Chapter 40
Slovakia

Michal Bošeľa and Vladimír Šebeň

40.1 The Slovakian National Forest Inventory

40.1.1 History and Objectives

In the Slovak Republic there are two primary information sources about forests: (1) stand-wise inventory—forest management plans (FMP) and (2) National Forest Inventory (sample-based inventory in a regular grid) (NFI). FMPs have a long history and have served as the basis for sustainable forest management in Slovakia. They are created periodically, on a 10 year cycle for total forest area registered in the cadastre as forest land. Only 10 % of the total forest area is inventoried per year, hence annual information on forest status does not reflect the status of the total forest area. Using the FMP, information on forest status at national level is provided by a simple summation of data from all the FMP which are valid at the time of reporting. Nevertheless, this inventory only allows to assess forest-management related variables such as growing stock, species proportion, age structure, etc. The spectrum of information and the level of detail required have however, broadened, as the importance of forests for society grows. Nowadays, the information covers not only the traditional forest production characteristics and the potential woodcutting possibilities, but also ecology, forest health status, forest value, and biological diversity.

To address these new information needs, the importance of the NFI project was supported by policy and the first NFI in Slovakia was launched in 2004 (Šmelko

M. Bošeľa (✉) · V. Šebeň
National Forest Centre, Forest Research Institute Zvolen, Zvolen, Slovakia
e-mail: bosela@nlcsk.org

V. Šebeň
e-mail: seben@nlcsk.org

M. Bošeľa
Faculty of Forestry, Technical University in Zvolen, Zvolen, Slovakia

C. Vidal et al. (eds.), *National Forest Inventories*,
DOI 10.1007/978-3-319-44015-6_40

et al. 2008). It's aim was to create a new integral system, which is able to give objective, up-to-date and comprehensive information about the condition and the development of all components of forest ecosystems at national and regional levels in a specified time point (at best in regular 10 year intervals). Also the NFI can be used as a basis for analyses and strategic decision-making by the managing bodies in forestry and other related sectors. The NFI in Slovakia is the first forest inventory based on statistical principles. It was established on a strictly defined grid over the Slovakia territory with strictly defined statistical principles and therefore it does not fit to any other monitoring systems being performed in Slovakia (e.g. monitoring plots within ICP Forests).

The first NFI revealed that there is higher amount of growing stocks in forests compared to traditional stand-wise inventory by 23 %. The likely causes of this difference have been discussed. From among many possible causes, stocking estimation was identified as the most probable and most important along with the fact that stand-wise inventory gives the results for the main stand (excluding thinnings to be done in the current decennium) while the NFI takes entire stand into account. Stand density estimated either by visual assessment or by comparing current basal area to potential one from yield models. It is common that the maximum stocking density is index 1, which means that the real basal area equal to the basal area from yield models. However, as results showed, there is a high frequency of forest stands with the higher density than that expected by models.

40.1.2 Sampling Methods and Periodicity

NFI data were collected during the two-year period, 2005–2006. The National Forest Centre (NFC) was responsible for data collection and data processing. It was a two-stage inventory primarily based on terrestrial sampling with help of remote sensing techniques. Terrestrial inventory plots were circular with an area of 500 m^2, established on a grid of 4 × 4 km over the whole territory of Slovakia. The total number of the plots in the grid was 3071. As many as 1419 plots were classified as forest applying the national definition for the forest, which is very close to the FAO definition (FAO 2004). The only difference is in the minimal crown coverage 20 % compared to 10 % in the case of FAO definition.

The aerial inventory was performed as a visual interpretation of orthophotographs (Geodis–Eurosense, 2002–2003 with the resolution of 1 m). The sampling units were the circular plots of the size 2500 m^2 distributed in the grid of 2 × 2 km. In total 12,667 plots were assessed in the aerial inventory. These plots were primarily used for the identification of Forest/Non-forest land, as well as a support for the orientation and navigation in the field. A base grid of 4 × 4 km was used for the terrestrial inventory, resulting in one quarter of the aerial inventory plots been assessed. Precise determination of the forest area and forest categories at national

and regional levels is also an important output. The combination of terrestrial and aerial inventory reduced the sampling error of the forest area estimate by more than one half.

