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Convention on Long-range Transboundary Air Pollution (CLRTAP)

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 VII.1

Assessment of Ground Vegetation

Version 2020-1

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1 Introduction

Vegetation is a major component of forest ecosystems. The composition, diversity, and structure of vegetation are important factors for assessing biological diversity of forest ecosystems. Vegetation is the source of primary production, controls the atmosphere gas exchanges playing a direct role in water and nutrient cycling, as well as climate and microclimate. It influences soil characteristics, and interacts strongly with other biotic components (insects, game, etc.), as it is a determinant habitat for many species. Vegetation has also been identified as a specific target for the calculation of critical loads/levels.

The species composition and structure of vegetation can serve as bio-indicators for environmental changes to ecosystems. Changes in vegetation and in underlying environmental factors can serve as indicators of the status of other organisms based on our current knowledge of the ecological niches of numerous plant species.

Thus, the long-term study of vegetation dynamics at selected locations will provide information on changes in other forest ecosystem variables (soil, microclimate, etc.). Ground vegetation is here defined as all terricolous vascular plants (herbs, shrubs and trees) bryophytes and lichens (excluding epiphytic and epilithic species).

2 Scope and application

This part of the Manual aims at providing a consistent methodology to collect high quality, harmonized and comparable forest ground vegetation data at selected UN/ECE ICP Forests monitoring plots. Harmonization of procedures is essential to enhance comparability of forest ground vegetation data. To have their data used in the international database and evaluations, National Focal Centres and their scientific partners participating in the UN/ECE ICP Forests programme should follow the methods described here.

An overview on assessed variables is given in Table VII.1-1 (details on variables measurements are given in the next Chapters).

Table VII.1-1: Variables assessed within the ground vegetation survey

Form	Variable	Level II	Level II core	Level I
PLV	Tree layer cover (in % of sampling area)	m	m	o
PLV	Shrub layer height (in m)	m	m	o
PLV	Shrub layer cover (in % of sampling area)	m	m	o
PLV	Low shrub sublayer (in % of sampling area)	o	o	o
PLV	High shrub sublayer (in % of sampling area)	o	o	o
PLV	Herb layer height (in m)	m	m	o
PLV	Herb layer cover (in % of sampling area)	m	m	o
PLV	Mosses cover (in % of sampling area)	m	m	o
PLV	Bare soil cover (in % of sampling area)	m	m	o
PLV	Litter cover (in % of sampling area)	m	m	o
VEM	Species code for species growing on the soil in the sampling area	m	m	o
VEM	Cover of the species in the sampling area	m	m	o
VEM	Species codes for species occurring on the rest of the plot	o	o	o
VEM	Species codes for species occurring on additional substrates	o	o	o
VEM	Certainty of species determination	m	m	o

3 Objectives

The main objective of the ground vegetation assessment is to estimate the status and changes in the diversity of plant communities at the monitoring plots (within monitoring sites) and to contribute to the understanding and evaluation of forest condition in Europe.

Objectives are defined as follows:

- Census of plant species, and species-specific relative abundance per vegetation layer.
- Distinction of structural diversity in terms of species composition, percentage cover and vertical stratification.
- Estimation of species richness (density) in terms of mean species number / area.
- Detection of temporal changes in vegetation and mean species density on a plot.

Surveys should allow the estimation of uncertainty.

Ground vegetation assessment will allow plots to be characterized within identifiable vegetation types. Vegetation changes will allow describing, explaining and modelling dynamical processes, by analysis of pathways, causes and mechanisms (including natural and anthropogenic environmental factors).

4 Location of measurements, assessments and sampling

The area selected for vegetation assessments must be representative for the whole ICP Forests Level II plot (e.g. the minimum size 2500 m^2) or Level I plot (e.g. 2000 m^2), in order to allow comparisons between vegetation changes and other parameters recorded on the same plot.

Observations might be conducted in a way that the produced data would be representative of the plot or the monitoring site (see Manual Part II).

4.1 Sampling design

Different sampling designs and methods can be applied in order to obtain a statistically representative sample and a reliable estimate of the species density and the mean cover of individual species, depending on the biogeographical region and vegetation type.

