Monitoring State Forest Lands in Standardization with a National Forest Inventory Program

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Introduction

Within the past decade, there has been increasing interest in uniformity of forest inventory techniques and methods. Where forest inventories are already in place, harmonization is often needed to recast various metrics and measurements to a common definition so that results can be compared and summarized across various spatial scales without regard to administrative boundaries, e.g., national borders (Winter et al. 2008). Although more difficult to achieve, standardization is more desirable as consistent methods are used at the outset and no post-hoc procedures are required (Köhl et al. 2000). While emphasis has primarily been on harmonization between nations, there are a number of advantages that accrue when standardizing small-area inventories with a national program that covers the same geographic area. In the U.S. Forest Service, the National Inventory and Monitoring Applications Center within the Forest Inventory and Analysis (FIA) program assists other organizations in planning and conducting forest monitoring. In most cases, these efforts can use the same definitions and protocols as the FIA program. Special local or regional information needs are addressed by additions or modifications to the existing methods. In this paper, recently established state forest monitoring efforts are used to illustrate the advantages of standardization with the FIA national program.

Materials and Methods

Currently, there are two state-sponsored continuous forest inventory (CFI) programs being conducted in standardization with the FIA program. In Indiana (IN), approximately 61,960 ha of state forest lands are being inventoried in 5-year cycles at a sampling intensity of one plot for approximately every 16 hectares, for a total of 3,850 plots. This effort is independent of the FIA inventory and the intensity is nearly 150 times greater than the FIA plot grid. For efficiency, each sample plot is equivalent to one FIA subplot (fixed area with 7.3 m radius) and all plots within a management compartment (~ 405 hectares on average) are measured within a given inventory year. The compartments have been assigned to rotating panels. Additional information needs, such as harvest limitations and cutting treatments, were accommodated by adding new variables to the existing field measurements. One year of data collection has been completed.

Nearly 202,350 hectares of state-owned forest lands in Wisconsin (WI) are also being inventoried in standardization with FIA methods. The goal of this program is to measure nearly 3,500 plots over a 5-year cycle (1 plot for approximately every 59 hectares), which is more than 40 times the sampling intensity of the FIA program. In this case, the sample plot design consists of two subplots (each having 7.3 m radius) with centers approximately 37 m apart within a rotating panel sampling design. On one-third of the plots, additional forest health information is

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obtained. These data are also collected in standardization with FIA protocols established for forest health data. Again, special information needs are accommodated by recording data on attributes such as soil disturbance and specific tree damage agents and severity. Two years of data collection have been completed.

Results and Discussion

There are a number of economy and efficiency advantages of designing a monitoring program that is standardized with the FIA national program. First, the consistency in protocols means that FIA data collected from within the area of interest can serve as a pilot study. This is particularly advantageous in the planning stages when decisions on precision requirements and associated sample sizes need to be made. Specifically, estimates of population variability can be calculated such that tradeoffs between precision and cost can be evaluated. FIA data were used in the planning process for both the IN and WI state forest land inventories, which allowed for identification of efficient plot and sampling designs. There was no expense incurred by the state agencies to obtain the data as FIA data are publicly available.

Another advantage of standardization is the availability of software and tools that FIA has developed. These items are in the public domain because the work was performed by employees of the U.S. government. There are three things that are particularly useful for forest inventory and monitoring efforts: 1) portable data recorder (PDR) software; 2) database design; and 3) analytical tools. Usually, local information needs above what is already measured by FIA are minimal. Thus, the FIA PDR software requires only minor modifications and/or additions to be tailored to a specific project. These changes can be accomplished relatively quickly and with low cost. Similarly, only minor changes are needed to accommodate project-specific data uploads and storage in an FIA-like database. Costs are incurred relative to the complexity of any additional computed fields that need to be programmed during the compilation phase, e.g., project-specific volume equations or classification algorithms. Finally, standardization with the FIA program provides access to analytical tools that already are capable of utilizing most of the information. As with the other tools, additional costs are incurred to modify the analytical tool to include extra data items such as those associated with local information needs.

