United Nations Economic Commission for Europe

Convention on Long-range Transboundary Air Pollution

International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests)

MANUAL

on

methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests

Part II

Basic design principles for the ICP Forests Monitoring Networks

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Contents

1. Introduction

Most of the success of a monitoring programme rests on its design. Design can follow a top-down approach when administrative structure, aims and objectives of the monitoring are simple and can be easily identified (Parr et al., 2002). On the other hand, design may be quite complex when the programme has to face multiple objectives (for achievements for which several investigation are necessary), must be carried out by an international and multi-agency co-operation (when different conceptual and operational perspectives have to be considered), and must accommodate existing monitoring "traditions" (which are always reluctant to change) (Parr et al., 2002). Under such circumstances, a top down approach is hardly feasible, and the bottom – up approach remains the only option (Köhl et al., 2000; Parr et al., 2002). This is particularly true for the ICP Forests monitoring networks: although developed following generally agreed principles, given the nature of the programme they were originated at national level and - as such - they largely reflect country-based design concepts. For example, the large-scale (Level I) network is in many cases a subsample of National Forest Inventories. As such, for example, the definition of the target statistical population and the plot design may be different from country to country (Cozzi et al., 2002). The same applies to the intensive monitoring (Level II) network, with a number of different plot designs being used across Europe. After 25 years of monitoring this situation cannot be denied, ignored or changed. Rather it can, and must, be acknowledged and managed as far as possible. This Part II of the ICP Forests Manual provide guidelines about (i) how to achieve basic design requirements and at the same time (ii) allow the continuation and consistency of the existing data series.

2. Scope and application

This Part II of the ICP Forests Manual is focussed on the description of the overall monitoring structure, the selection of the sample plots (large-scale and intensive monitoring), the design of the plots, the measurements (plot and stand description and geo-referencing, the variables to be measured) and the data submission. The guidelines provided here permit a minimum level of harmonization which is essential to ensure data comparability across participating countries and proper data processing. To have their data used in the international database and evaluations, National Focal Centers and their scientific partners participating in the UNECE ICP Forests programme should follow the methods described here.

3. Objectives

Monitoring design has the objective to ensure consistency between the aims of the programme and the activities carried out to achieve them. In this context, it is worth recalling the aims of the ICP Forests as described in the Strategy Paper 2007-2015 (http://www.icp-forests.org/pdf/strategy07-15.pdf):

- Aim 1: To provide a periodic overview on the spatial and temporal variation of forest condition in relation to anthropogenic and natural stress factors (in particular air pollution) by means of European-wide and national large-scale representative monitoring on a systematic network.

- Aim 2: To gain a better understanding of the cause-effect relationships between the condition of forest ecosystems and anthropogenic as well as natural stress factors (in particular air pollution) by means of intensive monitoring on a number of selected permanent observation plots spread over Europe and to study the development of important forest ecosystems in Europe.

Given the above objectives, relevant design issues are:

1. the type, number and characteristics of large-scale and intensive monitoring plots that will permit quantitative estimates with known uncertainty of forest condition at a given time and changes through time (Aim 1); and the identification of relationships between a given set of predictors and a given set of response variables (Aim 2). These issues will be covered in Chapter 4.
2. The set of investigations necessary to obtain data on forest condition (Aim 1) and on the stress factors of concern (Aim 2). This will be covered in Chapter 5.1
3. The set of variables to be measured within each investigation. This is under the responsibility of individual Expert Panels and will be covered within individual Parts of the Manual.
4. The Quality Assurance procedures, summarised in Chapter 5.2. These were developed following the approach described in Part III and will be described in Parts IV- Part XVI
5. The data submission and reporting rules, summarised in Chapter 6 and described in Part XVII.

4. Location of measurement and sampling

4.1 Definitions

4.1.1 Monitoring intensity levels

The two objectives of ICP Forests provide already some guidance for design, and ask for two different levels of monitoring intensity, called large-scale, or Level I monitoring, and intensive, or Level II monitoring. The two intensity levels of the monitoring are therefore defined by the number of investigations carried out on the plot and by the number of plots covered by the investigations. The two monitoring levels differ for the following three elements:

- Network design: Level I requires data to be formally representative at European level. As such, a probabilistic sampling is required in order to allow design-based inference. On the contrary, no formal representativeness is required for Level II, and observation plot can be allocated according to different criteria (purposive sampling).
- Variables to be measured: Level I is mostly concerned with the forest condition, and the attributes to be measured are typically those able to describe tree health. Level I is also the basis for large-scale assessments of forest soils and biodiversity. In short, Level I envisages a limited number of measurements on a large number of plots. On the other hand, Level II aims at understanding of the cause-effect relationships between the condition of forest ecosystems and anthropogenic as well as natural stress factors. As such, it requires measurements to cover a range of responses (from tree condition to growth and biodiversity), predictors (e.g. deposition, gaseous air pollutants, meteorology) and intermediate variables (having the role of response and predictors, according to the analysis, e.g. soil, soil solution and foliar nutrition) (Vos et al., 2001). In short, Level II envisages a large number of measurements on a limited number of plots.