Since there is a trade-off between the accuracy of species cover estimation and the surveyed area, and due to the expected ranges in the spatial pattern (homogeneity) and the structure of forest vegetation within Europe, two different sampling designs are proposed to achieve a common sampling area (see Chap. 4.1.1):

- in the first case, vegetation surveys are performed over a large area, utilizing sampling units of a surface ≥ 100 m^2, with a low to medium accuracy in specific cover estimates;
- in the second case, vegetation surveys concentrate on detecting small-scale dynamics in plant populations. Small sampling units (in general ≤ 10 m^2) are used for a more accurate estimation of specific cover.

In this context, the following definitions apply (see also Manual Part II):

- Level I plot: the large-scale plot.

- Monitoring site: Level II site, large homogeneous area including a plot and its buffer zone (see below).
- Plot: the intensive monitoring (Level II) plot with a surface of 0.25 ha.
- Sub-plot: part of the Level II plot if this is located in a dense, homogeneous stand (e.g. 0.1 ha).
- Buffer zone: outer belt surrounding the Level II plot.
- Sampling unit: surface unit on which the vegetation is assessed (e.g. 1 m^2).

4.1.1 Total area surveyed, number and shape of sampling units

The minimal requirement of Ground Vegetation assessment is to gather information on the relative specific abundance and the species richness at the plot level (eventually, at the monitoring site level).

The number of plant species is dependent on the studied area. In order to achieve comparability of results between countries, a common sampling area (CSA) of 400 m^2, representative for the ground vegetation of the plot, is mandatory for Level II plots.

This area will be reached as the sum of smaller sampling units within the plot. Countries are free to select the shape of the sampling units; number (thus size) of sampling units must fulfil the objective of representativeness.

In at least a fraction of Level II plots, it is recommended to achieve data from CSA by common (international) reference method in addition to the national assessments. It will consist in applying common sampling design, methods and survey techniques on a Standardized Sampling Area (SSA), defined as in Annex 2).

4.1.2 Selection and location of the sampling units

The sampling units should be not contiguous; they should be placed as far apart as possible within the Level II plot in order to minimize spatial correlation between the sampling units. All measures of the sampling units will be taken parallel to the slope.

To achieve a statistical representativeness, probability sampling methods will be adopted (random, systematic, stratification).

Location of sampling units should exclude major heterogeneities at any scale of sampling (boulders and cliffs, tracks and paths, fire places, streams and ponds, ditches and channels, peaty pools). Thus, terricolous plants growing on mineral and organic soil of the undisturbed forest floor will be represented. Information on species growing on special substrates or places can be also recorded (see chap. 5.1.2 and Annex 2).

In the case of Level I, the use of four not contiguous 10x10 m sampling units randomly placed within the circular plot generated from Level I points (radius of 25.24 m = 2000 m^2) and excluding the inner circle having a radius of 11.28 m (400 m^2), is suggested.

4.1.3 Marking the sampling units

A permanent marking system has to be installed for the sampling units. The precise method to be used is under the responsibility of each country (boundary markers, buried metal stakes, etc.) but the material used must be inert. The presence of markers should be regularly checked. It is recommended that maps should be used for recording the spatial arrangement and exact locations of the sampling units. Such maps should use the most permanent system of coordinates possible.

4.1.4 Fencing

Level II and Level I plots are subjected to the same management practices as the surrounding buffer zone and forest, and fencing is not required. Thus, if there is any fencing,

vegetation assessment should be done at least in the unfenced buffer zone. However, a parallel assessment inside the fenced zone is recommended, to assure the representativeness at the plot level. Both the inside and outside of the fence must be comparable at the beginning of the survey. The effectiveness of the fence must be regularly checked. Data from fenced and unfenced plots should be clearly indicated in the database.

4.1.5 Additional survey of species outside the sampling units

An additional list of all species of the plot not encountered within the sampling units should be compiled. Such a list will help to interpret future vegetation changes within the sampling units and will be of additional interest regarding the biodiversity. The species list will be submitted as a separate sample using the data submission forms.

4.1.6 Compatibility with other surveys

In all cases, the exact location of the vegetation plots has to be determined in a way that any conflict with other assessments will be avoided. During the installation of sampling units, areas already used for other intensive studies (e.g. soil studies or measurements of deposition) and the tracks leading to these areas have to be avoided. Adequate information (map, signs) must be provided to all survey teams in order to limit the intensity of vegetation trampling and soil compaction within the sampling units.

