Forest Inventories Generate Scientifically Sound Information on the Forest Resource, But Do Our Data and Information Really Matter?

Christoph Kleinn[1] and Göran Ståhl[2]

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

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 decisionmakers and policymakers responsible either for the management of the resource itself or for defining the regulatory framework for resource usage and management. The information requirements are relevant in particular when the resource becomes scarce: wise and target-oriented management is then required in particular, and sustainable usage strategies are in demand so as to secure the long-term provision of goods and services and to balance conflicting user interests.

Forest inventories have a long history; virtually no forest exists worldwide that has not experienced some sort of inventory exercise. Forests are ecosystems and serve as a resource at the same time. They are as variable as the concrete management objectives. Forest inventories are adapted to these very conditions and objectives, be it a mere resource inventory, a forest health assessment, an inventory of nonwood 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 that 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 such as "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 decisionmaking and policymaking processes?" and "What can be learned from these two questions for forest data acquisition practices?"

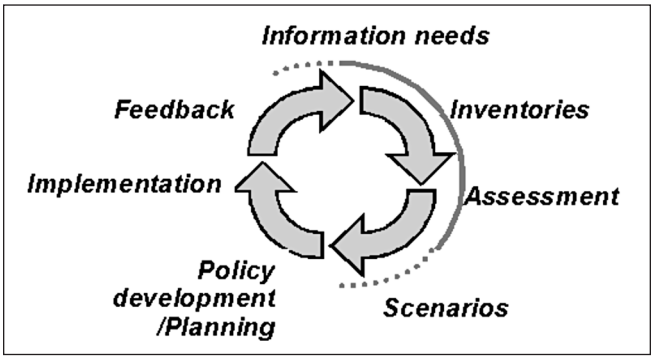
It is somewhat surprising that these fundamental questions are not as widely addressed and discussed in forest inventory research as other topics—although they are probably more relevant than the optimization of sampling techniques because they are the very fundamental questions; optimization

[1] Institute of Forest Management, Georg-August-Universität, Göttingen Büsgenweg 5, D-37077 Göttingen, Germany. E-mail: ckleinn@gwdg.de.
[2] Department of Forest Resource Management and Geomatics, Swedish University of Agricultural Sciences, Umeå, Sweden. E-mail: Goran.Stahl@resgeom.slu.se.

of forest inventories can only take place in the framework defined by the answers to these questions.

The questions are very complex, however. In this article we try to discuss them mainly from the point of view of large-area forest inventories (such as national forest inventories [NFIs]), and address the issue also for management-oriented inventories at the level of forest estates. The overall goal is to contribute to better-focused forest inventory activities in planning, implementation, reporting and communication. This is a discussion article and, as such, rather than giving answers, it poses the questions and discusses plausible paths toward the solutions.

Figure 1.—*In this illustration of the decisionmaking and policymaking processes, data collection takes place in the "Inventories" stage and information generation occurs in the "Assessment" and "Scenarios" stages. The outer line indicates where forest inventory may play a major role (from FAO 2000).*



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 Agenda 21, an entire chapter is dedicated to "Information for Decision Making" (Chapter 40). There, paragraph 40.1 reads in part, "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 policymaking and decisionmaking processes, as illustrated in figure 1. There, the outer circle describes the stages of the process where forest inventory expertise plays a major role.

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 decisionmakers in forest management or can be used by other interested parties. Forest inventory is usually about key questions such as the following:

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

In addition to the question of "What and how much," interest also exists in the question, "How precise is the estimation?"

Occasionally, criticism is expressed, in particular, in the context of large-area forest inventories, that the right information is not generated because "… the information presented [from forest inventories] is supply-driven …" and "… the mechanisms that formulate policy-relevant questions are lacking" (Janz and Persson 2002). Even if the right information has been generated, "… too often, scientific information is available, yet policy makers do not use it" (Guldin 2003). This observation is, of course, a phenomenon that is

not restricted to forest-related policymaking 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" (Gordillo and Andersson (2004).

Although forest inventory is probably the scientifically best developed and most systematically organized data collection exercise in the field of renewable natural resources, obviously some basic issues still need to be worked on because "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 in 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 sometimes confronted with seemingly simple questions on the scope of their activities.

When, for example, planning in inventory in a classroom 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 that 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 percent are defined as desirable precision levels, the authors of this article do not know scientific (or other) studies that 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-percent level of error probability is defined by default—without giving more thought to it or a justification about whether these 5 percent 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, namely the target attributes.

Some Thoughts on Decisionmaking

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 to look 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 decisionmaking." Many forest inventory reports and many scientific articles on forest inventory optimization begin with that or similar statements that are usually accepted undisputedly adhering to the following two implicit assumptions:

- It pays to spend money for information provision.
- Better information leads to better decisions and hence, to better management.

While assumption 1 is frequently addressed and sometimes questioned when funds are to be allocated to an inventory study, usually no doubt occurs about assumption 2. The relationship between information quantity/quality and decision quality is all but clear, however, and certainly not a simple and "linear" one. In fact, surprisingly few scientific studies attempt to establish or test this relationship. 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 of whether the information provided by that specific study actually made the decisions better.

Not only the "objective" information but also the decisionmakers themselves must be taken into account in that context. Data and information are but two factors in decisionmaking; information is only helpful if it is presented in an adequate manner to the target group, decisionmakers, or stakeholders. A certain level of education and expertise is usually required to make rational use of information. The more professional expertise exists, the less —but the more

specific—is the information that is required. More nontechnical factors may affect decisionmaking, including the type and extent of professional experience of the decisionmakers, their position within the institution, their motivation, their cognitive capacities, social and cultural norms, and their advisors. In addition, we may expect interactions between these factors.

