



# National Forest Inventory (NFI) in Slovak Republic



- description and design of the NFI system, legislation framework, problems in using NFI data, lessons learned, planned NFI upgrade

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# Slovakia – historical stand-wise vs. modern sample-based inventory

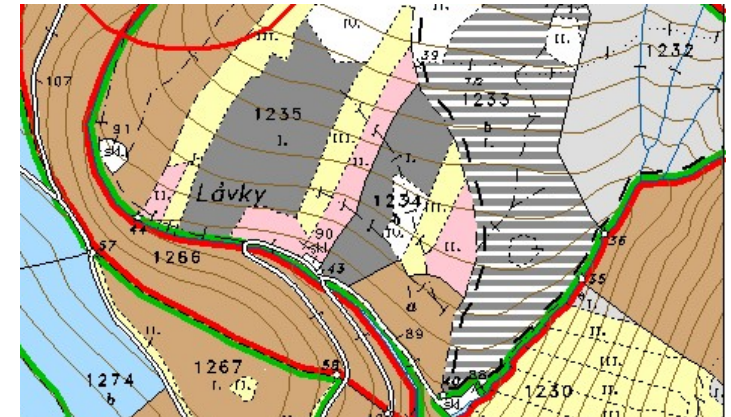
- **Stand-wise inventory**

- long history – long-term data available (after WW2)
- Aims at providing a guideline for forest managers at forest district and compartment level (forest stand) – forest management plans
- 1/10 of total forest area being assessed every year (so it takes 10 years to collect data for whole forest area in Slovakia)
- Data are sum up to provide national forest statistics and satisfy international reporting
- **Unknown precision** (theoretical  $\pm 5-25\%$  for volume on stand level)



- **Sample-based inventory**

- The first cycle NFI SR in 2005-2006
- 2-yr period for data collection in whole forest area of Slovakia
- Includes forests outside forest land classified as forest according to Slovakian cadastre (compare to stand-wise)
- Includes large bunch of assessed variables



**Known precision** (expected for area  $\pm 1.0\%$ , for volume per hectare with the error  $\pm 1.8\%$ )



# Preparation of Slovak NFI



- prof. Ing. Štefan Šmelko, DrSc. – „the Father“ or founder of Slovak NFI
- Preparation – year 2004; realization 2005-2006; we inspired from NFI of central european countries– Switzerland, Austria, especially Czech republic (NFI 2001-2004)
- Suggest more alternatives grid density from 1x1 km to 16x16 km- balance between costs and precision of results
- The sampling design should have to reach the precision of  $\pm 1.0\%$  for forest area at national level,  $\pm 1.8\%$  for growing stock per hectare, and  $\pm 2.1\%$  for total growing stock in the forest area
- Results serve primarily for whole country, and regions with height forest cover



# Aims and added value of NFI

- To provide information at national and regional level (compared to stand-wise inventory) in a timely, accurate and reproducible manner
- To monitor changes in forests and its development
- To provide data for international reporting (Forest Europe, Forest Resource Assessment)
- To provide large spectrum of data at national scale to support forest research

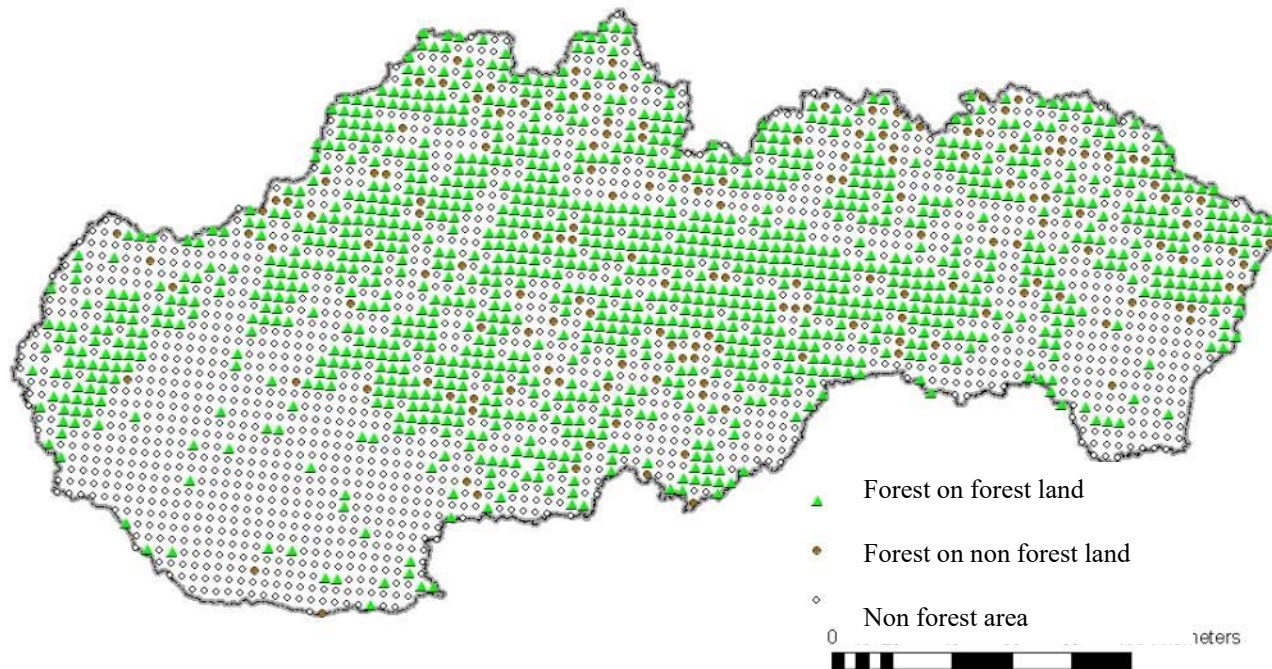
## Decision

- The decision to realize the NFI SR was made by the Ministry of Agriculture of the Slovak Republic (2004)
- Steering committee of the NFI SR established in the Forestry section of the Ministry of Agriculture
- From several proposals the committee selected the variant with 2-year field inventory 2005–2006 on the base of sampling methods in the grid of 4×4 km – 1 inventory plots represents approximately 1,600 ha).
- The „cheapest“ statistical inventory, but relatively sufficient precision
- 10-year interval between consecutive cycles
- 2015-2016 is realized field survey of NFI II.



# Design of NFI

- Combined aerial-terrestrial sampling method with a systematic distribution of sample units over the whole country (grid 2x2 km, 4x4 km)
- 2 years field data collection, 10 years interval between cycles
- Forest land, which are registered in the cadastre, as well as forests on non-forest land (agricultural or other land).



Zagreb, 1-2. june 2016

# Forest definition – NFI 1

The plot was considered to be a “forest plot”, when it met the following criteria of the definition:

- Tree species were growing on the plot,
- The area exceeded 0.5 ha with a minimum width of 20 m,
- The canopy closure exceeded 20 %,
- The potential height of tree species *in situ* was greater than 5 m (except for mountain pine *Pinus mugo* – we consider mountain pine stands as forest).
- **NFI 2** – modified to FAO Definition (canopy closure over 10%)



# Organisation NFI

- **Forest Research Institute** in Zvolen was authorized to prepare the methodology and to realize the NFI (1) of Slovak republic
- In 2004, a special working team called “Management Centre of the NFI SR” and the “Methodological and Technical Board of the NFI SR” consisting of forestry and ecology specialists from the relevant institutions in Slovakia were established.
- Owing to the restricted temporal and financial capacities, the NFI SR was performed simultaneously as a pilot project and as its practical realization
- In 2006 – creation of **National Forest Centre** in Zvolen – joining of Forest research Institute, Forest Management Institute and Institute for forest education – responsible for NFI is NFC
- Field survey – 5 working groups (selected from Forest management Institute staff, private taxatory agency, NFC staff)
- 1 control group (visited and re-measured 5-10% of established IP)

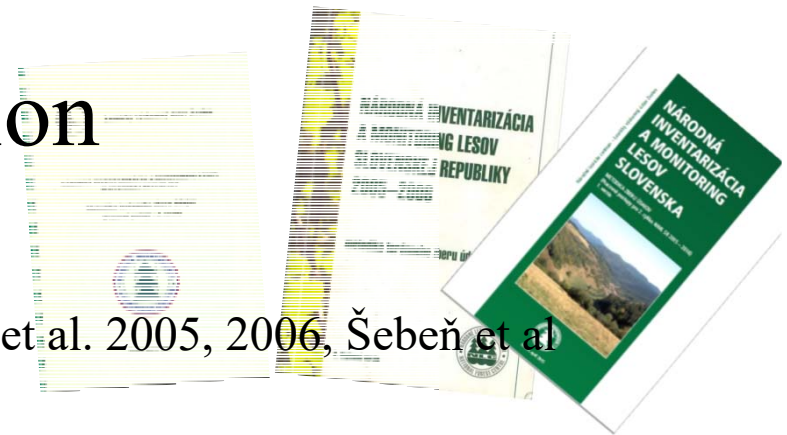


# Aerial inventory

- The aerial inventory was performed as a visual interpretation of orthophotomaps (Geodis–Eurosense, 2002 with the resolution of 1 m, Geodis-Eurosense 2011-2013; 0,5 m).
- The sampling units were the circular plots of the size 2,500 m<sup>2</sup> distributed in the grid of 2×2 km; in total 12,267 plots were inventoried in NFI1, 12,258 in NFI2 (improved precision of base data)
- Primarily used for the classification of Forest/Non-forest area, as well as a support for the orientation and navigation in the field
- The combination of terrestrial and aerial inventory reduced the sampling error of the forest area by more than one half.



