

Monitoring of forest structure and vegetation in Hessian strict forest reserves



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Abbreviations:

D1/D2	Diameter 1 / diameter 2
DBH	Breast height diameter
FM	FieldMap
GIS	Geographical information system
GPS	Global positioning system
ID	Identification number
MPKT_D1	Measure point diameter 1
MPKT_D2	Measure point diameter 2
NW-FVA	Nordwestdeutsche Forstliche Versuchsanstalt, North Western German Forest Research Institute
SFR	Strict forest reserve

1 Introduction

The long-term monitoring of forest structure and vegetation is a core area of natural forest research at the Nordwestdeutsche Forstliche Versuchsanstalt.

Forest structure refers to the structure and internal organisation of a forest ecosystem's components. Vegetation surveys serve to record the species composition of the tree, shrub, herb and moss vegetation. The inventories are carried out on sample plots, which are distributed in a regular grid over the entire area of the strict forest reserve (SFR).

By means of the recording procedure described below, data are to be obtained which provide a distortion-free and sufficiently accurate picture of the forest structure's development and the vegetation composition within the SFR. Since it does not make sense to determine all individual questions in advance in a multi-purpose inventory designed for longterm monitoring, the aim of the procedure is to build up a data pool that is as versatile and usable in the long term as possible and which also provides relevant information for future questions.

Many Hessian SFRs include not only the no longer managed total reserve but also a still managed reference area.

2 Overview of work steps

The collection of data in the forest is done with a mobile recording computer using the software "FieldMap" (FM).

The recording procedure is divided into the following steps:

1. create recording file of the prerecording from the database
2. creation of GIS (geographical information systems) shape files (*.shp) with sample plots and SFRs boundaries and background map
3. surveying and marking of sample plot centres with GPS (global positioning system)
4. creating the FieldMap project
5. inventory of the forest structure
6. preparation of forest structure data and import into the natural forest database
7. recording of the vegetation
8. compiling species lists of vascular plants separately for total reserve and reference area
9. preparation and input of vegetation survey data
10. import into the vegetation database
11. filling out the routing slip, preparation of the recording protocol
12. optional: Final report with standard evaluation

3 Structure and distribution of the sample areas

The forest structure surveys are carried out in the form of a sampling procedure with permanent sample plots.

Only horizontal distances are relevant for the recording of the forest structure. In horizontal projection, the plot reference area is a circle with a radius of 17,84 m ($\approx 1000 \text{ m}^2 \approx 0.1 \text{ ha}$) or 12,62 m ($\approx 500 \text{ m}^2 \approx 0.05 \text{ ha}$). In the case of sloping forest areas, the area of the circle corresponds to an ellipse from a horizontal point of view.

In contrast to the forest structure survey, the recording area for the recording of the vegetation is measured on the basis of the terrain distances.

The recording of the forest structure is carried out with the software "FieldMap" distributed by the company IFER (www.fieldmap.cz) and is executed with portable field computers such as the F110 or the T800 from Getac or the Toughpad FZ-M1 from Panasonic. For the vegetation survey, record sheets are filled out and the data is entered subsequently.

3.1 Spatial distribution and marking

The centres of the sample plot circle represent the intersections of a grid with a mesh size of 100 m x 100 m (see Fig. 1).

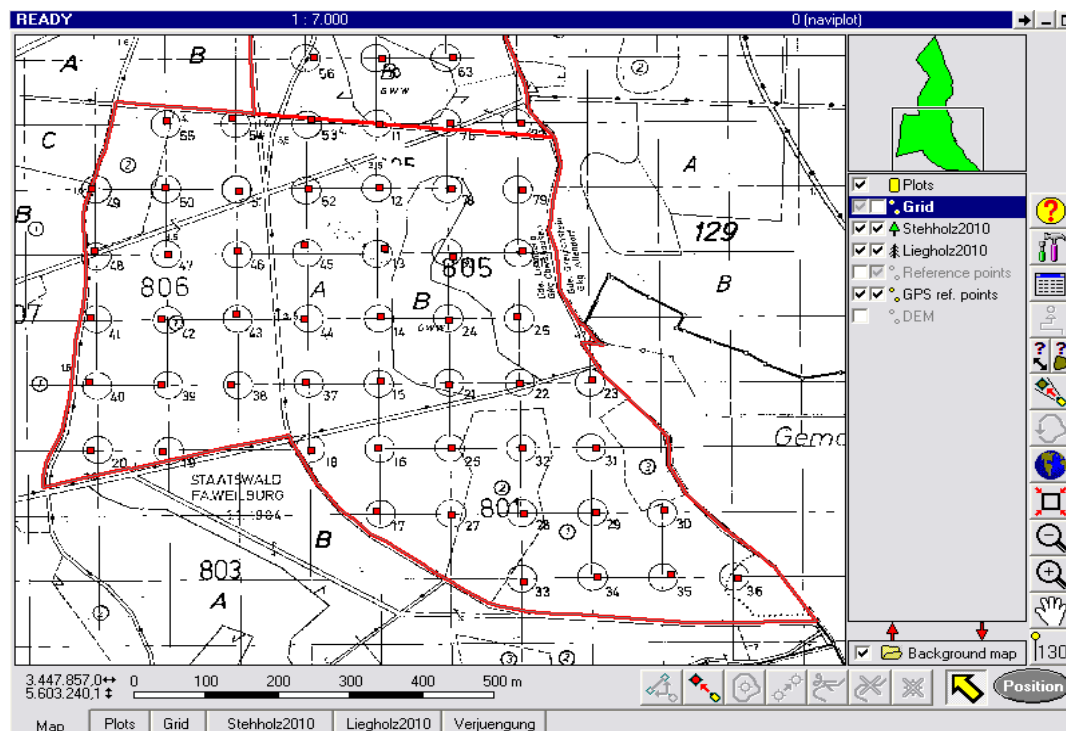


Fig. 1: Navigation plot in the FieldMap (FM) project (navigation plot)

In principle, the centres are calculated before the forest structure survey is carried out and then located and marked in the terrain. This step was already carried out in all Hessian SFRs during the 1980s - 1990s. However, since compass and measuring tape were used to create the grid, the positional accuracy of the test points is comparatively low and can deviate

te in places by 10 to 40 metres from the desired position (Fig. 1). However, in order to guarantee the identity of the area, the given centre will be maintained and the real position of the centres will be determined by GPS (TOPCON GMS-2; www.topcon.com) with an accuracy of 1-3 metres.

Before each inventory, the grid is checked for completeness. If old centres are not marked out, they are reconstructed and re-marked anew at the old location. It will be checked whether sample plots located at the edge of the SFR are still completely inside the reserve. If this is not the case, a partial area to be sampled (semicircle) is defined (see chapter 3.2.2). Sides of paths or embankments should not be located within the recording area, in particular in order not to influence vegetation recordings.

When the grid network was first set up in Hessian SFRs, the plot centres were marked by means of a plastic horsetail system plug embedded in the ground with a white (yellow or red) aluminium cap on which the plot number is engraved (see Fig. 2).

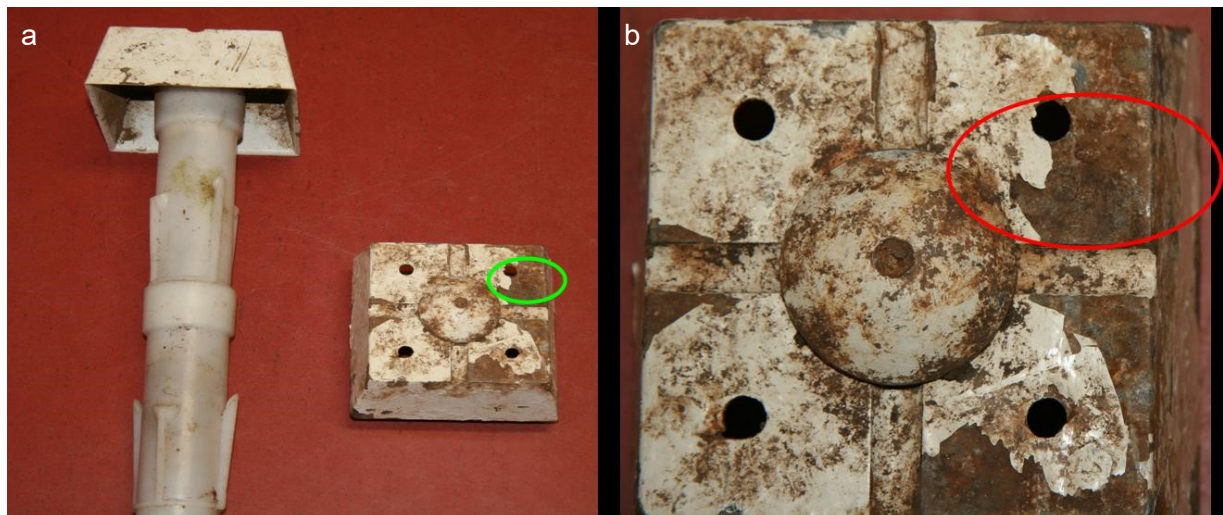


Fig. 2: (a) Horsetail system plug used for the first time with white aluminium cap to mark the plot centre; (b) Top view of the aluminium cap with plot-number (red framed) which is difficult to read here

Within an SFR, the white aluminium cap is driven in with the lower edge at most as far as the beginning mineral soil; in the reference area, this cap is often sunk completely into the mineral soil. This approach allows an uninfluenced management of the stocks in the reference area. Often, however, the cap is no longer available due to forestry work (backing/ mulching) and must be replaced.

In some SFRs there is an approx. 20 cm long steel pin under the aluminium cap, allowing to locate the centre of the sample plot if the white cap has been lost. However, this cannot be assumed in every SFR or test area (steel pins are often displaced by wild boars).

If a plug has been destroyed, it is replaced by a new sample plot mark. This consists of a steel pin as the actual centre of the sample plot and an aluminium cross profile with a yellow or silver, round end cap as a retrieval aid. This aluminium cross profile is hammered in 20 cm north of the steel pin so that approx. 30 cm still protrude from the ground. The plot number is stamped on one wing of the cross profile and on the end cap (s. Fig. 3).

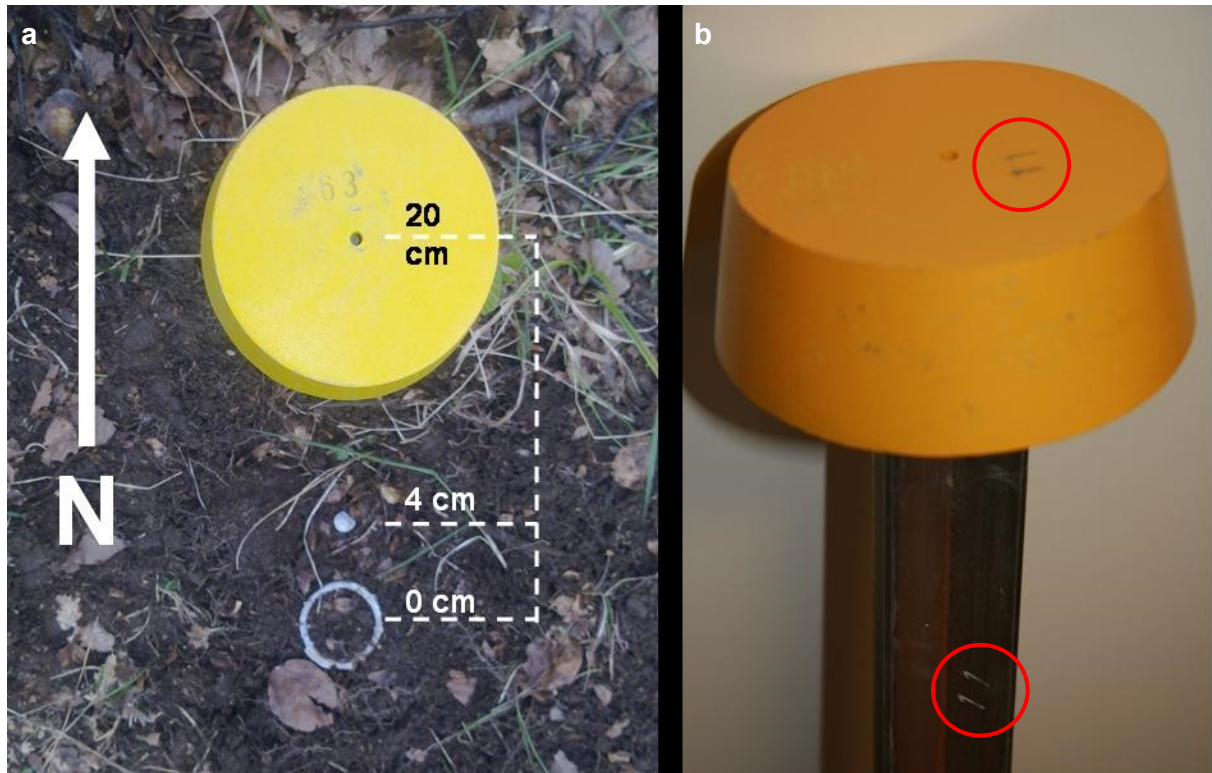


Fig. 3: (a) Position and inscription of the sample plot marking with (b) aluminium cross profiles; the plot number is marked in red on the cover cap and the wing of the cross profile

As shown in Fig. 3a, the stainless steel pin is inserted approx. 4 cm north of the former center point (horsetail system plug). This position should correspond approximately to the northern edge of the white square end cap as the position for the plot image. If there is still an old stainless steel pin, it is corrected to the new position. The plug visible above ground (aluminium cross profile with cap) is located 20 cm north of the actual center of the plot (stainless steel pin).

Note: *If the cross profile cannot be turned at the specified position, the deviation from the specified position is stored in the GPS calibration protocol in the file of the SFR.*

In the hessian SFR the designation of the sample plots takes place after a numerical procedure. The allocation of the consecutive numbers does not follow a regular pattern, but is due to the order of the initial setting of plot markings.

3.2 Structure of the test circuit

3.2.1 Standard structure

Until 2006 the radius of the test plot was 20 m (= 1,256.64 m²), on pole wood areas 10 m (= 314,16 m²) in horizontal projection.

In addition, lying objects were recorded with their full length, even if they extended beyond the plot (s. Fig. 4).

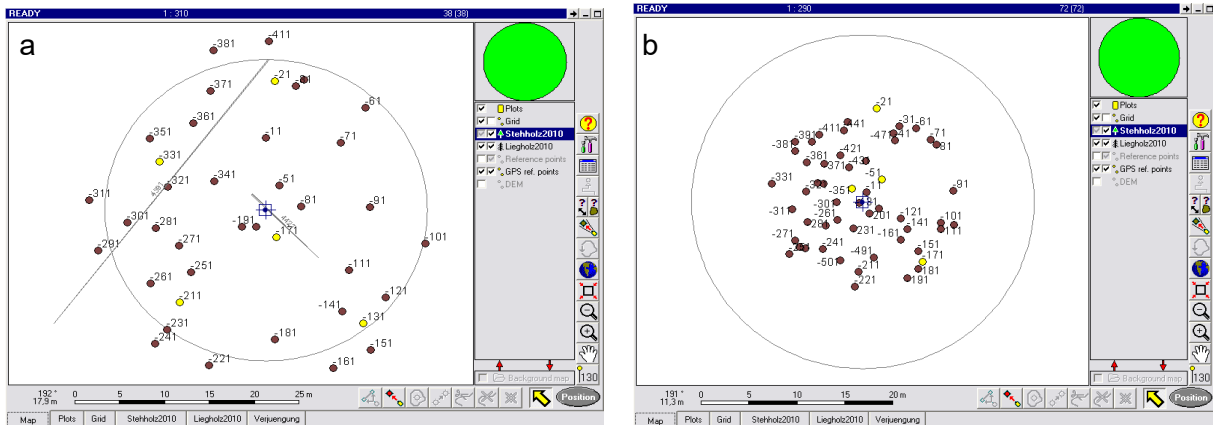


Fig. 4: Examples for sample plot collectives of the initial inventory with (a) 20 m and (b) 10 m radius (The plot line corresponds to the new radius of $r = 17.84$ m)

As of 2007 the radius of the plot is uniformly 17,84 m (= 1000 m² = 0,1 ha) (horizontal projection). In this plot the standing (≥ 7 cm DBH) and lying stock (≥ 20 cm diameter at the strongest point) is recorded. In contrast to the recording method before 2007, lying objects are only recorded up to the plot boundary.

Woody rejuvenation (living woody plants < 7 cm DBH) is recorded on a smaller, quadratic sample area, whose center is located 5 m east of the plot-center. The side length of the rejuvenation square is 5 m in horizontal projection. Thus the reference surface for the acquisition of the rejuvenation is 25 m². The corner and center points of the tapered area are not permanently marked.

The vegetation is recorded within a 10 m x 10 m (= 100 m²) square, the south-eastern corner of which is 2 m west of the plot-center. In contrast to the rejuvenation square, the sides of the vegetation square are measured in terrain distances, not horizontal distances. The area is not permanently marked.