- Plot design: given the differences in the measurements to be carried out and the different aims, Level I and II differ also in plot design, both in shape and size. Unlike Level I, Level II must accommodate a number of different investigations and at the same time must avoid conflicts between them. Level II should host permanent equipments, also. However a common requisite for Level I and II will be the area frame: both Level I and II plots should have a known area.

4.1.2 Monitoring plots and sites

4.1.2.1 Level I plots

A Level I plot is an area of defined dimension and shape. Most common and practical plots are circular plots defined by the coordinates of the centre and by a radius. However, the design of the plot is under the responsibility of the country and must be the same within the country. Level I plots are allocated over the statistical population of concern according to defined sampling design which may be different from country to country (see below), provided it is on a probabilistic basis. In the past, in some cases there was no plot: a fixed number of trees for crown condition was selected around co-ordinates of grid intersections and following a standardized scheme. This kind of design is not – by definition – a plot in formal terms, and has limitations with respect to area related statistical estimates. If a country wishes to keep such a design, it is worth noting that data can be processed only to derive sample statistics, but are not suited for estimation purposes and will not be considered in that respect. However, for the sake of time series it is possible to maintain the existing sample trees. Guidelines how to achieve a proper plot design while maintaining the former sample trees (and the existing time series) are provided in the Annex II.

4.1.2.2 Level II sites

A Level II site is a designated homogeneous forest area within which a Level II plot is installed. The area is not necessarily of defined shape and size, but should be large enough to accommodate the set-up of a Level II plot. The minimum size is 0.25 ha (see below). The plot is surrounded by a buffer zone (see below). The plot plus the buffer zone constitute the Level II site.

4.1.2.3 Level II plot

A Level II plot is an area of defined shape and size located within a Level II site. Desirably, all the *in-site* measurements are carried out within the plot's boundaries and according to sound statistical requirements. When it is not possible (e.g., limited area, destructive sampling), some measurements can be located outside the plot, but within the Level II site boundaries. Data collected within the plot and with a proper statistical design can be considered formally representative for the plot. Data originated from measurements located outside the plot, or within the plot but with an incorrect design, can not be considered formally representative for the plot. They can however be assumed to be indicative for the site, although with unknown confidence.

4.1.2.4 Level II sub-plots

For specific purposes (e.g. tree condition in dense stands, deposition sampling, ground vegetation assessment), one or more sub-plots may be necessary. A sub-plot is an area of defined dimension and shape within which the measurements are carried out. To be representative for the plot, the sub-plots must be selected according to a statistically sound procedure. If not, measurements carried out on the sub-plot can not be considered indicative for the plot.

4.1.2.5 Level II buffer zone

The buffer zone is an area surrounding the Level II plots designated to ensure plot protection against direct influence of nearby paths, roads and disturbances. The size and shape of the buffer

zone depends on local conditions. However, it must be large enough to protect the plot from direct disturbances and – at the same time – still be characterized by the same plot conditions in terms of aspects, slope, canopy cover and soil condition. In some cases, the buffer zone can also be used for some *in-site* measurements. By definition, these measurements are not formally representative for the Level II plot. However, they can be considered indicative for the site.

4.1.3 Mandatory and optional variables

Two main sets of variables are defined, called "*mandatory*" or "*optional*" variables. The status means that within the respective investigations the mandatory variables must be measured. On the other hand, "optional" identifies those parameters that may or may not be measured. This status must not be confused with the obligation of EU-Member States to assess and submit data under relevant EU Regulations.

4.1.4 Type of measurements

Two series of measurements are defined: *in-site* and *off-site* measurements.

In-site measurements are all those measurements that are carried out within the Level II sites. They include tree condition, tree growth, tree phenology, biodiversity, ozone injury on plot main tree species, soil sampling, soil solution, foliar sampling, throughfall and stemflow sampling, and litterfall sampling.

Off-site measurements are those that - by definition - are carried out outside the forest stand. They include open field bulk deposition, open field meteorological measurements, gaseous air pollutants, ozone injury at the forest edge.

4.2 Sample plots

4.2.1 Large-scale (Level I) plots

The selection and characteristics of Level I plots are always within the responsibility of the countries. However, to facilitate data evaluation, the following guidelines must be considered.

4.2.1.1 Plot density

The minimum number of plots per country should be equal to the forest area of the country (in km^2) divided by 256. This is to keep consistency with the traditional plot density adopted within the ICP Forests. For small countries and/or infrequent forest types, denser sampling should be considered (e.g., Köhl et al., 1994). Data from denser national grids are not submitted to the central data base.

4.2.1.2 Plot selection

A probabilistic sampling design is essential to ensure that large-scale plots fit the aims of the monitoring. Plots should be allocated over the target statistical population in such a way that – for each element of the population - a non zero probability of being selected is ensured. When setting-up a new Level I network, different designs can be adopted (e.g., random sampling, systematic sampling, tessellation stratified sampling) which fit the above requirement. The definition of the sampling scheme is under the responsibility of individual countries.

