Chapter 39
Serbia

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39.1 The Serbian National Forest Inventory

39.1.1 History and Objectives

The evolution of forest functions and their significance for human society has changed from a production focussed role to a more multi-functional role, with ever-increasing demands on forest resources. This has lead to a progressively greater demand for information on this natural resource. Information is required in terms of the quantity and quality of wood resources at all levels of planning and decision-making, from the local to the global. In this respect, Šmelko (1991) reports: "In addition to the data which characterise wood production (diameters, age structure, tree species, timber supply, increment and the expected felling volume), our attention has been increasingly directed to forest quality characteristics and forest health, as well as to the inter-relationship of forest functions and ecological characteristics. Taking this into account, the permanent monitoring of the trends of forest state and development is increasingly significant". The above change in forest function was followed by the permanent development of forest inventory to provide baseline information on forest production and the sustainable use of all forest resources. The development of forest inventory proceeded in three directions: (i) methodological (implementation of the principles of mathematical statistics,

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particularly sampling methods), (ii) technological (development of instruments used in forest measurement, application of computer technologies, aerial and satellite images) and (iii) increasing the scope of information acquired by the inventory. Thanks to its dynamic, multilateral development and flexibility, forest inventory can now meet the demands of numerous users of information on forest ecosystems. The union of the national organisations dealing with forest inventory (primarily large scale inventory) in different regional and global associations is also one of the characteristics of its development. The activities of such associations are reflected in the exchange of experiences, harmonisation of information and definitions of criteria for their acquisition, processing, and presentation within the National Forest Inventories (NFI). Their objective is to create a database for the monitoring of forest ecosystems using different ecological and economic indicators at the regional and global level. This database will inform professional and political decisions.

In the past thirty years or so, forestry in Serbia was characterised by the application of a methodologically and technologically modern stand inventory, but without a NFI. Stand inventories were conducted in Serbia for many years and focused exclusively on collecting data relating to the estimation of growing stock. To satisfy information needs for forest management planning, stand inventory methods were enhanced and modernised, in the 1980s by the:

- introduction of new forms of sample plots with partial measurement
- establishment of statistical based sampling methods
- classification of forest stands into homogenous units
- development of software for the processing of forest inventory data.

The methodology was fully adopted by the Serbian forest sector soon after its formulation, which resulted in the creation of a more reliable and more complex database for the elaboration of forest management plans and private forest management programmes, based on stand inventory data. In the absence of a national inventory, stand inventory data were also used for the elaboration of general forest management plans and macro-economic plans. The application of this unique methodology of stand inventory, computer data processing and the creation of a uniform database have been implemented since the 1980s in the Republic of Serbia. However, due to organisational and financial problems and inconsistent enforcement of the Law regarding forest management records, the requirements were not satisfied. Therefore in the past it was necessary to estimate data where information was missing, which facilitated the calculation of quantitative stand inventory data for higher level planning. This estimation process resulted in statistics with a high level of error in volume, volume increment and unreliable felling records. Overall, this made the information untrustworthy from the aspect of real multi-functional planning, particularly planning at a national level.

The first National Forest Inventory in the Republic of Serbia (excluding Kosovo and Metohija) started in 2004 after the methodology was defined in terms of scope of information and the training of field teams. The Kingdom of Norway provided financial support, and the Norwegian Forestry Group (NFG) provided expert

support for the implementation of the NFI1 in Serbia. Field data collection, data processing and database development was finalised at the end of 2006. By forming a national database on forests and through periodic updating (planned inventory cycle is 10 years), it is possible to overcome the previous problems related to higher-level planning, i.e. to elaborate more realistic and reliable macro-economic plans and National Forest Programmes. Also, the cooperation with international organisations dealing with forest ecosystem monitoring at the regional and global levels has been improved. Data is available to numerous users such as commercial sectors, nongovernmental organisations, professional societies, individuals, etc., as well as different ministries, in agreement with the Law on Free Access to Information of Public Importance (Official Gazette of the Republic of Serbia 12/04).

39.1.2 Sampling Methods and Periodicity

The concept of the NFI1 in Serbia includes the application of a systematic sample in the form of clusters, distributed in a 4 × 4 km grid (Fig. 39.1a, b). The term cluster refers to a set of sample plots which are surveyed in order to assess the state of the growing stock and to evaluate its development. Each cluster consists of 4 sample plots, with the centre of the first one being the reference point (i.e. intersection point of the cluster network). The other three sample plots are distributed at the corners of square with 200 m sides (Fig. 39.1c). The sides of the sample plot clusters are oriented in a north-south and east-west direction. The plot area consists of three concentric circles with radii of 3, 10 and 15 m (Fig. 39.1d). The following diameter thresholds are used in the concentric circles:

- 3 m circle, all trees of diameter below 5 cm are recorded, and all trees above 5 cm are measured
- 10 m circle, the dbh of all trees above 10 cm are measured
- 15 m circle, the dbh of all trees above 30 cm are measured.

Trees which qualify for diameter measurement are also assessed for height and other tree specific data as well. Azimuth and distance from the centre of the circle are surveyed as well. The data on the general identification of clusters and sample plots, site description, stand description and information about trees are collected in each plot.

Due to the absence of experience in large-scale inventories, more detailed research should be undertaken regarding the optimal distance between cluster centres in the districts with different forest cover percentages. The most appropriate sample plot form should be assessed and recommendations made for the next NFI, for a possible correction to the methodology applied in the NFI1 (Banković et al. 2009). Although the planned inventory cycle is 10 years, financial problems have delayed the implementation of the second NFI, which is now planned for 2017.

