Forest inventories generate scientifically sound information on the forest resource:

but do our data and information really matter ?

- a discussion paper –

by

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Abstract

Current research in forest inventory focuses very much on technical-statistical problems geared mainly to the optimization of data collection and information generation. Basic assumption is there that better information leads to better decisions and, therefore, to better forest management and forest policy. Not many studies, however, strive to explicitly establish this relationship between information quality and decision quality. In this paper we discuss this issue and suggest that forest inventory research should include more studies on the immediate and indirect impact that results and findings of forest inventories have.

Introduction

Forest inventories are carried out to collect scientifically sound and defendable data and generate equally sound and defendable information. This information is demanded and required by decision and policy makers responsible either for the management itself of the resource or for defining the regulatory framework for resource utilization and management. The information requirements come up at the latest when the resource becomes scarce: wise and target-oriented management is then required in particular, and sustainable utilization strategies are in demand so as to secure long term provision of goods and services and to balance conflicting user interests.

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Forest inventories have a long history; there is virtually no forest worldwide which has not experienced some sort of an inventory exercise. Forests as resource and ecosystem are as variable as the concrete management objectives, and forest inventories are adapted to the very conditions and objectives, be it a mere resource inventory, a forest health assessment, an inventory of non-wood goods and services, an inventory of a small property's or of an entire country's forest resource - to name just a few types of forest inventories.

To adapt to such manifold situations, forest inventory researchers and scientists have developed a highly versatile toolbox of techniques of data collection, making use of many data sources, analysis techniques and modeling techniques. Given the crucial role of forests in currently intensively debated issues such as climate change, combating desertification, and biodiversity conservation, it is not surprising hat forest inventory research is continuing to be intense and that forest information is demanded from many parties.

Browsing through the forest inventory research agenda, however, it calls one's attention that practically all forest inventory research is on technical issues of optimization of efficiency, be it statistical or economic efficiency, or both. Much less research is being carried out about questions like "What minimum information is needed for the sustainable management of a forest resource?" and, maybe even more relevant "What is the role of scientific information in decision and policy making processes?" and "... what can be learned from these two questions for forest data acquisition practices?"

It is somewhat surprising that these fundamental questions are not as widely addressed and discussed in forest inventory research as other topics - although they are probably more relevant than the optimization of sampling techniques because they are the very fundamental questions; optimization of forest inventories can only take place in the framework defined by the answers to these questions.

However, the questions are very complex. In this paper we try to discuss them mainly from the point of view of large area forest inventories (like national forest inventories, NFIs), but address the issue also for management-oriented inventories at the level of forest estates. The overall goal is to contribute to better focus forest inventory activities in planning, implementation, reporting and communication.

It is a discussion paper and, as such, rather than giving answers it poses the questions and discusses plausible paths towards the solutions.

Forest inventories in decision and policy processes

Forests are complex systems - whether we look at them as a resource or as an ecosystem. If such a system is to be sufficiently understood for specific management purposes, information is required. Here, we will not expand on the multitude and complexity of definitions of the term "information", but restrict ourselves to the simple and basic view of information as *interpreted data*, where interpretation is meant to be *knowledge-based* and data is meant to be the sort of sound and scientifically defendable data generated by inventories on scientific grounds.

In the Agenda 21, an entire chapter is dedicated to "Information for Decision Making" (Chapter 40). There paragraph 40.1 reads "In sustainable development, everyone is a user and provider of information considered in the broad sense. That includes data, information, appropriately packaged experience and knowledge. The need for information arises at all levels, from that of senior decision makers at the national and international levels to the grass-roots and individual levels."

Information generation and provision is but one part in the policy and decision making process, as illustrated in Figure 1. There, the outer circle describes the stages of the process where forest inventory expertise plays a major role.

