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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

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Part IV

Visual Assessment of Crown Condition and Damaging Agents

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1. Introduction

The 2nd Ministerial Conference on the Protection of Forests in Europe held in Helsinki in 1993 agreed on General Guidelines for the Sustainable Management of Forests in Europe (Resolution H1). The guidelines underline that forest ecosystem health and vitality has to be maintained. Tree defoliation and occurrence of biotic and abiotic damage are important indicators of forest health in ICP Forests, and are considered within the Criterion 2, "Forest health and vitality", one of the six criteria adopted by Forest Europe to provide information for sustainable forest management in Europe.

The assessment of crown condition has been central to the ICP Forests monitoring since 1985. The assessment methods developed in the mid-1980s for Level I formed the basis of the assessments for the Level II plots. Within Europe, the combination of plots on a systematic grid (Level I) and intensive monitoring plots (Level II) provides a unique data set of long time series. In some participating countries, the Level I system has been harmonized with the National Forest Inventory (NFI). As a consequence of this integration, a change in plots and in the frequency of assessment has occurred.

2. Scope and application

This Part IV of the Manual aims at providing a consistent methodology to collect high quality, harmonized and comparable crown condition data at the large-scale Level I plots and at the intensive Level II plots of the UNECE monitoring network. Harmonization of procedures of assessment is essential to ensure comparability of the crown condition data across Europe, which is in turn necessary to permit trans-national studies on status and trends of crown condition and its relationships with environmental factors. In order to have their data used in the international database and evaluations, National Focal Centres (NFC) and their scientific partners participating in the UNECE ICP Forests programme should follow the methods described here and achieve the reported data quality requirements.

Table IV-1 gives an overview of variables and application. Levels of monitoring are the systematic large scale Level I grid, modified in some countries by varying National Forest Inventory systems, intensive monitoring plots and core plots. The last two belong to the existing Level II network and cover selected relevant ecosystems in Europe. Intensive core monitoring plots contain the best monitoring information on key indicators of causes and effects.

Tab. IV-1: Parameter list of mandatory and optional variables of crown condition

Variable	Chapter	Level I	Level II	Level II core	Reporting units
Assessable crown	5.1.2	M	M	M	code
Crown visibility	5.2.1	O	M	M	code
Social class	5.2.2	O	M	M	code
Relative crown distance	5.2.3	O	O	M (only deciduous stands)	Relative measure
Crown shading	5.2.4	O	O	O	code
Defoliation	5.2.5	M	M	M	5 % classes
Reference tree	5.2.6	M	M	M	code
Foliage transparency	5.2.7	O	O	O	5 % classes
Flowering	5.2.8	O	O	O	code
Fruiting	5.2.9	O	O	M (only *Fagus* spp. and *Picea* spp.)	code
Apical shoot architecture (*Fagus* spp.)	5.2.10	O	O	M	code
Crown form / morphology (*Picea* spp., *Pinus* spp.)	5.2.11	O	O	O	code
Removals and mortality	5.2.12	M	M	M	code
Stand age	5.2.13	M	M	M	code
Tree age	5.2.13	O	O	M	code
Method of tree age assessment	5.2.13	O	O	M	code
Secondary shoots/epicormics	5.2.14	O	O	O	code
Specification of affected part	5.3.1.1	M	M	M	code
Location in crown	5.3.1.1	O	M	M	code
Specification of symptoms	5.3.1.2	O	M	M	code
Symptom	5.3.1.2	M	M	M	code
Age of the damage	5.3.1.3	O	M	M	code
Causal agents or factors	5.3.2	M	M	M	code
Scientific name of cause	5.3.2.1	M	M	M	code
Extent	5.3.3	M	M	M	% (classes)

O – optional, M – mandatory

3. Objectives

The main objectives of crown condition monitoring are:

(i) Crown condition assessment on large-scale Level I plots: Collect data to provide periodic information on the spatial and temporal variation of tree vitality in relation to biotic and abiotic stress factors in a European and national large-scale systematic network.

(ii) Contribution of Level I to a Europe-wide early warning system for detecting changes and pest and disease outbreaks in forest ecosystems.

(iii) Crown condition assessment on selected intensive monitoring Level II plots: collect data to contribute to a better understanding of the vitality of trees and forest ecosystems and causes and effects of stress factors.

(iv) Approved data quality: Field checks guarantee estimates on key crown condition indicators that permit high quality statistical analyses of spatial and temporal variation in European forest condition.

(v) (v) Provide information about the impact of damage causes on crown condition.

Information on the causes of damage to a tree and their influence on crown condition is essential for the study of cause-effect mechanisms. Without this information, data on defoliation and other crown parameters are extremely difficult to interpret. Data on leaf loss and discolouration caused by the actions of defoliating insects or other factors will also provide valuable information for interpreting e.g. litterfall measurements and phenological observations. Long-term monitoring may also provide baseline data on the distribution, occurrence and harmfulness of biotic agents or damage factors in Europe. These data may also contribute to other aspects relevant for forest policy like sustainable forest management.

4. Location of measurements and sampling

4.1 Selection of plots and sample trees

The selection of plots is described in detail in Part II of the Manual.

The national selection procedure for plots has to be described and reported by the NFCs to the Programme Coordinating Centre (PCC) (see Part II). Emphasis is put on the list of parameters that are suitable to indicate a holistic view on tree vitality. The assessments are linked to the statistically based sampling design (see Part II), including connections with NFI. It is strongly advisable to map the layout of the plot. Plot coordinates are submitted to the data centre with the respective forms for Level I and Level II, facilitating the use of GIS in the analytical stage. If the stand is clear-cut or wind thrown, no crown condition data will be submitted until a new stand has been established. A periodic revision of the Level I grid for adaptation to changes of forest area has to be conducted and reported to PCC by the submission of data on respective new or revised plots.

The sample trees have a minimum height of 60 cm. On Level I plots, preferably, all trees of Kraft classes 1-3 in the plot area should be assessed. On intensive monitoring plots assessments of crown condition and damaging agents can be conducted on a selected sub-plot (see Part II). The foliage of suppressed trees in high forests is mainly influenced by the overstorey. The inclusion of these trees in assessments is therefore optional and will depend on the aims of the national programme and the nature of the forest ecosystem.

Trees with >50% crown break (mechanical damage) are included in the crown condition sample, but in general no crown assessment is carried out if the assessable crown is severely affected. If countries decide to have a different procedure this has to be reported to PCC by using the code for parameter <removal and mortality> and if needed in addition by the submission of respective data accompanying reports in text format.

In coppice stands, macchia and other forest types where individual stools have many stems, the tree is considered as a single unit consisting of multiple stems.

In case of a Level I plot design with a fixed number of trees (e.g. four point cross cluster), trees that have been removed or have died should be replaced according to the procedure described in section 5.2.12.

The parameters described in this manual are assessed by ground survey. For the assessment of parameters on tree parts that are five or more meters above ground, the use of binoculars is mandatory. The use of photo guides with typical photos of trees with different defoliation is strongly recommended. Some parameters may require closer observation (e.g. some forms of needle discolouration and foliage deformation). Closer (in-hand) examination is also usually required for full diagnostic assessments. Usually, a closer investigation becomes possible only every two years when the leaves for foliar analysis are sampled.

If a field check by an expert phytopathologist in order to assess the causes of an observed damage is not possible, photographs of the affected tree and/or samples of affected foliage, branches, fungal fruitbodies etc. may be of help for diagnosis. Nevertheless, damaging trees in the plots by destructive sampling is not allowed. Sampling from nearby trees outside the plot showing the same damage symptoms may be considered. However one should remember that similar damage symptoms may result from different causes.

5. Measurements

5.1 Methods of assessment

5.1.1 Frequency of assessment

Crown condition assessments are mandatory for all levels at least once a year. However, on coexisting Level I and NFI plots a different procedure may be used. In this case, the respective NFC has to document the method and inform PCC. The time of the assessment should be between the end of the first flush of foliage (when the leaves and needles are fully developed) and the beginning of autumnal senescence. For most species, the most suitable time for the assessment is mid- to late summer. The assessments should be done during the same period each year and within this time frame if possible under similar conditions. In regions with regular damage caused by summer drought, monitoring may be shifted to early summer.

For the assessment of damage causes the observations in Level I plots should be carried out during regular crown condition assessment in summer.

For the Level II plots it is recommended and for core plots it is strongly recommended to do an additional visit for damage assessment, if important damage is observed outside the period of crown condition assessment. The observations of the staff responsible for deposition sampling or phenological observations may act as an early warning system. This additional visit should be made at the time when the main damage cause is supposed to be at its maximum (e.g. spring for defoliators).

5.1.2 Assessable crown

The estimation of crown condition strongly depends on the definition of the assessable crown. The crown present at the moment of the assessment is to be considered, regardless of the potential or theoretical crown which may have existed in previous years. The influence of any present or absent trees on the crown of the sample tree must be taken into account when determining its condition. In cases where the sample tree crown is influenced by competition, the assessable crown includes only those parts that are not influenced by other crowns (i.e. shading). Parts of the crown directly influenced by interactions between crowns or competition are excluded (see Fig. IV-1). The following parts of a crown must be excluded from the assessment:

- Epicormic shoots below the crown
- Gaps in the crown where it is assumed, that no branches ever existed

The assessable crown includes recently died branches, but excludes snags that have been dead for many years (i.e. which have already lost their side-shoots). Snags represent the historic mortality of parts of the crown and have no influence on the current condition of the tree. They are therefore excluded from the assessment. Dieback of shoots and branches represents an active process in the crown and is therefore included.

