plots, or deleting slivers from the analysis.

3.4.2.2 Slivers and Classification Variables Based on Tree Data

Slivers have the potential to inflate per-acre continuous variables that are computed for individual condition classes and then grouped into discrete classes for presentation in summary tables (e.g., area by volume-per-acre class). Such inflated values are rare and never stand alone. They are simply grouped into the highest class presented in the summary table. The most serious consequence is increased within-class variance caused by estimates from plots of different sizes.

Slivers can pose a slightly different problem for computed classification variables that are not per-acre estimates (e.g., forest type). When the tree tally on a given plot falls below a certain threshold, sufficient data may not be available to make an accurate classification. In such cases it is necessary to accept the computed classification at face value, revert to a subjective field classification, or engage in auxiliary sampling to obtain enough field data to compute the classification. The amount of field data required for reliable area classifications depends on the spatial scale of the vegetation upon which the classification is based (Williams and others 2001). FIA is still evaluating the minimal areas required for classifications most commonly computed from tree data, forest type and stand size, so subjective field calls are available in addition to computed values for these. Preliminary analyses suggest that computed values for forest type and stand size are unreliable for conditions that occupy areas smaller than one full subplot.

A related problem involves attributes, usually indices, for which it is important to base the classification on plots of equal size (e.g., species diversity index). This is not a common application of FIA data and there is no prescribed method for handling this situation, but an analyst has the option to adjust the index (e.g., species/area curves), delete partial plots from the analysis, or pool data from other conditions on the plot. It is noteworthy that pooling vegetation data is not an option for plots that contain nonforest land uses, because FIA protocols ignore vegetation on land uses defined as nonforest.

3.4.3 Nonsampled Plots and Plot Replacement

For various reasons, some plots (or portions of plots) within a given population cannot be sampled at the time they are scheduled for measurement. Such plots are classified as "nonsampled", a "nonsampled reason" is assigned, and no additional data are recorded. The magnitude of the problem has not been fully evaluated, but nonsampled plots have the potential to be a significant factor in populations with relatively few forested plots (e.g., Plains States). FIA currently assumes these plots are randomly distributed, so nonsampled plots assume the **strata** means for all estimated values as discussed in chapter 4, which ensures that estimates are produced for the entire population—not just the accessible portion. This approach presumes that conditions on nonsampled plots are missed at random, which may not be valid under some circumstances. More precise methods of assigning attributes to nonsampled plots are being considered, and will be implemented if they yield better results.

Access refusal by landowners is the most common reason for nonsampled plots, but plots occasionally are inaccessible due to hazardous situations encountered by field crews. To avoid altering the sampling network such that it becomes nonrepresentative of the population, inaccessible plots usually are not replaced. However, inaccessible plots may be replaced where nonreplacement causes inadequate sample size, or where there is evidence that replacement results in estimators that are less biased.

Less often, missing data or corrupted plot files are discovered after the field measurements for a panel are completed. When it is impractical to correct the situation, such plots also are classified as nonsampled. They are then resampled at their next scheduled measurement.

Field crews occasionally fail to relocate previously established plots. Upon verification that a plot is truly lost, a replacement is installed at the approximate location of the original, and the lost plot is retired from the panel.

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