INTEGRATING P3 DATA INTO P2 ANALYSES: WHAT IS THE ADDED VALUE[1]

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Abstract—The Forest Inventory and Analysis and Forest Health Monitoring Programs of the USDA Forest Service are integrating field procedures for measuring their networks of plots throughout the United States. These plots are now referred to as Phase 2 (P2) and Phase 3 (P3) plots, respectively, and 1 out of every 16 P2 plots will also be a P3 plot. Mensurational methods will be identical on both types of plots, as will the procedures used for coding tree damages. Measurements of crown dieback, crown density, and foliage transparency; and measurements related to soils, lichens, and ozone indicators will distinguish P3 tree data from P2 tree data. Questions arise as to what value the unique P3 data add to reporting forest health conditions, and whether the P3 attributes can be extended to the greater number of P2 plots and forest landscape. This paper explores the latter question by showing how representative the P3 plots are of the forest as depicted by P2 plots. In empirical analyses of P2 and P3 data recently collected in Georgia, the P3 data were treated as a one-sixteenth subset of the P2 data. Stratifications of the data by forest-type group demonstrated that P3 plots were representative of the predominant forest-type groups and spatial distributions showed how the two types of plot data were comparable at different levels of resolution.

INTRODUCTION

The Forest Inventory and Analysis (FIA) and Forest Health Monitoring (FHM) Programs of the USDA Forest Service are integrating field procedures for measuring plots throughout the United States. All FHM plots [herein referred to as Phase 3 (P3)] will be collocated on a systematic grid with 1 of every 16 FIA plots [herein referred to as Phase 2 (P2)]. Mensurational methods on both types of plots will be identical, and FHM procedures for recording tree damages will be applied to the P2 plots. Crown measurements of dieback, density, and foliage transparency in 5-percent classes will remain as the only attributes that distinguish P3 tree data from P2 tree data. Measurements related to soils, lichens, and ozone bio-indicators will also be unique to P3 plots, and other data related to woody debris, herbs, and shrubs will most likely be collected in the near future on these plots.

Integration of the P2 and P3 field procedures will also result in combined use of P2 and P3 attributes for the reporting of forest health conditions. In these analyses, the P3 data will be regarded as a one-sixteenth subset of the P2 plots with the additional attributes described above. This proposed use of the data gives rise to several related questions:

1. Do P3 plots represent the forest landscape as depicted by P2 plots?
2. What is the appropriate spatial scale of use for the P3 data?
3. Can attributes unique to the P3 plots be extended to the P2 plots?

Past analyses have addressed only the first two questions by showing that estimates of some attributes from P2 and P3 data are comparable at a regional scale of resolution (Brooks and others 1992). However, recent unpublished applications of the P3 data have demonstrated their use for smaller geographic areas. Given this interest, the objective of this paper is to explore the spatial relationships between P2 and P3 data at different scales.

METHODS

Empirical data from Georgia were used in an analytical approach to compare spatial distributions of various attributes common to the P2 and P3 data. Georgia was selected as a case study because (1) recent years of measurement for P2 and P3 data closely coincide (1997 and 1995, respectively), and (2) sampled data distributions for the State are similar among forest-type groups and stand sizes (table 1). Analytical methods focused on whether spatial distributions of the P2 and P3 data were

Table 1—Percentages of forest-type groups and stand size in Georgia as estimated by Phase 2 (P2) and Phase 3 (P3) data sources

	Data source and year		
Forest-type groups and stand size	P2 1997	P3 1995	Difference P2 – P3
	- - - - - - - - *Percent* - - - - - - - -		
Forest-type groups			
Oak-hickory	23	17	6
Oak-gum-cypress	16	13	3
Oak-pine	15	21	-6
Loblolly-shortleaf pine	30	28	2
Longleaf-slash pine	14	19	-5
Stand size			
Sawtimber	40	41	-1
Poletimber	24	24	0
Seedling-sapling	36	35	1

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still comparable at higher levels of resolution within the State.

In 1995, P3 data were collected in Georgia on a systematic grid of hexagons wherein one P3 plot was located within each hexagon cell. In 1997, P2 data were collected from a nonsystematic plot network dissimilar to the new systematic grid of the Southern Annual Forest Inventory System (SAFIS) (Roesch and Reams 1999). Therefore, to make realistic comparisons between data from P2 and P3 plots, it was necessary to simulate the SAFIS grid using the 1997 data.

