THE METHODOLOGY OF MONITORING

1 Array of inventory plots

The methodology of inventory investigation is based on statistical (selective) inventory on the permanent network of inventory circle plots.

1.1 Network of inventory plot centres

There is possible to use various span of the network for the purpose of statistical selective investigation. Nevertheless, considering locality area of 40 – 60 ha, it is expected to choose one of the span values: 62.5 m, 88.5 m, 125 m.

Table 1 – Density of inventory plots (related per hectare of area)

Span of net	Density of sampling
62.5 m	1 plot per 0.4 ha
88.5 m	1 plot per 0.8 ha
125.0 m	1 plot per 1.4 ha

1.2 Shape and size of inventory plot

The invetory plot has circle shape with radius of 12.62 m. Three another concentic circles with various radiuses are situated inside the invetory plot. All measurements of tree inventory used to be realized inside them. Three "regeneration circles" (with radius of 2 m) are located variously in accord with attributes of natural regeneration on the plot – spatial distribution, development and species representation.

1.3 Sorts of studied objects

All important components of forest ecosystem are studied on invetory plot. Both whole plot and individual objects are focused: standing stems including dead ones, lying dead wood, stumps and forest stand's regeneration.

Table 2 – Sorts of objects to be measured and their features

Object	Project layer	Feature
Plot	Plot	Description of the plot
Vegetation	Relevée	Species representation on all vegetation storeys
Live stems	Standing stems	With relevant concentric circe determinated minimal d.b.h. of individual tree
Standing dead stems		
Dead lying tree	Dead wood	Diameter from 7.0 cm on the base of stem
Stumps	Stumps	Diameter from 30.0 cm on ground level, height up to 1.3 m
Natural regeneration	Regeneration	Height from 0.1 m, diameter up to 7.0 cm
Marked points	Marked points	Positions and description of important points

2 Establishment and procedure on inventory plot

The first step – searching fot the centre of inventory plot (and its adjustment in case of the basic measurement). Description of the plot and consequent registration of defined layers (attributes) follow as the second and the other steps. Finally, the database check comes before leaving the plot.

There is neccessary to modify this procedure in point of Trees‘ measurement and registration, if the repeated measurement is to be processed. Firstly we have to identify trees from the previous measurement. Then we append the new recruits – trees reaching the threshold dbh just now. Analogically with tree identfication, the disappeared trees are to be deleted from a database or to be moved into the dead wood layer, respectively. The same is the procedure for stump and dead wood layers.

Table 3 – Establishment and procedure on inventory plot

Phase	
Basic measurement	Repeated measurement
Searching for inventory plot center	Regressive seeking for inventory plot center
Adjusting of inventory plot center	Renovation of significant point marking
Registration of basic plot characteristics	Registration of basic plot characteristics
Registration of vegetation storeys	Registration of vegetation storeys
Stem measuring and attributes‘ filling	Through basic measurements recorded stems‘ identifiction and attributes‘ update
	Measurements and attributes‘ filling of new recruits (stems reached threshold d.b.h.)
Registration of natural regeneration	Registration of natural regeneration
Registration of lying dead wood	Through basic measurements recorded dead wood identifiction and attributes‘ update
	Measurements and attributes‘ filling of new recruits (stems reached threshold d.b.h.)
Registration of stumps	Through basic measurements recorded sumps identifiction
	Measurements of new stumps
Database check	Database check

3 Registration of inventory plot‘s basic features

Inventory plot could be described with basic parameters refered to its whole area.

Table 5 – Evaluated and measured attributes within the PLOT layer

Attribute name	Field type	Unit
Plot ID	Numeric	-
Coordinates of plot‘s center	Numeric	m
Magnetic declination	Numeric	°
Starting point	Numeric	-
Measurement datum	Datum	-
Plot renovated	Lookup list	-
Responsible person	Lookup list	-
Accessibility	Lookup list	-
Evaluation forest/non-forest	Lookup list	-
Inclination	Numeric	°
Exposure	Lookup list	-
Terrain	Lookup list	-
Altitudinal vegetation zone	Lookup list	-
Edaphic category	Lookup list	-
Attendance of trees	Lookup list	-
Attendance of regeneration	Lookup list	-

Attendance of dead wood	Lookup list	-
Attendance of stumps	Lookup list	-

4 Registration of vegetation

Releve is to be registrered on each inventory plot. Radius of a plot for a releve is 12.5 m. Thus the evaluted area counts 491 m^2. Center of releve is situated just in the center of inventory plot.

Standard evaluation of total degree of coverage, cover of tree species synusia and cover of herb synusia used to be usual.

4.1 Total cover

Total cover used to be registered in [%] of total vegetation on a releve refered to total releve area. Vegeteation is divided to tree and herb synusia.