4.2.1.3 Plot selection to achieve harmonization/integration with existing networks

Different forest monitoring networks may already exist within a country. Due to their nearly ubiquitous presence in European countries, the most common networks are National Forest Inventories (NFI) and Level I. Two cases may exist (Ferretti, 2010):

Case 1. Level I and NFI are already merged in the same network. This may be the case because Level I was established on existing NFI networks (most frequent) or the other way round. In general, a subsample of NFI plots was used for Level I (Köhl et al., 1994; Neumann, 1993). In these cases, networks are already integrated and harmonized. Some further harmonization may be necessary due to a possible adaptation of survey methods in agreement to international procedures, but this can be traced and documented.

Case 2. Countries with separate NFI and Level I networks. This may have happened because (i) there was no NFI in the past, and Level I was created before NFI; (ii) the NFI and Level I were developed independently; (iii) countries with a former joint NFI-Level I network (Case 1) abandoned (for a variety of reasons) their original NFI for a newly designed one, thus having now two separate networks. The result is that Level I and NFI are carried out on different networks.

In Case 2, it may be useful to apply some harmonization/integration concept that may allow maximum use of existing networks and information. A functional integration of networks (*sensu* Ferretti, 2010) is suggested in the Annex I.

4.2.1.4 Plot design and selection of sample trees and sample locations for other surveys

Plot design is under the responsibility of the countries, and must be reported when submitting the data. Figure 1 shows different plot designs adopted for Level I in Europe. While different designs are possible, it is important that plots are designed on a fixed area basis, a condition necessary for estimation purposes and to allow a better integration with NFIs. Deviations from the fixed area concept are only possible in exceptional cases for tree health assessments in order to ensure time series. When such deviations are adopted (e.g. fixed number of trees without area related information), data can be used for descriptive statistics, but not in design-based inference. Although desirable, it is not necessary that plots are of the same size and shape between different countries; rather it is essential that they are of the same design within a country, respectively *Bundesland* within Germany. When NFI and Level I networks are separated, it is recommended that the Level I plots will in addition adopt the country-specific NFI design (see Chapter 4.2.1.3). As an alternative, and since it was already used for measurements of DBH, deadwood, ground vegetation, the BioSoil design is also recommended.

Annex II provides a suggestion on how to move from a fixed-number of trees sample point to a fixed area plot, without missing the connection with existing data series.

On Level I, annual tree health assessments are obligatory. On an voluntary basis tree growth, ground vegetation and foliar chemistry are assessed according to the respective methods (see Manual Parts V, VII and XII). A European wide soil condition survey has been carried out twice based on Level I plots. The concept foresees a repetition of the soil survey in larger time intervals (e.g. every ten or twenty years). Soil surveys should be carried out temporally synchronized in all participating countries. Methods for soil condition surveys are described in Part X.

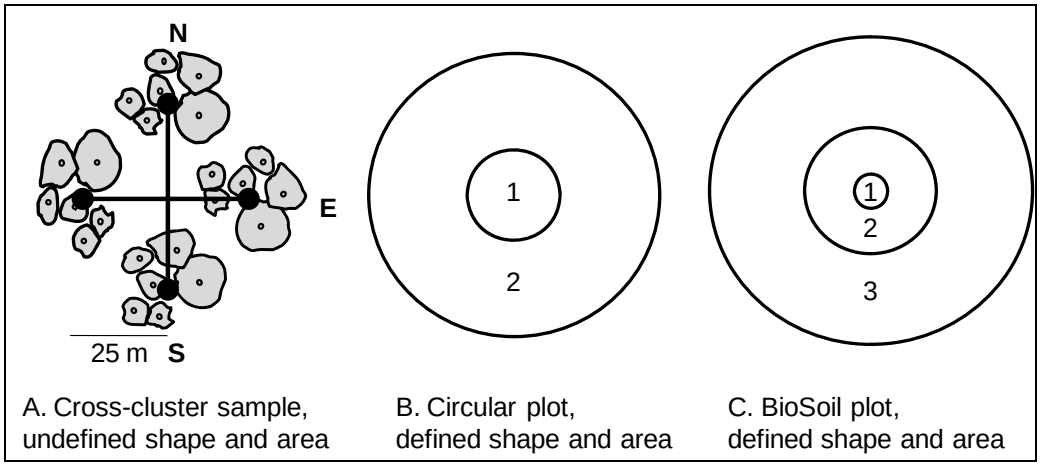

Figure 1: Examples of designs adopted for Level I plots in Europe. A. Cross-cluster; B. Circular: 1, subplot for all tree above given DBH thresholds; 2, subplot for large trees only; C. BioSoil plot: 1, 30 m2 subplot; 400 m2 subplot; 2000 m2 subplot. (Drawing: M. Ferretti).

4.2.2 Intensive (Level II) sites

The selection and characteristics of Level II plots are always within the responsibility of the countries. However, to facilitate data evaluation, the following guidelines must be considered

4.2.2.1 Number of sites

The number of Level II plots should equal at least approx. 10% of the Level I plots.