# Field data collection



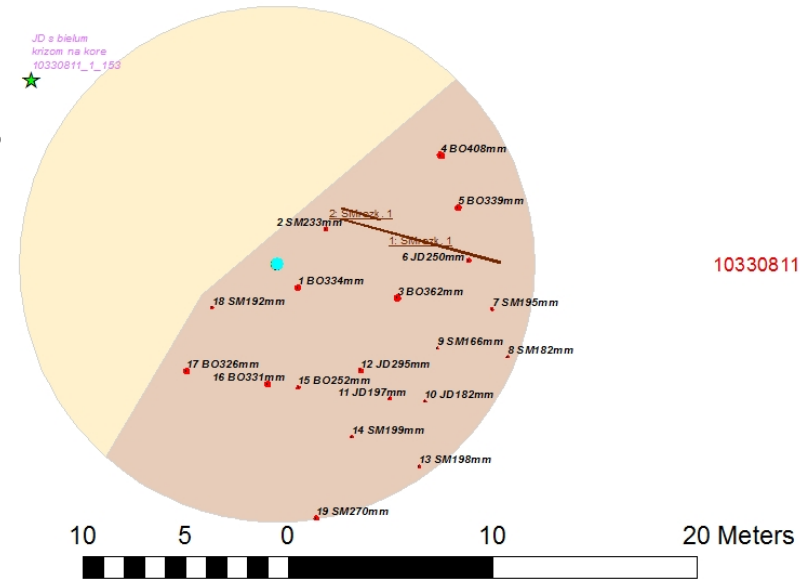
- A detailed guidelines – working manual (Šmelko et al. 2005, 2006, Šebeň et al 2015) - detailed practice for fieldwork
- 5 inventory crews, each consisting of 2 or 3 members
- Time of field survey - April 2005-November 2005, April 2006-October 2006
- Mai 2015-November 2015, April 2016 – September (? - planned) 2016
- Of course all NFI field staff participated every year in one-week training.



# Invisible plots

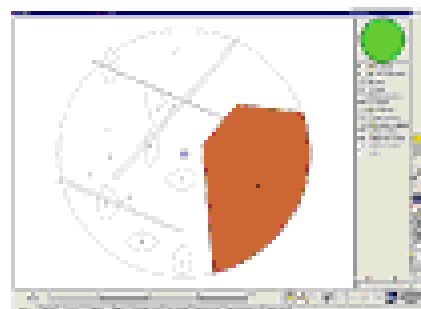
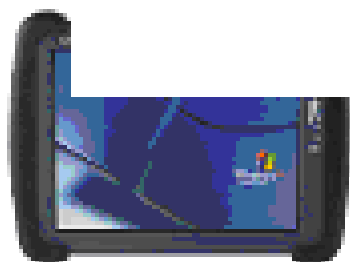
- Inventory plots were fixed in terrain permanently but invisibly – prevention of commercial or other influence
- To next find inventory plots we used localization of centre point (metall detector) sample trees (Field-Map technology)

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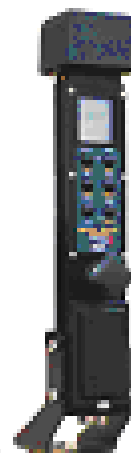
# Equipment in 1<sup>nd</sup> cycle Field-Map technology (IFER, CZ)

Field computer  
Hammerhead RT800



Field-Map

Digital compass  
MapStar II



Laser range finder  
Forest PRO



computerbased  
Technology (IFER  
1992–2015)  
supplemented with  
the  
GPS navigator





# Equipment in 2<sup>nd</sup> cycle Field-Map technology (IFER, CZ)



In 2015 we rebuilt Field-Map (Instrument innovation)  
Electronic caliper  
More accurately GPS  
Simplified Computer and  
rangerfinder



# Field-data collection

consist of follower steps – navigation, localization, measurement of dendrometric parameters, data survey



# Design of inventory plots

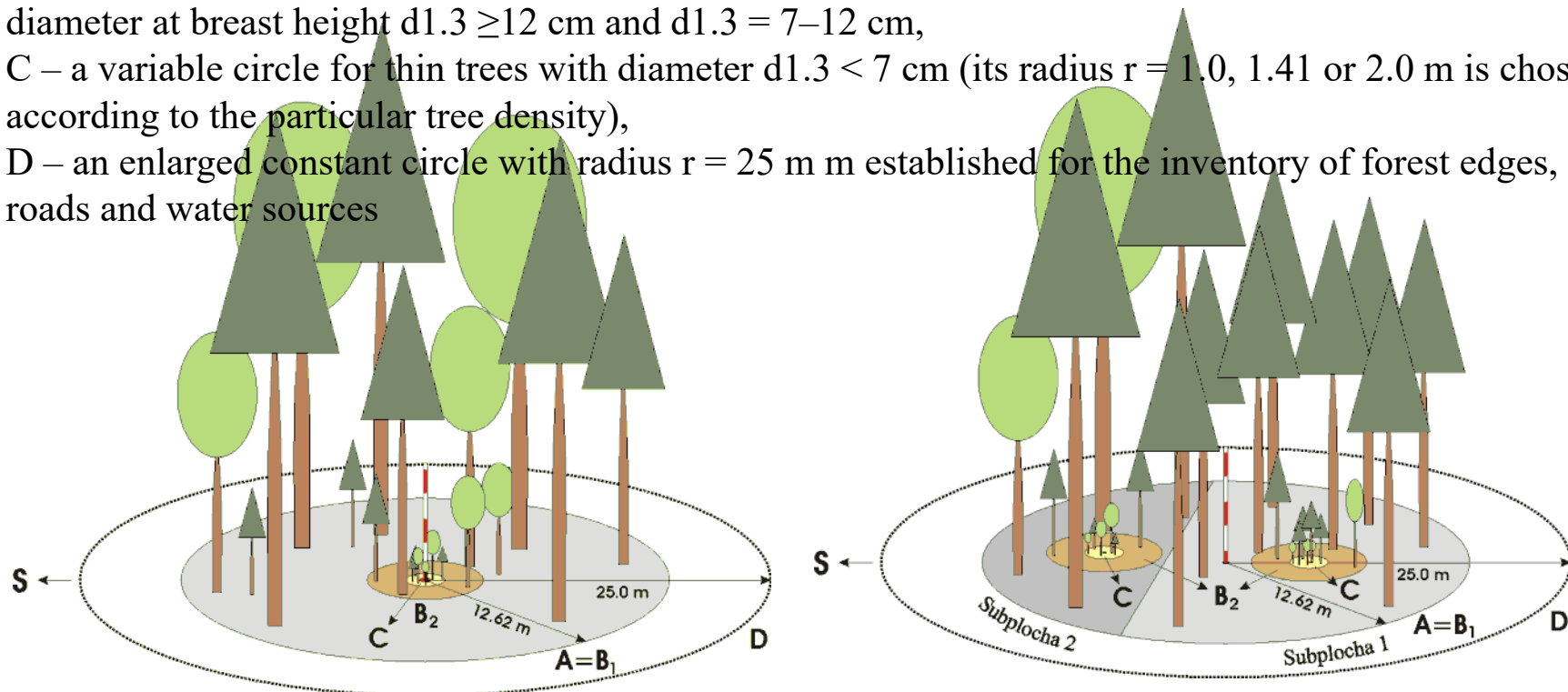
4 Type of plots - Ground inventory plot (A, B, C, D),

A – a constant circle with radius  $r = 12.62$  m on which terrain, site, stand, and ecological characteristics are assessed and lying deadwood and stumps are inventoried,