4.2 Cover of woody layer

Woody synusia is registered w ith the assistance of Zlatník's vertical structure of woody layer (Randuška et al. 1981):

I. Overstrorey trees; trees higher than mainstorey trees.

II. Mainstorey trees; mainstorey includes trees fitting by their tops mainstrorey trees too.

III. Understrorey trees – trees higher than the half of the mainstorey height, nevertheless their crowns do not reach to mainstorey crown level.

IV. Understorey woods with tree-growth species and shrubs from height of 1.3 m up to half height of mainstorey.

V. Wood species up to a height of 1.3 m – this layer could be divided to:

V_1 Individual conifers with one lateral shoot, deciduous individual broadleaves without cotyledons

V_{1a} Woody species of height ranging from 0.2 to 1.3 m.

V_{1b} Woody species up to a height of 0.2 m, individual conifers with at least one lateral shoot, individual broadleaves without cotyledons.

V_2 Seedlings.

Total cover of a storey in [%] of studied area related to total releve area is recorded for each storey on the species.

Table 7 – Evaluated and measured attributes within the TREE SPECIES SYNUSIA layer

Attribute name	Field type	Unit
Total cover	Lookup list	-
Cover of overstorey trees	Lookup list	-
Cover of mainstorey trees	Lookup list	-
Cover of understorey trees	Lookup list	-
Cover of understorey woody species with tree-grown species and shrubs	Lookup list	-
Cover of woody species up to a height of 1.3 m	Lookup list	-
Cover of conifers with one lateral shoot and broadleaves without cotyledons	Lookup list	-
Cover of individuals over a height of 0.2 m	Lookup list	-
Cover of individuals up to a height of 0.2 m	Lookup list	-
Cover of seedlings	Lookup list	-

4.3 Cover of herb layer

Also some shrubs and semi-shrubs are included to herb layer (Randuška et al. 1986, Plíva 1991) e.g. genera Hedera, Rubus, Vaccinium, Vinca). Nomenclature by Kubát (Kubát et al. 2002) is used for vascular plants‘ determination. There are observed in deteil neither mosses nor lichens. To classify vegetation we use combined abunddance and dominance Braun-Blaquet scale. It has been extended and softened by Zlatník (Randuška et al. 1986).

Table 8 – Evaluated and measured attributes within the HERB SYNUSIA layer

Attribute name	Field type	Unit
Species	Lookup list	-
Cover of a species	Lookup list	-

Species

The Latin names of species are stated.

Cover of a species

To evaluate species‘ participation of herb layer, there is used combined abunddance and dominance scale supplemented and softened by Zlatník (Randuška et al. 1986) – see Table 9.

Table 9 – Field COVER OF A SPECIES

Signature	Cover of a species [%]	Cover on average [%]
Rare species	1 – 3 pieces	0.1
+	< 1	0.5
1	1 – 5	3
-2	5 – 15	10
+2	15 – 25	20
-3	27 – 37	31
+3	37 – 50	44
-4	50 – 62	56
+4	62 – 75	69
-5	15 – 87	81
+5	87 – 100	94

5 Measurement and registration of trees

All measurements and registrations are reduced just at i) trees inside inventory plot ande ii) trees exceeded threshold D.B.H. Dead standing trees and stubs (taller than 1.3 m) fitting threshold D.B.H. are registered, too.

Table 10 - Evaluated and measured attributes within the STEMS layer

Attribute name	Field type	Unit	Evalueated / Not evaluated	
			Live tree	Standing dead tree
Tree ID	Numeric	-	Yes	Yes
Center of tree‘s position (X,Y,Z coord.)	Numeric	m	Yes	Yes
D.B.H.	Numeric	mm	Yes	Yes
D.B.H. 1	Numeric	mm	Yes	Yes
D.B.H. 2	Numeric	mm	Yes	Yes
Height of measurement	Numeric	cm	Yes	Yes
Tree height	Numeric	m	Yes	Yes *
Height of live crown base	Numeric	m	Yes	No
Species	Lookup list	-	Yes	Yes
Tree status	Lookup list	-	Yes	Yes
Twin-stem tree	Lookup list	-	Yes	Yes
Stem ID	Numeric	-	Yes	Yes
Breakage	Lookup list	-	Yes	Yes
Dead standing stem	Lookup list	-	Yes	Yes
Social status of a tree (Zlatník)	Lookup list	-	Yes	No
Bark peeling	Lookup list	-	Yes	No
Age of peeling	Lookup list	-	Yes	No
Root damage	Lookup list	-	Yes	No
Stilt roots	Lookup list	-	Yes	No
Other damages	Lookup list	-	Yes	No
Map key	Numeric	-	Yes	Yes

* only when live trees are not present on the plot

5.1 Concentric inventory circles in inventrory plots

The concentric invenory circles principle is used due to reduce labouriousness and working time. Systém is based on several intersecting concentric inventory circles with varying diameter. Three concentric circles for tree inventory and one excentric circle for regeneration evalutation were defined. Threshold tree D.B.H. for each circle was defined, too.