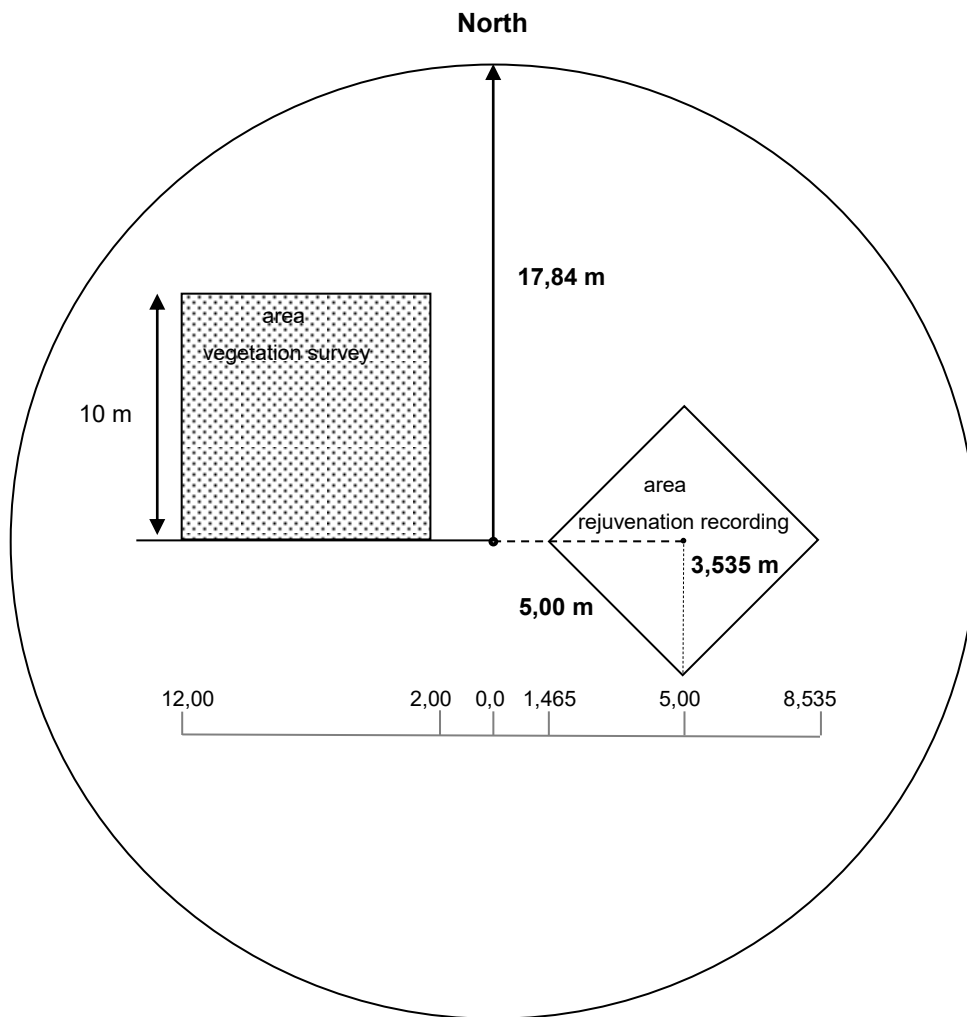


Fig. 5: Establishment of a sample plot in Hessian SFR

3.2.2 Structure of the semicircles

Many SFR consist of a strict reserve and a managed reference area. If the sample plot lies on a boundary, e.g. between SFR and managed forest (including reference areas belonging to the SFR) or paved roads open to traffic or other areas not belonging to the total reserve of the SFR, the plot must be included as a semicircle.

The prerequisite for recording is that at least one half of the plot lies completely within the respective area.

In the recording layer of the FieldMap project, this reduction of the sample area to a semicircle must be entered in the field "Recording methods" as well as the gon values of the boundary course in the field "Remarks" (s. Fig. 6). If possible, the borderline should be on full ten-gon divisions. Quarter circles are not surveyed.

The establishment of the boundary sample circles and the respective semicircle takes place during the surveying and marking of the grid or its reconstruction and, if necessary, re-marking of the plot centres. This takes place before the forest structure and vegetation survey.

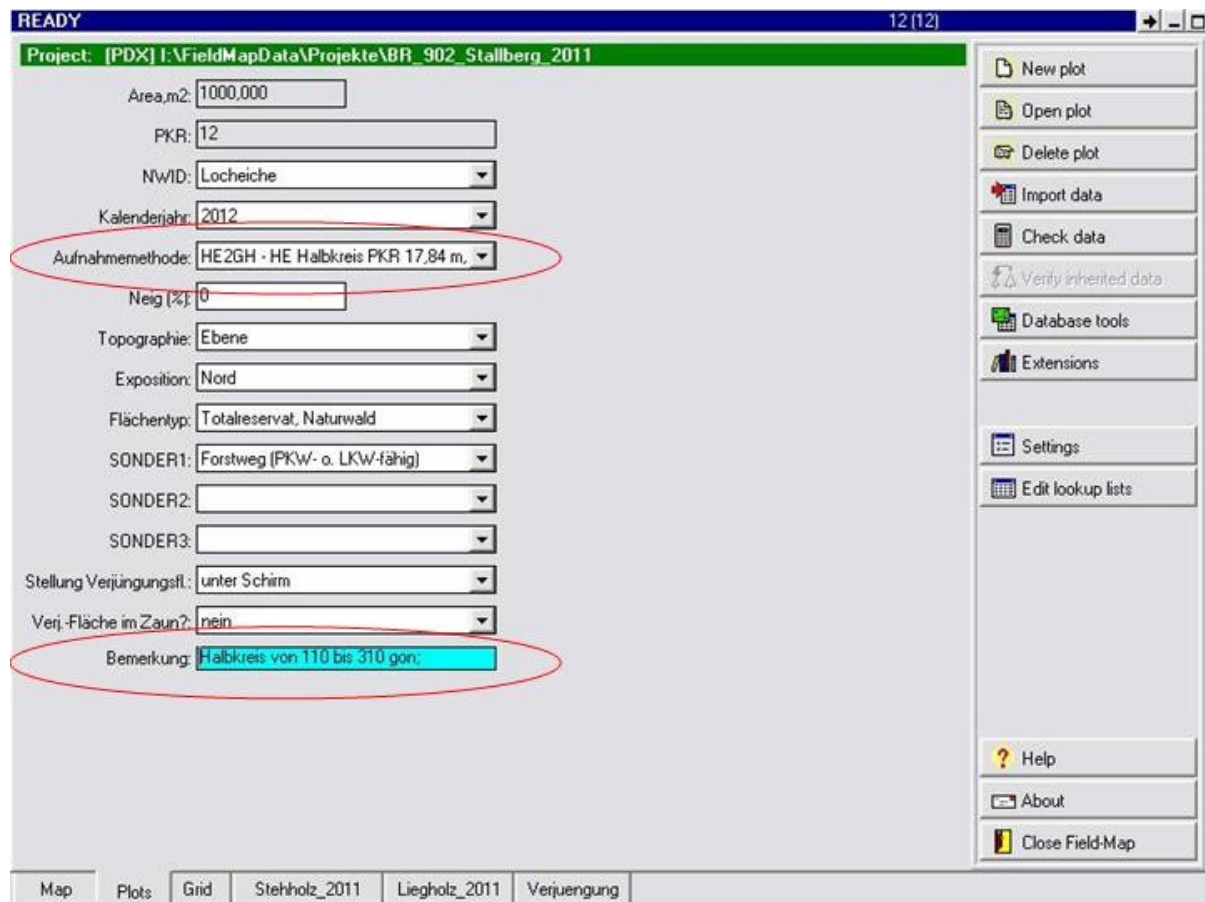


Fig. 6 Enter the recording method "Semi-circle" (red marker at the top) and the borderline in the annotation field (red marker at the bottom) for a semi-circle image

Special case 1: Sample plots on paved forest roads

Old paths, back lanes, division lines etc. are included as full circles. Only in the case of paved roads that are still open to traffic (indicators: gravelled or otherwise paved road) the plot area must be reduced to a corresponding semicircle. The borderline to such paths is the upper edge of the embankment, the outer edge of the path bank, the centre of the trench, etc..

The centre of the rejuvenation recording area is positioned 5 m from the plot centre orthogonally to the plot bisector on the side of the plot to be recorded. In the same way, the vegetation cover is rotated clockwise in the middle of the semicircle (plot bisector plus 50 gon). This results in overlapping of rejuvenation and vegetation recording areas (s. Fig. 7).

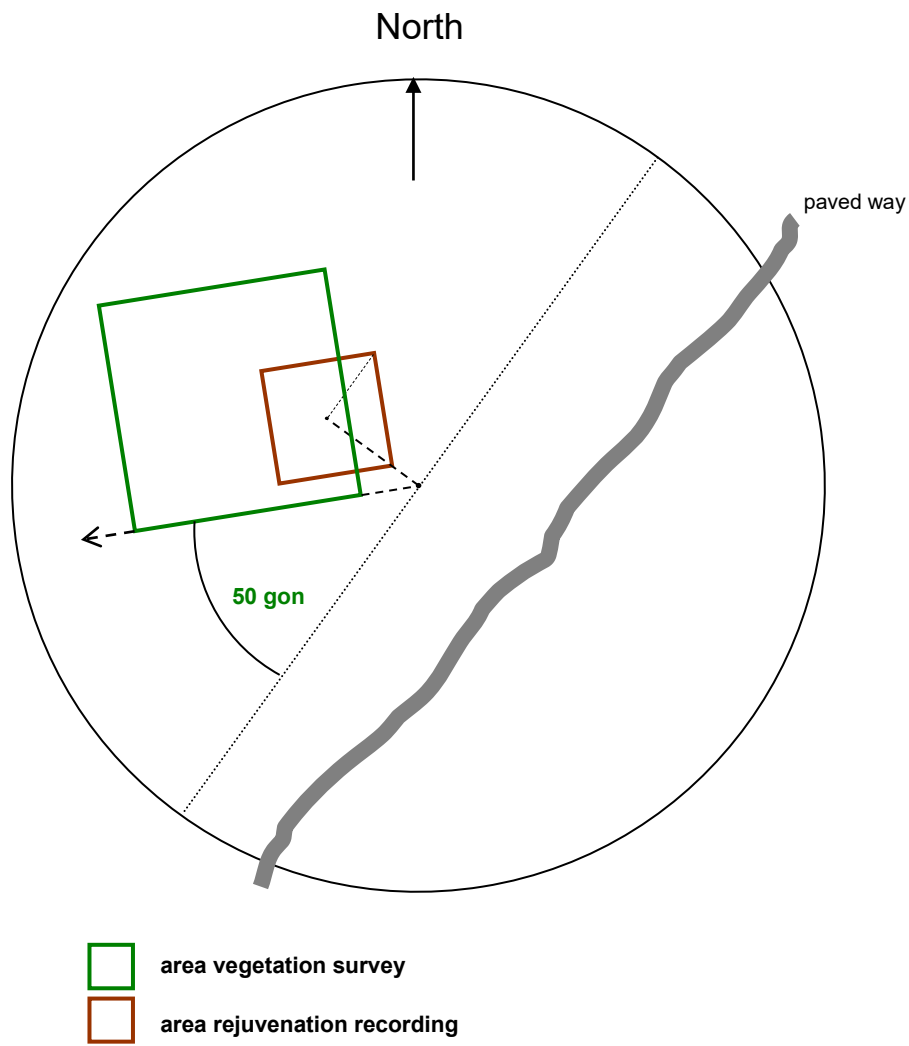


Fig. 7: Semicircle with nature rejuvenation and vegetation reception area (example)

3.3 Captured objects and object parts

In the standing stock, those objects are assigned to the sample plot whose centre point (horizontal projection of the centre of the trunk) at chest height has a horizontal distance of $\leq 17,84$ m from the centre of the plot. For stumps ≤ 1.3 m high, the distance in object height is decisive.

All objects within the test area are detected, including those fallen in from outside or outwards projecting pieces. The plot can therefore be imagined as a "punched out" recording surface (s. Fig. 8).

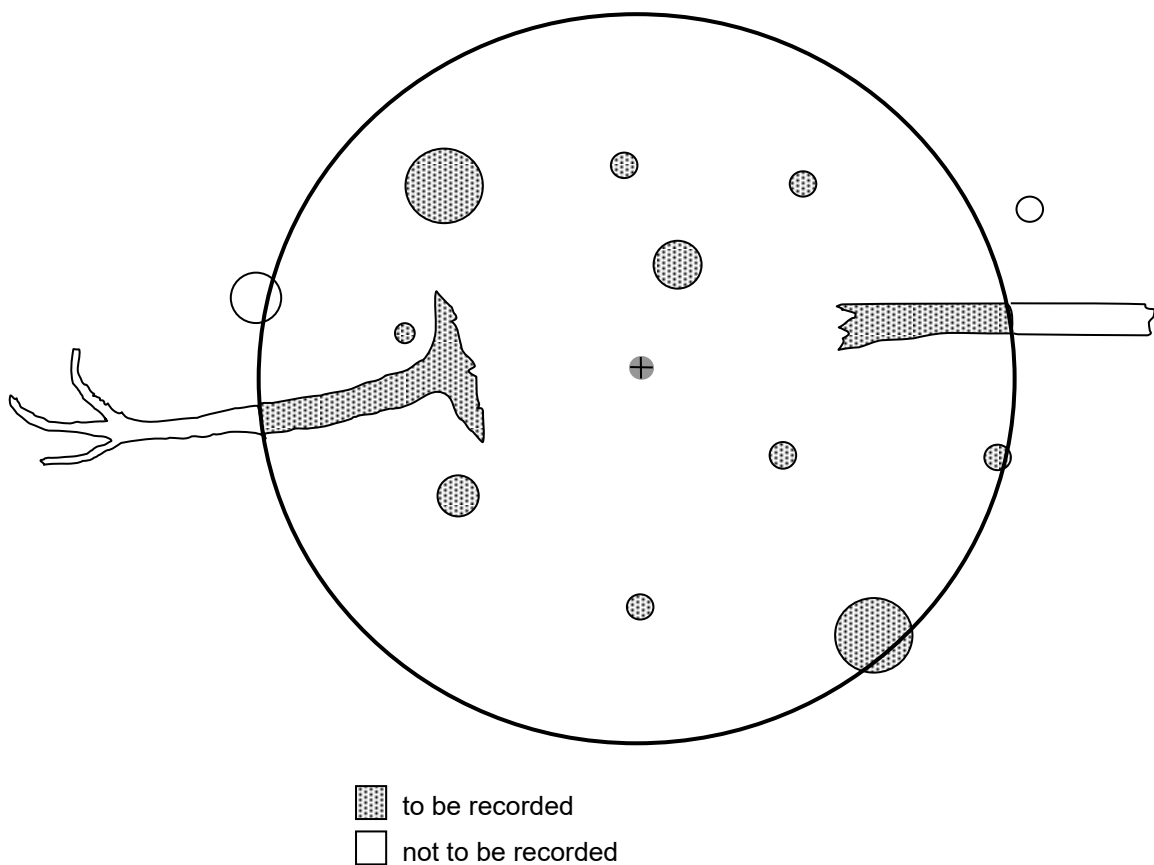


Fig. 8: The objects or object parts to be recorded or not to be recorded in the plot

The reduction of the old plots with $r = 20$ m to a circle with $r = 17,84$ m in the course of the second survey (see above) is also carried out retroactively for the initial inventory already carried out. Since only one inclination value was recorded for the entire plot in the initial image, it is not possible to calculate the horizontal coordinates of the individual objects from the initial image in inclined terrain. For this reason, the horizontal coordinates of all objects in the initial recording must be checked during the second survey and assigned to the following groups:

- Objects of the initial recording that are located outside the current smaller plot ($r = 17.84$ m) (variable OUTSIDE = "outside" in the FM project)
- Objects that are located within the current smaller plot ($r = 17.84$ m) during first and second exposure (variable OUTSIDE = "within" in the FM project)
- Objects that are no longer present in the second recording but were within the current smaller plot ($r = 17.84$ m) in the first recording (Variable OUTSIDE = "away inside" in the FM project)

Linear objects are treated analogously. For all linear objects of the initial survey, the points of intersection with the plot boundary are recorded.

Subsequently, the recording collective of the initial recording is reduced to the plot circle of 17,84 m.

If small plots ($r = 10$ m) were recorded in the initial inventory, the recording collective is retained in the repeated inventory. All objects which are no further than 10 m away from the centre of the plot in the horizontal projection are recorded. The method ID in the plot description is "HE2R" or "HE2RH" for half circles.

In the initial survey, lying timber was recorded up to its end point, even if this lay outside the plot. For line objects, therefore, the coordinates of the intersection of the object with the plot boundary replace the coordinates of the initial scan that lie outside the current plot.

Objects that protrude slightly beyond the edge of the plot during the new measurement can be cut off at the edge of the plot during evaluation using an existing data routine.

4 Recording compartments

The large number of different individual objects that make up the structure of a forest (seedlings, young plants, larger trees of different ages, standing and lying dead wood, etc.) makes it necessary to differentiate the recording methods and recording parameters accordingly. The stand is divided into different recording compartments according to height and diameter at breast height (DBH). The individual compartments are defined as follows:

Standing merchandable timber stock:

All standing, living and dead trees, tree stumps and stumps with a DBH ≥ 7 cm (with bark, if present). Dead stumps or tree stumps $\leq 1,3$ m high, (class TS(s)), are only recorded from an upper diameter ≥ 20 cm. The angle between the longitudinal axis of the objects and the ground surface is > 10 gon.

Lying merchandable timber stock:

All linear woody objects whose longitudinal axis is inclined ≤ 10 gon to the ground surface. Living objects are detected from a DBH ≥ 7 cm, dead objects from a diameter at the stronger end ≥ 20 cm (with bark, if present). There is no lower length limit for recording.

Rejuvenation:

All live woody plants except seedlings with a DBH < 7 cm.

In addition to the objects of the woody structure the vegetation is recorded.

Vegetation:

All vegetation layers (total tree layer, tree layer 1, tree layer 2, shrub layer, herb layer including woody plants up to 50 cm high, mosses and lichens) and the corresponding species with their percentagewise coverage are recorded. The method is described in a separate chapter below (see chapter 11).

5 Survey parameters

5.1 Assignment to the survey compartments

The individual compartments are each assigned specific recording parameters, which are collected for each individual object - with the exception of the browsing damage percentage, which is an estimate of the total rejuvenation (s. Tab. 1).

Tab. 1: Parameters of the sample plot inventory: √ = Registration for all objects, (√) = Registration for a part of the objects, - = not recorded

Parameters (in summary)	Standing stock		Lying stock		Rejuvenation
	living	dead	living	dead	living
Quantity	-	-	-	-	√
Azimut	√	√	√	√	-
Solar radiation	-	√	-	√	-
Scientific species name	√	√	√	√	√
Diameter	√	√	√	√	-
Distance	√	√	√	√	-
Origin	-	-	-	-	√
Height	√	√	-	-	-
Height class	-	-	-	-	√
Small habitats	√	√	√	√	-
Crown base	√	-	-	-	-
Situation	-	-	√	√	-
Measuring point DBH	(√)	(√)	-	-	-
Measuring point MPKT_D1	-	-	√	√	-
Measuring point MPKT_ABST	-	-	√	√	-
Cause of mortality	-	√	-	(√)	-
Inclination	√	√	√	√	-
Number	√	√	√	√	-
Layer	√	-	-	-	-
Browsing damage percentage	-	-	-	-	√
Degree of decomposition	-	√	-	√	-
State type	√	√	√	√	-

5.2 Definitions and surveying procedures

The parameters are defined below (s. Tab. 2). The surveying modes are explained in chapter 6.2.