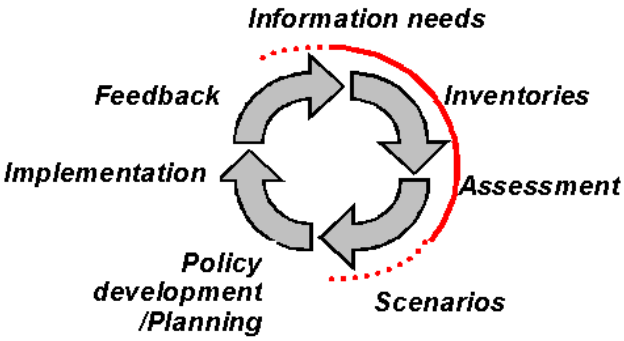

Figure 1. In this illustration of the decision and policy making processes, data collections takes place in the "inventories", and information generation in the "assessment" and "scenario" stage. The outer line indicates where forest inventory may play a major role. (Source FAO 2000)

Forest inventory is the process of gathering data. Through analysis and assessment these data are processed, interpreted and turned into information that can be used by decision makers in forest management or other interested parties. It is usually about key questions such as

- how much is out there at a given point in time (growing stock) and what is the quality / value ?
- where is it ?
- what are the changes and trends (of the stock, of the uses, of the functions, …) ?
- how much may sustainably be harvested (accessibility, ownership restrictions, …) ?

In addition to the "what and how much?" there is are also an interest in the question "how precise is the estimation?"

Occasionally, criticism is expressed, in particular in the context of large area forest inventories, that not the right information is generated as "… the information presented [from forest inventories] is supply-driven …" and "… the mechanisms that formulate policy-relevant questions are lacking" (Janz and Persson 2002). But even if the right information has been generated, "… too often, scientific information is available, yet policy makers do not use it" (Guldin 2003). This is, of course, a phenomenon which is not restricted to forest related policy making but has been stated by Gordillo and Andersson (2004) in more general terms: "… the link between policy evaluation and policy action is often quite weak or entirely missing".

Although forest inventory is probably the scientifically best developed and most systematically organized data collection exercise in the field of renewable natural resources, there are obviously still some basic issues to work on as "our scientific and technical abilities far outstrip our decision making methods and ability to understand the relationship between science and its many outcomes" (Crow 2000, cited after Guldin 2003).

Much of what we discuss here is about the efficiency of forest inventory data collection. An inventory strategy is efficient, in simple terms, if the defined objectives are achieved with low input. In this context, those who design, implement and analyze forest inventories are some times confronted with seemingly simple questions on the scope of their activities:

When, for example, planning in inventory in a class-room manner we usually resort to a sample size formula like $n = t^2 s^2 / A^2$, where A is half the width of the confidence interval (as a measure of precision) and t comes from the

t-distribution. On the right hand side of this equation, the (estimated) population variance s^2 is the only characteristic which has to do with the resource forest itself. The value of *A,* describing the target precision, needs to be defined on the basis of strategic or demand criteria. While usually even numbers such as 5%, 10%, 15% or 20% are defined as desirable precision levels, the authors of this paper do not know scientific (or other) studies which give proof, evidence and justification that these precision levels are adequate for a specific inventory. It appears largely to be based on tradition and convention. The same holds for the level of statistical significance. An α=5% level of error probability is defined by default – without giving more thought to it nor a justification whether these 5% are appropriate or not, and why so. In order to be able to define scientifically an optimal level of α and of precision, it would be necessary to formally establish a relationship between them and the objectives of the study viz. the target attributes.

Some thoughts on decision making

When the goal is to raise the overall efficiency of forest inventory data provision, it is necessary not only to look at the sampling and data processing stages, but also in more general terms at the ways and mechanisms how data and information are eventually used and how they affect decisions.

"Information about the subject/matter problem is a basis for good decision making": many forest inventory reports and many scientific articles on forest inventory optimization begin with that or similar statements which are usually accepted undisputedly adhering to the implicit assumptions

(1) that it pays to spend money for information provision and, above all, that

(2) better information leads to better decisions and hence, to better management.

While assumption (1) is frequently addressed and some times questioned when funds are to be allocated to an inventory study, there is usually no doubt about assumption (2). However, the relationship between information quantity / quality and decision quality is all but clear– and certainly not a simple and "linear" one. In fact, surprisingly few scientific studies attempt to establish or test this relationship. And hardly any study that begins with a statement like the above that "good information is required for good decision making" ends with a critical evaluation whether the information provided by that specific study actually made the decisions better.

