Forestry-related Databases of the Hungarian Forestry Directorate

Version 1.1

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Contents

1. Introduction

1.1 Short history of forest management in Hungary

Planned forest management has a long history in Hungary. The main steps of it were the following:

- 1791. The first feudal type of forest act was enacted by the Parliament.
- 1879. The first modern civil forest act was passed. In the 19th century the German-type, planned forest management was typical both in state forests and in large private forest estates.
- 1920. As a result of the Treaty of Trianon at the end of World War I, Hungary lost 84% of its forests and the forest area was reduced from 26% to 12%.
- 1935. With the announcement of the IV. Act of 1935, a forest act corresponding to the new geographical conditions of the country, as well as the first Hungarian law on nature conservation entered into force.
- 1936. The Second World Forestry Congress and the ninth Congress of the International Union of Forest Research Organizations (IUFRO) were held in Hungary. The opportunity to host the congress was an international recognition of the Hungarian forestry mainly due to the afforestation programme launched in the middle of 1920's.
- 1945. Private forest holdings exceeding 100 cadastral acres (~ 58 hectares) were nationalized; properties of 10-100 cadastral acres were taken into state management.
- 1959-60. Forest joint tenures were cut back; about 30% of the forests were assigned to agricultural cooperatives.
- 1961. The VII. Act on forests and wildlife management was based on the socialist ownership structure.
- 1970. The first Forest Inventory covering the total forest area of Hungary was completed.
- 1996. After the political transition in Hungary and the withdrawal of Soviet forces, about 40% of the forests were privatized. In order to control the multiple-use and sustainable forestry with legislative tool, the Parliament passed the LIV. Act of 1996 on forest and forest protection.
- 2009. The new Forest Act (XXXVII. Act of 2009), which closed the transition related to the ownership structure in Hungary, carried on tradition, however, the importance of sustainable forest management and the impact reduction of climate change are also emphasized. Furthermore, the public is provided more opportunity than ever before to provide input during forest planning and the act introduces the quantitative definition of naturalness as a qualitative parameter of forest management.

1.1. The definition of forest

According to the Forest Act of 2009 in force, a tree stand is considered a forest if it includes specific (forest) tree species (as detailed in the Act), its width is at least 20 metres, trees are higher than 2 metres, its area is at least 0.5 hectares and the canopy closure is at least 50 %. In the previous Forest Act (of 1996) the area threshold was 0.15 hectares.

1.2. Main facts on Hungarian forest on January 1, 2013

The forest area of Hungary has been increased since the second half of the 20th century (Figure 1). Currently, 22.1 % the total area of Hungary covered by forest lands, which include forests, as well as forest roads and other areas serving forest management practice but actually not covered by trees. Forest area by county is very diverse (Figure 2). The most forested county is Nógrád (38.9 %) and the least one is Békés (4.6 %). 55.7 % of forests are state owned, 42.1 % of them are privately held, 1.2 % of them are publicly owned (community forests), and 1.0 % of them are of mixed ownership forests with different distribution of the first three ownership types.

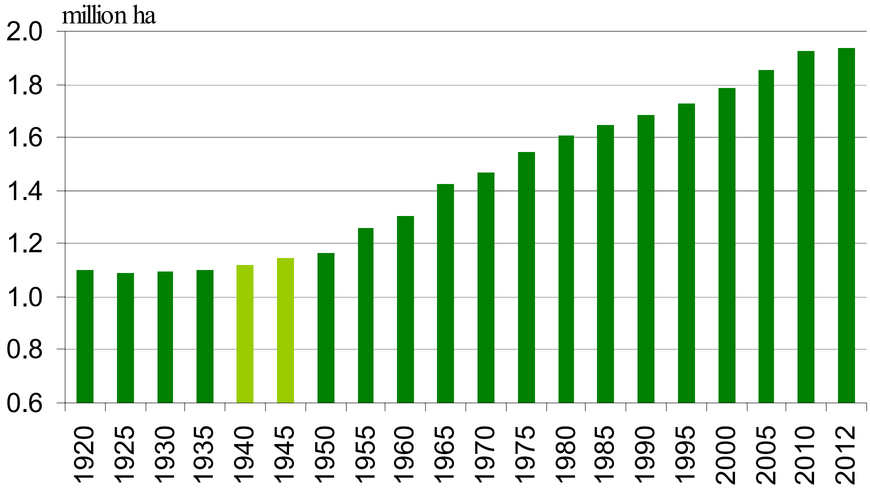


Figure 1. Forest area (actually covered by trees) in Hungary since 1920.

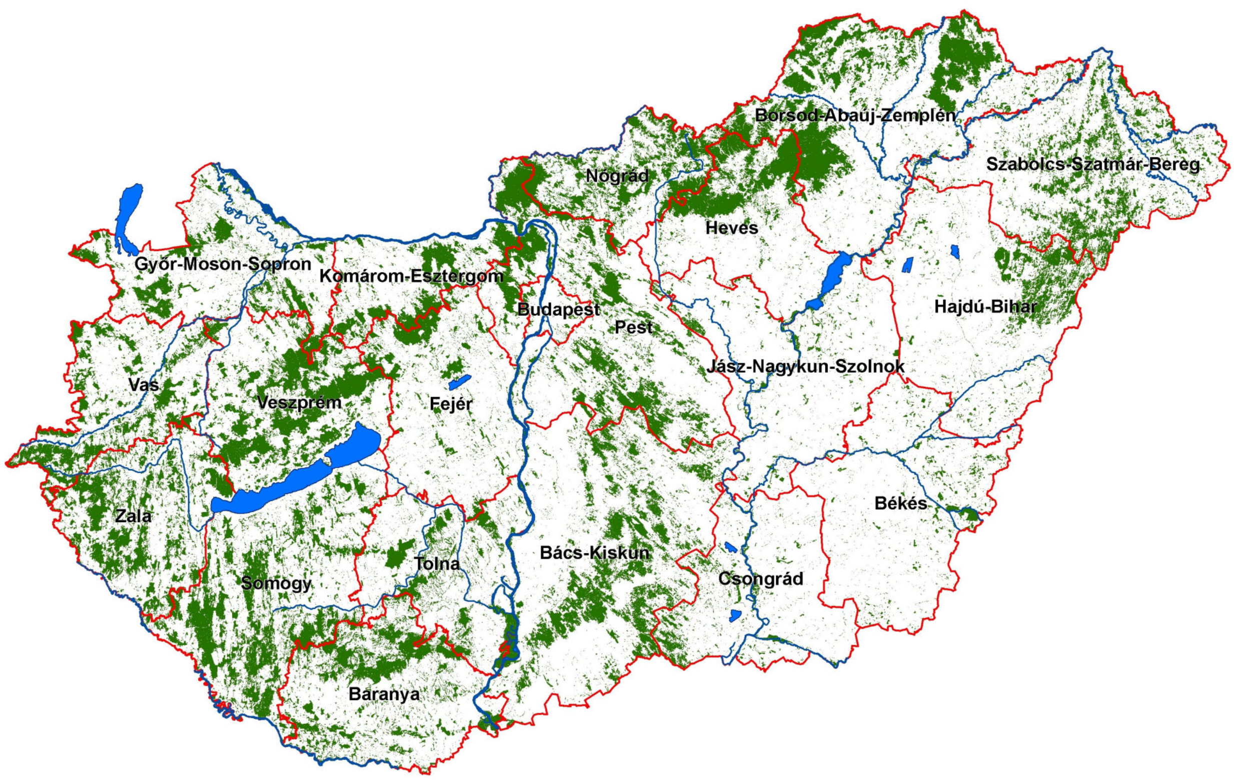


Figure 2. Forest area in counties of Hungary.