B1 and B2 – two concentric circles ( $r = 12.62$  m and 3 m) for detecting tree characteristics of trees with diameter at breast height  $d_{1.3} \geq 12$  cm and  $d_{1.3} = 7-12$  cm,

C – a variable circle for thin trees with diameter  $d_{1.3} < 7$  cm (its radius  $r = 1.0, 1.41$  or  $2.0$  m is chosen according to the particular tree density),

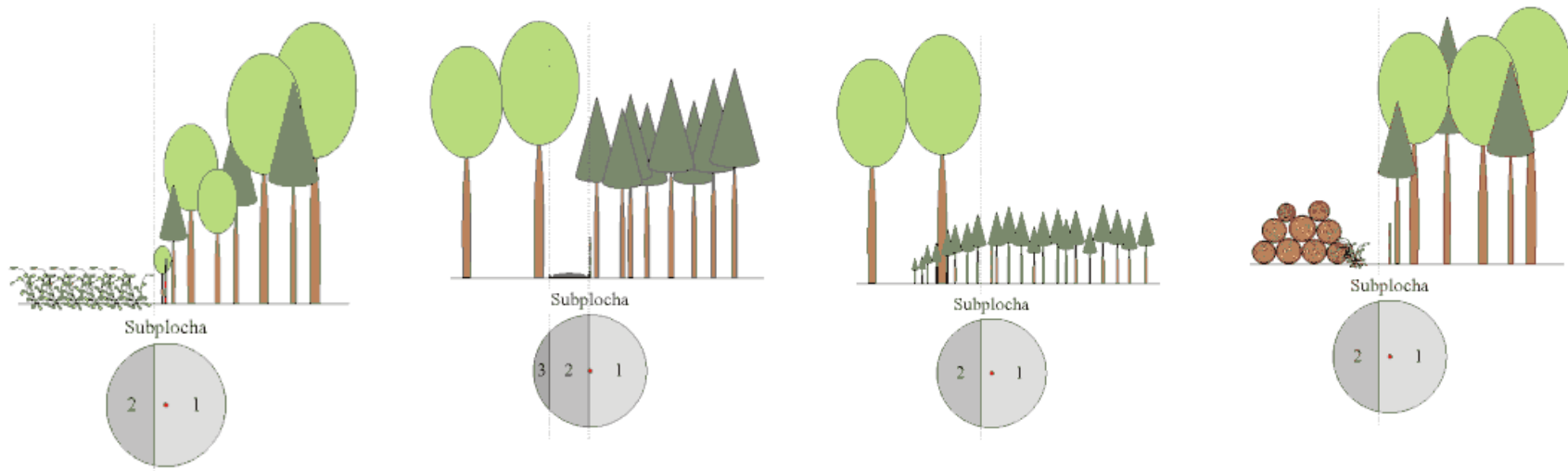
D – an enlarged constant circle with radius  $r = 25$  m established for the inventory of forest edges, forest roads and water sources



a – homogenous, b – divided into two sub-plots (in a case of non-homogenous forest stand or on bounds or forest edges)



# Decision for plot partitioning - examples



Forest/Non forest

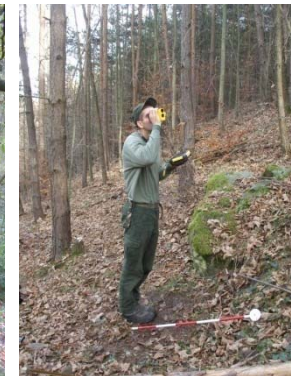
Different growth stage beside each other

Different species beside each other

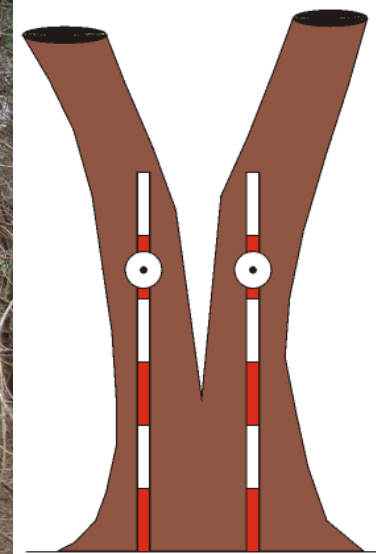
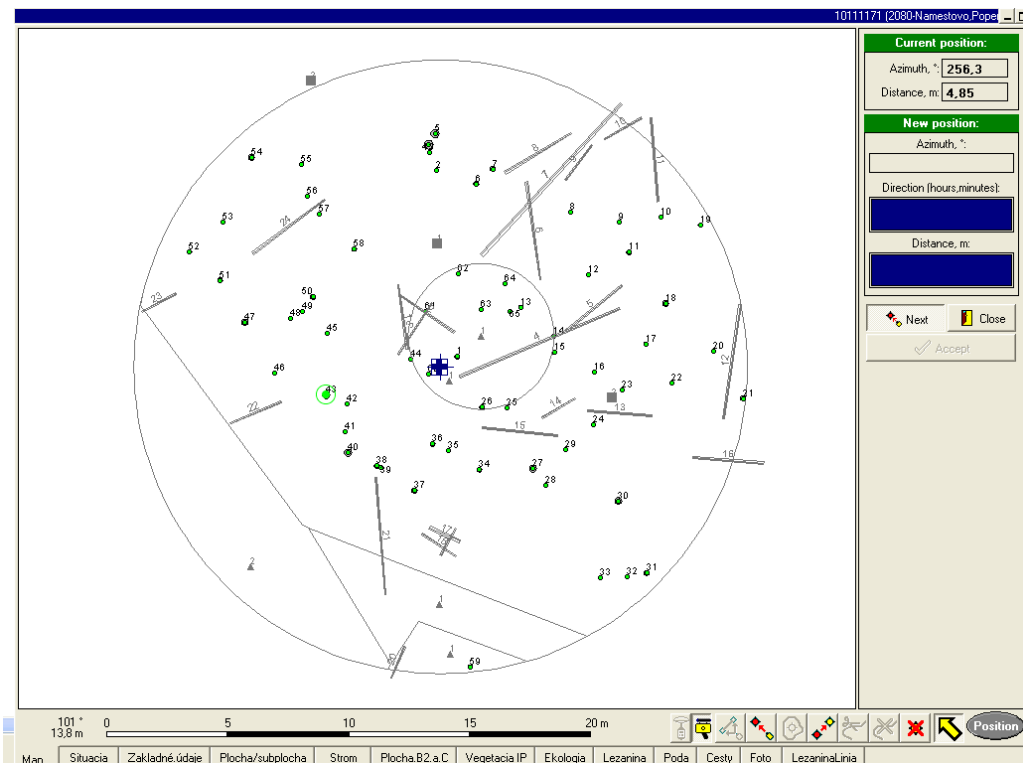


# About 100 parameters and attributes were sampled, for instance:

- Tree characteristics (species, dbh, height, crown, stem damage, crown density, stem quality, etc.)
- Stand characteristics (age, species proportion, stand structure, silvicultural and quality status of stands, forest regeneration, etc.)
- Site and ecological characteristics (soil, forest, function type, degree of naturalness, risks, ecological stability, biodiversity, deadwood, forest edges, etc.)
- Other characteristics (length, density and state of forest transport network, frequency and parameters of water sources and streams, etc).



