Personal Reflections on Federal Forest Inventories in the USA

Hans T Schreuder

Abstract--The history of forest inventories in the US conducted by Forest Inventory and Analysis (FIA) and National Forest Systems (NFS) of the US Forest Service is described, with recommendations to what should be resolved and considered in the future. Some emphasis is given to the fact that FIA is a very good value to industry, the states, academia and the country, including environmentalists. Lawsuits and the threat of such have been very beneficial to the development of scientifically defensible surveys on National Forest Lands.

INTRODUCTION

Inventories have a long and illustrious history in the US Forest Service (USFS). It is difficult to manage forest resources without a good inventory and, when resource supplies run low or are feared to be low, monitoring of these resources becomes equally important. Forest Inventory and Analysis (FIA) was the third national inventory (after Sweden and Finland) and has been conducting strategic surveys since about 1929. Strategic surveys refer to the generation of statistical information for large areas such as states or the entire nation. The National Forest System (NFS) has been gathering information for management surveys ever since National Forests were established but such data collection efforts were usually not statistically designed to be of use beyond the boundaries of specific projects such as timber sales or special management areas. Management surveys require knowledge of where the resources are as well as how much is there.

Previous articles on the history of FIA (Frayer and Furnival 2000, Van Hooser and others1992) focused on accomplishments with little discussion of problems encountered along the way. No history of NFS inventories is available. The history for both is presented here from a personal perspective. Open and honest differences of opinion should be encouraged whenever possible leading to change and protection against errors. A reluctance to consider different ideas relating to inventory objectives and needs within FIA may be understandable with the need to produce and to absorb all the major changes that have been made in the last 8 years. But this attitude may eventually be disastrous since new objectives will not be addressed, new technology and ideas will be rejected and FIA could be replaced by more dynamic organizations providing better service. This in turn could be damaging because estimation of historical change might be lost when going to a completely new system.

Whereas FIA surveys have been generally statistically based, NFS has traditionally relied on subjective approaches. FIA surveys were not perceived to be useful to NFS because the latter required in-place management level information, not just statistical information for large areas. NFS inventories are moving slowly in a direction permitting greater statistical rigor.
THE PAST

Forest inventories in the US have a long and illustrious history. Forest Survey, now called Forest Inventory and Analysis (FIA) was initiated around 1930 (Frayer and Furnival 2000, Van Hooser and others 1992) and it appears that at least in parts of the country this was implemented in a statistically valid manner (Lentz 1932). Forest biometrics or exposure to it has a long history in the USFS. R. A. Fisher, generally considered the father of inferential statistics, advised the USFS Southeastern Experiment Station on statistical methods in the 1930’s and names such as A.A. Hasel, F.X. Schumacher, R.A. Chapman, and J.G. Osborne were acquainted with and known by famous statisticians such as Fisher (see Picture 1 for example) and were well recognized in the statistical arena as well as in forestry.

The book by Schumacher and Chapman 1942 on sampling techniques may be the first one of this kind anywhere, as noted by Gregoire (1992). Up to the 1980’s, forest biometricians pretty much went their separate way from colleagues in pure statistics, even though sophisticated sampling methods such as variable radius plot sampling (VRP) (developed in Europe by W.Bitterlich), and Poisson (called 3-P sampling in forestry) and point-Poisson sampling (by L.R. Grosenbaugh) were developed in forestry (Schreuder and others 1993). For example, Poisson sampling was apparently developed independently in statistics by Hajek (1957) and Grosenbaugh in forestry (Grosenbaugh 1964). Whereas Hajek dismissed Poisson sampling as impractical partially because the unbiased estimator he suggested is a good example of how the generally desirable property of unbiasedness can be overemphasized, Grosenbaugh with his practical insights
provided a much more efficient, slightly biased estimator. And his work on Poisson sampling eventually led him to suggest point-Poisson sampling, an unusual example of sampling essentially proportional to a difficult-to-measure variable of interest, tree volume). Even in the 1980’s the statistics profession was unaware of 3-P sampling (personal communication with K.R.W. Brewer, an internationally known survey sampler with one specialization being in unequal probability sampling (Brewer and Hanif 1983). Even though there was not much communication with the statistical community, there was considerable input from forest biometricians to FIA. Floyd Johnson, Station Biometrician at the Pacific Northwest Forest Experiment Station worked with FIA people and several of them also attended Ed Frayer’s short courses at Colorado State University taught by George Furnival, Ken Ware, Mike Cunia, and Jerry Clutter, all prominent forest biometricians.