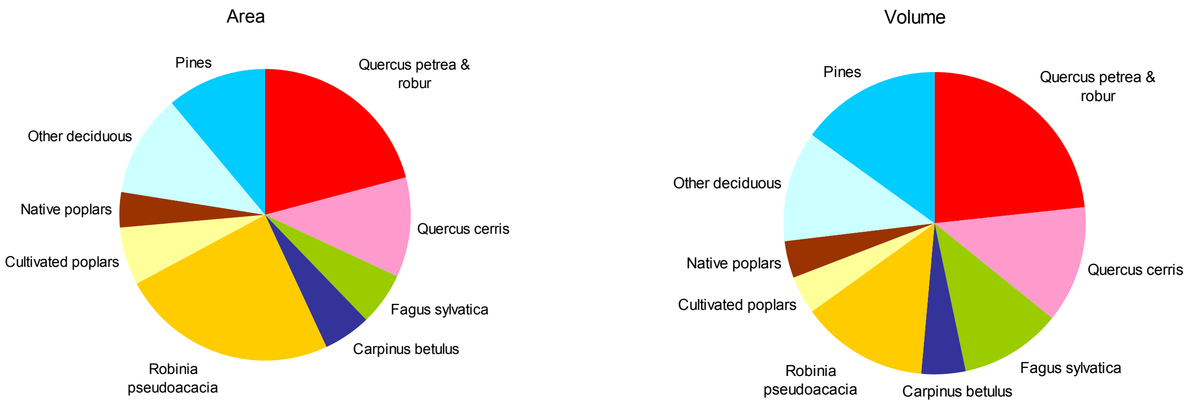


Figure 3. Area and volume of forest tree species.

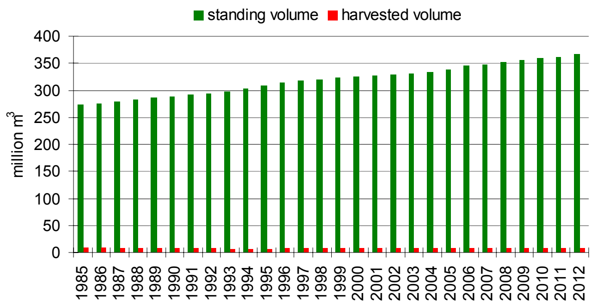


Figure 4. Standing and harvested volumes in the last three decades.

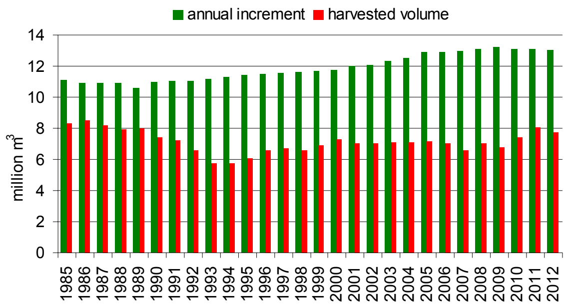


Figure 5. Annual increment and harvested volume since 1985.

Hungarian forests comprise mainly Central European deciduous tree species, out of which Black locust (*Robinia pseudoacacia*) accounts for the largest area (24.0 %) while noble oaks (*Quercus robur* and *Q. petraea*) have the highest standing volume (23.4 %; Figure 3). The gross standing volume of the Hungarian forests amounts to 366.3 million m^3, and it has been continuously increasing for the last 30 years (Figure 4). This increase is due to the considerably lower harvested tree volume (felling) compared to wood increment (Figure 5), and also to the allowable cut prescribed in the approved management plans (see Chapter 2.2.1.). In Hungary, most forests are relatively young due to the rather intensive afforestation programme in the middle of 1920's (Figure 6). Forest health condition in Hungary is considered to be good (Figure 7).

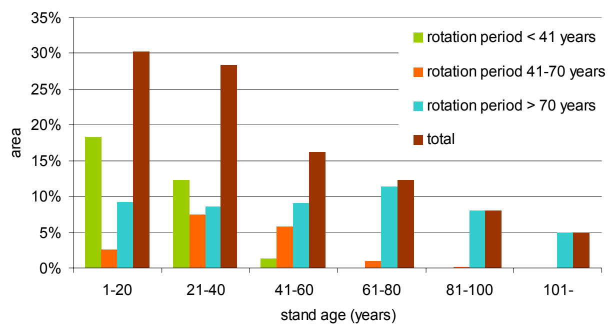


Figure 6. Area of stands of various rotation periods by stand ages.

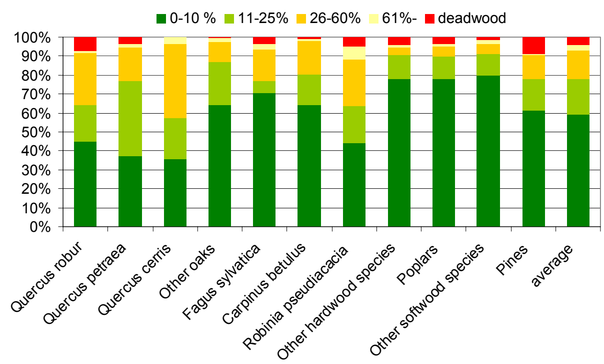


Figure 7. Defoliation of forest tree species.

Since the end of the 20th century, the protective and environmental role and the social (public welfare) function of forests have been more and more emphasized. Therefore, the proportion of forest areas designated for protective purposes has been steadily increasing. 40% of forest areas have been given the special status of Natura 2000 site (Figure 8). The Forest Act in force created the legal basis for transition from clear cutting and shelterwood system to selection (during this transition, the management method is considered 'transitional'). The interest in close-to-nature forestry has increased tremendously and it has been wildly introduced into the forest management practice (Figure 9).

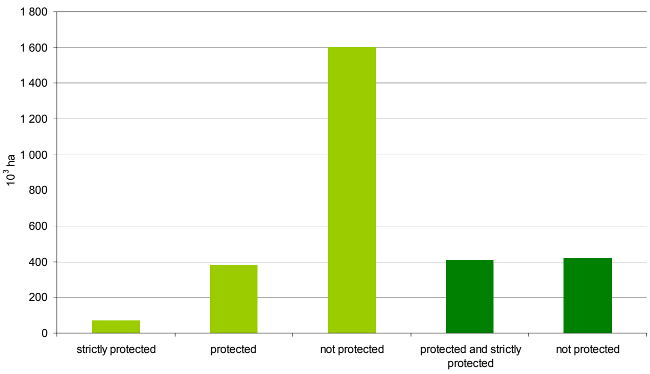


Figure 8. Total, protected (light green) and Natura 2000 forested areas (dark green).

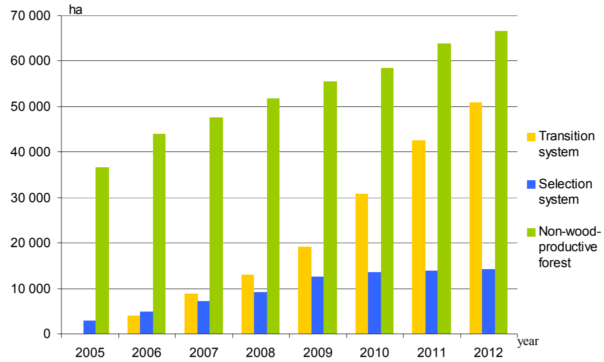


Figure 9. Area of forests not managed in clear cutting or shelterwood system.

1.3. Forest fires in Hungary

Large-scale (50 ha<) uncontrolled forest fires rarely occur in Hungary, though size of the burned area has been increasing for the last years (Figure 10). Compared to the total forest area of Hungary, areas affected by fire are very small (0.0015 %). In Hungary, the so-called surface fires are common in which loose debris (including dead branches and leaves), as well as, small shrubs are burnt. High intensity surface fires can become crown fires in coniferous forests, especially in the Great Hungarian Plain.

