

An Annualized Forest Inventory for Nebraska

Hans T. Schreuder and Tom D. Wardle

Abstract.—This paper addresses opportunities presented to states by an annualized forest inventory system, to be conducted by the Forest Inventory and Analysis program of the USDA Forest Service, and concerns about these inventories. The importance of a balanced approach in assessing timber and nontimber attributes is emphasized, and the paramount importance of maintaining and even increasing the credibility and utility of inventories is discussed. Annualized inventories appear to be a very good idea for Nebraska if implemented properly. A key issue facing forestry and agriculture in Nebraska is used to illustrate how annualized inventories can be more informative than the previously implemented periodic surveys in managing a state's land resources.

Traditionally, the USDA Forest Service's inventory of the nation's forest resources has involved a periodic visit to each state, with the stated intent of a 10-year cycle. When a given state's "turn" came, Forest Inventory and Analysis (FIA) field crews would move to that state and measure plots as quickly as possible; when the field work was complete, data analysis would begin and the crews would move to the next state in the sequence.

An annual inventory system is based on the concept of sampling a certain number of FIA plots annually in each state. This approach was developed in collaboration among the Minnesota Department of Natural Resources, the FIA unit of the North Central Research Station, and the Multiresources Inventory Project of the Rocky Mountain Research Station. The idea was to test the system initially in the Aspen/Birch Survey Unit of northern Minnesota and, after a few years, apply it in other parts of the state. This approach was intended to be cost-neutral relative to the periodic survey, and this was shown to be true (Schreuder *et al.* 1998). The original plan was to divide the permanent plot database for a state into one or more "disturbed" strata plus an undisturbed stratum, using Landsat TM data. What constitutes disturbed depended on what could be consistently assessed as such from the TM data, such as clearcut plots. Then a large sample of disturbed plots and a small subset of undisturbed plots would be remeasured annually, subject to the constraint that all plots would be remeasured over a 20-year period. The thinking was that growth, mortality, and other change on the undisturbed plots could be predicted using models, with only a few

sample plots being remeasured to verify the validity of the models. The disturbed plots could not be modeled so information would be gathered by visiting a large sample of these plots on the ground.

Another annualized inventory approach, Southern Annual Forest Inventory System (SAFIS) was introduced and quickly accepted as the way to conduct surveys in the Southern US. In SAFIS, a certain percentage of the plots in the state would be remeasured each year, with the intent of measuring 20 percent of the plots each year across the state without regard to disturbance.

In 1998, the "Agricultural Research, Extension, and Education Reform Act of 1998," Senate Bill 1150, was passed and signed into law. It mandates that 20 percent of all FIA plots in each state be measured each year. The purpose of this paper is to examine the impact and opportunities of this mandate in Nebraska and similar states.

BACKGROUND

Nebraska's commercial forest land base is small, and the industry that depends on it is also small and widely scattered. Nebraska's resource, however, produces all the benefits that other states' resources produce, and its forest industries, while fewer in number, are as important in their local economies as anywhere. Other values, including soil protection, water quality protection and enhancement, wildlife habitat, and recreation are also important. FIA needs to address this wide range of interests even better than in the past for maximum utility to key user groups such as the State Forest Services of Nebraska and other Great Plains states. The limited amount of forest land in Nebraska relative to other states means that only a small number of sample plots are used currently in the FIA survey and selecting only 20 percent of these plots each year constitutes a small sample.

Mathematical Statistician, USFS, Rocky Mountain Research Station, Fort Collins, CO, USA, and Deputy State Forester, Nebraska State Forest Service, Lincoln, NE, USA.

The responsibility of the FIA units is to inventory the forest resources of the nation. Thus, it is important that the annualized inventory apply in all states, not just in the major timber-producing ones. Also, it is critical that analyses cover other forest outputs as well as wood fiber. The shift in the USDA Forest Service in recent years from interest in timber products to interest in all forest products is a necessary and welcome evolution that is continually forcing change in the work done by FIA.

FOREST INVENTORY AND ANALYSIS IN NEBRASKA

In Nebraska, FIA data are used for essentially the same purposes as in other states. There are, however, significant differences. Nebraska's forest industry is characterized by small plants that are widely scattered and not organized into trade associations. Industry requests to FIA and the Nebraska Forest Service for data are infrequent and unpredictable. Most sawmills in the Plains states are very small and, in many cases, the quantity of wood available to a mill is not a serious concern. In most locales, timber does not play a dominant role but is one of many benefits derived from the forests. FIA data are used by the Nebraska Forest Service to understand the resource, to help make predictions on future forest condition, and impacts on range and wildlife resources, and to help understand the influence of change in the agricultural environment on the forest resource itself and vice versa.