4.2 Sampling equipment

Each crew will bring in the field appropriate standard forms, tools for delimitating the sampling units, and any other material for the measures eventually adopted.

4.3 Frequency of sampling

Vegetation studies on Level II ICP Forests Monitoring sites must be undertaken at least every five years. In order to help separating short-term fluctuations from long-term vegetation dynamics, it is recommended that vegetation assessment is undertaken every year; this will also help to earlier recognize and correct eventual errors. On Level II plots with established SSA, a frequency of two years is recommended. If the frequency of sampling is not annual, special attention should be given to disturbances that may affect the vegetation assessment. Heavy disturbances caused by management operations (e.g. thinning) preceding or occurring during the sampling year should be avoided. Whenever possible, it is recommended to sample vegetation at least the year before these operations, in addition to the normal frequency.

4.4 Sample collection, transport and storage

Specimens should be collected only when necessary for proper identification, and if not rare within the sampling units. Collection will be carried outside the area of assessment and preferably outside the plot. Specimens will be stored in a herbarium.

Pictures can also be useful for plants identification, avoiding impacts.

5 Measurements

5.1 Parameters to be assessed and reporting units

5.1.1 Selected variables

The variables considered within the ground vegetation surveys and for different vegetation layers at ICP Forests monitoring sites of different levels are listed in Table VII.1-1.

5.1.2 Species studied

All phanerogams, vascular cryptogams, terricolous bryophytes and terricolous lichens shall be taken into account. The list of species must be complete for these groups. Non-terricolous species and fungi can be noted additionally, but should ideally be the subject of separate surveys, as for epiphytic lichens and bryophytes.

Unidentified species should be noted as such, and, if not rare within the sampling units, should be sampled and stored in a herbarium for subsequent identification; the same herbarium should contain also specimens of the local *florula* as a long-term reference.

Information on (un)certainty of the species determination enables to transfer additional information like subspecies, variant or cf. (species identification is uncertain). Also for questions of species richness it is important to know if species which could be only determined on genus level (*Genus* sp.) are certainly different from those which are already part of the species list of the respective survey. Therefore the (un)certainty of the species determination should be submitted as a code using the data submission form (VEM). Codes for data submission are defined in the forms document (www.icp-forests.org/Manual.htm).

The nomenclature should follow the *Flora Europaea* (Tutin et al., 1968-1980; Tutin et al., 1993) for vascular plants and Frey et al. (1995) for bryophytes. However, countries are free to use other regional Floras as well. Whichever Flora is used at the national level, the submission of data to the European coordination centre must follow the coded lists for vascular plants and cryptogams, available through the related Expert Panel.

Regular update of the coded list will be necessary, as the above mentioned Floras do not cover lichens as well as some countries or parts of countries. Moreover, growing taxonomic knowledge may also require some updates. The countries may prepare lists of species proposed for update and report them to the European coordination centre for further evaluation. In such a list, apart from species names, also citations of the relevant taxonomic references must be included, e.g. national floras, or scientific papers dealing with these species. An update of the coded list will be done by the European coordination centre after consultation of the Expert Panel and occasionally of additional taxonomic experts. To make discussion of problematic cases easier, the countries may indicate into their proposal some national taxonomic experts to be consulted. As the procedure for an update of the coded list needs some time, a list of proposals for update should be reported by a country not later than eight weeks before end of deadline for data submission.

The occurrence of all non-terricolous species growing in the Common Sampling area (CSA) on special substrates and places (e.g. litter, rocks, deadwood, living ligneous, and living non-ligneous) should be recorded as well. For each species the substrate should be indicated in a separate column using the specific codes as defined in the forms document (www.icp-forests.org/Manual.htm).

The submission of information on terricolous species (with substrate code = 1) is mandatory on Level II. Submission of species information for other substrates is optional.

5.1.3 Layers to be recorded

A separate record must be made for each species in the different vertical strata, disregarding the two shrub sublayers. In order to attain comparability of results between countries, a common fixed definition of the following layers is mandatory:

- moss layer (i.e. terricolous bryophytes and terricolous lichens),
- herb layer (all non-ligneous irrespective of height, and the ligneous only if ≤ 0.5m height), including eventual seedlings and browsed trees,
- shrub layer (only ligneous and all climbers) > 0.5 m and ≤ 5 m height,
- tree layer (only ligneous and all climbers) > 5 m height.

