

Some Directions in Forest Inventory

By Kim Iles December, 1994, J. Forestry

What information do we "need"? he asked innocently ...

I suppose you should try to assess inventory needs, but you are *not* going to get the full list. Not now - *and not ever*, so plan for it. The more naive people in the sampling fraternity actually think they can compile such a list, push off from shore, then sink slowly (at someone else's expense). They are surprised that the rules keep changing and keep repeating that *they* really don't need to know anything about the problem, the biology, the details of making measurements, and *certainly* not about the decision process they are imbedded within. The first chapter of the statistics book may tell them to "find out the information needed and the required precision" but this is virtually never possible. *Deciding* is not the same as knowing. *Assume* that the list is incomplete.

In this article, when I speak of inventory I mean the long-term, large-area inventory that has to last for decades on a basic data set which can be projected and refined over time. For short-term projects it is possible to know the objectives, and to do some of the fancy work shown in the literature, but this is not normally possible in a long-run inventory. Such an inventory also needs a staff with a long tenure. Many important problems have been solved by the team in the back room who have been there a long time, know why certain decisions were made, and know where the bodies are buried.

I think we need to develop the art of producing reasonable numbers from simulations, then asking what the user would do *if it was* correct. If the user does not know, then the sampling process should be aborted on takeoff. In an era of complicated data "needs" some mock-ups of databases, data sheets and reports would all have a positive effect in shaking out sloppy thinking before it becomes very expensive. Time spent in finding answers that cannot be used or that make matters worse is not just wasted, it distracts from productive work and squanders precious resources. By precious resources I do not mean principally time and money. I mean patience, goodwill, perspective and other attitudes so easily eroded in land use decisions.

The role of data is to reduce friction, give perspective and ease tension. Only rarely does it solve a problem directly. This aim is regularly derailed because the data is too late, is not compatible, is not credible, is not understood, etc. But then, you already know that - don't you? I vividly remember a trip to a USFS inventory group where they said something like this: "Timber volumes? Oh, that's about number 30 on our list of priorities. Our problems are about everything else *but* timber data." The world never seemed the same after that, *and that was 20 years ago*. Traditional inventory people need to utilize other specialists for perspective on these new problems.

"Needs assessments" are useful, but I believe that everyone must know that the question of "what is required" is not completely answerable. I do not mean that the needs are not *known*, I mean that they are *not knowable in principle*. The inventory must provide a useful service in full recognition of this fact. Any professional who is going to design an inventory has to get to the root of the problem, and this is going to require some uncomfortable probing, the calling of

bluffs, some speculative expenses, and often the reply that something cannot be done. This is not the most pleasant of processes. Users and managers need to learn to appreciate straight talk and hard questions from specialists in this field. At the same time they should expect balance, good sense and frank admission of the limitations.

Capturing and Revisiting the data

We should remember that in many cases the objective is to "capture" data, not to make measurements. Photos capture data, and so do videotapes. For example, perhaps we should let the future user decide for themselves what they mean by a term like "heavy branching", then (with their own budget and effort) measure the data from our stored video records. Perhaps it would suffice to do this on 1% of the plots. As we incorporate more types of measurements into the inventory process we can be sure that the definitions and procedures will change, and change too quickly. One alternative may be to use the initial measurement as an estimate, then subsample when the method changes. More important than knowing the "right" definition is knowing what to do when it inevitably changes.

The ideal system for Growth & Yield, for instance, would be to take a high resolution hologram of the plot, then let the analysts in 50 years figure out what to measure and how to measure it. "Capture" of data is a more fundamental and a more flexible idea than the weaker alternative of making measurements. New high volume storage opportunities in computers will give us more flexibility here.

The inventory system must assume that the data will be recompiled, and probably in the near future. It is a mistake to round data, or put it into classes (except for presentation). Keep the original data, and keep the detail. Assume that new instruments will make formerly difficult measurements easy, and set up the system to adjust to that change when it happens. The Global Positioning System looks like it will be widely useful for locating and describing these plots. It is a technology which is maturing quickly into a reliable product.

The ongoing efforts of inventory groups to insure common sampling and measurement techniques must be applauded. Compatibility is often of much greater importance than efficiency. Video records of field techniques are valuable training and documentation methods. All future manuals should be available in word processor format.

"You need it when ?", he asked, "and how ??"

Major information items had better be ready quickly. A lot of damage can be done while waiting for basic numbers. There is seldom adequate time to do a major amount of work, but if there is anything that will foster foolishness, expense and anxiety it is a data vacuum. The inventory should provide *some* data on *all* land types and provide a base for gathering any new information. In addition, the display systems will be vital in the future. I think that GIS will become one of our principle tools, although they have been a general disappointment to date. They are obsessed with making maps, not sharing and creating information. In addition, they have too few ways to check current information before recreating it all. We went through the same failures and lack of performance with computers not so many years ago.