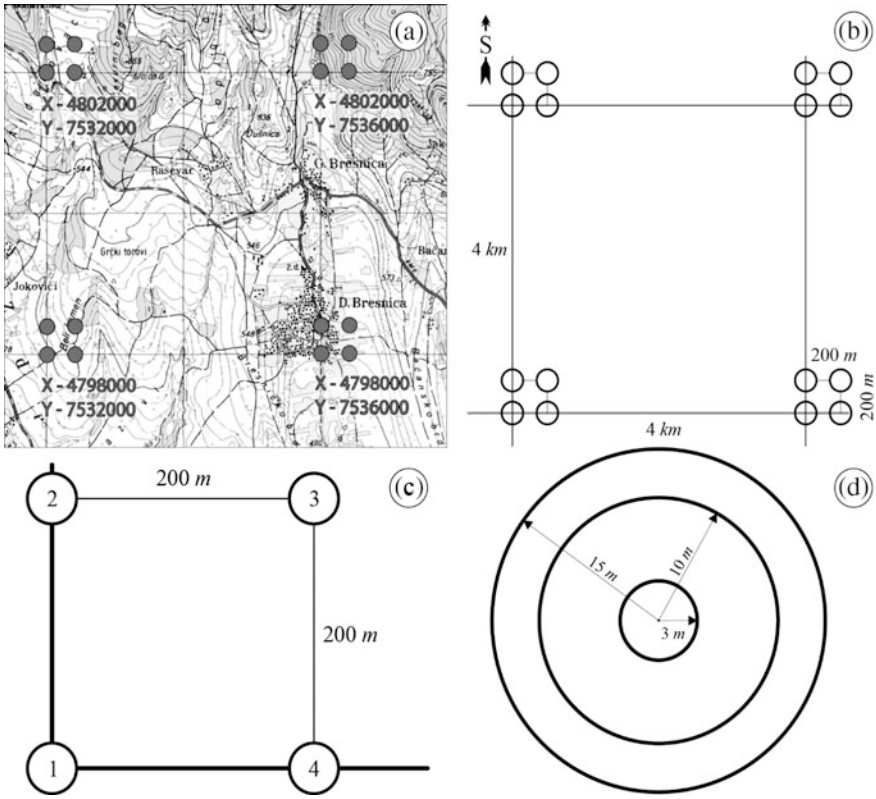

Fig. 39.1 Sampling plot system of Serbian NFI1 (2004). **a** Systematic sample in the form of clusters; **b** network (grid) 4 × 4 km; **c** distribution of sample plots on the cluster; **d** plot area of three concentric circles

The cluster and sample plot network was designed on four-colour topographic maps at the scale 1:25,000. Some maps were already in digital form, and the other maps were first scanned in *TIF* format, with a resolution of 300 dpi, and then georeferenced using the software package *Wingis 2003*. The prepared maps were upgraded with administrative boundaries of districts and political municipalities, and the boundaries of state forests by forest areas. The cluster network (grid) was also created using the above software, and the starting reference points (centre of the first cluster) were the coordinates of the plots used for monitoring for the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forest). The clusters were numbered (each reference point) and their coordinates were entered. Also, the numbers and coordinates of reference points were entered into a GPS receiver, which made their identification in the field easier. Using the described procedure, the territory of Serbia (excluding Kosovo and Metohija) was covered with 19,371 sample plots. The use of satellite imagery in Vojvodina (the northern part of Serbia), to acquire

preliminary data on clusters led to a reduction in fieldwork. This positive experience points to its wider use in the future National Forest Inventories of the entire territory of the Republic of Serbia.

39.1.3 Data Collection

The volume and definition of the information collected during NFI1 in Serbia is in compliance primarily with national standards, needs and available financial resources. As a result, the database contains accurate information about the growing stock of Serbia. However, the information is largely incompatible with the requirements of COST Action E43 (2010) standards and Global Forest Resources Assessment (FAO 2010). One of the reasons for this was the lack of experience with large-scale forest inventory. Due to this, and unlike other countries with a long NFI tradition, it is difficult for Serbia to fully meet the criteria of various international questionnaires. Therefore, this report is compatible with current reporting abilities on the forests of Serbia. The experience gained with the NFI1, combined with the knowledge gained from being a member of the European National Forest Inventory Network (ENFIN), and participating in international projects, will allow Serbian experts to eliminate the above-mentioned information gaps during the second NFI.

The qualitative and quantitative data of the NFI1 are structured as follows:

Group A. GENERAL IDENTIFICATION OF CLUSTERS AND SAMPLE PLOTS determines the position and inventory status of each cluster and sample plot, and includes the following information:

- cluster identification number
- sample plot identification number
- inventory status
- sample plot status
- district
- municipality.

Group B. SITE DESCRIPTION determines land use, land ownership, conditions of the development of forest vegetation, also including some risk factors, as well as the following data:

- land use
- altitude
- slope
- aspect
- land ownership
- erosion
- litter
- humification process.

Group C. STAND DESCRIPTION provides a comprehensive information on forests, including preliminary definition of management goals. It includes the following data:

- tree species
- age
- age class identification number
- forest categories (defined according to the principal tree species in the stand)
- forest origin
- forest structure
- development stage in even-aged stands of high origin
- preservation status;
- mixture
- canopy (crown cover)
- main characteristics of the young crop
- naturalness
- potential silvicultural treatment.

Group D. INFORMATION ON TREES provides the data on individual trees on sample plots, such as:

- diameter at breast height (dbh) or diameter at half of the length of the stem if the tree is fallen
- height (h) or length of a part of a fallen tree
- distance and azimuth from plot centre
- health status
- usability of dead trees (classes defined according to whether or not a dead tree can still be used in mechanical or chemical processing)
- biological (social) position of a tree
- wood quality
- cause and degree of damage.

All the information with the codes, definitions and the procedures can be found in the Technical Guidelines and the Code Manual for the National Forest Inventory of the Republic of Serbia (Banković et al. 2009). Based on these data, the values of the basic inventory elements (number of trees, basal area, volume and volume increment) are obtained both per unit area (1 ha) and at municipality, district, and the Republic level. Additionally, stand health and technical quality of timber can be evaluated. In the future, based on the principles of permanent inventory, it will be possible to monitor the evolution of individual trees, stands and larger forest areas.

39.1.4 Data Processing, Reporting and Use of Results

As already stated, a cluster of 4 plots are positioned on a 4 × 4 km grid, representing 1600 ha and containing 4 sample plots, each covering the area of 400 ha. In

cases where a sample plot is divided into different segments in different situations (for example, forest and barren land, high and coppice forests, even-aged and uneven-aged forests, etc.), the area of every segment in ha is obtained on the basis of the percentage of their share of the 400 ha area. Recapitulations at the level of municipalities, districts and the whole of Serbia were generated by adding areas represented by circular plots or their individual segments by various characteristics.