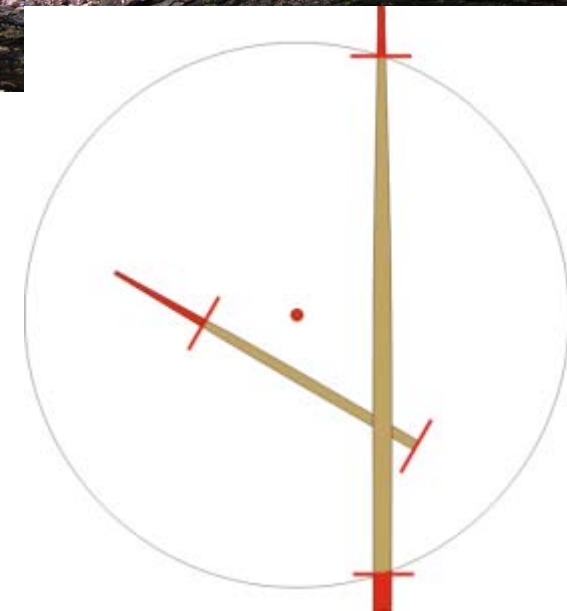
# Measurement of tree position



Forest Inventory Workshop,  
Zagreb, 1-2. june 2016

# Coarse deadwood measurement

Coarse woody debris : >7  
cm at the thinner end,  
on whole IP

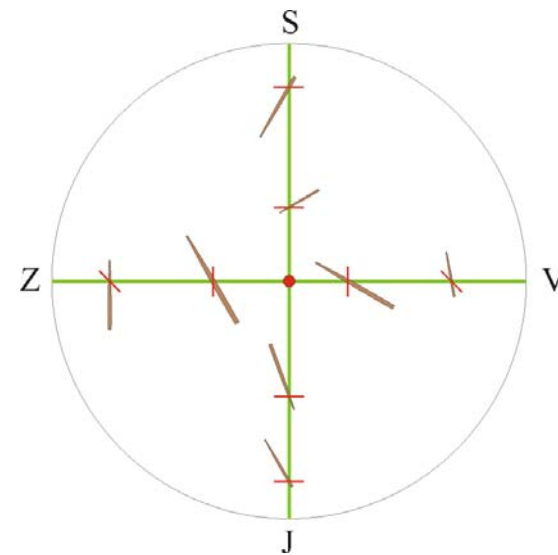
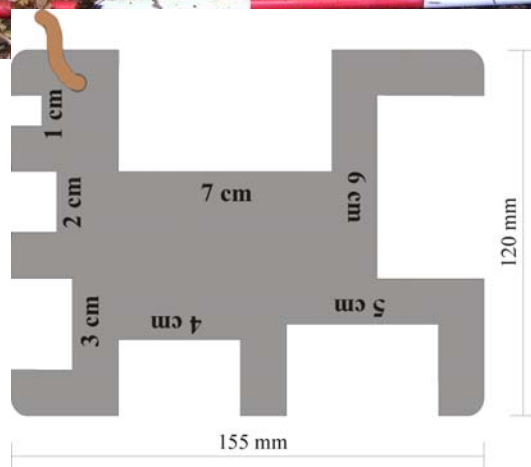


# Small deadwood (1-7 cm)

2 methods – visual assessment (easy; with lower precision) and line intersect sampling (more precision but lower sample)

$$V (m^3) = A * p(t)\% * v(t)/m^2 * p(dr)\%$$

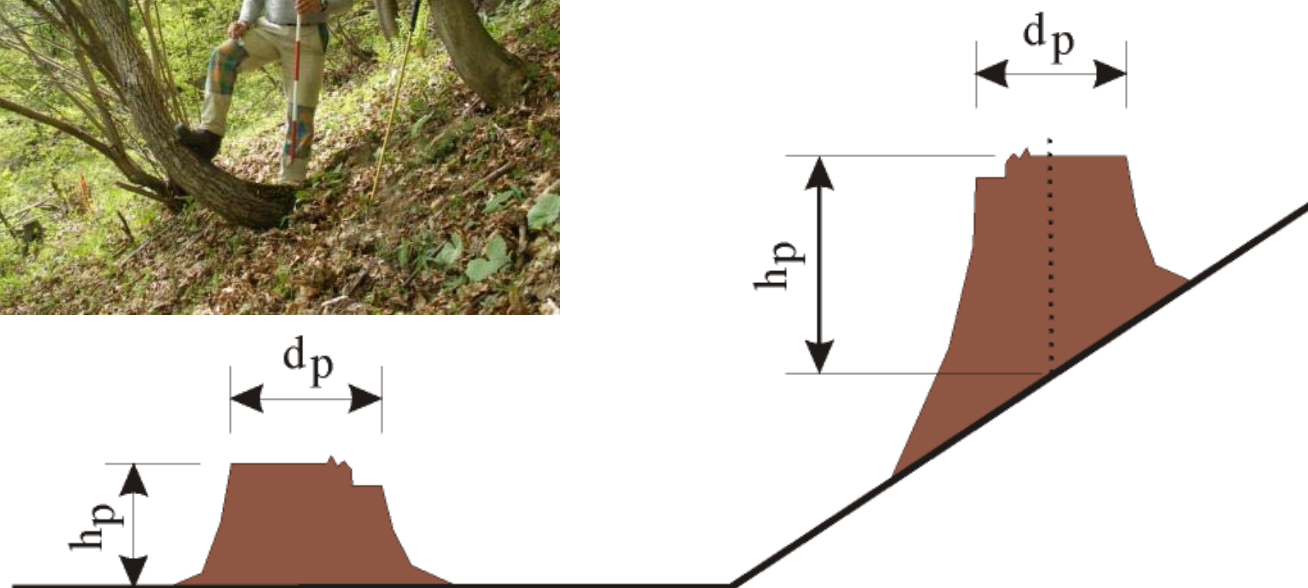
$$v(t)/m^2 = 0.0039 * D_s * 1.4195$$



Forest Inventory Workshop,  
Zagreb, 1-2. june 2016

# Deadwood - stumps measuring

- As a component of deadwood (thinning, cutting)
- Identification of cuttings
- Conifers  $v(m^3) = 0.724703 * D^2.014485 * H^1.02642 / 1000000$
- Broadleaved  $v(m^3) = 0.46533 * D^2.094175 * H^1.060645 / 100000$

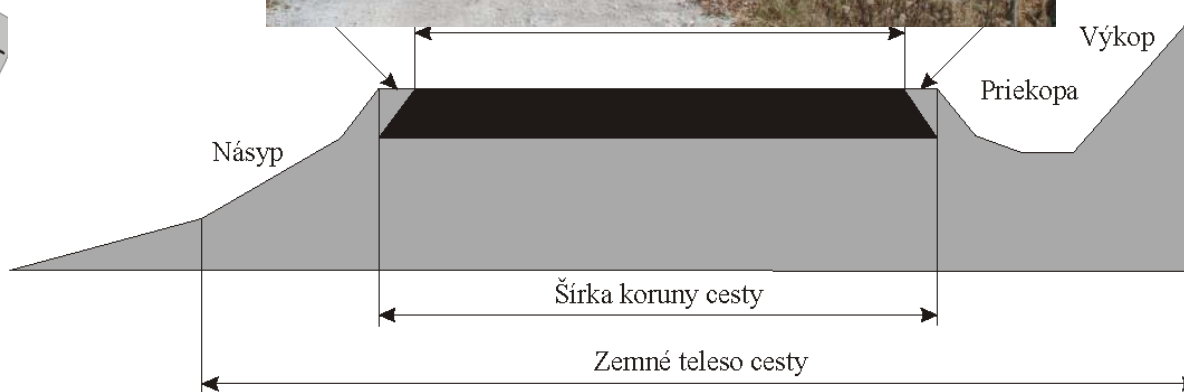
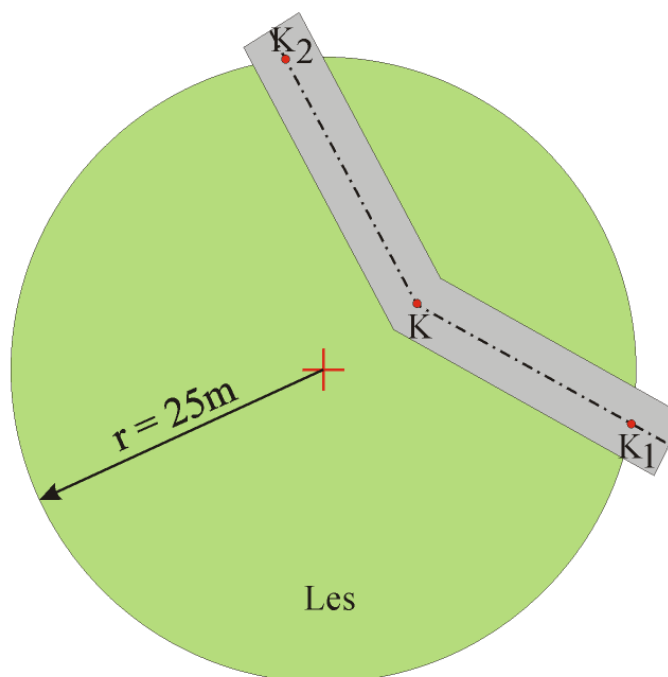


# Deadwood - decay degree

4 classes – from hard to decomposed



# Density and quality of forest roads, forest edges, water sources,...



# Soil sample

- Estimation of soil and ecological properties
- Chemical analysis of C, N%, pH



# Data post-processing

- 1) After data collection - data analysis, verification, and completion
- 2) Calculation of the so-called derived variables for trees and inventory plots
  - Data processing from the combined assessment estimation/measurement,
  - Completion and verification of volume equations for main and related tree species,
  - Assortment calculation
  - Quantification of deadwood
  - Assignment of the tree growth area to the trees
  - Age structure
- 3) Generalisation of data obtained from inventory plots to higher regional units