Nebraska's most recent forest inventory was conducted in 1994 and involved 431 sample plots. The inventory found that timberland totaled 898,400 acres of which 174,000 acres were ponderosa pine and 110,000 acres were eastern redcedar or eastern redcedar/hardwood. The remainder was made up of hardwoods of various types. In 1994, in total, the state contained 947,700 acres of forest and 1,253,500 acres of nonforest land with trees, scattered throughout more than 49,000,000 acres.

Previous inventories were conducted by FIA in 1955 and 1983. Because of the long delay following the 1955 inventory, the state conducted its own survey in 1977 using FIA procedures, but not their plots. In this situation, it is meaningless to speak of an average cycle (time interval) for inventories. In the past 2 decades, the North Central Station has set a goal of a 10-year cycle but has been unable to maintain it. The long and unpredictable cycle length is perhaps the greatest disadvantage of the current system. In a state such as Nebraska, which is dominated by production agriculture, a forest inventory that comes out perhaps every 10 or 12 years is not very visible. People forget about it and are unaware that useful data are available to assist them in managing the land resource. Agricultural interests get data on some crop and livestock issues several times a year, monthly, or even

daily where prices are concerned. Forest inventory data have, as a result, had little impact on agricultural decisions.

An important advantage of the current system is that it involves a periodic visit by a credible and neutral outside entity and the results are accepted. To the extent that states become more involved in the data gathering and analysis, the idea of a largely unbiased inventory could be eroded. A shorter cycle, if it brought with it the perception of less credible data, would not be the choice of the Nebraska Forest Service.

Some states, perhaps because of the great importance of their timber resources, have been successful in going to their state legislatures, or forest industry groups, and requesting funds each time a Forest Service inventory was scheduled. For at least some states, it would likely be easier to obtain a relatively small amount of funding on an annual basis.

OPPORTUNITIES PRESENTED BY AN ANNUALIZED SYSTEM

More frequently updated inventory results may well increase the visibility of forestry information in states that are heavily influenced by agricultural interests such as Nebraska. Annualized updates will mean more awareness and acceptance for forest inventory data, and greater awareness of the forest resource by all interests should result in improved land management programs. In addition, more users and more frequent uses of FIA data should, over time, improve the quality and the importance of the data. A real opportunity exists to develop consistent, comprehensive, well-documented, and user-friendly computer programs for estimating and analyzing the national resources, something that has been conspicuously lacking in FIA.

CONCERNS WITH AN ANNUALIZED INVENTORY SYSTEM

Concerns have been raised about the potential for FIA to direct more of its analytical and data processing resources toward the more heavily forested states. In the old system, there was a clear focus on each state each time its inventory was conducted. The national mandate of FIA would be weakened if the annualized system's requirement for nearly continuous analysis of data gathered in the major timber producing states would be met at the expense of the smaller ones.

An annualized inventory system will produce some results each year. A potential danger is that some of these estimates will be accepted as reliable even when they are not. Annual estimates for states with many sample plots,

such as Minnesota, will be reliable, but this may not be true in Nebraska. The reliability of the estimates generated and the closely related impact of an annualized inventory process on confidence intervals need to be addressed.

Other concerns relate to budgeting. What, for example, would be done if, 4 or 5 years into an annualized system, budgets were cut and field work had to be interrupted? Under the traditional system, the cycle length would be extended by whatever time period the budget problem dictated, but the statistical validity of the end result would not be compromised. Similarly, if Nebraska had a perceived serious problem in its western part, so that most or all of the ground sampling should be done there in a given year, how might this affect the estimation and analysis? Would it be feasible to interrupt the annual sample with a one-time inventory focusing on a specific geographic area? Intensification of the sampling grid, if the budget were available, is straightforward, but other approaches focusing primarily on subsets of attributes should be considered.

DISCUSSION

At present an approach that does not include disturbance detection appears to be the logical one to use initially for annualized surveys. The simplicity that results from not having to use such detection before implementing the sample of ground plots makes the approach much easier to implement and more generally applicable. Assuming 20 percent of the plots are measured each year, approximately 86 field plots will require measurement annually in Nebraska. This number of plots is based on the total number of plots from the 1994 inventory and could change if the sample grid or expansion factor or other characteristic of the inventory design changes.

The main product of an annualized inventory is the annual database, which should be made available immediately to the State Forest Service and other interested user groups. FIA in the North Central Station may need to set up a full-time position for a statistical analyst to encourage proper and full use of the data by states and other user groups. The best approach to staffing is likely to combine national level expertise for support and coordination with increased local capacity. Development of consistent, comprehensive, user-friendly estimation and analyses programs should be a high priority for FIA to facilitate such interactions. The FIA Table Generator Web site, operated by the Southern FIA office in Starkville, Mississippi, is an excellent example of the kind of user-friendly access to data that can be established. Such necessary interaction between the Plains states and FIA will have the further benefit of encouraging a better balance between timber information and other forest resource information in future FIA surveys of the states.