In 1982 the FS established the Multi-resource Inventory Project in what is now called the Rocky Mountain Research Station and in 1987 the Remote Sensing group at the Starkville Laboratory at the Southern Forest Experiment Station. More frequent communication with the general statistics profession was reestablished by the multi-resource inventory project. This was facilitated by the advent of Forest Health Monitoring (FHM), done for a period of time in a close collaboration between the FS and the Environmental Protection Agency (EPA), by the joint investigation of FIA and the Natural Resources Inventory of the National Resources Conservation Service (NRI) whether their surveys could be integrated (Goebel and others 1998), and by the establishment of the Region 6 and Region 1 Statistical Advisory Boards in NFS. There has been a major change in the mission of FIA. In 1972 H.R. Josephson said: “And we also need to stress that the Forest Survey is a research job and not an action program. For this reason we have increasingly referred to this program as “forest resources research.” Collection of field data is of course an essential part of inventory—as it is with any research study-- but the development and improvement of techniques, the evaluation of data collected, the interpretation of facts in terms of the supply-demand outlook, and interpretation of price, management, and policy implications are the major needs and challenges of resources research.”

Clearly this is not the primary mission of FIA now. FIA data are critical for decision making by industry, the states, and the FS. The production of frequently collected, reliable data appears to be and should be the primary objective of FIA now. For example, only 12 percent of FIA staffing in 2001 was directed at data analysis and only 6 percent is devoted to techniques research (Forest Inventory and Analysis 2002). On the other hand, four of the FIA units now have one or more PhD statisticians or biometricians and certainly the capability of doing research in modeling and development of new sampling strategies exists and some of the units are actively doing research.

An additional quote from Josephson (1972) indicated a strong awareness of an issue that still plagues us today: “The survey must also strengthen its ties with Timber Management and other National Forest Divisions to assure that we have comparable and adequate forest resource data for all classes of forest ownership, and projections of timber supplies that show with reasonable accuracy available future harvests under specified management
conditions. Similar cooperation with some other Federal and State agencies is of critical importance for efficient operation and local acceptance of the Survey.”

In a similar vein, Barnard and others (1979) noted from the Resources Planning Act of 1974 that “…This act further directed the Secretary of Agriculture to, ‘as part of the assessment effort… to develop and maintain on a continuing basis a comprehensive and appropriately detailed inventory of all National Forest System lands and resources. The Forest and Rangeland Renewable resources Act of 1978 which updated Forestry Research legislation, only repeated the amendment contained in the Resources Planning Act.’”

Furthermore, in the same article: “Other legislation such as the Federal Land Policy and Management Act of 1976 (PL94-597) and the Soil and Water Resources Conservation Act of 1977 (PL95-192) share common themes with the above legislation directed to the Forest Service. All of this legislation directs either the BLM, the SCS, or the Forest Service to …2) coordinate and cooperate with other resource agencies and organizations to avoid duplication of inventory and planning efforts,… The importance of cooperation and coordination with these other agencies as we focus on the natural resource situation in this nation is evident.”

There was a marked change in objectives over time in FIA and NFS. Up to the 1960’s, the emphasis was on timber availability, but evolved over time to include expected supply over time as equally important. Still, all the way up to the late 1970’s the emphasis in FIA and NFS was on timber. This changed to a more balanced mix of ecological parameters in the mid 1990’s and in 1998, through lobbying by Southern state foresters and industry personnel (Paul van Deusen, personal communication). FIA was mandated by Congress to go to annualized inventories where 20 percent of the plots in each state would be measured each year.

