

A Simple View of the Inventory (DRAFT)

Species—Stand—Site

By
Ian Moss,
Andrea Eastham,
Mishtu Banerjee¹

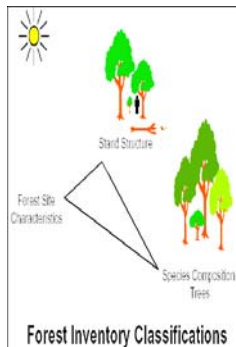
|
|
|



A WINDOW INTO THE INVENTORY.....	2
WHY HAVE AN INVENTORY?.....	3
DESIGNING AN OPERATIONAL INVENTORY MONITORING PROGRAM.....	4
OPERATIONAL INVENTORY AND FOREST ASSET MANAGEMENT	6
A SIMPLE VIEW OF THE INVENTORY.....	8
RESOURCES FOR FURTHER INFORMATION	9

¹ Andrea Eastham, IFS Ltd.; Ian Moss and Mishtu Banerjee, Harmeny Systems Ltd.

A WINDOW INTO THE INVENTORY



What is a forest inventory? A forest inventory represents “everything out there” on your forest land base. Trees, lakes, landforms, roads it has been the accounting of what is present in a management unit at a single point in time. However, since trees grow and roads degrade, the inventory is constantly changing. We need to know not only about the “current inventory”, but the past and future inventories (where we were, where we are going). The inventory is a list, but the “items” in that list are created via, and function, in accordance with biological principles and processes. Every activity on the forest land base, modifies the list, but also affects the process pathways. The inventory reflects forest dynamics.

Relative to the detailed biological processes, our management activities are rather “coarse”. We can control which trees we harvest, which trees we leave; we can choose to use certain kinds of equipment on certain sites, to do treatments like fertilization, etc. Each of these management activities affects the inventory. Though the inventory is simply a list, we are interested in the list from a particular perspective – that of operational management practice. So let us call the inventory we are interested in the “Operational Inventory”; that list of items on the landscape that we can use to improve our daily management decisions (operations) as well as critical long-term decisions (strategy).

In one sense, the inventory is simply a list. In another sense, the inventory is a list of such complexity and detail, that it is difficult to develop intuition around. To help develop intuition around the inventory, and to provide a framework for linking the inventory to management practices (what we are calling the Operational Inventory). We need a perspective. The perspective we take is this:

Link each item in the list to those basic things a forester can observe when she walks into a stand. This will allow her to develop intuition between the inventory and operations.

What are those key linkages that define our window?

- **Species Composition.** The first thing that catches our eye as we enter a stand is the mix of Tree Species we encounter. Are we in a Douglas-fir stand? A Lodgepole Pine stand? A mixed Fir/Pine stand which also contains a large component of Aspen? Is this a place for a logger or a mule deer – or both?
- **Stand Structure.** We look around a little more. Is this a uniform stand? A very dense “toothpick” stand? Is this a stand with small gaps? Is this a stand with a complex mix of age classes, and a mosaic of tree sizes? How are the trees distributed both looking across (horizontal) and looking up (vertical)?
- **Site (“Capacity”).** Next we begin to look at more subtle information about the site itself. What Biogeoclimatic unit is it in? What is the topography like? Are the soils very clay-like? Site defines the basic capacity for growth (known to ecologists as “Carrying Capacity”). But foresters often look for the direct consequence of site, the tree growth itself, commonly called Site Index (the height of an average tree at a standard age, say 50 or 100 years)

WHY HAVE AN INVENTORY?

The most fundamental decision made on any forest land base is simply this:

Which trees to leave and which trees to cut.

Given a particular resource value, be it timber, habitat or some other defined economic or social value, we can break this question down into four aspects (a) the amount of resources available, (b) where are they located (c) how are they affected by our management practices and/or natural succession patterns (i.e. how do we affect forest/tree dynamics), and finally (d) what will be the anticipated answers to these questions in the future². Each of these aspects defines a major use of the forest inventory.

In defining the amount, growth and depletion of timber resources, the inventory helps set the Annual Allowable Cut (AAC): the amount of timber that can be sustainably removed from the land-base without depleting the forest resource (long term timber supply).