We propose that the standard core tables generated by FIA should be published every 5 years for Nebraska using simple averages and totals for the entire 5-year data set, until better weighting methods are available for combining the information from the 5-year period. For some parameters, such as area under forest or change in forested area, statewide Thematic Mapper coverage used in conjunction with even only 86 ground plots could yield reliable annual estimates. For other parameters, improved models should be developed by researchers, using plot-level models, single-tree models, and multiple imputation to update plots not remeasured in the years of interest. Such updating techniques should be developed to accommodate user groups but should not be used to update the plot information in the actual public database until proven to be completely reliable. Modeling might become useful for projecting the current inventory results into the future so the implications of continuing current trends could be evaluated.

With annualized inventories, opportunities might exist to sample specific parts of Nebraska more intensively at some times to investigate something of particular interest. This would be accomplished by either obtaining special funding to intensify the sample in the area of special interest, or by using low altitude photography to gather information, or both. Satellite imagery might also play a role.

The possibility that the 20 percent annual sample might not be sustained has to be considered. Changes due to the increased sampling for issues of special interest or any change that makes it impossible to maintain the 20 percent sample each year will cause differences in probabilities of selection of plots. This complication in analysis should be accommodated immediately in estimation and analyses programs developed for annualized inventories.

Examples of special interest in Nebraska include assessing the impact of single-tree selection cutting, often involving only a few trees per acre, used with black walnut, assessing the impact of the seed-tree partial cuts now being used in ponderosa pine stands, and monitoring the proliferation of eastern redcedar in the state. The following data are from the 1983 and 1994 Nebraska inventories:

Area and number of eastern redcedar in Nebraska		
	1983	1994
Area (thousands of acres)	42.2	109.8
Number of trees(thousands)	18,719	30,023

(Source: Table 4, Area of Timberland by County and Stand Size Class, and Table 11, Number of Growing-stock Trees on Timberland by Species and Diameter Class, FIA Table Generator web site maintained by the Southern FIA

unit at Starkville, MS, World Wide Web address:
<http://www.ssrsfia.usfs.msstate.edu/scripts/ew.htm>).

Although these figures indicate a significant increase in the occurrence of eastern redcedar, many important questions remain unanswered; for example, was the increase consistent from year to year or was it concentrated in specific years? Was there an increase in the first few years after the 1983 inventory but that has now ended? An annualized system would help answer such questions. This change in Nebraska is so significant that even the 86-plot, 20 percent annual sample, resulting in about 7-8 plots in the eastern redcedar resource might at least give a hint that something is going on and could lead to follow-up work. Certainly 2 or 3 years of data would. For a full understanding, it is likely that more data would be needed, e.g., by acquiring and interpreting low altitude photography that should be cheaper than measuring additional ground plots. In this case, the cost of the additional work should probably be met by the Nebraska State Forest Service. If the same phenomenon is observed in adjacent states, there might be a case for increasing the frequency of sampling in each, perhaps funded by the affected states. The traditional FIA system would require that we wait another full cycle of perhaps 10 or more years before investigating the phenomenon further.

Under an annualized system, field crews will probably be located in the "center" of a group of plots assigned to them for measurement. In heavily forested states, crews will be able to work relatively close to home, but that won't be possible in the Plains states. We recommend that two field crews of two people each be stationed in a central location such as Lincoln, Nebraska, or perhaps one crew in Lincoln and another in Rapid City, South Dakota. Other cities may be selected provided the crews are located close to their areas of responsibility. Such crews, for example, might be responsible for Nebraska and parts or all of the surrounding states. These crews, perhaps partially state funded, could also collect harvest and production data from local mills, not a usual responsibility of FIA field crews. In addition, it may be possible for them to collect forest health or other data, again not an activity typically associated with FIA field work.

Whether permanent FIA crews or contract crews should be used for annualized inventories needs to be addressed. Both approaches have clear advantages and disadvantages. In either case, the crews need to be supervised by FIA staff to help maintain the quality and credibility of the data collected.

An annualized system presents a real opportunity for obtaining a better quality database than was possible previously. Because people from the Nebraska State Forest Service and other users will examine the data each year, obvious errors will be detected more quickly and

corrected. If FIA can standardize its basic assessment procedures, it should be possible to improve the quality of the data further. National coordination of the annualized inventories is critical for quality assessment and quality control procedures. Quality assessment and quality control crews from other FIA units should be used to ensure consistency and to obtain more unbiased estimates of the measurement errors made on the plots.