4.2.2.2 Selection of sites

Plots are selected on a preferential basis taking into account:

- ecological and logistic issues. The situation shall be as homogeneous as possible (regarding e.g. tree species, stand type and site conditions within the plot. However, the more homogeneous the plot, the higher is the chance its homogeneity will decrease with time as result of different factors (Palmer, 1993). Plots should be accessible to allow routine operations;
- the importance of forest ecosystems within a country. One important selection criterion is that the Level II plots in a country should be located in such way that the most important forest species and most widespread growing conditions in the country are represented. It is advisable to give priority to replicates within the same forest ecosystem type, rather than spreading plots over a huge variety of types, in order to facilitate data analysis;
- the existence of data series and the importance of their continuation. Whenever possible, plots should be selected which have been monitored during the last years. The great advantage of existing data on air quality and meteorological parameters from nearby stations should be taken into consideration whenever establishing Level II plots.

4.2.2.3 Site and plot design

There are different designs adopted for Level II sites and plots (Figure 2). Countries are responsible for selecting the most appropriate design, provided they can conduct the investigations as described in Parts III-XV. While different designs are allowed, some requirements must be attained:

- Plot boundaries must be permanently identified and geo-referenced;

- Plot must have a minimum size of 0.25 ha. The area of the plot must be always reported.
- Sub-plots are allowed, and the sub-plot selection criteria must be described. Sub-plot boundaries must be permanently identified and geo-referenced. The area of the sub-plots must be always reported.

The selection of sample trees and/or and the positioning of measuring devices for different surveys is described in the Parts of the Manual dealing with the concerned survey.

Examples of location of a Level II site and plot with in-site and off-site measurements is given in Figure 2.

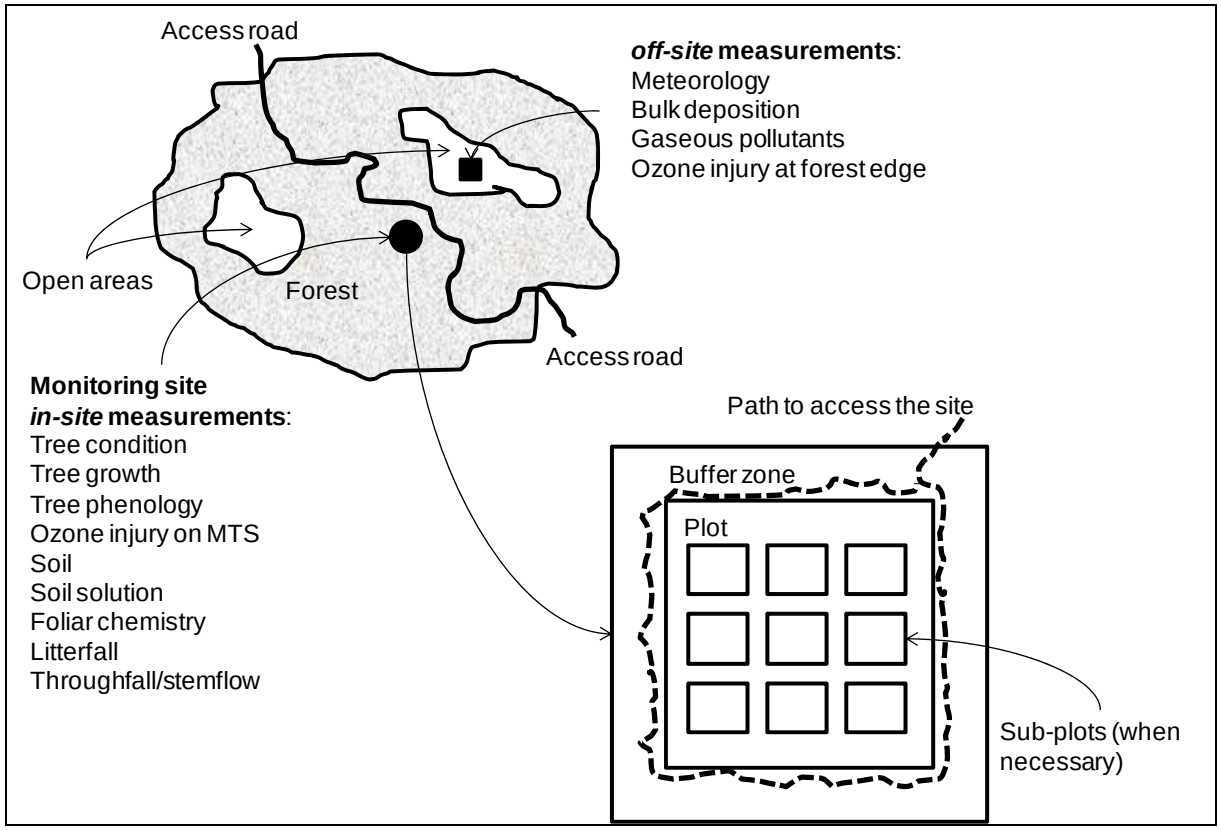

Figure 2: Example of location of a monitoring site and its possible organization, with buffer zone, plot and sub-plots. In-site measurements are those that must be carried out within the site; off-plot measurements are those to be carried out in an open area close to the plot. Note that different shape (e.g rectangles, polygons) and size (min 0.25 ha) are possible, as well as different type of internal organization of the plot. Size and shape must however be known and reported (Drawing: M. Ferretti).