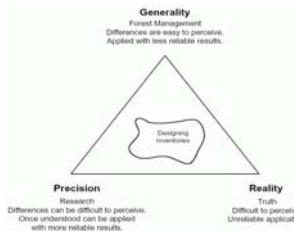
In defining where these resources are located, the inventory supports management activities – whether it is the timber cruise to supply the mill; the search for a particular type of habitat required for maintaining the grizzly population, or the areas most susceptible to bark beetle attack. All monitoring activities that are part of operations (cruises, surveys) are intimately related to the inventory – indeed they are the basis of updating the “global perspective” of a broad inventory with the “local perspective” of the forest worker on site. The link between operational monitoring and the inventory is developed by ensuring a common information framework for defining Species-Stand-Site in surveys and cruises, consistent with the inventory as a whole.

The relationship between what we do as forest managers, and the forest that results as a consequence of (or in spite of) provides the basis for choosing among alternative management practices (adaptive management). In addition to operational monitoring – the inventory should be linkable with custom designed experiments. Again, a common information framework based on Species-Stand-Site links management practices and management experiments to a broader context. In particular we wish to know whether our practices fall within the natural range of variation.

In defining the amount, location, and consequences of management practices on the forest land base both now and in the future, we have the basis of calculating forest asset values. The assets may be timber. They may be habitat related. They may be social values. Regardless, preserving any particular desired value will have costs and it will have benefits. Using a forest asset management framework we can begin to “game” or anticipate the consequences – in terms of risk, regret, and reward – of management alternatives, as well as catastrophic events such as fire and pestilence (anticipatory management).

² To build a dynamic model of the forest, we have to estimate items a-c, so we may predict item d.

DESIGNING AN OPERATIONAL INVENTORY MONITORING PROGRAM



The inventory is critical to provide a scientifically defensible information base on which to determine the forest asset values. In implementing an operational inventory, the quality, representativeness, linkages among, and cost effectiveness of information gathered is primary. It is this information that will provide the connection between daily operations and strategic goals. We can measure too little, too much, or the wrong things. How should we go about designing an operational inventory management program? We must ensure we are measuring (a) in the right way (sampling design) (b) the right things (forest biology) for (c) the right questions (forest management practices) with (d) the correct linkages among sources of information (information technology). A well-defined operational inventory-monitoring program develops a virtuous positive feedback cycle where inventory guides operations and operations update the inventory. A poorly designed inventory means a lot of money was spent for a bunch of numbers to end up in a box un-used or under utilized. A well-designed inventory balances precision, generality and reality.

A successful inventory design begins with thinking clearly about one's business goals with respect to the forest land-base, and then working backwards to the information needed to meet those goals. We cannot "measure everything, everywhere". We must thus restrict the variables we chose to a small set, which can be consistently measured. Unless we have a very small land base, we usually must also develop a sampling strategy, so we can estimate the state of the forest, by taking detailed measures on a portion of it. The four points below cover the key items that must be considered in developing an inventory.

1. Define the strategic business goals you would support via an inventory.
2. Define how the inventory will support daily operations.
3. Design a monitoring program to support Strategic and Operational objectives with the following design principles:
 - a. Simple and Cost Effective (you can afford it and maintain it)
 - b. Modular and Flexible (You can add too it, modify it)
 - c. Integrate-able (You can combine it with other information)
 - d. Changeable (You can re-direct it to new goals)
4. The monitoring program will be based on an information system that can support the following components, as re-usable templates
 - a. Sampling Design
 - b. Field (and Office) Measurement Protocol
 - c. Information Technology Design
 - d. Management framework

Weak inventories tend to come out of lack of sufficient care and attention in two areas: Sampling Design and Information Technology Design. Additionally – field measurement protocols must be well integrated with the field workers on one end (i.e. they must be clear, and practical) and with the IT system on the other end (your data design should be consistent with the logic of your field protocol). Finally, your management framework should assign a single person clearly responsible for items 4a to 4d at the design stage, and a Protocol Steward and an Information Steward to maintain the protocol and information system respectively.

DESIGNING AN OPERATIONAL INVENTORY MONITORING PROGRAM (continued)

With respect to sampling design – the obvious error is to have none at all, usually leading to a very biased data set. The “opposite” mistake is to have an overly complex sampling design that is difficult to implement in the field. Where possible, stick with either a simple random sample based design, or a systematic but unbiased design such as sorted lists. Inventory sampling design involves a subtle interplay of statistical and biological knowledge, as well as strong insight into practical forest mensuration and plot design strategies. You might not have anyone in your organization with this skill set. If so look into a forest sampling design expert for consultation in developing the sampling strategy (see “A Sampler of Inventory Topics” by Kim Iles – listed in the resources for further information section).