Tab. 2: Definition of parameters and acquisition criteria

Parameters (in summary)	Definition
Quantity	Countable individuals at the recording of the rejuvenation
Species name	Species of individual trees and shrubs recorded
Azimut	Clockwise angle indicating the deviation from north, measured in degrees (gon) (400 gon compass)
Solar radiation	Assessment of the solar radiation of dead wood in three steps
Compass	Compass, here with graduation (100 gon correspond to 90°)
Diameter	Trunk diameter at breast height (= 1,3 m), measured in mm
	First diameter (lying stock D1), measured in mm
	Second diameter (lying stock D2), measured in mm
	Upper diameter (stump < 1,3 m), measured in mm
Distance	Distance in m from the centre of the sample plot to the tree centre (DBH); maximum up to the plot limit or to the coordinate measuring point
Cause	Cause of the rejuvenation
Height	Perpendicular measurement in m; follows the trigonometric principle; measure all trees without crown or with incomplete crown; do not measure hanging trees
Height class	Altitude layer in which the terminal shoot of the rejuvenating plant is located
Small habitats	Biodiversity-relevant small habitats on (standing and lying) woody objects in solid wood
Crown base	Height of the crown base measured in whole meters. Only for living woody objects
Situation	Position of lying objects
Measuring point DBH	Height of the diameter measurement on standing trees.
Measuring point MPKT_D1	Position on the lying wood where the diameter D1 was measured
Measuring point MPKT_ABST	Distance between D1 and D2 in dm
Cause of mortality	Rough classification of the cause of death
Inclination	Inclination from the centre point to the object, determined in %; the stopping point is e.g. the eye level of the opposite person (pay attention to body height).
Number	Permanent two-digit numbering consisting of upper number (= IDNR1) and lower number (= IDNR2), separated by a dot
Layer	Height layer oriented to the upper height (= h_o) of the standing stand
Browsing damage percentage	Proportion of young plants with leading shoot browsing damage per species and height class
Degree of decomposition	Decomposition progress of standing and lying dead wood
Stand type (class)	Classification of the recorded objects according to the criteria vitality, position and the existing tree components

5.3 Importance of recording sizes

Some of the recording parameters to be recorded are auxiliary values in order to calculate other characteristic values, serve for grouping or are target values of an evaluation (s. Tab. 3).

Tab. 3: Explanation of parameters

Parameters	Evaluation
Azimut	Determination of the location of the object according to the cardinal point of the plot centre
Solar radiation	Evaluation parameters for the qualitative assessment of the deadwood supply and for the analysis of the decomposition process as a function of the microclimatic conditions
Scientific species name	Grouping variable for data analysis and the presentation of evaluation results; input variable for the analysis of tree diversity
Diameter	Evaluation parameters for diameter distributions; input variable for the calculation of base area, volume and diameter increase
Distance	Determination of the location of the individual according to the distance from the terrain
Origin	Evaluation parameters for separating natural and artificial rejuvenation
Height	In the solid timber stand: Input variable for the calculation of height curves, tree volume and height increase
Height class	Evaluation parameters for the analysis of the height class distribution of woody rejuvenation
Small habitats	Evaluation parameters to quantify the variety of special structures (stem cavity, bark injury etc.) on standing and lying objects.
Crown base	Input variable for the calculation of the crown length.
Coordinates	Auxiliary variable for re-identification of objects during repeat recording; input variable for analysis of spatial tree distribution; input variable for length calculation of linear objects.
Situation	Evaluation parameters for the qualitative assessment of the deadwood supply and for the analysis of the decomposition process.
Measuring point DBH	Auxiliary variable for determining the diameter at breast height or in case of deviating measurement height (e.g. bump, forked stem).
Measuring point MPKT_D1 and MPKT_ABST	Auxiliary variable for determining the 1st and 2nd diameter for horizontal objects or for deviating measuring point
Cause of mortality	Evaluation variable for assessing the occurrence of dying and the extent of human intervention (e.g. traffic safety); input variable for correctly estimating the volume increase
Inclination	Determination of the location of the object in inclined terrain
Number	Re-identification of identical objects over several shots. Merging of several objects to one individual
Layer	Input variable for the analysis of vertical structural diversity
Browsing damage percentage	Evaluation parameter for assessing the influence of game on the regeneration of wood
Degree of decomposition	Evaluation variable for the qualitative assessment of the dead wood supply and input variable for the correct estimation of the wood volume
State type (class)	Basis for differentiated data analysis, e.g. for the volumisation of different objects; is used to display structural diversity

6 Measuring instruments

Tab. 4 lists the devices and equipment required for the recordings. Fig. 9 shows some of the devices and equipment.

The recording is done with a mobile recording computer (Tablet-PC; currently Getac F110) using the software "Field-Map" (FM) by IFER. The FM system is a GIS supported, relational database in which the recording values are entered on site. The FM system has proven itself in the NW-FVA after a three-year test phase and offers the following advantages:

1. Subsequent data entry is no longer necessary.
2. The default settings of the data model ensure uniform formats and correct variable states with simple input or selection (e.g. tree species are processed as a number code, but selected as plain text from a standard list).
3. Data check for plausibility and completeness on site.
4. Visualisation of the object distribution on the sample plot makes it easier to check the recording and to find objects again during a repeated recording.

Overall, the use of the FM system ensures a smooth data flow and high data quality.

Tab. 4: List of measuring instruments

Survey instructions
Getac F110 Tablet PC
Photo tripod with charging tray
Spare battery (2 pieces) - Set
Diameter caliper with mm graduation (100 cm for old stocks, 60 cm or 80 cm for young to medium old stocks)
Ultrasonic altimeter and rangefinder (Vertex IV © incl. Transponder T3)
1.3 m long wooden stick with blunt iron tip and holder for the vertex transponder
Pullsaw
Monopod
Suunto compass with gon graduation
Plug for Suunto compass
Suunto clinometer with percentage graduation
10 ranging poles
2 clotheslines to delimit the rejuvenation and vegetation reception area
Telescopic measuring rod (5 m)
Chalk holder with chalk
2 measuring tapes (25 m)
Metal detector

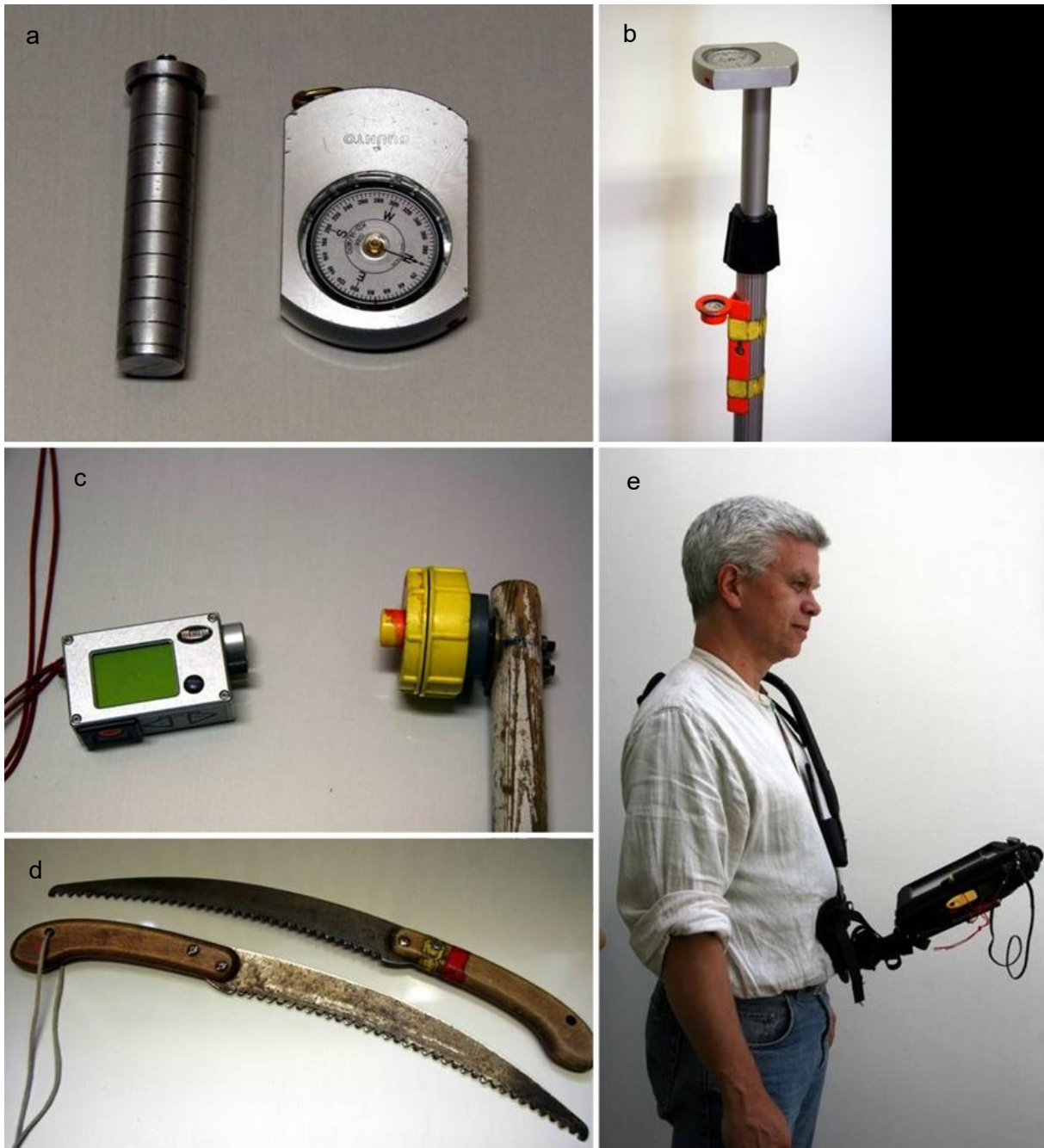


Fig. 9: Measuring instruments and equipment: (a) Suunto compass with plug, (b) monopod with compass and water level, (c) Vertex IV © with transponder T3, (d) pull saw for marking the DBH measuring point, (e) carrying device for the Getac F110

7 Procedure for the structure survey

7.1 Overview

After the creation or restoration of the plot-grid, including the definition of those plots to be recorded as semicircles, the actual recording is carried out in the following individual steps:

1. Preparation:

- a Assembly and functional testing of the measuring instruments
- b Configuring the FM system

2. Inventory of the standing and lying stock:

- a Searching for the recording point
- b Input of the sample plot information
- c Survey of the standing stock including stumps and representative height measurement
- d Recording of the lying stock
- e Checking the recording data
- f Marking of the plot-center on the nearest tree (e.g. tracing tape)

3. Recording the rejuvenation

- a Staking out the recording surface
- b Recording of the young plants
- c Checking the recording data

4. Recording of vegetation

- a Searching for the recording point
- b Staking out the recording surface
- c Recording the vegetation
- d Checking the recording data

The recording work is done by a two-person team.

The standing and lying stock is recorded in the leafless period because of the better visibility. The rejuvenation survey will be carried out, if the season permits, during the survey of the horizontal and vertical stock.

Depending on the forest community, the vegetation is recorded once or twice during the vegetation period.

7.2 Individual recording steps

7.2.1 Preparations

The required measuring instruments (see Tab. 4 and see Fig. 9) are put together and checked for proper function.

The FM system is configured for the specific recording, i.e. an appropriate recording project is created under FM. The data of a preliminary survey (plot information, data of the standing and lying stock) can then be loaded into the project.

The recording project defines the structure of the recording data for the levels

- investigation area
- sample plot and
- single object.

An outline map of the SFR and the coordinates of the plot centres are saved as a shape file (*.shp) to represent the entire investigation area. For orientation purposes, it is recommended that a topographical or forest map at a suitable scale (1:10,000 to 1:50,000) is also stored in the FM system. Finding and identifying the sample points is made much easier by orientating oneself along forest edges, paths, etc..

At the following level, the information to be collected per sample group (inclination, exposure, etc.) is defined. Finally, the lists of variables are specified for the individual objects separately for regeneration, vegetation, standing and lying stock. Look-up lists of the possible states, e.g. a list of tree species, a list of the degree of decomposition etc., are stored for the classified variables.

7.2.2 Finding the sample plots

When checking the grid at the beginning of a recording, the tree closest to the plot centre is marked with a red and white tracing tape. The node should point in the direction of the centre of the plot. After completion of the recording (the last recording is usually the vegetation recording), the markings are removed again (in rejuvenation areas or higher vegetation, the centre of the plot can be additionally marked with plastic tape or spray-paint to make it easier to find during the vegetation period).

7.2.3 Navigation plot and information per plot

The "navigation plot" displayed in the FM system shows the grid and the plots and is used for orientation as well as for identification of the individual sample plot and ensures an overview of the work status (s. Fig. 1).

After locating and identifying the centre of the plot, the following information is entered for the plot (s. Fig. 10).

NWID = ID number of SFR and reference area

KALENDERJAHR = year of data collection, specification of vegetation year is done via IMPORT of data to database of natural forests using NWIN

AUFNAHMEMETHODE = key which method is used for later statistical evaluation (e.g. recording as full or half circle)

NEIG = maximum inclination of the plot in %

TOPOGRAPHIE = input of the type of terrain (plateau, crest, upper, middle, lower slope, valley, valley head, level)

EXPOSITION = exposure to eight cardinal points (N, NO, O, SO etc.)

FLÄCHENTYP = affiliation of the sampling area (total reserve, reference area)

VERJ.-FLÄCHE IM ZAUN = position of the tapered area in the fence (yes/no/partial)

SONDER1, SONDER2, SONDER3 = special structures:

ID-TEXT Value

- BACH Stream, watercourse
- STILL Standing water body
- QUELL Spring
- RUECK Logging trail
- FWEG Forest track (suitable for cars and trucks)
- MEIL Fomer charcoal kiln („Meilerplatte“)
- GEROE Scree, boulder
- FELS Rock
- RGEB Dismantled forest track
- NHB Permanently not timbered area, open land

For special structures, up to three multiple answers are possible. Beginning with the feature in the SPECIAL1 field that most strongly influences the surface or that occurs most frequently.

BEMERKUNG = Remark field for free input, e.g. definition of a semicircle (from ... to ... GON)

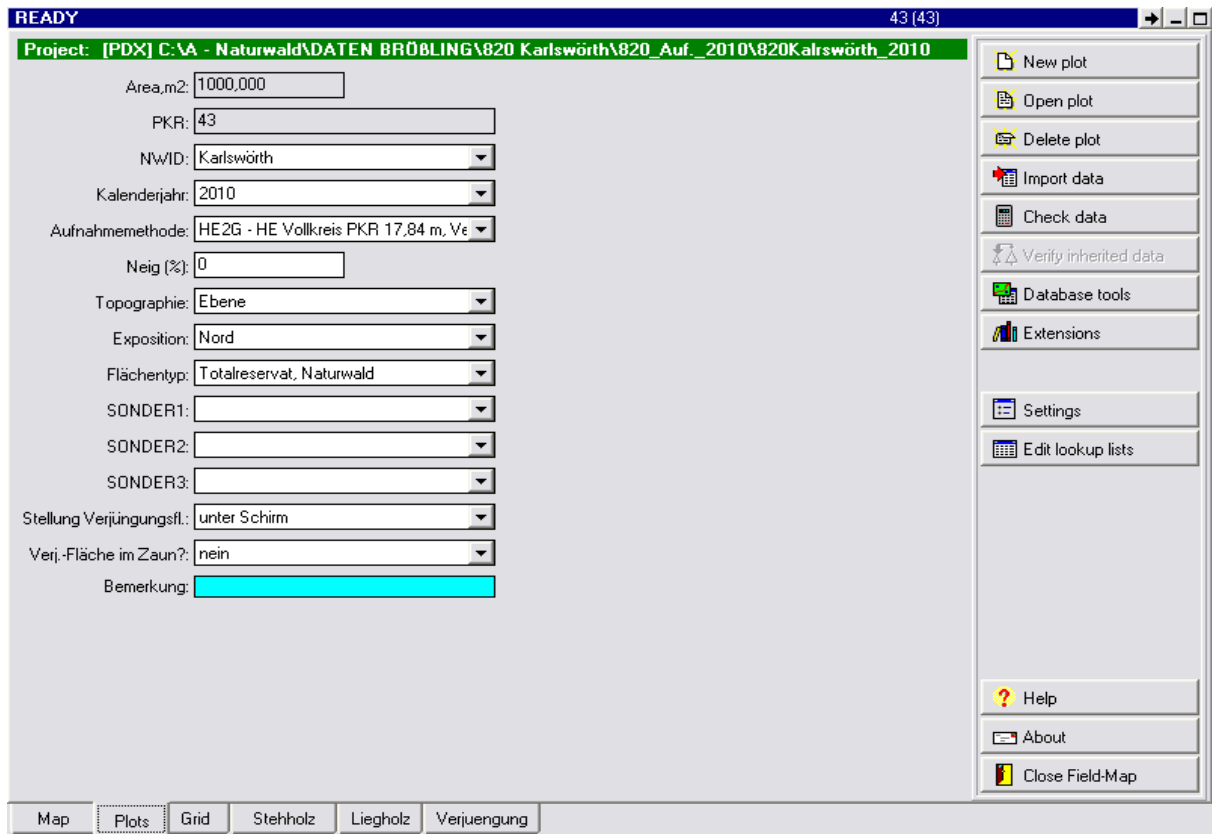


Fig. 10: Screen of the FM system when collecting the plot data

7.2.4 Data collection of the standing stock

The Vertex IV © (www.haglofsweden.com) altimeter and rangefinder must be calibrated before collecting the first plot of the day. Further calibration is only necessary if the air humidity or wind conditions change. The device must not be exposed to significant temperature changes (e.g. in winter temperatures, do not put it in your jacket pocket or take it into a heated room). For the calibration procedure, see the Vertex IV instruction manual ©.

Special case 2: Basic setting / calibration of the Vertex

On arrival at the workplace, the Vertex should be immediately hung in the air to adapt to the ambient temperature.

Be sure to observe the basic setting of the Vertex!

In the SET_UP area the attributes must be set as follows:

METRIC (transponder type 1 or 2) – type 2

P.OFFSET (PIVOT OFFSET) – 0.3

T.HEIGHT (transponder height) – 1.3

M.DISTANCE (manual distance) – 20.0

Before starting work on the plot, the vertex is calibrated as follows:

*Person 1 holds the 1m mark of a tape measure to the receiver of the switched on Vertex, while person 2 rolls out the tape measure, tightens it and holds the 11m mark to the transponder. Then the vertex is calibrated to **10 m** under the menu item CALIBRATE.*

To enable FM to calculate an exact ground clearance, the transponder height and the distance of the transponder to the front edge of the tree must be set. To do this, click on the button with the number "130" in the lower right corner of the "Map" (s. Fig. 11 a).

In the menu that opens, enter the distance (in cm) between the front edge of the transponder and the front edge of the tree in the "Reflector offset" field.

The distance of the transponder from the ground (height) must be entered in the fields "Equipment height" and "Pole length" (s. Fig. 11 b).