# Legislation framework

- According to Forest Law No. 326/2005, § 46 Z.z., National forest inventory „is surveying and evaluating of selected quantitative and qualitative forest status parameters in choised time moment. It is realized by sample based inventory methods on temporary inventory plots. Monitoring is periodic repeating of NFI cycle. Monitoring makes it possible to compare forest status and observe their trend. It is realize on permanently inventory plots.“
- § 58 of Forest Law 326/2005 Z.z., letter i), „Agriculture government department, as a central autorhity of forest state administration, direct realization of NFI“
- § 66 of Forest Law 326/2005 Z.z., letter e), „Agriculture government department give a binding instruction, in them constitute circumstances about process of realization of NFI“



# Problems in using NFI data

- In annual reports of Slovak forests mostly are used data from FMP (for instance too in last State of Europe's Forests 2015)
- FMP – continuals data updating – every year, 10% of forest area (only forest land from cadastre)
- NFI – 10 years interval
- Up to now (second cycle of Slovak NFI) we haven't information about changes obtained from sample based inventory (increment, felling)
- After processing of data from NFI 2 we suppose more utilization of all data
- Actual problem – growing stock - difference between FMP – NFI +23,7% of average volume per hectar - difference could have been expected and results from several factors (aggregated data from the sources that are differently actual (1–10 years); mean stand variables (mean height and mean diameter), yield tables are used as input; stand volume of the secondary crop is not recorded; increment during the current period (1 to 10 years) is not accounted; a subjective factor plays an important role (number of plan-makers with a different level of experience and confidence).
- Forest area (from cadastre) is in consistency – NFI found +14% forest on non forest land



# International collaboration

- European National Forest Inventory Network (2003)  
NFI SR became a member in 2006
- Participation on EU funding:
  - COST Action E43 (2004-2008)
  - COST Action FP1001 (USEWOOD) (2010-2014)
  - Framework contract for the provision of forest data to European Data Centre (supported by Joint Research Centre under EK)
    - Species distribution (basal area estimations) in Europe
    - Species biomass in Europe
  - Project DIABOLO (Distributed, integrated and harmonized forest information for bioeconomy outlooks) – 2015-2019



# Planned NFI upgrade

- NFI I. was realized in 2005-2006
- Now is realized NFI II. 2 - 2015-2016

Monitoring mechanism – requires same (identical) methods for comparison of forest parameter changes; it must be ambition for minimal changes

- Upgrade of NFI II. – we find the first time to real changes (ingrowth – mortality – felling) by sample-based inventory
- Actualization and little modification of information spectrum (new requirements, height precision, lower survey costs)
- Actualization and modification of survey methodic (technical of repeated measurement, finding of same inventory plots)



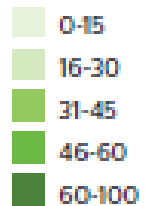
# *Some selected results*

## *Forest area*

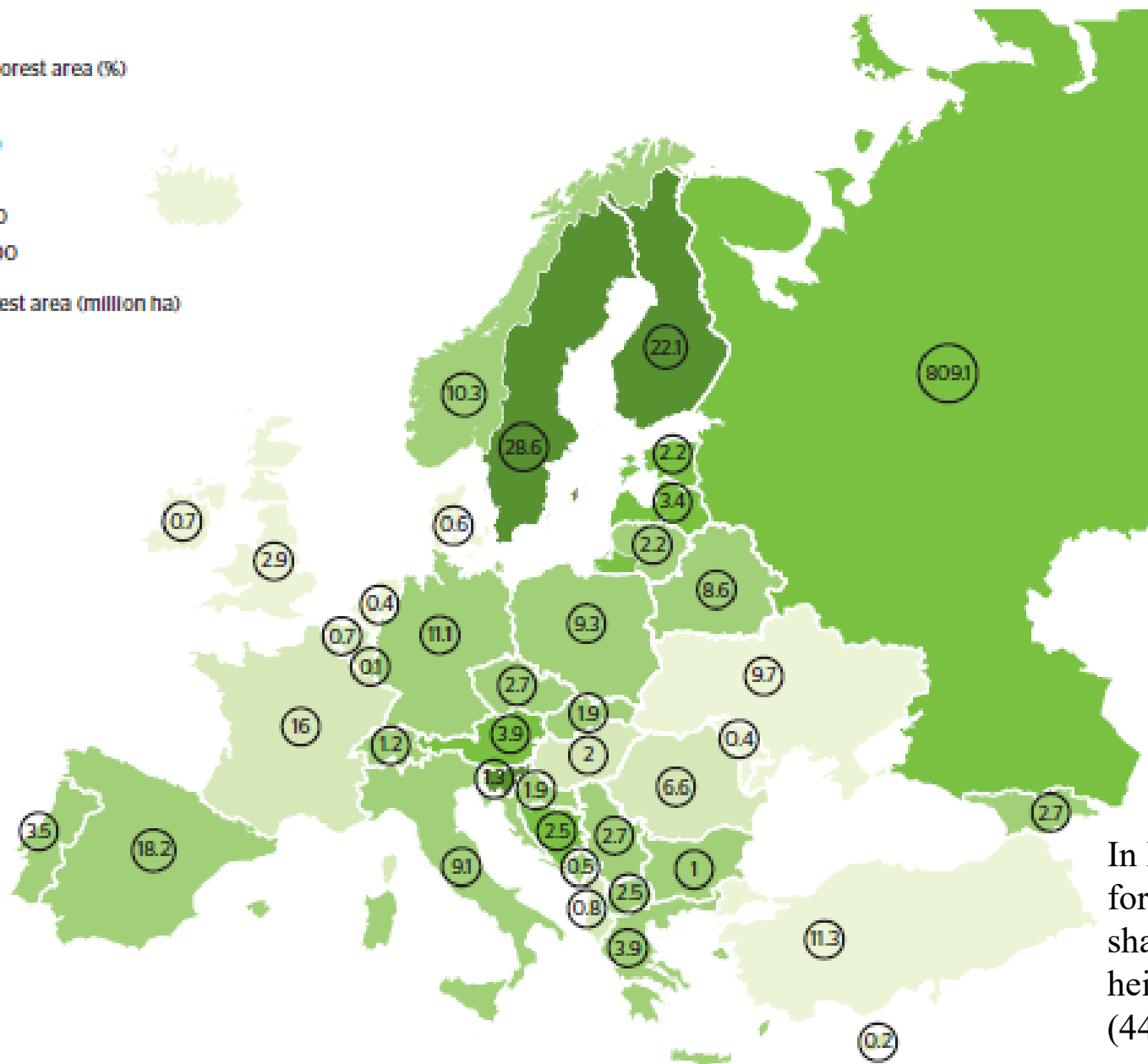
- Forest area of over 2.17 mil. ha ( $\pm 1\%$ ).
- Forests on non-forest land (e.g. agricultural land covered by trees) cover around 275 thousand ha ( $\pm 3.7\%$ ), which is several times higher than so far estimations.



Share of forest area (%)



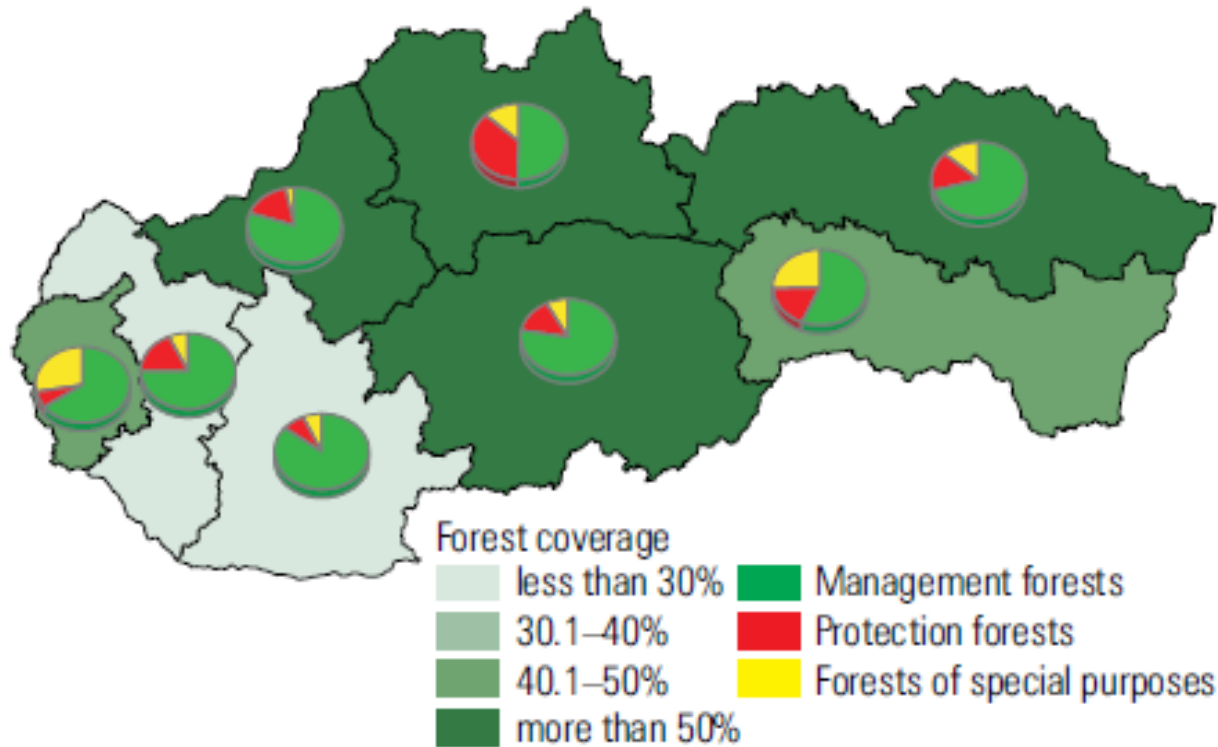
3.5 Forest area (million ha)