The weaknesses in an IT design tend to be of three major types. One is to have the same information residing in multiple places (redundancy). The second is to have the IT design overly complicated (lack of clarity). The third is for the design to be dependant on a particular technology (lack of portability). Technology platforms change – your inventory design must be tied to logic, not technology. One way to proceed is this: first develop the “summary data tables” that will report on the inventory, and work backwards to the “raw data tables”, guaranteeing that each table is tied to a set of concrete “objects”(a set of measurements, a tree, a plot, a stand are good candidate objects) in the inventory. You will sometimes find that between the “raw data” and the “summary data tables” a few tables of “intermediate calculations” need to be maintained (document those calculations!). Contrary to the advice on getting a consultant on sampling design early, get a consultant on IT design late – mainly to review and refine the design; or if you are really stuck in the process of working backwards from summary reports to raw data. You want to have your design roughed out, and you want IT to “polish it” (hopefully to jewel like brilliance). You can access IT internally (if you work in a forest company of moderate size) or from an IT consulting firm. In general, don’t expect the IT folk to know much biology or forestry (and consider it a bonus if they do).

The actual monitoring program, and field protocols, should be incorporated into the IT design or built so that the two work closely together. Otherwise, the protocol documentation gets out of sync with the information. A template-based system, where there is a clear progression from a document explaining the measurements that need to be made, to the field cards (or field handheld screens), to the raw data tables simplifies life immensely. Such templates support modularity – where one can update a piece of information (in a measurement document, field-card, or raw-data table) without having to update the whole system. For any coded variable, maintain a list of all allowable codes. For any measured variable, maintain a list of the maximum, minimum, and precision of that variable. Make sure your data entry system checks against these lists, to prevent typos or ridiculous measurements from entering the system (preventing bad data from entering a system is preferable to post-hoc tracking of bad data AFTER it has entered the system). Field-test your protocol documents and field cards. Better yet, have them designed by an experienced field worker.

Develop the simplest monitoring system possible, and no simpler.

OPERATIONAL INVENTORY AND FOREST ASSET MANAGEMENT

The inventory is a list of your forest assets. Like any other concrete asset, forest assets will show up as line items on the balance sheet of your business. How trustworthy those line items are, depends directly on the veracity of your inventory. Yes, forest companies without an inventory often have such line items “guesstimated” for their forest assets. These are fantasies. A strong inventory is a vote for reality. The state of the forest, as reflected in the inventory, will affect the valuation of your company in a sale, the amount of capital borrowed, the value of shares. The forest inventory is the biological basis of forest asset management.

Forest Asset Management is a unified system of accounting for Social, Economic and Environmental assets. It helps communicate the values of forests to stakeholders and public interest groups, as well as to Executives and Directors. It helps Managers to identify opportunities for enhancing Forest Assets through innovative forest practices.

The foundation for this system of accounting is embodied in the following equation:

$$AV = CT_{PY} + CT_{FD} + CE_{FD} + CS_{FD}$$

where,

AV = Total Asset Value

CT_{PY} = Net cash flow from liquidation of timber and expenditures in the previous year, including allowance for depletion.

CT_{FD} = Expected discounted net revenue - future liquidation of remaining timber.

CE_{FD} = Opportunity Cost of expected discounted net revenue from future liquidation of remaining timber, allocated for environmental protection.

CS_{FD} = Opportunity Cost of expected discounted revenue from future liquidation of timber, allocated for community well being.

This basic equation provides a foundation for Generally Accepted Accounting Principles (GAAP) as applied to the management of forest assets. It develops a common currency for describing forest assets. The environmental and social accounts identified above can be further subdivided into more specific uses such as “Maintenance of Biodiversity” or “Maintenance of Visual Quality” for specific landscapes.

