

## Forest Management Monitoring

### Basic knowledge



**This module is intended for forest owners and managers involved in monitoring forest management. It introduces the concepts and common methods of monitoring and provides links to tools and case studies.**

Effective monitoring is essential for sustainable forest management (SFM). An important distinction exists between **monitoring** and **auditing**, which are complementary components of a monitoring system. **Monitoring** can be defined as the ongoing assessment of the technical, environmental and social performance and impacts of management. A **monitoring system** is a way of steering and organizing monitoring so that it is efficient and easy to implement. Monitoring systems vary in sophistication – they may use simple measuring tools and paper-based recording, or they may involve advanced electronic equipment. The most important thing is not how sophisticated a system is, but whether information is collected, reviewed and used efficiently to ensure effective management.

Monitoring should be aligned closely with management objectives, and its results should feed into the planning process; forest management cannot be improved without [data on its impacts](#).

It is not uncommon in literature to distinguish between operational and strategic monitoring. **Operational monitoring** is done to ensure that present prescriptions and guidelines are being followed. It is also a basis for improving present practices and identifying areas where corrective or remedial action is required. **Strategic monitoring** is more about long-term observations and measurements of the environmental and social effects of forest management, which are used to guide and adapt management strategies.

This module concerns activities in **forest management units (FMUs)**, defined as clearly demarcated areas of land covered predominantly by forests, managed to a set of explicit objectives and according to a long-term forest management plan. The management of an FMU may have several objectives, although subunits within them may be managed for specific objectives and under specific management regimes. Monitoring ensures that the activities set out in a management plan are implemented as planned and enables the evaluation of the performance of an FMU and its management approach.

Key parameters typically addressed in monitoring the performance of an FMU include log production; boundary delineation and demarcation; respect for protected areas; the proper execution of conservation measures; forest health; the success of regeneration efforts; the timely implementation of stand treatments; unit costs; and the environmental and social effects of ongoing operations. Monitoring should include actual performance as well as actual expenditure against budgets, and it should consider the effects of management operations on the forest as well as on key social parameters.

A monitoring system should be sufficiently robust, detailed and frequent to enable the identification of problems at an early stage and the adjustment of management to address them; it should also demonstrate successes that can be built on. In both operational and strategic

monitoring, records and data should be comparable over time, and procedures should be consistent and replicable.

The following may be helpful in keeping monitoring costs under control and achieving understandable results:

- Keep monitoring focused on forest management – that is, on what you really need to know.
- Whenever possible, use simple and cheap methods.
- Use resources already available in the company or organization.
- Wherever appropriate, use easily applied indirect approaches.

**Criteria and indicators (C&I)** are tools for defining, guiding, monitoring and assessing progress towards SFM in a given context. The overall aim of C&I is to promote SFM, taking into consideration the social, economic, environmental, cultural and spiritual needs of stakeholders. **Criteria are categories of conditions or processes by which SFM can be assessed, and each criterion is characterized by a set of indicators that can be monitored to assess change over time.**

**Participatory monitoring** refers to forest monitoring performed directly by forest stakeholders. It has the advantages of obtaining information on stakeholder perceptions of the impacts of forest activities; helping to track progress on issues of particular concern to stakeholders; ensuring that stakeholders are well-informed about forest changes; encouraging stakeholders to review their own objectives in the light of outcomes; and facilitating face-to-face contact among stakeholder groups. Participatory approaches to monitoring can be employed in monitoring economic, social and environmental aspects of forest management.

**Forest management monitoring contributes to SDGs:**



**Related modules**

- [Forest certification](#)
- [Forest inventory](#)
- [Forest management planning](#)

- [Wood harvesting](#)

**Auditing** can be defined as a systematic, documented verification process of objectively obtaining and evaluating evidence to determine whether specified activities, events, conditions or management systems, or information about these, conform with audit criteria. Auditing is usually based on monitoring data and verified through sampling. **Audit criteria** are policies, practices, procedures or requirements against which an auditor collects evidence. In forest management auditing, criteria are typically related to management performance. Management systems often also need to be verified (for example, to ensure the reliability of inventory data and information systems). [Terminology in this field is not always consistent, and the difference between “auditing” and “strategic monitoring” is not always clear.]