Data collection on National Forest lands in the West took a different path. Besides knowing how much was there, NFS required knowledge of where it was for overall management and project planning. This led to heavy reliance on maps and on stand examinations, the latter usually relied on ocular estimation (the idea being ‘it is my data, so it is good data’ or ‘this is what I saw so it must be correct). Even when probabilistic samples were taken with trees measured for characteristics such as tree diameters for individual stands, the stands were not a probabilistic sample of the forest and therefore had limited inferential value. Typically, managers were more interested in certain areas than others, again usually associated with whether big trees were present or could be raised there. And in some cases money was so plentiful that there was an expectation by some forest managers that they could do a census of all stands on the forest. That has clearly changed but on several forests we have a large number of stands that were sampled but are not representative of the whole forest. For example, samples were typically put in forested areas suitable for timber production, whereas areas too rugged or inaccessible for harvesting equipment, prime wildlife areas, wilderness and recreation areas could be excluded from consideration.
NFS in the West had little use for FIA since its grid sample was too coarse to be of much help in NFS management and project planning. Instead, NFS relied (and still does) heavily on models in combination with the special surveys mentioned above (see for example Eav 2002 and other references in the same symposium proceedings). These models usually have not been tested for prediction accuracy and have unknown reliability. We then had the odd situation that although FIA was responsible for inventorying all forestlands in the US, some of the lowest quality information for strategic planning was available on western National Forests. Because of the pressure of lawsuits in the West, NFS began to realize that statistically designed surveys are more defensible than the manager-designed and implemented surveys. Region 6 (R6) of NFS in 1992 set up a statistical advisor committee including 2 FIA people, a FIA statistician, an additional statistician from the FS as well as from the Bureau of Land Management (BLM), EPA and from the private sector. This committee designed the Current Vegetation System (CVS) sampling strategy (Max and others 1995) which is at least as good as the FIA survey design from a statistical point of view and has the advantage of meeting both FIA and NFS management objectives. This effort was in some ways too late to allay fears about what was being done on NFS lands in regards to inventory and monitoring.

The lack of perceived quality of NFS data in the West and the failure to be able to generate acceptable estimates of key parameters such as the amount of old growth, led to the establishment of the Forest Inventory and Monitoring Institute (IMI) in Ft Collins, CO in 1998 (Patrice Janiga, personal communication). IMI provided the necessary coordination to lead to similar efforts of that of R6 in R5 (California) and especially R1 (Montana, Idaho, South Dakota).

**FIA and NFS Inventory and Monitoring Both Have Strengths and Weaknesses**

FIA inventories have been important to their users, industry, the states, academia and the country, including environmentalists and have become more so over time. (More so in the East than in the West, perhaps due to differences in ownerships and information needs because of those differences.) This has necessitated changes in objectives over time, generally by adding objectives. FIA has or should have been working with the following principles:

1. Credibility and hence validity. This is generally foremost.

2. The Keep It Simple (KIS) principle. Data collection, analysis, etc should be as simple as possible so all interested parties can understand and know clearly what was done.

3. Practicality. Being production oriented, FIA often has put too much stock in this principle. Short cuts are taken with the justification that they are OK as long as they do not violate the first principle above. In several instances they did. An interesting recent example in one FIA program allowed field crews to drop the fourth subplot from measurement in the current plot design if they could not otherwise meet their target of eight plots per 2 week period. This can potentially introduce serious bias in
what is measured and estimated since the more difficult subplots are likely to be dropped.

4. Timeliness of data and reporting results. One of the major challenges for FIA has been, and continues to be moving the field data through the analysis and reporting process so the user gets the information in a timely fashion. More and more it will become as critical to make the data available online for users to do their own timely analyses. This brings with it the need for FIA to develop procedures and post warnings to minimize inappropriate uses of the data.

FIA Shortcomings

FIA originally was very much a timber survey. Right from the start, some FIA units insisted on locating all subplots of their plots in a given forest type (Lentz 1932) such as, for example, saw-timber stand, pine plantation, or hardwood stand, despite the undesirability of this as eloquently enunciated by L.R. Grosenbaugh (personal communication), the most prominent forest mensurationist at the time in the US. This was done to make computing simple and to ensure a good sample for each stand in that type rather than partial information on several stands by a given plot. Some of the FIA units did not make this mistake, but instead averaged over conditions so that a state might be estimated to have much more acreage in mixed pine/hardwood stands (for example plots with half of the subplots in a hardwood stand and the other half in a pine plantation would be classified as a mixed pine/hardwood stand) than the next-door state rotating plots into the same condition as the center location. (The inconsistency in results between 2 fairly similar states because of their difference in approaches was pointed out in the 1980’s by a forester working in Florida but for a long time no action was taken to remedy this problem, nor did the states or industry raise a furor). Another unfortunate situation occurred in that although destruction of original data is not permissible in the FS, the field data from the first three FIA surveys in various regions disappeared somehow.