The investigated tree is tree with D.B.H. corresponding to concentric circle, which it is inside. The tree‘s position inside the plot is surveyed. Corresponding attributes are recording into database. If D.B.H. of a tree doesn‘t match its concentric circle parameters, it could not be registered. The threshold D.B.H. values were set empirically, based on done field experiences to harmonize diameter classes‘ representation in total sample of measured trees.

Described inventory system of concentric circles allows to react to growth capacity of site. Technically, work proceeds with three concentric circles, which have radius defined and varying limits of threshold D.B.H. Choosing the option of invenotry circles’ parameters (below) is to be set commissionally just before the field work‘s start. The capacity of site and prevailing forest site type(s) determinate an option.

Three options of inventory circles settings are defined (see Table 11):

Option A … low production capacity of site

Option B … middle production capacity of site

Option C … high production capacity of site

Table 11 – Parameters of concentric circles by the growth capacity of site

Radius / Area of concentric circles [m/m^2]	**Threshold D.B.H.** [cm] overbarked		
	A	**B**	**C**
2 / 12.5	< 7*	< 7*	< 7*
3 / 18.8	≥ 7	≥ 7	≥ 7
7 / 153.8	≥ 12	≥ 12	≥ 15
12.6 / 499.9	≥ 20	≥ 25	≥ 30

*) *regeneration circle* is set up to evaluate trees from 0.1 m of height and up to 7 cm of D.B.H. (overbark)

The smallest circles (radius of 2 m, area of 12.57 m^2) are set for regeneration findings to include regeneration individuals (up to 0.1 m or height, up to D.B.H. 6.9 cm overbark).

The circles with radius of 3 m (area of 18.8 m^2) are set for stem measurements with D.B.H. over 7 cm overbark.

The circles with radius of 7 m (area of 153.8 m^2) are set for stem measurements with D.B.H. of 12 cm and more overbark (options A, B) or 15 cm and more overbark (option C).

The largest circles (radius of 12.6 m, area of 499.9 m^2) are set for stem measurements with D.B.H. at least 20 cm (option A), 25 cm (option B), 30 cm (option C).

6 Registration of natural regeneration

Natural regeneration includes all trees from a height of 0.1 m and up to a diameter of 7 cm. Firstly, the plot must be divided into segments. Segments should be homogenous by the occurence itself, composition of species and maturity (vertical structure, diameter structure). By hands-on experience, the number of segments is limited up to three. Then the regeneration circle (radius of 2.0 m) used to be situated subjectively into each segment to get its best representation. Position of regeneration cirlce's centre must be surveyed and recorded into database.

Evaluation of natural regeneration is proceeded on the regeneration circle using the methodology (below). Finally, proportional reprepresentation of each segment on total area of plot can be finished.

Classifying individuals into regeneration classes is the basis of on regeneration circle based evaluation of natural regeneration. The class is defined by tree's height, species, possibly type of damage. Count of trees in a class, average diameter, average height, possibly the damage and damage's age and type are to be recorded for each individual class.

Table 12 – Evaluated and measured attributes within the REGENERATION layer

Attribute name	Field type	Unit
Origin	Lookup list	-
Distribution	Lookup list	-
Mixture of species	Lookup list	-
Segment proportion	Numeric	%
Height class of regeneration	Lookup list	-
Species	Lookup list	-
Average diameter	Numeric	cm
Average height	Numeric	m
Count of individuals	Numeric	-
Steps to protection	Lookup list	-
Type of damage	Lookup list	-
Age of damage	Lookup list	-
Count of damaged individuals	Numeric	-

7 Dead wood

All plots except unaccessable and impassable ones are under registration of dead wood. It should bring information about an extent of to natural decomposition left wood. Lying stems, their segments and stumps are observed.

Neither processed timber (e.g. benches, raised stands) nor recently felled timber ready to hauling are not included. But in forest forgotten timber or nontransported roadside stacks are not included.

Dead wood is classified into two categories:

1. Dead wood or its segments (chipped part of main stem) of a diamater up to 7 cm in the distance of 1.3 m from stem foot.
2. Stumps with a height of at least 30 cm.

Each of dead wood categoires is evaluated separately.

7.1 Lying stems (segments)

Lying stem is dead stem or its part with a diameter up to 7 cm in the distance of 1.3 m from stem foot, except standing dead trees (see Tree layer chapter). The accurate surveying of main stem shape is a neccessary step of lying stem evaluation. Position of all segments (fitting threshold diameter overbarked) should be surveyed if the stem was broken into pieces. Broadleaved tree has often low-lying start of

branching. It is difficult to determinate certainly main stem‘s shape. Usually the thickest or the most important (from the crown biomass point of view) branch is chosen and its shape is surveyed as a main stem‘s part.