## In more depth

### Operational monitoring

Operational monitoring is used to determine whether prescribed practices are being followed and if they are having the desired effects. It therefore provides a basis for modifications to improve practices and identifies areas in which corrective or remedial action is required. Typically monitored operations include:

- Harvesting
- Timber production
- Road construction
- Occupational safety and health
- Observation of protected zones
- Conservation programmes and measures
- Regeneration
- Thinning
- Other silvicultural treatments
- Contractor performance
- Productivity
- Unit and total costs.

Generally, operators are responsible for monitoring their own operations to ensure that standards are observed. Operators should (and may be required by law to) undertake statistically sound sampling of specified operational aspects, with the monitoring method depending on the type of operation. Serious deviations from operational standards should be reported in writing to the overseeing body. Sampling procedures should be designed to suit the operations to be monitored; for example, operators can ensure through monitoring (e.g. by means of measurement using relascopes) that residual stands have the desired basal areas and species compositions after thinning. The intensity of measurement should be decided at the local or company level.

### *Post-harvest assessment*

A post-harvest assessment is a systematic check to determine whether a harvesting operation (usually of wood, but also of non-wood forest products) has followed the harvesting plan and met its objectives while complying with established economic, social and environmental standards of practice.

Post-harvest assessments can be done for every operation, or for selected operations. If conducted while the harvest is in progress, monitoring can include direct observations of workers and operating equipment and enable immediate remedial action (if required). It is important that monitoring results are communicated to those concerned – from logging crews to higher management or public agencies – so they can be used to address any issues identified.

Operating standards, manuals and other checklists should be used to determine the data that need to be collected. Parameters that could be measured in post-harvest assessments include:

- the effectiveness of directional felling and grading;
- whether cutting and extraction have followed harvesting plans;
- volume and value losses caused by poor practices;
- the location and standard of roads, landings and skid trails compared with plans, and reasons for major diversions from plans;
- the impacts of roads, landings and skid trails on drainage and erosion;
- the extent of soil disturbance;
- impacts on potential crop trees, regeneration and wildlife;
- the extent to which conservation prescriptions and protected areas have been respected;
- the appropriateness of disposal methods for chemicals and related waste;
- the availability and use of appropriate personal protective equipment; and
- living conditions in workers' camps.

### **Strategic monitoring**

Strategic monitoring involves longer-term observations and measurements of the effects of forest management, which are used to guide and adapt management strategies. Key areas for strategic monitoring include management regimes, growth and yield, and environmental

and social impacts.

#### *Management regimes*

The strategic monitoring of management regimes normally involves periodic inventories of forest condition. Many large companies have ongoing inventory programmes that aim to assess the entire forest estate under management in a ten-year cycle. Among other things, the results of such inventory programmes provide data for estimating the sustainable annual harvest. Monitoring should also aim to assess the effectiveness of silvicultural treatments such as forest regeneration methods, thinning regimes and fertilization programmes.

#### *Growth and yield*

In natural forests, permanent sample plots should be established to monitor forest growth over time; such plots can also be used in environmental monitoring.

In tropical forests, permanent plots are usually 1 hectare in size. The density of such plots in a forest is determined according to forest heterogeneity (i.e. a forest that is relatively uniform over a large area might require a lower density of plots than a forest that varies considerably in, for example, its topography, species' associations, pressures and management regimes); management objectives; cost; the availability of data from other sources; and other factors. At a minimum, there should be at least one permanent sample plot per 1 000 hectares (i.e. a sampling intensity of 0.1 percent). An abundance of literature is available on how to establish and measure permanent sample plots (see tools and case studies).