The NFI was carried out on all land covered by tree species, i.e. forests registered in the cadastre as forest land, as well as on other forested lands which met the national forest definition. Four types of ground inventory plots (A–D) were used:

- A—constant circle with radius r = 12.62 m for collecting data concerning terrain, site, stand and ecological characteristics, and for the inventory of deadwood and stumps on the ground; classification of forest/non forest category was done for this circle
- B—two concentric circles (r = 3 m and 12.62 m) for collecting tree characteristics of trees with diameter $d_{1,3}$ = 7–12 cm and $d_{1,3} \geq 12$ cm
- C—variable circle for young trees with diameter $d_{1,3} < 7$ cm, its flexible radius r = 1.0 m, 1.41 m or 2.0 m was chosen depending on the actual regeneration density
- D—enlarged constant circle with the radius 25 m established for the inventory of forest edges, forest roads and water resources.

Terrestrial inventory plots were in specific cases divided into separate homogenous parts—subplots (difference in forest structure, age, forest/non-forest land, etc.) for which all parameters were recorded separately. Minimum area of a subplot was 10 % of the inventory plot. For example, if the plot was established at the border of two forest stands with different age, species or at the forest edge creating the line between forest and non-forest area, or growing on different sites (e.g. forest site type) the plot was partitioned into two (or more if necessary) parts and all attributes were measured or assessed separately.

40.1.3 Data Collection

At least 100 parameters were recorded in each terrestrial inventory plot: production characteristics (number of trees, volume, assortments, stand structure, silvicultural and quality status of stands, forest regeneration, etc.); health status and forest damage; site and ecological characteristics (soil, forest, function type, degree of naturalness, risks, ecological stability, biodiversity, deadwood biomass, food for animals, forest edges, etc.); other characteristics (length, density and state of forest transport network, frequency and parameters of water sources and streams, etc.). In addition, increment cores, humus samples (three per plot) and soil samples (depth 0–10, 10–20 cm per plot) were taken from each plot identified as forest. All samples were archived and may be used for further analyses.

40.1.4 Data Processing, Reporting and Use of Results

40.1.4.1 Volume Estimation

Two-parameter volume equations were completed and verified for the main and related tree species (for 12 groups of species), which estimated tree volume (v) using tree diameter at breast height (dbh) and tree height (h). To ensure a more general utilisation of the results and the comparison with other EU countries, volume equations were prepared for the following five volume units:

1. timber from ground to the top diameter of 7 cm inside bark (HBK), which represents the official timber volume unit in Slovakia
2. timber from ground to the top diameter of 7 cm outside bark (HSK), which is most common in EU countries
3. timber from ground to the tree top excluding bark (KBK)
4. timber from ground to the tree top including bark (KSK)
5. volume of whole tree including tree top, branches and bark (SSK), which is important for other calculations, e.g. for the estimation of carbon storage in the aboveground biomass, etc.

The tree volume equations applied represent the regression $v = f(dbh,h)$, and were derived for 12 tree species from the data collected in the Czech Republic and Slovakia by various authors (see Petráš and Pajtík 1991). Prior to their use, all equations were verified and analysed in detail. The analysis revealed new findings that these equations approximate this relationship not only in the diameter range above 7 cm, which was so far the subject of the main interest, but also in the range from 0.1 to 7 cm (for KBK, KSK, and SSK). Hence, these equations are also applicable to trees with a dbh < 7 cm, which are inventoried within the scope of the NFI for the first time. In addition, the existing volume equations were also used for the tree species, for which no equations are currently available.

Assortment estimation (s) was completed for every tree with a minimum dbh of 7 cm using mathematical models of the national tree assortment tables (Petráš and Nociar 1991a; Mecko et al. 1993).

40.1.4.2 Deadwood

All standing and lying deadwood was measured in the plots. Each piece of lying deadwood with a diameter at the smaller end equal to or over 7 cm (coarse woody debris) was assessed by measuring the diameter at both ends, the length and the position in the plot (fixed area sampling). Deadwood smaller than 7 cm at the smaller end (small deadwood) was assessed by recording an estimated coverage and mean diameter (fixed area sampling). In addition, two perpendicular line transects (line intersect sampling) were used for inventory of small deadwood and the results were compared to fixed area sampling.

The volume of standing dead trees was determined from the volume equations of living trees (HSK). In order to determine the volume, new regression equations were derived, while the diameter at the top of the cut area D and the stump height H represent input variables. The volume of the lying deadwood with the top diameter of 7 cm was calculated from the measured diameters d_1 and d_2 (cm) outside bark at both ends and the length of each piece inside the terrestrial inventory plot using the Smalian's equation. The volume of small-sized lying deadwood (having diameter from 1 cm to 7 cm) was estimated by the original method, where the volume of small-sized lying deadwood (m^3) densely arranged in 1 m^2 is calculated from the biometrical model as a function of the middle diameter of small-sized lying deadwood multiplied by the area of the terrestrial inventory plot, estimated coverage of small-sized lying deadwood, and tree species proportion.