4.2.2.4 Type of Level II sites and plots

Two types of Level II sites/plots are identified:

1. Level II standard: on these sites the following surveys are obligatory

- Crown condition (annually)
- Tree growth (every 5 years)
- Foliar chemistry (every 2 years)
- Ground vegetation (every 5 years)
- Deposition (continuously)
- Soil (every 10 years)
- Meteorology (at least at 10% of the plots) (continuously)

2. Level II core: these sites are a sub-sample of the previous standard Level II sites. On core sites, the same surveys as on the standard Level II sites are carried out. In addition, the following surveys are conducted:

- Litterfall (continuously)
- Tree phenology (several times within a year)
- Growth (intensive) (every year by growth bands)
- Soil solution (continuously)
- Soil water (continuously)
- Air quality (continuously)
- Ozone injury (continuously, except Northern Europe)
- Meteorology (continuously)

Core plot surveys are carried out on a voluntary basis. But in case that countries are willing and interested to carry out intensified monitoring beyond standard Level II surveys, it is strongly recommended to carry out the complete set of core plot surveys in order to facilitate transnational and integrated data evaluations including modelling. Preference shall be given to a smaller number of intensive monitoring plots with complete sets of core plot surveys instead of operating bigger numbers of plots that carry different combinations of surveys beyond the Level II standard surveys. (In response to specific national interests and needs and/or thematic focuses - different combinations of surveys can be applicable.)

5. Measurements

5.1 Measurements and reporting units

5.1.1 Plot description

Plot descriptive information has to be submitted once at plot installation or whenever changes are occurring (Table 1).

5.1.1.1 Plot number.

The plot number is an identification number and must be unique within each participating country. For each new plot a new plot number has to be used and has to be submitted. In case that an existing plot is replaced by a newly installed plot, a new plot number has to be used and has to be submitted.

Table 1: Quick reference of variables to be reported for the general plot description.

Variable	Reporting unit	Target plot type		
		Level I	Level II standard	Level II core
Country code	Code	m	m	m
Plot number	Number	m	m	m
Plot size	hectare	m	m	m
Plot design	Code	m	m	m
Installation date	Date	m	m	m
Plot status	Active/not active	o	m	m
NFI status	Y/N	m	o	o
Latitude	WGS84	m	m	m
Longitude	WGS84	m	m	m
Altitude class	Code	m	m	m
Altitude	metres	o	o	o
Orientation	Code	m	m	m
Slope	Degrees	o	m	m

5.1.1.2 Plot design

The plot design of Level I and Level II plots is described by codes, as defined in the forms document (www.icp-forests.org/Manual.htm)

5.1.1.3 Plot coordinates:

A plot centre (so called "reference point" has to be marked permanently. It's coordinates are specified in Degree (WGS84, format: <+/-ddmmss>; see Explanatory Items of forms document).

5.1.1.4 Additional information:

Definitions for the following information are specified in the forms document (see 6.1; explanatory items

- Country code
- Plot size
- Installation date (ddmmyy)
- Plot status (active, inactive)
- NFI status (y/n)
- Altitude class
- Altitude (e.g. GPS) in meters above sea level

- Orientation (at reference point)
- Slope (at reference point)

5.1.2 Stand description

Information on the stand must be reported every five years. Reporting should occur every full and half decade (year 2010, 2015, 2020…). Table 2 presents an overview of variables to be reported. Each variable is explained in the following text.

Table 2. Quick reference of variablqes to be reported for the general stand description.

Variable	Reporting unit	Target plot type		
		Level I	Level II	Level II core
Stand history	code	o	m	m
Previous land use	code	o	m	m
Origin of actual stand	code	o	m	m
Main tree species	code	m	m	m
Type of tree species mixture	code	o	m	m
Top height	meter	o	m	m
Forest type	code	m	m	m
Age class	code	m	m	m
Number of tree layers	code	o	m	m
Coverage of tree layers	5 % steps	o	m	m
Canopy closure	5 % steps	m	m	m
Protection status	code	o	m	m
Fencing	code	o	m	m
Non-timber utilisation	code	o	m	m
Management type	code	o	m	m
Intensity of management	code	o	m	m
Management method	code	o	m	m
Forest ownership	code	o	m	m

o – optional, m - mandatory

5.1.2.1 Stand history

The continuity of forest cover is of relevance for a number of ecological forest functions, including forest species composition. Stand history is reported in 5 classes (forested more than 300/100/25 … years) (Bastrup-Birk et al., 2006). Codes for data submission are defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.2 Previous land use

Previous land use information is reported in 7 classes (farmland, grassland …etc.). Codes for data submission are defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.3 Origin of actual stand

The origin of the stand on the plot is reported in 5 classes (planted, seeded … etc.) (Bastrup-Birk et al., 2006). Codes for data submission are defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.4 Main tree species

The tree species dominating the forest canopy in terms of canopy closure of the plot is reported using a three digit code. The related codelist is defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.5 Type of tree species mixture

The type of tree species mixture on the plot is reported in 5 classes (monoculture, single tree wise mixture … etc) (Anonymous 2005). The related codelist is defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.6 Top height

Average top height can be derived from measured values (usually the case at Level II plots) or from estimates. The method of determination is to be indicated in the data submission forms. Top height is defined as the mean height of the 100 thickest stems per ha.