In Europe – Slovak forest has a little share, but relatively height forest cover (44,3%)



# Forest categories



**Management forests prevail (> 70%).**

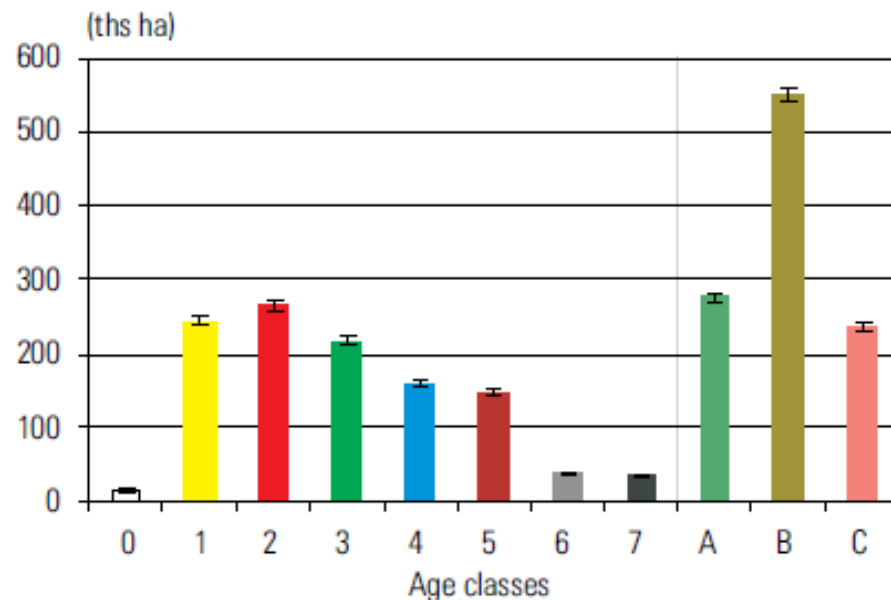
Protection forests (17%), managed in order to sustain and enhance their ecological functions (above all soil protection and water management roles)

Forests of specific purposes that preferentially fulfill public services (spa and therapeutic function, recreation, research and education, hunting, nature protection, etc.) exceeds 12%.

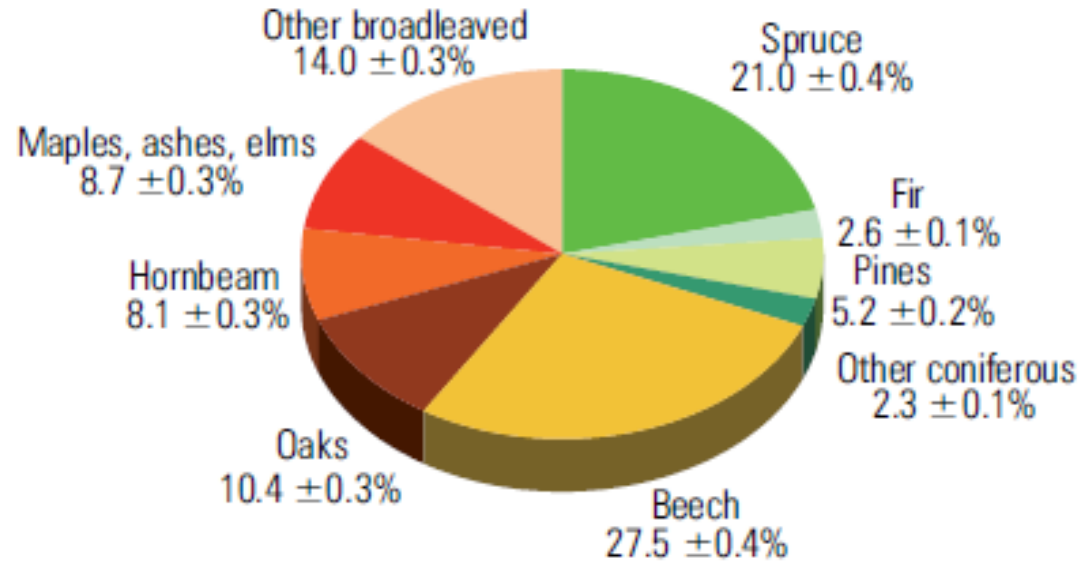


# Age structure

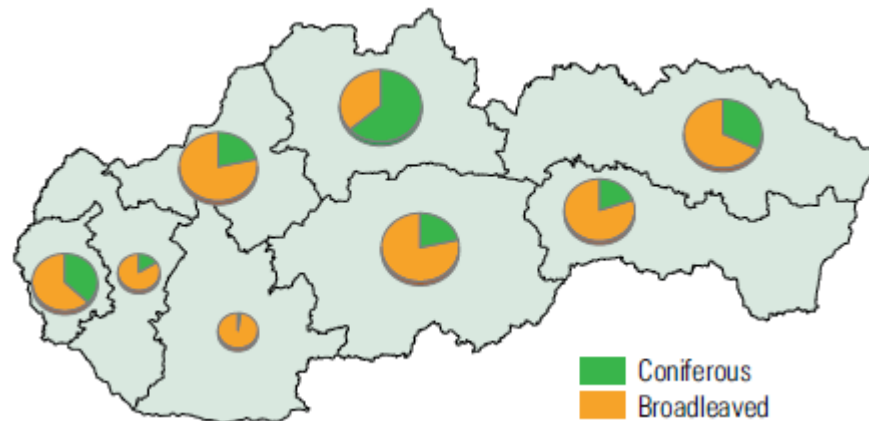
- To determine the age is in general a very complex task – un-even aged forests, different approach was applied: even-aged single-storied stands were classified into age classes, while for uneven-aged stands three new classes were introduced:
  - A – younger uneven-aged (younger than 60 years),
  - B – older uneven-aged (stands older than 60 years), and
  - C – two-storied regenerated stands with the parent stand and the regeneration below.



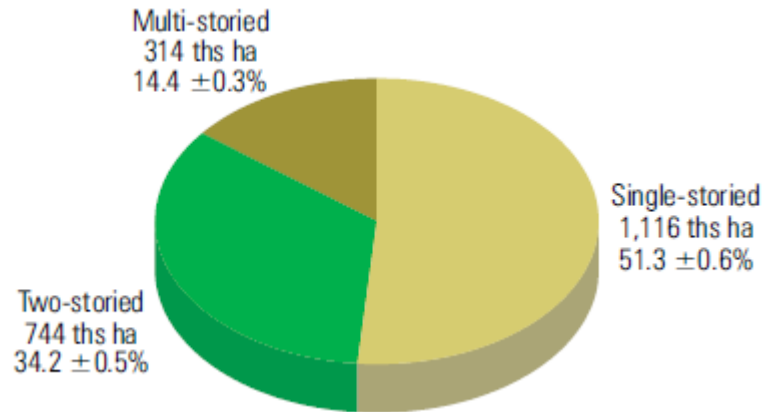
# Tree species composition



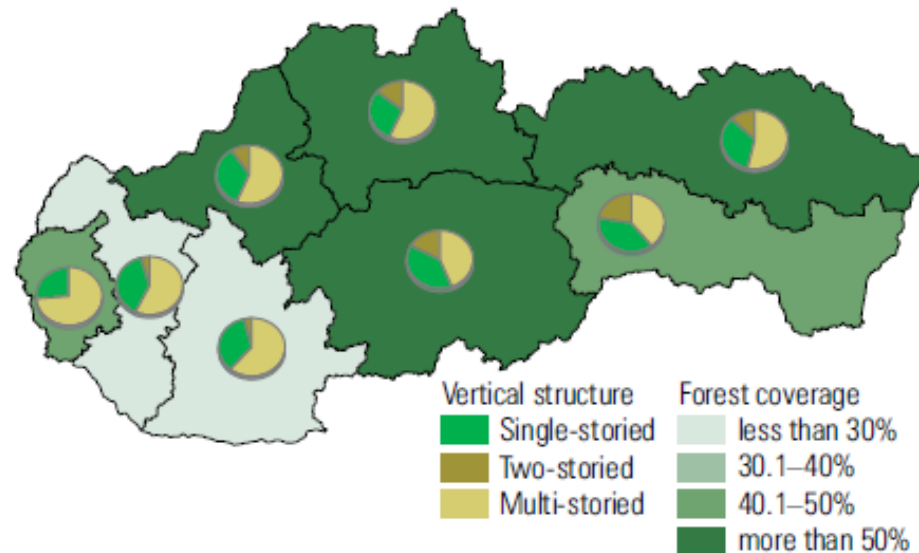
Broadleaved forests dominate (they cover approximately 50%), while pure coniferous stands (with the proportion of coniferous tree species equal to or greater than 90%) cover only 20%.