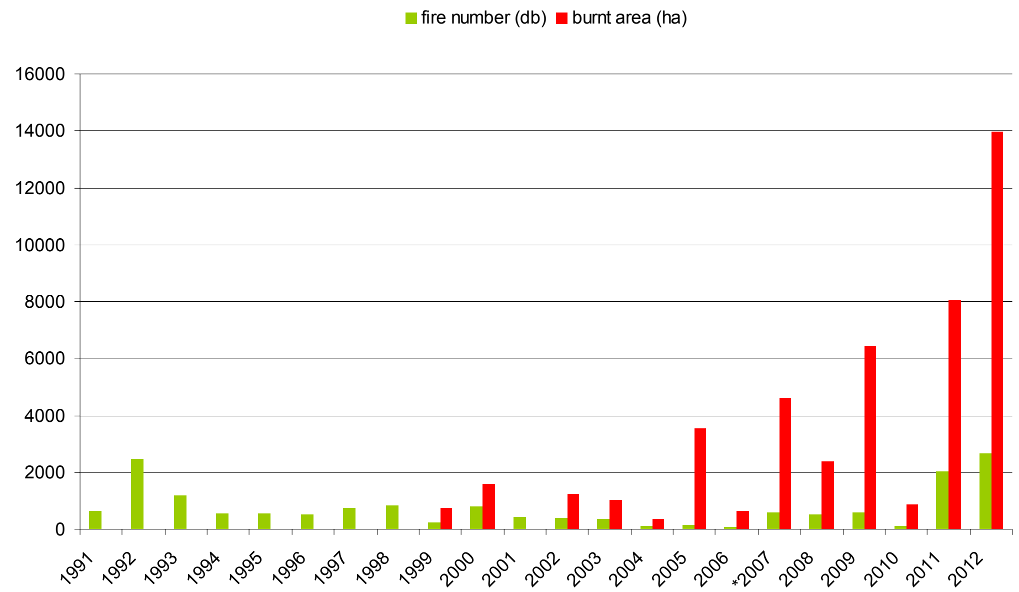


Figure 10. Number of forest fires and total burned forest area in the last decades (in 2007, data collecting methods was changed)

In Hungary underground fires are unimportant, but not completely unknown. Approximately 10 % of the fires are crown fires (data of 2007-2008) which may lead to the total destruction of the tree stands. It is estimated that most (99%) of the forest fires are caused by human activities (negligence or intentional arson).

Forest fires may entail forest regeneration obligation (see Chapter 2.2.2.) to the forest holder. If specific conditions (according to the provisions of related laws) are met after loss of tree cover due to fire, forests are to be professionally restored. Burned (but not totally destroyed) trees are to be felled (sanitary cutting).

1.4. Structure of the Hungarian Forestry Administration

Currently (2013), the institutions of the first and second instance of forestry administration are the Forestry Directorate of National Food Chain Safety Office (coordinating and supervisory organ of second instance) and under its supervision, the ten Forestry Directorates of the County Government Offices (organs of first instance). Area of jurisdiction of the County Forestry Directorates is not identical to the administrative (municipal, county and region) boundaries because it is determined by forest management purposes, as well as, by management areas of various forest managers. Therefore, it is changing in medium- and long-term.

The current structure of organs of first and second instance was the result of organizational changes at the end of 2010. Legal predecessors were the Forestry Directorates of the Central and the County

Agricultural Offices between 2007 and 2010, and the State Forest Service before 2007. The changes of the organizational structure have not affected the professional task specialization of the Directorates, only the accounting and the administrative jobs changed.

There are altogether 300-400 field officers collecting and processing data. More than three fourths of them are forest engineers. Each County Forestry Directorate employs 25-50 people. Their tasks and responsibilities can be grouped as follows:

1. forest management planning;
2. forest inspection.

For the coordinating tasks in the Forestry Directorate of National Food Chain Safety Office, approximately 50 people are employed to carry out country-wide data management tasks, to ensure informatics related technical support, to conduct development work, to carry out statistical analyses, and to coordinate the activities of the County Directorates.

1.5. Forest-related Databases of the Hungarian Forestry Administration

Four databases were developed from available data on Hungarian forests by the Hungarian Forestry Administration as follows:

1. National Forestry Database (NFD);
2. Forest Protection Network Database (FPN);
3. Growth Monitoring System Database (GMS);
4. National Forest Fire Database.

The National Forestry Database is the most outstanding one due to the amount of data stored in it and its role in forestry administration. For each forest subcompartment of the country, there are available data on site conditions, composition of tree species, forest manager, prescribed and already completed forest management activities (related to harvest and regeneration). Therefore, the NFD is an inevitable instrument of planning and inspection to implement forestry policy as prescribed by statute. Although data stored in the three other databases are not directly connected to forestry administration activities, they provide essential information on some characteristics of the Hungarian forests which are essential to preserve the forest assets.

2. National Forestry Database (NFD)

2.1. Objectives of the establishment and history of NFD

The two main objectives of the establishment of NFD are:

1. monitoring necessary to forestry administration and
2. storing data of the main attributes of Hungarian forests.

The harmonization of the above objectives is quite difficult. The current structure of NFD corresponds rather well only with the first objective. Partly this is the reason for the existence of the other databases describing Hungarian forests (FPN, GMS). As a consequence of the first objective, the two main sources of data of NFD are forest planning and inspection. It must, however, be emphasized that data are mainly derived (almost 90%) from forest planning related data collection.

2.2. Data sources of NFD (partly sampling-based data collection)

2.2.1. Forest planning

Forest planning is regulated at the highest level by the Forest Management Plan Regulation issued by the responsible Minister. The Regulation includes the main limits of forest management activities (e.g. the maximum degrees of timber harvest are prescribed). The result of the forest planning activity is the **forest management plan**. It is based on field surveys and prescribes tasks and their timelines that have to be fulfilled during the next 10-year-long-period. Each forest manager receives his or her forest management plan (in the form of a decision) which describes his or her rights and responsibilities. Requested derogation from the forest management plan might occur exceptionally, but only on request.

Forest management planning activities cover the entire forest area of Hungary. About one tenth of the forest area of Hungary is subject to forest management planning each year. In other words, each forest subcompartment is planned once in every 10 years. Forest management planning is conducted in each forest district separately.

Before the previous Forest Act of 1996, forest management plans were developed for state forestry companies managing the vast majority (90 % <) of the Hungarian forests and not for forest districts. After the Forest Act of 1996 came into force, forest management plans could be divided into two groups: (1) forest management plans for private forests according to forest planning districts and (2) forest management plans for state forests according to forest managers with no respect to forest management districts since forests managed by state companies can belong to more than one district.

After the Forest Act of 2009 came into force, districts were selected with no respect to which forests are managed by identical forest managers. Thus, forest planning districts were developed for practical reasons in order to avoid overload of forest planning managers of County Forestry Directorates. Currently, there are 150 forest planning districts (Figure 11). Each County Forestry Directorate has to plan one or two districts, and each forest planner has 1500-2800 ha area to plan annually.

During the planning process, forest managers and other (e.g. environmental) organizations can participate in selecting the best-fit management options that will become the forest management plan itself. The County Forestry Directorates are obliged to consider modification proposals during a negotiation process (i.e., negotiations both before and after the field inventory), but it also has discretionary right to decide on the modification of forest management plan if the proposal is in compliance with statutes.