40.1.4.3 Tree Growth Area

Each tree was assigned a tree growth area, the sum of which for all trees equalled the total plot area. If the inventory plot included different tree species, age classes, growth stages or other forest categories, the plot was divided into separate parts for which the parameters were assessed separately. The particular tree growth area was determined from the regression models derived from the whole NFI data set separately for the individuals with the height below 1.3 m (in this case tree growth area is a function of their height), and for the trees with the height above 1.3 m (in this case tree growth area is a function of their diameter). For each inventory plot the sum of tree growth area of all recorded trees gave the total plot area. Tree growth area is a critical attribute during data analysis in expanding tree data to national estimates.

40.1.4.4 NFI Results

The NFI results were first published in a report for Ministry of Agriculture after the first cycle was finished. The first public-available publication was prepared in 2008 (Šmelko et al. 2008). However, NFI results have not been used for national or international reporting. Results from FMP were used for such reporting due to the long history and to ensure continuity. In addition, there has not yet been sufficient political pressure to use NFI data instead of FMP ones for reporting purposes at national and regional level. One of the reasons is that the results showed high differences between statistics made from FMP and NFI, especially in relation to growing stock.

The data from NFI have been used for some scientific studies (Bošela et al. 2013) and are now considered in several ongoing research projects (e.g. estimating soil carbon stocks using soil samples collected during NFI). Slovakia has joined the

ENFIN group and participated at several projects aiming at establishing NFI network harmonised over Europe for different purposes.

40.2 Land Use and Forest Resources

40.2.1 Classification of Land and Forests

40.2.1.1 General Land Classification

The national land use classification system recognises built-up land, agricultural land, forest land and other land according to cadastre. In total, there is more than 2 million ha of forest following the national definition (Table 40.1). Forests outside of the cadastre forest areas are referred to as "white areas". These areas are classified as agriculture in the national cadastre, but are not managed for agriculture. The total area of this category was officially 50–60,000 ha, but according to NFI it accounts for ca. 273,000 ha or 14 % of the forest area.

In the Slovak NFI, an area is considered as forest area when: (i) is covered by tree species with 5 m of potential height; (ii) crown coverage is more than 20 %; its width is at least 20 m; and (iii) is spanning more than 0.5 ha. The national forest definition indicates that it almost meets the FAO definition except for the crown coverage, as the FAO definition applies a 10 % threshold for crown cover.

Table 40.1 Area by national and FRA (FAO 2004) classifications

Category	Subcategory	Area (1000 ha)	FRA
Forests	Forests on forest lands (forests in cadastre)	1901 ± 20[a]	Forest
	Forests on non-forest lands (agricultural lands)	273 ± 10[a]	Forest
Agricultural land	Arable land	1360[b]	Other land
	Grassland	527[b]	Other land
	Other lands	58[b]	Other land
Build-up land	–	230[c]	Other land
Other land	–	555[d]	Other land
Total	–	4904	

Note [a]Area according to NFI in SR (2005–2006)
[b]Area according to forest management plans (stand-wise inventory) 2012
[c]Area of build-up land was 4.7 % of the total area of SR. *Source* Geodesy, Cartography and Cadastre Authority of Slovak Republic; area of SR according to Statistical Office of SR is 4,903,600 ha
[d]The difference between sum of the individual categories and the total land area of SR

40.2.1.2 Forest Classification by Use

Since 2005, forests available for wood supply (FAWS) have been assessed. To date FAWS has been assessed on 91.5 % of the forest area. The primary functions of the forest area according to FMPs (2012) are:

- Commercial forests (ca. 69 %)
- Special purpose forests (14 %). This includes forests in the protective zones of water sources, spa forests, recreational forests, forests for game management, protected areas, forests for genetic resources preservation, forests for study and research, military forests
- Protective forests (17 %). This includes forests growing on highly unfavourable sites, high-mountains forests under the timber line, forests in the zone of dwarf pine, and other forests were soil protection is considered as prevailing function.

40.2.1.3 Classification by Ownership Categories

Ownership of the forest estate according to forest management plans (2012) is:

- State (ca. 40 %)
- Private (13 %)
- Municipal (10 %)
- Community (26 %)
- Church (3 %)
- Agricultural cooperative (0.2 %)
- Other (8 %).