#### *Environmental monitoring*

Environmental factors to be monitored in an FMU include:

- the extent and impacts of erosion;
- changes in site productivity;
- the impact of forest activities on water quality and quantity;
- the impact of forest activities on wildlife populations, including species on the IUCN Red List of Threatened Species; and
- the presence and impacts of exotic species – for example invasive alien plant species.

Independent auditing may play a role in environmental monitoring, and specialist inputs may also be required.

#### **Monitoring forests for climate change**

Forest managers may need to carry out additional monitoring to guide their forest management actions in the face of climate change. Forests may change in unexpected ways as the climate changes, and actions taken to mitigate climate change (e.g. to sequester more carbon in growing forests) may have unintended economic, social and environmental consequences. Monitoring can help guard against "surprises" brought about by climate change or by actions taken to mitigate it.

The approach taken to monitoring the impacts of climate change will vary depending on the vulnerability of the forests, the spatial scale of the operation, and the availability of technical and financial resources. Vulnerability and risk assessments generally involve climate sensitivity analyses and evaluations of the capacity of forest ecosystems and communities to adapt to climate change. In assessing the sensitivity of forests and forest-dependent communities to changing climatic conditions, the forest manager, in partnership with other stakeholders, should determine: the known climatic conditions and how these affect a forest area; the current and expected stresses on the forest area; the projected change in climatic conditions; and the likely impacts of these changes on forests.

Key issues to monitor include:

- Climate-related impacts on forest productivity, health and pests (i.e. parameters for which data are normally collected in inventory programmes).
- Biodiversity – the best species to monitor are those expected to be vulnerable to climate change and that are also easy to census. Ideally, such species will also be species of special concern.
- Water – dry-season base flows and suspended sediments during periods of low flow might be appropriate indicators of climate-related change to water regimes. The abundance and diversity of macro-invertebrates in streams may be good indicators of ecological integrity.
- Social factors – forest-related parameters related to vulnerability and the benefits of adaptation measures are unlikely to be included in standard forest inventories. Forest managers should develop social indicators that can be measured either by their own systems or by using other data sources.

- Forest carbon and other [REDD+](#)-related parameters - for meeting monitoring, reporting and verification obligations to demonstrate carbon benefits (with a view to obtaining payments for the sequestered carbon).

Climate-change monitoring, including for REDD+, requires baseline data (that is, data on the situation before an intervention) and the identification of indicators. Monitoring and evaluation procedures should be adaptable to allow for additional requirements related to specified adaptation and mitigation actions.

Monitoring expertise is often available locally (e.g. in community-based management). Arrangements may need to be put in place to incorporate both local expertise and institutional support (e.g. from local and regional governments). In some cases (e.g. for monitoring forest carbon in climate-change mitigation projects), aspects of monitoring will need to be outsourced to organizations or academic institutions with specialized laboratories and staff. Where possible, expert knowledge from the academic, practitioner and resource-user communities should be combined to increase monitoring power and provide a resource management platform suitable for addressing climate change.

See [Climate change guidelines for forest managers](#) for more information on climate-related forest monitoring.

### **Examples and advice**

- **The Forest Stewardship Council (FSC)** proposes the following [eight principles of forest monitoring](#):

1. **Think of your objective.** Don't collect information that you won't use. Two common mistakes are collecting too much information and collecting information without knowing how it will be used.
2. **Decide what you can measure.** What is to be monitored should be broken down into measurable values/indicators. Define simple indicators for what you want to look at.
3. **Consider scale.** There may well be changes in an indicator in a small area, but not when considered over a larger area. Avoid measuring in only one small area.
4. **Collect information regularly.** This is essential for detecting change.
5. **Pick the right frequency.** The frequency of measurement varies according to the parameter – for example, stream flow might be measured daily, but tree growth might only require measurement every few years.
6. **Think long term.** Short-term fluctuations may not be indicative of long-term change.
7. **Focus on detecting change.** This is key for assessing the quality of management.
8. **Use the results.** If results are not used, why bother monitoring anything?