The validation of fieldwork was conducted in parallel with the NFI, which aimed to minimise systematic measurement errors. Due primarily to the overall number of sample plots assessed, the control was conducted on a single sample (Stojanović 1985; Banković et al. 2002b). The size of the control sample accounted for 2–5 % of the total number of sample plots (clusters). On the control sample plot, all the data were collected and all cruising measurements were taken in the same way as during the regular inventory, considering the same types of field forms. The control was conducted by an experienced field worker from NFG, under the supervision of representatives of the responsible Ministry. A lot of information was controlled, such as sample plot status, stand origin, stand structure, preservation, mixture, canopy, etc. The proportion between the number of circular plots with errors data and the total number of circular plots in the control sample did not exceed 5.5 %. Therefore, it can be concluded that there was a high degree of conformity between the field teams and the control. The errors in diameters at breast height and tree height account for 0.28 and 0.13 % respectively, of the average values of these elements. Also, there were no statistically significant differences between the field teams and the control results at the 99 % level of significance (Hadživuković 1975), which implies a high degree of reliability in the cruising data (area, volume, volume increment) per unit area, and altogether, at the level of individual Districts, i.e. Serbia.

The volume was calculated following the procedure for concentric circles, outlined by Banković and Pantić (2006). Two-way—model type V = f (d,h) volume tables were used, i.e. three-way volume tables for some tree species in even-aged forests—model type V = f (d,h,t) local area of validity (Pantić 1995, 1996, 1997a, b; Banković et al. 2003a, b). In these models d is diameter at breast height, h is tree height, and t is age of stand. In this way, volume per ha is distributed by diameter classes and was calculated for every tree species registered at a sample plot. Multiplication of this volume by 400 ha resulted in the total volume of every tree species in the area represented by one plot, distributed by diameter classes. Knowing the spatial position of every plot allowed the generation of summary statistics for volume at the level of a municipality, district or the whole Serbia.

The data were processed in specially developed software (for internal use only) and the database was established, followed by the drafting of a report on the results of NFI1 of Serbia. The NFI1 data were used in reports for the SORS (Statistical Office of the Republic of Serbia), the Government of the Republic of Serbia, the commercial sector, nongovernmental organisations, professional associations, etc. In order to avoid preparation of standard reports in the future, and to unburden experts, the intention after the second NFI is to make the database available online

and to allow numerous users to create their own required statistics through a higher number of queries.

39.2 Land Use and Forest Resources

39.2.1 Classification of Land and Forests

39.2.1.1 General Land Classification

Forest cover in Serbia is 29.1 % of the total area (in Vojvodina 7.1 %, and in central Serbia 37.6 %). Other Wooded Land (OWL), which also includes thickets and bushes, includes 4.9 % of the territory. When combined, OWL and forest represents 34.0 % of the total land area (Table 39.1).

The percent forest cover nationally is close to the global percentage of 31 % (FAO 2010), but it is considerably lower than the European (including Russian Federation) percentage, which is 45 % (FOREST EUROPE, UNECE and FAO 2011). In Serbia, the forest cover per capita is 0.3 ha and is half the world average, which amounts to 0.6 ha per capita (FAO 2010).

The national land use definitions are:

- Forest—Land with canopy cover of more than 10 % and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ. May consist either of closed forest formations, where trees of various storeys and undergrowth cover a high proportion of the ground, or open forest formations with a continuous vegetation cover in which canopy cover exceeds 10 %. Young natural stands and all artificially established stands that have not yet reached, but are expected to reach, a canopy cover of 10 % and tree height of 5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked, as a result of human intervention or

Table 39.1 Land use classes according to the national definition with area estimates (first NFI, 2004-2006)

Class name	Area (1000 ha)	Area (%)	Correspondence to FRA categories (2010)
Forests	2252	29.1	Forest
Other wooded land	382	4.9	OWL
Barren land	92	1.2	OL
Agricultural land	3595	46.4	OL
Meadows and pastures	1030	13.3	OL
Built-up area	312	4.0	OL
Inland water	85	1.1	Inland water bodies
Total	7748	100	

natural causes, and that are expected to regenerate (felling units, burned areas, etc.). It also includes forest nurseries and seed orchards that constitute an integral part of the forest; forest roads, cleared tracts, firebreaks and other small open areas within the forest; forest in national parks, nature reserves and other protected areas, such as those of specific environmental, scientific, historical, cultural or spiritual interest; windbreaks and shelterbelts of trees with an area of more than 0.5 ha and width of more than 20 m. Excludes: Land predominantly used for agricultural practices.

- Other Wooded Land (OWL)—is the land either with a canopy cover of up to 10 % of trees able to reach a height above 5 m at maturity in situ; or a crown cover of more than 10 % of trees not able to reach a height of 5 m at maturity in situ, and a combined cover of maquis, shrubs and bushes. The category of Other Wooded Land does not include those areas with tree, shrub or bush and maquis cover of less than 0.5 ha and width to 20 m, which are classed under "other land", or land predominantly under agricultural or urban land use.
- Barren land—includes infertile areas which are not used as forests, or for agricultural production (public roads, rocky land, stock piles, waterlogged land, pools, etc.).
- Agricultural land—includes the areas used for agricultural production (farmland, orchards, vineyards, etc.).
- Meadows/pastures—are grassland areas which are used exclusively for livestock and wild animal pasturage.
- Built-up land—includes the areas under buildings (towns, villages) and other urban structures.
- Inland water—includes lakes and reservoirs, major waterways, larger pools, etc.

39.2.1.2 Classification by Ownership Categories

According to the national forest definition the total forest area in Serbia amounts to 2,252,400 ha, of which state forests cover 1,194,000 ha or 53.0 %, and private forests cover 1,058,400 ha or 47.0 %.