40.2.1.4 Forest Management and Cutting Systems

Close-to-nature shelter-wood system prevails in Slovakia, while clear-cutting is applied to less than 20 % of the forest area. In particular, protective forests have usually very low harvesting intensity, which is caused by natural circumstances (inaccessible sites, very steep slopes, etc.) and low density of forest road network. The following cutting systems are practiced in the Slovak forest estate:

- Establishment—natural regeneration, planting, or sowing (very low frequency)
- Brush cutting and cleaning (removal of unwanted shrubs or tree species)
- Thinning in young stands aged 50 years or less (no harvesting)
- Thinning in stands of aged over 50 years or more

- Clear cutting (whole mature stand is removed at once)
- Cutting in stands managed by close-to-nature techniques:
  - Preparation cutting (allow seeds to germinate)
  - Cutting to increase a light-use efficiency by seedling or advanced regeneration
  - Final cutting (removal of the rest of trees)
- Selection thinning and cutting (special management of selection forests—uneven-aged, especially those forests consisting of spruce and fir species).

40.2.1.5 Legal and Other Restrictions for Wood Use

In Slovakia forests are generally available for wood supply, but a small proportion of the forest area is strictly protected and thus not available for normal forest management practices. Forests available for wood supply exclude forests under the highest level of protection (such as natural reserves) and forests which are not accessible for harvesting (mountain pine forests on rocky terrain). In Slovakia, military forests are not accessible without permission. However these are commonly managed so the forests are considered to be available for wood supply and should be included in the FAWS category. As a result, there are approximately 96 % ± 1.1 % of forests available for wood supply in Slovakia (Table 40.2). In addition, there are some special-purpose categories where forests are managed but with a level of restriction (Tables 40.3 and 40.4). For example, forests in the National Parks with the 2nd–3rd degree of protection (the scale starts from 1st degree—minimal protection and ends with 5th degree, which is the highest level of protection usually used for natural reserves with total exclusion of forest management) are available for wood supply, but the management is limited so that no clear-cutting is allowed and close-to-nature management is to be preferred.

Table 40.2 Area of forests available for wood supply (NFI)

Category of forests	Area (1000 ha)	% Area (±error)
FAWS	2002 ± 20	92.2 ± 1.1
Natural reserves	92 ± 12	4.2 ± 0.6
Military forests	79 ± 11	3.6 ± 0.5
Total	2173 ± 22	100

Table 40.3 Area of forests according to prevailing functions in relation to FAWS (NFI)

Category	Prevailing functions	Area (1000 ha)	Area % (± error)
Commercial forests	Wood production[1]	1542 ± 31	70.9 ± 1.4
Special purpose forests	Education and research forests[a] National parks and natural reserves, etc.[b] Protected zones of water resources[b] Enclosed game parks[b] Urban forests[a] Military forests[a]	225 ± 19	11.9 ± 0.9
Protective forests	Unfavourable sites[c] Zone of dwarf pine[c] Prevailing function of soil protection[c] High mountain forests[c]	374 ± 22	17.2 ± 1.0
Total		2173 ± 22	100

Note [a]Forest available for wood supply, but with some level of restriction
[b]Forests include strictly protected areas which are not available for wood supply
[c]Forests in which the management is not restricted, but the production function is not primary, and it is often economically inefficient

Table 40.4 Legal restriction classes (NFI)

Degrees of natural protection	Number of plots	Area		Growing stock		
		1000 ha	%	%	Million m^3	m^3 ha^{-1}
1st Basic protection	881	1334 ± 32	61.3 ± 1.4	57.9 ± 2.0	332.8 ± 11.4	250 ± 6
2nd Landscape areas	321	500 ± 25	23.0 ± 1.2	25.6 ± 1.6	147.1 ± 9.3	294 ± 11
3rd National parks	155	242 ± 18	11.1 ± 0.9	12.0 ± 1.1	68.9 ± 6.5	285 ± 16
4th Nature monuments	4	6 ± 4	0.3 ± 0.2	0.3 ± 0.2	1.9 ± 1.1	297 ± 49
5th Reserves	58	92 ± 12	4.2 ± 0.6	4.2 ± 0.7	24.1 ± 4.0	261 ± 27

Note 1st to 3rd degree—wood supply is generally not restricted; 4th degree—management is limited to use close-to-nature techniques (clear-cuttings are not allowed); 5th degree—no management measures are allowed

40.2.1.6 Further Classification of Forests

Among other, the age structure of the forests is traditionally reported information in forestry, because it is an important indicator for ensuring sustainable forest management. However, estimation of forest age is often complicated and sometimes very difficult due to multi-storied forests which have become more frequent. For

this reason, the NFI in Slovakia provided new age categorisation of the forests (Table 40.5). Here, forests with only one a clearly identified vertical layer were classified using the standard system with age estimation only for the main layer. Forests, in which two and more vertical layers were present, were classified into three new categories: (a) uneven-aged with the age of upper layer up to 60 years; (b) uneven-aged with the age of upper layer over 60 years; and (c) forests in which the second vertical layer was natural regeneration—typical one-layered forests with the next generation below.