Inventories on Different Geographical Scopes

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

Community Forestry

In an instructive study on information, communication, and decisionmaking in community forest user groups, Banjade *et al.* (2006) analyze, 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 decisionmaking 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 the "experiences of community members and stories coming from within the community" outweighed that scientific information by far (Banjade et al. 2006). In an attempt to quantify the contributions of different types/qualities of information in community forest decisionmaking, the following observations resulted: experience (47 percent), stories (18 percent), enthusiasm (14 percent), scientific information (12 percent), and images and representation (9 percent) (Banjade *et al.* 2006).

The fact that knowledge and experience (and also rumors and stories) are relevant to decisionmaking is probably known to everybody also in the context of everyday decisions. It has also to do with the question of to what extent an expert may replace data and scientific evidence. A well-trained forest officer with a longstanding experience in local forest management will probably demand only very specific inventories (if at all). Such a decision system is based completely on trust and belief in the expert, however, 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 sometimes required for exactly that reason. 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; i.e., if a return may be expected that exceeds the investment.

Although generally not used in practice, studies trying to incorporate the "decisionmaking effects" of using different types of data in planning forest resource usage do exist. Most of these studies are based on the minimization of inventory cost plus expected loss due to nonoptimal decisions ("cost-plus-loss analysis"); e.g. Hamilton (1978) and Ståhl (1994). The studies are few, however, 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 nonoptimal 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" (Duvemo and Lämås 2006). 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 (Duvemo and Lämås 2006).

National Forest Policy Formulation

In contrast to forest enterprises where a fairly direct link exists between information procurement and decisionmaking and where economic analyses can possibly be done, NFIs aim at supporting, formulating, and monitoring of forest and related policies—without immediate economic implications. NFIs are carried out for many decades in some countries (but not at all in other countries). Their frequent repetition in some countries may be evidence enough for their usefulness. 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: the Food and Agriculture Organization of the United Nations' (FAO's) project to support national forest assessments convened recently an expert consultation on "Generating knowledge through National Forest Assessments —Towards improved forest, land use and livelihood policies" (FAO 2007). Linking forest assessments better to forest and related policies was a major topic.

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

- The development and evaluation of general forest and environmental policy.
- Supporting the allocation decisions of larger wood-based industries.
- Documenting the state and trends in the development of the forest resource.
- Generating a database and information base for scientific research into forest uses and forest development.
- Informing the public about the state of the forest resource.
- 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 toward 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 policymaking 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 policymakers 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 questions of dissemination and use of the information generated by NFIs: who knows about the results and who uses them for what purpose?

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," (Duvemo and Lämås (2006) 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 agendas, including the following questions:

- *How is forest inventory data and information (and which part of it) being used and for what purposes?* This requires that an inventory does not end with the publication and dissemination of the report, but that some followup 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 effects of our forest inventory results and findings.

- *What data is required for different users?* This question refers to the variables of interest, their precision of estimation, the spatial resolution (geographic unit of reference), the periodicity, etc. This is actually a question that 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 usage 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 cannot 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, the decisionmakers themselves, and their motivation and agenda.
- *How to optimize the communication strategy?* The role of communication is sometimes underestimated in forest inventory reporting. Whether forest inventory data and information are 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 …." (Brewer 2006).

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, etc. It is suggested that the development of the discipline forest inventory will benefit very much if we work on the "information procurement and decisionmaking" 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 that 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 article'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. In science, "belief" is not enough, however, and forest inventory experts must put more emphasis in adding tangible evidence to this belief.

Literature Cited

Banjade, M.R.; Schanz, H.; Leeuwis, C. 2006. Discourses of information in community forest user groups in Nepal. International Forestry Review. 8(2): 229-240.

Brewer, C. 2006. Translating data into meaning: education on conservation biology. Conservation Biology. 20(3): 689-691.

Crow, M.M. 2000. Linking scientific research to societal outcomes. In: Proceedings, American Association for the Advancement of Science Colloquium on Science and Technology Policy. Washington, DC: American Association for the Advancement of Science: 129-131.

Duvemo, K.; Lämås, T. 2006. The influence of forest data quality on planning processes in forestry—a review article. Scandinavian Journal of Forest Research. 21(4): 328-339.

Food and Agriculture Organization of the United Nations (FAO). 2000. Global forest survey concept paper. For. Res. Assess. Working paper 28. Rome, Italy: Food and Agriculture Organization of the United Nations. 41 p.

FAO. 2007. Generating knowledge through national forest assessments—towards improved forest, land use and livelihood policies. NFM Working paper 05. Rome, Italy: Food and Agriculture Organization of the United Nations. 67 p.

Gordillo, G.; Andersson, K. 2004. From policy lessons to policy actions: motivation to take evaluation seriously. Public Administration and Development. 24: 305-320.

Guldin, R.W. 2003. Forest science and forest policy in the Americas: building bridges to a sustainable future. Forest Policy and Economics. 5: 329-337.

Hamilton, D.A. 1978. Specifying precision in natural resource inventories. In: Integrated inventories of renewable resources. Gen. Tech. Rep. RM-55. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimentation Station: 276-281.

Janz, K.; Persson, R. 2002. How to know more about forests? Supply and use of information for forest policy. CIFOR Occas. Pap. 36. Bogor, Indonesia: Center for International Forestry Research. 28 p.

Ståhl, G. 1994. Optimal stand level forest inventories under deterministic and stochastic stumpage value assumptions. Scandinavian Journal of Forest Research. 9: 405-412.