- **The World Wide Fund for Nature (WWF)** and the **Tropical Agricultural Centre for Research and Higher Education** identified the following [ten steps in developing an adaptive forest](#) management system, in which monitoring plays a key role:

1. Define the management objectives.
2. Identify high conservation values (if any).
3. Conduct an environmental impact assessment to identify the positive and negative impacts of the principal management activities on important ecological variables, in accordance with the national regulations of the country in which the FMU is located and, if relevant, with the requirements of certifiers.
4. Establish mitigation measures to reduce the negative impacts of the operation.
5. Define the specific objectives of the monitoring programme (what is to be monitored?).
6. Select indicators for their assessment in the monitoring programme.
7. Establish a robust sampling design for the monitoring programme.
8. Establish limits or values for the measured indicators that "activate" a response (usually a change in management operations).
9. Monitor the operations in accordance with the established scheme.
10. Adapt the management activities and planning documents (return to 4 above).

- A company in the [Brazilian Amazon](#) has adopted a [monitoring system that focuses on generating reliable information on the growth and yield of forest](#) stands to support the decision-making processes of forest managers on silvicultural interventions. The system specifies a sampling intensity of one permanent 0.5 hectare sample plot for every 200 hectares of production forest. Modern technologies are applied to increase the reliability of diameter and height measurements to obtain accurate growth and yield data. Data on natural regeneration, saplings, and trees below 15 cm diameter (at breast height) is not collected because of difficulties with botanical identification. Observations of sampled trees focus on crown form, position and diameter, the status and intensity of vines, and damage to the stems and crowns of trees.

The system was designed to gather data for the ecological grouping of species based mainly on their light requirements and natural

diameter growth ranges, as well as on their diameter distribution patterns and potential commercial uses. Species groupings based on these variables have proved satisfactory for decisions on how to intervene in order to stimulate the growth of the potential crop trees in forest stands.

- A large private **Swedish company** has defined [objectives and guidelines for monitoring its operations](#). Monitoring is conducted according to clear, detailed guidelines for every treatment and operation, much of it by the operators themselves but also by third parties at regular intervals focused on one treatment (e.g. regeneration, thinning or final felling) at a time. The company also carries out inventories of its own, and inventories are conducted in a ten-year cycle. Most large private Swedish companies have similar approaches.

Another large private Swedish company ensures that every working crew is evaluated at four operational sites per year – more, if performance is below standard. The company's experience is that regular routines are more efficient than campaigns. The company spends 90 person-months (i.e. roughly eight person-years) on monitoring per year. In addition, all employees are required to monitor their own work.

Both these Swedish companies are certified by the FSC and the Programme for the Endorsement of Forest Certification, and both own large areas of forest. The first-mentioned company uses the following guidelines for monitoring and evaluating thinning operations, which are carried out by contractors:

#### *The purpose of monitoring and evaluation of thinning*

- o Ensure that basal areas prescribed for residual stands are observed, and, if not, that corrections are made.
- o Keep the number of trees damaged to a minimum (no more than 3 percent).
- o Check that secondary roads and other tracks are established as per instructions.
- o Ensure that operational plans are followed.
- o Ensure that data for the stand catalogue and other relevant planning documents are up to date.
- o Provide forest owners with feedback.
- o Ensure adherence to current environmental and forest management policies.

#### *Guidelines for monitoring and evaluation of thinning*

- o Harvester operators should ensure that thinning intensity is in accordance with the residual basal area specified. Relascopes and/or calipers should be used.
- o Use the harvester computer to document the number of high stumps created.
- o The thinning crew should document data for two plots per shift.
- o Serious deviations from current guidelines should be reported in a special format.
- o A sample of thinned stands is measured regularly in accordance with routines at the district or central company level (this is more a part of strategic monitoring).

## E-learning

### [Collecting household welfare data through forestry modules](#)



Collecting household welfare data through forestry modules

The e-learning on the 'National socioeconomic surveys in forestry' comprises four courses that aim to provide guidance on the use of forestry modules to collect data on the socioeconomic contributions of forests and non-forests environments to household welfare and livelihoods...