In Slovakia, NFI results show that broadleaved species dominate the conifer species, with 60 % of the total basal area broadleaved versus 40 % conifer. The main tree species are European beech (*Fagus sylvaica*), spruce (*Picea abies*), oak (*Quercus petraea*), pine (*Pinus sylvestris*), hornbeam (*Carpinus betulus*), fir (*Abies alba*), and others (larch (*Larix decidua*), maple (*Acer* spp.), ash (*Fraxinus excelsior*), elm (*Ulmus* spp.), etc.). The proportion calculated from species area (tree growth area) is slightly different (Table 40.6).

40.2.2 Wood Resources and Their Use

40.2.2.1 Standing Stock, Increment and Drain

Total growing stock in Slovakia, estimated by the NFI, was more than 570 million m^3 (Table 40.7). This amount includes also the growing stock of forests which were found in the total forest area, which includes forest land outside of the cadastre forest area. Growing stock estimated from NFI was found higher by about 23 % compared to the growing stock reported by the FMP.

Increment and felling are not yet available in NFI, since only 1st NFI was performed in 2005–2006. The next round started in 2015 and results are to be

Table 40.5 Forest area (national definition) by age classes (NFI)

Age classes (years)	Area (1000 ha)	Area (%)
Clearing—0	15 ± 5	0.7 ± 0.2
1–20	243 ± 19	11.2 ± 0.9
21–40	264 ± 19	12.1 ± 0.9
41–60	215 ± 18	9.9 ± 0.8
61–80	158 ± 16	7.3 ± 0.7
81–100	148 ± 15	6.8 ± 0.7
101–120	38 ± 8	1.7 ± 0.4
>120	33 ± 8	1.5 ± 0.3
Uneven-aged <60	275 ± 19	12.6 ± 0.9
Uneven-aged ≥60	550 ± 26	25.3 ± 1.2
Two-layer regenerated	236 ± 19	10.8 ± 0.8
Total	2173 ± 22	100

Table 40.6 Forest area (national definition) by dominant tree species

Tree species	Area (1000 ha)	Area (%)	Basal area (%)
Picea abies	457 ± 25	21.0 ± 1.1	26.4 ± 1.7
Abies alba	58 ± 10	2.7 ± 0.5	3.5 ± 0.6
Pinus spp.	117 ± 14	5.4 ± 0.6	6.6 ± 0.9
Other coniferous	50 ± 9	2.3 ± 0.4	1.8 ± 0.4
Fagus sylvatica	596 ± 26	27.4 ± 1.2	30.0 ± 1.6
Quercus spp.	226 ± 18	10.4 ± 0.8	11.8 ± 1.0
Carpinus betulus	174 ± 16	8.0 ± 0.7	5.5 ± 0.6
Hard broadleaved	188 ± 17	8.7 ± 0.8	4.9 ± 0.6
Other broadleaved	304 ± 20	14.0 ± 0.9	9.5 ± 1.0
Total	2173 ± 22	100	100

Table 40.7 Growing stocks of tree species aggregated into species groups

Tree species	Number of plots	Growing stock (million m^3)	Growing Stock (%)
Picea abies	577	161.8 ± 10.2	28.1 ± 1.8
Abies alba	232	22.6 ± 4.1	3.9 ± 0.7
Pinus spp.	222	32.1 ± 4.3	5.6 ± 0.7
Other coniferous	116	8.9 ± 2.1	1.5 ± 0.4
Fagus sylvatica	813	202.6 ± 10.5	35.3 ± 1.8
Quercus spp.	404	64.1 ± 5.7	11.1 ± 1.0
Carpinus betulus	407	20.9 ± 2.3	3.6 ± 0.4
Hard broadleaved	643	25.3 ± 2.9	4.4 ± 0.5
Other broadleaved	780	36.7 ± 3.7	6.4 ± 0.6
Total	1419	574.8 ± 12.4	100

available in 2017–2018. However, this information is available from permanent FMP. In 2012, total annual felling was 78.7 % of the annual total increment, and 2.0 % of the total growing stock.