The system is implemented operationally in the course of preparing an annual statement that shows the change in forest asset value relative to the expected state as of the start of the previous year (excluding the term CT_{PY}). If, for example, a large amount of timber is liquidated in a poor market (relative to the expected long-term average established in the forecast) then the change in forest assets from the previous year will be negative (There is a decline in Forest Asset Value). Harvesting that involves a liquidation of social and environmental assets are indicated as such by assigning a reduction in the values assigned to those accounts. While there may be good reason for this activity (e.g. windthrow), such changes in asset value require explanations of the kind that would typically be found in the footnotes of a standard accounting Statement of Assets and Liabilities.

OPERATIONAL INVENTORY AND FOREST ASSET MANAGEMENT (continued)

The challenge for forest managers is to ensure that environmental goods and services are indeed maintained or enhanced while providing for cash flow to maintain a profitable and competitive forest management operation. This provides a focus on the forest values that are actually being protected (as opposed to their attributes), for example the production of clean water throughout the year. The Forest Manager must constantly evaluate the forest attributes and management practices that are necessary to achieve that objective.

Opportunities for enhancing forest assets may be available to the Manager by effecting a transfer of assets from the Environmental account to the Economic Account while at the same time maintaining or enhancing Environmental goods and services (win-win). In economic terms there is a potential to expand the frontiers of production to the overall benefit of everyone. The challenge for the Forest Manager is to find those opportunities. The Forest Asset Management accounting system enables clear and consistent reporting when such opportunities are realized, by indicating a shift in assets from the Social and Environmental portions of the ledger to the Timber Harvesting / Forest Management side of the ledger. Along with this shift in assets, a footnote is provided as to why such a shift occurred. Reducing the costs of management can also enhance Forest Assets provided that such reductions do not also reduce revenues.

Sustainability involves maintaining or enhancing Environmental, Social and Economic goods and services such that future generations will be endowed with a range and extent of opportunities that are similar to our own. Environmental issues include the following:

- Protection of Biodiversity through Ecosystem Management
- Amelioration or prevention of Greenhouse effects and the effects of pollutants in general (e.g. Water Quality).
- Social issues revolve around the allocation of Property Rights, for the purposes of maintaining or enhancing: traditional uses, recreation and aesthetic values, employment, health.

Forest Asset Accounting is designed as means of weighing up the allocation of assets to each of the social, environmental and economic accounts. Forest assets should be maintained or enhanced and the balance of accounts amongst the various kinds of assets be managed to obtain sustainability. Actions causing a decline in environmental assets, either directly (logging an old growth reserve without providing a substitute) or indirectly (harvesting a Riparian area after extensive windthrow) are management's failures to provide for sustainability. Actions ameliorating the impacts of these kinds of events or preventing them from occurring at minimum cost result in management that is increasingly consistent with the notion of sustainability. The Forest Asset Accounting System provides a consistent means for communicating on the degree to which success in managing for sustainability is being achieved and helps managers focus on where and when the degree of success can be improved through a change in forest practices.

A SIMPLE VIEW OF THE INVENTORY

The forest inventory is a list of those items on the forest land base that are under management (or stewardship). To simplify all the biological and ecological processes occurring on the forest land base into a framework easily tied to operations, we look at the forest inventory items in the context of species composition, stand structure, and site. This is our “simple view”. It provides an entry point to the greater complexity of the forest we are trying to represent via an inventory.

The forest inventory represents the basic asset under management by forest companies. Regardless of whether the forest estate is on public, or on private land – in addition to its “value” to a forest company, there are also public values that need to be accounted for. Thus both from the perspectives of “managing internal resources” and “dealing with the public interest”, it is vital to have reliable, up-to-date, and inventories of the forest land base. By gaining the ability to project such inventories into the future we can make strategic decisions that balance both the short and long term.

To be trusted as truly representative of the land base, such inventories have to be designed on sound scientific principles based in sampling design theory. To be affordable, the inventories must be developed cost effectively – as part of an integrated forest monitoring system. To be efficient, such inventories need to explicitly consider how best to represent and handle information using current technologies. Ideally, the forest inventory and your operational monitoring program are strongly integrated, so each strengthens the other.

As the forest land base is an asset, it must be incorporated into an accounting framework to properly value forest companies, and to value forest management decisions. Such an accounting framework will be grounded in a reliable forest inventory. Forest asset management is the basis of the accounting framework. Unlike many other assets, the forest has a natural growth rate. Our management activities can either preserve, enhance, or reduce the growth of forests. In trying to decide among alternate management practices we need to realistically weigh the costs and benefits of any action in terms of timber, social, and environmental values. There is a “fundamental” equation for forest asset management that allows us to do so. Essentially the equation is provides a way to value current decisions, in terms of how they will affect future timber, environmental and social values. Sustainability requires one to balance these values, rather than optimizing one to the detriment of the others. As such, forest asset management represents a commitment to continuously improve our management efforts.