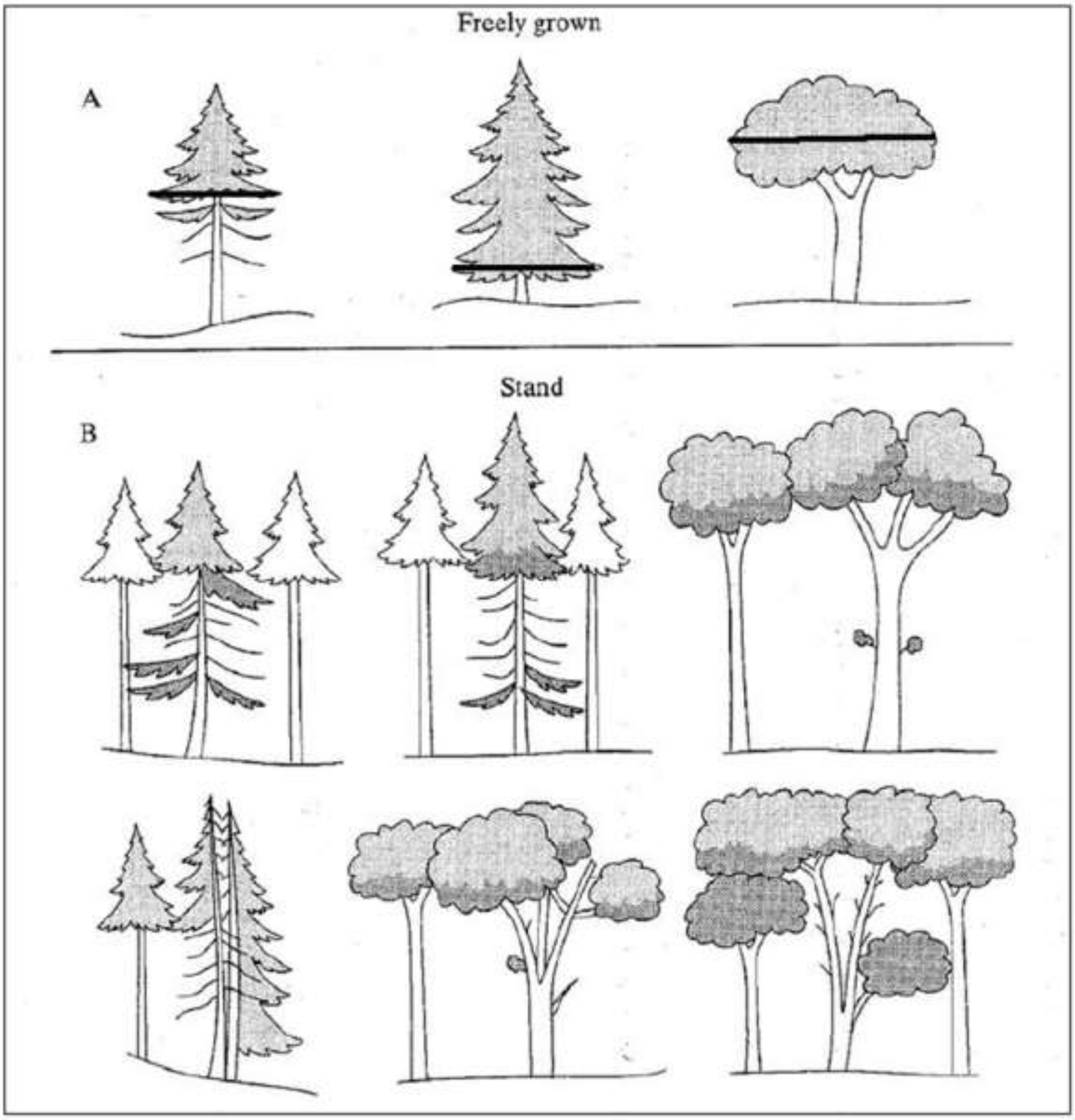

Fig. IV-1: A suggestion of the assessable crown for freely grown trees and trees in the stand: A - freely grown trees (assessable crown upwards from the black line), B - stand (lighter colour indicates assessable crown)

The definition of the assessable crown varies between countries. It is therefore essential that for each country, region and tree species the definition of assessable crown is documented. Data have to be sent to the ICP Forests data base unit with form TRE (Level I) and TRC (Level II), respectively.

The following classes are used:

Code	Description
1	Upper third of the crown

2	Upper half of the crown
3	Widest span of the crown is lower limit
4	Crown part without effects of competition
5	Entire crown
9	Other (please specify)

In coppice (and macchia) stands it may be necessary to consider the assessable crown as a single unit consisting of crown parts from different stems.

5.1.3 Definitions

Damage is defined as an alteration or a disturbance to a part of the tree which may have an adverse effect on the ability to fulfil its functions.

Symptom: Any condition of a tree resulting from the action of a damaging agent that indicates its occurrence (e.g. defoliation, discolouration, necrosis)

Sign: Evidence of a damaging factor other than that expressed by the tree (e.g. fungal fruiting bodies, nests of caterpillars)

Discolouration: any deviation from the usual colour of the living foliage for the assessed tree species.

Dieback: branch mortality which begins at the terminal part of a branch and proceeds towards the trunk and/or the base of the live crown.

Definitions of crown condition assessments are assigned to the related crown condition parameters.

5.2 Variables for Crown Condition Assessment

5.2.1 Crown visibility

Definition

The visibility of a crown is the degree to which different parts of the assessable crown can be viewed from the ground.

Crowns with poor visibility are not removed from the sample, but information about the visibility of individual tree crowns is useful to help with the interpretation of the data from those trees. Such trees remain in the sample as the use of an objective sampling design means that their exclusion could lead to bias in the results. Some parameters, e.g. stem and branch damage may be assessable on such trees.

Method

The following four classes for the visibility of assessable crown are used:

Code	Description
1	Whole crown is visible
2	Crown only partially visible
3	Crown only visible with backlighting (i.e. in outline). Note that some parameters can still be assessed when only back-lighting is present.
4	Crown not visible

5.2.2 Social class

Definition

Social status is a measure of the height of a tree relative to the surrounding trees. Information on social status is useful as an aid to interpreting crown condition and increment data for the individual trees.

Method

Five classes are recognized:

Code	Description
1	dominant (including free-standing): trees with upper crown standing above the general level of the canopy
2	Codominant: trees with crowns forming the general level of the canopy
3	subdominant: trees extending into the canopy and receiving some light from above, but shorter than 1 or 2
4	suppressed: trees with crowns below the general level of the canopy, receiving no direct light from above
5	Dying

Note: The assessment of the social class of a tree is in some cases difficult. Suppressed trees should not be equated with dying trees as, in a mixed-age stand, they represent future generations of trees. Classification on steep slopes presents a problem as even relatively short trees may receive direct light from above. In such cases, classification should be based on the relative height of the trees.

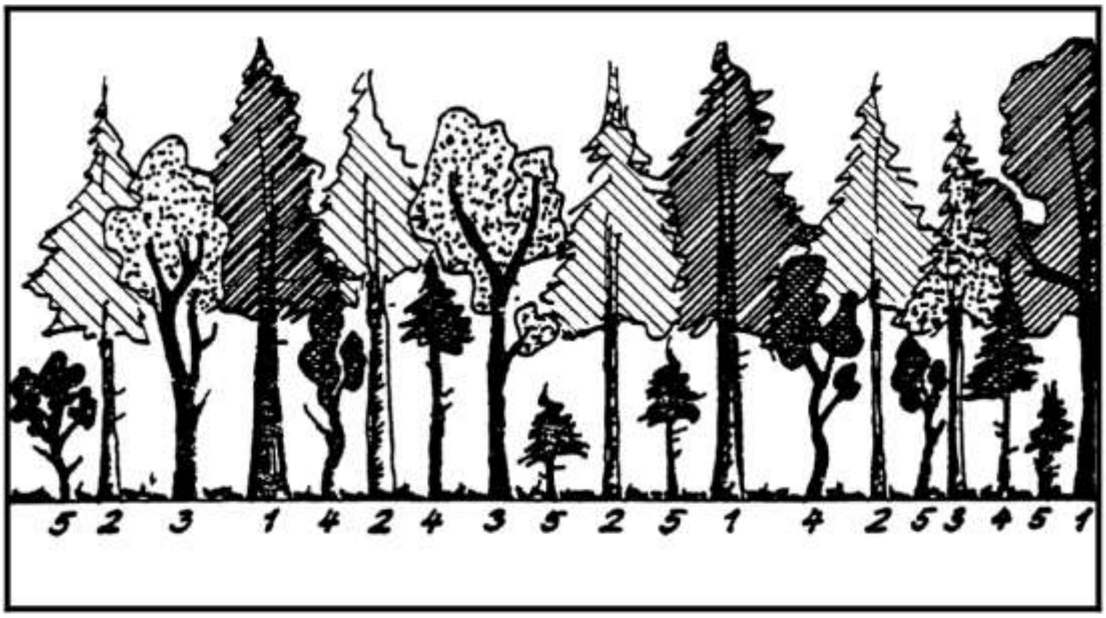

Fig IV-2: Illustration of social status classes (crown canopy classes) after Kraft (1 = dominant, 2 = codominant, 3 = subdominant, 4 = suppressed, 5 = dying)

5.2.3 Relative crown distance

Definition

Relative crown distance is crown diameter related distance to surrounding trees in main directions (CDRD_N).

The relative distance between trees explains to a high degree the variability of characteristic defoliation data of deciduous trees.

Method

Scores are given for each perpendicular direction.

Code	Description
1	cramped, canopies overlap
2	closed, crowns touch one another
3	loose spread, gap between crowns up to one third of average crown diameter
4	spread, gap between crowns up to two thirds of average crown diameter
5	distant, gap between crowns from two thirds up to one whole of average crown diameter
6	very distant, gap between crowns > than 1/1 of average crown diameter

It is recommended to start with the tree standing closest to the sample tree in a clockwise procedure. Dead trees are taken into account, as long as they are in the crown condition sample (see: 5.2.12).

Calculation

(Score1 + Score2 + Score3 + Score4) / 4 = CDRD_N

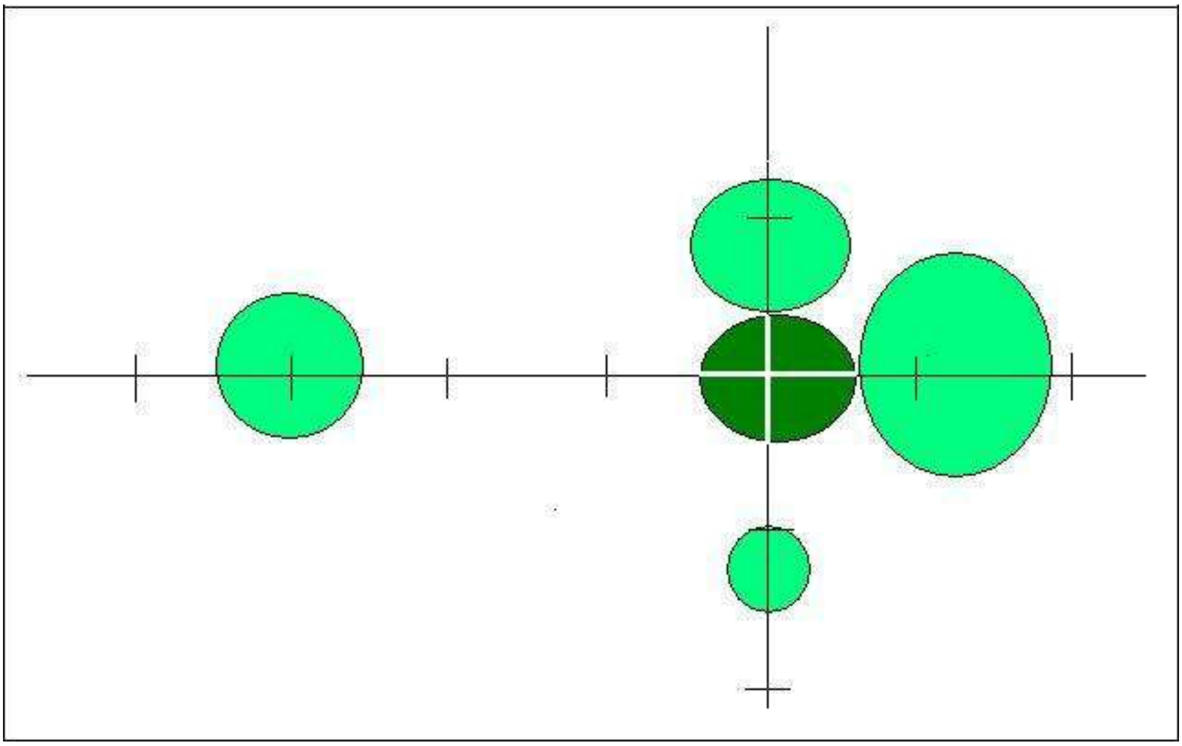

Fig. IV 3: Example: Crown diameter related distance to surrounding trees

Example:

[2+2+6+5]/4= 3.75

Crown diameter is a relative measure used to analyse crown stand structure in four perpendicular directions. Score values are to be averaged.