The above mentioned layers should be identified on each survey area by using some reference point to visual estimates (especially for the critical 5 m threshold). Dominant projection belonging to a given layer defines the layer of the individual.

A visual estimate of the average height (in m) will be made for shrub and herb layer; the visual estimate of the global percentage cover of each above mentioned layers as well as the global covers of bare soil and litter, is mandatory at Level II and optional at Level I.

For the sake of harmonization with the Canopy Leaf Area survey, the shrub layer may optionally be subdivided into a high shrub layer, which is recorded in optical LAI measurements, and a low shrub layer below 2 m height, which does not contribute to the optical LAI measurement. Thus, it is recommended to perform this subdivision in stands with optical LAI measurements.
In the case this option is adopted, the two shrub layers are defined as follows:

- low shrub layer (only ligneous and all climbers) > 0.5 m and ≤ 2 m height,
- high shrub layer (only ligneous and all climbers) > 2 m and ≤ 5 m height.

A detailed record of saplings and seedlings is recommended (e.g. counting, coverage, etc.); data will be stored at the Country level.

5.1.4 Measurement of species abundance or cover

In the sampling design with large units, countries are free to choose their own abundance-coverage scales (as presented by van der Maarel, 1979) as far as they can be directly converted into percentage cover (see table in Annex 1 for the correspondence between various scales and percentage cover values). A more accurate estimation of specific cover can be obtained using sampling designs with small sampling units (in general under 10 m^2), those possibly divided into smaller subunits (0.01 m^2) used for visual estimates of individual species cover. In the finest scale grids, a presence-absence assessment can be made and then transformed into a percentage cover estimate. It is also possible to use line intercept methods to obtain a quantitative cover estimate. Whatever the method used, the exact boundaries of the sampling units must be delimited during the survey operations, using strings, cords, ropes or other tools. A minimum of two people, of which at least one must be a trained expert, should form a working team and should assess all of the sampling units in a Plot at each sampling date.

The object of plant cover assessments will be the projection of plants' living parts (excluding empty spaces).

Records of additional information on each plant species, such as sociability or vitality, are also of interest. The latter is likely to be of particular interest in the context of atmospheric pollution effects (flowering, fruiting, height, leaf discoloration, etc.). However, this should be preferably the object of separate monitoring projects.

Comparability of cover assessments can be tested and enhanced by QA activities (see chap. 5.2). This includes a common (international) reference method suggested for parallel adoption to national methods (see chap. 5.2.1 and Annex 2).

5.1.5 Mapping and pictures

Detailed maps of understory vegetation within the plots, as well as photographs from fixed points, are recommended, especially at the beginning of the monitoring programme. Documents and related data will be stored at the Country level.

5.1.6 Date of observations

The number of visits during one year must be defined in order to account for as many synphenological stages as possible, so that the number of species observed is maximized. In forest types with a well-developed spring flora, at least two visits per year are needed.

Moreover, two visits per year minimize the risk of missing or misidentifying species. Periods of heavy rainfall should be avoided in order to limit soil compaction. The results of different surveys at different dates during a single year should not be merged but recorded separately.

As a minimum requirement, a summer survey (during the maximum biomass) must be performed. Spring and/or autumn surveys should be periodically added, depending on biogeographic regions and vegetation types.

5.1.7 Additional environmental data collection

In recognition of the importance of light conditions in interpreting vegetation dynamics, it would be very useful to make a direct assessment of the light level in each sampling unit, on each assessment date. However, this should be preferably the object of separate monitoring projects.

5.2 Quality Assurance and Quality Control

5.2.1 QA/QC procedures

National Focal Centres (NFCs) are responsible for Quality Assurance and Quality Control procedures. All steps in the procedures should be described in a national quality assurance programme.

At the international level, training, intercalibration, and intercomparison courses, as well as the ICP Forests Manual and the species code list update and use, should be organized on the European level in close connection with the Expert Panel.

Important points of QA/QC in ground vegetation assessments include: compilation of a field National manual, selection of field teams components, repeated National training and calibration of field teams, plausibility checks of data, independent field controls and checks, participation in international cross-calibration courses, additional parallel assessments with the use of a common (international) reference method.

A proposal of QA/QC procedures by relevant steps for adoption on Level II Plots is suggested in Annex 2.