Not only the "objective" information but also the decision makers themselves must be taken into account in that context. Data and information is but one factor in decision making; information is only helpful if it is presented in an adequate manner to the target group / decision makers / stakeholders. A certain level of education and expertise is usually required to make rational use of information. The more professional expertise there is, the less - but the more specific - is the information that is required. More non-technical factors may affect decision making among them type and extent of professional experience of the decision makers, their position within the institution, their motivation, their cognitive capacities, social and cultural norms, their advisors, … In addition, we may expect interactions between these factors.

Inventories on different geographical scopes

The question of relevance of information about the forest resource occurs at all geographical levels of forest inventories (stand, enterprise, national, global), where, however, it is not predominantly the geographical scope but the overall setting of people and institutions which determine the role of scientific information. We briefly discuss three cases:

Community forestry

In an instructive study on information, communication and decision making in community forest user groups, Banjade et al. (2006) analyse, among other points, the factors that make the users make use of information and the contribution of different types/qualities of information in community forest decision making in a case study in Nepal. Not really surprisingly, scientific information (the type of data-based information as provided by forest inventories) does not play a major role, but "experiences of community members and stories coming from within the community" outweighed that scientific information by far. In an attempt to quantify the contributions of different types/qualities of information in community forest decision making, the following resulted (Banjade et al. 2006): experience (47%), stories (18%), enthusiasm (14%), scientific information (12%), images and representation (9%).

The fact that knowledge and experience (and also rumors and stories) are relevant to decision making is probably known to everybody also in the context of every-day decisions. It has also to do with the question to what extent an expert may replace data and scientific evidence. A well trained forest officer with a long standing experience in local

forest management will probably demand only very specific inventories (if at all). However, such a decision system bases then completely on trust and belief in the expert, and decisions are not necessarily transparent or replicable.

In addition, the "traditional know-how" of forest officers becomes less and less valid as the system becomes very complex. "Decision support systems" are needed that account for all kinds of goods and services and allows different types of analyses to be made. To feed and update these decision support tools and to generate realistic scenarios, we do obviously need data.

It is not suggested here that expert decisions are all bad; but if independent monitoring is an issue and external experts want to have insight into the decisions and their background, the scientifically sound and defendable data and information provided from forest inventories on statistical grounds are probably indicated. In regulatory frameworks for community forestry, for example, forest inventories along statistical principles are some times required for exactly that reason. However, such an inventory needs then to be properly done and used in order to fulfill its functions.

Forest enterprises

Forest enterprises have clear economic objectives and planning follows usually straightforward managerial paths. Resources (in terms of manpower, time, money) will only be invested if it is economically reasonable, that is, if a return may be expected that exceeds the investment.

Although generally not used in practice, studies trying to incorporate the "decision making effects" of using different types of data in planning forest resource utilization do exist. Most of these are based on the minimisation of inventory cost plus expected loss due to non-optimal decisions ("cost-plus-loss analysis"), e.g. Hamilton (1978) and Ståhl (1994). However, the studies are few and in general they are based on assumptions of what data should be acquired and explicit knowledge on how the quality of the information is related to the loss due to non-optimal decisions.

In their review article on the influence of data quality on planning processes in forestry, Duvemo and Lämås (2006) state that "in general, a more accurate description of the state of the forest leads to more accurate forecasts … and, hence, to better decisions." And they also state "It is concluded that research in this area is scarce" and that "… those who seek to evaluate forestry data often oversimplify the problems", which is probably due to the inherent complexity of forest planning.

National forest policy formulation

In contrast to forest enterprises where there is a fairly direct link between information procurement and decision making and where economic analyses can possibly be done, national forest inventories aim at support, formulation and monitoring of forest and related policies - without immediate economic implications. National forest inventories are carried out in some countries for many decades (but in others not at all). Their frequent repetition in some countries may be evidence enough for their usefulness. However, studies that establish a clear link between policy decisions and availability of scientifically sound information are scarce. This research question, however, appears to receive more and more attention currently: FAO´s project to support National Forest Assessments NFA convened recently an expert consultation on "Generating knowledge through National Forest Assessments - Towards improved forest, land use and livelihood policies" (FAO-FRA 2006). To link forest assessments better to forest and related policies was a major topic there.

