

# Rationale

The USDA Forest Service Forest Inventory and Analysis (FIA) program is changing to an annual inventory system that will operate at reduced intensity simultaneously in all states every year. This system will provide annual inventory updates in all parts of the country every year, and will make it easier for partners (mainly state forestry agencies) to collaborate in program planning and implementation. The change has significant implications for traditional and new users of the national inventory system.

By Andrew J.R. Gillespie

The USDA Forest Service Forest Inventory and Analysis (FIA) program provides periodic information on status and trends on a variety of parameters describing forests and forest use: area and location of forests; structure and composition of forests in terms of species, sizes, and volume; rates of tree growth, mortality, and removals; patterns of ownership of forestlands; and information on harvest efficiency and wood product flows throughout the United States (USDA-FS 1992). This information is of vital interest to numerous customers including managers, policymakers, environmental organizations, business interests, consultants, scientists, the media, and citizens who are interested in status, trends, stewardship, and sustainability of the nation's forested ecosystems. This program is referred to as a strategic inventory to distinguish it from more local, project-level inventories aimed at providing specific information for planning management actions.

FIA has historically conducted forest inventory on a state-by-state cycle. Under this model, we divide the country into zones and, within each zone, conduct statewide inventories one state at a time for all forestland outside of national forests. (National forest managers are responsible for forest inventory within national forests; many contract with FIA to provide consistent coverage across states.) Past inventory cycles have ranged from six to eight years in the South and 11 to 18 years in the rest of the country. In 1998, the total federal appropriation for FIA was \$19.8 million, which was approximately 10.5 percent of the total research budget of \$188 million, or 0.7 percent of the total Forest Ser-

vice budget of \$2.73 billion.

Alternatives for reducing the cycle with available funds, such as reducing the sample intensity or scope of data collected, are not acceptable to many program customers. Program investments in remote sensing tools have led to interesting new products, but current remote sensing technology is not capable of providing the required level of detail demanded by customers at the state and regional scales at which we operate. For example, FIA is required to report area estimates by detailed classifications of forest type, stand size, and stand volume that are not possible to classify with sufficient accuracy without substantial levels of ground-truthing. Nevertheless, we will continue to conduct research into ways to integrate new remote sensing tools into our inventory system to increase efficiencies and to develop useful new products.

In recent years, as budgets have remained relatively flat or declined (in real terms), FIA units have tended to divert ever-increasing shares of their budgets to collecting field data in an attempt to reduce or at least maintain the current inventory cycle. These steps have proved insufficient to maintain the inventory cycle at the desired eight to 10 years, and have compounded the problem by slowing the analysis and publication of inventory results. The result has been increasing customer concern that the FIA program is not meeting present customer needs, neither in terms of frequency of data nor in diversity of analytical products. These concerns have been expressed in two reviews of the FIA program by a cross section of program customers (American Forest & Paper Association 1992, 1998) who have encouraged us

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to reassess the existing program to improve program performance.

One way to address some of the problems facing the program is to change to an annual inventory system. This approach has two major attractions. First, it guarantees that all states will have at least some new data available every year, which addresses concerns about data currency. Second, it makes it easier for partners to help share the costs of the program through a steady annual level of participation, which removes the program from total fiscal dependency on federal dollars.

FIA has been seriously considering an annual approach to forest inventory since 1992, when we began development of a prototype annual inventory system in Minnesota in cooperation with the Minnesota Department of Natural Resources. Satellite imagery analysis was used to differentiate between plots that could be modeled rather than visited, and plots where sufficient change had taken place to warrant a field visit. By visiting a smaller set of plots annually, and leveraging that information with remotely sensed data and models, it was hoped that a state-level report could be produced at more-frequent intervals—four years or less—for the same cost.

In 1996 we began testing and implementing a simpler approach in cooperation with a coalition of industry and state partners in the South. We divided the existing set of field plots into five overlapping panels, with the intent of measuring one full panel each year so that each plot would be measured once every five years. Because federal funding levels could only support a seven- or eight-year cycle, this approach would require additional sources of funds, either from the Forest

Service or from partners. Several southern states have already stepped forward to invest significant amounts of their own money and staff time in support of the program (USDA-FS 1999b).

Other FIA units have until now been interested observers. However, the Agricultural Research, Extension, and Education Reform Act of 1998 (PL 105-185) directs all FIA units to change to an annual inventory system over the next five years. This law also significantly changes and expands the FIA mission in other ways, requiring more data collection on a wider array of parameters, mandating consistency in methods and data across all lands including national forests, and requiring analysis and reporting by states at five-year intervals. These requirements imply other necessary program changes that are described in the *Strategic Plan for Forest Inventory and Monitoring* (1999a). For purposes of this article, we assume that FIA will implement the full extent of sampling required by the legislation: 20 percent per year per state.