Note: If detailed stand structure information including crown projection maps of single trees is available, crown diameter related distance of sample trees can be calculated from this information (see: Part V: Tree growth).

5.2.4 Crown shading

In order to allow for the continuation of existing time series the method of Crown shading is defined.

Definition

Crown shading is an estimate of the degree to which a sample tree is affected by neighbouring trees.

Open-grown trees usually have much larger crowns than trees growing in stands with closed canopies. In addition, the absence of any competition may change the susceptibility of a tree to particular stresses. A change in the degree of shading may have significant effects on crown condition. Consequently, this assessment should refer to the degree of shading at the time of assessment. This may change from one year to the next through, for example, thinning operations or storm damage. Consequently, it should be recorded annually.

Method

Crown shading is assessed on a six-point scale.

Code	Description
1	crown significantly affected (shading or physical interactions) on one side
2	crown significantly affected (shading or physical interactions) on two sides
3	crown significantly affected (shading or physical interactions) on three sides
4	crown significantly affected (shading or physical interactions) on four sides
5	crown open-grown or with no evidence of shading effects
6	suppressed trees

5.2.5 Defoliation

Definition

Defoliation is defined as needle/leaf loss in the assessable crown as compared to a reference tree. Defoliation is observed regardless of the cause of foliage loss.

Methods

Defoliation is assessed in 5% steps. These classes are 0, 5 (>0-5%), 10 (>5-10%) and so on. Trees should be reported in these 5% classes and not in aggregated groupings.

A tree with >95% and up to 100% defoliation, which is still alive, is coded as “99”. The code “100” is reserved for dead trees.

Code	Description
0	0%
5	>0-5%
10	>5-10%
15	>10-15%
20	>15-20%
25	>20-25%
30	>25-30%
35	>30-35%
40	>35-40%
45	>40-45%
50	>45-50%
55	>50-55%
60	>55-60%
65	>60-65%
70	>65-70%
75	>70-75%
80	>75-80%
85	>80-85%
90	>85-90%
95	>90-95%
99	>95-100% (alive)
100	100% (dead)

Hint: If the above-ground parts of a tree die (e.g. after a forest fire), the tree is classified as dead. The above-ground parts of the tree are considered dead, if the phloem and xylem is dead. Note that dormant buds may continue to flush for one or more seasons on cut logs, indicating that the tissues may remain alive for some time after some people might consider them as dead. Regrowth from the roots is excluded until the shoots attain the requirements for inclusion in the assessments. Although biologically inappropriate, for practical reasons regrowth from the base of the trees should be classified as new stems with new crowns.

Hint: Some species produce large amounts of green tissues associated with the flowers (e.g. *Carpinus betulus* and *Fraxinus excelsior*). These tissues contain chlorophyll and contribute to the carbon budget of the tree. It is recommended that such tissues are included with the foliage mass when assessing defoliation.

5.2.6 Reference tree

Definition

Two different types of reference trees are recognised: local reference trees and absolute reference trees. A local reference tree or a conceptual (imaginary) tree is defined here as the best tree with full foliage that could grow at a particular site, taking into account factors such as altitude, latitude, tree age, site conditions and social status. Its defoliation is set at 0% defoliation. This tree should represent the typical crown morphology and age of trees in the plot. Absolute reference trees are the best possible trees of a genotype or species, regardless of site conditions, tree age, etc.

Methods

The concept of the reference tree is one of the most controversial issues in the monitoring programme, yet it is crucial for the assessments. Use of absolute reference trees may lead to higher defoliation estimates than the application of local reference trees, but the results are perhaps more amenable to temporal and spatial analyses. Most countries have adopted local reference trees as standards. This local reference takes into account the build-up and the development stage of the tree.

Hint: A number of photo guides exist which provide guidelines on absolute reference trees in different parts of Europe.

The use of a reference tree is reported in four classes:

Code	Description
1	Local/conceptual reference tree
2	Absolute reference tree
3	Combination of a local and absolute reference tree
4	None

5.2.7 Foliage transparency

Definition

Foliage transparency is defined as the additional amount of skylight visible through the crown compared to the amount of skylight visible through a fully foliated crown.

Method

Estimate foliage transparency in 5% classes based on the live, normally foliated portion of the crown and branches using the transparency diagram in Fig. IV 4. Dead branches, crown dieback and missing branches where foliage is expected to be missing are excluded from the estimate (Fig. IV 5).

Code	Description
0	0%
5	>0-5%
10	>5-10%
15	>10-15%
20	>15-20%
25	>20-25%
30	>25-30%
35	>30-35%
40	>35-40%
45	>40-45%
50	>45-50%
55	>50-55%
60	>55-60%
65	>60-65%
70	>65-70%
75	>70-75%
80	>75-80%
85	>80-85%
90	>85-90%
95	>90-95%
99	>95-100% (alive)
100	100% (dead)

Large uniform crowns are scored as if the whole crown should be foliated. When defoliation is severe, branches alone will screen the light, but the surveyors should exclude the branches from the foliage and rate the area as if light was penetrating. For example, an almost completely defoliated dense spruce may have less than 20% light coming through the crown, but it will be scored as highly transparent because of the missing foliage. Old trees, and some broad-leaved species, have crown characteristics with densely foliated branches which are spaced far apart in the crown. These spaces between branches should not be included in the foliage transparency score. When foliage transparency in one part of the crown differs from another part, the average foliage transparency is estimated and recorded.

Hint: The easiest way to assess foliage transparency is first to mentally draw a two-dimensional crown outline. Then block the foliated area into the crown outline. Lastly, estimate the transparency of this foliated area.

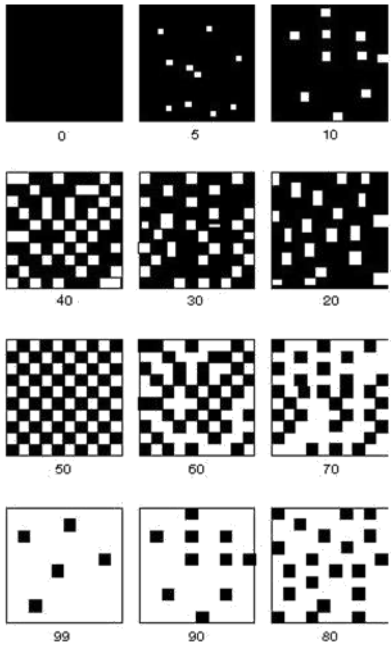

Fig. IV 4: Guide to estimating transparency (derived from Tallent-Halsell, 1994).

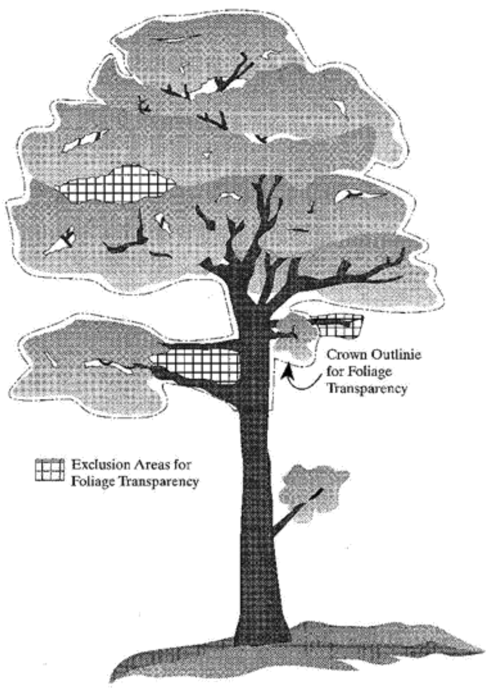

Fig. IV 5: Crown outline to be taken into account when estimating foliage transparency. Note the areas to be excluded from the estimates. This is a free standing tree, therefore the assessable crown covers a rather large area (derived from Tallent-Halsell 1994). Hint: Stem and dead branches have to be deleted from the estimate as well.

5.2.8 Flowering

Definition

This score is defined as the estimation of (current) flowering in the crown.

Flowering is a precondition for natural regeneration, may affect defoliation scores and is of interest because of its effects on the carbon balance of the tree.

Method

Two assessments are made: (i) in the assessable part of the crown and (ii) in the whole crown. Three classes are used to describe flowering:

Code	Description
1	Absent or scarce. The flowers are not seen in a cursory examination.
2	Common. Flowering effect is clearly visible.
3	Abundant. Flowering dominates the appearance of the tree.

Hint: In some species, such as *Pinus* and *Larix*, the flowers will probably have been dropped by the time of assessment. Scoring is based on the gaps along the shoots where the flowers formerly were.

5.2.9 Fruiting

Definition

Fruiting is defined as annual seed production of trees.
Annual seed production of trees with heavy seeds such as beech can cause considerable changes in internal cycles. Annual seed production may cause a significant change in allocation of carbon, nutrients and energy from leaves and stem growth to generative structures. This is an important criterion for tree vitality.

Method
Only the fruit of the respective assessment year is to be considered (*Picea abies*: cones greenish to magenta, at end of shoots, scales close to the cone. *Pinus* spp.: only green cones).

Two assessments can be made: in the assessable part of the crown and in the whole crown according to the following classes:

Code	Description
1.1	absent: Fructification is absent or inconsiderable. Even reasonably lengthy observation of the crown with binoculars yields no signs of fruiting.
1.2	scarce: Sporadic occurrence of fruiting, not noticeable at first sight. It must be looked for on purpose with binoculars.
2	common: Fruiting is clearly visible, can be observed with the naked eye. The appearance of the tree is influenced but not dominated by fructification.
3	abundant: Fruiting dominates the appearance of the tree, immediately meets the eye, determines the tree’s appearance.

5.2.10 Apical shoot architecture (*Fagus sylvatica*)

Application and Definition

Apical shoot architecture is defined as assessment of growth patterns of the topmost twigs of crown of *Fagus sylvatica*.