The share of private forests in the total volume is 38.9 and 40.6 % in the total current volume increment. Average volume in private forests is 133 m^3 ha^{-1}, and volume increment is 3.5 m^3 ha^{-1}. In state forests the average volume is 185 m^3 ha^{-1}, and volume increment is 4.5 m^3 ha^{-1}. They are predominantly of coppice origin, corresponding to FRA classes (FAO 2004), but their structure is defined as thinned, clear-cut and even-aged as well. The average size of a private forest plot in Serbia is 0.27 ha, which is a burdening factor with regard to the preparation of planning documents for these forests. Despite the planning challenges in the private forest sector, these are highly important from an environmental, social and production aspect, due to the significant area they represent.

39.2.1.3 Forest Management and Cutting Systems

Forest management systems used in Serbia can be grouped as follows:

- regeneration management system (area or stand management), which is applied in even-aged (regardless of origin) and uneven-aged forests (in case of regeneration felling of long regeneration period)
- selection management system (single-tree or group selection), which is applied in selection forests
- group management system, which is applied in difficult stand conditions, commonly in beech and spruce forests at the border of forest vegetation, whereby silvicultural units (groups) must be no larger than 3 ha.

All forests in Serbia are classified into four categories by structural form. Even-aged stands dominate with 91.6 % of the total forest area, followed by uneven-aged stands with 7.5 %, selection stands with 0.8 % and virgin forests with 0.1 % (Table 39.2). A long-term strategic problem which is evident from Table 39.2 shows the need to restructure the even-aged stands that dominate to an extent that limits the bio-ecological characteristics of the species, site characteristics and goals of forest management.

39.2.1.4 Legal and Other Restrictions for Wood Use

The forests of Serbia are zoned according to global and primary functions. The global purpose refers to the entire complex of forests as a natural unit that synchronises and integrates the condition of sites and stands with societal requirements for forests into unique-general forest management goals. Global purposes and general goals of forest management are normally legally defined. According to Banković and Medarević (2003), 18 global purposes are defined in Serbia (for example, forests and forest sites with production function, forests with priority protection function, forests intended for recreation, general cultural and educational functions, nature reserve, game park, etc.). The primary function is a lower legal category, which may be established in advance as a legal obligation, or established subsequently on the basis of specific criteria. Areas designated by legal acts (Forest Law, Law on Environment Protection, Law on Waters, Law on National Parks, etc.) implies also the definition of protection regimes, which provide guidelines and

Table 39.2 Forest area by stand structural form (first NFI 2004–2006)

Stand structural form	Area (1000 ha)	Area (%)
Even-aged stands	2063	91.6
Uneven-aged stands	169	7.5
Selection stands	19	0.8
Virgin forest	1	0.1
Total	2252	100.0

limitations with regard to management (Medarević 2006). The following three categories are differentiated:

- degree I of protection regime—strict protection (excludes any human activity, other than scientific, and only with special authorisation from the competent ministry);
- degree II of protection regime—active protection;
- degree III of protection regime—sustainable use.

In addition, limitations in using wood also result from extreme terrain conditions which make difficult, or prevent access for, mechanised forest operations. However, these are smaller areas, as most of the forests in these sites are protected forests under the first or the second degree of protection.

39.2.1.5 Further Classification of Forests

Forests by origin

In Serbia, high stands occupy 27.5 %, coppice regenerated stands 64.7 %, artificially established stands 6.1 % and plantations (poplar and willow clones) 1.7 % of the total forest area. The above forest categories differ significantly in terms of production. The average volume in high forests is 254 m^3 ha^{-1}, in coppice forests 124 m^3 ha^{-1}, plantations of conifers and broadleaves 127 m^3 ha^{-1} and in poplar and willow clonal plantations 172 m^3 ha^{-1}. Current volume increment in naturally regenerated high stands is 5.5 m^3 ha^{-1}, in coppice forests 3.1 m^3 ha^{-1}, plantations 6.5 m^3 ha^{-1}, and in clonal plantations 9.0 m^3 ha^{-1} (Table 39.3). Regarding the differences in production effects, it can be concluded that the loss in increment associated with coppice forests is about 3.5 million m^3 per year compared to high forests, and there are also differences in the quality of actual production of both forest categories. The percentage of plantations is a concern only at the local level and in state forests.

The high share of coppice forests is a consequence of poor economic conditions during most of the twentieth century (particularly after World War I and World War

Table 39.3 Area, volume and volume increment of forests by origin (first NFI 2004–2006)

Stand origin	Area		Volume			Volume increment		
	1000 ha	%	1000 m^3	%	m^3 ha^{-1}	1000 m^3	%	m^3 ha^{-1}
Natural high stands	621	27.5	157,511	43.5	253.6	3388	37.3	5.5
Natural coppice stands	1456	64.7	181,189	50.0	124.4	4458	49.1	3.1
Artificially established stands	175	7.8	23,787	6.5	136.1	1234	13.6	7.1
Total	2252	100	362,487	100	160.9	9080	100	4.0

II) and, as a result of that, a strong and often unplanned anthropogenic impact on forests. The recovery of such a situation requires an extremely long period of time as well as high technological and financial resources.

Forests by mixture

Mixed stands are defined as stands in which the percentage of other species have a high proportion of volume exceeding 25 %. All forests in Serbia are classified into five categories as follows: pure broadleaf stands dominate with 59.0 %, mixed broadleaf stands cover 29.3 %, pure coniferous stands cover 8.7 %, mixed broadleaf and coniferous stands cover 2.4 % and mixed stands of conifers that cover only 0.6 % of the total forest area (Table 39.4).

The highest productivity has been identified in mixed conifer forests (mostly fir and spruce) and mixed broadleaf and conifer forests (beech-fir-spruce in different combinations). Furthermore, these forests occur in uneven-aged and selection structural forms; they are biologically more stable and more valuable functionally in terms of the modern understanding of the role of forests in a human society. In this respect, increasing the level of mixture is one of the imperatives of forest management in Serbia.