Both the WI and IN CFI projects were implemented because the sampling intensity of the FIA program was insufficient for providing estimates of acceptable precision for these areas. For comparative purposes, data from the first year of the IN CFI were compared to a single year of data collected by FIA for the same area. Compartment 8 of the Yellowwood State Forest (SF) has an area of roughly 1,185 ha and it would be unlikely that an FIA plot would exist in an area of this size. From the CFI data, a volume estimate of approximately 198,435 m^3 with a sampling error (SE) of 9.1% is obtained (Table 1). Obviously, no estimate is possible using FIA data. Similarly, for the entire Yellowwood SF (9,440 hectares), a volume estimate of 2,596,130 m^3 with a SE of 44.9% is computed. No FIA estimates are computed as only one FIA plot would be expected on the Yellowwood SF. Finally, estimates for all state forest land (61,960 hectares) were generated using both the IN CFI and FIA data. Estimates of volume were 9,130,413 m^3 (SE = 12.3%) and 8,111,303 m^3 (SE = 28.1%), respectively. Thus, estimates that are compatible with FIA were generated for smaller areas than otherwise would not have been possible to calculate and more precise estimates were obtained for larger areas.

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Readers may have noticed that the SE for the Yellowwood SF was notably higher than the SE for Yellowwood SF Compartment 8, even though the Yellowwood SF is a much larger area. This is due to the decision to measure all plots within a compartment at one time, effectively making the compartments the primary sampling units for a state forest in a subsampling with units of unequal size design (Cochran 1977). However, for compartment-level estimates, the plots are the primary sampling units within the compartment and estimation procedures follow those described by Scott et al. (2005). In the example provided, there were many more plots within the compartment than compartments within theYellowwood SF, resulting in a smaller SE for the compartment estimate.

An important advantage of standardization is the ability to spatially compare forest resource conditions and trends. It may be of interest to evaluate how conditions on state forest land compare with those on adjacent privately owned forest land. For example, the distribution of area by stand-size class on the Yellowwood SF can be compared with the distribution on private lands within Brown County (the Yellowwood SF is mostly in Brown County). The analysis shows that the proportion of forest area in each stand-size class is similar between state and privately owned forest lands (Figure 1). Comparisons will be of increasing interest when remeasurement data are available, e.g., how do rates of mortality and harvest compare between public and private ownerships?

Another advantage is the capability of doing cumulative effects analyses across the landscape. By including other ownerships in the analysis, the state forest managers can better evaluate the watershed and landscape-level implications of management decisions.

Standardization with the FIA program also allows other organizations to take advantage of existing data quality software for quality assurance (QA) purposes. This provides a comprehensive evaluation of field measurement consistency. The software generates tables similar to those of Pollard et al. (2006) that indicate how many repeated measurements were within a specified tolerance, e.g., ± 0.25 cm for diameter at breast height (dbh) measurements. Additionally, this provides the ability to compare measurement consistency with FIA to see how the CFI crews' performance compares to that of the national program. The QA data from the WI CFI shows that WI CFI crews do slightly better than WI FIA crews at consistently measuring dbh and identifying tree species (Table 2). Conversely, FIA crews are more consistent in measurements of crown ratio and total tree length. Such comparisons are valuable for identifying areas where additional training or other actions may be needed to improve measurement consistency.

Conclusion

A number of advantages for conducting forest inventories in standardization with the FIA national forest inventory have been shown. From an economic standpoint, costs are substantially reduced by taking advantage of existing information and tools, such as 1) FIA plot data for planning purposes; 2) field measurement protocols; 3) PDR software; 4) database design; and 5) data analysis tools, including QA data. This also allows for much quicker initiation of the data collection effort and minimizes delays in data analysis and reporting.

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More importantly, the standardization allows for valid comparisons with other areas where only FIA data exist. In the example, proportion of forest area by stand-size class was compared between state-owned lands and adjacent privately owned land. However, numerous other comparisons could be made as well, both for current values and estimates of change over time. These types of analyses can provide indicators of how forest resources and management practices differ between various entities.