The beech architecture model allows recognising vitality anomalies in time series. From a distance apical shoot architecture indicates typical growth patterns, which can be assessed using binoculars.

Methods

Only the top most twigs of a beech's crown are suitable for assessment of the apical shoot architecture. If there is a good visibility of the top of the sample trees, it can be assessed during summer assessment. It is recommended to derive a concluding estimation by using the weighted value of three observation values, e.g. using a clockwise pattern at 11 hrs, 12 hrs and 13 hrs in the very top part of beech crowns. If there is only a limited view of the top of trees (for example in dense stands), it is recommended to carry out the assessment in the dormancy period.

The assessment is recommended (mandatory for *Fagus sylvatica* on core plots) once every 3 years, starting in 2010.

1. Exploratory phase: Apical shoots and upper side buds form long shoots. Flat, longitudinal, expansive shoot development.

Fig. IV 6: Exploratory phase (right: drawing by ROLOFF, 2001)

2. Intermediary form between 1 and 3

3. Degeneration phase: Only apical bud forms a long shoot. Shoots of side buds are stunted. Spear-shaped development of main shoots with reduced side shoot formation "spear-shaped".

Fig. IV 7: Spear-shaped degeneration phase (right: drawing by ROLOFF, 2001)

4. Intermediary form between 3 and 5

Fig. IV 8: Intermediary form 3/5

5. Stagnation phase: Stunted long shoots, claw-like appearance because of pluriannual short shoot chains

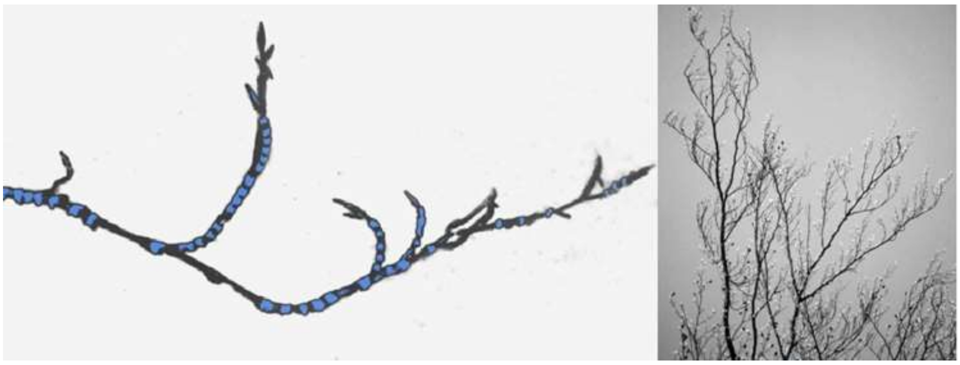

Fig. IV 9: Stagnation phase

6. Intermediary form between 5 and 7

Fig. IV 10: Intermediary form 5/7

7. Resignation phase: Dieback of twigs of the topmost part of the crown or even the whole crown itself.

8. Regeneration phase. Phase with obvious regeneration: From worse phase to a better form on the same branch.

5.2.11 Crown form/morphology (*Picea spp., Pinus spp.*)

Definition

Crown form is defined as the appearance of the crown. It may be influenced by crown shape and/or by branch habit.

Crown form provides supplementary information about the condition of a tree. In many cases, crown form changes through time. The premature development of such changes often indicates the action of one or more types of stress. However, the separation of stress- and genetically-induced changes is often difficult.

Methods

For *Picea* species the following crown forms can be specified (Fig. IV-11):

Code	Description
11	comb
12	brush
13	plate
14	mix

For *Pinus spp.* the following crown forms can be specified:

Code	Description
31	vigorous apical dominance with tree growing strongly upwards
32	reduced or no apical dominance with crown showing signs of widening
33	as 32, but lower branches lost through suppression
34	platform developing, with dominant growth direction no longer upwards
35	platform fully developed, no vertical growth
39	other (specify)

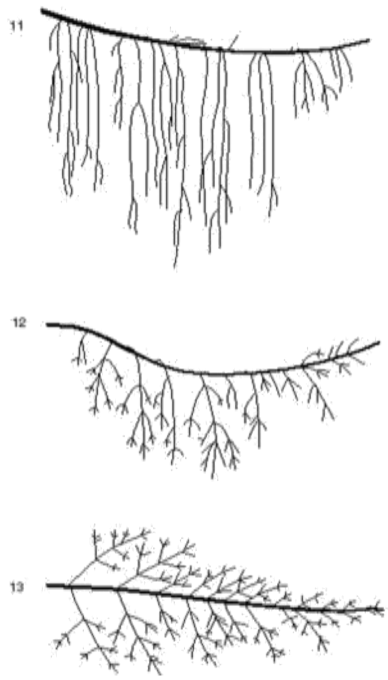

Fig. IV-11: Crown form in *Picea* spp.: 11 Comb; 12 Brush; 13 Plate.

5.2.12 Removals and mortality

Definition

Removals are trees that for some reason are not included in the sample of assessed trees. Mortality refers to sample trees which have died. A tree is defined as dead if all conductive tissues in the stem(s) have died.

Trees may have to be withdrawn or eliminated from sampling for several reasons. It is important to record this information so that the causes of changes in the numbers of assessment trees in each plot can be assessed and annual mortality rates can be derived.

If a tree has died, the cause must be determined (if possible). Standing dead trees (classes 31–39) of Kraft classes 1–3 have to be reported with defoliation=100% and the cause of death (if possible) only during first assessment after their death. When they have fallen or have been removed the dead tree is replaced by a new sample tree in case of a sampling design which is not area related.

Method

The yearly state of removals and mortality covers the assessment or derivation of an annual mortality rate.

Tree is in the sample and values for parameters (e.g. defoliation) were assessed and submitted:

Code	Description
01	tree alive, in current and previous inventory
02	new alive tree (ingrowth)
03	alive tree (present but not assessed in previous inventory)

Tree is not in the sample or at least no data are available for this tree in the submitted year:

Code	Description
04	alive tree but tree no longer in crown sample due to heavy disturbances (e.g. heavy storm damage); may be assessed and data submitted
07	no info on this tree with this submission (e.g. tree forgotten during field work)
08	alive tree but due to alternating tree selection not in the submitted sample

Tree has been cut and removed, only its stump has been left:

Code	Description
11	planned utilization, e.g. thinning
12	utilization for biotic reasons, e.g. insect damage
13	utilization for abiotic reasons, e.g. windthrow
14	cut, reason unknown
18	reason for disappearance unknown
19	reason for disappearance not determined/observed

Tree is still standing and alive, but crown condition parameters are no longer assessed:

Code	Description
21	lop-sided or hanging tree
22	heavy crown break (over 50% of the crown) or broken stem (only applicable in those countries that do not record trees with more than 50% crown damage).
23	tree is no longer in Kraft classes 1, 2 or 3 (not applicable to the first inventory in a plot, only applicable in those countries that restrict assessments to Kraft classes 1, 2 and 3)
29	other reasons (specify)

Standing dead tree:

Code	Description
31	biotic reasons, e.g. bark beetle attack
32	abiotic reasons, e.g. drought, lightning
38	unknown cause of death
39	cause was not determined/observed

Trees that have fallen (living or dead):

Code	Description
41	abiotic reasons (e.g. storm)
42	biotic reasons (e.g. beavers)
48	unknown cause
49	cause was not determined/observed

This classification allows for reporting the reason why a tree has died or has been removed in broad categories only (e.g. biotic/abiotic reasons). If more details are available, e.g. the exact cause of mortality of a tree was determined, this shall be reported by using the codes of the guidelines on assessment of damage causes.

Note: Mortality and the number of dead trees present in a plot are two different issues. Annual mortality can be calculated from the number of living trees that are dead the following year. The total number of dead trees in a plot at any one time provides no information on mortality rates, but provides information on the condition of a stand in the year of assessment.

Note: If trees in the plot have not been mapped, there may be some difficulty in identifying the fate of individual trees that have disappeared between surveys.

5.2.13 Stand age, tree age and method of age assessment

Definitions

Stand age is defined as the mean age of the dominant storey.

Tree age is defined as tree specific age of sample trees.

Different age of sample trees has been shown to be one of the main causes for differing results in defoliation estimations in various European countries. Studies show, that even rough age estimations help to explain a substantial amount of defoliation variability.

Even if assessment accuracy is expected to be low in most cases, the submission of tree specific age should help for a better understanding of stand structure during data evaluations.

Method

Stand age and tree age are reported in 20 year classes.

Codes for stand age:

Code	Description
1	≤ 20
2	21— 40
3	41— 60
4	61— 80
5	81—100
6	101—120
7	> 120
8	Irregular stands

Codes for tree age assessment:

Code	Description
1	≤ 20
2	21— 40
3	41— 60
4	61— 80
5	81—100
6	101—120
7	121—140
8	141—160
9	>160

For core plots, tree age must be specified for all sample trees of a plot. The best exact method should be used and described, indicating also the uncertainties of this method:

Methods of age assessment:

Code	Description
1	assured dates of stand establishment
2	tree stumps
3	age determination of the lowermost twigs (add estimated time it has taken to grow to that height)
4	increment borer, stem discs (from similar sized trees/median sized trees) outside the plot
5	assessment (impossible in most cases)
6	estimation without any exact information

5.2.14 Secondary shoots and epicormics

Definition

Secondary shoots and epicormics are used synonymously and are defined as shoots that have developed from dormant buds on the stem or on branches. In some cases, old epicormics can be difficult to separate from branches.

In some species, the development of secondary shoots is the normal part of crown formation. For example, in *Picea abies*, secondary shoots develop along the main branches to replace older shoots that have lost their needles. In other species, particularly broadleaves, the development of epicormic shoots in the crown and on the stem may reflect increased levels of light penetration through the foliage of the outer crown.

Scoring of the presence of shoots reveals whether the tree is responding to loss of foliage and thus the regenerative capacity of the tree. For example, a heavily defoliated *Picea abies* that has no secondary shoots is indicative of a tree under extreme stress.

Methods

Assessments are made of the frequency of epicormics in the assessable crown and on the stem. The assessment must include all epicormics, not only the ones of the current year.

Scoring is in three classes:

Code	Description
1	None or rare
2	Medium: light development or only present in parts of the crown or stem
3	Abundant: present throughout the majority of the crown or all over the stem

5.3 Variables for Damaging Agents

The assessment of damage causes consists of 3 major parts:

- symptom description
- determination of the cause
- quantification of symptoms (extent)

5.3.1 Symptom description

"Describe what you see" could be a summary of the aims of the symptom description: it indicates which part of the tree is affected and the type of symptom it shows. It is an essential step for diagnosis of the causal agent and for the study of cause-effect mechanisms. However this does not mean that every symptom observed has to be reported. The symptom description should focus on important factors which may influence the condition of the tree.

The symptom description specifies the presence of damage symptoms. It does not deal with the extent of the damage. For quantification see section 5.3.3.