Forests by tree species

The first NFI in Serbia identified 39 broadleaf and 8 conifer tree species. Although the number of species present is higher, considering that some species are grouped as "other broadleaves" and "other conifers", the high number of species indicates that the there is a diverse range of tree species in Serbia's forests. However, most of the volume and current volume increment is related to only 9 broadleaf species, primarily European beech (*Fagus sylvatica* L.) and 4 conifer species, primarily spruce (*Picea abies* (L). *Karsten*). In that respect, it is necessary to increase the level of mixture in the forests of Serbia. One of the measures for achieving this long-term goal is the introduction of rare broadleaves in the area under beech forests

Table 39.4 Area, volume and volume increment of forests by mixture (first NFI 2004–2006)

Stand mixture	Area		Volume			Volume increment		
	1000 ha	%	1000 m^3	%	m^3 ha^{-1}	1000 m^3	%	m^3 ha^{-1}
Pure broadleaf stands	1328	59.0	227,074	62.7	171.0	5158	56.9	3.9
Mixed broadleaf stands	661	29.3	84,527	23.3	127.9	2046	22.5	3.1
Mixed broadleaf and coniferous stands	54	2.4	11,693	3.2	216.5	310	3.4	5.7
Mixed stands of conifers	14	0.6	4028	1.1	287.7	128	1.4	9.1
Pure coniferous stands	195	8.7	35,165	9.7	179.8	1438	15.8	7.4
Total	2252	100.0	362,487	100	160.9	9080	100	4.0

and to avoid the removal of rare tree species. Although the number of introduced species is substantial (8 species), their share in the total volume and volume increment is minimal, and it can be stated that the natural composition of Serbian forests is preserved to a certain extent. Further processes introducing allochthonous species must be minimised and strictly controlled.

Forests by stand categories

All forests, according to the National Forest Inventory Manual, differ also by stand categories, defined according to the principal tree species in the stand, regardless of the percentage of other species. Pursuant to this criterion, NFI1 identified 20 stand categories in Serbia, from the linear willow forests in the riparian areas to spruce forests at the upper altitudinal belt of forest communities. The dominant stand category is beech (*Fagus sylvatica*) forests, which cover 29.3 %, followed by turkey oak (*Quercus cerris* L.) forests with 15.3 %, forests of black locust (*Robinia pseudoacacia* L.), aspen (*Populus tremula* L.) and birch (*Betula pendula* Roth.) with 9.9 %, sessile oak (*Quercus petraea* (Matt.) Liebl.) forests with 7.7 %, Hungarian oak (*Quercus frainetto* Tenore) forests with 7.1 %, hornbeam (*Carpinus betulus* L.) forests with 5.3 %, pine (*Pinus* spp.) forests with 5.6 % and spruce (*Picea abies*) forests with 3.8 % of the total forest area. Alder (*Alnus glutinosa* (L.) Gaertn) forests have a minor percentage of only 0.3 % (Table 39.5).

Even-aged forests by age classes

Age classification was determined on the basis of the age of principal tree species and the age class span. The age class span is defined in advance:

- for all high forests, whose rotation is longer than 80 years, the age class span is 20 years
- for all high and coppice forests, whose rotation is 40–80 years, the age class span is 10 years
- for all high and coppice forests, whose rotation is 15–40 years, the age class span is 5 years
- if the rotation is shorter than 15 years, age classes are not established.

Even-aged forests, irrespective of origin, are characterised by the distribution of age classes and in particular the domination of areas under middle-aged and maturing forests and substantially lower share of areas under young and mature stands (Table 39.6). This situation is undesirable from the aspect of sustaining yield and indicates that it will be achieved in the future primarily through thinning. This statement is also confirmed by the distribution of areas under high even-aged forests by development phases (Table 39.7). The representation of individual development phases is a result of intense exploitation and premature felling, primarily of beech stands, in the first half of the last century, caused by the increased demand after World War II.

Table 39.5 Area, volume and volume increment of forests according to stand category (first NFI 2004–2006)

Stand categories	Area		Volume			Volume increment		
	1000 ha	%	1000 m^3	%	m^3 ha^{-1}	1000 m^3	%	m^3 ha^{-1}
Beech forests	660	29.3	153,837	42.4	232.9	2929	32.3	4.4
Turkey oak forests	345	15.3	49,565	13.7	143.6	1162	12.8	3.4
Sessile oak forests	173	7.7	21,596	6.0	124.7	542	6.0	3.1
Hungarian oak forests	160	7.1	21,087	5.8	132.1	533	5.9	3.3
Spruce forests	86	3.8	18,926	5.2	219.1	607	6.7	7.0
Pine forests	126	5.6	16,451	4.5	130.6	888	9.8	7.0
Forests of birch, aspen and black locust	223	9.9	13,402	3.7	60.0	617	6.8	2.8
Hornbeam forests	119	5.3	13,267	3.7	111.7	298	3.3	2.5
Common oak forests	32	1.4	10,119	2.8	312.3	178	2.0	5.5
Fir forests	26	1.1	9839	2.7	384.3	226	2.5	8.8
Poplar forests	48	2.1	7816	2.2	162.8	398	4.4	8.3
Lime forests	30	1.3	6134	1.7	201.8	121	1.3	4.0
Forests of narrow-leaved ash	25	1.1	5979	1.6	237.3	163	1.8	6.4
Forests of oriental hornbeam, hop hornbeam and flowering ash	87	3.9	4795	1.3	55.0	133	1.5	1.5
Forests of other broadleaves	54	2.4	3284	0.9	61.3	102	1.1	1.9
Willow forests	22	1.0	2175	0.6	97.1	52	0.6	2.3
Forest of ash and maple	13	0.6	1583	0.4	123.7	43	0.5	3.4
Forest of other conifers	5	0.3	1054	0.3	202.8	42	0.5	8.1
Pubescent oak forests	10	0.5	907	0.3	87.2	28	0.3	2.6
Alder forests	6	0.3	673	0.2	105.2	19	0.2	3.0
Total	2252	100	362,487	100	160.9	9080	100	4.0

39.2.2 Wood Resources and Their Use

39.2.2.1 Standing Stock, Increment and Drain

Volume and current volume increment include trees dbh ≥ 5 cm with bark, including the above-ground part of the stump, and branches with a diameter above

Table 39.6 Area under even-aged forests by age classes (first NFI 2004–2006)