Note: *The transponder must always be placed at a height of 1,3 m ("chest height") on the tree. The transponder rod used is 1,3 m long and thus provides the correct transponder height.*

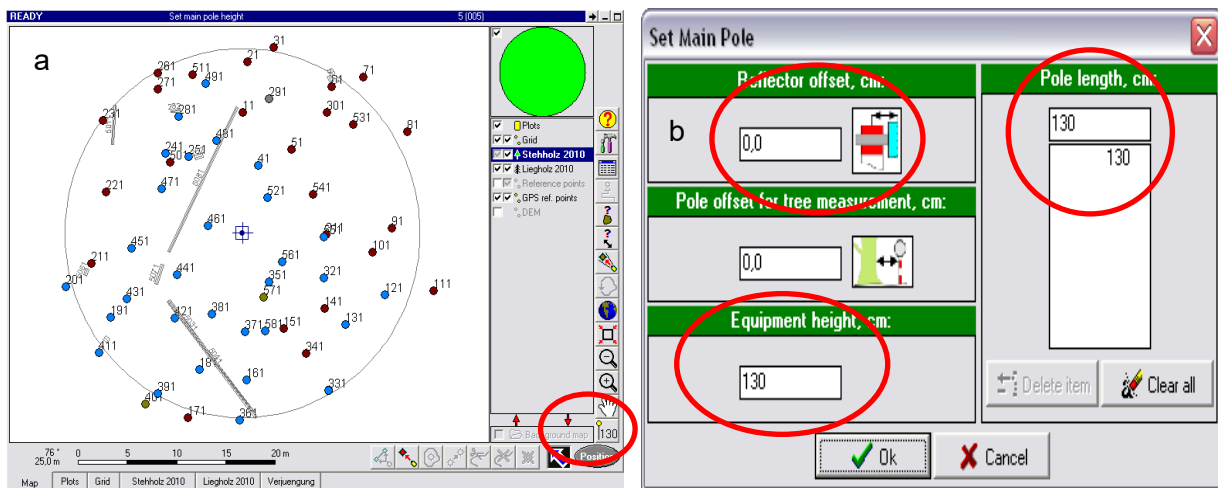


Fig. 11: Red markings: (a) Button for setting the transponder values in the FM project and (b) Fields for entering the transponder distance ("Reflector offset") and the transponder height ("Equipment height" and "Pole length")

The actual collection of the standing stock in the plot starts with Person 1 of the surveying team placing a monopod with a Suunto busssole attached to it on the plot centre and bringing it into a vertical position with the help of a water level also attached to the tripod. If the plot centre has been pegged with a horsetail system plug with square aluminium cover cap, the monopod is placed on the northern side of this cover cap; if the centre was pegged with a stainless steel pin and an aluminium cross profile with a round cover cap, the stand is placed directly at the stainless steel pin, towards the aluminium cross profile.

Person 1, standing at the plot centre, subsequently enters the data into the tablet PC and carries out the azimuth and distance measurements. The survey takes place in the standing wood layer of the FM system (s. Fig. 12). Person 2 visits the objects to be measured, carries out the inclination and DBH measurement as well as a marking cut at the DBH measuring point (saw cut, at right angles to the trunk) on the tree and reports the determined data to the entering person.

Note: In the case of repeated surveys, the original coordinate values must be checked randomly, in the case of more frequent major deviations, all values must be checked. For deviations of more than +/- 15 cm in distance, +/- 3 gon in azimuth and +/- 5 % in inclination, the old values are overwritten.

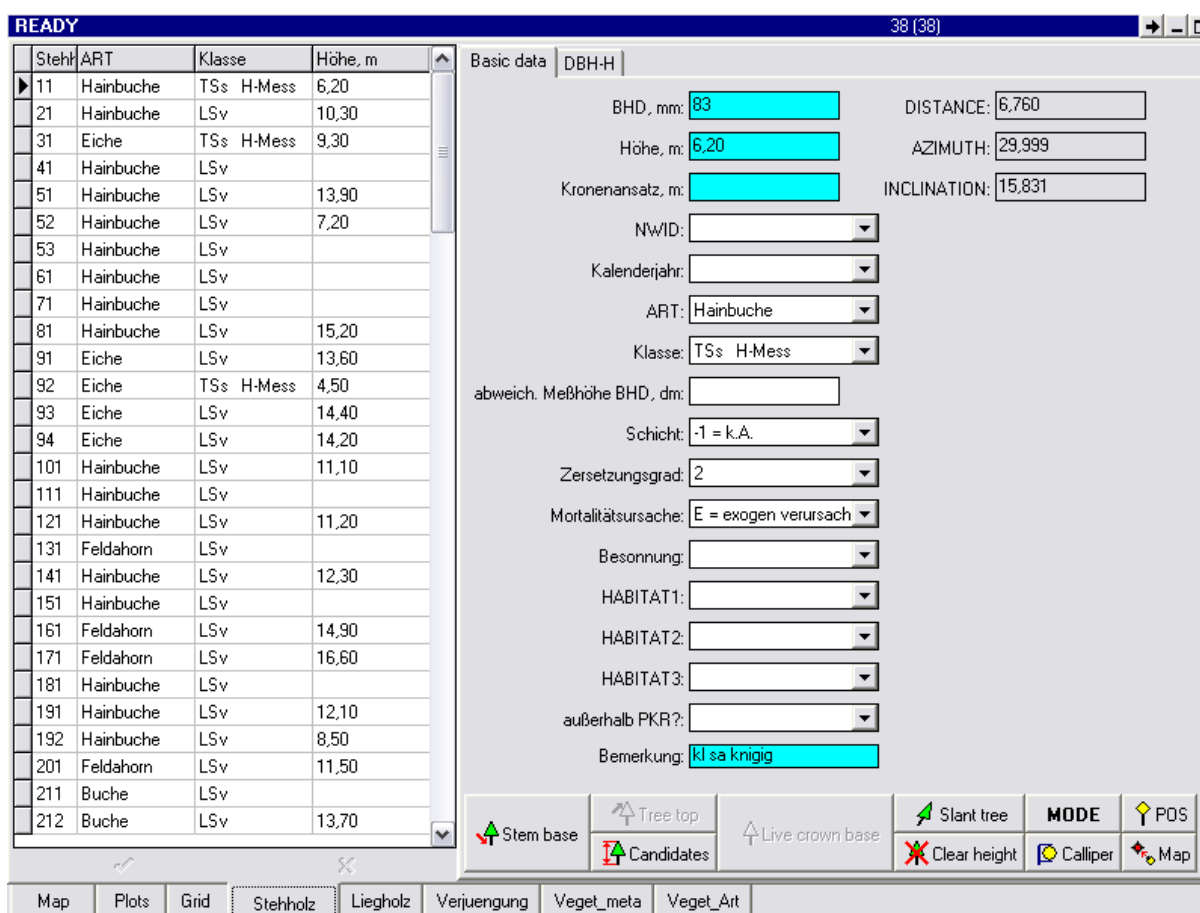


Fig. 12: Standing wood layer of the FM project

In each subsequent inventory, the trees to be included in the standing inventory are marked with a negative sign (-) before the object number. This facilitates data control at the end of the plot recording. As soon as the DBH is confirmed or changed, the object number receives a positive sign ("+" sign is not displayed).

The variables are collected in the following order:

GON = Azimuth between the centre of the plot and the respective object [in degrees]. The target point for azimuth and distance measurement is the tree centre at breast height. The height of the breast is determined in sloping terrain from the mountain side. Person 2 places the transponder stick directly in front of the centre of the tree as a locating aid.

Special case 3: Azimuth measurement on inclined trees

In the case of inclined trees, the transponder rod must be set up vertically at the height of the DBH measuring point, the target point for reading the gon number is the transponder at the upper end of the transponder rod.

GAB = Distance from the centre of the plot to the object [in m], measured with the Vertex IV ©. The target point is the transponder at the front of the tree centre at breast height. If the

tree is located above the centre of the plot in inclined terrain, the transponder must be held in front of the tree in the direction of the centre, the transponder should be located at a height of 1,3 m breast height measured uphill.

In sloping terrain, the slope inclination is determined in percent for each individual tree. The measured terrain distance is automatically converted into horizontal distance by the FM programme after data input.

(Conversion s. Tab. 1 in the supplement).

Special case 4: DBH measurement for inclined trees

For inclined trees, the DBH is measured in 1,3 m length of the tree from the centre of the root. The centre of the root must not be in the plot (see Fig. 13), but the DBH.

If the root is in the plot, but the measuring point protrudes beyond the plot limit, then the tree is not recorded.

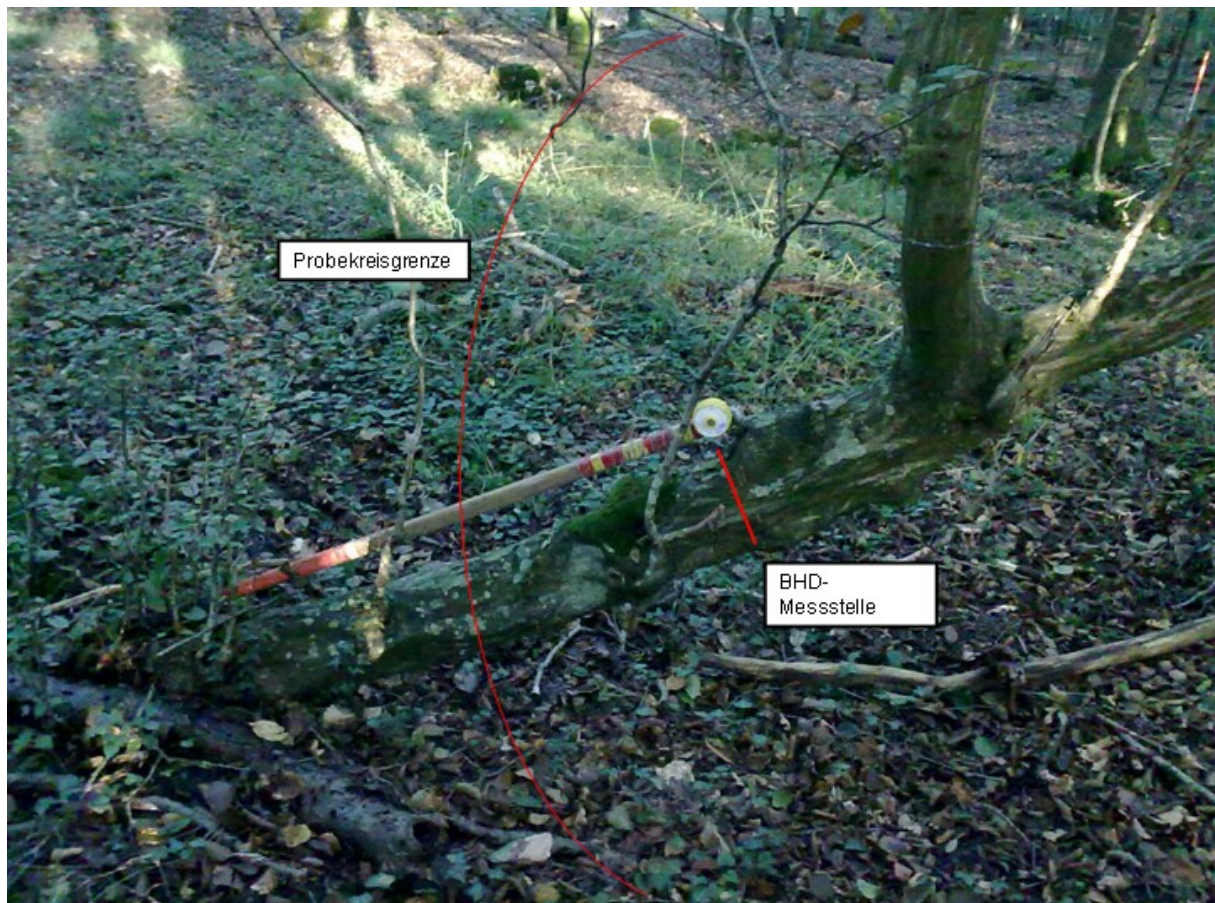


Fig. 13: DBH measurement on inclined trees

NEIG = Inclination between centre of plot and object [in %]. Person 2, who is on the object, measures the inclination by targeting the eyes of person 1 with the Suunto clinometer. If the persons are not the same height, they agree on a measurement point on the body of person 1 that corresponds to the eye level of person 2. In sloping terrain, person 2 must stand on the upper-slope side of the respective tree. The sign of the inclination value is reversed to obtain the corresponding measured value seen from the centre.

If a tree is outside the plot, the FM system will give an appropriate message after entering the inclination. If the tree cross section is cut by the plot, the FM system reports the DBH value that the tree must exceed in order to be outside the plot with its centre (s. Fig. 14).

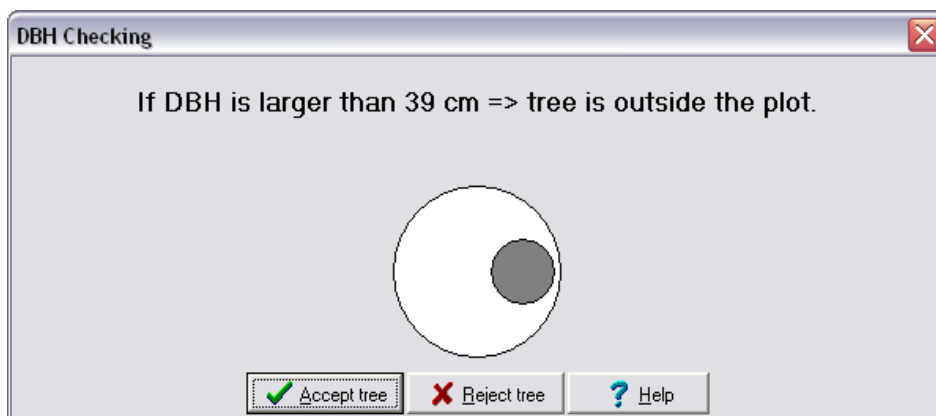


Fig. 14: Message from which diameter the tree no longer belongs to the sample plot

IDNR = Assignment of a two-part object number (ID number). Starting with the upper number 1 in the standing inventory, the objects are numbered consecutively in the order in which they were recorded. In the case of one-piece objects such as single stems or whole lying trees, this sub-number is assigned the value 1. The first recorded, undivided tree thus receives the object number 1.1. If a tree is forked below breast height, each individual trunk/branch ≥ 7 cm DBH is coded with different sub-numbers and receives its own coordinates. The original object always receives the sub-number 1 (s. Fig. 17). In the case of rhizomes, forked stems or fragments of living or dead trees, the "descendants" of the original object are numbered consecutively, starting with sub-number 2. The connection is also made between objects that are in the standing and lying stock (s. Fig. 20+21).

Note: Each newly grown tree receives a new ID number, which the FM system selects from the now sequential numerical sequence. This ID should definitely be used. An exception is, for example, the case described above where a tree is to be divided into several individual objects, in which case the individual objects are assigned the existing top number of the original tree, but their own sub-numbers.

FieldMap expresses the two-part object number in a one-digit ID number, for example:

17.1 in FM: 171

18.1 in FM: 181

18.2 in FM: 182

After recording this information, the respective object appears on the FM system's plot (s. Fig. 15).

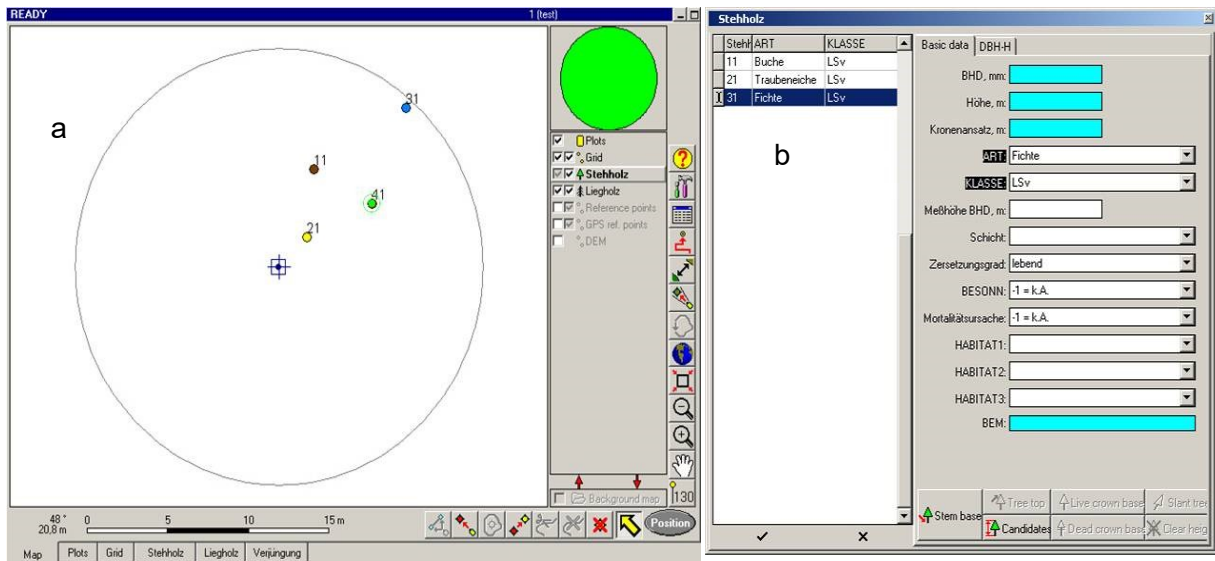


Fig. 15: Screen of the FM system when recorded the standing stock: (a) sample circuit plot and (b) data sheet

Special case 5: Inclined or lying stumps

Stumps are picked up in the standing wood layer.

Frequently, stumps from lying or pushed trees have been partially or completely torn out of the ground. These objects are theoretically erected again and measured on their old position.

For stumps whose upper diameter deviates from the vertical (or: from the vertical stem axis) for other reasons (inclined growth due to competitive pressure, formerly pushed trees that have become firmly rooted again, etc.), the centre of the upper diameter should be taken as the point of view. This position point is decisive for the membership in the tree collective of the plot.

The following variables are then collected:

DBH = Breast height diameter [in mm] is usually measured at a height of 1,3 m. The DBH is measured with a caliper. The measuring bar with the reading scale must point to the centre of the plot and the caliper legs must be held at right angles to the log axis (s. Fig. 16). If a tree is forked below breastheight, the DBH is determined from each trunk/branch ≥ 7 cm. Person 2 marks the measuring point with the hacksaw without hurting the bast.