It is significant that this legislation was written and passed with little direct input from the Forest Service, which is largely a reflection of how frustrated so many program clients have been with the slow rate of change within the FIA program. This high level of interest is not to be taken lightly. Some aspects of the legislation, such as that mandating visitation of 20 percent of all plots in all states every year (essentially a five-year inventory cycle for every state), may not be the most efficient way to spend public resources. It is also important to note that the 1998 act is authorizing legislation and not appropriation legislation; there is no guarantee that funding will

be provided to implement the mandated program. We are confident, however, that we can collaborate with our partners to craft a program that addresses customers' concerns in an efficient fashion, to the best ability of available resources.

Changing from the periodic approach to the annual approach has tremendous implications for many aspects of the FIA program, including logistics, cost efficiencies, partnerships, and the quality and utility of the resulting information products. The implications will be viewed differently depending on whether one is involved in implementing the program or is simply using the results. The following discussion touches on some of the major implications for program participants and customers alike.

## Logistics and Cost-Efficiency

Changing to an annual inventory will have different implications for logistics and cost-efficiency in different parts of the country. Under the periodic approach, field personnel must relocate every year or two as they finish one state and begin another. This reduces retention of experienced crew people, who soon tire of the nomadic life and seek positions with more stability. Where we can operate year-round (mainly in the southern half of the country and in some flat northern states), an annual approach allows for stability in field staff by permanently stationing them within a certain working area. This will eliminate the cost of constantly relocating people, and will provide field staff with an opportunity for more normal lives, which should in turn lead to greater retention of experienced staff and lower training costs for replacements. Some of these savings

will be needed to offset the increased travel costs, as crews will now cover every part of every state every year.

In the rest of the country, the combination of snow and steep terrain make fieldwork seasonal. In these areas, logistics for an annual inventory are more complicated and expensive because large numbers of people must be moved into these areas to complete the 20-percent plot coverage across the region within the operable window. For example, in the interior West, we estimate a need for 112 person-years of field crew effort per year to cover the entire region, or roughly double the staffing needed to implement an equivalent five-year cycle under a periodic inventory system (D. VanHooser 1998, pers. commun.). Where crews once would concentrate on measuring all plots in a smaller area, they will now need to cover a larger area, on average driving (or walking, in roadless areas) past two plots three miles apart for every plot they measure. Providing the coverage required will mean higher travel costs. Costs could be reduced by concentrating annual fieldwork in survey units; that is, dividing a state into five subunits and measuring all the plots within each subunit, one subunit per year. But we believe this approach is not consistent with the intent of the legislation, which aims to provide annual statewide updates of forest inventory data. At present we plan to provide uniform coverage by dividing all plots in a given state into five panels, where each panel provides full state coverage at approximately even density.

One immediate opportunity for increased efficiency is through the merger of the FIA program with the field plot portion of the Forest Health Monitoring (FHM) program (USDA-FS, 1998). Currently FHM is a related program that collects data on forest health parameters in all implemented states on an annual basis during a 10-week summer measurement window. There is some redundancy between the programs: for example, FHM collects a set of mensurational data that is largely duplicated on FIA plots, and it involves many of the same management and supervisory staff that also manage FIA. As FIA changes to an an-

nual system, we intend to merge the sets of plots so that FHM plots will be a subset of the annual FIA panel of plots and will be visited by a single crew during the summer window to collect both FIA and FHM data. This merger would allow more-efficient use of the FHM funds (about \$7 million in 1999) for focusing on extended ecological data. In addition, the merger will reduce the likelihood of multiple visits to the same plot that might annoy private landowners, and will increase analytical effectiveness by providing maximal linkage between the two databases. Because many states are partners in both FIA and FHM, combining these programs will enable states to reduce some overhead associated with participation.

The financial implications of the annual inventory system are not limited to fieldwork. We also expect to gain some efficiencies in data analysis. Data from adjacent states will now be available over common time periods, which will eliminate the need for investing time and energy in complicated and sometimes arbitrary updating processes as a precursor to analyses that span multiple states. The annual approach also offers a low-cost opportunity for additional reports to reflect significant environmental events that occur randomly over time, such as floods, ice storms, hurricanes, or fire. The annual approach provides a constant platform for responding to unpredictable events without having to commission or fund a special study.

### Information Quality

Both the periodic and the annual inventory approaches are designed to provide unbiased estimates of parameters of interest. However, the parameters estimated are not necessarily the same for each approach. Under the periodic approach, the parameter estimates are assumed to describe the state of the forest at some specific point in time. The inventory is generally assigned to the year in which the bulk of the data were collected, although in reality inventory for some larger states may involve data collected over two to three years.

Under the annual inventory ap-

proach, we have more choices for parameters of interest. One approach would be to use some kind of moving average, combining the most recent observation for all  $n$  plots taken over the past five years. This would yield an estimate of the mean value over the past five years, which is not the same as the mean value in the present year. Another approach currently under consideration includes using a variety of modeling or imputation procedures to constantly update the past four years of data to the current year, to provide a full data set of  $n$  observations for the current year. Such modeling approaches will rely on historical data or other auxiliary information, which will themselves add components of variance. Research will be needed to quantify and incorporate the additional variance elements.