Simulating the New P2 Grid

The new SAFIS P2 grid was simulated by choosing plots measured in 1997 that were nearest to the center of each grid cell. This technique populated about 4,500 of the 6,413 SAFIS grid cells with data. Empty cells occurred mostly in areas that were purposely undersampled in 1997, such as nonforested landscapes (e.g., the Atlanta area) and the Okefenokee Swamp. Aside from these areas, the simulation of the SAFIS grid produced a uniform and representative sampling intensity of 16 P2 plots for each P3 hexagon cell (fig. 1).

Quantifying Spatial Associations between P2 and P3 Plots

The simulated grid was used to depict spatial distributions of P2 plots located within different forest-type groups throughout Georgia. Likewise, spatial distributions of P3 plots within corresponding forest-type groups were then overlaid for comparison. Considering that individual plots can occupy multiple forest conditions, plots were considered representative of a given forest stratum only if at least 50 percent of their sampled area was within that stratum. Plots sampling the oak-hickory and loblolly-shortleaf pine forest-type groups were used in example analyses because these groups are abundant yet unevenly distributed in Georgia.

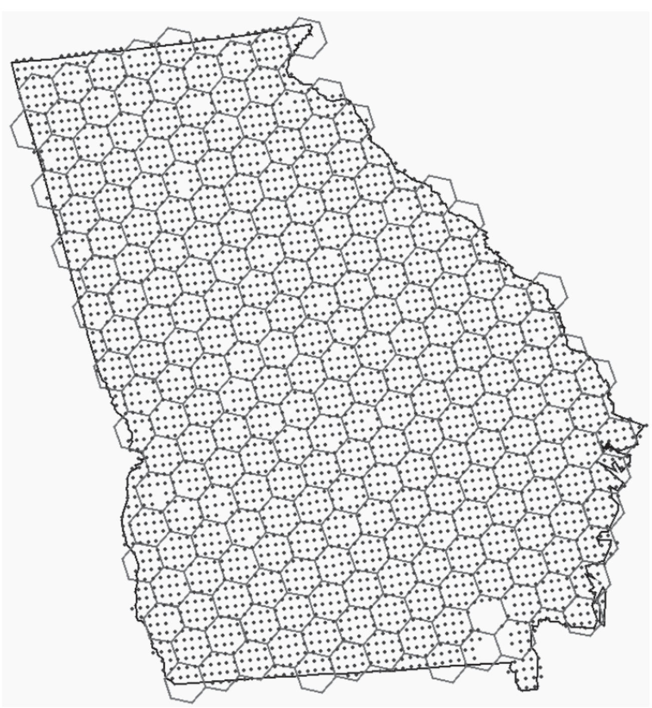

Figure 1—P3 hexagons in Georgia overlaid with a simulated grid of P2 plots using data from 1997 to simulate the one-sixteenth P3 sampling intensity of P2 plots.

The ratio of the number of P2 to P3 plots was calculated for each forest-type group at different spatial scales and compared to the base-grid ratio of 16:1. The smallest unit of area (highest resolution) used for analysis was a P3 hexagon grid cell, where the number of P2 plots representing a given forest stratum was compared with that depicted by the individual P3 plot for the cell. A tally of all counts was then used to examine how the classification of a P3 cell compared to that of each P2 plot contained within the cell. This Geographic Information System technique was easy to implement and provided an unbiased match between P2 plots and P3 hexagons.

In a similar manner, a coarser resolution was analyzed using a cluster of seven P3 hexagon cells, with one cell surrounded by six others. This technique involved classifying each cluster of seven cells, or "hepta-hexagon," according to the P3 attributes of the center cell, and then determining how many P2 plots within the cluster had matching attributes. Each P3 hexagon cell was evaluated, which resulted in a sequence of overlapping clusters equal in number to the number of individual P3 hexagons. However, only hepta-hexagon clusters located completely within Georgia were retained for analysis.

RESULTS

Ratio of P2 Plots per P3 Hexagon

A tally of all P2 and P3 plots that sampled oak-hickory forest conditions showed a total of 670 P2 and 29 P3 plots, equivalent to a ratio of 23:1. This deviation from the base-grid ratio of 16:1 corresponds to a slightly greater estimate of oak-hickory forest abundance obtained from the P2 data (table 1) and suggests that the P3 plots under-sampled the resource. For plots that sampled loblolly-shortleaf pine forest conditions, the ratio of P2 to P3 plots was 18:1, which was expected, considering that both types of plots provide similar estimates of the loblolly-shortleaf pine abundance in the State.