Both the IN and WI CFI programs are essentially equivalent to having an intensification of the FIA national inventory in the geographic area of interest. The result is estimates for small areas that otherwise would not be possible and more precise estimates for areas where there are limited numbers of FIA plots. Options also exist for addressing local information needs that are not available from FIA data. Organizations interested in establishing forest inventory and monitoring programs should carefully consider these advantages when weighing various implementation strategies. From a forest resource monitoring perspective, standardization with a broader national inventory program is a win-win situation.

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Table 1. Estimates of volume (m^3), associated sampling errors (SE), and sample sizes (n) from IN CFI and FIA data for three State Forest (SF) areas.

Description	Area (ha)	IN CFI			FIA		
		Volume (m^3)	SE (%)	n	Volume (m^3)	SE (%)	n
Yellowwood SF comp. 8	1,185	198,435	9.1	72	--	--	0
Yellowwood SF	9,440	2,596,130	44.9	4	--	--	1
All SF	61,960	9,130,413	12.3	29	8,111,303	28.1	5

Table 2. Percent of dbh, species, total tree length, and crown ratio measurements within tolerance from QA data on WI CFI and WI FIA plots.

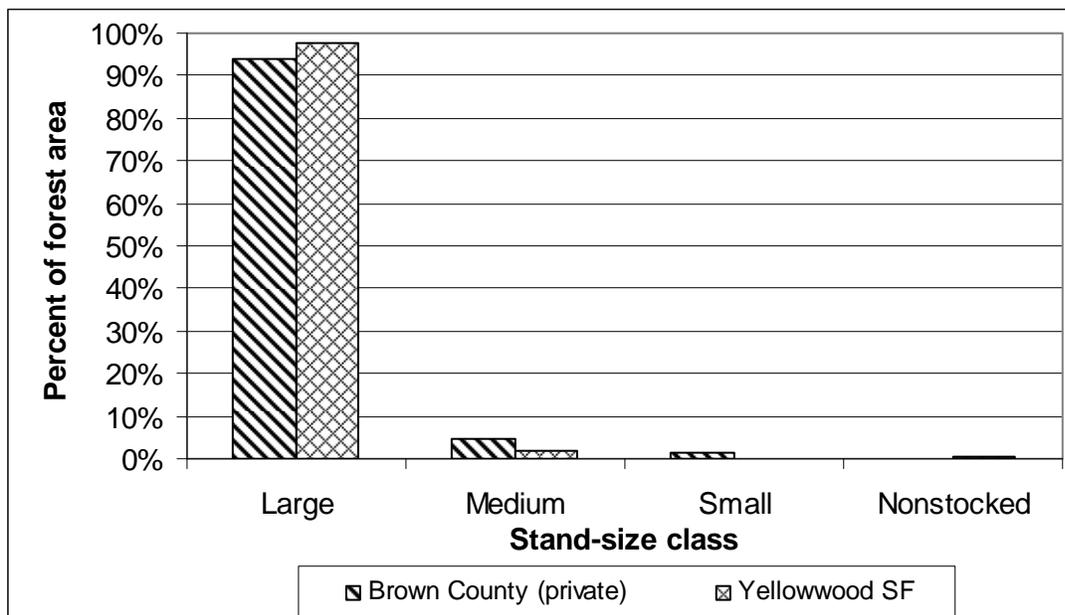| Variable	Tolerance	WI CFI	No. trees	WI FIA	No. trees
Dbh	±0.25 cm per 50.8 cm	96.5%	86	95.0%	4548
Species	No Tolerance	98.9%	93	96.6%	4680
Total length	±10 %	88.3%	60	89.4%	2960
Crown ratio	±10 %	88.5%	87	92.2%	4680

Figure 1. Percent of forest area by stand-size class for the Yellowwood State Forest and for privately owned forest land in Brown County, Indiana.

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