# Vertical structure



Does not coincide with the published information from stand –wise inventory (single-storied stands cover 80%).



# Stand volume, quality and assortments

Volume unit	Abbrevia- tion	Value m <sup>3</sup> /ha	Error	Ratio to HBK
Stem inside bark	KBK	252.6	± 4.9	0.96
Timber to the top diame- ter of 7 cm inside bark	HBK	264.2	± 5.2	1.00
Stem outside bark	KSK	282.4	± 5.3	1.07
Timber to the top diame- ter of 7 cm outside bark	HSK	295.9	± 5.7	1.12
Tree outside bark	SSK	331.0	± 6.1	

stand volume in the following units:

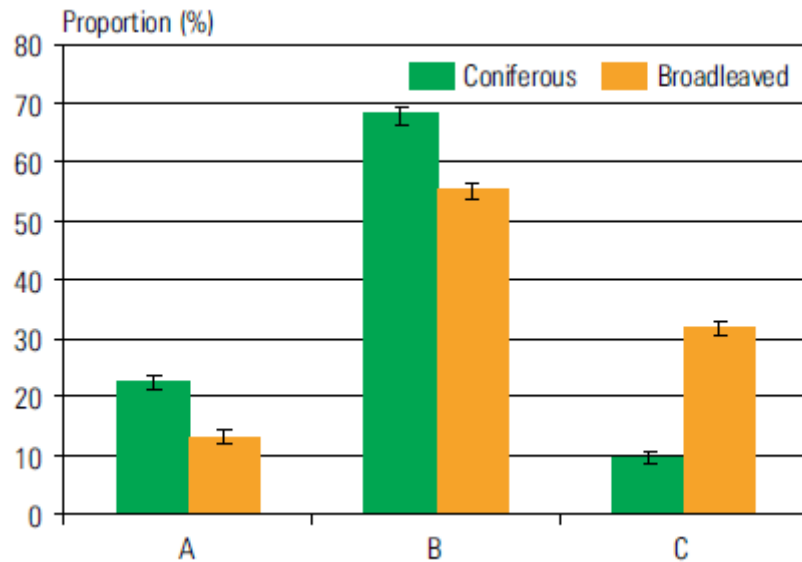
- timber to the top diameter of 7 cm inside bark (HBK),
- timber to the top diameter of 7 cm outside bark (HSK),
- stem inside bark (KBK),
- stem outside bark (KSK),
- tree outside bark (SSK).

Growth stage RS	Stand volume per hectare			Total stand volume			Proportion %
	current	standard. m <sup>3</sup>	error	value	from million m <sup>3</sup>	to	
0+1+2	0	0	± 0	0.0	0.0	0.0	0
3	0	5	± 1	0.5	0.4	0.6	0
4	2	52	± 5	5.1	4.6	5.6	1
5	12	128	± 7	26.9	25.5	28.3	5
6	34	254	± 8	75.0	72.4	77.6	13
7	33	408	± 15	70.9	68.3	73.6	12
8	22	507	± 26	46.8	44.3	49.3	8
9	12	579	± 48	25.4	23.2	27.5	4
A	4	76	± 7	8.7	7.9	9.5	2
B	104	318	± 7	226.1	220.3	231.8	39
C	41	378	± 15	89.1	85.5	92.7	16
<b>Total</b>	<b>264</b>	<b>264</b>	<b>± 5</b>	<b>574.4</b>	<b>562.4</b>	<b>586.5</b>	<b>100</b>

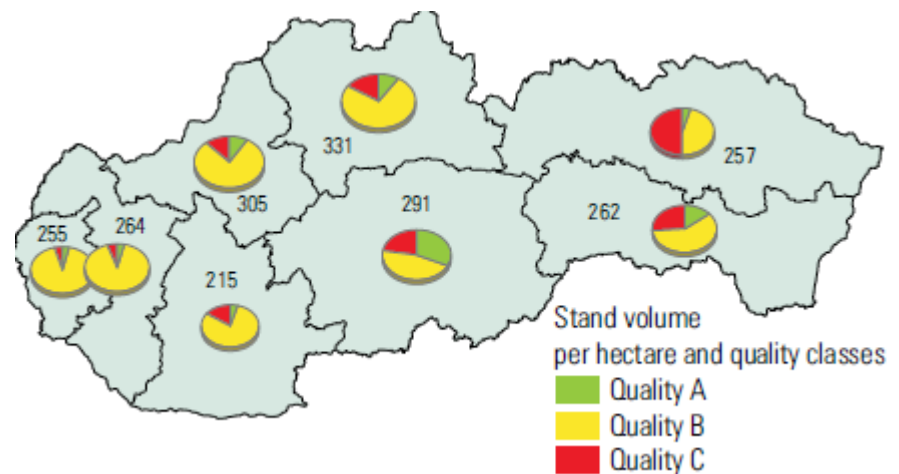
0 – clearing, 1+2 – natural seeding, advanced regeneration, young plantation, 3 – thicket, 4 – small pole stage, 5 – pole stage, 6 – small-sized large-diameter stand, 7 – medium-sized large-diameter stand, 8 – large-sized large-diameter stand, 9 – very large-sized large-diameter stand, A – inflexible growth stage (below 20 cm), B – advanced mixed growth stage (above 20 cm), C – regenerated stand



# Quality classes assessed in the field

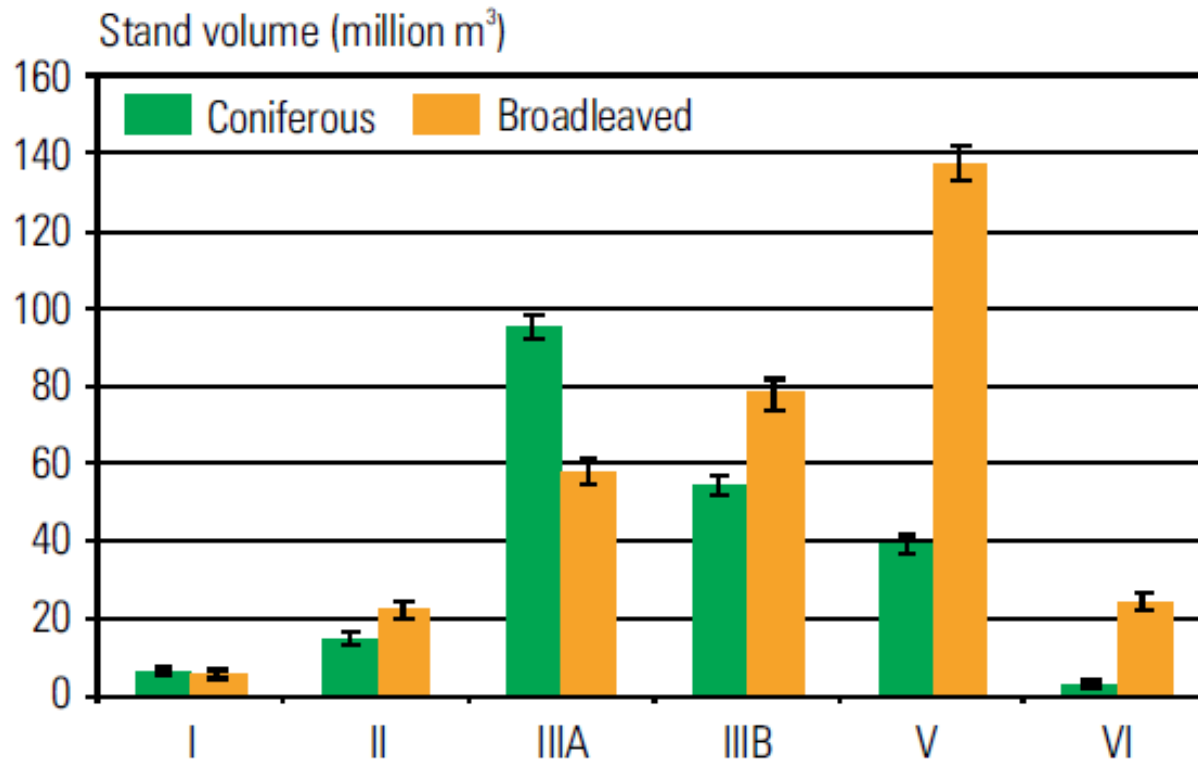


informs about the potential and the real utilisation of standing timber (timber of standing trees)