I think that the distinction has not been clear enough between the functions of the database, where much of the real action is, and the display methods of drawn maps and theme overlays. Database first, displays second - please!! When we do really get the philosophy of GIS sorted out then I have great hopes. There is good psychology behind the phrase "show me". We have developed for millions of years using color vision and only a few hundred with the concept of numbers. Graphics always win - no contest. The point here is that the GIS concept is *so* right-minded that we simply have to tough it out and make it work well - and I think it will.

Multimedia databases can recall a great deal of visual data, and inventory plans should consider the acquisition and use of video and still photographs of sample sites and typical examples of inventory information. The inventory should be able to pull up the area in question, or at the very least a scene "typical" of the area in question. I believe that the display of stereo maps overlaid on recent stereo photos is an important application of GIS technology. Other than for quality control purposes it may be time to stop displaying information on a map that is better seen against a photo. I would like to see the river directly and have the overlay display the name, sensitivity or other non-visual items, then be able to fade back and forth between the map and photo versions. Map use seldom requires a "flat" representation, and I think we will eventually get away from that mentality, including the intermediate step of orthophotos. Common map bases for communication between GIS systems is extremely important, and I would be willing to give up a fair amount of accuracy for that benefit.

What is the Base ?

Like many people, I believe that an inventory should be based on vegetation polygons, with forest stands as a special case of vegetation. Such an inventory would cover the *land* base, not only the commercial forest base. Some information must be available, immediately, on *every* vegetation type. Wildlife populations are just too variable over time, and other than simple species presence or absence I believe that they should be handled as a separate process. The vegetation information should provide an excellent basis for short-term sampling of wildlife populations.

Credibility

I recall the comment of a friend in the data processing business: "If someone tells me they came at the problem from several different directions and came to the same conclusion I'm sold - but with one approach I want to check everything". When possible it is certainly wise to have secondary sources for any answer, even though you may use only one. We would be wise to learn from other fields that gain credibility from an outside audit. The message of a bank audit is: "we are careful people, checked by other careful *independent* people".

The fixed sampling positions we have in the forest should be available for other people to check and to use as first-stage estimates, but we had better be prepared to suggest a proper sample to these potential users because years of painful experience suggest that they will pick an incorrect sample. The overlay of remote sensing images can do a lot to increase the emotional credibility of an inventory product.

I vividly remember the response of an inventory specialist at a conference to the comment that "our problem" was cost-effectiveness, he patiently but firmly replied: "Professor, the issue is *not* cost-effectiveness, *the issue is credibility*". This man had been around the block a time or two.

Design Concepts

It is going to be very difficult to get a variety of specialties to adopt a *common* measurement process or sample plot, and I doubt that it can be done. *Compatibly* should be easier to arrange and we should at least try to provide a process where anyone can measure with their own method but assign the answer to the same point or polygon.

Simplicity of sampling design has a cost, but so does complexity. There seems to be a kind of "conservation of energy" principle in sampling where "efficiency" at one stage gets converted into inefficiency at some other stage. My personal rule of thumb is that efficiency increases of less than 30% are likely to be illusions.

I believe that the concept of the inventory as a sample base for future needs is pushing us in the direction of some form of 2-level sampling such as "double sampling" on large areas or "3P sampling" on small areas. We can often get good first-level estimates before we ever visit the sample location. Schemes which make use of initial estimates, projected estimates or research-based estimates just make a great deal of good sense for future inventories. Other by-products of this first level of data may be just as important as the increased statistical efficiency.

Technical Problems in Estimation

Many of the disciplines (such as Landscape Design, Recreation and even Wildlife) which will influence land use decisions have little background and experience with sampling approaches. They are accustomed to case studies or the examination of "typical areas". This has given rise to definitions for which we cannot sample - The term "Old Growth" has presented this problem. The definitions that are considered in land use decisions should be *pressed hard* to come up with an accompanying sampling method. We need to promote the attitude that a proper definition includes a sampling process for producing the numbers *or it is not complete*. Currently, we can only hope to minimize the problem, bearing in mind that forestry has taken a long time to sort out some simpler problems and that we have cause for humility here. It should be assumed that every estimation method will undergo a legal test.

There are certainly some problems to overcome on the statistical side of the business. We have a great need to aggregate data from a number of sources into combined estimates. The problem is often too much data, rather than too little. It is very difficult to cleanly insert data from outside sources into an inventory, even when that data is complete and known to be better, let alone when it is incomplete.

The role for monitoring

We already know a great deal about our land base, and this has changed the basic questions of inventory. More than ever we ask not "what is out there?", but rather "is it what we expected?". Therefore, the role of monitoring or correcting estimated values is increasingly the appropriate frame of mind.

We frequently have an estimate of change before we visit the site, and this is why a two-level process is often desirable. Radical changes are usually detectable by remote sensing or known activities, and many other changes can be approximately modeled. The public want to know that changes are being monitored.