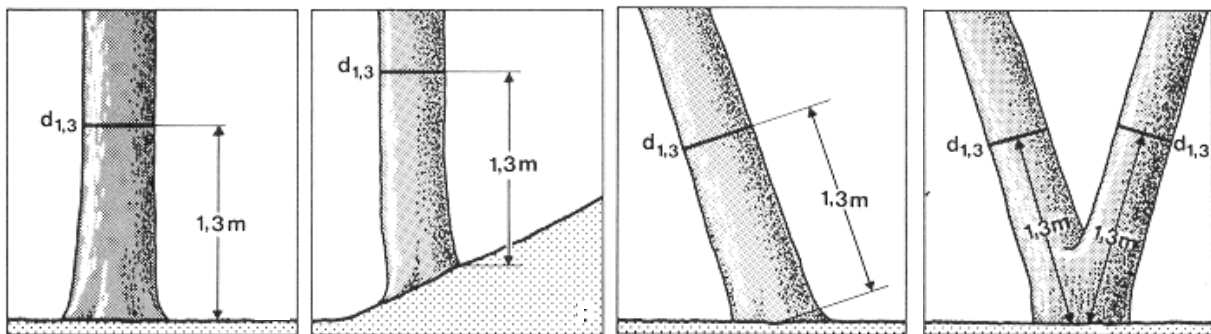


Fig. 16: Definition of breast height (from: Kramer and Akça 1996 modified)

Note: *The measuring height of 1.3 m should not be regarded as static: in the case of dents, dense loading, rust, peeling damage, deep forked stems etc., the measuring point should be sensibly shifted (usually upwards) in order to achieve a realistic measurement (see MPKT_BHD).*

In cases of deep forked stems etc. the tree-measuring side must also be varied. In these cases a note is made in the remarks column.

Special case 6: Surveying of steep branches, forked stems, etc.

If there is a steep branch, forked stem or similar on a tree in the area of the trunk base up to a height of 1,3 m, it must be included if it has a diameter of ≥ 7 cm. The starting point of the measuring point for the diameter (DBH) of this object is located at a height of 1,3 m (s. Fig. 17).

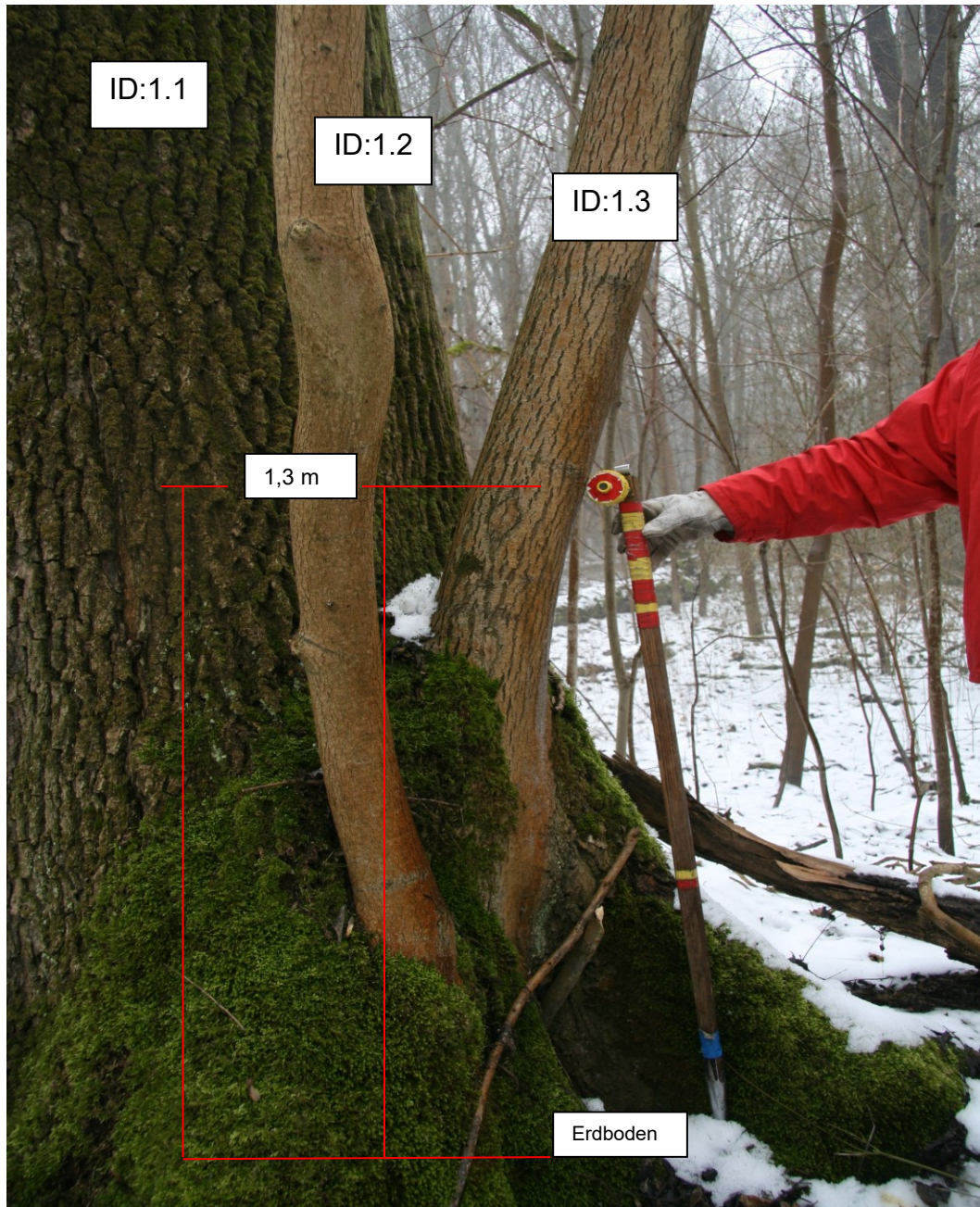


Fig. 17: Tree with steep branches ≥ 7 cm in diameter (showing the DBH measuring and numbering)

Special case 7: Transfer of IDNR when changing from standing stock to lying stock

If a tree has been recorded in the first shot with a twin fork < 20 cm DBH and has tipped over until the next recording, only the piece with the diameter ≥ 20 cm at the stronger end has to be recorded.

If a tree that branches several times at a height of 1,3 m and whose DBH measuring point must therefore be moved downwards was included in the preliminary inventory as a single object, then this object in the horizontal inventory must also be included with only one object number. The diameter at the thicker end must also be at least 20 cm (s. Fig. 18).

If two branches are broken off when the tree falls, these branches are not recorded separately if they can be clearly attributed to the original object. Individual double breaks or heavy load losses, which are located at some distance from the original object, but which are recorded separately, are then given a subsequent ID of the original object.



Fig. 18: Tree with 3 branches (red markings) at a height of 1,3 m, but only one object number in the standing inventory of the preliminary survey (due to the relocation of the DBH measuring point downwards) and correspondingly only one in the lying inventory of the follow-up survey

Special case 8: Riders (harp branches)

Riders are branches growing towards the light (crown parts, adhesive branches, etc.), which have developed from a lying tree still alive and now have a diameter of ≥ 7 cm (s. Fig. 19). Its position is taken as for normal standing stock, i.e. for each rider an azimuth and a distance is measured. At each rider the DBH is measured at a height of 1.3 m, whereby the horizontal medullary tube line of the lying tree is regarded as 0-point. (Procedure for DBH marking: see below).

The sequence of numbers is as described above.

Caution!: Double branches that have oriented themselves upwards again are not riders!!!!!!!

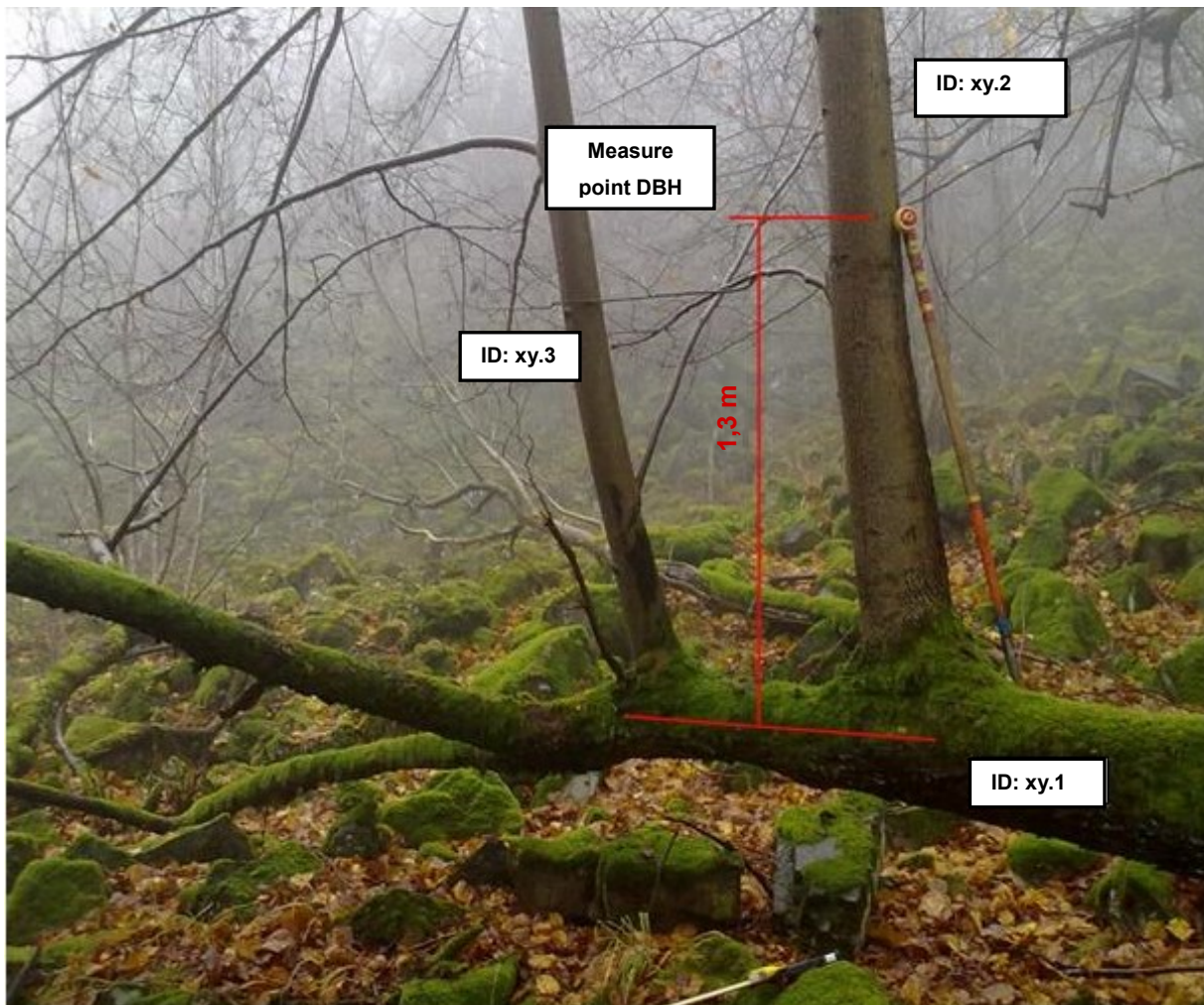


Fig. 19: A rider branch oriented to the light

Special case 9: Dead lying object with living, standing forked stem branch

In the initial survey, a living deep forked stem was given the ID = 65.1. Because of the forked stem the DBH measuring point had to be relocated to a height of 0,7 m.

In the follow-up picture, the tree has now mostly died and fallen down, only one stem branch is still alive and has an inclination > 10 gon (s. Fig. 20). As the diameter at the stronger end of the dead lying section \geq is 20 cm and its inclination \leq is 10 gon, the survey is carried out according to the surveying instructions for the lying stock (s. ch.. 7.2.5). This is the class TLws (s. Tab. 5). The first diameter would have to be measured at 1,3 m (DBH measuring point), but this is not possible due to the forked stem branch - therefore the measuring point of the first diameter is at 0,7 m. This new measuring point is entered in decimeter in the query "Measuring point_D1". The D2 is 3 m above D1 according to the surveying standard and is entered in the query "Measuring point_D2". The IDNR = 65.1 is retained for the object.

The living stem branch belongs to the standing stock (inclination > 10 gon), the coordinates of the DBH measuring point are taken as position data. The DBH measuring point is located in the area of the fork and therefore has to be moved, if possible upwards on the living trunk, in order to have a measuring point for the next follow-up recording. This measuring point provides the position data of the standing object. The ID number of the second object is 65.2.



Fig. 20: Dead, lying tree, which has a living stem / branch belonging to the standing class

Special case 10: DBH measure on a twisted tree (Fig. 21)

In this case, measurements are also taken along the log axis and after a distance of 1.3 m the DBH measuring point is created.



Fig. 21: DBH measure point on a twisted tree

MPKT-BHD = Measuring height of the DBH [in dm]. If the diameter measurement at a height of 1.3 m is not useful due to high root starts, peeling, cracking or other disturbances, the measuring point is moved to a height between 0.5 m to 2.3 m.

An entry in this data field is only necessary if the measuring point is moved.

ART = Selection of the species name from a standard list. If no clear determination of the species is possible (e.g. willow species), the genus can also be coded. German names are used in the standard species list.

In order to guarantee unambiguousness, a three-digit number key is deposited, which is used in subsequent data analysis.

KLASSE = Condition / state of the respective object; the class consists of three classifications:

1. Life class (LKL) e.g. living = L
 2. Position class (PKL) e.g. upright = S
 3. Compartment class (KKL) e.g. complete = v
- determination according to Tab. 5.

SCHICHT = Layer; classification of the living and dying individual trees in the upper, middle and lower layers in relation to all tree species within a plot (see Table 6); not recorded for dead objects.

Special case 11: Layer classification for stand changes within the plot

If the timber stock on a plot is composed of two or more stand types, e.g. old stock and pole wood, the stratification must be carried out for each individual stand type.

ZERSETZUNGSGRAD = Degree of decomposition; To be addressed for standing and lying dead wood; classification according to Tab. 6.

LAGE = Position; to be addressed with lying dead wood; classification according to Tab. 6.

BESONNUNG = Solar exposure; to be applied for standing and lying dead wood; based on one day in the vegetation period; classification according to Tab. 6.

MORTALITÄTSURSACHE = Cause of death; only for dead trees, not relevant for fragments, crown parts, etc.; classification according to Tab. 6.

BEMERKUNG = Free text input of comments

Tab. 5: Identification key for classification of above-ground woody objects of the solid wood stand

nr.	Criteria	Class assignment			Continue to nr.
		LKL	PKL	KKL	
1	Object clearly living	L			3
	Not so				2
2	Object clearly dead	T			5
	No clear assignment	A			3
3	Vertical (> 10 gon to the horizontal plane)	L/A	S		4
	Lying (≤ 10 gon to the horizontal plane)	L/A	L		4
4	No relevant crown and/or heavy losses (< 25 % of crown)	L/A	S/L	v	-
	Relevant crown and/or heavy losses (≥ 25% of the crown) IMPORTANT: this does not apply to subordinate trees having dried back, they are encrypted as LSV	L/A	S/L	(v)	-
	Vertical stem breakage ≥ 1.3 m with living residual stump (vital bark, living buds on branches)	L/A	S	s	-
	Stumps < 1.3 m with and without growth, with clearly vital bark	L/A	S	(s)	-
5	Vertical standing (see above 3)	T	S		8
	Lying (see above 4)	T	L		7
7	Tree components (root, stem (piece), crown) distinguishable	T	L		8
	Tree components not distinguishable	T	L	s	-
8	All tree components are present at least in parts (root, trunk, crown (with coarse branches and fine brushwood))	T	S/L	v	-
	All tree components present at least in parts, but fine branches missing	T	S/L	(v)	
	At least one component missing				9
9	Stem(piece) and crown(piece), root separated	T	L	sk	-
	Not so	T	S/L		10
10	Root plate and stem piece (height of stem piece 0.3 m), root plate partly or completely lifted out of the ground	T	L	ws	-
	Individual component	T	S/L	-	11
11	Root plate (height of stem piece, if available < 0.3 m)	T	S/L	w	
	No root plate	T	S/L		12
12	Trunk piece or strong branch (also the objects coming from the crown area of the standing stock)	T	S/L		13
	Crown or crown part (except individual star boxes from the crown area of the standing stock)	T	S/L	k	-
13	Stumps (= stumps < 1.3 m height)	T	S	(s)	-
	Strong branch, trunk part or stump (fragments stuck in the ground are addressed as lying)	T	S/L	s	-

Tab. 6: Classification of the variables layer, degree of decomposition, cause of mortality, solar exposure and location

Variable	Classes
Layer	<p>OBER = upper layer: height $2/3 h_0$</p> <p>MITTE = middle layer: height: $1/2$ and $< 2/3 h_0$</p> <p>UNTER= lower layer: height $< 1/2 h_0$</p> <p>UEBER= emergents. Trees exceeding the main canopy.</p>
Degree of decomposition	<p>1 = recently dead</p> <p>2 = beginning decomposition</p> <p>3a = advanced decomposition; wood with "soft rotten" parts $< 50 \%$ of the volume. Oak and other heartwoods with decomposed sapwood, but heartwood with auxiliary strength</p> <p>3b = advanced decomposition; wood with "soft rotting", no longer hatchet-stable portions $> 50 \%$ of the volume, but outlines still clearly visible.</p> <p>4 = strongly decomposed, rotten; outline no longer clearly recognizable, lying wood already sunk into the ground to a considerable extent.</p>
Cause of mortality	<p>D = depending on competition or density</p> <p>E = exogenous causes of abiotic or biotic nature</p> <p>A = age-related</p> <p>M = by human influence</p> <p>? = unknown</p>
Solar exposure	<p>SCHA = mainly shaded</p> <p>MITTL = average ratios</p> <p>SONN = predominantly sunny</p>
Position („Lage“)	<p>VOLL = fully supported</p> <p>WVIE = $< 1/4$ of the length free</p> <p>FREI = $> 1/4$ of the length free or free floating</p>
Comment	Free entry of hints and comments

Small habitats:

- Bark damage: Not yet overgrown, bark-less disturbance spots on the trunk surface (10 cm length or width), such as impact or felling damage, peeling spots, open cracks, bark pockets or lightning cracks etc.
- Trunk cavity above 50 cm height and below the crown: Trunk injury with recognizable cavity formation, e.g. branch cavity (caused by branch breakage and rot), woodpecker holes and cavities, cavity with or without mulch substrate, hollowed out trunk etc.
- Trunk foot cavity below 50 cm height: injuries to the tree in the immediate trunk foot area, e.g. back damage, hollowing out due to fungal attack, etc.
- Console fungi: Mushroom consoles (perennial, living, dead or strongly decomposed fruit bodies) of e.g. tinder sponge, red-edged tree sponge, sulfur porling, trame-ten etc. recognizable (species information, age and condition are not considered)
- Mucus flow / necrosis: local death and bursting of the bark, sometimes with sap discharge, also necrotic changes and puffing in beech (several outlets must be clearly visible)
- Moss / Lichen: Blankets of mosses and / or foliage / lichens. For standing trees the lower 3 m, for lying objects the topside, are addressed over the whole length. The characteristic is only assigned above 33 % coverage of the trunk surface with mosses or lichens.