In principle the symptom description is restricted to causal agents or factors which may influence crown condition (defoliation, discolouration). However this does not mean that the symptom description is restricted to symptoms observed on the foliage: damage to the branches or the stem (e.g. bark beetle attack) often results in defoliation but its contribution in the defoliation score may be very difficult to assess. Therefore the symptom description should cover all parts of the tree.

In the symptom description, the whole tree i.e. stem, collar and the total crown (which may be different from the assessable crown) should be taken into account. This is important because symptoms that are recognized outside the assessable crown may indicate the start of a process which may affect the assessable crown at a later stage (e.g. *Peridermium pini* infection in *Pinus*).

5.3.1.1 Affected part of the tree and location in crown

Three main categories are distinguished for indicating the affected part of the tree: (a) leaves/needles; (b) branches, shoots, buds & fruits; (c) stem & collar. For each affected part further specification is required, which is important for diagnostic purposes (Table IV-2). A separate code

(Table IV-3) allows for reporting the location of affected part (leaves/needles, branches, shoots, buds and fruit) in the crown. This may provide further valuable information for the diagnosis.

Affected part	Code	Specification of affected part
LEAVES/NEEDLES	11	Current needle year
	12	Older needles
	13	Needles of all ages
	14	Broadleaves (incl. evergreen spec.)
BRANCHES, SHOOTS, BUDS & FRUITS	21	Current year shoots
	22	Twigs (diameter < 2 cm)
	23	Branches diameter 2 – < 10 cm
	24	Branches diameter ≥ 10 cm
	25	Varying size
	26	Top leader shoot
	27	Buds
	28	Current year fruits
STEM & COLLAR	31	Main trunk or bole within the crown
	32	Trunk between the collar and the crown
	33	Roots (exposed) and collar (≤ 25 cm height)
	34	Whole trunk
	4	Dead tree
	0	No symptoms on any part of tree
	9	No assessment

Tab. IV-2: Affected parts of a tree and the specification of affected part

Code	Location in crown
1	Upper crown
2	Lower crown
3	Patches
4	Total crown

Tab. IV-3: Location of affected part in the crown

Special cases:

The following codes for special cases shall be reported in the column for 'specification of affected part of the tree:

- Dead trees:

Dead trees should be reported using code 04. Defoliation score of this tree is "100". The cause(s) of death should be reported in the column for the causal agent / factor. The death is reported in the first year when it is observed. In general, no information is submitted in the succeeding years. Only in case that in the succeeding years the reason – i.e. a biotic damage – may be found to be the reason for the tree’s dying, this damage should be submitted with the respective forms.

- No symptoms at all are observed on any part of the tree (no further damage parameters are assessed or submitted):

Report code 00 in the column for specification of affected part.

- No assessment of damage causes was made

Report code 09 in the column for specification of affected part. No other damage parameters are assessed or submitted for this tree.

5.3.1.2 Symptoms and their specifications

Symptoms are grouped into broad categories like wounds, deformations, necrosis etc. A separate code (specification of symptom) allows for a more detailed description. Nests of caterpillars, fungal fruit bodies etc. are not considered as symptoms but are defined as ‘signs’ of insects, fungi, etc. Their presence provides valuable information for diagnostic purposes and should be reported. If signs of insects or fungi are observed it is important to report also the observed damage symptoms.

An overview of symptoms, specifications and codes is given in Table IV-4. For the field teams this table provides a complete overview of the section on symptom description, including the codes for reporting. Each code for <symptom/sign specification> is used only for the specified combination of <affected part> and <symptom/sign> on the respective left part of the table. E.g. in case of bronzing leaves (symptom is bronzing, affected part is leaves/needles) only symptom specification 37 to 44 are used.

Affected part	Symptom / sign (mandatory Level I and Level II)	Code	Symptom/sign specification (optional Level I, mandatory Level II)	Code
Leaves/needles	Partly or totally devoured/missing	01	holes or partly devoured/missing notches (leaf/needle margins affected) totally devoured/missing skeletonised mined Premature falling	31 32 33 34 35 36
	Light green to yellow discolouration Red to brown discolouration (incl. necrosis) Bronzing Other colour	02 03 04 05	overall flecking, spots marginal banding interveinal tip, apical partial along veins	37 38 39 40 41 42 43 44
	microfilia (small leaves) other abnormal size	06 07		
	Deformations	08	curling bending rolling stalk twisting folding galls wilting other deformations	45 46 47 48 49 50 51 52
	other symptom	09		
	Signs of insects	10	black coverage on leaves nest adults, larvae, nymph, pupae, egg masses	53 54 55
	Signs of fungi	11	white coverage on leaves fungal fruiting bodies black coverage on leaves	56 57 53
	Other signs	12		
Branches, shoots, buds & fruits	devoured /missing Broken Dead /dying Abortion /abscission Necrosis (necrotic parts)	01 13 14 15 16		
	Wounds (debarking, cracks etc.)	17	debarking cracks other wounds	58 59 60
	Resin flow (conifers) Slime flux (broadleaves) Decay/rot	18 19 20		
	Deformations other symptom	08 09	wilting bending, drooping, curving cankers tumours witches broom other deformations galls	51 61 62 63 64 52 50
	Signs of insects	10	boring holes, boring dust nest white dots or covers black coverage adults, larvae, nymph, pupae, egg masses	65 54 66 53 55
	Signs of fungi	11	fungal fruiting bodies	57
	Other signs	12		
Stem / collar	Wounds (debarking, cracks etc.)	17	debarking cracks (frost cracks, …) other wounds	58 59 60
	Resin flow (conifers) Slime flux (broadleaves) Decay/rot	18 19 20		
	Deformations	08	cankers tumours longitudinal ridges (frost ribs, …) other deformations	62 63 68 52
	tilted fallen (with roots) broken Necrosis (necrotic parts)	21 22 13 16		
	other symptom	09		
	Signs of insects	10	boring holes, boring dust nest white dots or covers adults, larvae, nymph, pupae, egg masses galleries	65 54 66 55 69
	Signs of fungi	11	fungal fruiting bodies yellow to orange blisters mycelium rhizomorphs	57 67 70 71
	Other signs	12		

Tab. IV-4 (previous page): Symptoms/signs and specification of symptoms/signs

Important remarks:

Table IV-4 aims at giving an overview of the more important symptoms that may occur in trees. The symptom description is mandatory for foliage, branches and stem, but countries are free to select for each affected part the more important symptoms at national level. If a selection is made this should be reported to the international data centre.

In order to reduce the time needed for the symptom description, countries may wish to compose a national standard list with a complete symptom description for well-known and frequently occurring damage factors for their field teams. In this way the surveyor will only have to fill in the name of the causal agent and the quantification of the damage. In the event of damage by a factor which is not on the standard list, the complete symptom description should be made.

Reporting to the international data centre, however, should always include the complete symptom description.

The categories 'other' (symptom, sign, colour etc.) should be specified in the remarks (<other observations>) column.

In the event of symptoms of ozone damage the guidelines and forms of the Manual Part VIII: Assessment of Ozone injury shall be applied.

Specifications

a. Cause is unknown

If damage symptoms on a tree are observed and the cause is unknown, the symptoms and the extent should be reported nevertheless. However, in the field "cause" the code 999 should be entered. See also (b.) "Avoiding duplication of crown condition assessment".

b. Avoiding duplication of crown condition assessment:

Crown condition assessment in the ICP Forests monitoring programme mainly focuses on defoliation. This symptom is also very important for the assessment of damage causes. In this respect the following rules apply:

If defoliation of a tree is observed and the cause is unknown, defoliation should only be reported in the crown condition assessment (TRC or TRE, respectively), and should not be reported as a symptom in the damage causes section and form (TRD or TRF, respectively). However, other relevant symptoms observed on the same tree (e.g. dead branches) should be reported.

If defoliation can partly or totally be attributed to a certain, identified cause(s) (e.g. defoliators), defoliation should be reported in the damage causes section in addition.

c. Necrotic leaves

Necrosis of leaves/needles and its pattern is an important symptom for diagnostic purposes. According to the definition in this manual, discolouration is "any deviation of the usual colour of the living foliage of the considered tree species". Totally brown or necrotic leaves are considered to be dead, hence 'discolouration' does not apply here since this symptom is restricted to living foliage. Thus, totally brown leaves/needles should be considered as defoliation. However, leaves that are only partially necrotic should be reported under 'red to brown discolouration' (symptom code 03).

d. Multiple symptoms

In the event of several symptoms on a tree caused by the same, identified agent/factor, only the main symptom shall be reported.

e. Dead branches

Snags (dead branches which are dead for several years and without side shoots) and dead branches due to competition are excluded from the assessment of dead branches.

In some tree species (e.g. spruce), small dead branches may be a 'normal' phenomenon. This should not be reported except when an abnormal percentage of dead branches is observed.

5.3.1.3 Age of the damage

Recording this parameter helps in detecting new epidemics. Moreover, some injuries, like harvesting scars remain visible for many years.

The age of the damage shall be reported using four classes:

Code	Class	Description
1	Fresh	damage that has begun after the last year's inventory
2	Old	damage that has begun earlier
3	Fresh and old	both fresh and old damage is visible
9	Not defined	

Tab. IV-5: Age of damage classes

5.3.2 Causal agents / factors

Determination of the causal agent that is responsible for the observed damage symptoms is crucial for the study of cause-effect mechanisms. The description of symptoms is an important step in the diagnostic process, but damage symptoms on their own do not always provide the explanation for the observed damage. In many cases further examination will be necessary to determine the causal agent.

In case that more than one damaging agents are found on the same tree they should be reported using additional lines in the submission forms (more than one line per tree possible).

In case that damage has to be reported that is caused by a damage factor for which no code is foreseen this should be reported to the PCC of ICP Forests. PCC will take care that a respective code will be defined by the EP and be provided to the NFCs.

Causal agents are grouped into the following categories:

Agent group	Code
Game & grazing	100
Insects	200
Fungi	300
Abiotic agents	400
Direct action of man	500
Fire	600
Atmospheric pollutants	700
Other	800
(Investigated but) unidentified	*999*

Tab. IV-6: Main causal agent groups

In each category a more detailed determination is possible according to a hierarchical coding system (see Tables IV-7 to IV-15 and Chapter 7.1 Data submission procedures, forms and codes). Report the damage cause as detailed as possible, if possible up to species level. E.g. a code 210 for insects is more helpful than a score 200, as in the first case it is specified that the causal agent is a defoliator.