Fast, easy electronic access will be much more important under an annualized system than under a periodic system. User access to the data, with proper safeguards, needs to be facilitated right from the start. For example, the capability of "on demand" printing by individual users at their own computers should be available. In such an environment, a user could work at his or her own computer, access the data, generate tables, and print them as needed. This would make FIA data much more available to users and would free FIA from having to predict user needs and produce all of the tables that might be needed. National coordination of this computerized access will be important.

Integrating or merging the remote sensing phases for inventory and monitoring by FIA of the USDA Forest Service and the Natural Resources Inventory (NRI) of its sister agency, the National Resources Conservation Service, is very desirable, but integrating the ground sampling phases is premature at this time. There are political problems currently with integrating the field work, but a joint remote sensing process in which relevant remote sensing information for both agencies is collected and used to locate the field plots to be measured by the appropriate agency should be attainable. Such coordinated monitoring would be useful, for example, in the issue of the increase in eastern redcedar on both agricultural and forest land from 1983 to 1994.

IMPLICATIONS FOR THE FUTURE

Given that field crews work independently, there will be a need for cross-checking in different states and, in fact, across the country. Having the work checked by people who do not normally work closely with the field crews should result in a more unbiased quality assessment. With the current, highly desirable push for national consistency, there are opportunities to do this nationwide. Perhaps something like an "FIA crew of the year" award might be desirable. An award, for example, might include such a crew doing quality assessment work in one or two locations of their choice, anywhere in the country.

It is also possible that, given a more frequently updated and thus more useful data source, Nebraska and other states that have not been able to contribute significant resources to the FIA process may be able to do so. For example, many states currently acquire satellite imagery

for a variety of purposes. Perhaps, in the future, states could contribute imagery for the FIA process, thus helping to maintain an annualized forest inventory system and assuring themselves of having access to the best resource data available. In-kind contributions of office support or similar state assistance might also be considered.

Increased state and other user group involvement could have mixed results. To the extent that such users contributed resources to annualized inventories, the contributions could be favorable if not relied on, but they might be unfavorable if relied on and not forthcoming. The basic responsibility, it would seem, should remain a federal one with state or other user involvement adding sampling intensification or other improvements as deemed desirable by such users.

SUMMARY AND RECOMMENDATIONS

We welcome the shift in FIA policy to annualized inventories. If handled appropriately, it will give such data higher visibility and credibility in states such as Nebraska where all benefits derivable from the forests have equal status. The second author, who was originally deeply skeptical of annualized inventories, now sees real opportunities in it for his state.

However, we have some caveats to the above statements in that:

1. The credibility of the FIA inventories needs to be maintained at all costs. This means that the base program should remain funded and supervised by the federal government. It also means that states with relatively small timber production should not get short shrift relative to big timber-producing states in data collection and analysis.
2. We welcome the change in the USDA Forest Service policy to emphasize better balance between the various benefits derived from the forest resource. This change needs to be expressed more clearly in FIA, and the Nebraska Forest Service is well positioned and willing to help achieve this. We encourage the use of Nebraska as a test site for merging the remote sensing phases of FIA and NRI, anticipating that it will facilitate the production of reliable annual estimates of change in forested areas. Opportunities exist for using high-resolution photography to give improved, relatively cheap estimates of mortality, removals, regeneration, and tree heights in forestry, as well as similar parameters in agriculture and range surveys.
3. "Updating" plots that were not re-measured in the field using models, including multiple imputation

procedures, should not be used for compiling public databases until the models are fully tested and proven reliable through the standard scientific process complete with peer review and publication in credible scientific journals. But models should be developed for use by the appropriate user groups (Schreuder and Reich 1998) and for updating purposes.

4. Decisions about the number and location of FIA permanent crews or contract crews, their supervision, and the ensuring of national QA/QC standards should be made in full consultation with the states involved. Perhaps crews could collect harvest and production data as well as the traditional FIA information.
5. The basic product of the forest inventory should be the annual database made available in a form readily usable by State Forestry staff and other user groups. At 5-year intervals, the traditional FIA core tables should be produced by a well-documented, consistent, comprehensive, and user-friendly national computer program. FIA should work closely with State Forestry and other organizations to foster intelligent use of annual, but limited, data sets and to point out opportunities for possible follow-up including the collection of additional state or privately funded data.

LITERATURE CITED

- AFIS. 1992. Annual forest inventory system problem analysis. (Unpublished document.) U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis Unit. 51 p.
- Schreuder, H.T.; Reich, R.M. 1998. Data estimation and prediction for natural resources public data sets-what is desirable? Res. Pap. RM- . Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. (in press).
- Schreuder, H.T.; Gregoire, T.G.; Wood, G.B. 1993. Sampling methods for multiresource inventories. New York, NY: J. Wiley and Sons.
- Schreuder, H.T.; Hansen, M.; Kohl, M. 1998. Relative costs and benefits of a continuous and a periodic forest inventory in Minnesota. Environmental Monitoring and Assessment (in press).