5.2.2 Plausibility limits

Plausibility limits are indicated in Table VII.1-2, on logical bases and assuming the thresholds defined in the previous chapters.

5.2.3 Data completeness

Tables VII.1-1 and VII.1-2 outline for all variables whether and under which conditions they are mandatory or optional to report. When a country/federal state decides to report optional variables, they should also fulfil the data quality requirements.

5.2.4 Data quality objectives or tolerable limits

Given the poor experience on national and international calibration and intercalibration courses, only the Data Quality Objectives are defined for species cover/abundance estimates per layer, taking into account the precision level allowed by the scales used. Also in the case of direct visual estimates of cover, percentage scales can be arranged following the data distribution (e.g.: percentiles). With reference to the results of the first Trans-national training and field inter-comparison course in Ground Vegetation (2009, Cansiglio, Italy), the precision level can be defined by an interval of ± 1 class-scale respect to a given value, whatever the species recorded by any observer, and whatever the technique used for cover estimation (Table 2).

Table 2: Plausibility limits and quality requirements for variables assessed in the ground vegetation survey. Further details in chapter 5.2.4 and 5.2.5

	Variable	Reporting unit	DQO	DQL	Plausibility limits, lower	Plausibility limits, upper
	Tree layer cover sampling area	%	n.a.	n.a.	0	100
	Shrub layer height sampling area	m	n.a.	n.a.	0,51	5
	Shrub layer cover sampling area	%	n.a.	n.a.	0	100
	Herb layer height sampling area	m	n.a.	n.a.	0,01	0,5
	Herb layer cover sampling area	%	n.a.	n.a.	0	100
	Moss layer cover sampling area	%	n.a.	n.a.	0	100
	Baresoil cover sampling area	%	n.a.	n.a.	0	100
	Litter cover sampling area	%	n.a.	n.a.	0	100
	Species list sampling area	species codes	**not applicable**			
	Species cover per layer sampling area	%	±1 class	90-95-98% *	0,01	100
	Additional Species list (rest of the plot, sampling area excluded)	species codes	**not applicable**			
	Indication of substrates	codes	**not applicable**			
QA/QC info	Duration of survey (per Sampling Unit)	minutes				
	Teams composition	number				
	Uncertainty of species determination CSA, SSA	codes				

DQO: Data Quality Objective (minimum acceptable accuracy) for measurements, also referred to MQO (Measurement Quality Objective); DQL: Data Quality Limits (minimum frequency of data that must fit the DQO), i.e. the threshold for validating the data set; * Tree layer: 90%; shrub layer: 95%; herb layer: 98%; moss layer: not applicable; n.a. = not applicable until now

5.2.5 Data quality limits

The results are considered of sufficient quality when:

- at international level: the National Reference Team of a given country is within the data quality objectives as identified by the mean results obtained at the comparison exercise;

- at national level: the crew is within the data quality objectives as identified with reference to the mean results obtained at the comparison exercise.

As a threshold for validating the data set for each parameter, the minimum frequency of data that must fit the DQO is given in Table 2. DQL of Specific cover values fit the DQO in 90% of cases for the tree layer, 95 % for shrub layer, and 98 % for the herb layer.

Further implementation, including layer cover values and height, can be achieved after the results of foreseen national and international exercises.

6 Data handling

6.1 Data submission procedures and forms

All data must be sent to the relevant National Focal Centre after each sampling year. Each focal centre is in charge of data validation. The data should be submitted in standard format, following the data submission forms of this manual.

The submission of data to the European coordination centre must follow the coded lists for vascular plants and cryptogams available through the Expert Panel on Biodiversity and Ground Vegetation. Species not included in the list should be reported to the Expert Panel for further evaluation, following procedures outlined in Chap. 5.1.2. Data are to be submitted for the total CSA (or SSA) area, not per sampling unit (aggregated data by arithmetic mean of % transformed data). Information on ground vegetation shall be submitted as estimates of species coverage in percent (with a minimum of 0.01%).

In the case of adjunctive designs with larger or smaller surveyed area, aggregated data can be also added to the same forms, specifying the different total sampled area.

NFCs should keep the results of separate sampling units in their national databases.

6.2 Data validation

Data checks should be done as soon as results from the analyses are available. Data validation and quality assurance should be applied in accordance with QA/QC procedures as depicted in Chap. 5.2 and Annex 2.