A visual display of locations of P2 and P3 oak-hickory plots illustrates their respective spatial distributions within Georgia (fig. 2). From these data it is evident that the number of oak-hickory P2 plots within each oak-hickory P3 hexagon is much less than 16. Conversely, a large number of oak-hickory P2 plots are located in areas not represented by oak-hickory P3 hexagons.

A cross-classification of the plot distributions quantifies the disparity in plot locations (table 2). All 29 oak-hickory P3 hexagons contain 10 or fewer oak-hickory P2 plots. Furthermore, about two-thirds of the hexagons contain fewer than six P2 plots. Conversely, a large number of oak-hickory P2 plots are located in areas where the nearest P3 plots are in other forest-type groups or are nonforested.

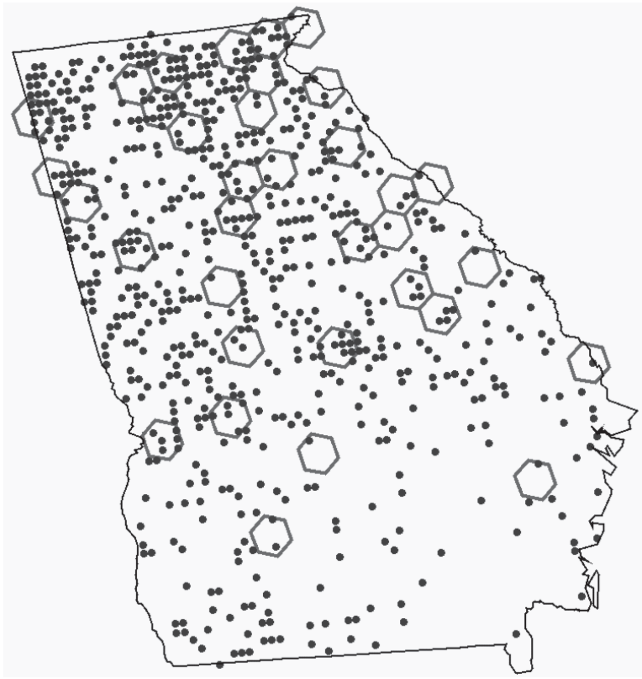

Figure 2—P3 hexagons and P2 plots, each representing sampled oak-hickory forest-type groups.

Table 2—Spatial associations between Phase 2 (P2) and Phase 3 (P3) plot locations that sample oak-hickory forest-type groups

Number of oak-hickory P2 plots per P3 hexagon	Number of P3 hexagons	
	Oak-hickory	Other
0	0	29
1–5	19	135
6–10	10	25
11–15	0	2
>15	0	0

Similar results were found for the loblolly-shortleaf forest-type group. The arbitrary difference was that loblolly-shortleaf pine types are more abundant in the southern part of Georgia.

Ratio of P2 Plots per Cluster of Seven P3 Plots

As expected, use of the clusters of seven P3 hexagons resulted in greater numbers of oak-hickory P2 plots within each hepta-hexagon cluster (table 3). All but three of the clusters with an oak-hickory P3 plot in the center hexagon cell also contained at least 16 oak-hickory P2 plots somewhere within the cluster. Visual inspection of the plot and cluster distributions also confirmed that the area defined by the hepta-hexagon clusters captured most of the P2 plots (fig. 3).

Results at this spatial scale were also similar in analyses of the distributions of the loblolly-shortleaf pine types.

Table 3—Spatial associations between Phase 2 (P2) and Phase 3 (P3) plot locations that sample oak-hickory forest-type groups

Number of oak-hickory P2 plots per P3 hexagon	Number of P3 hexagons	
	Oak-hickory	Other
0	0	0
1–5	1	22
6–10	1	24
11–15	1	23
>15	16	81