In the early 1960’s FIA was mandated to go immediately to variable radius plot sampling (VRP) for trees larger than 5” dbh (the small ones were still measured on a small fixed area plot) instead of the fixed area plots being used (see Spada 1960, which was the basis for the decision apparently). In fact, one project leader told the author that he was ordered to do so in the middle of a state survey. VRP sampling is quite efficient if interest is in timber volume because it gives larger, more valuable trees a higher probability of selection. It also makes it more likely to have enough sample trees in the forest types of main interest (such as saw-timber stands) because they require a sufficient sample of large trees and has the practical advantage that fewer trees have to be sampled since many nearby small trees may not be selected. Having to count and sample a large number of small trees is considered (understandably) a bane in FIA, even now. The disadvantage of VRP sampling is that this method is not particularly efficient for change estimation, which at that time was already as important an objective as amount of standing timber and VRP sampling makes analysis of change more complex. It thereby violated the FIA KIS principle, so vital to users and field crews. Clearly change was not part of the assessment of the relative merits of plot designs but should have been a key component in
evaluating the utility of fixed vs. VRP plots. Changing field plot design makes inference about assessing change difficult and caused considerable difficulties in FIA during the 1980’s in the Alabama/Georgia growth decline controversy (Schreuder and Thomas 1991 with comments and references therein) especially since estimation procedures were not well documented either. Changing sampling methods also created problems in making projections for the 1970 and 1980 RPA reports.

Complexity was also introduced by the use of sampling with partial replacement of plots over time (SPR), developed by A. Bickford in the late 1950’s. From a statistical/conceptual point of view this offers considerable statistical efficiency over complete remeasurement and especially over complete replacement sampling. SPR estimation was reasonably feasible at the time of the first remeasurement but was difficult to implement and was discontinued at later times because it too violated the KIS principle and required too much analysis time to process requests from users.

A serious problem at one of the FIA units existed but was never publicized. In the 1970’s growth and mortality models used for research studies were modified to update FIA plots that were not remeasured at a given time. The quality of these updates was never established and to make matters worse, such update information was then treated as real data in state reports.

An example of a good idea, badly implemented, is the use of quality control crews to monitor the quality of the data collected by the regular field crews. Not only were bad data replaced by good data on a non-random set of plots checked, but in some cases crews knew what plots were going to be checked before they did those plots.

A continuing and unfortunate problem in FIA is the serious underanalysis and timeliness of the data and reports (see for example letter from State Forester of Texas James B. Hull to the Chief of the FS, June 4, 2003). It is expensive to acquire the data and it could be used in many new applications, especially if FIA had encouraged users to do so and had a national database. Differences in sampling strategies between FIA units, lack of documentation, sudden change in plot design and the complexity of the variable radius plot sampling made the data difficult to use for users and limited the number of people that were even aware of it. An example is the collection of understory vegetation data thought to be useful for wildlife managers who apparently did not use such data and often were not aware of it.

Another serious problem hampering FIA was the extreme decentralization in the FS, creating numerous problems. FIA project leaders/program managers were quite autonomous especially since they reported to station directors who were even more autonomous, reporting directly to the Chief of the FS. This and the fact that all project leaders/program managers were taken out of the research evaluation career process in the 1990’s and became pure managers to give them better promotional opportunities led to FIA having very little flexibility in responding to national or interstate user needs and de-emphasized the creativity that FIA did exhibit before then. A national database should have been a priority for FIA right from the start and yet this was not considered important in the decentralized framework that FIA was allowed to work under. This was recognized
in the 1980’s and an Eastwide data base was started at that time. But because of a lack of national vision, it took at least 15 years to complete an east-wide FIA database and several more years to then complete a west-wide one.

NFS Shortcomings

The data collection efforts conducted were, as mentioned before, quite subjective and indefensible. They also yielded constantly different results, as managers changed. An interesting example of this is when the author joined the FS he found out after he helped plan a statistically valid recreation survey for a National Forest that the managers there were quite unhappy with the results since it showed only 10 percent of the use they had been reporting up to then. When two other recreation specialists were pressured to consult with him, at the end of the day they were quite honest, saying ‘we don’t want a valid statistical procedure. We were required to report recreation use one year and every year since we have simply added 5 or 10 percent to that number’. Lack of statistical expertise often led to NFS surveys with hazy objectives and unrepresentative data resulting in considerable waste of money and time consuming and expensive lawsuits. Inconsistent methods, variable scales, and lack of statistical basis often precluded aggregation of NFS data in a meaningful way. There was little or no coordination between the various regions; they rarely met together until the Inventory and Monitoring Institute (IMI) facilitated such a meeting in 1998.

THE PRESENT

FIA was criticized harshly in regards to responsiveness to users, timeliness of reports, and lack of creativity by the Second Blue Ribbon Panel Report of 1998 (Forest Inventory and Analysis 1998) even though many of the members of this panel were quite pro-FIA. The Assistant Secretary of Agriculture had been rightfully quite critical of FIA and the Natural Resources Inventory (NRI) of the National Resources Conservation Service that two sister agencies generated very different estimates of the amount of forest area in several states even though they supposedly used the same definition. This nagging problem has been allowed to persist for over 15 years and is still not resolved although the problem has been clearly identified and could be resolved without much difficulty (Goebel and others 1998). Differences were due to different implementation of a common definition of forestland, differences in what constitutes a tree and reliance on remote sensing by the NRI vs ground sampling by FIA.