Agent group	Code	Class	Code	Type	Code
Game and grazing	100	Cervidae	110	Roe deer	111
				Red deer	112
				Reindeer	113
				Elk/Moose (*Alces alces*)	114
				Other Cervidae	119
		Suidae	120	Wild boar	121
				Other Suidae	129
		Rodentia	130	Rabbit	131
				Hare	132
				Squirrel etc.	133
				Vole	134
				Beaver	135
				Other Rodentia	139
		Aves	140	Tetraonidae	141
				Corvidae	142
				Picidae	143
				Fringillidae	144
				Other Aves	149
		Domestic animals	150	Cattle	151
				Goats	152
				Sheep	153
				Pigs (domestic)	154
				Other domestic	159
		Other vertebrates	190	Bear	191
				Wild goat	192
				Other vertebrate	199

Tab. IV-7: Codes for agent group 100 (Game and grazing)

Agent group	Code	Class	Code	Scientific name	Code
INSECTS	200	**Defoliators**	210	*Acantholyda hieroglyphica*	ACANHIE
				Brachonyx pineti	BRACPIN
				Brachyderes suturalis	BRACSUT
				Diprion pini	DIPRPIN
				Gelechia senticetella	GELESEN
				Lymantria dispar	LYMADIS
				Lymantria monacha	LYMAMON
				Bupalus piniarius	BUPAPIN
				Choristoneura murinana	CHORMUR
				Cephalcia abietis	CEPHABI
				Cephalcia lariciphila	CEPHLAR
				Dendrolimus pini	DENDPIN
		Stem, branch & twig borers (incl. shoot miners)	220	*Dioryctria sylvestrella*	DIORSYL
				Hylobius abietis	HYLOABI
				Ips acuminatus	IPSACUM
				Ips sexdentatus	IPSSEXD
				Ips typographus	IPSTYPO
				Magdalis memnonia	MAGDMEM
				Orthotomicus erosus	ORTHERO
				Phaenops cyanea	PHAECYA
				Pissodes castaneus	PISSCAS
				Pityogenes chalcographus	PITYCHA
				Pityokteines curvidens	PITYCUR
				Petrova resinella	PETRRES
				Semanotus laurasi	SEMALAU
				Tomicus destruens	TOMIDES
		Bud boring insects	230	*Rhyacionia buoliana*	RHYABUO
				Rhyacionia duplana	RHYADUP
		Fruit boring insects	240	*Dioryctria mendacella*	DIORMEN
				Pissodes validirostris	PISSVAL
		Sucking insects	250	*Haematoloma dorsatum*	HAEMDOR
				Leucaspis pini	LEUCPIN
				Matsucoccus feytaudi	MATSFEY
		Mining insects	260	*Epinotia subsequana*	EPINSUB
		Gallmakers	270		
		Other insects	290		

Tab. IV-8: Codes for main species in agent group 200 (insects) present on conifers. For the full list of scientific names of insects see Chapter 7.1.

Agent group	Code	Class	Code	Species name	Code
I N S E C T S	200	Defoliators (incl. skeletonizers, leaf rollers etc.)	210	*Calospilos pantaria*	CALOPAN
				Agelastica alni	AGELALN
				Altica quercetorum	ALTIQUE
				Epirrita autumnata	EPIRAUT
				Galerucella lineola	GALELIN
				Gonipterus scutellatus	GONISCU
				Leucoma salicis	LEUCSAL
				Lymantria dispar	LYMADIS
				Archips xylosteana	ARCHXYL
				Lymantria monacha	LYMAMON
				Melolontha hippocastani	MELOHIP
				Operophtera brumata	OPERBRU
				Operophthera fagata	OPERFAG
				Thaumetopoea processionea	THAUPRO
				Chrysomela populi	CHRYPOP
				Tortrix viridana	TORTVIR
				Xanthogaleruca luteola	XANTLUT
		Stem, branch & twig borers (incl. shoot miners)	220	*Agrilus grandiceps*	AGRIGRA
				Cerambyx sp.	CERASPP
				Coroebus florentinus	COROFLO
				Agrilus pannonicus	AGRIPAN
				Agrilus viridis	AGRIVIR
				Crematogaster scutellaris	CREMSCU
				Cryptorrhynchus lapathi	CRYPLAP
				Melanophila picta	MELAPIC
				Paranthrene tabaniformis	PARATAB
				Phoracantha semipunctata	PHORSEM
				Platypus cylindrus	PLATCYL
				Sesia apiformis	SESIAPI
		Bud boring insects	230		
		Fruit boring insects	240	*Curculio glandium*	CURCGLA
		Sucking insects	250	*Ctenarytaina eucalypti*	CTENEUC
				Kermes sp.	KERMSPP
		Mining insects	260	*Rhynchaenus fagi*	RHYNFAG
		Gallmakers	270	*Andricus quercustozae*	ANDRQUE
				Dryomyia lichtensteinii	DRYOLIC
				Mikiola fagi	MIKIFAG
		Other insects	290		

Tab. IV-9: Codes for main species in agent group 200 (insects) present on broadleaves. For the full list of scientific names of insects see Chapter 7.1.

Agent	Code	Class	Code	Scientific name	Code
F U N G I	300	Needle casts and needle- rust fungi	301	*Lophodermium pinastri*	LOPHPIN
				Cyclaneusma minus	CYCLMIN
				Phaeocryptopus gaeumannii	PHAEGAE
				Rhabdocline pseudotsugae	RHABPSE
				Mycosphaerella laricina	MYCOLAR
				Cyclaneusma niveus	CYCLNIV
				Thyriopsis halepensis	THYRHAL
				Dothistroma septosporum	DOTHSEP
				Chrysomyxa abietis	CHRYABI
		Stem and shoot rusts	302	*Melampsora pinitorqua*	MELAPIN
				Cronartium ribicola	CRONRIB
				Coleosporium spp.	COLESPP
				Cronartium flaccidum	CRONFLA
		Dieback and canker fungi	309	*Brunchorstia pinea*	BRUNPIN
				Cenangium ferruginosum	CENAFER
		Blight	303	*Sphaeropsis sapinea*	SPHASAP
				Sirococcus strobilinus	SIROSTR
		Decay & root rot fungi	304	*Phellinus pini*	PHELPIN
				Armillaria mellea	ARMIMEL
				Heterobasidion annosum	HETEANN
		Other fungi	390		

Tab. IV-10: Codes for main species in agent group 300 (fungi) present on conifers. For the full list of scientific names of fungi see Chapter 7.1.

Agent	Code	Class	Code	Scientific name	Code
FUNGI	300	**Leaf Spot fungi**	305	*Marssonina brunea*	MARSBRU
				Rhytisma spp	RHYTSPP
				Taphrina aurea	TAPHAUR
				Mycosphaerella maculiformis	MYCOMAC
				Septoria populi	SEPTPOP
				Harknessia eucalypti	HARKEUC
				Mycosphaerella eucalypti	MYCOEUC
		Anthracnose	306	*Discula nervisequa*	DISCNER
		Powdery mildew	307	*Uncinula salicis*	UNCISAL
				Microsphaera alphitoides	MICRALP
		Wilt	308	*Ceratocystis ulmi*	CERAULM
				Ceratocystis fagacearum	CERAFAG
				Venturia populina	VENTPOP
		Rust	302	*Melampsora allii - populina*	MELAALL
				Melampsoridium betulinum	MELABET
		Blight	303	*Botryosphaeria stevensii*	BOTRSTE
				Biscogniauxia mediterranea	BISCMED
				Fusicoccum quercus	FUSIQUE
				Chondroplea populea	CHONPOP
		Canker	309	*Cryphonectria parasitica*	CRYPPAR
				Pezicula cinnamomea	PEZICIN
				Stereum rugosum	STERRUG
				Cytospora chrysosperma	CYTOCHR
				Nectria spp.	NECTSPP
		Decay & Root rot	304	*Ungulina fomentaria*	UNGUFOM
				Ganoderma applanatum	GANOAPP
				Fomitopsis pinicola	FOMIPIN
				Armillaria mellea	ARMIMEL
				Phytophthora spec.	PHYTSPP
		Deformations	310	*Taphrina kruchii*	TAPHKRU
		Other fungi	390		

Tab. IV-11: Codes for main species in agent group 300 (fungi) present on broadleaves. For the full list of scientific names of fungi see Chapter 7.1.

Agent group	Code	Class	Code	Type	Code	Specific factor	Code
ABIOTIC	400	**Chemical factors**	410	Nutritional disorders nutrient deficiencies	411	Cu - deficiency	41101
						Fe - deficiency	41102
						Mg - deficiency	41103
						Mn - deficiency	41104
						K - deficiency	41105
						N - deficiency	41106
						B-deficiency	41107
						Mn - toxicity	41108
						Other	41109
				marine salt + surfactants	412		
		Physical factors	420	Avalanche	421		
				Drought	422		
				Flooding /High water	423		
				Frost	424	Winter frost	42401
						Late frost	42402
				Hail	425		
				Heat /Sun scald	426		
				Lightning	427		
				Mud/ land slide	429		
				Snow /Ice	430		
				Wind/ Tornado	431		
				Winter injury - winter desiccation	432		
				Shallow/ poor soil	433		
				Rock fall	434		
		Other abiotic factor	490				

Tab. IV-12: Codes for the agent group 400 (abiotic factors).

Agent group	Code	Class	Code	Type	Code
Direct action of man	500	Imbedded objects	510		
		Improper planting technique	520		
		Land use conversion	530		
		Silvicultural operations or forest harvesting	540	Cuts	541
				Pruning	542
				Resin tapping	543
				Cork stripping	544
				Silvicultural operations in close trees and other silvicultural operations	545
		Mechanical/ vehicle damage	550		
		Road construction	560		
		Soil compaction	570		
		Improper use of chemicals	580	Pesticides	581
				De-icing salt	582
		Other direct action of man	590		

Tab. IV-13: Codes for the agent group 500 (direct action of man).

Agent group	Code	Class	Code
Atmospheric pollutants	700	SO_2	701
		H_2S	702
		O_3	703
		PAN	704
		F	705
		HF	706
		Other	790

Tab. IV-14: Codes for the agent group 700 (atmospheric pollutants).

Agent group	Code	Class	Code	Species/Type	Code
Other	800	Parasitic/Epiphytic/Climbing plants	810	*Viscum album*	81001
				Arceuthobium oxycedri	81002
				Hedera helix	81003
				Lonicera spp.	81004
				Clematis spp.	81005
				Clematis vitalba	81006
				Loranthus europaeus	81007
				Humulus lupulus	81008
				Vitis vinifera ssp sylvestris	81009
				Smilax aspera	81010
				Rosa spp.	81011
				Other species	81012
		Bacteria	820	*Bacillus vuilemini*	82001
				Brenneria quercinea	82002
		Viruses	830		
		Nematodes	840	*Bursaphelenchus xylophilus*	84001
		Competition	850	Lack of light	85001
				Physical interactions	85002
				Competition in general (density)	85003
				Other	85004
		Somatic mutations	860		
		Mites	870	Eriophyes ilicis	87001
		Other (known cause but not included in the list)	890		

Tab. IV-15: Codes for the agent group 800 (other).