40.2.2.2 Tree Species and Their Commercial Use

Similar to other central European countries, Norway spruce is the most economically important species in Slovakia followed by Euroepean beech and oak. According to the Green Report on Forest Management in Slovakia total fellings in 2012 amounted to over 8 million m^3 (Ministry of Agriculture and Rural Development 2013). However, as much as 43 % of it was reported as incidental caused by different kinds of disturbance, but mostly windstorm damage. From this amount, coniferous species dominated amounting to approximately 60 %. More than 7 million m^3 of the felling were sold to the timber companies in Slovakia and more than 2 million m^3 were exported (not all timber amounts sold to companies

established in Slovakia are processed, and are exported). Less than 500,000 m^3 of roundwood from broadleaved species is processed in Slovakia. There is a lack of veneer and high-quality assortments processed by Slovakian timber companies and they are mostly sub-contractors to foreign companies. There is a high demand for pulpwood from both coniferous and broadleaf in Slovakia. Use of timber for energy has been slowly increasing and reached 900,000 tonnes in 2009, from which woodchips amounted to 210,000 tonnes.

40.3 Assessment of Wood Supply

40.3.1 Forest Available for Wood Supply

Around 40 % of the forests in Slovakia are owned by the State, with the remaining privately owned (usually community forests). The primary use of the privately owned forests is wood production and wood supply. However, areas which are in some degree legally restricted for wood supply (natural reserves, national parks, habitats defined under NATURA 2000, and military forests) are often located in such forests making the owners limited to use the wood for industry purposes. On the other hand, only a few forested areas, mostly natural reserves, can be considered completely unavailable for wood supply in Slovakia. However, for the international reporting, only forests in natural reserves that have the highest level of protection are excluded.

Concerning the assessment of FAWS within NFI, each inventory plot was assigned the forest category according to the prevailing forest function it serves at that time (Table 40.3). In addition, for each inventory plot, the degree of protection was recorded as well (Table 40.4). In addition to field assessment, each plot was assigned to the restriction class using GIS techniques and existing GIS layers for comparison and check. To date NFI data have not been used for international reporting and FAWS have been reported using summation of FMP area.

40.3.2 Assessment of Stem Quality and Assortments

40.3.2.1 Stem Quality and Assortments

Stem quality and assortments are assessed and quantified in the Slovakian NFI (Šmelko et al. 2006, 2008). While stem quality is visually assessed in the field, assortments are generated from models developed for Slovakia in the past.

40.3.2.2 Assessment and Measurement

In the Slovakian NFI wood quality was assessed for two objectives. The first was to evaluate the development of the stem quality (including potential and current status —assessment of the quality classes A, B, C) and to quantify the quality structure of the forests (combination of the wood quality and assortments). The Slovakian grading system used in forestry, combines both quality classes with assortments to assess the end use of the tree bole. Information on the wood quality structure describes the current and the potential standing timber. In the NFI, the quality of each tree was assessed, while in mature stands it was evaluated as the actual status and in the younger stands as a potential regardless of the dimension (dbh, height). In this context, potential means that each tree is expected to achieve the particular quality class when it is mature. Each tree was classified into one of the three classes: A (healthy, straight, untwisted, centric, with no shape deformations), B (slightly twisted, with smaller technical defects, thin or medium-sized branches or knots are allowed), C (with great technical defects, large-sized branches, twisted, crooked). These quality classes in combination with tree dimension (dbh) were then used for partitioning the volume of each tree (volume under bark, but also over bark) into the quality classes and assortment.

Parameters used in the field assessment of stem quality:

- *Tree height*
  It is the length of tree from the ground to the tree top. A two-phase method for tree height estimation is applied. All trees on the plot are visually estimated for their height and 1/3 or a minimum of 10 trees for same tree species are measured for their height. The final height of the estimated trees was derived using mathematical models.
- *Diameter at breast height* (*dbh*)
  Measured for each tree on the plot and recorded only for those trees with dbh over 7 cm. In case dbh is less than 7 cm the count of trees at 1 cm dbh classes are recorded on the small-area plot.
- *Living crown base*
  It is the distance between the tree base (or ground level) up to the lower part of living crown. It was measured/estimated for each tree with dbh over 7 cm.
- *Tree fork*
  The occurrence of tree fork at the height below 1.3 m and above 1.3 m is assessed.
- *Damage to stem*—the assessment is performed on lower 1/3 of tree stem, including tree base (stump) and aboveground roots:

  0. No damage
  1. Mechanical (mostly caused by logging)
  2. Insect (bark beetles, ligniperdous, others)
  3. Fungus (necrosis, sporocarps, rot)
  4. Game (debarking, peeling)

5. Others (frost, bolt, birds, etc.)
6. Stem break (breakage below living crown).

- Moreover, the extent of damage is also recognised:

1. Slight damage (up to 1/8 of the circumference)
2. Moderate damage (from 1/8 up to 1/2 of the circumference)
3. Intensive damage (more than 1/2 of the circumference).

- And according to *age of damage*:

1. New damage (recent): The damage that occurred recently or from the last growing season
2. Old damage: The damage that occurred 2 or more growing seasons ago
3. Repeated damage: The damage has signs that it has occurred repeatedly for several years.