It is tempting to "correct" the inventory with outside data. There are, unfortunately, difficult problems involved when data comes from only one part of the land base. Sampling procedures for monitoring problems are quite tricky, and need careful review. Even if you have excellent results from specific parts of the overall area there is probably no simple way to use this data to correct the overall inventory. Nevertheless, the fact that the actual forage yields have been 10% more than predicted by the inventory for the past 2 years may be of great interest to current ranchers, even if this is not true over the entire land base.

Presentation of data

We can do a much better job of presenting the data stored in databases. The help screens so often incorporated into spreadsheets and standard computer products are a good model of how users should be able to find out about data definitions. The quality of inventory data is often judged by the presentation, and that is not altogether unfair. An organization which cannot put these problems into perspective is likely to have other blind spots.

The presentation of statistical information is especially dismal. Most of the statistical concepts can be presented in graphical form without using any statistical terms, and we would all be better off for it. The purpose of descriptive statistics is, broadly speaking, to put the data into perspective. In addition, it is the control of anxiety. Anxiety is enormously expensive in forest inventory. We need to alleviate it with technique, not just by pounding in more plots. The computer industry finally got the word on this and gave it to their programmers: "Our customers will *not* be required to remember the arcane language and procedures of your computers. Find a way to make it simple *or you are gone*." It is time, perhaps, to tell our statistical friends something similar.

A current writer on evolution often uses the quote "God lies in the details". Negotiators of arms and economic treaties, I am told, use the quote "The Devil is in the details". In any case, the scientific truth is undoubtedly in the details. The message, however, is in the presentation. Master the details, *but deliver the message*.

A good example is the concept of sampling error. A sensible person, hearing that "the $t=2$ sampling error is 12%" would reasonably suppose that the data is only accurate to about 12%. In fact, we are saying that it is *very unlikely* that the error is as large as 12%, but who wanted to know that? This problem was approached in statistics much more rationally many years ago by

the use of the "probable error". How much more informative, more honest, and more reassuring to give the *same* message as: "well, we about a 1/20 chance of being closer than .7%, a 1/20 chance of being off more than 12%, and a 50:50 chance of being on either side of a 4% error". The persistent use of the 95%_(t=2) sampling error is a mistake we could easily reverse, but the main message must be: "the purpose of statistics is to make things simpler and to give perspective - *so get it done*".

Summary

I love a saying that I saw on a craft studio wall a few years ago, it read: "Stop doing things that don't work". Why do we remove most of the information on a photo and make the space white so we can draw map lines to replace it? Why not warp the maps to fit the photos since we no longer have to measure areas, distance and direction on a map? Why don't we insist that data presentation and statistics become more intuitive? The process of streamlining our systems needs to be done by people with a bone-deep appreciation of the difficulty in the details, the role of routine and the value of consistency. Some of this only comes from having been in the field. At the same time they need to step back and see the problem from a distance, because it is slowly drifting and often in predictable directions. Balance, flexibility and credibility in inventory design are far more important than putting in a few more plots or trimming the sampling error.

Inventory people will need to know more biology for the same reason that map makers need to take another look at how maps are *used*. We have structures that continue to stand after the needs that once supported them have evaporated, and while tending these we have not noticed some new requirements. There is a pressing need for processes that reduce turnaround time, provide clarity or consistency, and insure that new types of data can either be properly sampled or "captured" for future use. The traditional forest inventories of North America have done a pretty good job over the past decades, and I think that it will do a good one in the future. The expanding fringe of new items and the resolute application of some central principles will need our careful attention.

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Dr. Iles current assignment is the design of a vegetation inventory over a quarter of a billion acres in British Columbia.

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To the Reader:

This is the original version of an article published in the December 1994 Journal of Forestry, which was a special edition devoted to Forest Inventory. I was invited to write the lead article. At first I was reluctant, but relented, and submitted the article months in advance. With little time to spare, just before it went to print, the editors rewrote the article -- and were quite surprised that I would object. Apparently, the dull writing in journal articles is not all due to dull authors, but they are helped quite a bit to sound that way.

I was not particularly happy with the heavy rewriting of the article which was done at the last minute, after the article had been accepted. Although the editor put most of the article back as it was first written, I required them to add a comment at the end of the article which would indicate that it was not in its original state. I was particularly sorry to see that they did not include the acknowledgements section.

The editors could not tolerate using the word "rewritten" (although they were not embarrassed to do it) and we settled on the comment included at the end of their version of the Journal Article. I had suggested:

"Most of this article required rewriting to conform to the Journal editorial style. The author would be pleased to send the original to anyone with an actual interest in the topic".

We settled on:

"This article was adapted and edited from a longer manuscript. For a copy of the complete work, please contact the author."

I think that the folks at the Journal of Forestry have come a long way in the last few years in improving the Journal of Forestry, and one can only appreciate their effort in this but they seem to be well known for a heavy editorial hand. For those of us who want to hear the authors own voice, it is at least necessary to be warned about changes of this kind.

If you want to see a copy of my letter to the Journal of Forestry, drop me an email.

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