Data and information generated by forest inventories for larger areas (including NFIs) serve a multitude of functions the benefits of which are undisputedly there, but are difficult to rate and quantify. Among those benefits are

- development and evaluation of general forest and environmental policy;
- supporting allocation decisions of larger wood based industries;
- documenting the state and trends in the development of the forest resource;
- generating a data and information base for scientific research into forest uses and forest development;
- informing the public about the state of the forest resource; and then
- raising public awareness about the forests and their functions.
- Reporting to international conventions such as the Climate Convention (and the Kyoto Protocol) and the Convention on Biological Diversity as a means to cooperate on the global scale towards sustainable development.
- …

It is suggested to evaluate the benefits of forest inventory information not only in a "one-dimensional manner" as input into immediate decision and policy making processes, but to take the whole of the benefits into account. It may well be, for example, that the direct effect of the provided information on policy makers is much less than the

indirect effect that is provoked by a clearly expressed and informed public opinion. An interesting study would, therefore, be to systematically research into questions of dissemination and use of the information generated by national forest inventories: who knows about the results and who uses it for which purpose?

Some conclusions

We join the statement of Duvemo and Lämås (2006) that "evaluation of forest data should also include its usefulness in the forest management and decision process" and would like to extend that also to large area forest inventories that do not have an immediate forest management objective. It is suggested that forest inventory planners and scientists do also put the lesser technical-statistical topics more seriously on their research agenda including the following questions:

- *How is forest inventory data and information (and which part of it!) being used and for which purposes?* This requires that an inventory does not end with the publication and dissemination of the report, but that some follow-up is being done: do the results meet the needs and expectations of the users? Are there potential users who miss information that could have been generated? Essentially, we should do an "inventory" of uses and users and of the impacts of our forest inventory results and findings!
- *What data is required for different users?* This refers to the variables of interest, their precision of estimation, the spatial resolution (geographic unit of reference), the periodicity, etc.. That is actually a question which comes close to the technical-statistical optimization issues in forest inventory research, because precision is immediately linked to inventory design and inventory cost.
- *How do information requirements and information utilization interact with other factors* such as professional experience, academic and professional education, and position and power within the institution? It is likely that the information requirements can not be formulated in absolute terms but must be seen in the very concrete context not only of the forest resource and the biophysical conditions, but also in the context of other determinants like the organizational setting, the decision structures and the decision makers themselves and their motivation and agenda.
- *How to optimize the communication strategy?* The role of communication is some times underestimated in forest inventory reporting. Whether forest inventory data and information is eventually being used by

potentially interested stakeholders depends mainly on the communication strategy. Generating information is not enough. This is not only the case in forestry; Brewer (2006) states the same for conservation biology: "The data we continue to collect and report on … may make no difference … if this information is not translated into meaningful stories …".

To work on these questions, forest inventory experts need to resort to and integrate expertise from various disciplines from the social sciences, such as sociology, psychology, cultural anthropology, … It is suggested that the development of the discipline forest inventory will benefit very much if we work on the "information procurement and decision making" topic with an integrated interdisciplinary approach. It is further suggested to integrate such elements also into university teaching: forest inventory must not predominantly be seen as a technical-statistical field that requires quantitative skills above all, but equally as a discipline which is embedded in a multitude of other disciplines and requires a considerable amount of communication and analysis skills beyond sampling.

It is expected that this approach will help to even better guide the technical-statistical optimization of forest and natural resource inventories.

Coming eventually back to the question posed in the paper's title: "Do our data and information really matter?", the authors clearly believe that yes, scientific information does matter very much, in particular when credibility and transparency are ranked high. However, in science "belief" is not enough, and forest inventory experts must put more emphasis in adding tangible evidence to this belief.

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