6.3 Transmission to co-ordinating centres

All validated data should be sent yearly to the European central data storage facility at the ICP Forests Programme Coordinating Centre. Detailed time scheduled is provided by the relevant bodies.

6.4 Data processing guidelines

The following sections are provided only as a guideline; individual countries remain free to analyse the data from their plots in whichever way is felt to be most appropriate. With available lists of species (to be derived from the specific cover by layers) it is possible to estimate the mean species density (with associate error and interval of confidence when national data per sampling units at national level are available). When possible, the estimated mean number of species can be related to the total number of species surveyed on the overall plot area, in order to test the indicator value of the estimate. Species-specific

cover values per layer and global layer coverage may be used to define the compositional structure according to recognized vegetation types. Ecological multivariate methods e.g. ordination and cluster analyses enable to identify the major vegetation gradients and classify communities to distinct groups basing on dissimilarity in floristic composition, respectively. Environmental variables measured from the same monitoring site can be related to the ordination or classification patterns. Classical diversity indicators incorporating species number, frequency and evenness, and deriving Ellenberg indicators or other functional groups can be weighted by cover values as well. The abundance or occurrence curves of plant species along environmental gradients can be used to develop more reliable quantitative indicators of environmental status. Temporal changes can be assessed by using repeated ANOVA.

Abundance-dominance relations can be easily described, namely for the dominated layers.

Vegetation data can be used as a response variable relative to data provided by other investigations and measurements.

Results must be clearly referred to monitoring site, buffer zone or representative of the plot as allowed by the adopted sampling design.

6.5 Data reporting

Each National Focal Centre must submit an information describing deviations from UNECE recommended procedures or changes of assessment methods. Periodical quality control evaluations may be requested by the Programme Coordinating Centre to be part of integrated evaluations. References to any publications arising from the work on the Level I/ II plots should be notified so that they can be listed on the ICP Forests web site.

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Annex I – Proposal for the transformation between scales and percentage for the estimation of species cover

(van der Maarel 1979; literature therein)

Cover-abundance estimation

Braun-Blanquet (1928)			Barkman *et al.* (1964)			Schmidt (1986)			Londo (1976)		
Scale	**Cover (%)**	**Ø**	**Scale**	**Cover (%)**	**Ø**	**Scale**	**Cover (%)**	**Ø**	**Scale**	**Cover (%)**	**Ø**
r	rare	0.01**[]	r	sporadic/association							
+	few	0.5**	+r	sporadic (1-2 indiv.)/plot	0.01**	+	<1 %	0.5	0.5	0.1* <1	0.5
1	numerous cover <5 %	3.0 [2.5]	 +p +a +b	few (3-20 indiv.) <1 % <1-2 % <2-5 %	 0.1 1.5 3.5	1a 1b	1-3 % 3-5 %	2 4	1 3 5	0.2* 1-3 0.4* 3-5	2 4
			 1p 1a 1b	numerous (20-100 indiv.) <1 % <1-2 % <2-5 %	 0.8 1.5 3.5				8 10 15 20 25	1 5-15 1- 5-10 1+ 10-15 2 15-25	10 7.5 12.5 20
			2m	very numerous (>100 indiv.) cover <5 %	4						
2	5-25 % or numerous cover <5 %	15.0**	2a 2b	5-12.5 % 12.5-25 %	8.8 18.8	2a 2b	5-12.5 % 12.5-25 %	8.8 18.8			
3	25-50 %	37.5	3	25-50 %	37.5	3	25-50 %	37.5	30 40 50	3 25-35 4 35-45 5 45-55 5- 45-50	30 40 50 47.5
4	50-75 %	62.5	4	50-75 %	62.5	4	50-75 %	62.5	60 70 75	5+ 50-55 6 55-65 7 65-75	52.5 60 70
5	75-100 %	87.5	5	75-100 %	87.5	5	75-100 %	87.5	80 90 100	8 75-85 9 85-95 10 95-100	80 90 97.5

* additional symbols: r (rare) = 1 ind., p (*paulum*) = few ind., a (*amplius*) = numerous ind., m (*multum*) = very numerous ind.