Even the most creative idea in FIA, the idea of annualized inventories, originally called AFIS (annual forest inventory system) was spawned to a considerable degree by a state (Minnesota), although a PhD dissertation by a NC FIA researcher also played a significant role (Hansen 1990). The idea came about when FIA could not address the issue raised that aspen/birch was being cut excessively in Minnesota. The Minnesota Department of Natural Resources (DNR) was not happy with the FIA response that they would have to wait 10 more years before it was back in that state with its periodic survey. AFIS was spared from ignominy because of a complete lack of progress in developing analysis reports summarizing the AFIS data collection, not by FIA, but by southern state
foresters and industry biometricians anxious to get the needed FIA data on a 5-year time period rather than over a longer period. (Partial credit should also be given to a meeting between the Chief of the FS with the State Forester of Minnesota who was instrumental in arranging the meeting, the Chief Executive Officer of the Society of American Foresters, the President of the American Forest and Paper Association and the author. It is not sufficiently well known that the Minnesota DNR more than anybody else deserves the credit for FIA going to an annualized inventory). This led to the adoption of SAFIS (the southern annual forest inventory system), a simplified version of AFIS mandated to be used nationwide by the FS through a congressional law (Agricultural Research, Extension, and Educational Reform Act 1998-PL105-185). The congressional mandate was passed to a large extent because of strong lobbying on the part of the American Forest and Paper Association and also because it was recommended in the second blue ribbon report of FIA (Forest Inventory and Analysis Program 1998).

Only recently is a central computing algorithm being implemented that can handle the data from all FIA units. Not having this before led to inconsistencies, lack of credibility and perpetuates the false impression that only the NRI has a national database (even though it only covers private lands), whereas FIA does not (personal communication from users of NRI testifying before a blue ribbon panel (USDA Natural Resources Conservation Service 1995). FIA still falls short of getting the information required or desired by many user groups. Examples are clear guidelines on what FIA can offer on cause-effect and reliable spatial information, lack of willingness to cooperate with obvious collaborators such as NFS and the NRCS, lack of information on riparian zones, good taper models so industry could fit the data to any desired standards for their products, national information on understory vegetation, etc. Although one might argue that such collaboration is now ongoing because of the presence of NFS, State and Private, Academics, and state personnel on the various working groups set up by FIA, these people are not true collaborators but more advisors. A typical response to their requests is: yes, if you provide the money or personnel to collect that, we will. This is a lack of vision. And such a lack of vision in FIA is also the reason for the following problem:

Rather than work with NFS, FIA is trying to do NFS inventories too, with insufficient input from NFS, even though NFS needs are to a large degree different from those FIA can accommodate currently. NFS requires knowledge of where a resource is and how to classify key information correctly often with a 1-way error (Williams and others 2001, Schreuder and others 2000), for example, plots that are old growth may not be classified as such but plots that are not may never be classified as such. NFS needs a combination of mapping (assessed for accuracy), larger sample plots, and more intensive data sets so reliable small area estimates can be generated. Because of pressures on the parts of courts and threats of lawsuits, NFS is now much more open to scientific approaches to data collection and analyses. But the desire to use purposively selected stand examination data is one that does not seem to disappear rapidly. NFS finds it difficult to let go of ideas such as ‘I can judge what is representative’, ‘it is my data so it must be good data’ and lack of faith in the rather sparse FIA grid. NFS needs ownership in the data collected just as FIA does and this can only be accomplished through close collaboration.
If successful in completely taking over the role of doing all surveys for the USFS, this shortsighted view on the part of FIA will lead to gross inefficiencies in inventories, unmet NFS objectives, inadequate analysis, political empire building, and lack of cooperation. Such issues need to be addressed initially in a scientific framework instead of the parochial approach being attempted by FIA. FIA objectives have changed, yet there is no real awareness that some new objectives are at odds with a timber survey. Also, new complex objectives may necessitate engineering an essentially new program particularly with the new technology available for more efficient sampling, i.e. including less intensive ground sampling (see for example the scenario described in Schreuder and Wardle 1999). Key new objectives are the development of a good data base as the primary product, facilitating the identification of possible hypotheses about changes detected, assessment of ecological parameters not necessarily related to big trees, serious quality assessment work to maintain credibility at an even higher level than currently and the opportunity to integrate with the NRI to take advantage of opportunities in cost efficiency and (for example) the NRI special expertise in assessing key parameters on soil and erosion of considerable interest to users such as industry and environmentalists.