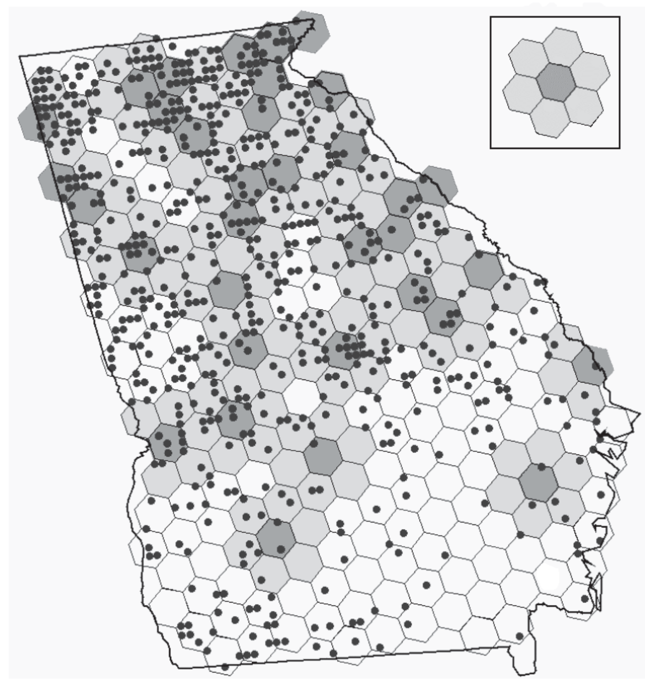

Figure 3—Clusters of seven P3 hexagons used to search a more extensive area for neighboring P2 plots that represent oak-hickory forest-type groups.

Locations of P2 plots in this stratum were strongly associated with seven-hexagon clusters that had a P3 loblolly-pine plot in the central cell.

DISCUSSION

Although this study used only a subset of empirical data from Georgia, some general conclusions can be inferred from its analyses. Findings help quantify which spatial resolutions are suitable for use with the P3 data.

For a given P3 plot, the distance to neighboring P2 plots with similar attributes can be great. The Georgia data show that a low number of oak-hickory P2 plots are usually found within the hexagon cell of an oak-hickory P3 plot. This finding confirms that an individual P3 plot is not necessarily representative of its surrounding hexagon and that the P3 hexagons are thus not an appropriate level of resolution for interpretation. However, results showed that 16 P2 plots that match one attribute were found by expanding the search area to a cluster of seven hexagons. For some individual forest strata, this spatial resolution can therefore be achieved.

However, results from this study also imply that analyses of more detailed forest strata would involve searching larger areas to find 16 P2 plots for every matching P3 plot. For example, searches for P2 and P3 plots that sample pole-sized, oak-hickory forests on well-drained sites would obviously result in a smaller number of P3 plots and require going a greater distance to find 16 neighboring P2 plots (fig. 4). In other words, forest strata by several attributes will have lower spatial resolutions of interpretation than those strata defined by just one attribute. In some instances, a forest stratum of interest may be too detailed to obtain much spatial resolution within a State, and the default approach to regional analyses would be necessary.

This paper did not directly demonstrate how data from the P3 plots can be extended to P2 plots. However, one plausible method is to assign P3 values to neighboring P2 plots within the same strata. The distance at which P2 plots were to be considered neighbors would depend on the results stated in this paper. In addition, it would be of interest to examine the variability of P3 data attributes themselves.

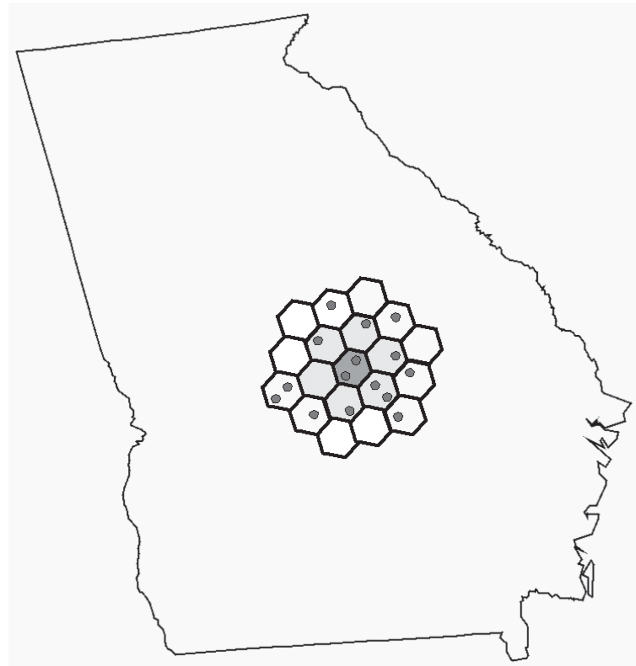

Figure 4—A cluster of 19 P3 hexagons to illustrate a more extensive search area for P2 plots with matching attributes.

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