5.1.2.7 Forest type

The forest type of the plot is reported following the nomenclature of the European Environment Agency (EEA 2006), and further developed by UNECE/FAO (2010) (boreal, hemiboreal, alpine coniferous …etc.). The related codelist is defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.8 Age class

The mean age of the dominant storey is given in age classes (20 years classes). The related codelist is defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.9 Number of tree layers

The number of layers is reported in 4 classes (one layer, two layers, mulitlayered…) (Anonymous 2005). The related codelist is defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.10 Coverage of tree layers

The coverage of each layer is reported in 5% steps, only layers are included that have at least a 10% coverage. The sum of the coverage of all tree layers may be > 100%. Coverage of tree layers is estimated as a projection of branches and foliage to the plot surface. (note: The coverage estimate refers to the plot area, whereas tree coverage estimates conducted within the ground vegetation survey are related to the ground vegetation subplot.)

5.1.2.11 Canopy closure

Canopy closure is reported as the estimated percentage coverage of tree layer > 5 m in 5 classes (Bastrup-Birk et al., 2006). Codes for data submission are defined in the forms document (www.icp-forests.org/Manual.htm). The maximum value is 100% as multiple coverage is not considered separately.

As layers may overlap, the sum of the coverage of the layers may be higher than the canopy closure. Canopy closure is estimated as a projection of branches and foliage to the plot surface. (note: The canopy closure estimate refers to the plot area, whereas tree coverage estimates conducted within the ground vegetation survey are related to the ground vegetation subplot).

5.1.2.12 Protection status:

The Protection status of the monitoring plot is described following the MCPFE classification (FOREST EUROPE/UNECE/FAO 2010)

- MCPFE Class 1.1: No Active Intervention

The main management objective is biodiversity

No active, direct human intervention is taking place

Activities other than limited public access and non-destructive research not detrimental to the management objective are prevented in the protected area

- MCPFE Class 1.2: Minimum Intervention Guidelines

The main management objective is biodiversity

Human intervention is limited to a minimum

Activities other than listed below are prevented in the protected area :

- ungulate/game control

- control of diseases/insect outbreaks[1]

- public access

- fire intervention

- non-destructive research not detrimental to the management objective

- subsistence resource use[2]

- MCPFE Class 1.3: Conservation Through Active Management

The main management objective is biodiversity

A management with active interventions directed to achieve specific conservation goal of the protected area is taking place

Any resource extraction, harvesting, silvicultural measures detrimental to the management objective, as well as other activities negatively affecting the conservation goal, are prevented in the protected area

- MCPFE Class 2 : Main Management Objective 'Protection of Landscape and Specific Natural Elements'

Interventions are clearly directed to achieve the management goals landscape diversity, cultural, aesthetic, spiritual and historical values, recreation, specific natural elements

The use of forest resources is restricted

A clear long-term commitment and an explicit designation as specific protection regime, defining a limited area is existing Activities negatively affecting characteristics of landscapes or/and specific natural elements mentioned are prevented in the protected area

- MCPFE Class 3 : Main Management Objective 'Protective Functions'

[1] in case of expected large disease/insect outbreaks control measures using biological methods are allowed, provided no other adequate control possibilities in the buffer zone are feasible.

[2] subsistence use to cover the needs of indigenous people and local communities, in so far as it will not adversely affect the objectives of management

The management is clearly directed to protect soil and its properties or water quality and quantity other forest ecosystem functions, or to protect infrastructure and managed natural resources against natural hazards

Forests and other wooded lands are explicitly designated to fulfil protective functions in management plans or other legally authorised equivalents. Any operation negatively affecting soil or water or the ability to protect other ecosystem functions, ability to protect infrastructure and managed natural resources against natural hazards is prevented.

The related codelist is defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.13 Fencing

Fencing is reported in 3 classes (fenced, unfenced, fenced in parts). (Bastrup-Birk et al., 2006). Codes for data submission are defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.14 Non-timber utilisation

Non-timber utilisation is reported in 5 classes (grazing, fire wood collection, litter raking…). Only regular non-timber utilization is to be reported which may have a measurable impact on nutrient and water cycles. Do not report very occasional utilizations. The related codelist is defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.15 Management type

Management type is reported in 3 classes (high forest, coppice with/without standards). The related codelist is defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.16 Intensity of management

Intensity of management is reported in 4 classes (managed, unmanaged …). (Bastrup-Birk et al., 2006). Codes for data submission are defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.17 Management method

Management method is reported in 5 classes (clear cut, shelterwood …etc.). (Anonymous, 2005). Codes for data submission are defined in the forms document (www.icp-forests.org/Manual.htm).

5.1.2.18 Forest ownership

Forest ownership is reported in classes following the FAO Forest Resource Assessment 2010 (FRA 2010, www.fao.org/forestry/fra). Codes for data submission are defined in the forms document (www.icp-forests.org/Manual.htm).