Although NFS in certain regions has made great strides in developing scientifically defensible surveys, there is no general strategy to do this. R6 has such a survey, R5 is developing one, and R1 may be developing one that may serve as a prototype of how NFS surveys should be conducted. Unfortunately because of what was done in the past, the Western National Forests do not have a reliable historical data base. The other regions with few National Forests in the South, East and Midwest rely to a large degree on FIA.

**What FIA has done right?**

FIA clearly enjoys considerable support from state foresters and industry despite a very critical second blue ribbon report that criticized FIA for its lack of responsiveness to user requests. FIA enjoys considerable scientific credibility because there is a reasonable amount of quality control if not quality assessment on the measurements taken. Variables are usually measured in a very repeatable manner by highly trained professionals dedicated exclusively to such data collection, rather than using subjectively estimated data. FIA has often taken the mandated annualized inventory as an opportunity rather than seeing it as a problem at least in the Southern, Eastern and Midwestern FIA units. Examples of such opportunities are the switch by the SO FIA unit to heavy reliance on state crews, the use of contractors to lower costs in the north central FIA unit, the appointment of national committees with representatives from several partners (called technical bands) to work on common FIA problems, the SAFIS advisory board meeting and its successor, the Annual FIA Symposium which meets annually with representatives present from FIA, industry, the states, and universities; and increased funding from Congress to do more work.

The utility of FIA data and Public Laws 95-313 and 101-624 resulted in a new program called Forest Health Monitoring (FHM) around 1990. This effort was kept essentially separate from FIA (rightfully so in the author’s opinion since it was determined initially that it required considerable destructive sampling on the FHM plots and several annual
visits) but is now being merged into FIA as a sub-sample of FIA with additional data being collected including some potentially useful new variables. FHM serves in one sense as a field laboratory of potentially useful data that may or may not be collected in the more intensive FIA grid data collection in the future.

*What NFS has done right?*

The IMI has made significant strides in helping NFS develop more scientifically valid sampling strategies especially in Region 1: Idaho, Montana, and North Dakota. They are providing the needed leadership to allow the Regions to develop scientifically valid inventory and monitoring systems for strategic, management, and project planning purposes. The Western Regions are collaborating more to take advantage of each other’s strengths. R6 was on the forefront of starting annualized inventories with several remeasured panels and is taking the lead on how to estimate annual changes in populations. In 1999 NFS vegetation inventory programs in Regions 5 and 6 concurred with synchronizing their plot designs and collection methods with the FIA units to ensure consistency of strategic vegetation inventory in Oregon, Washington and California.

Also, in 2000 NFS signed memoranda of understanding (MOUs) with FIA to establish NFS funding to FIA to cover costs of data collection on NFS lands and establish participation on FIA management and executive teams. The NFS representatives to the FIA executive and management teams can foster coordination and continued alignment of NFS information needs with the data obtained and managed through FIA and its comprehensive program of coordinated statistical, analytical, information management, quality assurance and reporting methods.

In 1999 the Interregional Ecosystem Management Coordinating Group (comprised of Deputy Regional Foresters and Associate Station Directors) charged the IMI to lead a team of NFS inventory coordinators in an assessment of inventory programs throughout the agency. The findings and recommendation from this group served as the foundation for the agency Framework for Inventory and Monitoring. In 2001 the three branches of the FS, NFS, research and state and private forestry entered into collaboration on a strategic framework and action plan for all inventory and monitoring programs to improve the quality of programs by adopting the following vision and principles:

“The FS leadership is committed to using state-of-the-art methods and a systems approach to provide highly credible data and information to meet a wide range of customer business needs in collaboration with our land management partners.”

The vision was elaborated as follows:

- Utilize a systems approach to inventory and monitoring that adopts a holistic view, recognizes complexity and interactions, and accounts for the dynamic nature and finite capacities of ecosystems.
• Inventory and monitoring are done with the clear purpose of meeting the agency business requirements (at all scales and organizational levels) as determined by the needs of our varied customers and partners.
• Inventory and monitoring are conducted in coordination, cooperation, and collaboration among Forest Service program areas and organizational units and with partners and customers.
• Inventory and monitoring methods and results are scientifically credible and meet rigorous quality assurance and quality control standards.
• Leadership clearly defines the structure for implementing the Framework; provides the resources needed to accomplish the tasks; and is held and holds others accountable for the success of inventory and monitoring programs.