5.3.2.1 Scientific name of cause

If the organism involved can be identified, the scientific name must be reported, using the codes of 7 letters. As a general rule the codes consist of the first 4 letters of the Genus name, followed by the first 3 letters of the species name (e.g. *Lophodermium seditiosum* = LOPHSED). If the Genus name has only 3 letters, these are followed by the first 4 letters of the species name (e.g. *Ips typographus* = IPSTYPO). For the full list of scientific names of insects and fungi see Chapter 7.1. If no code for the identified species can be found in this list, please inform the data centre of PCC which will amend the list in cooperation with the Expert Panel on Crown Condition and Damage Causes and make it available to the NFCs. Examples, descriptions and photographs of damage caused by important categories of insects and fungi can be found at (http://icp-forests.net/page/ad-hoc-group-on-assessment-of). However keep in mind that these are possible damage causes, other factors may cause similar symptoms. Diagnosis should be confirmed by an expert phytopathologist whenever possible.

Important remark

The tables IV-7 to IV-15 give an overview of some important damaging factors in Europe. At national level however, important factors may be missing, while others may be less important. Therefore countries may wish to compose their own national list of damaging agents/factors and classify these according to the groups and classes of the manual. Reporting to the international data centre should always be done according to the categories and codes of the manual.

5.3.3 Extent

The **extent** of the damage indicates the portion (%) of affected leaves/needles, branches or stem due to the action of the causal agent or factor. Damage to the branches is expressed as percentage of affected branches, damage to the stem as percentage of the stem circumference.

The extent of **symptoms** reflecting defoliation (e.g. leaf damage by defoliators) indicates the percentage of the leaf area which is lost due to the action of the agent/factor concerned. This means that the extent should take into account not only the percentage of affected leaves, but also the 'intensity' of the damage on leaf level: physiologically it makes a difference for a tree if 30 % of its leaves show only some small holes or if 30 % of its leaves are totally devoured.

For foliage and branches quantification of symptoms is referring to the assessable crown.
The affected **leaf area** is expressed as a percentage of the actual foliage in the assessable crown at the time of observation.

Examples:

- Crown condition assessment results in a total defoliation score of 40 % (including defoliation by identified causes like defoliators). 20 % of the leaves in the assessable crown are totally devoured by defoliators extent of defoliator damage = 20 % (class 2 – see Table IV-16);
- Crown condition assessment results in a total defoliation score of 40 % (including defoliation by identified causes like defoliators). 20 % of the leaves in the assessable crown are partly devoured by defoliators extent of defoliator damage is e.g. 10 % (in any case < 20 % since the affected leaves are only partially devoured).

Extent classes

The damage extent will be reported in eight classes.

Code	Class
0	0%
1	1 – 10 %
2	11 – 20 %
3	21 – 40 %
4	41 – 60 %
5	61 – 80 %
6	81 – 99 %
7	100%

Tab. IV-16: Damage extent classes.

Countries using different classes (e.g. 5%) should report their results according to the classes as above.

Specifications:

a.) Damage to the stem is expressed as a percentage of the stem circumference according to the classes above.

b.) Signs of insects and fungi should be quantified only if observed on affected part needles/leaves. The symptoms 'tilted tree' and 'fallen tree' should not be quantified.

c.) When two or more similar symptoms caused by different agents/factors occur on the same part of the tree, it may be extremely difficult to assess the respective contributions of the agents/factors in the damage extent. In this case only the overall extent and the different factors involved should be reported.

d.) Assessments in coppice (and macchia) stands:

- Quantification of stem damage present on different shoots: the damage is expressed as a percentage of the total stem circumference of coppice i.e. the sum of circumferences of each shoot;
- Stem damage present on different parts of different shoots (for example cankers present on crown stem in one shoot and on roots & collar in other shoots): for 'specification of affected part' use code 34 (whole trunk); for quantification see above;
- Assessment of a dead shoot(s) with the contemporary presence of other living shoots: by convention the dead shoot(s) shall be recorded as illustrated in the table below. Quantification of the symptom (dead branches of varying size) follows the general rule, thus is expressed as % of affected branches.

N. tree	Specification of affected part	Symptom	Location in crown
1	25	14	4

Coppice shall only be recorded as a dead tree (code 4) when all the shoots are dead.

Note: The symptom description is related to the total crown and the quantification is related to the assessable crown. Therefore it is possible that the presence of damage symptoms is indicated in the symptom description, but that the extent is 0 % if symptoms occurred outside the assessable crown.

6. Reference standard

6.1 Quality Assurance and Quality Control

The scientific value of crown condition time series underline the need of further efforts to follow up quality assurance and quality control tools in particular in the field of temporal consistency of data.

6.1.1 Field teams and training

Expertise of field teams, standardised training and field checks on national and international level are the most relevant procedures to guarantee high quality data.

It is recommended that any assessments should be done by a team of two trained observers. All countries should have a designated person who is considered as a national expert on crown condition assessments and who is responsible either for undertaking the assessments or for training teams to make the assessments. It is recommended that the person is familiar with assessments at an international level and should if possible be a member of the National Reference Team in international calibration meetings (International Cross-Comparison Courses).

The knowledge of regional forest ecology, patterns of tree morphology of given species and indicators of biotic and abiotic diseases and phytopathology is needed. Frequent changes of staff should be avoided. Each team or team member has his own ID coordinated by the NFC. All training and control assessment data must contain the surveyors' IDs and date of assessment.

Training of field teams has to be done at national level. Prior to the beginning of the annual field season, survey crews should undergo a period of mainly practical training in measurement and assessment procedures for all relevant tree species, age classes and biotic and abiotic factors. In addition, filling out the various forms should be trained.

Training should be given in the use of the ICP Forests or national manuals. The latter has to be updated (at least for those parameters that are used at an international level) in line with recommendations and updates in the ICP Forests manual.

6.1.2 Plausibility checks

There are two major concepts to understand and document data under field conditions:

Comparison courses on international level and calibration courses on national level.

Comparison and calibration courses offer the option to analyse variation of classes or codes among different teams under given field conditions. Calibration courses additionally/further aim at a harmonisation/harmonization among teams.

For conducting the courses a large number of trees have to be assessed for selected tree species and age classes. It is necessary to include all relevant classes or codes in the course. E.g. regarding defoliation, in the range from 0 % to 100 % at least each 10 % step should be represented in the sample, the number of repetitions per step has to be derived from real variability of data in the field. As, in addition, other parameters than defoliation may be assessed and checked, the minimum number of trees per species in the field check should be 30.

Comparison and calibration courses have to be organized on the international and on the national level at regular intervals (at least every second year).

b) Test repetition of 5 % of plots (Level I) or of 5 % of trees (Level II, Core plots)

Test repetition allows to document if a certain percentage of similar estimations can be achieved in a field survey. It is defined that at minimum 70 % of assessments should vary less than ± 10% (or one class) regarding defoliation (or fruiting) assessments.

	Test repetition	Measurement quality objective	Data Quality Objective
Defoliation	5 % of plots (Level 1) 5 % of trees (Level 2, Core plots)	+/- 10 %	70 % of repeated assessments have to conform with the defined quality frame
Fruiting	5 % of plots (Level 1) 5 % of trees (Level 2, Core plots)	+/- one class	70 % of repeated assessments have to conform with the defined quality frame

Tab. IV-17: Quality limits.

In a first step the Expert Panel on Crown Condition and Damage Assessment agreed in Tampere (2010) to use both measures of mandatory quality assurance for the variables: "defoliation" and "fruiting" assessment.

6.1.2.1 National quality control

Regular quality field checks have to be included in the training and in the assessment in the field. An independent check survey should re-measure a proportion (at least 5%) of the Level 1 sample plots (5 % of trees at Intensive monitoring and Core plots) assessed by each survey crew. This should be done very close to the actual survey date to avoid differences due to crown development. In case of significant discrepancies, adjustments or clarification of instructions and their application must be arranged immediately to avoid serious systematic errors.

Plausibility checks should also be integrated into the national data analysis system. For defoliation and fruiting assessment, field checks are mandatory. Regarding these parameters, original field check data have to be reported to the data coordinating centre. A summary of quality checks together with details of any action that has been taken should be documented for potential evaluations. National Focal Centres are responsible for the quality of national data reported.

6.1.2.2 International quality control

International Cross-Comparison Courses (ICCs) are field exercises that aim to (i) document the relative position of individual National Reference Teams (NRTs) within the international context, (ii) monitor the consistency of NRTs' position through time, (iii) improve the traceability of the data by establishing a direct connection with the data collected at national level. Detailed methodology see Annex I.

6.1.3 Documentation and photographs, photo guides

Photo guides are a very helpful tool. All observer teams should be provided with locally applicable, standard photographs of trees of each species and of various defoliation classes.

In addition it is advisable to document and photograph a selection of the trees in different defoliation classes in each area in each year. Photographs should be accompanied by complete assessments of the trees using the relevant forms (PHOT, see below) and should be permanently stored at the appropriate National Focal Centres. It is necessary to document reference trees.

Photo examples of biotic and abiotic factors support the assessment of damages. In addition photo examples of other tree vitality indicators help to clarify definitions of the manual.

Photographs are an essential tool to evaluate and to confirm the observer level of assessments over periods of many years. Photographs should be used as a part of the training exercise both to determine variation between surveyors and field scores and variation over time by using the same (or a sub set) of photographs every year. Results of national training courses should be available for national and international audit/analysis.

Photo calibration courses have to be organized on the international and on the national level at regular intervals (at least every second year) see Annex I.

"Form PHOT

Form for recording characteristics of photographed tree

Surveyor name/code :

Characteristics of plot/location

Countrycode :
Plotnumber :
Date (DDMMYY) :
Latitude (+DDMMSS) :
Longitude (+DDMMSS) :
Altitude :

Photo

Tree Characteristics

Tree identificat.	Species code	Soc. class	Cr. Shad.	Defol.	Disc.

Visibility	Specificat. affect. part	Symptom	Spec. sympt	Location in crown

Cause	Scientific name of cause	Extent

Flowering ass cr	Flowering whole	Fruiting ass cr	Fruiting whole	Foliage transp.

Crwn form	Sec. shoot	Obs.

Distance to tree (m):
Direction to tree (^{o}):

Description of location:

Description of photographed tree and crown:

Reasoning of scoring of assessment, including specific details (to be photographed in detail (zoom) and documented in separate page)

Other remarks

6.1.4 Field condition of assessments, direction of assessments

Observers should have a satisfactory view of the tree from several observation points. On ground level, the optimal view is attained at a distance of one tree length. On slopes, trees should be observed at a distance of about one tree length above the tree or at least on the same level. Assessments should be done in full daylight.

6.1.5 QA/QC related to the assessment of damage causes

In general the field observers who are performing crown condition assessment will also be responsible for the assessment of damage causes. Ideally at least one of the observers of a team should be familiar with forest pathology.

Field crews should undergo a theoretical and practical training in diagnosing and quantifying the more important damage symptoms at national level prior to the start of the annual field season. At the international level, training and intercalibration courses will be organised. Participation in these courses is a precondition for data submission. At national level, National Focal Centres (NFC) are responsible for quality control.