Tab. 7: The small habitats to be addressed, differentiated by the state type

	Variable	Standing stock		Lying stock	
		living	dead	living	dead
1	Bark injury \geq 10 cm	✓	✓	-	-
2	Console mushrooms present	✓	✓	✓	✓
3	Trunk cave above 0,50 m height	✓	✓	✓	✓
4	Trunk foot cave up to 0,50 m height	✓	✓	✓	✓
5	Mucus flow / necroses	✓	-	-	-
6	Ceilings of mosses and / or leaf / shrub lichens on the lower part of the trunk up to 3 m height or in case of horizontal objects \geq covering 33 % of the trunk surface	✓	✓	✓	✓

The final step of the inventory of the standing stock is the measurement of tree heights and crown approaches:

HÖHE = Tree height [m]. For each frequently represented tree species at least 3 height measurements per plot should be carried out. Measurements for deciduous trees with sufficient accuracy are usually only possible in a leafless condition. When measuring height it is important not to aim directly at the crown edge (see Fig. 22). The measured trees should cover the given DBH span and stand layers as evenly as possible. In the case of rare tree species (less than 30 trees per species in the entire SFR) and in the case of trees that have grown into the solid wood and have therefore been newly measured, all individuals present should be measured.

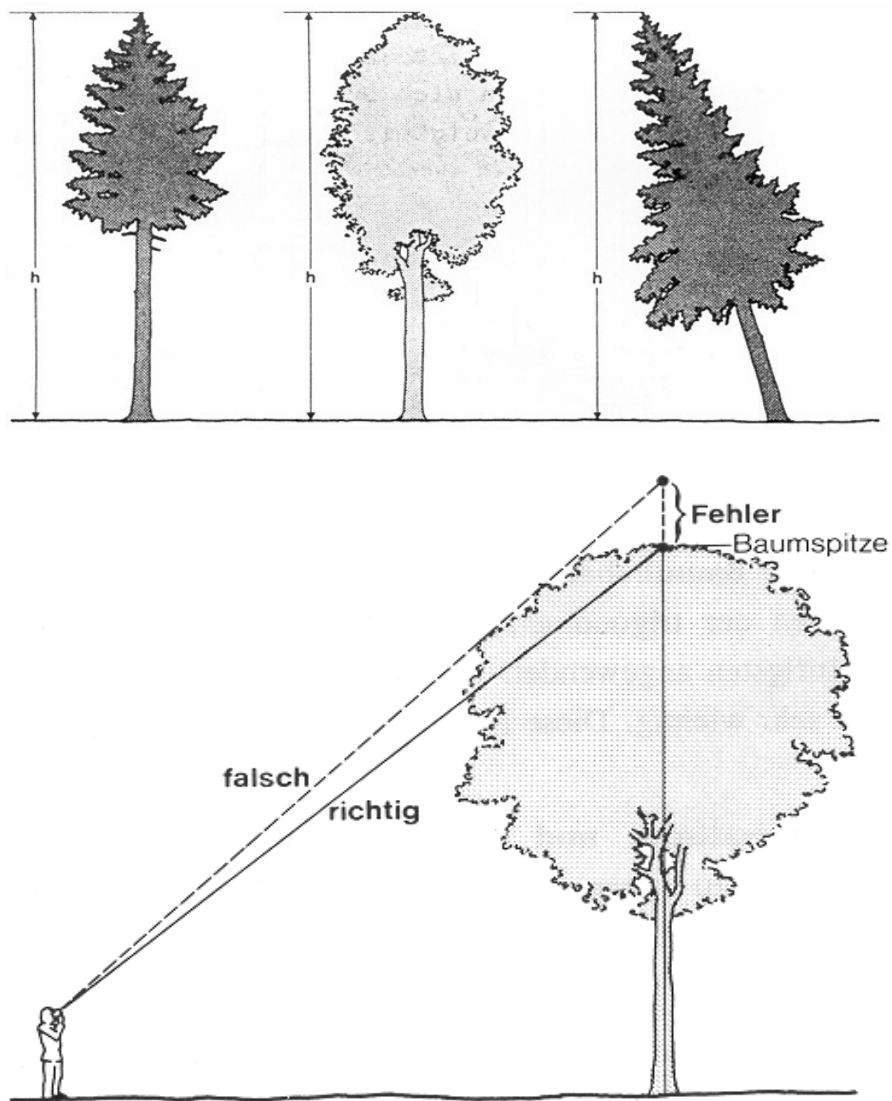


Fig. 22: Definition of tree height and technique of height measurement (from: KRAMER and AKÇA 1996, modified)

Complete height measurements shall also be carried out for stumps (classes = TS(s), TSs, LS(s), LSs and all trees with severe crown loss (classes = TS(v), LS(v), AS(v)). To repeat surveys, trees which already have height values from the old survey are to be preferred to trees without height values.

Note: No dead wood can be detected on a living tree! This means that only the height of the living area may be measured for the height measurement. Any dead tree parts protruding above it are not taken into account!

Note: Selection of trees for which no height has been measured yet: The heights of the trees not yet measured are supplemented by corresponding data routines via calculated height curves during import into the database. It is therefore important to distribute the height measurements as evenly as possible across the tree species and diameters of the stand. The FM system offers appropriate support. For this purpose, the register sheet "DBH-H" in the data sheet "Standing timber" must be clicked on. There you can see a diameter distribution and a height curve of the currently available (old or new) picture (see Fig. 23). It can also be displayed separately according to tree species.

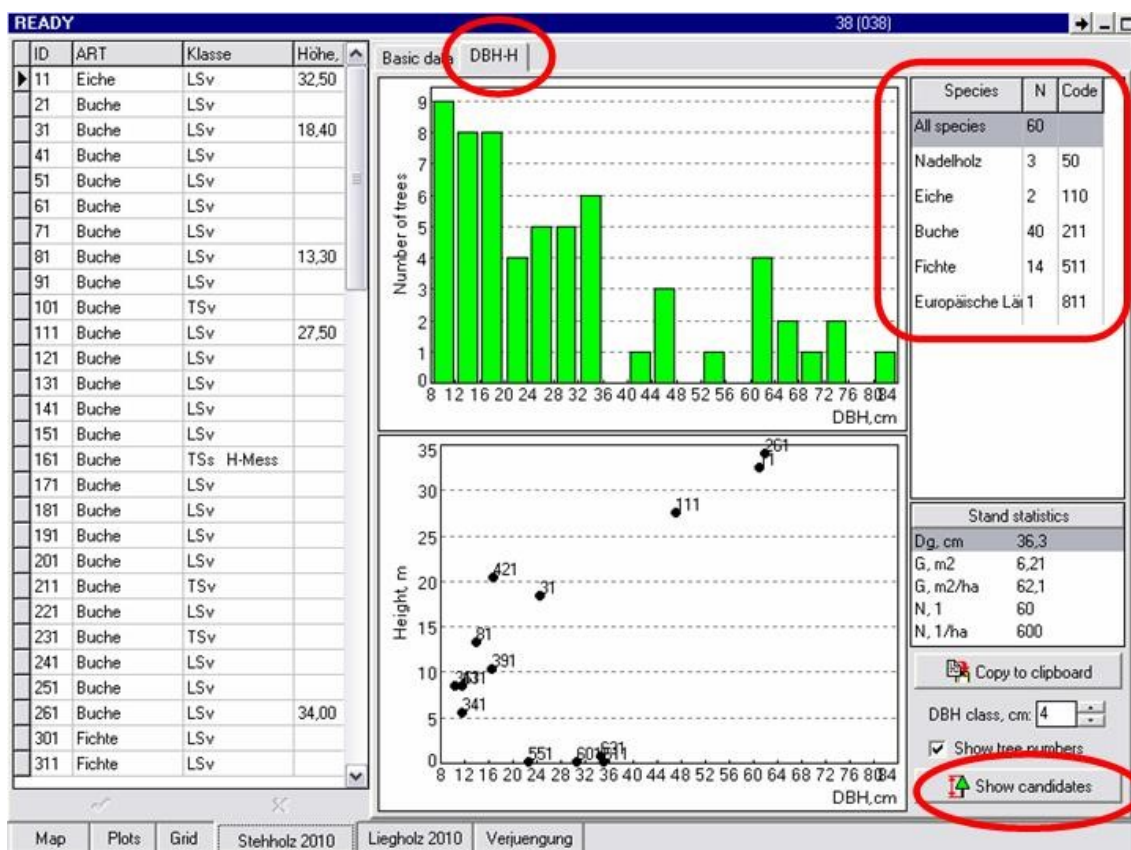


Fig. 23: Diameter distribution and height curve of the measured trees and support fields for the selection of height measurement trees. When clicking the button "Show candidates" a table appears, which shows how many trees per diameter class already have a height measurement and for which tree numbers it is still missing (see Fig. 24).

Note: The old altitude readings are included in the altitude curve until they are updated. In most cases, they can be identified by italics and the absence of the crown base height. A real overview of the measured diameter classes is only available when all old values have been deleted. The measured heights of the s- and (v)-classes are also included in the field map height curve.

DBH,cm	Candidates for height measurement	Measured
0 - 4		
4 - 8	-261,-181,-141,-271,	1
8 - 12	-251,-201,-171,-211,-111,-151,	5
12 - 16	-231,-191,	3
16 - 20	-221,-161,	1
20 - 24		2
24 - 28		
28 - 32		
32 - 36		
36 - 40	-241,	
40 - 44		
44 - 48		
48 - 52		
52 - 56		
56 - 60		
60 - 64		
64 - 68		
68 - 72		
72 - 76		
76 - 80		
80 - 84		
84 - 88		
88 - 92		
92 - 96		
96 - 100		
100 - 104		
104 - 108		
108 - 112		
112 - 116		
116 - 120		
120 - 124		
124 - 128		
128 - 132		
132 - 136		

Fig. 24: Table showing how many trees of a diameter class have already been measured in height (column "Measured") and which tree numbers of this class have not yet been registered (column "Candidates for height measurement")

KRONENANSATZ = Treetop base. The height of the treetop attachment is determined for all living height measuring trees and refers exclusively to the primary crown. Water sprouts and branches remain unconsidered.

- **coniferous wood** = the base of the lowest whisk with at least 3 green branches (exception: old pine)
- **hardwood and old pine** = the base of the first green primary branch (primary crown)

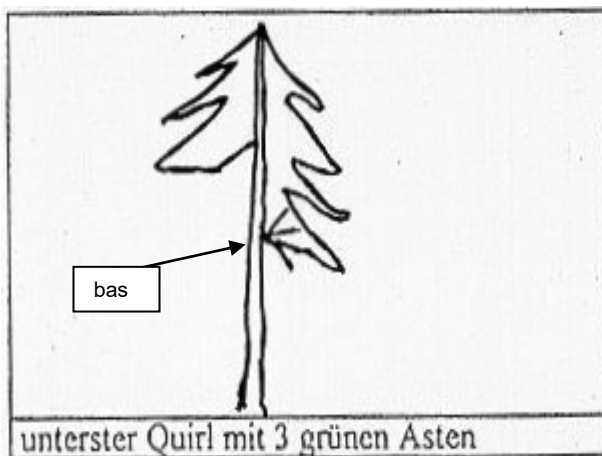
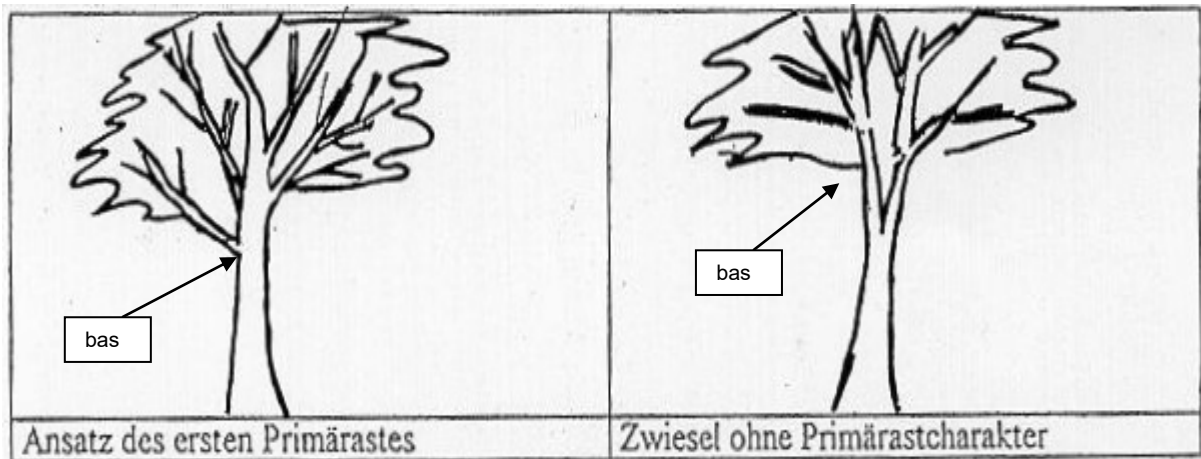


Fig. 25: Measuring points for the crown attachment (KA) for coniferous and deciduous wood

7.2.5 Survey of the lying stock

The survey of the lying stock follows directly after the survey of the standing stock and takes place in the so-called "lying wood layer" in the FM system (see Fig. 26).

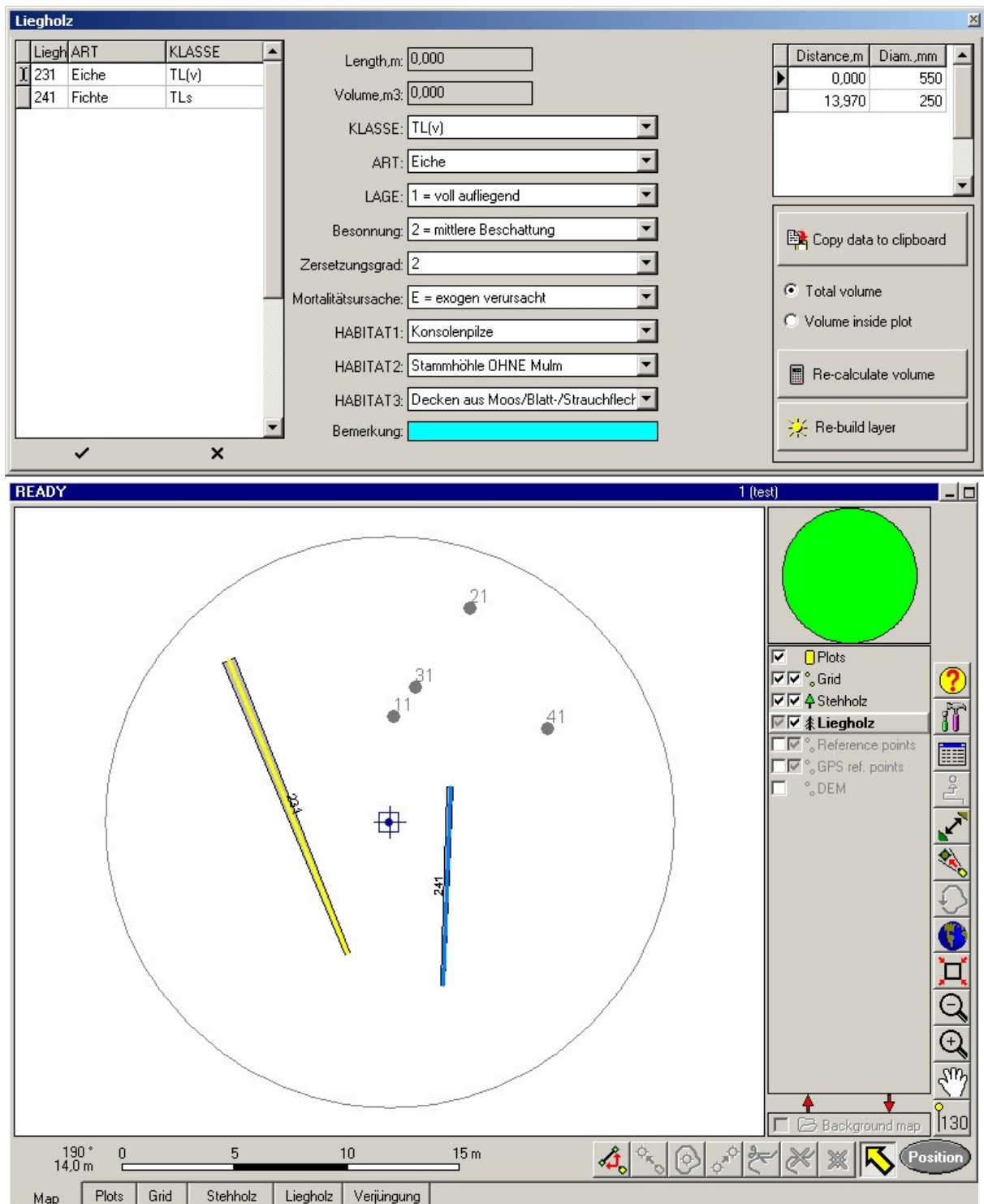


Fig. 26: Screen of the FM system when surveying the lying stock ("Liegholz-Layer"): (a) data sheet and (b) sample circle plot ("Map")

First the diameter and coordinate information is taken from the PCR center (see chapter 7.2.4). As with the standing stock, the position of the first lying object is entered first. The position measurement starts with the base point "F" (starting point; trunk base or the stronger end of an object). The variables azimuth (GON), terrain distance (GAB) and terrain inclination (NEIG) (see standing inventory) are required. To display the measuring point on the "map", the first diameter (D1) is immediately queried. The first diameter measured is the initial diameter of the lying piece. If there is still a root on the lying log, the first diameter is determined at 1.3 m. After input the position of the root can be seen in the "Map". Now the acquisition of the position data of the top point "W" follows. After the input of the second diameter (D2) the lying object appears on the "Map". If possible, the second diameter is measured 3 m away from D1 by default.