Information may be accurate and precise, yet still not be useful to users. Under the periodic approach, highly accurate and precise inventory information is available only periodically—at present, every eight to 15 years for each state. For users who need current information, this is not sufficient if too many years have passed since the inventory data were collected, or if a major disturbance event has occurred since the last inventory. The advantage of the annual approach for data users is that it yields some new information each year, with the information having an average age of 2.5 years (half the length of the measurement cycle) at any given time. Users who want continuous access to relatively recent data will prefer the annual approach, and users who can wait longer for more-precise data will prefer the periodic approach. The preference for an annual approach to inventory will likely be greatest for systems where the rate of change is greatest; for relatively stable systems, a periodic approach is probably more efficient.

### Customer Confidence

Regardless of how accurate and precise the data, the information will not be useful if the ultimate consumers of the information do not believe it is reliable. Accurate information presented in a manner that undermines its own

credibility is not useful. With the periodic approach to inventory, we have maximum precision at fixed intervals. We can say with confidence that the data reflect observations of a trend at fixed points in time, and that changes that occur between the points are reflected with some accuracy in the periodic observations.

Reporting updated estimates on an annual basis will inevitably invite comparison of the present estimates to the previous years, and will cause consternation and distrust if there is deemed to be a significant variation from year to year. While statistically understandable, such behavior could nonetheless cause users unfamiliar with technical issues to mistrust and doubt the results. This is more of a risk under the annual paradigm than it is under the periodic, where the lack of mid-cycle data prevents users from making the same comparison. Auxiliary information in the form of models or other assumptions may be incorporated to increase the precision of the annual estimates, but such procedures will themselves add additional components of variance that will need to be quantified and incorporated into variance estimates.

### **Partnerships**

As the Forest Service increases its efforts at collaborative stewardship, FIA is increasingly relying on partnerships to accomplish the FIA mission. For purposes of this article, partnership is defined as a relationship where two or more parties share objectives and pool resources to reach those objectives. State forestry agencies in particular have historically partnered with FIA by contributing office space, staff time, vehicles, and other resources that allow FIA work to proceed at a faster pace. Many states have also contributed resources to FIA for purposes of collecting additional data beyond the base program, for example to intensify the plot network or to collect special interest variables on some or all plots.

However, it is often difficult for partners to participate more fully in the FIA program under the periodic inventory approach because the long intervals between repeated inventory activities make it difficult for states to sup-

port permanent inventory staff. Over time, normal employee turnover tends to reduce the number of staff familiar with the FIA program, methods, and opportunities. In addition, partners who want to seek resources to invest in FIA are forced to make infrequent requests to state legislators for large sums, rather than seeking a more modest investment on a continuous basis. The periodic nature of past inventory programs often leads to periodicity in relationships between FIA partners, resulting in a program that is forever locked in a less-productive "still-getting-to-know-you" kind of relationship.

The annual approach allows those relationships to mature. With operations in every state every year, FIA and partner staff will have the continuous contact required to build long-term working relationships. Partners wanting to contribute to enhancing the base program will be able to seek permanent budget allocations and staff to do so, and states that do not choose to contribute resources will still be guaranteed a base level of federal service. Because of annual fieldwork in each state, partners will have the opportunity in any given year to inject additional resources into the program for collecting

additional data about some issue relevant to their needs, without having to wait years until the next inventory for their state. For organizations looking to increase their involvement in FIA, the annual approach to inventory is clearly preferable to the periodic approach. In fact, full implementation of the 20-percent program envisioned by Congress likely will depend on significant partner contributions to augment a base federal program. Significant partner contributions are already forthcoming from many eastern states.

### Conclusion

The change to an annual inventory program offers us the opportunity to simultaneously make other key changes that are needed to improve the FIA program, such as better integration with FHM, increased collaboration with partners, and increased consistency in approaches across all ownerships. It appears that the political momentum has already determined that

FIA will move to an annual approach for the next generation of fieldwork, in advance of development and testing of the necessary technical program components such as compilation and analysis approaches. We have some work to do to catch up.

Simply changing the order in which we visit field plots is unlikely, by itself, to address customer dissatisfaction with the timing and scope of FIA program outputs. Nevertheless, the transition to an annual inventory system, if made simultaneously with other critical changes in the FIA program, in the long run will be in the best interest of the largest number of FIA customers whose greatest needs are for current information and a flexible program framework. If we can simultaneously address the existing problems of inconsistency in methods and incompleteness in coverage, and if we can form partnerships to make available the resources needed to increase the timing and scope of data collection

and analysis, then we will be able to create a collaborative FIA program that will deliver better information for many years to come.

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*Andrew J.R. Gillespie (e-mail: agillesp/wo@fs.fed.us) is leader, Forest Inventory National Program, USDA Forest Service, 201 14th Street SW, PO Box 96090, Washington, DC 20090-6090.*