Stem quality classification system

Stem quality is assessed using visual indicators regardless tree dimension (height, dbh). Each tree over 7 cm in dbh was assessed for its quality. Only lower 1/3 of the stem is assessed into the following categories (these categories were used for timber grading of each tree using the model, which is described in the last chapter):

A. High quality logs, almost without knots (only healthy knots under 1 cm in diameter at the base), twisting (spiral growing), and without other technical defects. From the tree of the A quality the assortments of I and II classes can be made (as according to Slovak Technical Norm—STN).
B. Average quality logs, with small technical defects. In the case of hardwood all of healthy or unhealthy knots under 4 cm are allowed. For spruce and fir healthy or unhealthy knots under 4 cm and for Scots pine fewer than 6 cm are allowed. This category includes the roundwood used as saw logs (IIIA class).
C. Low quality logs with large technical defects, with high frequency of branches (densely branched trees), twisting up to 4 %. Healthy knots without limit for the size (diameter) are allowed, unhealthy up to 6 cm in the case of softwood, and up to 8 cm for hardwood. It includes the logs which meet the requirements from the quality C2 (III.B class) or C3 (V class).

Quality and assortment classes

National standards define minimal dimensional characteristics (length and diameter) for each individual grading class. The quality classes and the assortments are defined in the STN 480055 for softwood and 480056 for hardwood. The standards define minimal dimensional characteristics (length and diameter) for each individual grading class. Both softwood and hardwood species are assorted into six main quality classes: A1, B1, C1, C2, C3 a D1.

Roundwood of the highest quality A1 is used as veneer logs for sliced veneer or as a special raw wood for musical instruments. High quality class B1 is used for making peeled veneers, sporting goods or wooden barrels. Average quality

roundwood is categorised in class C1. This is used as saw logs (C1.1, C1.2, C1.3), logs used for constructions (C1.4) and logs for aggregate processing (C 1.5). Quality class C2 is used in mining industry as pit wood (C2.1) or thin poles (C2.2). Pulpwood for chemical or mechanical processing and chips for particle boards are made from logs of C3 class. Wood logs not sorted in previous classes belong to quality class D. Firewood assigns into this category.

40.3.2.3 Estimation and Models

Model for grading standing trees into stem quality and assortment classes

Tree height, DBH and the tree quality classes (A, B, C) were used as the input variables into a model, which refines the stem quality classification system and produces assortment information. The mathematical model (developed by Petráš and Nociar, 1991a, b; Mecko et al. 1993; 1994a, b) gives the proportion of overbark volume in each standing tree of assortments in six assortment classes I, II, IIIA, IIIB, V, VI. Only trees with DBH over 12 cm are used.

Empirical material and the model description

Data were obtained from 167 research plots which were established over the main growth regions of Slovakia taking into account tree species. In each plot, minimum of 70–80 trees were assessed. In total 16,020 trees were destructively sampled: 1705 trees of Norway spruce, 1161 of silver fir, 1836 of Scots pine, 3042 of oak sp., 4203 of European beech, 1401 trees of hornbeam, 1359 trees of birch and 1313 larch trees.

The tree-level model of wood quality and assortments was built up using regression modelling of the proportion of quality classes and assortments dependent on tree dendrometric characteristics. From among many possible parameters, the dbh, quality and damage to the tree were used from all main species (mentioned above), except for European beech, for which the tree age and the growth region were found to be important in addition to the previous parameters. The damage to trees and the quality are visually estimated in the field. Each standing tree (log) is categorised into quality classes A, B, C.

Estimations of stem quality and assortments from the NFI

Timber quality and assortment structure of all forests in Slovakia were estimated for the first time. The results showed, as expected, that the average stem quality class was most frequent. However, coniferous species were found to have higher proportion of the highest quality stems, while the proportion of growing stock in the worst quality class was found higher for broadleaves (Fig. 40.1).

Concerning the assortment structure of Slovakian forests (Fig. 40.2), the highest proportion of growing stock of conifers was found for IIIA and IIIB (saw timber, logs used for construction, aggregate processing), but the pulpwood (V) was most frequented for broadleaves. Also the higher proportion of firewood was found for broadleaves. The structure of assortments suggested that coniferous species were of better timber quality.