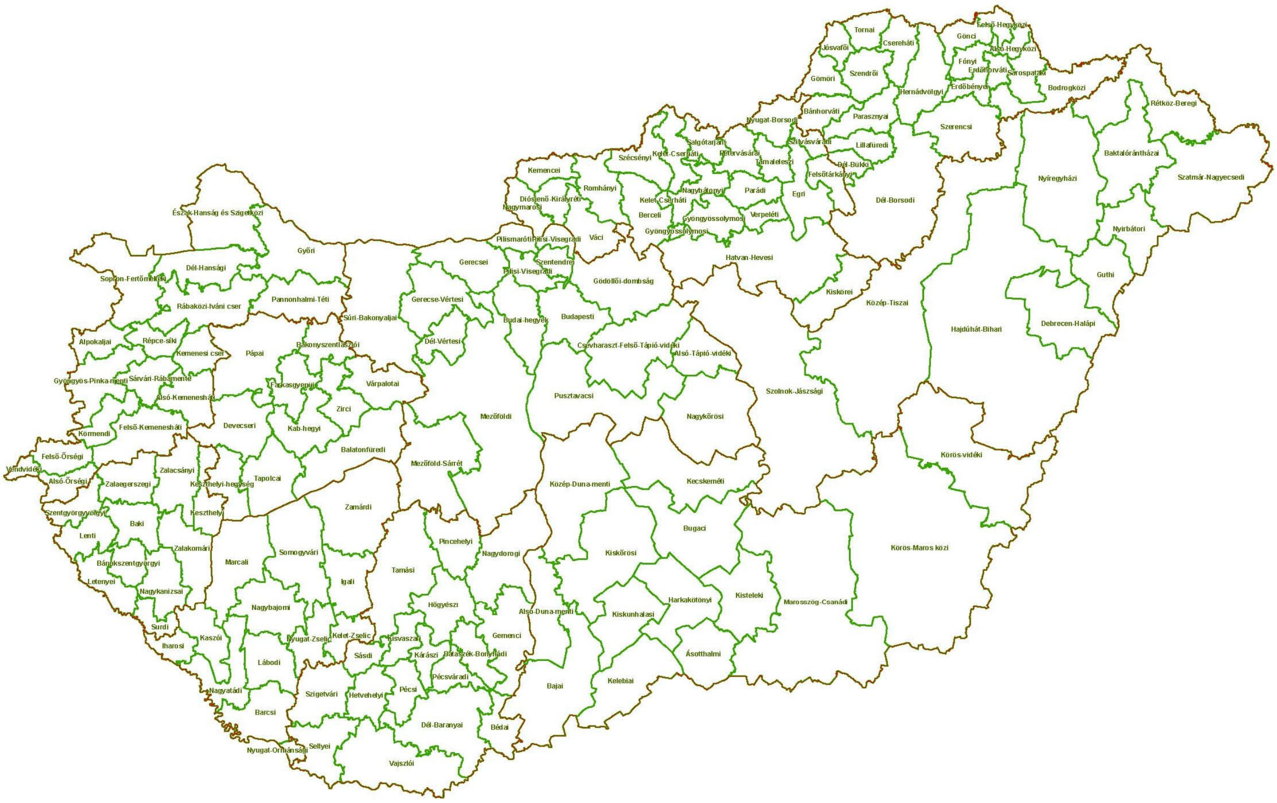


Figure 11. Forest planning districts in Hungary.

After the final consultation, the County Forestry Directorates carry out a so called ‘yield prediction’ in order to compare areas planned for final cut in the proposed forest management plan with opportunities provided by the Forest Management Plan Regulation and if necessary modify the proposed forest management plan.

The unit of forest planning is the forest subcompartment. Site conditions and tree layer composition are more or less homogeneous within the each subcompartment. Consequently, forest within a given subcompartment can be managed by the same silvicultural tools as long as the forest management plan is in effect. Furthermore, the areal extent of the subcompartment is to be geographically reasonable (neither too big nor too small) so that the same management activities could be conducted in the stand. The mean size of forest subcompartments in Hungary is about 4 ha. Due to the fact that the forest subcompartment is the unit of forest planning, the NFD contains data by subcompartments.

Forest subcompartments are grouped into forest compartments by geographical administrative units (municipalities). Grouping helps spatial organization of forest management activities and orientation within the forest. Thus, altogether three variables are used to identify forest subcompartments: the name of the municipality, the number of the forest compartment and the identifier (a letter in the alphabet) of the forest subcompartment. A forest management plan *native identifier*, such as *Káld 35 B*, determines unambiguously a forest subcompartment.

Forest planning process starts in the office in the actual year. Documents necessary to field work are compiled. The documents are the following:

- Description sheet describing the actual state of forest subcompartment (L-sheet, see Chapter 2.3.);
- Forest subcompartment map (since 2004 digital) and orthophoto;
- List of forests in the Land Registry (previously non-forest therefore not planned areas that became forested can be planned);
- List of areas that are not forests in the Land Registry and might have became forested since the previous forest planning (the list is compiled by using orthophotos, forest subcompartment and land parcel coverages).

Field work starts when the necessary documents are compiled. Field work results affect the forest management plan and therefore the forest management activities for the following 10 years for which the plan is in effect. The field work comprises the following parts:

1. identification of the subcompartment to be planned in the field;
2. sampling of the tree stand;
3. estimation cover of shrub layer species;
4. estimation of forest naturalness based on the composition of the tree stand by a Hungary-specific method;
5. examination of site conditions directly or indirectly;
6. marking subcompartments border lines permanently (e.g. painting trees, using stakes etc.).

Quantitative sampling is obligatory if the tree stand:

- reaches the end of the felling cycle, or is prescribed for final felling within the planned period;
- reaches the end of felling cycle within the 10 years after the planned period (that is the rotation is not yet complete);
- is for quality wood production and commercial thinnings are prescribed.

In other forest stands, sampling is not obligatory, but recommended.

Two of the nine stand assessment methods that can be applied for sampling the tree stand and that are most frequently used by forest planners are: the method of basal area sampling and forecasting using yield tables.

Stand basal area is measured by standard angle-count sampling. This method gives an estimate of the average basal area by tree species using Bitterlich relascope. The sampling points are located in a grid covering the entire area of the forest subcompartment. The average stand basal area (m^2/ha) is calculated as the mean of the estimates calculated for the sampling points. The average basal area of the tree species is then calculated from this value multiplying it with the relative proportions of the species which is visually estimated by the forest planner. At the same time, height of a few average trees is measured. There is no set rule as to how many sampling points should be applied, but sampling is required to be statistically valid which means that sample size depends on the spatial variability of basal area and tree species composition.

Yield tables compiled by the Hungarian Forest Research Institute are used to determine the yield class and volume of the tree species (Figure 12). The following stand characteristics are necessary by tree species to obtain these data: age (already known from NFD), mean height of average trees (measured in the field), origin (seed/sprout, already known from NFD), composition of tree species (estimated in the field). Sampling points for the field survey are established in representative parts of the subcompartment.

Kor	A főállomány					A mellékállomány					Az egészállomány					Összes előhasználat	Előhasználati részarány	Az összes fatermés		
	átlagos		fatérfogata V_s	körlapösszege G	törzsszáma N	átlagos		fatérfogata V_s	körlapösszege G	törzsszáma N	átlagos		fatérfogata V_s	körlapösszege G	törzsszáma N			fatérfogata V_s	átlag-növedéke	folyó növedéke
	magassága H_g	átmérője D_g				magassága H_g	átmérője D_g				magassága H_g	átmérője D_g								
év	m	cm	m^3	m^2	db	m	cm	m^3	m^2	db	m	dm	m^3	m^2	db	m^3	%	m3	m^3	m^3
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.
5	4,3	3,8	19	4,6	3964	3,9	2,3	3	0,6	1587	3,9	3,5	22	5,3	5551	3	12,3	22	4,3	0,0
10	8,6	7,0	47	7,8	2007	5,1	4,1	15	2,5	1957	8,3	5,8	62	10,4	3964	18	27,7	65	6,5	8,6
15	12,5	10,5	85	11,1	1280	7,0	6,1	17	2,2	727	12,1	9,2	101	13,2	2007	34	28,9	119	8,0	10,9
20	15,8	13,9	129	14,2	930	9,3	8,3	17	1,9	350	16,4	12,6	146	16,1	1280	52	28,6	181	9,0	12,3
25	18,6	17,2	176	17,0	734	11,8	10,3	17	1,6	196	18,2	16,0	193	18,7	930	69	28,1	244	9,8	12,7
30	20,9	20,2	222	19,6	613	14,2	12,3	16	1,4	121	20,6	19,1	238	21,0	734	85	27,6	306	10,2	12,4
35	22,9	22,8	265	21,8	533	16,4	14,0	15	1,2	80	22,6	21,9	280	23,0	613	100	27,3	365	10,4	11,7
40	24,5	25,2	306	23,8	478	18,4	15,5	13	1,0	55	24,2	24,3	319	24,8	533	113	27,0	419	10,5	10,7
45	25,9	27,2	342	25,4	438	20,2	16,8	12	0,9	40	25,5	26,5	354	26,3	478	125	26,8	467	10,4	9,6
50	27,0	28,9	374	26,8	409	21,7	18,0	10	0,7	29	26,7	28,3	384	27,6	438	135	26,6	509	10,2	8,5
55	27,9	30,4	402	28,0	387	23,1	19,0	5	0,6	22	27,6	29,9	411	28,6	409	144	26,4	546	9,9	7,4
60	28,7	31,6	426	29,0	370	24,2	19,8	8	0,5	17	28,4	31,2	433	29,5	387	152	26,3	577	9,6	6,3
65	29,3	32,6	445	29,8	356	25,2	20,5	7	0,5	14	29,0	32,3	452	30,2	370	159	26,3	604	9,3	5,3
70	29,9	33,5	463	30,5	346	26,0	21,1	5	0,3	10	29,5	33,2	468	30,9	356	164	26,2	627	9,0	4,6