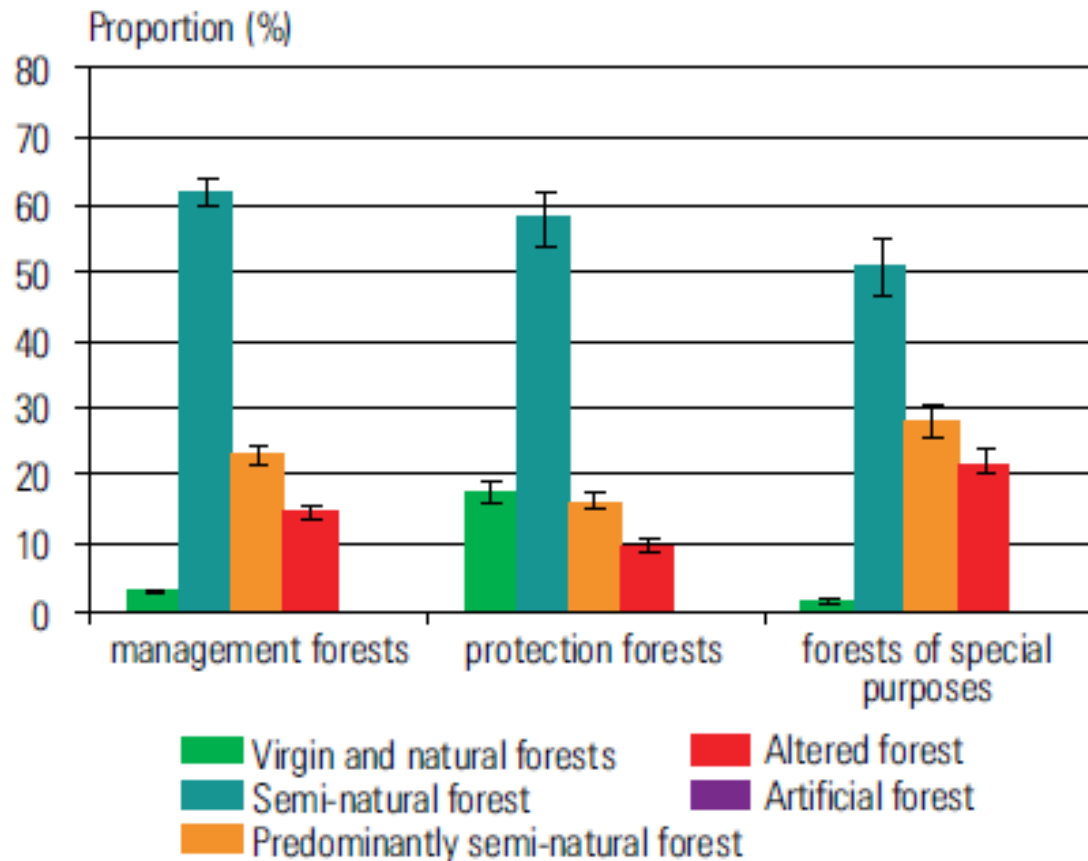


# Timber assortments (Log grades)

An assortment model developed in the past was used for this purpose



# Forest naturalness

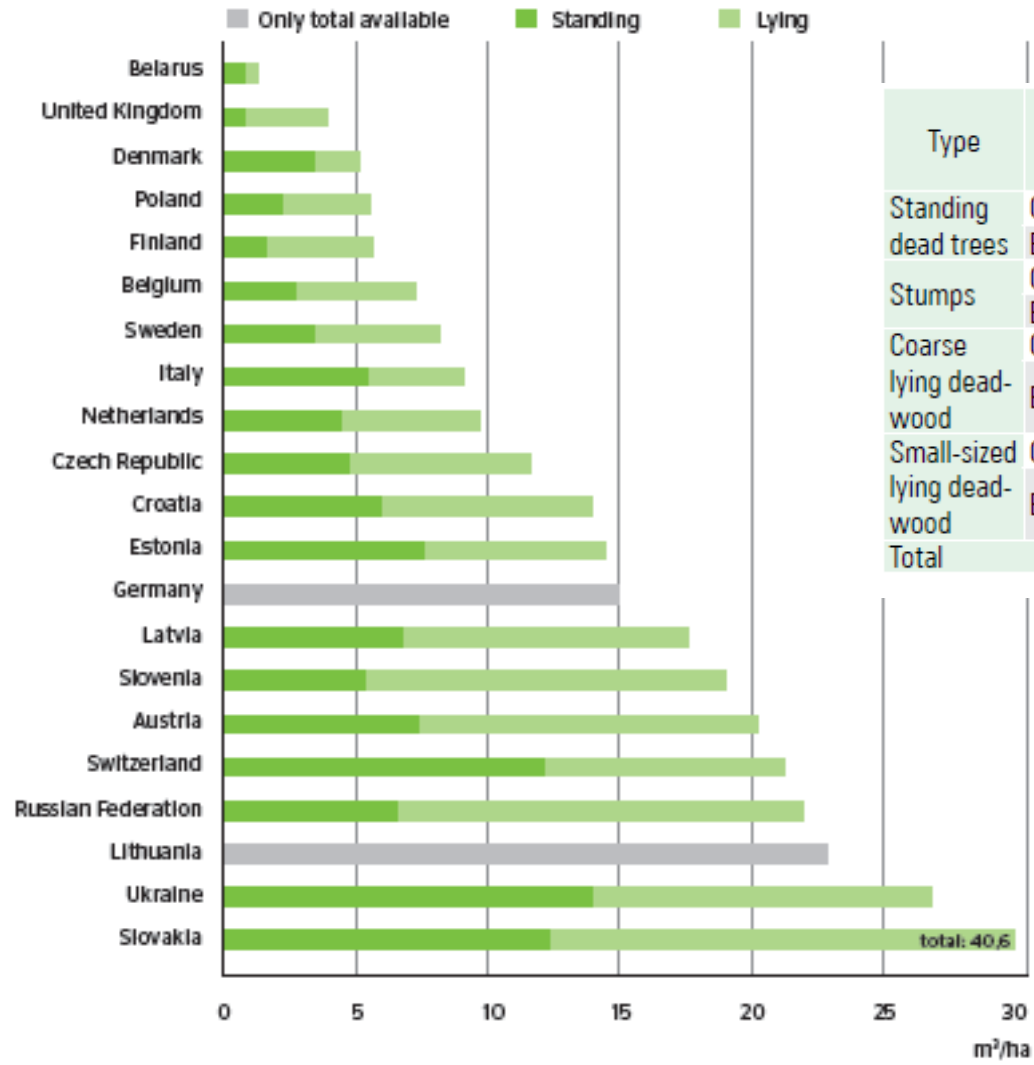


The naturalness degree represents the level of approximation of the natural status in the given site conditions by the current stand condition



# Deadwood

## State of Europe's Forests (2011) – Deadwood - average volume



Type	Tree species	Volume	Error	Total volume	from	to	Proportion
		m³/ha					
Standing dead trees	Coniferous	4.1	± 0.3	8.8	8.0	9.6	11
	Broadleav.	2.2	± 0.2	4.7	4.3	5.1	6
Stumps	Coniferous	3.0	± 0.1	6.4	6.1	6.8	8
	Broadleav.	2.2	± 0.1	4.8	4.6	5.1	6
Coarse lying dead-wood	Coniferous	9.8	± 0.7	21.3	19.8	22.7	26
	Broadleav.	8.0	± 0.4	17.3	16.3	18.3	21
Small-sized lying dead-wood	Coniferous	3.2	± 0.2	7.0	6.5	7.5	9
	Broadleav.	5.2	± 0.3	11.4	10.8	11.9	14
Total		37.7	± 2.1	81.9	77.3	86.6	100

?  
 Not most deadwood amount, but most detail inventoried (from 1 cm diameter)



Thank you for your attention