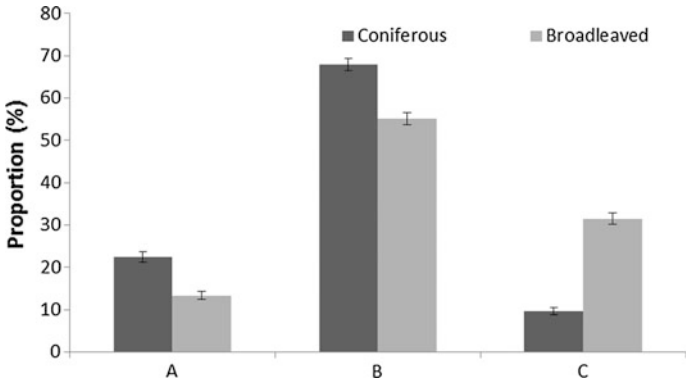

Fig. 40.1 Percentage of growing stock by quality classes assessed directly in the field (Šmelko et al. 2008)

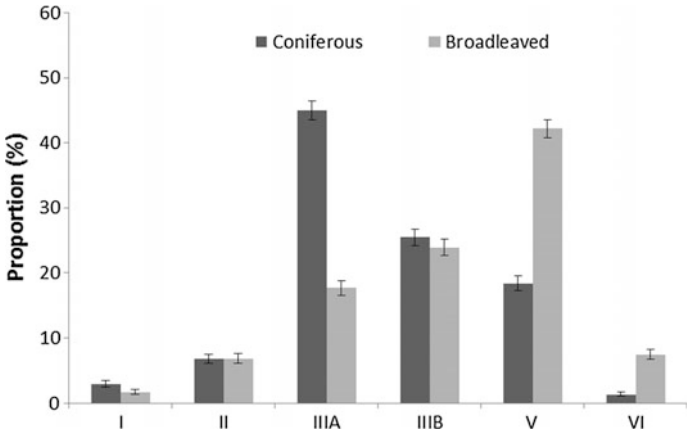

Fig. 40.2 Percentage of growing stock by timber assortments generated by a model using the parameters assessed or measured in the field during the NFI (Šmelko et al. 2008)

40.3.3 Assessment of Change

Since only one cycle of National Forest Inventory has been conducted to date in Slovakia, no information on change estimation is available. The second NFI is being conducted between 2015 and 2016.

40.3.4 Other Wooded Land and Trees Outside Forests

The Slovakian NFI does not assess Other wooded land (OWL), other land with tree cover and trees outside forest. It only distinguishes between forests on forest land (defined as forest land in the cadastre) and forests on non-forest land (defined as e.g. agricultural land in the cadastre). There are no plans to include OWL in the second NFI cycle. However, this may become necessary in the future since there is increasing demand on information about these categories throughout Europe.

References

Bošela M, Máliš F, Kulla L, Šebeň V, Deckmyn G (2013) Ecologically based height and derived raster maps of Norway spruce site index in the Western Carpathians. Eur J Forest Res 132:691–705

FAO (2004) Global Forest Resources Assessment update 2005: terms and definitions (final version). Forest Resources Assessment Programme. Working Paper 83/E, FAO Forestry Department, Rome, 34 p

Mecko J, Petráš R, Nociar V (1993) Konštrukcia nových stromových sortimentačných tabuliek pre smrekovec, hrab a brezu. Lesnícky časopis 39(3):2096–2221

Mecko J, Petráš R, Nociar V (1994a) Konštrukcia nových porastových sortimentačných tabuliek pre smrekovec, hrab a brezu. Lesnícky časopis 40(2):115–124

Mecko J, Petráš R, Nociar V (1994b) Sortimentačné tabuľky pre smrekovec, hrab a brezu. Bratislava, Veda, 76 s

Ministry of Agriculture and Rural Development of the Slovak Republic (2013) Green Report on Forest Management in Slovakia from 2013. Accessed 15 Feb 2016

Petráš R, Nociar V (1991a) Sortimentačné tabuľky hlavných drevín. Bratislava, Veda, 304 s

Petráš R, Nociar V (1991b) Nové sortimentačné tabuľky hlavných ihličnatých drevín. Lesnícky časopis 37(5):377–392

Petráš R, Pajtík J (1991) Sústava česko-slovenských objemových tabuliek drevín. Lesnícky časopis 37(1):49–56

Šmelko Š, Merganič J, Šebeň V, Raši R, Jankovič J (2006) Národná inventarizácia a monitoring lesov Slovenskej republiky 2005–2006. Metodika terénneho zberu údajov (3.vydanie). Národné lesnícke centrum Zvolen, 130 s

Šmelko Š, Šebeň V, Bošela M, Merganič J, Jankovič J (2008) National Forest Inventory and Monitoring of the Slovak Republic 2005–2006. Basic concept and selected summary informations. National Forest Centre – Forest Research Institute Zvolen, 16 pp