Surveyors should be provided with forest pathology field guides to facilitate diagnosis (see Recommended reading). Additional information regarding symptoms and their possible causes can be found on the web page of the Expert Panel on Crown Condition and Damage Causes.

6.1.5.1 Plausibility limits

When performing crown condition assessment, defoliation is estimated in 5% classes relative to a tree with full foliage. This score reflects the overall defoliation, regardless what the causes are. If the observed defoliation can partially or totally be attributed to a certain identified cause (e.g. defoliators) this should be reported in the damage causes section, using the appropriate extent class. This implies that the overall defoliation score should always be higher than the lower limit of the extent class for the symptom "devoured/missing leaves".

E.g. overall defoliation score of a tree (CCA) = 30% highest possible extent class for symptom "devoured/missing leaves" is class 3 (21 – 40%).

Remark:

In order to collect more detailed information about the impact of defoliators on crown condition an additional visit in spring may be needed. At the time of crown condition assessment in summer trees may have developed new foliage after spring defoliation by e.g. defoliating insects. As a result the overall defoliation (CCA) assessed in summer may be lower than the defoliation estimated in spring. Therefore this plausibility check may not apply if a summer defoliation score is compared to the extent of "devoured/missing leaves" estimated in spring.

7. Data handling

The National Focal Centres (NFC) are responsible for data processing, data storage and submission and also for evaluations at the national level.

7.1 Data submission procedures, forms and codes

Data forms, explanatory items/codes and species lists are commonly defined by the ICP Forests Expert Panels and the Programme Coordinating Centre. Based on the ICP Forests manual they are routinely updated and contain explicit definitions and specifications that need to be applied for data upload.

Information regarding data submission procedures can be found at http://icp-forests.net/page/data-submission. Explanatory items, dictionaries, and information on forms for data upload can be found at http://www.icp-forests.org/documentation/.

7.2 Data validation

Make sure that no inconsistent combinations of tree species, specification of affected part (SAF) and symptoms occur. Most codes for SAF and symptoms can be used regardless of the tree species. Some combinations, however, are only possible in broadleaves, while other combinations are only possible for conifers. E.g. current year needles (code 11) should always refer to a coniferous species, while affected leaves in broadleaves can only be reported using SAF code = 14.

All combinations of tree species and symptoms are possible except for resin flow which should always refer to a coniferous species, while slime flux is only found in broadleaves.

Inconsistent combinations of 'specification of affected part' and symptom should be avoided too, e.g. broken leaves. See table IV-3 for possible combinations of SAF and symptoms.

Validation rules Data should be checked and corrected or completed if:
Field 'specification of affected part' (SAF) is empty
Specification of affected part is present (and ≠ 0, 4, 9) but symptom is absent
Defoliation = 100 but specification of affected part ≠ 4
Specification of affected part<14 and broadleaves
Symptom = 18 and broadleaves
Symptom = 19 and conifers
Specification of affected part = 14 and conifers
% Defoliation (data CCA) => lower limit of extent class for symptom "devoured/missing leaves" (cf. Plausibility limits)

Tab. IV-18: Examples of validation rules

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9. Annex: Design of International Cross-Comparison Courses

A1.1 The concept of the ICC system

Details concerning the "New Design of International Cross-Calibration Courses of ICP Forests and the EU Scheme", hereafter referred to as International Cross-comparison Courses (ICCs), are described by Ferretti et al. (2002).

A1.2 Basic design elements

The system of the International Cross-comparison Courses (ICCs) is installed to provide exercises with sufficient space and time replication for the most frequent tree species of the transnational surveys under realistic work condition. It incorporates formally photo QA exercises and its link with the traditional field exercises.

For each of the most frequent tree species ICC sites are spread across Europe. These ICC sites are selected by the hosting countries to ensure the possibility of re-assessments of the same plots in a periodic system to provide data for the documentation of temporal consistency. The willingness of the host countries and of the forest owners to provide the ICC site must therefore be ensured.

A1.2.1 Plot and tree selection

For each ICC site, a number of visual assessment plots (hereafter referred to as visual plots), eventually supplemented by a special photo assessment plot (hereafter referred to as photo-plot), are selected. Each ICC in principle is dealing assessments on two tree species, 3-4 plots per species are used as visual plots, each of them covering a wide range of defoliation values. According to available field conditions the host countries should select the plots varying according to only one or two environmental factors. The plots should be designed consistently with the actual Level I plots in the host country. This will help to provide realistic assessment conditions

All plots should be located as close together as possible in order to prevent cost and time consuming travelling between the ICC plots. Each visual plot should consist of 24-30 trees of the same species. Trees within the visual plots should be selected according to the usual Level I tree selection criteria of the host country. When visual plots are unsuitable for the purposes of photo QA, an ad-hoc photo plot with 24-30 trees should be selected in the surroundings.

The plots should be managed as permanent plots. Plot locations should be recorded and trees permanently numbered and/or geo-referenced to enable the re-assessment of the same trees.

Photo-QA exercises can be carried out on the visual plots when the trees fulfil the selection criteria reported in the annex on photo QA. When the visual plots are not suited for the photo QA exercise, then there is the need to select ad-hoc photo-plots. The photos of the photo exercise should be assessed as long as possible after the field assessment of the respective trees. The photos can be mirrored to ensure that objective assessments are made and not the field assessments be remembered by the participants. Furthermore, photos from other ICCs on the respective tree species should be re-assessed in terms of the documentation of temporal consistency.

A1.2.2 Invitation and participation

The host countries decide in co-operation with the Programme Co-ordinating Centre (PCC) of ICP Forests about the dates of the ICCs at the end of the survey period (usually this period lasts from end of June to end of August). For the evergreen tree species in the Mediterranean region, an extension up to the end of September can be allowed. The host countries invite all other NFCs by end of March of the respective year to send their National Reference Teams (NRT) for participation in the ICCs.

The participants of the ICCs should be the NRTs for the concerned species. The National Focal Centres decide about the participation. Ideally National Reference Teams should participate as it is important that the participants at the ICCs also participate in the national courses to get the linkage to the survey results.

A1.3 Implementation of the ICCs

A1.3.1 Field work, use of home references

It is important that the participants work independently and that there is no mutual influence of their assessments. Each team should use its own method and reference standard. Positions for assessments should be marked in the field. After assessing from this position the participants may make a second assessment according to their national methods.

The host country should present site and stand information (age, below/above average site, altitude, etc.). Usually, local reference trees will be not presented, unless a specific request will be made by the crews.

Any discussions or exchange of information, especially concerning individual trees, between the teams should be avoided before and during the cross-calibration field work for the concerned species. However, the experience gained in the past suggests that a brief discussion about the most diverse assessments could help clarification.

There is no evaluation/presentation of assessment results in the field before finishing the last plot of a given tree species. Nevertheless, e.g. presentations of national or regional evaluations could be a topic in the evening to introduce a discussion about special issues.

A1.3.2 Codes

A1.3.2.1 Participant code

Participants of National and International Courses as well as field teams will receive a unique ID number that stays the same through time (Country, Region, Person // CCRRPPPPP). "Country" refers to the usual country code; "Region" (when applicable) refers to the code of a given region in a country. If it is not necessary to develop a code for "region" the digits for RR should be filled with "99". "Person" is the code given by the NFC to every members of its NRT. NFCs are responsible for the distribution of codes to their staff. Code lists and their annual updates are submitted to PCC by the National Focal Centres by the end of September.

A1.3.2.2 Plot code

The host countries provide the plot IDs for the ICC test ranges according to the following method: the plot ID should be the plot number in case of Level I plots, otherwise "99" and an ICC plot specific ongoing number of 4 digits both divided by an underline. The test range specific ongoing number consists of the country code (first two digits) followed by a plot specific ongoing number.

An example of four plot IDs is given below with the second plot being a real Level I plot with plot ID 194:

99_5501, 194_5502, 99_5503, 99_5504

A1.3.3 Data to be recorded

The host countries are asked to provide the plot ID code and a detailed stand description for each ICC test site/plot including latitude, longitude, site type, altitude, exposition, canopy closure, tree species, tree heights, DBH, stand age and recent thinning.

Data	Provided by host	Collected by participant	Entry in the field form by participant	Submitted to PCC by host
General data				
Calendar date			+	+
Participant code			+	+
Plot data				
Plot ID	+		+	+
Latitude	+			+
Longitude	+			+
Altitude	+			+
Aspect	+			+
Canopy closure	+			+
Tree species assemblage	+			+
Tree height (dominant storey, average)	+			+
DBH (dominant storey, average)	+			+
Age (dominant storey, average)	+			+
Tree data				
Species	+	+	+	+
Number	+	+	+	+
Determine assessed part of crown e.g. using photographs		+	+	+
Defoliation (0, 5, 10, 15, ..., 95, 99, 100%)		+	+	+
Specification of affected part (11, ..., 34)		+	+	+
Symptom (01,..., 22)		+	+	+
Cause (codes see annex 2, e.g. 81001		+	+	+
Scientific name of cause (codes see annex 6, e.g. LOPHSED)		+	+	+
Extent of fruiting (0, 1, 2, 3, 4, 5, 6, 7)		+	+	+

Table A1-1: Overview of the data and parameters to be provided, collected and reported.

Ideally, all mandatory parameters of the Level I and II crown condition surveys should be covered by the ICCs. However, given the importance of defoliation in the reporting of forest condition, this parameter has the highest priority. The mandatory damage parameters are to be assessed too. Additional parameters may be assessed after explicit requests of participating countries or in consequence of changes of the manual on a voluntary basis. Plot ID, date, and ICC participant code should be recorded by the participants once per plot. All these parameters and codes must be entered in the field form. The field forms should be supplied by the host countries.

A1.4 Data submission

If possible data should be digitised during the course. Thus, uncertainties could be clarified directly with the participants.

The data can be handed over to PCC directly at the end of the courses or should be sent to PCC latest by the end of September of the respective year. Furthermore the host country provides a list with the participants and their codes used during the ICC which should be the same as given for the field survey.

Excel Format:

All results of one species (ICC test range) are listed in one file (filename containing species, year, host country, e.g. "ICCFagusSylvatica2003Germany.xls", or short: "ICCFagSylv03GER.xls").

The file includes several sheets for the respective plots and parameters, the name of the sheet gives plot ID and parameter (e.g. 99_5501_defoliation, 194_5502_discolouration, …).

Structure of table as follows

Filename (e.g.ICC2003FagusSylvaticaGermany)						
Plot ID and parameter (e.g. 99_5508_defoliation)						
Tree No.	NRT1 (CCRRPPPPP, CCRRPPPP)	NRT2 (CCRRPPPPP, CCRRPPPP)	NRT3 (CCRRPPPPP, CCRRPPPP)	...		
1						
2						
3						
6						
...						
24						