### [Forests and transparency under the Paris Agreement](#)



Forests and transparency under the Paris Agreement

The objective of this course is to learn about the Enhanced Transparency Framework (ETF) under the Paris Agreement. It will be useful to those wishing to understand the importance of forest-related data collection, analysis and dissemination in meeting the Enhanced Transparency Framework...

### [Introduction to national socioeconomic surveys in forestry](#)



Introduction to national socioeconomic surveys in forestry

The e-learning on the 'National socioeconomic surveys in forestry' comprises four courses that aim to provide guidance on the use of forestry modules to collect data on the socioeconomic contributions of forests and non-forests environments to household welfare and livelihoods...

### [Istituzionalization of forest data](#)



This course is designed for individuals who have an interest in establishing and developing a national forest monitoring system (NFMS), and to learn about the institutionalization process. The course targets legal experts, ministries, government officers, academia and private sector...

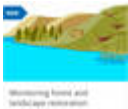


### [Measuring the role of forests and trees in household welfare and livelihoods](#)



The e-learning on the 'National socioeconomic surveys in forestry' comprises four courses that aim to provide guidance on the use of forestry modules to collect data on the socioeconomic contributions of forests and non-forests environments to household welfare and livelihoods...

### [Monitoring forest and landscape restoration](#)



As countries work to meet their national commitments to restoring degraded landscapes, it is important that all FLR interventions have manageable monitoring systems in place, to assess progress towards specific goals, support adaptive management and ensure transparency...

### [Operationalising the forestry modules](#)



The e-learning on the 'National socioeconomic surveys in forestry' comprises four courses that aim to provide guidance on the use of forestry modules to collect data on the socioeconomic contributions of forests and non-forests environments to household welfare and livelihoods...

### [SDG indicators 15.1.1 and 15.2.1 - Forest area and sustainable forest management](#)



This course has been developed to guide countries in reporting on Indicators 15.1.1 and 15.2.1. It illustrates the rationale of the indicators, the definitions and methodologies on which monitoring activities are based, and explains the process and the tools available for compiling...

[Sharing the "Forests and Transparency under the Paris Agreement" MOOC multilingual experience](#)



**This Massive Open Online Course (MOOC) was based on the FAO e-learning course “Forests and transparency under the Paris Agreement” available on the FAO e-learning Academy. In this course participants learnt about the importance of forest-related data collection, analysis...**

[Sharing the experience on “Forest and land monitoring for climate action – SEPAL” facilitated course](#)



**The overall objective of this course is to support knowledge and skills development to operationally apply high-resolution satellite imagery to critical forest and land monitoring in tropical forest countries. More specifically, the course focuses on how the System for Earth Observation Data Access...**

## Further learning

**Appanah, S. & Kleine, M.** 2001. *Auditing of sustainable forest management: a practical guide for developing local auditing systems based on ITTO's criteria and indicators*. Forestry Research Support Programme for Asia and the Pacific (FORSPA) 26. Bangkok, FAO. 131 pp.

**Avery, T.E.** 1975. *Natural resources measurements*. McGraw-Hill Inc. ISBN 0-07-002502-9. 339 pp.

**Contreras, F., Cordero, W. & Fredericksen, T.** 2001. *Evaluación del aprovechamiento forestal*. Santa Cruz, Bolivia, Proyecto de Manejo Forestal Sostenible (BOLFOR). 33 pp.

**FAO.** 1990. *The community's toolbox: the idea, methods and tools for participatory assessment, monitoring and evaluation in community forestry*. Community Forestry Field Manual 2. Rome.

**FSC.** 2008. *Small, low intensity and community forests*. Forest Stewardship Council Briefing Note 5.

**Fröde, A. & Masara, C.** 2007. *Community-based ecological monitoring: manual for practitioners*. Harare, Southern Alliance for Indigenous Resources. 64 pp.

**Higman, S., Mayers, J., Bass, S., Judd, N. & Nussbaum, R.** 2005. *The sustainable forestry handbook*. London, The Earthscan Forestry Library. ISBN 1-84407-118-9. 332 pp.