Where Do We Go From Here and How Do We Go About It?

To answer these questions, we need to know what the objectives are and how to address them fully in future FIA surveys or their successors. Clearly, there needs to be a concerted effort by both FIA and NFS to ascertain what the current objectives of their surveys are, should be and where cooperative efforts can occur. I see the objectives as:

1. Generate current status estimates such as acreage in forest, volume by species groups, growth, mortality, harvest, and forest products for large areas.
2. Change in the above parameters.
3. Establish procedures required for identifying possible cause/effect relationship hypotheses. Ideally it would be desirable to attach probabilities or weights to these hypotheses. For example, if there is a growth decline in pine forests what are the possible reasons: pollution, drought, and disease? Subjectively we might then assign probabilities of 0.33 to each unless the data suggests that one hypothesis is more likely than another.
4. Establish procedures required to prove or document cause-effect. Since cause-effect can rarely be established with FIA data and usually requires follow-up experimentation, it is important to indicate what can and cannot be done in this regard.
5. Provide in-place information for managers by proper development of such techniques as using maps in conjunction with small area estimation. This requires documenting the approaches needed to generate reliable information and how to assess the reliability.
6. Provide timely information for decision makers. Bayesian techniques could have real utility here.
7. Maintain a reliable database with comprehensive documentation and reliable archiving and encourage better and more analyses.
8. Define desirable additional information and how to collect it. Different types of plots at the same grid locations should be investigated in order to collect variables efficiently especially now with the increased resolution of remote sensing sources. Even if FIA does not collect the relevant information it should have recommendations on how it ought to be done and perhaps by whom. Examples of desirable additional variables that can be collected with different plots are riparian habitats, certain types
of aquatic information, and wildlife nesting habitats whereas recreation use can clearly not be collected in the current FIA context.

Originally the Forest Survey was established for objective 1. Over time as concern for timber supplies became more critical, #2 became as important. An example of number 3 became important in the 1980’s with the growth decline issue controversy in the states of Georgia and Alabama. We would like to establish cause effect (#4) but this takes both survey sampling and experimentation except in rare circumstances. #5 has always been an important issue for NFS but only now can it probably be done in a satisfactory manner using small area estimation and the opportunity to use very good remote sensing information that was not available earlier, #6 is a critical one for national forests which awaits to be resolved, and #7 has always been important but will become even more so with the annualized inventory where industry and the states will want to analyze the data much more frequently without help from FIA. The limitations of FIA data as in #8 should be clearly documented in one or more documents and updated as needed over time. This requires further research into plot designs and integrating plots of different sizes as well as integrating different surveys.

There should be a big push to merge FIA strategic and NFS management inventories, highly desirable under proper circumstances from a cost and utility point of view. But both NFS and FIA should have ownership in this. It is also quite desirable to merge FIA and NRI. How should this be done properly? How do we go about ensuring that FIA and NFS procedures are documented properly, how do we stay away from the us vs. them mentality where data are discounted because they are not ours and considerable waste occurs because of duplication of effort, how do we develop a national estimation and analysis computing algorithm, how do we make sure science is properly considered in all decisions, and how can we lower costs of data collection without sacrificing quality and credibility of data?

Solutions

The following solutions typically have a bearing on all or most of the objectives listed, the main difference being in what they might emphasize in meeting specific objectives:

1. The FS and NRCS need to appoint a statistical advisory board of at least three highly qualified biometricians to approve any plans regarding a joint or separate NRI/FIA/NFS inventory sampling strategy. (The 1998 Blue Ribbon Panel on FIA recommended an external Statistics Review Board, but this has not been implemented by FIA, a serious omission). Only after this board has given the green light should it be handled politically. To paraphrase Lave (1990) who made a similar argument to have a statistical advisor needed for the Surgeon General of the US (my modifications in bold): ‘The greatest need is for a statistical advisor who will bring informed, skeptical perspectives to interpretation of the data. Sometimes, despite the best efforts of analysts, the estimates are meaningless. When this is true, someone has to say it. Government and industry decisions that involve millions of people, billions of dollars, and that have implications for forest health must have as solid a basis as can
be achieved in data analysis. A statistics advisor is needed to interpret what the data mean and what are incorrect inferences’. This may be possible now that the FS is making some efforts to become more centralized in its decision making because of financial and political pressures.