Figure 12. A yield table. Data of the various columns are the following: No. 1 – stand age; No. 2-6 – data of the remaining stand (such as average height and diameter at breast height, total volume per hectare, basal area per hectare and number of trees per hectare); No. 7-11 – data of the removed trees (the same variables as in columns No. 2-6); No. 12-16 – data of the whole (remaining and removed together) stand (the same variables as in columns No. 2-6); No. 17-18 – other properties of the removed trees; No. 19-21 – other yield variables

Tree stand data are stored in the NFD on the so-called L-sheets (see Chapter 2.3., Figure 13).

The estimation of site conditions (characteristics) is based on a country scale site map created by the Central Forestry Directorate in the middle of the 20th century. This map was developed based on direct field observations (soil profile analyses). Site data are also recorded in the NFD. Recently, some of the County Forestry Directorates have refined the site map by carrying out further soil samplings in systematically or preferably established points.

During forest planning, most frequently indirect NFD data verification is carried out by the forest planner based on the site vegetation. Direct data verification is always conducted in the following cases:

- in case of afforestations; and
- if outstanding deviation exists between NFD data and vegetation indicated site characteristics.

Direct site inventory conducted by a country-wide used, well elaborated methodology is based on the detailed assessment of all soil profile layers. Raw sampling data are recorded on the so-called T-sheets (see Chapter 2.3., Figure 14) and the summarized site characteristics are also recorded on the L-sheets (Figure 13).

Based on the results of sampling of the tree stand, the aim of forest management, as well as, if necessary regeneration and harvesting methods of the next 10-year-long period (such as timing and intensity of harvests by tree species) are specified for each subcompartment with respect to the site characteristics and the nature conservation status. So called silvicultural model tables compiled by the Hungarian Forest Research Institute are used to calculate the optimal volume of the removed trees at thinning occasions. These tables show the optimal stand density (number of stems, basal area of the remaining stand) in different stand types, under different site conditions after each thinning operation (Figure 15). Harvesting prescriptions are recorded in the forest management plan and also on the L-sheets.

If, during the next 10 year-long-period, regeneration obligations arise, regeneration prescriptions are also specified and recorded in the forest management plan and on the L-sheets. These include: the area of regeneration, target stand type with tree species composition and the method of forest regeneration (clear cutting and artificial regeneration, shelterwood with natural regeneration, selection cutting with natural regeneration, etc.).

Harvesting and regeneration prescriptions as detailed in the forest management plan impose rights and obligations on forest managers. All forests are subject to periodic inspection carried out by forest inspectors to ensure compliance with prescriptions. A forest manager who contravenes prescriptions commits an offence and becomes liable to a fine.

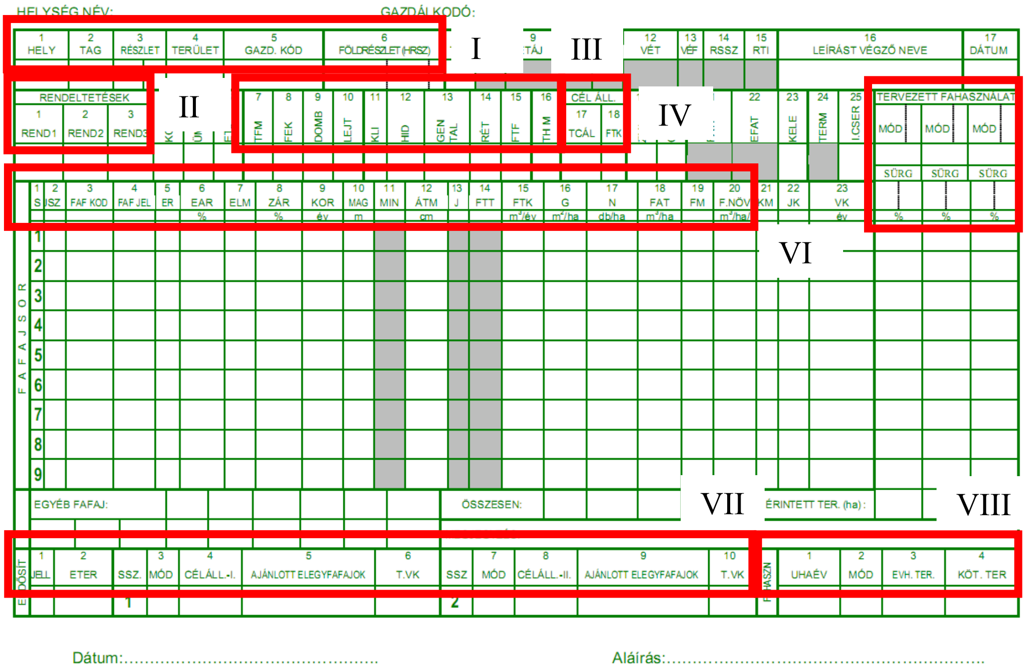


Figure 13. Information storing on the L-sheets. The main variable types describing the subcompartment are delineated by red lines. I: ID data; II: function; III: site conditions; IV: future tree stand composition and yield; V: methods and urgency of planned cuts; VI: variables describing the tree stand (detailed in the text); VII: regeneration prescriptions; VIII: prescriptions for harvesting.

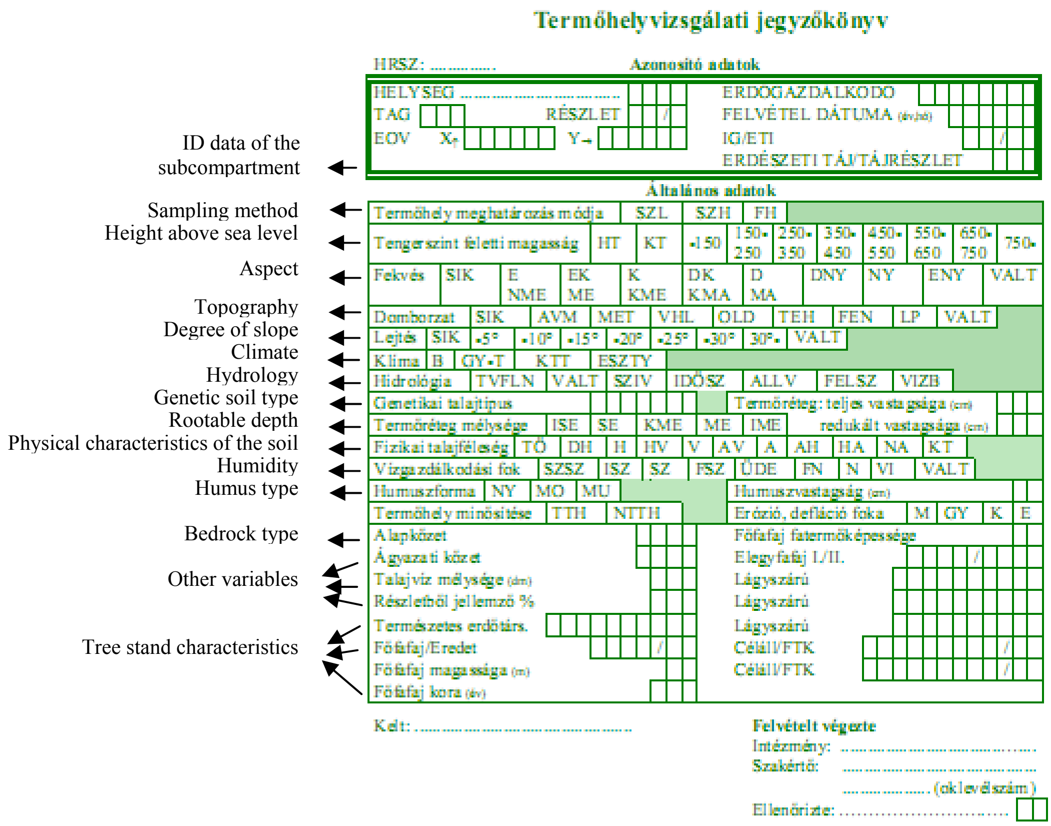


Figure 14a. Information storing on the T-sheets.