Stand origin	Area	I	II	III	IV	V	VI	VII	VIII	Total
Width age-class (year)		0–20	21–40	41–60	61–80	81–100	101–120	121–140	141–160	
High natural stands	1000 ha	10	44	108	87	55	102	19	6	432
	%	0.5	2.2	5.2	4.2	2.7	4.9	0.9	0.3	20.9
Width age-class (year)		0–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	
Coppice natural stands	1000 ha	49	90	299	310	279	196	107	127	1456
	%	2.4	4.4	14.5	15.0	13.5	9.5	5.2	6.2	70.6
Artificially established stands	1000 ha	12	32	58	34	22	6	7	4	175
	%	0.6	1.6	2.8	1.6	1.0	0.3	0.3	0.2	8.5
Total area (1000 ha) of even-aged forests in Serbia										2063

Table 39.7 Area under high even-aged forests by development phases (first NFI 2004–2006)

Stand development stage	Area (1000 ha)	Area (%)
Regeneration	18	3.0
Sapling	100	16.5
Middle-aged stand	333	54.9
Mature stands	156	25.6
Total	607	100.0

3 cm. Since this is the first NFI, it was not possible to calculate drain. However, according to the principles of permanent inventory, the centre of every circular sample plot is fixed permanently by a metal pole positioned below the ground surface and the position of every tree was surveyed, which will also allow for the calculation of drain after the second NFI. The volume and current increment by tree species are presented in Table 39.8.

An important parameter for the assessment of forest qualitative structure is also the tree and volume distribution by the main diameter classes. For this reason, total volume is presented by 20 cm diameter class intervals (Table 39.9).

The proportion of the total volume thinned (10–30 cm) is 51 %: mid strong (31–50 cm) is 30 %: strong (>50 cm) is 19 %. This indicates an opportunity for future felling, both with regard to quantity and quality (potential assortment structure). Regardless of the dominant share of thin trees, it should be pointed out that some tree species reach substantial diameters. Beech (*Fagus sylvatica*), common oak (*Quercus robur* L.), sessile oak (*Quercus petraea*), maple (*Acer pseudoplatanus* L.) and Norway spruce (*Picea abies*) in the forests of Serbia reach diameters even above 90 cm, narrow-leaved ash (*Fraxinus angustifolia* Vahl.), Hungarian oak (*Quercus frainetto*), fir (*Abies alba* Mill.) and Austrian pine (*Pinus nigra* Arnold) up to 90 cm, and aspen (*Populus tremula*), birch (*Betula pendula*), black locust (*Robinia pseudoacacia*), smooth-leaved elm (*Ulmus minor* Miller), flowering ash (*Fraxinus*

Table 39.8 Tree species by number of trees, volume and volume increment (first NFI 2004–2006)

Tree species	Number of trees		Volume		Volume increment	
	1000 trees	%	1000 m^3	%	1000 m^3	%
European beech (*Fagus sylvatica*)	436,582	20.6	146,851	40.5	2782	30.6
Turkey oak (*Quercus cerris*)	234,089	11.1	46,980	13.0	1035	11.4
Sessile oak (*Quercus petraea*)	129,995	6.1	21,543	5.9	554	6.1
Hungarian oak (*Quercus frainetto*)	153,216	7.2	20,986	5.8	519	5.7
Hornbeam (*Carpinus betulus*)	254,122	12.0	15,157	4.2	335	3.7
Black locust (*Robinia pseudoacacia*)	218,845	10.3	11,244	3.1	517	5.7
Common oak (*Quercus robur*)	10,996	0.5	9242	2.5	158	1.7
Euroamer. Poplar (*Populus euroamericana*)	6490	0.3	6138	1.7	338	3.7
Narrow-leaved ash (*Fraxinus angustifolia*)	15,417	0.7	5792	1.6	154	1.7
Large-leaved lime (*Tilia platyphyllos*)	16,763	0.8	3536	1.0	71	0.8
Flowering ash (*Fraxinus ornus*)	103,787	4.9	3506	1.0	102	1.1
Field maple (*Acer campestre*)	47,615	2.3	3181	0.9	73	0.8
Other broadleaves	45,576	2.2	2942	0.8	90	1.0
Aspen (*Populus tremula*)	22,521	1.1	2358	0.7	93	1.0
Willow (*Salix* spp.)	6663	0.3	1912	0.5	43	0.5
Silver lime (*Tilia tomentosa*)	5958	0.3	1779	0.5	32	0.4
Oriental hornbeam (*Carpinus orientalis*)	88,444	4.2	1718	0.5	55	0.6
Hop hornbeam (*Ostrya carpinifolia*)	21,952	1.0	1481	0.4	34	0.4
Maple (*Acer pseudoplatanus*)	10,863	0.5	1433	0.4	39	0.4
Cherry tree (*Prunus avium*)	12,660	0.6	1292	0.4	32	0.4
Smooth-leaved elm (*Ulmus minor*)	18,665	0.9	1098	0.3	43	0.5
Black poplar (*Populus nigra*)	1458	0.1	1017	0.3	42	0.5
Pubescent oak (*Quercus pubescens*)	12,129	0.6	956	0.3	29	0.3
Small-leaved lime (*Tilia cordata*)	7526	0.4	945	0.3	20	0.2
Birch (*Betula pendula*)	11,643	0.6	875	0.2	33	0.4
White ash (*Fraxinus excelsior*)	5983	0.3	767	0.2	21	0.2
Alder (*Alnus glutinosa*)	5080	0.2	764	0.2	23	0.3
White poplar (*Populus alba*)	1988	0.1	607	0.2	25	0.3
Norway maple (*Acer platanoides*)	1694	0.1	418	0.1	10	0.1
Common walnut (*Juglans regia*)	2547	0.1	314	0.1	10	0.1
Turkish hazel (*Corylus colurna*)	2523	0.1	207	0.1	7	0.1

(continued)

Table 39.8 (continued)