- Public ownership: forest owned by the State; or administrative units of the public administration; or by institutions or corporations owned by the public administration.
- Private ownership: forest owned by individuals, families, communities, private co-operatives, corporations and other business entities, private religious and educational institutions, pension or investment funds, NGOs, nature conservation associations and other private institutions.

- Individuals (sub-category of Private ownership): Forest owned by individuals and families.

- Private business entities and institutions *(sub-category of Private ownership):* Forest owned by private corporations, co-operatives, *companies and other business entities*, as well as private non-profit organizations such as NGOs, nature conservation associations, and private religious and educational institutions, etc.

- Local communities *(sub-category of Private ownership): Forest owned by a group o*f individuals belonging to the same community residin*g within or in the vicinity of a fore*st area. The community members are co-owners that share exclusive rights and duties, and benefits contribute to the community development.

- Indigenous / tribal *communities (sub-category of Private ownership): Forest owne*d by communities of indigenous or tribal people.

- Other types of ownership: Other kind of ownership arrangements not covered by the categories above. Also includes areas where ownership is unclear or disputed.

5.1.3 Investigations and measurements at the plot and site level

Several measurements should be carried out within individual investigations at the large-scale plots (Level I) and/or at the intensive monitoring (Level II) sites. Table 3 reports a quick reference for the various investigations foreseen, their target plots and expected frequency. Specific measurements foreseen within individual investigations as well as their status (mandatory/optional) are described and reported in details in the individual parts of the Manual, also indicated in Table 3.

Table 3. Quick reference for surveys to be carried out on different plot types.

Survey	Provide data on	Methods described in	Target plots and frequency of assessment/measurement/sampling		
			Level I	Level II	Level II core
Plot description	Location, size and status of the plot,	Part II	Install.	Install.	Install.
Stand description	Basic characteristics of the stand	Part II	5 yr	5 yr	5 yr
Tree condition	Indicators of crown, branches and stem status of the trees	Part IV	1 yr	1 yr	1 yr
Tree growth and yield	Actual periodic growth of the stand and of individual trees	Part V	-	5 yrs	5 yrs
Tree growth and yield (intensive)	Intra-annual and annual growth of individual tress	Part V	-	-	comtinuousely
Tree phenology	Timing of the annual development stages of forest trees (plot level)	Part VI	-	-	weekly
Tree phenology (intensive)	Timing of the annual development stages of forest trees (individual tree level)	Part VI	-	-	continuosly
Ground vegetation	Species richness and abundance	Part VII	project	5 yrs	5 yrs
Ozone injury on plants	Presence on visible injury attributable to tropospheric ozone	Part VIII	-	-	1 yr
Meteorological Measurements	Basic (T, Pr, wind speed) meteorological variables	Part IX	-	continuously	continuously
Soil sampling and Analysis	Soil profile and chemical concentration of elements and ions in soil solid phase. Information	Part X	project	10 yrs	10 yrs
Soil solution collection and analysis	Chemical content of elements and ions in soil liquid phase	Part XI	-	-	1-2 weeks
Foliar sampling and analysis	Chemical concentration of elements in foliage of trees	Part XII	project	2 yrs	2 yrs
Sampling and analysis of litterfall	Amount, composition and chemical content of litter	Part XIII	-	-	1-2 weeks
Sampling and Analysis of Deposition	Chemical concentration of elements and ions in openfield, throughfall and stemflow precipitation	Part XIV	-	2-4 weeks	2-4 weeks
Ambient air quality	Concentration of SO2, NOx, O3 in the air	Part XV	-	-	1-2 weeks

Install – at plot instalment, project – within dedicated projects

5.2 Quality Assurance and Data Quality Requirements

At its 22nd Task Force in 2007, ICP Forests has adopted an overall Quality Assurance (QA) perspective. The overall concept and the QA components are described in Part III, while individual QA/QC measures are reported in details in individual Parts for the investigations based exclusively on field measurements, and in Part XVI for investigations involving on laboratory analysis.

6. Data Submission

Data are submitted to the yearly to the European central data storage facility at the ICP Forests Programme Coordinating Centre using formats specified in annually updated documents. The documents are annually adopted by the Task Force of ICP Forests and is provided on the ICP Forests web page at http://www.icp-forests.org/Manual.htm.

6.1 Procedures and forms

From 2007 a collection of all forms for data submission and respective explanatory items are available on the ICP Forests web page. Those documents are prepared by the PCC data centre in cooperation with the ICP Forests Expert Panels.

6.2 Data Transmission to co-ordinating centres

Data will be sent to PCC using a data submission web application within defined data submission periods. The data are submitted survey by survey and year by year. Thus, each NFC has to submit a complete set of files/forms per survey and year via the submission module. In general, this set includes a reduced plot file and data files. Additionally, all files containing respective QA/QC information (e.g. results of laboratory ring tests or field comparison courses) and data accompanying reports (word documents) should be submitted together with the data files.

An exception to the annual submission is the general plot information which is submitted only in case of a need for updating the ICP Forests database (e.g. new plots or improved/updated plot relevant information).