Note: *There is no lower length limit for the lying objects to be captured. Only the diameter decides whether an object is captured or not. It is possible that the D1 is < 20 cm, although the diameter at the strongest end (F) measures more than 20 cm: e.g. a TLv is 21 cm (root neck) at the strongest end; for complete lying objects, the first diameter is always measured at a distance of 1.3 m from the root neck, which in turn can then be less than 20 cm.*

The strongest end of a lying object does not always have to be the lower trunk of a tree. It is quite possible that due to decomposition processes or the position of the object, the former treetop side has the strongest end.

GONF, GONW = Azimuth values of the base and apex [in degrees].

The end or apex point is always the intersection with the plot boundary for objects protruding beyond the plot boundary.

The starting point for objects extending beyond the plot boundary is always the intersection with the plot boundary.

GABF, GABW = Terrain distance of the base and vertex from the center of the plot [in m], measured with the Vertex IV ©. (see chapter 7.2.4)

NEIGF, NEIGW = Slope between plot center and the base or top [in %]. Person 2, who is on the object, measures the inclination by aiming the Suunto clinometer at person 1's eyes. If the persons are not of the same height, another measurement point should be agreed upon with person 1. The sign of the inclination value is reversed to obtain the corresponding measurement value when viewed from the center.

Figures 27 to 31 show the coordinate and diameter measuring points for the different lying objects graphically. In the corresponding box the possible object types are explained with acquisition parameters and class classification.

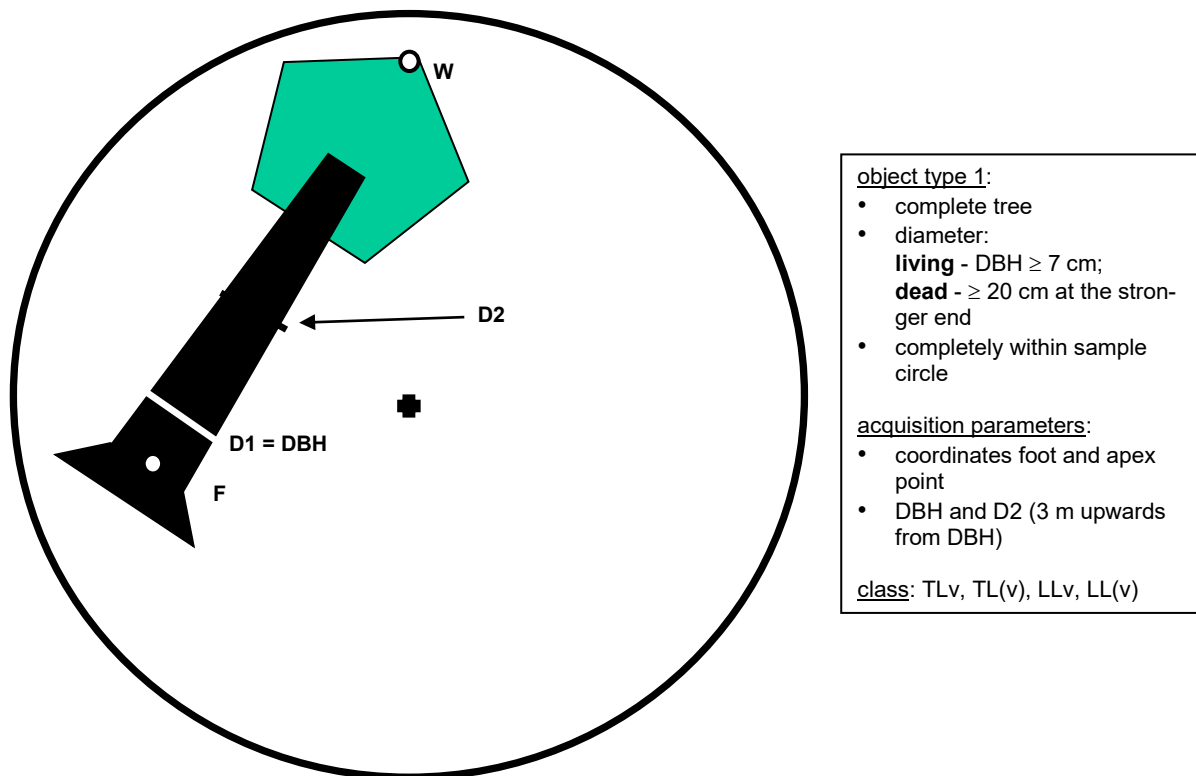
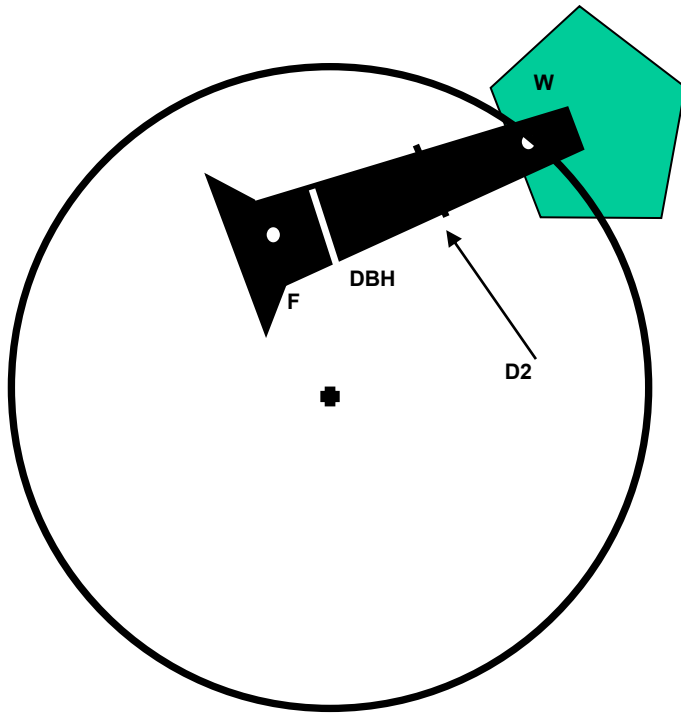
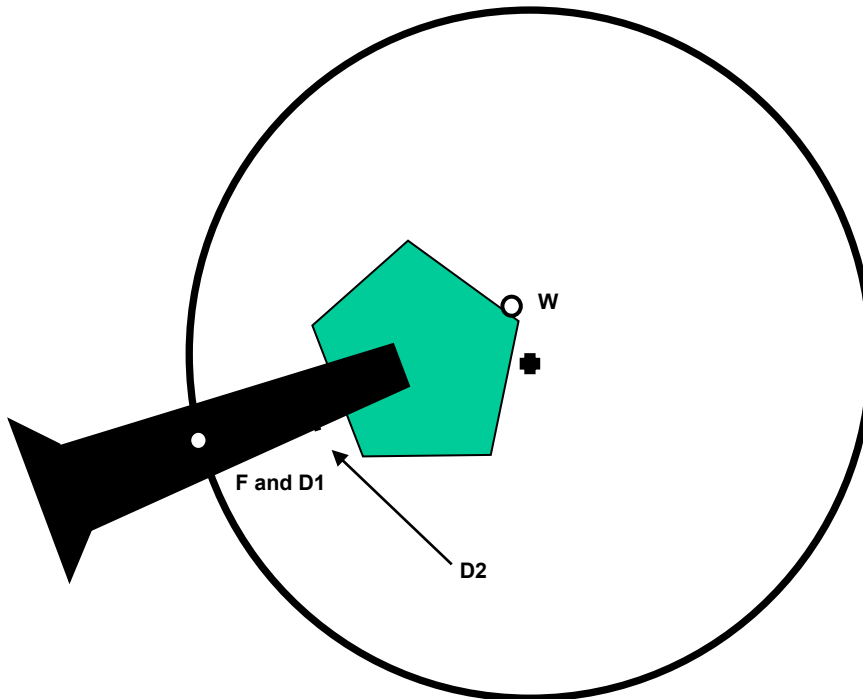


Fig. 27: Surveying scheme of dead or living complete lying trees in a plot



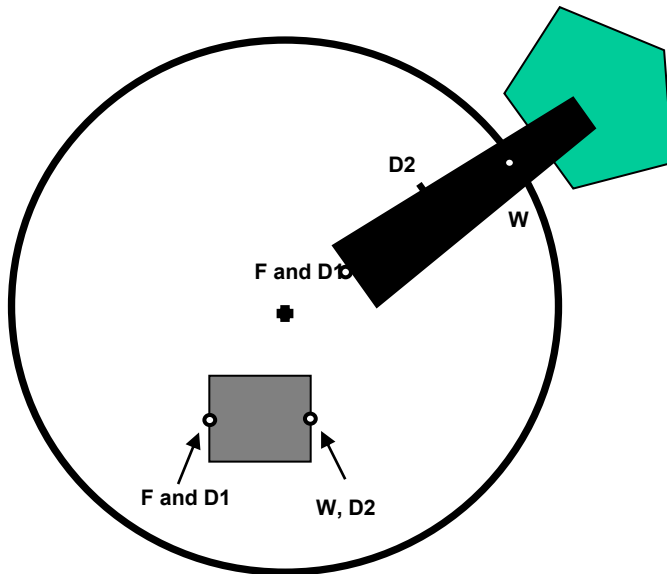
- object type 2:
- complete tree
 - diameter:
living - $DBH \geq 7$ cm;
dead - ≥ 20 cm at the stronger end
 - partially within sample circle
- acquisition parameters:
- coordinates base point, top point at sample circle edge
 - DBH and D2 (3 m upwards from DBH)
- class:
- registration and description only the part within sample circle, here TLws, LLws

Fig. 28: Surveying scheme of lying trees with root and stem without crown within the plot



- object type 3:
- complete tree
 - diameter :
living - $DBH \geq 7$ cm;
dead - ≥ 20 cm at the stronger end
 - partially within sample circle
- acquisition parameters:
- coordinates base point at sample circle edge, top point
 - D1 at point of intersection with sample circle edge
 - D2 (3 m upwards from D1)
- class:
- registration and description of only the part inside sample circle - TLsk, LLsk, TLs(k), LLs(k)

Fig. 29: Surveying scheme of lying objects without root and within the plot



Object type 5:

- stem piece without root or broken
- diameter ≥ 20 cm at the stronger end
- partially within sample circle

acquisition parameters:

- coordinates base point and top point at sample circle edge
- D1 at base point
- D2 3 m upwards from D1

class:

- Registration and description of only the parts within sample circle - TL(s)

object type 4:

- stem piece < 3 m length
- diameter at stronger end ≥ 20 cm
- completely within sample circle

acquisition parameters:

- coordinates base point and top point
- D1 at base point
- D2 at end point (note D1 + D2 in Messpkt_D1 and Messpkt_D2)

class:

- TL(s)

Fig. 30: Surveying scheme of broken trees without root and of stem pieces ≥ 20 cm

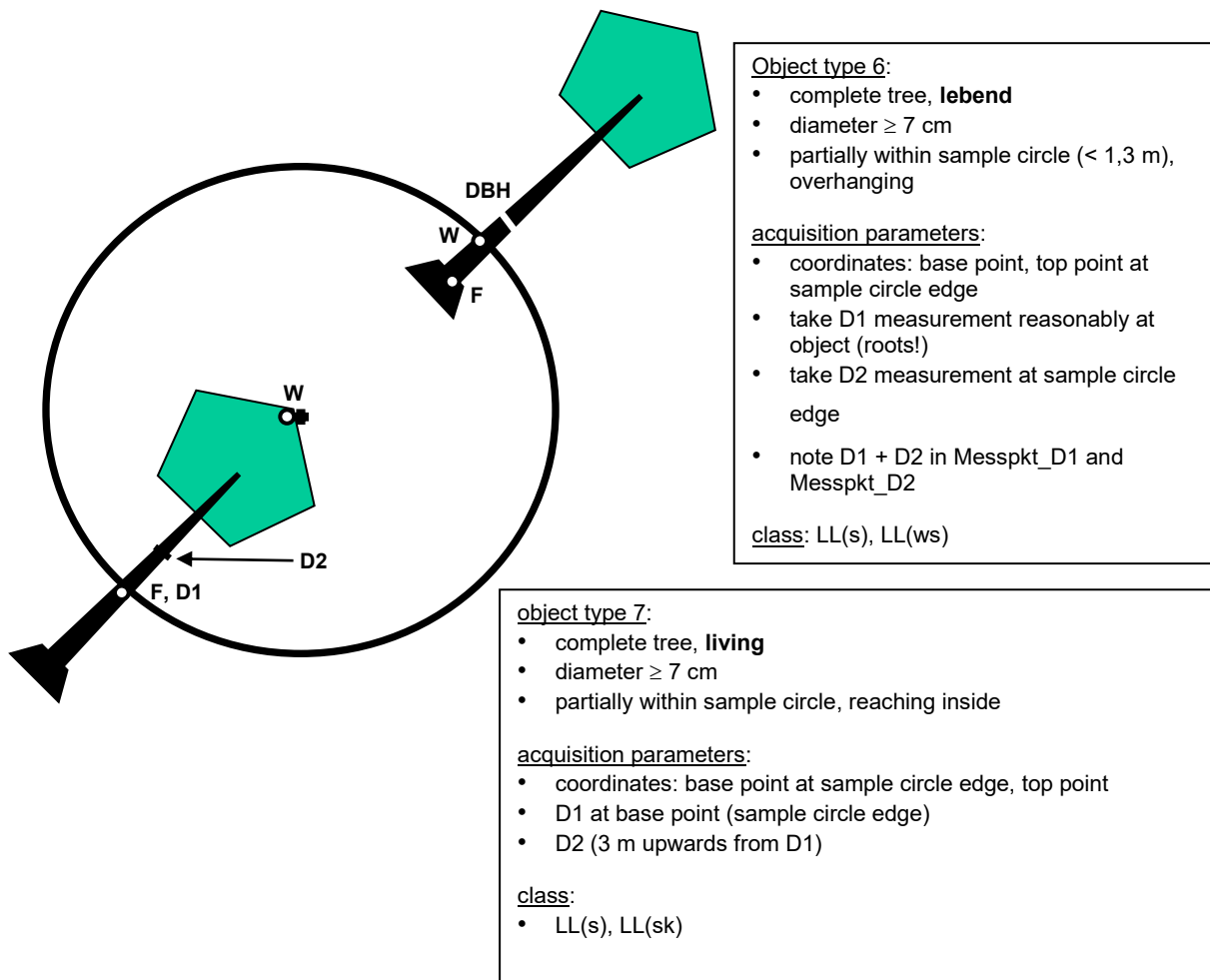


Fig. 31: Surveying scheme of living lying stems (≥ 7 cm)

ID-Nummer = See Chapter 7.2.4 "Capturing standing wood".

If there is a lying object on the plot, which cannot be assigned to any other existing object on the PCR (lying or standing stock), the assignment of the ID starts with the number 501.1 (upper number 501 + sub-number 1). Each additional object that can be assigned to this object is assigned a consecutive number as the last digit (sub-number); a maximum of nine sub-numbers can be assigned to a super-number (5010+9 5019). If the sub-numbers one to nine are not sufficient, the next upper number specified by FM must be used. This must be noted in the notes.

Attention: Change from standing wood to lying wood

If a standing object from the previous inventory has become a log in the subsequent inventory (e.g. due to windthrow), then the ID of the former log object is taken. If an object in the standing log (e.g. a broken branch) can be uniquely assigned to an object in the standing log, the standing log object is assigned a follow-on ID of the standing log object.

D1 = First diameter [in mm] to be measured at the starting point, or at 1.3 m for trees with existing roots.

D2 = Second diameter [in mm] to be measured at a distance of 30 decimeters from the first diameter (standard distance: 30 dm = 3 m)

The "D1" and "D2" measuring points must be selected in the log layer from the existing attribute lists "MPKT_D1 (measuring point D1)" and "MPKT_ABST". In the attribute list "MPKT_ABST" the distance from "D2" to "D1" must be given in decimeters.

For objects with root plate and a length ≥ 1.3 m, the first diameter is measured at the position of the (former) DBH. "D2" is to be indicated as described above.

For objects with root plate and a length ≤ 1.3 m only the upper diameter is measured analogous to the stump and entered as D1 as well as D2. For objects without a root plate, which are less than 3 m long, the second diameter is measured at the thinner end. All measuring points, even if they are located at the standard positions, must be entered in the fields MPKT_D1 and MPKT_ABST (see Fig. 32).

If decomposition progresses more strongly, an "idealized" diameter is determined which comes closest to the outer boundary line of the object cross-section.

The clip legs must be held at right angles to the course of the log axis, usually vertically. Cross-clamping does not occur.

ID	Art	Klasse
132	Buche	TLsk
1001	Stieleiche	TLs
1002	Traubeneiche	TLk
1011	Stieleiche	TLws
1012	Stieleiche	TLs
1021	Stieleiche	TLk
1022	Stieleiche	TLk
1023	Stieleiche	TLk

Art: Stieleiche
Klasse: TLs
Zersetzungsgrad: 3a
Mortalitätsursache: -1 = k.A.
Lage: voll aufliegend
Besonnung: überw. beschattet (Bestand, Vegetatic)
Meßpunkt D1: AD Anfangsdurchmesser
MPKT_ABST: 20
HABITAT1: Decken aus Moos/Blatt-/Strauchflecht
HABITAT2:
HABITAT3:
Bemerkung:
Distance, m: 13.660
Azimuth, gon: 230.002
Inclination, %: 0.000

Fig. 32: Entering the measuring points of lying objects in the lying wood layer

Note: After the position input of the base point, the FM system queries the diameter "D1" and then the coordinates of the top point and the second diameter "D2". This sequence must be run through in FM before the object appears on the map and further information can be entered. Therefore, person 2 should determine the second diameter immediately after measuring the first diameter to save unnecessary walking distances and time.

Special case 12: Determination of the "D2" in tree crowns (broken twig and crown pieces)

When measuring twigs or parts of crowns that branch out immediately after the first measuring point, the second diameter cannot be measured meaningfully. Instead, an estimated value of $D2 = D1 - 3 \text{ cm}$ is used, and the following must be entered in the remark field of the couchwood layer: "D2 averaged / estimated".

After these data have been taken, the respective object appears on the FM system's plot plot (see Fig. 26, below). Then the following variables are taken (see Fig. 26, above).

ART = selection of the species from a standard list. If no clear determination of the species is possible (e.g. due to advanced decomposition), the genus or the groups "hardwood" and "softwood" can be coded.

KLASSE = state type of the respective object; the determination is made according to Tab. 5.

LAGE = classification according to Tab. 6.

ZERSETZUNGSGRAD = decomposition degree; to be addressed only with dead wood; classification according to Tab. 6.