In summary, the forest inventory represents both the assets under management, and the key information needed to manage those assets responsibly. The forest inventory is simply necessary. What is the state of your forest inventory? What is the present value of your forest estate?

RESOURCES FOR FURTHER INFORMATION

Contacting the Authors

On Inventory/Sampling Design and Forest Asset Management

Ian Moss, Harmeny Systems Ltd. (Duncan Office)

1458 Kingsview Road, Duncan, BC, V9L 5P1

ian@harmeny.com

On Forest Monitoring Protocol Design and Implementation:

Andrea Eastham, Industrial Forestry Service

1595 Fifth Avenue, Prince George, BC, V2L 3L9

aeastham@indforserv.bc.ca

On Woodland Information System Design and Decision Support Information Technology

Mishtu Banerjee, Harmeny Systems Ltd. (Richmond Office)

309-7297 Moffatt Rd., Richmond BC, V6Y 3E4

mishtu@harmeny.com

Books

A Sampler of Inventory Topics.

By Kim Iles.

Kim Iles and Associates Ltd. 2003.

The "Sampler" focuses on providing insight into the logic, thought processes and practical considerations behind developing an inventory. The book emphasizes how practical problems and theoretical issues keep running into each other in any realistic inventory program (often in the form of a witty series of memos between a young inventory theoretician and an older and more practically oriented inventory specialist). It is particularly suitable for people who have done inventory fieldwork and have curiosity about the theory underlying field-sampling methods. The writing is delightful, and the book is well illustrated and geared towards visual thinkers. The "Sampler" is accompanied by a CD of spreadsheets that illustrate many standard calculations required during inventory development. To gain more understanding of sampling read: Chapter 5 distinguishes random and systematic samples, and has a good example of the sorted list method (pp. 175-183). Chapter 9 is a historical overview of sampling methods. Later chapters focus on more sophisticated sampling methods.

Forest Mensuration. 4th Edition.

By Bertram Hush, Thomas W. Beers, and John A. Kershaw, Jr.

John Wiley and Sons. 2003

A well designed carefully presented book covering forest mensuration. The final five chapters cover inventory issues, and provide a good first introduction to inventory methods, with a brief introduction to growth and yield methods. As befits a textbook, a little dryer in tone than the "Sampler", but a very good source of background information, and as a reference for key formulae and calculation methods with fully worked out examples.

RESOURCES FOR FURTHER INFORMATION (continued)

Websites

The list below is not exhaustive, but represents a starting point for exploring forest inventory information that has been put up on the web.

Kim Iles and Associates www.island.net/~kiles/ Has links to a number of other sites, as well as overview articles on forest inventory.

Australian National University. Overview. Forest Measurement and Modeling. <http://sres.anu.edu.au/associated/mensuration/overview.htm> . This site, and links within it, provides a very nice overview of information on traditional forest measurements, including many clear definitions.

John Bell and Associates. Inventory and Cruising Newsletter. www.proaxis.com/~johnbell/ This site contains several excellent series of articles, introducing statistics “for practical people”, demystifying “myths and folklore about forest sampling” and describing 3P sampling (a method of sampling that is fairly easy to implement with inexperienced field workers, but which still is efficient, and provides valid estimates)

USDA Forest Inventory and Analysis. www.fia.fs.fed.us/ Gateway to the USDA’s forest inventory program, which has been in place since the 1930’s with access to articles, history and online database and online library.

BC MSRM. <http://srmwww.gov.bc.ca/tib/> Gateway to information on the various resource inventories maintained by the BC Ministry of Sustainable Natural Resources.

Western Mensurationists’ Homepage. www.westernforestry.org/wmens/ Has various links, including one to “Favorite Papers of ten Western Mensurationists”.

Forrex. The Forest Research and Extension Partnership. Has relevant articles in its various programs. Deals with the “IT” side in its “Natural Resources Information Mngt” program (www.forex.org/programs/program6.asp)

If you find other general information sites in your web searches, please let us know, and we will add them to this list.