** value contains abundance, the determination of an average cover degree

[ ] these average values are also mentioned in common literature

Ø average value of cover degree

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Annex II – Example of QA/QC procedures by relevant steps, suggested for Ground vegetation assessments on Level II Plots

1 *Field manual:* The National responsible (coordinator) for ground vegetation assessments should “formalize” a field manual including: clear definitions of the parameters to be assessed; the descriptions of design and methods, operative schemes and instructions; a detailed protocol of field assessments as well as the rules for data treatments and transmission; description of national QA/QC procedures, and application of any other issues of the part VII of the ICP Forests Manual. It is assumed that the national field manuals will be officially adopted by the NFC in each country as a standard reference.

2 *Selection of field teams*: Ideally field crews should consist of two people, with one of them at least being a trained specialist in vegetation and/or floristic surveys. Whatever the adopted criteria for selection, the observers will be trained and calibrated (see next point 3). The number of field crews per country should be optimized in order to facilitate training and harmonization, taking into account workloads and inaccuracy due to too long survey periods. Frequent changes of staff should be avoided.

3 *Training and Calibration of field teams at National Level*: Prior to the beginning of the annual field season, survey crews should undergo a theoretical and practical training in assessment procedures and data handling. Calibration will be linked to field training exercises. Between-observer effect and teams’ performance (possibly including timing) will be evaluated, and possible critical points of the procedure, affecting the results, will be highlighted for modifications. As "true" or "blank" values are not available, the observed values will be compared with a reference; the use of data dispersion, average values, relative distances can give relevant information in this respect. Results of national training courses should be available for audit/analysis. All countries should have a designated person who is considered as a national expert familiar with assessments at an international level. Among the employed teams, National Reference Teams (NRTs) will be designated for international activities (see point 6, below).

4 *Plausibility Checks*: It is strongly recommended that plausibility checks are included along the field procedure (see next point 5) as well as integrated into National data analysis system. Plausibility tests and cross-checks should be made when data are read into the database and during data transcription, validation, acquisition, submission, analysis. Particular attention must be given to species nomenclature and codes (see chap. 5.1.2). All information, including adequate documentation of changes, should be made available by inclusion into the official data bank.

5 *Field controls/checks*. An independent check survey should re-assess a proportion (e.g. 5-10%) of the plots (and a relative proportion of the sampling units and measured variables, e.g. 5-10%, or an adequate minimum from repeated observations) parallel to the actual survey. In case of significant discrepancies, adjustments or clarification of instructions and their application must be arranged immediately to avoid serious systematic errors. The independent control-team must participate to the national training and calibration field courses as the usual teams. This can help to depict the expected relative distance of the crews’ performances. NFCs should compare the control data with the original observations and take action as appropriate. A summary of the data comparisons, together with details of any action taken, should be documented for potential evaluations.

6 *International Cross-Calibration Courses*: Field exercises should be regularly conducted following the main forest biogeographical regions They are aimed to (a) document the relative position of individual National Reference Teams (NRTs) within the international context, (b) monitor the consistency of NRTs’ position through time, (c) maintain a direct connection with the data collected at national level, to improve data traceability, and help

to explain anomalous year-by-year fluctuations, (d) explore the relationships between the performance of the various NRTs and the major site and stand characteristics by using field estimates.

7 *Reference Method:* Given the differences in sampling strategy and cover assessment techniques, comparability of data must be tested and implemented. Bridging functions among country's methods can be possibly adopted by using common references. A common reference method is used on at least a subset of Level II plots in addition to the national assessments (if it is the case, both on fenced and unfenced areas). It will consist in a Standardized Sampling Area (SSA) and common assessment techniques. Four 10x10 m non-contiguous sampling units are randomly or systematically selected and permanently marked, to achieve SSA. Namely, on each sampling unit of the SSA, the full list of species with visual estimates of the species-specific cover will be assessed and recorded with the following precision levels:

Coverage	Precision level
≤ 1%	0.01%
> 1 – 10%	1%
> 10%	5%

Species on special places within SSA will be not excluded and the indication of the most frequent substrate for each species will be recorded by using the ground vegetation substrate codes (as reported in the online ICP Forests documentation https://icp-forests.org/documentation/Dictionaries/d_substrate.htm). An additional list of species for the remaining plot surface (except the SSA) is an integral part of the QA assessments based on the SSA.

Annex III – Minor changes after 2020

Date	Minor change to latest published version in 2020	Affected sections of this document