Tree species	Number of trees		Volume		Volume increment	
	1000 trees	%	1000 m^3	%	1000 m^3	%
Wych elm (*Ulmus glabra*)	899	0.0	187	0.1	4	0.0
American (white) ash (*Fraxinus americana*)	6482	0.3	158	0.0	4	0.0
Black walnut (*Juglans nigra*)	337	0.0	155	0.0	4	0.0
Wild service tree (*Sorbus torminalis*)	1983	0.1	110	0.0	2	0.0
Balkan maple (*Acer heldreichii*)	817	0.0	95	0.0	3	0.0
Ash-leaved maple (*Acer negundo*)	1090	0.1	92	0.0	3	0.0
Europ. Hackberry (*Celtis australis*)	941	0.0	56	0.0	2	0.0
Europ. white elm (*Ulmus laevis*)	783	0.0	32	0.0	2	0.0
Mountain ash (*Sorbus aucuparia*)	6	0.0	3	0.0	0	0.0
Total broadleaves	1,927,126	91.1	317,930	87.8	7341	80.9
Spruce (*Picea abies*)	57,532	2.7	18,811	5.2	605	6.7
Fir (*Abies alba*)	13,797	0.7	8305	2.3	200	2.2
Austrian pine (*Pinus nigra*)	84,964	4.0	12,659	3.5	715	7.9
Scots pine (*Pinus sylvestris*)	26,178	1.2	3775	1.0	177	1.9
Douglas-fir (*Pseudotsuga menziesii*)	1641	0.1	511	0.1	16	0.2
Weymouth pine (*Pinus strobus*)	2080	0.1	355	0.1	19	0.2
Larch (*Larix decidua*)	996	0.0	108	0.0	5	0.1
Yew (*Taxus baccata*)	13	0.0	2	0.0	0	0.0
Other conifers	309	0.0	31	0.0	2	0.0
Total conifers	187,510	8.9	44,557	12.3	1739	19.1
Total	2,114,636	100.0	362,487	100.0	9080	100.0

Table 39.9 Distribution of volume by diameter classes (first NFI 2004–2006)

Tree species	Volume (million m^3)	Diameter class (cm)					
		<10	11–30	31–50	51–70	71–90	>91
Total broadleaves	318	25	137	93	47	11	5
Total conifers	45	3	21	15	5		
Total	362	28	158	109	52	11	5

ornus L.), hop hornbeam (*Ostrya carpinifolia* Scop) and wild service tree (*Sorbus torminalis* (L.) Crantz) up to 50 cm. These dimensions indicate diversity in the diameter distribution within a tree species.

39.2.2.2 Tree Species and Their Commercial Use

According to the SORS (Statistical Office of the Republic of Serbia) data, the volume of harvested wood and its use for commercial purposes varied in the period 2009–2013 (Table 39.10). The maximum harvested volume equalled 31 % of current volume increment. Fuel wood was dominant use for the harvested volume, followed by technical wood and wood for chemical processing. The waste resulting from harvesting has been treated in recent times as biomass for various uses. There are no reliable data on the share of individual tree species in harvested volume, but it can be claimed with a high level of certainty that such a share corresponds to their share in the total standing volume.

39.3 Assessment of Wood Resources

39.3.1 Forest Available for Wood Supply

39.3.1.1 Assessment of Restrictions

In accordance with the criteria for the assessment of natural values, rarities and cultural and historical monuments (the Law on Forests, the Law on Environmental Protection, the Water Law, the Law on National Parks, etc.), the Institute for Nature Conservation of Serbia has defined the protected areas and established protection regimes as the limiting factor in the use of forest resources. The spatial distribution of these areas and a number of other characteristics are presented in detail in the decision on the declaration of each protected area, which was adopted by the Government of the Republic of Serbia.

39.3.1.2 Estimation

Areas under various protection regimes were also identified within the total area under forests, as a limiting factor to various forms of use (Table 39.11).

If forests under the first regime of protection, in which any exploitation is prohibited, as well as the forests on extreme slopes intended to protect soil from

Table 39.10 Harvested timber volume from 2009 to 2013 (1000 m^3)

Use of harvested timber	2009	2010	2011	2012	2013
Industrial and technical wood	935	968	1019	939	992
Fuel wood	1365	1451	1514	1422	1402
Waste	303	277	300	275	285
Total	2603	2696	2833	2636	2679

Table 39.11 Area of protected forests by protection regime (first NFI 2004–2006)

Protected areas	Degree of protection (1000 ha)			
	I	II	III	Total
Reserves (general and special)	7	32	42	81
National parks	8	44	108	159
Nature parks and landscape	14	18	172	205
Geo-heritage	–	2	–	3
Natural monuments	–	–	–	–
Cultural and historical monuments	–	–	4	4
Total	29	96	327	452

erosion, are excluded, it can be stated that around 95 % of forest area in Serbia is available for wood supply.

39.3.2 Wood Quality

39.3.2.1 Stem Quality and Assortments

Individual trees are assessed for stem quality in Serbia's NFI. Assortments are not assessed during field data collection nor are they derived during subsequent data analysis.

39.3.2.2 Assessment and Measurement

The technical quality of timber was assessed on trees with dbh > 25 cm on sample plots, by the following classes:

- High quality—a tree which has a straight stem with slight taper, preferably free of branches, in good health and without technical defects. In broadleaves, the stem must produce a minimum of one veneer log, cylindrical in form and with a diameter of at least 40 cm;
- Medium quality—a tree with straight stem with slight taper, branched, in less good health and with minor technical defects;
- Low quality—a tree with a curved stem with sweep, a heavily branched stem, in poor health and with other technical defects.

The limitations existing in the NFI1 database do not allow for summary statistics to be presented on the quality of wood, although it was assessed during the course of field work.

39.3.3 Assessment of Change

39.3.3.1 Assessment and Measurement

Presently only one NFI cycle has been completed and it was not possible to estimate drain or increment directly using NFI data. As the NFI plots are permanent and the locations of trees are recorded, it will be possible to use the NFI data in the future for estimating both increment and drain.