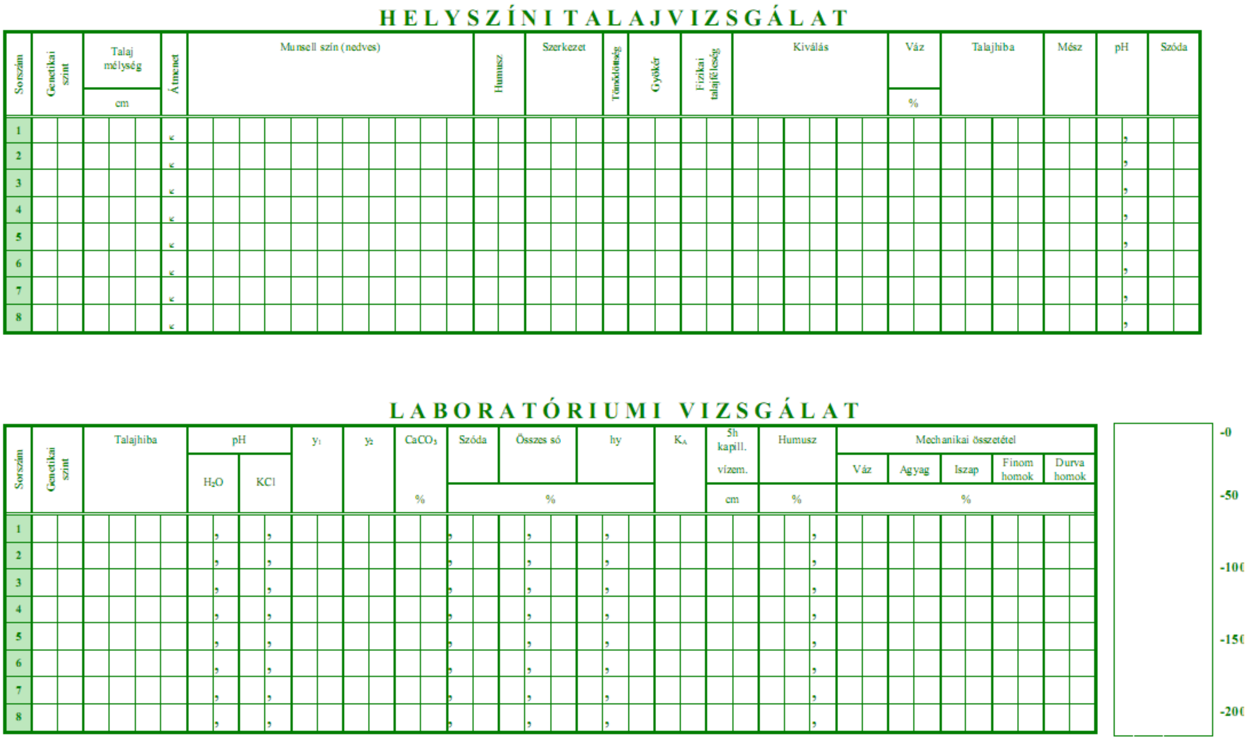
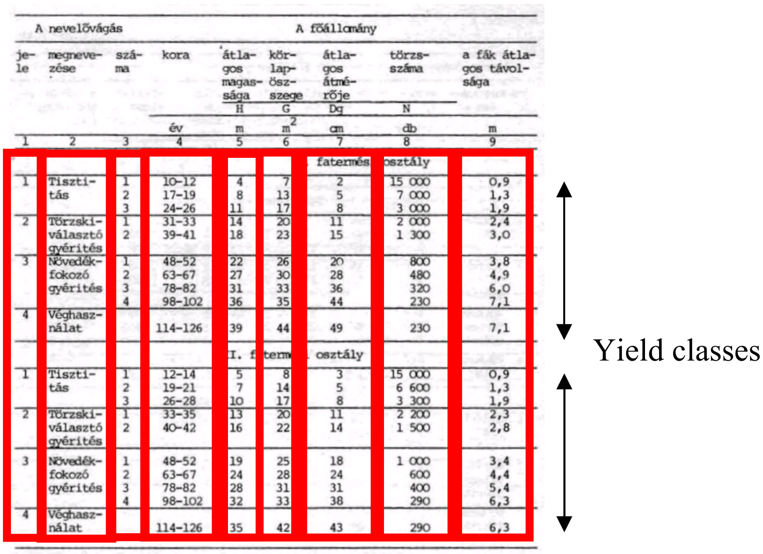


Figure 14b. Data sheets for in situ and laboratory analyses.



A nevelővágás			A főállomány					
jele	megnevezése	száma	kora	átlagos magassága H	körlapösszege G	átlagos átmérője Dg	törzsszáma N	a fák átlagos távolsága
			év	m	m^2	cm	db	m
1	2	3	4	5	6	7	8	9
						fatermés	osztály	
1	Tisztitás	1	10-12	4	7	2	15 000	0,9
		2	17-19	8	13	5	7 000	1,3
		3	24-26	11	17	8	3 000	1,9
2	Törzskiválasztó gyérités	1	31-33	14	20	11	2 000	2,4
		2	39-41	18	23	15	1 300	3,0
3	Növedékfokozó gyérités	1	48-52	22	26	20	800	3,8
		2	63-67	27	30	28	480	4,9
		3	78-82	31	33	36	320	6,0
		4	98-102	36	35	44	230	7,1
4	Véghasználat		114-126	39	44	49	230	7,1
				I. f	term	osztály		
1	Tisztitás	1	12-14	5	8	3	15 000	0,9
		2	19-21	7	14	5	6 600	1,3
		3	26-28	10	17	8	3 300	1,9
2	Törzskiválasztó gyérités	1	33-35	13	20	11	2 200	2,3
		2	40-42	16	22	14	1 500	2,8
3	Növedékfokozó gyérités	1	48-52	19	25	18	1 000	3,4
		2	63-67	24	28	24	600	4,4
		3	78-82	28	31	31	400	5,4
		4	98-102	32	33	38	290	6,3
4	Véghasználat		114-126	35	42	43	290	6,3

Figure 15. Structure of the silvicultural model tables. The first three columns (No. 1-3) show information about thinnings, while the others describe the remaining tree stand by yield classes. Data of the various columns are the following: No. 1 – ID number of the thinning types; No. 2 – name of the thinning types; No. 3 – sequential number of the thinnings; No. 4 – age of the tree stand; No. 5 – average height of the remaining stand; No. 6 – sum of basal area of the remaining stand (per hectare); No. 7 – average diameter at breast height of the remaining stand; No. 8 – number of trees of the remaining stand (per hectare); No. 9 – average distance between adjacent trees of the remaining stand.

2.2.2. Forestry Inspection

The Forestry Authority inspects conformance of forestry operations with prescriptions in the forest management plan. Forest inspection activities include, among others, the following:

1. inspection of afforestations and regenerations;

2. inspection of harvested volume;
3. on-the-spot assessment of strong natural disturbances;
4. review/audit of the use of afforestation subsidies;
5. imposing sanctions of violating rules in the above cases;
6. NFD up-dating according to data on afforestation, regeneration, the implemented forestry activities and disturbances surveyed;
7. record keeping of forest managers (registry);
8. other managing specific issues (e.g. land use change, conversion of forest into agricultural land, division of forest subcompartment etc.) and correspondingly updating the NFD data.