Table 13 – Evaluated and measured attributes within the DEAD WOOD layer

Attribute name	Field type	Unit
Dead wood ID	Numeric	-
Position of a segment	-	-
Species	Lookup list	-
Windthrow	Lookup list	-
Stem status	Lookup list	-
Stem’s degree of decomposition	Lookup list	-
Origin of a segment	Numeric	-

7.2 Stumps

In the same way as dead wood, the stump enables important living space for insects and tiny fauna. The stupmps reached „layer diameter“ of 30 cm are surveyerd and registered on each plot. Species and origin attributes are filled up. The stools in the coppice (low) forest are not included. A stump has to be evaluated (and in Tree layer registered) as a stub if exeeds a height of 1.3 m or as standing dead tree, respectively.

Table 14 – Evaluated and measured attributes within the STUMPS layer

Attribute name	Field type	Unit
Stump ID	Numeric	-
Position of stump	-	-
Species	Lookup list	-
Origin of stump	Lookup list	-

8 Core area

Detailed forest ecosystem maping and its both horizontal and vetical structure‘s obsevering is realized on the core area. Core are is defined inside the area of interest (locality) everytime.

The most representative part of locality should be selected to define. Possibly, the part of locality with rare vegetation types‘ occurence could be included. Area of „the core“ is 1 ha. Rectanguar (square or rectangle) shape is considered for reasons of inside-locality navigation. If locality area and shape allow, square 100 to 100 m is an optimal shape of core area. In other cases, the rectangle shape is used (e.g. stripe-shaped floodplain forest stands).

These are the preconditions of core area‘s localization:

- **Reperesentativeness of core area**: Either the most representaive or the most important part of locality should be embraced in core area. Using map of forest site types, there is effort to locate core area into desirable (selected) forest site type.
- **Homogenity of core area**: Nature and both spatital and woody sturcture of forest stands covering core area should be similar. The best would be location inside one forest stand.
- **Accessibility of core area**: Relative accessibility of core area should be taken into consideration surveying the boundary. Non-propottional time of routine measurement could be spent choosing outlying or hard-to-get-at parts of locality.

- **Protection of core area**: Core area should be protected against the surrounding impacts with buffer zone of a width from 20 to 50 m.

Core area orientation depends on slope of a terrain. In case of flat land, the orientation is north – south. In case of a slope, the orientation respects the line perpendiculat to the countour.

9 Measuring on the transect

Transect should describe verical strucutre of both forest stand and terrain profile.

Vertical crown profile, horizontal crown projection, trees‘ slant, height of live (and dead) crown‘s height are to be measured on the transect.

9.1 Survey of transect axis

Transect axis represents the transect – it is surveyed directly in the field. Assistant conseguently puts the pole on vertices of an axis; operator surveyes them. Operator also checks appropriate drawing of the axis in field computer and orders the directional corrections.

The trancest axis is drawn parralel with longer core area‘s boundary. It passes through its center. Due to good visualisation of transect, the transect axis exeeds about 10 m both transect ends. Width of transect (depht of a view) is 10 m – 5 m on each side of axis.

The transect axis in neccessary to vizualize vertical crown profiles of the trees. With respect to its axial position in transect narrow, it divides transect into two identical halfs – left hand and right hand views. Views have depth of 10 m.

9.2 Measurement of stem slant

If inclination of a stem exeeds conventional angle, there is necessary to measure its slant. Assistant puts the position under top of measured tree well. Operator could survey the pole and slant angle could be calculated.

9.3 Measurement of dead crown

Height of crown bottom is an important attriute of transect. Height of live crown’s underneath is included in current measurement procedure (see Table 9). Unless the stem is a stub or a standing dead tree without obvious crown, height of dead crown’s underneath have to be surveyed. Operator realizes all measurements, assistant helps under the tree informing about details.

9.4 Measurement of crown projections

Both horizontal crown projection and vertical crown profile should be measured for each live tree inside core area and situated up to 5 m from transect axis.

Horizontal crown projection means a sequence of vertices which pass well horizontal projection of crown on terrain. Assistent finds these vertices. Operator records the pole’s positions and checks building up shape of a crown.

Constructed vertical crown profile allows to give true picture of crown‘s shape. Operator consequently collects vertices of side projection of a crown and checks its shape with no support of assistant.

To keep true draw of vertical crown profile, the direction of measurements may not exceed angle of +/- 10 degrees from perpendicular direction to transect axis.

If the measurement of all transect elements (see 9.2, 9.3) are completed, crown projections could be displayed correctly.