2. All designs and estimation theory flowing from the annualized inventory, possible modifications of it and NFS inventories should be reviewed critically by competent biometricians in-house as well as by outsiders before being published in peer-reviewed journals and used by inventory groups in generating estimates and doing analyses. Evaluations should be made in terms of meeting strategic, management and local planning needs.

3. A major effort is needed to develop a national, well-documented, easy to access database for the FS with a careful documentation of what the database can and cannot do for its users. The Blue Ribbon Reports commented on the lack of user friendliness in FIA. Such a data base should really be the main product of FIA. As indicated in Maurer and others (2000), large sophisticated databases should not be left to chance and improvisation.

4. Mapping and sampling using VLSP, Thematic Mapper (TM) remote sensing, and successors to TM such as IKONOS and LIDAR should become integral components of the large-scale inventories. The utility of using several plot designs at each sample location, rather than only the current poorly defined FIA primary sampling unit (plot) should be investigated. Map accuracies should be assessed in a statistically valid manner (Schreuder and others 2003).

5. The dogma of confidentiality of plot locations needs to be carefully (and cautiously) revisited. Although it is true that this is supposed to be confidential information, how do we deal with the potential issue that on federal lands it is not kept confidential or plots are visited so frequently that they are no longer representative of the conditions they are supposed to represent and what are the implications of these concerns on permanent plot sampling? Confidentiality and representativeness will be especially issues on NFS and other federal lands because locations of plots will be more generally known and plots are likely to be visited more frequently.

6. NFS representatives to the FIA executive and management teams should regularly attend the meetings of these teams and express their opinions in regards to NFS needs and desires.

7. A committee should investigate the desirability and feasibility of privatizing FIA and possibly the other inventories to be done. It is quite likely that private companies can do the whole survey better and cheaper than FIA. And such organizations could be more responsive to changes requested from those controlling the budget. At the very least contract fieldwork appears to be quite cost-effective and should be applied more generally.

8. Changes to the national inventories should be carefully considered, written down, and widely discussed before being implemented. FIA, NFS and NRI inventories and monitoring efforts should be integrated and merged. There is no scientific reason why there could not be one national natural resources inventory combining the strengths and satisfying the objectives of FIA, NFS, and NRI. New objectives should be carefully considered for inclusion. For example, Olsen and Schreuder (1997) concluded that a pronounced shift is needed in the designs applied to forest and range.
The designs should not only address simple status and trends estimation but also emphasize identification of interesting changes in the sampled populations and facilitate identification and establishment of possible cause-effect relationships.

9. Through implementation of the annualized inventory nationwide, FIA can become an annual national resources database that can answer such key environmental state-of-the-health questions as change in tree growth and mortality annually, change in forested area and species composition, etc. Combining FIA with NRI and NFS inventories can extend this to range, croplands, and lands going into urbanization to include also additional key soil, erosion, and urbanization variables and have reliable information of where the variables occur as well as how much there is. Let us make sure we have a national database that is perceived as such, that is credible, and for which data are collected and analyzed with maximum efficiency!

POSTSCRIPT

As I look back over time, I have learned the following lessons in my career:

1. The objectives of a successful survey will change over time. They will become more encompassing! For example we in FIA have changed from estimation of current stocks to that plus change in them, to those two plus identifying possible hypotheses why changes occurred and maintaining a reliable and readily available data base. We are still looking into providing better spatial information as wanted for management purposes.

2. Be creative and don’t lock yourself into existing approaches. Allow for change. An example is plot design where we have gone from strip sampling to line sampling with square plots to VRP subsampling of circular plots to sampling circular subplots of a circular plots and I suspect we will be moving at some time to sampling locations with various plots for different purposes. (Personally I favor long narrow strip plots of a fixed length and width but I have not been able to get many others excited about this). If sampling systems are changed, provision needs to be made for assessing changes (growth, mortality, removals, densities of forests, insect and fire impacts, etc.).

3. The estimates/analyses can be and should be as defensible as possible. There is a fundamental principle in FIA: KIS. My recommendation is to keep the design simple but allow for more complexity in the analyses, since different people want to do different things with the data. My suspicion is that we will have big controversies in the US in analyzing the annualized data sets before things settle down. It is likely that big annual changes will be detected, supposedly due to one or another bad development (disease outbreak, overcutting of a certain species, etc.), when in fact due to the small sample size used.

REFERENCES


Spada, B. 1960. Office report of the results of “a test of several designs for sampling an acre to obtain forest survey volume and area statistics and area condition classification data” Sept. 26 1960.