6.3 Data Validation

Submitted data will be tested in three stages: Compliance, Conformity and Uniformity tests. Only those data which pass those stages successfully will be up-loaded into the ICP Forests data base.

Compliance tests will test the format of the submitted data. Conformity tests focus on the submitted values and compare them with test ranges or test their relation to the values of other fields or of the same field from former years. Uniformity tests check the spatial and temporal comparability of the data by the production of graphs and maps. Whereas compliance and conformity checks will be applied in time by the submission application of the data base during the transmission procedure, the uniformity checks will be applied by staff of the PCC data centre.

7. References

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Annex I

Recommendations for functional integration between Level I and National Forest Inventory for tree condition assessment

Marco Ferretti

(adapted after Ferretti M., Harmonizing forest inventories and forest condition monitoring - the rise or the fall of harmonized forest condition monitoring in Europe? iForest 3: 1-4 (2010)).

First, in addition to the ongoing annual assessments on the existing Level I plots, Level I variables are measured annually according to Level I methods on (a subsample of) NFI plots (to be selected according to the country-specific NFI design). Permanent numbering on trees should be avoided in order to keep the plot as anonymous and undisturbed as possible. Level I assessment on the selected NFI plots may be carried out at every NFI repetition (e.g. every 5 or 10 yrs) to favour data integration.

Secondly, at the same time, the country-specific NFI plot design and attributes are applied on the existing Level I plots. This includes the selection of new sample trees on existing Level I plots. However, even the former sample trees at the Level I plots are retained. Annual Level I assessments on the old as well as on the newly selected sample trees are carried out on an annual basis.

This functional integration will result in several advantages: the existing time series is maintained by the continuation of the assessment on existing sample trees); comparison between the two datasets (Level I and NFI) will be possible at defined time intervals (e.g., at each NFI cycle); combined and more precise estimates may be possible at defined time intervals (e.g., at each NFI cycle). This latter possibility depends, however, on the nature of the Level I network (its origin and target statistical population), and under the assumption that Level I and NFI samples concern the same statistical population. NFI plots will stay undisturbed. The disadvantage is a slight increase of costs (Level I plots adaptation in the first year; some new attributes in addition on NFIs every 5 or 10 yrs).

Annex II

Recommendations for converting cross cluster plots into fixed area Level I plots

Marco Ferretti

Figure 1 shows an approach to convert a cross-cluster design (with undefined shape and size) into a fixed area plot, while keeping the old sample trees. This kind of procedure is applicable for different plot sizes (e.g., different radius, according to the country) and/or may allow sub-sampling of trees (e.g. angle count sampling; concentric plots for smaller DBH class) in case of dense stands and/or with many small trees where the assessment of all the trees is not feasible. This procedure can be of interest for those countries facing the integration between NFI and Level I.

Note that – according to this procedure – data series on "old" sample trees can be kept. At the same time, the adoption of fixed area plot will favour the estimation process.

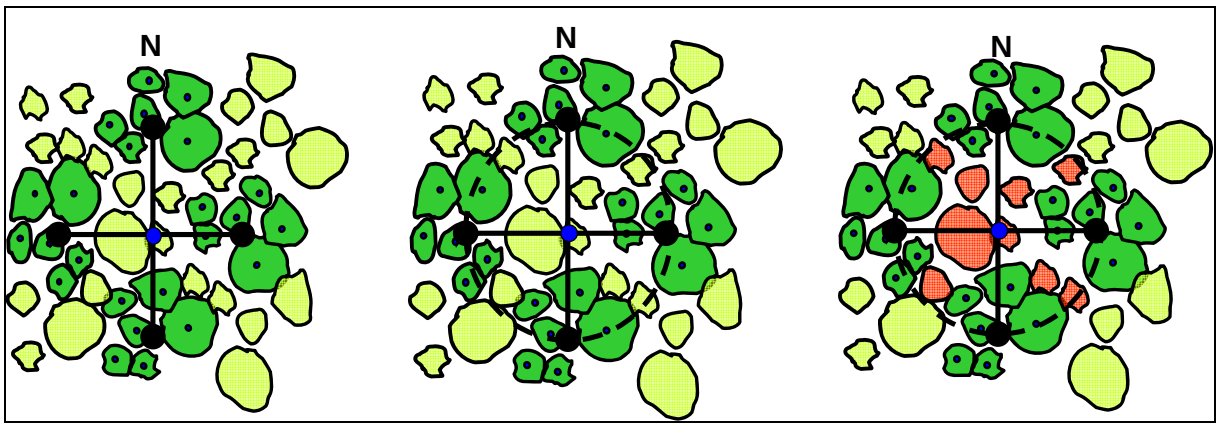

Figure 1: Example of change from a cross-cluster sample to a circular plot. Left, cross cluster plot with six trees (dark green ones) selected at each compass direction, 25 m from the centre; middle, a 25 m radius plot is designed; right, the trees within the 25 m radius plot previously not considered are now incorporated in the sample trees (red ones). The old sample trees are kept to ensure continuation of dataseries. The same procedure is applicable for different plot size (e.g. 18 m radius). (Drawing: M. Ferretti).