According to the provisions of the Forest Act in force, forest inspectors are required to check afforestations and regenerations on the spot at the beginning of the afforestation processes (i.e. at the time of first successful forestation), at the end of the first year, and five years after the completion of forestation. The last inspection is called review. In addition to the obligatory inspections, additional ones can be made by the forest inspector.

The forest managers must reforest each area after final cutting, if trees are destroyed for any reason on an area exceeding five thousand square meters, or if, in a forest serving wood production, the crown closure has decreased below seventy percent.

According to the Forest Acts of 1996 and 2009 and the Regulations of the Minister on the implementation of the Acts, the criteria of the first successful and the completed afforestation are the following:

Table 1. Criterion of the first successful and the completed afforestation as prescribed in forest acts of 1996 and 2009.

	Criteria	First successful afforestation	Completed afforestation
Forest Act of 1996	No. of seedlings	Binary criterion, forest inspectors decide whether or not it is accepatable	Binary criterion, forest inspectors decide whether or not it is accepatable
	Minimum height	Not criterion	Not criterion
	Deadline	In 2 years after regeneration obligation arised	In 5-10 years after regeneration obligation arised
Forest Act of 2009	No. of seedlings	300 (cultivated poplars) – 8000 (slow-growing hardwood species) seedlings/ha	600 (cultivated poplars with associated species) – 7500 (slow-growing species with associated species)
	Height	Not criterion	150 cm
	Deadline	In 2 years after regeneration obligation arised	In 5-14 years after regeneration obligation arised

As Table 1 shows, the Forest Act of 2009 has introduced an additional criteria: the prescribed (minimum) number of seedlings that must be healthy and develop freely. In order an afforestation is to be declared completed, maximum 10% of the seedlings may be damaged by game. According to the Forest Act of 2009, seedlings must be evenly distributed throughout the regeneration area. The manual of sampling methods of the inspections is under development.

Inspection data are recorded on the so called E-sheet that includes, among others, the following data (Figure 16):

- target stand type (its definition is similar to stand type that was historically used in relation to afforestation subsidies and that did not require identifying the exact proportion of species);

- number of seedlings by tree species in the forest subcompartment;
- areas occupied by each tree species;
- size of area that complies with provisions (so called 'successful area');
- deadline to complete regeneration.

The data on the E-sheets are parts of NFD (see Chapter 2.3.). The NFD retrieves the E-sheets from the L-sheets. The connection between the two sheets has been automatic and complete since 2005 when the standard central informatics system was implemented. Before 2005, connection was indirect and created by the forest inspector based on the comparison of the native identifiers (name of municipality, number of forest compartment and letter of forest subcompartment) of the two sheets.

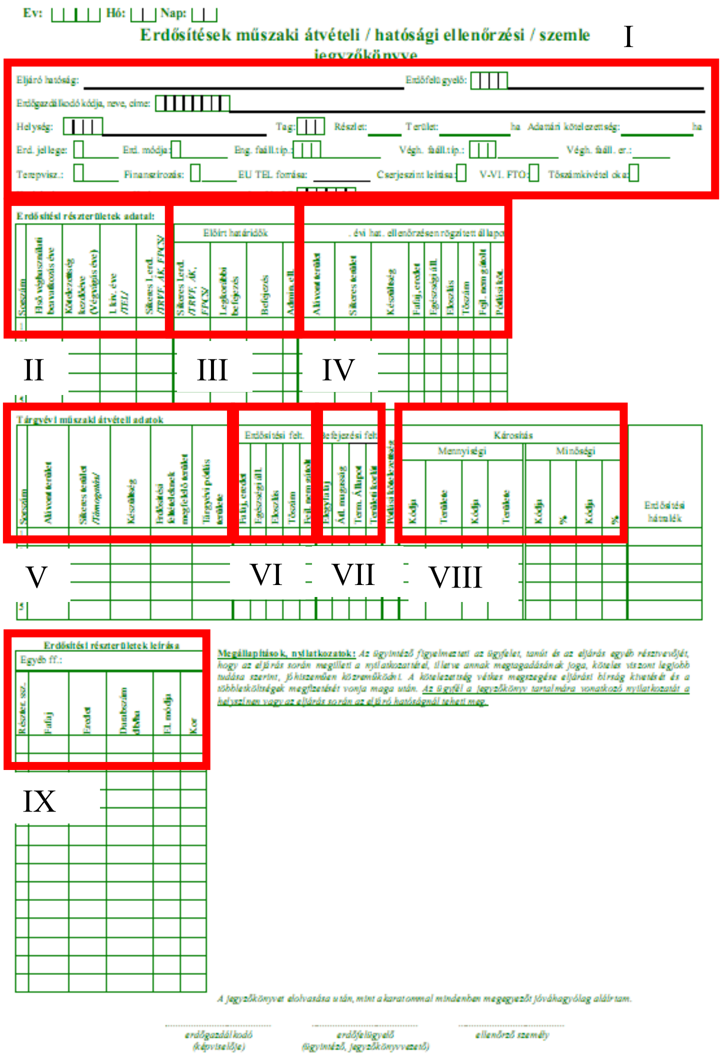
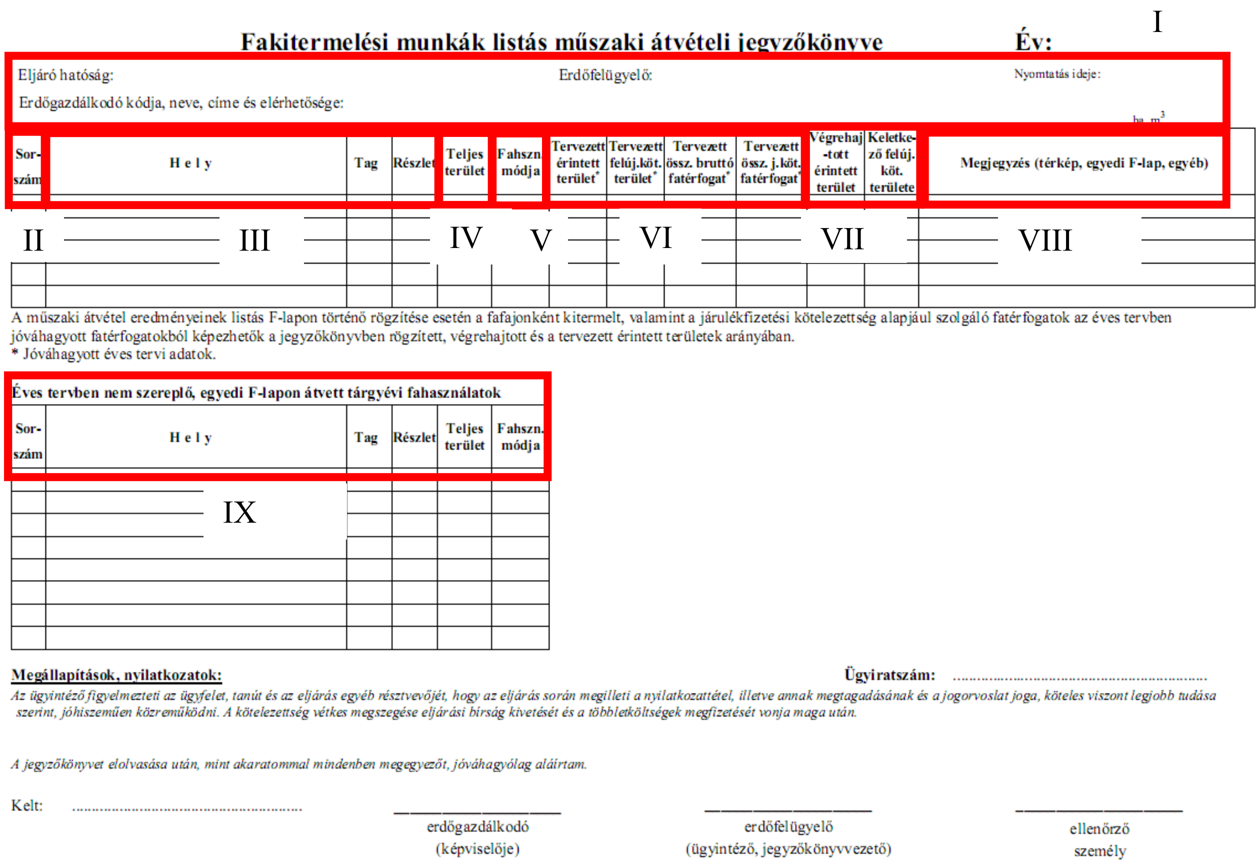