**INRENA & CIFOR.** 2006. *Manual del auditor. Auditoria de planes de manejo en las concesiones forestales con fines maderables* (RJ061-2006-INRENA). C. Sabogal, V. Colán, J. Arce & V. Sobrevilla, eds. Lima, Instituto Nacional de Recursos Naturales & Centro Internacional de Investigación Forestal. 65 pp.

**Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A., Soehartono, T., Stanley, S. & O'Brien, T.** 2005. *Life after logging: reconciling wildlife conservation and production forestry in Indonesian Borneo Implications for forestry and concession management*. Bogor, Indonesia, Center for International Forestry Research. 370 pp.

**Normark, E.** 2011. *Guidelines for sustainable forest management*. Ornskoldsvik Sweden, Holmen Skog.

**Orozco, L., et al. (ed.)**. 2006. *Aprovechamiento de impacto reducido en bosques latifoliados húmedos tropicales*. Serie Técnica. Manual técnico No. 63. Turrialba, Costa Rica, Centro Agronómico Tropical de Investigación y Enseñanza. pp. 399-434.

**Pokorny B., Sabogal, C. & de Camino, R.** 2001. Metodologías para evaluar la aplicación de criterios e indicadores para el manejo forestal en bosques tropicales de América Latina. *Revista Forestal Centroamericana*, 36: 14-19.

**Pokorny B., C. Sabogal, Silva, J.N.M., Souza, J. & Bernardo, P.** 2004. Criterios e indicadores para el monitoreo de operaciones forestales: un caso en Brasil. *Revista Recursos Naturales y Ambiente*, 42: 19-28.

**Pokorny B., Sabogal, C., Galvão, C.A., Mendoça, R., Silva, J.N.M., De Carvalho, J.O.P., Puerta, R. & Zweede, J.** (organizadores). 2006. *Manual de vistoria de campo para planos de manejo florestal madeireiro na Amazônia*. Brazilia D.F., Cooperação IBAMA/EMBRAPA. 105 pp. + CD-ROM.

**Philip, M.S.** 1994. *Measuring trees and forests*. Cambridge, UK, CAB International. ISBN 0 58198 883 0. 305 pp.

**Sabogal, C., Carrera, F., Colán, V., Pokorny, B. & Louman, B.** 2004. *Manual sobre técnicas de manejo forestal para profesionales forestales*. Proyecto INRENA-CIFOR-FONDEBOSQUE "Apoyo a la implementación del nuevo régimen forestal a través de la capacitación a asociaciones de productores forestales concesionarios en la Amazonía peruana". Lima, INRENA, Centro Internacional de Investigación Forestal, FONDEBOSQUE & Centro Agronómico Tropical de Investigación y Enseñanza. 279 pp.

**Sabogal, C. & Sobrevilla, V.** (eds). 2008. *Monitoreo de operaciones de manejo Forestal en concesiones con fines maderables de la Amazonía Peruana*. Centro Internacional de Investigación Forestal & INRENA. 134 pp.

**Stanley, S.** 1996. *Monitoreo estatal en concesiones forestales comunitarias en la reserva de la biosfera Maya, Petén, Guatemala*. Serie técnica. Informe técnico N° 281. Turrialba, Costa Rica, Consejo Nacional de Áreas Protegidas & Centro Agronómico Tropical de Investigación y Enseñanza. 38 pp.

**WWF Malaysia.** 2007. *Ecological monitoring of forestry management in the humid tropics: a guide for forestry operators and certifiers with emphasis on high conservation value forests.* A reference for the Wildlife Assessment and Monitoring in Sustainable Forest Management (WAMSFM) Module of the Tigers Alive! Project. Translated from *Monitoreo ecológico del manejo forestal en el trópico húmedo: una guía para operadores forestales y certificadores con énfasis en bosques de alto valor para la conservación* by WWF Central America. Translated by Eugene Lee for WWF Malaysia.

## Credits

This module was developed with the kind collaboration of the following people and/or institutions:

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