39.3.3.2 Estimation of Increment

The current volume increment is calculated on the basis of a mathematical model which expresses a link between the percentage of volume increment (p_{iv}), number of trees (N), mean diameter per basal area (d_g) and its appropriate height (h_g), and the share of specific tree species in the mixture (s) (Banković et al. 2000a, b, 2002a, b).

$$p_{iv} = a \cdot N^b \cdot h_g^c \cdot d_g^e \cdot s^f \tag{39.1}$$

The multiplication of the percentage of increment by the volume per ha (v) generates volume increment per ha in an absolute amount (I_v):

$$I_v = V \cdot \frac{p_{iv}}{100} \tag{39.2}$$

Recapitulations of increment at various territorial levels were generated in the same way as for volume. Once the second NFI is implemented, it will be possible to calculate volume increment on the basis of the volume of two consecutive inventories and the volume of the trees removed in the meantime.

39.3.3.3 Estimation of Drain

As there is currently only one completed NFI cycle, it was not possible to estimate drain using NFI data. In the meantime, the SORS data will be used to estimate drain.

39.3.4 Other Wooded Land and Trees Outside Forests

Measurement of trees in NFI1 was limited only to forests areas. Trees which were on OWL, and on other categories of land as well, were not subject either to measurement or to any assessment.

39.4 Conclusion

The first NFI in the Republic of Serbia was implemented in the period 2004–2006. The sampling methodology was compatible with methodologies of most European countries with a long NFI tradition. Unlike the sampling methodology, the scope, structure and definitions of some data were not, in most cases, compliant with COST Action E43 and FAO criteria. This resulted in a highly reliable database on Serbian forests, which meets national needs, but is somewhat more limited in terms of meeting international reporting obligations. Serbia is already benefiting from NFI1 in a number of ways including a better insight into the spatial distribution of forests, the availability for use and the distance from processing capacities, classification of forests by a single purpose, particularly the protection of soil, water, etc. All of this has led to a higher quality of strategic forest planning in Serbia and its further development. The availability of the database and an opportunity to prepare various overviews of the condition of forests meets the needs of the private sector, NGOs and individuals looking for information on the forest estate. Serbia is benefiting greatly from the cooperation with international associations, such as ENFIN and FAO, particularly in terms of involvement in various NFI projects, and the experience of other member states. The NFI will be institutionally established to ensure stable and permanent sources of funds. Certain methodological corrections are required, thus increasing the scope of information collected and its harmonisation with international criteria. This will facilitate the long-term monitoring of forest ecosystems in Serbia and facilitate reporting to regional and global organisations.

References

Banković S, Medarević M (2003) Code manual for the forest information system of Serbia. Ministry for the Protection of Natural Resources and Environment—Forest Administration, Belgrade

Banković S, Pantić D (2006) Dendrometry. University of Belgrade—Faculty of Forestry, Belgrade

Banković S, Jović D, Medarević M, Pantić D (2000a) Tables of percentage of volume increment for common oak, narrow-leaved ash, bitter oak and hornbeam in the forests of Ravni Srem. Bulletin of the Faculty of Forestry 82, University of Belgrade—Faculty of Forestry, Belgrade, pp 25–39

Banković S, Jović D, Medarević M, Pantić D (2000b) Regression models of the percentage of volume increment in clear and mixed beech and sessile-flowered stands in Serbia. Bulletin of the Faculty of Forestry 83, University of Belgrade—Faculty of Forestry, Belgrade, pp 21–31

Banković S, Medarević M, Pantić D (2002a) Regression models of the percentage of volume increment in the most common stands of conifer tree species in Serbia. Bulletin of the Faculty of Forestry 85, University of Belgrade—Faculty of Forestry, Belgrade, pp 25–35

Banković S, Medarević M, Pantić D (2002b) The reliability of information on forest reserves as the basis for realistic forest management planning. Bulletin of the Faculty of Forestry 86, University of Belgrade—Faculty of Forestry, Belgrade, pp 67–79

Banković S, Medarević M, Pantić D, Filipović M (2003a) Volume tables for spruce in the territory of the National Park Kopaonik. Forestry 3–4, UŠITS, Belgrade, pp 51–60

Banković S, Medarević M, Pantić D, Filipović M (2003b) Volume tables for fir in the territory of the National Park Kopaonik. Forestry 1–2, UŠITS, Belgrade, pp 27–34

Banković S, Medarević M, Pantić D (2006b) Regression models of the percentage of volume increment for large-leaved, small-leaved and silver lime on Fruška Gora. Forestry 4, UŠITS, Belgrade, pp 37–46

Banković S, Medarević M, Pantić D, Petrović N (2009) The National Forest Inventory of the Republic of Serbia—the growing stock of the Republic of Serbia. Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia-Forest Directorate, Belgrade

COST Action E43 (2010) Harmonisation of National Forest Inventories in Europe: techniques for common reporting. https://metla.fi/eu/cost/e43/. Accessed 26 Jan 2016

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

FAO (2010) Global Forest Resources Assessment 2010: terms and definitions (final version). Forest Resources Assessment Programme. Working Paper 144/E, FAO Forestry Department, Rome

FOREST EUROPE, UNECE and FAO (2011) State of Europe's forests 2011. Europe's status & trends in sustainable forest management in Europe. Forest Europe Liaison Unit Oslo; United Nations Economic Commission for Europe; Food and Agriculture Organization of the United Nations

Hadživuković S (1975) Technique of sampling method, Naučna Knjiga, Belgrade

Medarević M (2006) Forest management planning. University of Belgrade—Faculty of Forestry, Belgrade

Pantić D (1995) Volume tables for common oak in the forests of Ravni Srem. Forestry 4, UŠITS, Belgrade, pp 61–72

Pantić D (1996) Volume tables for narrow-leaved ash in the forests of Ravni Srem. Forestry 1–2, UŠITS, Belgrade, pp 58–62

Pantić D (1997a) Three-way volume tables for common oak in the forests of Ravni Srem. Forestry 2, UŠITS, Belgrade, pp 37–44

Pantić D (1997b) Three-way volume tables for narrow-leaved ash in the forests of Ravni Srem. Forestry 4–5, UŠITS, Belgrade, pp 67–74

Šmelko Š (1991) Biometrické vlaznosti rôznych druhov skunych plôch pre zistovanie a monitorovanie stavu lesa, Acta facultatis forestalis XXXIII, Zvolen (in Czech)

Stojanović O (1985) Control of field works and testing of results of estimated assessment of forests. Forestry and Wood Processing 1–3, special print, Sarajevo, pp 25–50