BESONNUNG = solar exposure; to be addressed only with dead objects; classification according to Tab. 6

MORTALITÄTSURSACHE = cause of death; only to be addressed in the case of dead trees, not relevant in the case of broken parts etc; classification according to Tab. 6

HABITAT 1-3 = presence of small habitats at the addressed object; relevance depends on state type; classification according to Tab. 7.

BEM = free entry of comments

7.3 Surveying rejuvenation

The rejuvenation is surveyed using a data sheet in the FM system (see Fig. 33). Information on the fencing of the receiving area is already provided with the plot information.

In preparation, the center of the surveying area is determined 5 m from the center of the plot to the east (100 gon). Based on this, the 4 corner points are measured at a distance of 3.54 m each in northern, eastern, southern and western direction and marked clearly visible (see Fig. 5).

Magnetic declination: In order to ensure the surface accuracy in a repeat inventory, the magnetic declination should be taken into account when staking out the tapering square in deviation from the initial inventory.

For example, the center point set at 100 gon in the initial inventory may be set at 96 gon in the repeat inventory. Correspondingly, the north must be measured at 396 gon, the south at 196 gon and the west at 296 gon.

The square for capturing the taper represents a horizontal projection (side length of 5 meters in the horizontal plane) as in the standing and lying inventory. The alignment poles at the 4 corner points are spanned with a rope close to the ground to clarify the delimitation of the test area. All trees and shrubs are determined, counted and measured whose roots are located within the sample area and whose DBH is < 7 cm. The surveying square can be additionally subdivided, e.g. with additional alignment poles, to make the counting of the rejuvenating plants clearer.

Seedlings are not recorded.

Each core growth is counted as one plant. Shoots or similar rejuvenation forms (e.g. hazelnut) that originate from a center are also counted as one plant. The height class is determined at the highest shoot. Shoots which grow away from the corresponding center (e.g. from root brood) and which can develop into individuals of their own are counted separately. Indications of vegetative rejuvenation are entered in the remarks column.

The young plants in the sample area are counted separately by species and the following height classes:

- up to 1 m
- > 0,1-0,5 m
- > 0,5-1,3 m
- > 1,3-3,0 m
- > 3,0 m to 5,0 m; > 5,0 m to 7,0 m; > 7,0 m to 9,0 m etc.

In addition, the browsing percentage in the steps is determined for each type of wood and height class:

- no browsing damage
- low browsing damages = < 10 %
- moderate \geq 10-30 %
- strong \geq 30-90 %
- very strong \geq 90 % of individuals damaged by browsing

Only the damage of last year's terminal shoot is taken into account.

Finally it is indicated for each type of wood and height class whether it concerns predominantly artificial rejuvenation (planting, sowing) or natural rejuvenation (generative and vegetative forms).

In addition, free text can be entered in the remarks field.

Verjüngung	ART	Hoehenklasse	Anzahl
1	Buche	< 0,1 m	5
2	Buche	0,1 - 0,5 m	2
* 3	Esche	< 0,1 m	7

Vegetationsjahr: 2007

ART: Esche

Hoehenklasse: < 0,1 m

Anzahl: 7

VERBISS: 30 - 90 % = stark

ENTSTEHUNG: Naturverjüngung

Bemerkung:

Map Plots Grid Stehholz Liegholz Verjüngung

Fig. 33: Rejuvenation layer screen in FM system

8 Data control on the sample circuit

Once the images have been processed on a test circuit, the first data check is performed on site. In the "Plot-Layer" a first data control is possible with the function "Check Data".

Missing values must be added, then a new data check must be performed (see Fig. 34).

Tree position in plot/segments checked.		
Plots (4)	NwID	Missing value.
Plots (4)	Kalenderjahr	Missing value.
Plots (4)	Aufnahmemethode	Missing value.
Plots (4)	Neig [%]	Missing value.
Plots (4)	Topographie	Missing value.
Plots (4)	Exposition	Missing value.
Plots (4)	Flächentyp	Missing value.
Plots (4)	Stellung Verjüngungsfl.	Missing value.
Plots (4)	Verj.-Fläche im Zaun?	Missing value.
Grid		No records.
Verjüngung		No records.
Veget_meta		No records.
Veget_Art		No records.
Stehholz 2010 (-271)	BHD, mm	Not updated.
Stehholz 2010 (-271)	Höhe, m	Missing value.
Stehholz 2010 (-271)	NwID	Missing value.
Stehholz 2010 (-271)	Kalenderjahr	Missing value.
Stehholz 2010 (-271)	Zersetzungsgrad	Missing value.
Stehholz 2010 (-271)	Mortalitätsursache	Missing value.
Stehholz 2010 (-271)	Besonnung	Missing value.
Stehholz 2010 (-271)	außerhalb PKR?	Missing value.
Stehholz 2010 (-261)	BHD, mm	Not updated.
Stehholz 2010 (-261)	Höhe, m	Missing value.
Stehholz 2010 (-261)	NwID	Missing value.
Stehholz 2010 (-261)	Kalenderjahr	Missing value.
Stehholz 2010 (-261)	Zersetzungsgrad	Missing value.
Stehholz 2010 (-261)	Mortalitätsursache	Missing value.
Stehholz 2010 (-261)	Besonnung	Missing value.
Stehholz 2010 (-261)	außerhalb PKR?	Missing value.
Stehholz 2010 (-251)	BHD, mm	Not updated.
Stehholz 2010 (-251)	Höhe, m	Missing value.
Stehholz 2010 (-251)	NwID	Missing value.
Stehholz 2010 (-251)	Kalenderjahr	Missing value.
Stehholz 2010 (-251)	Zersetzungsgrad	Missing value.

Fig. 34: Data control on the plot

With the data control at the plot the work for the surveying teams or the contractors is finished. When the entrepreneurs have taken all plots and presented their work, the NW-FVA takes over the work and randomly checks the recorded data on site. Furthermore, the collected data are checked for plausibility on the PC.

If the checked data is too inaccurate, the companies have to improve their work.

9 Data processing

After an initial check for completeness of the data in the inventory, the data must then be prepared in the office.

As a first step it is advised to run the following processes in FieldMap:

1. DataCollector → input mask „lying wood“ → „Re-build layer“
2. DataCollector → input mask „plots“ → „Database Tools“ → „Refresh database“
3. create polar coordinates via → input mask „Plots“ → „Extentions“ → „Polarcoordinates“
4. Possible problems with the data in the ProjectManager → „Tools“ → „Compact and reprepare database“

Then the project is exported via the FM project manager to a directory on an internal drive as an Excel file. The file is renamed with the addition "...edited" to distinguish the unedited project (addition: "...empty") from the edited one.

After opening the file on the screen, the data must be read into the database in a predefined data structure. Prior to this, a new check for completeness and plausibility is performed.

The data structure for the data import into the database must contain five spreadsheets:

- PKLIST: List of all possible plots both in the SFR and in the reference area with the required information
- PKAUFN: List of the plots that were surveyed during the current data collection with the required information
- PKSTEH: List of objects which are included in the standing stock, including the stumps, with the required sizes and surveying methods (s. Tab. 2 + 3).
- PKLIEG: List of objects that are included in the lying inventory, with the required sizes and surveying methods (s. Tab. 2 + 3).
- PKNV: List of woody rejuvenation except seedlings, with required sizes and surveying methods (s. Tab. 2 + 3).

With the help of an import tool, the previously created file is read into the existing natural forest database.

The initial survey of the Hessian SFR must be exported from the database in the course of this process. This initial survey must then be corrected to the current sample circle radius of 17.84 m and then re-imported into the database.

Minor corrections, such as incorrect specification of type or position from the first image, are also made before the data is imported into the database.

10 Completion of the survey

After the completion of the field survey and the data processing in the office, a survey protocol and a routing slip are filled out, which lists information on all the work carried out during the project, e.g. measurement, persons involved, costs, etc.

This information includes the location of the raw data and the name and description of the files that are required for further statistical analysis.

In the survey protocol all points should be listed which could be of importance for the next survey (e.g. black stork clouds, semicircle recordings, if necessary overnight possibilities etc.).

Finally, the corresponding inventory project is marked as completed in the work plan.

11 Vegetation record

The vegetation is surveyed on a permanently defined, square sub-area within the sample plots (Fig. 5). If possible, the survey takes place in the vegetation periode, which follows the inventory of the forest structure.

11.1 Surveying sizes and methods

The survey is carried out using the **form for vegetation recordings** in Hessian SFR (see Appendix, Table 2). As so-called **header data**, area name and - number, plot number, admission team and date as well as data to cover ratio and height of the individual vegetation layers in the upper part of the survey form, are noted. In the lower part the **vegetation data** are entered in form of a species list with layer affiliation and degree of coverage in percent. The most important parameters are summarized and explained in Tab. 8.

Tab. 8: Surveying sizes and their definition

Surveying size	Definition
Coverage of the vegetation layers [%]	Presented as horizontal projection of the layers in percent - Tree layer (BS): Total trees in percent, with clear separation into two tree layers (B1, B2): additional separate estimation - shrub layer: woody plants over 0,5 m height - Herb layer: all herbaceous plants and woody plants up to 0.5 m - Moss layer: soil-dwelling mosses and lichens
Height of vegetation layers [m]	Height indication for the shrub and herb layer in meters - Shrub layer: maximum height - herb layer: medium height (Tree layer heights are captured when the forest structure is surveyed).
Scientific species name	Naming according to GermanSL1.2 (electronic reference list for vegetation databases in Germany). For ferns and flowering plants this is currently WISSKIRCHEN & HAEUPLER (1998), for mosses KOPERSKI et al. (2000) and for lichens SCHOLZ (2000); documentation of deviations, if necessary
Coverage of species [%]	Estimation of the coverage of each type (separated by layers) in percent. For mosses and lichens, do not assign degrees of coverage, only enter "v" (present). > 10 % in steps of 5; <1 %: 0.5; <1 %, up to 5 Ind.: +; <1 %, 1 Ind.: r

11.2 Time of recording

The main surveying period extends from mid-May to September. For SFRs with spring geophytes, the data collection is necessary already in April/May. Forest grasses are usually not fully developed until mid-June, therefore a second survey is carried out on areas with geophyte occurrences. The forest vegetation of soil-acidic sites is surveyed once in the period

from mid-May to September, but a first survey in spring should be carried out to look for early flowering plants that may be present at certain points.

11.3 Survey area, list of measuring instruments and materials

The survey area is square and has a side length of 10 m. The south-east corner of the square is by default 2 m west of the center of the plot (see Fig. 5). The position is indicated in the admission form with 300 gon.

If only half of the plot was surveyed during the survey of the solid wood, e.g. at the border of the natural forest, or if a paved path leads through the circle, the surveying area of the vegetation is relocated accordingly (see chapter 3.2.2, Fig. 7). The deviation from the usual position scheme is documented on the admission sheet (position: gon number of the new orientation). Further deviations from the standard position should only occur in rare individual cases and need to be reported (in the comments field).

From the center of the plot, the surveying surface is measured with the help of the Suunto bussole and tape measure, and alignment rods (or tonkin rods) are used to mark the surveying surface. In contrast to the forest surveys, the surface is measured parallel to the surface (see chapter 3).

However, the surface accuracy between the first and subsequent inventory must also be maintained in the tapered image. For this purpose, the magnetic declination is determined in advance (for example during the measurement and marking of the plot grid or in the course of the forest structure survey). If a declination exists, the image acquisition area is staked out where it was when the initial image was taken (see page 50).

The following measuring instruments and materials must be carried along when taking vegetation surveys:

- Data collection instructions
- Forms for vegetation surveys
- GPS device, list with coordinates of the plots
- Working map of the area with plots and information, which semicircles were worked on (with gon information)
- Suunto bussole with gon graduation, monopod, plug-in candle
- 5 alignment poles, if necessary 4 tonkin poles for staking out the test area
- Rolling tape measure (20 m) to measure the surface
- Folding rule for measuring the layer heights

In large investigation areas with a high number of plots, the radius of the plots may be reduced to 12.62 m during forest structure mapping. However, the area size of the vegetation record (100 m²) is maintained. So that the square does not protrude over the edge of the plot, its south-eastern corner is measured 1 m west, then 5 m south of the plot center.

11.4 Performance of the vegetation record

In the following, the procedure is illustrated using the admission sheet and the data fields are explained:

GEBIETSNAME: Name of SFR

GEBIETSNUMMER: 08 for Hesse and SFR number (01-31) emerges in **GEBIETS-ID** – SFR ID

PROBEKREISNUMMER: Sample plot number

AUFNAHMETEAM: Name/names of surveying personnel

AUFNAHMEDATUM: Date of the first and, if applicable, the second image with day, month, year

LAGE: Gon number of the connecting line between the center of the plot and the base line of the receiving surface clockwise (normally 300 gon)

BEMERKUNGSFELD: Deviations from the standard procedure are noted here, as well as special features, in particular disturbances of all kinds, side light, old earth paths, pronounced game passes, skidder ruts, erosion gullies, large amounts of deadwood, stones, animal feed, location within the fence, etc. The text is inserted in the protocol under "Notes on individual surveys". In the protocol you will also find at this point references to critical species information or species that are difficult to distinguish vegetatively, which can only be entered in the database at genus level.

DECKUNGSGRAD: In the form the degrees of coverage of the vegetation layers are indicated. The degree of coverage is the percentage of the sub-areas that are mapped on the ground when all above-ground living plant parts of a clan are projected vertically (DIERSCHKE 1994).

The maximum height [m] of the shrub layer is measured to distinguish it from the tree layer or layers. The mean height [m] of the herb layer is estimated.

The types of tree layer 1 and 2, shrub layer and herb layer are noted separately by layer and their degree of coverage is estimated.

The moss species are noted or recorded and determined at a later date. The degree of coverage of the individual moss species is not estimated.

Only plant species that grow on the soil are recorded. In this area special locations (e.g. stones, rocks, lying tree trunks) are not deducted in terms of area. Their species are not taken into account in the vegetation relevée. The maximum height [m] of the shrub layer is measured to distinguish it from the tree layer or layers. The mean height [m] of the herb layer is estimated.

11.5 Overview of work steps

The most important steps of the vegetation recording are summarized below. It has proven to be useful to keep a fixed order so that nothing is forgotten. A possible sequence of work steps could look like this:

- (1) Locating the center of the plot
- (2) Measuring and staking out the sample area
- (3) Filling in the head part of the admission sheet
- (4) Estimate the coverage percentage of each layer
- (5) Measuring the maximum height of the shrub layer
- (6) Estimating the mean height of the herb layer
- (7) Recording the plant species in the individual layers
- (8) Estimating the percentage of cover of each type
- (9) Remarks, location sketch, if applicable
- (10) Final check

11.6 Controls

Controls of the vegetation uptake take place at different stages of the procedure. The following has proven to be essential:

- Before the estimation of the species richness, the species list is checked for completeness (overview of all layers, species)
- Re-check of the data for completeness at the end of the individual data collection, recording of the special features of the area. It should be noted that the sum of the degrees of coverage of the species in a layer must be at least as high as the total degree of coverage of the layer. In the case of overlapping, significantly higher sums may also be plausible.
- Checking all records for plausibility before completion of the terrain work
- If necessary, check sample specimens and, if necessary, make additions on the recording sheet.

12 List of species

Lists of all species of vascular plants are recorded separately for total reserve and reference area. For this purpose, all "special locations" of the area, such as clearings, wet areas, hill-tops, forest roads, forest edges, must be searched for species that were not recorded during the processing of the sample areas. The lists are entered into a database analogous to the vegetation surveys.

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Supplement

Tab. 1: Conversion table horizontal distance to terrain distance

Probekreisrand								
%	12,62 m	17,84 m	%	12,62 m	17,84 m	%	12,62 m	17,84 m
1	12,62	17,84	28	13,11	18,53	55	14,40	20,36
2	12,62	17,84	29	13,14	18,58	56	14,46	20,45
3	12,63	17,85	30	13,18	18,63	57	14,53	20,53
4	12,63	17,85	31	13,21	18,68	58	14,59	20,62
5	12,64	17,86	32	13,25	18,73	59	14,65	20,71
6	12,64	17,87	33	13,29	18,79	60	14,72	20,80
7	12,65	17,88	34	13,33	18,84	61	14,78	20,90
8	12,66	17,90	35	13,37	18,90	62	14,85	20,99
9	12,67	17,91	36	13,41	18,96	63	14,92	21,09
10	12,68	17,93	37	13,46	19,02	64	14,98	21,18
11	12,70	17,95	38	13,50	19,08	65	15,05	21,28
12	12,71	17,97	39	13,55	19,15	66	15,12	21,38
13	12,73	17,99	40	13,59	19,21	67	15,19	21,47
14	12,74	18,01	41	13,64	19,28	68	15,26	21,57
15	12,76	18,04	42	13,69	19,35	69	15,33	21,67
16	12,78	18,07	43	13,74	19,42	70	15,40	21,78
17	12,80	18,10	44	13,79	19,49	71	15,48	21,88
18	12,82	18,13	45	13,84	19,56	72	15,55	21,98
19	12,85	18,16	46	13,89	19,64	73	15,62	22,09
20	12,87	18,19	47	13,94	19,71	74	15,70	22,19
21	12,90	18,23	48	14,00	19,79	75	15,78	22,30
22	12,92	18,27	49	14,05	19,87	76	15,85	22,41
23	12,95	18,31	50	14,11	19,95	77	15,93	22,52
24	12,98	18,35	51	14,17	20,03	78	16,01	22,63
25	13,01	18,39	52	14,22	20,11	79	16,08	22,74
26	13,04	18,43	53	14,28	20,19	80	16,16	22,85
27	13,07	18,48	54	14,34	20,27	81	16,24	22,96

Tab. 2: Form for the vegetation survey in Hessian SFR

Formblatt für die Vegetationsaufnahme in hessischen Naturwaldreservaten												
Gebietsname:				Gebiets-Nr.:			Probekreis-Nr.:					
Aufnahmeteam:				Datum (Termin 1, 2):								
Vegetationsschicht		BS (gesamt)		B1		B2		SS		KS		MS
Deckungsgrad [%]												
Höhe [m] (bei SS: max. Höhe, bei KS: mittl. Höhe)												
Bemerkungen:										Deckungsgrade: - alle Angaben in Prozent - ab 10 % in 5er Schritten - unter 1 %: 0,5 - unter 1 %, bis 5 Ind.: + - unter 1 %, 1 Ind.: r		
Schicht	DG [%]				Artname	Schicht	DG [%]				Artname	
	100 m ²		Viertelkreis NO				100 m ²		Viertelkreis NO			
	Termin		Termin				Termin		Termin			
	1	2	1	2			1	2	1	2		