Figure 16. Information storing on E-sheets. The main variable types describing the subcompartment are delineated by red lines. I – ID data of the County Forestry Directorate and the subcompartment; II-IV – data of the regeneration area: II – dates describing the regeneration process (i.e. date of the final cut, the regeneration obligation, the first successful regeneration etc.); III – deadlines; IV – description of the regeneration state observed at the previous inspection (i.e. regeneration area, number and distribution of seedlings, notes on how freely seedlings grew etc.); V-VIII – data of the actual inspection: V – summary data (i.e. total regeneration area, successfully regenerated area; area of beating up etc.); VI – information whether criteria of the first successful regeneration are fulfilled (yes/no); VII – information whether criteria of the completed afforestation are fulfilled (yes/no); VIII – information on damaged seedlings; IX – detailed data on seedlings (species name, origin, number, distribution, age).

Forest managers are obliged to fill out the afforestation-implementation plan containing land policy data, data on soil profile analyses and afforestation plan. Afforestations have to be carried out according to the afforestation-implementation plan. If the afforestation is declared completed, the new forest is recorded in NFD as a new subcompartment with its native identifier. The L-sheets of the newly recorded forest subcompartments contain tree species description for the time of the first successful afforestation based on yield tables. Changes of the stand characteristics are not recorded on L-sheets till the completion of afforestation. During this period, subsidy is related to the so called 'subarea of the regeneration' on which seedlings are at the same regeneration phase. The data of the subareas are updated annually on the E-sheets that are the only information sources on the actual state of afforestations.

Forest managers can apply for EU support for afforestation. Similarly to non-subsidized afforestation, the first step is the submission of the afforestation-implementation plan, and, if it is approved by the Forestry Authority, the application must be submitted to the Agricultural and Rural Development Agency. In case of acceptance, the time of first successful afforestation is to be reported to the Forestry Authority and request for land use conversion (to forest) is to be submitted to the Land Registry Office. The administration related to EU subsidies is the same as for national supports, i.e., data are recorded on E-sheets, afforested areas are considered as subcompartments. Subsidized and non-subsidized afforestation are inspected in the same way by the Forestry Authority. Furthermore, 5 % of the completed afforestation is checked on the spot by the Agricultural and Rural Development Agency.


I

Fakitermelési munkák listás műszaki átvételi jegyzőkönyve Év:

Eljáró hatóság: Erdőfelügyelő: Nyomtatás ideje:

Erdőgazdálkodó kódja, neve, címe és elérhetősége:

ha m³

Sor-szám	H e l y	Tag	Részlet	Teljes terület	Fahszn. módja	Tervezett érintett terület*	Tervezett felúj.köt. terület*	Tervezett össz. bruttó fatérfogat*	Tervezett össz. j.köt. fatérfogat*	Végrehaj-tott érintett terület	Keletkező felúj. köt. területe	Megjegyzés (térkép, egyedi F-lap, egyéb)
II	III			IV	V	VI				VII		VIII

A műszaki átvétel eredményeinek listás F-lapon történő rögzítése esetén a fafajonként kitermelt, valamint a járulékfizetési kötelezettség alapjául szolgáló fatérfogatok az éves tervben jóváhagyott fatérfogatokból képezhetők a jegyzőkönyvben rögzített, végrehajtott és a tervezett érintett területek arányában.
* Jóváhagyott éves tervi adatok.

Éves tervben nem szereplő, egyedi F-lapon átvett tárgyévi fahasználatok

Sor-szám	H e l y	Tag	Részlet	Teljes terület	Fahszn. módja
	IX				

Megállapítások, nyilatkozatok: **Ügyiratszám:** ....

Az ügyintéző figyelmezteti az ügyfelet, tanút és az eljárás egyéb résztvevőjét, hogy az eljárás során megilleti a nyilatkozattétel, illetve annak megtagadásának és a jogorvoslat joga, köteles viszont legjobb tudása szerint, jóhiszeműen közreműködni. A kötelezettség vétkes megszegése eljárási bírság kivetését és a többletköltségek megfizetését vonja maga után.

A jegyzőkönyvet elolvasása után, mint akaratommal mindenben megegyezőt, jóváhagyólag aláírtam.

Kelt: ....

erdőgazdálkodó (képviselője) — erdőfelügyelő (ügyintéző, jegyzőkönyvvezető) — ellenőrző személy

Figure 17. Information storing on the F-sheets. The main variable types describing the subcompartment are delineated by red lines. I – ID data of the County Forestry Directorate and the forest manager; II – sequential number; III – ID data of the forest subcompartment; IV – total area of the subcompartment; V – harvesting method; VI – data on the planned harvest (harvesting area, harvested volume, area of regeneration obligation); VII – data on the performed harvest (harvesting area, area of regeneration obligation); VIII – notes; IX – data on unplanned harvests (which are detailed on another special F-sheet type).

Any type of harvesting has to be reported to the Forestry Authority in advance, as well as, after harvest has been undertaken. If the obligatory reporting takes place after the activity, it can be done in the middle of the year (till 31 July, the actual state as of 30 June has to be reported) and at the end of the year (till 31 January, the actual state as of 31 December has to be reported). Completed harvest is inspected randomly by forest inspectors. Volumes of the removed and the remained trees are estimated on 5% of the total area affected by the reported harvesting activity.

On the basis of the report and the field measurement, the F-sheet of the affected forest subcompartment is filled out by the forest inspector. F-sheets include the following main data (Figure 17):

- harvesting method (e.g. clearcut, precommercial and commercial thinning, etc.);
- harvested volume by tree species;
- size of area affected by harvesting;
- size of area of regeneration obligations.

Any disturbance of the tree stand has to be recorded on an F-sheet as well.

F-sheets are recorded in NFD. On the basis of F-sheets data, L-sheets are updated, i.e., the stand volume is decreased. If the completed harvesting was carried out in compliance with the prescribed cut, the updating is automatic. Figure 18 shows how the NFD is built up from field data recorded during forest planning and inspection.

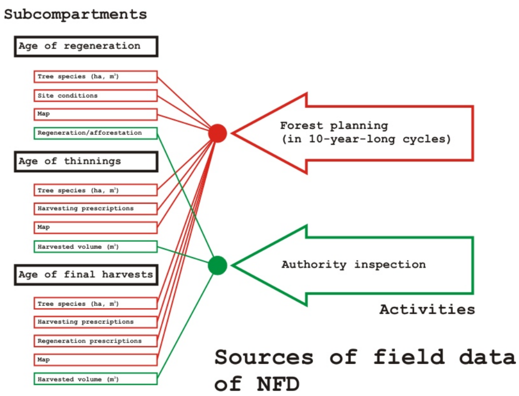


Figure 18. Data storing in the stand-based NFD and their relationships with activities of Forestry Directorates.

2.2.3. Mapping System

Before 2004, analog maps were created during forest planning (Astralon, i.e., a plastic sheet was used as a transparent or translucent base for colours for map production). Maps were projected according to the *Uniform National Projection* (EOV) system. The EOV is a plane projection system used uniformly for the Hungarian civilian base maps and, in general, for GIS. Further characteristics were the application of scale, geographic names, field objects and other notations (cartographic maps). Astralon maps could be purchased and used as management maps by forest managers. Maps were continuously modified according to changes (e.g. boundary changes) of subcompartments over the 10 year-long periods of forest management plans and if it was necessary were recreated in the year of forest planning according to aerial photos and field measurements. Due to the recreation of the maps, forest area changed. Despite the emergence of new technologies such as the application of digital mapping, GPS and orthophotos, area changes caused by mapping activities occur nowadays, too. Thus, forest area (including the so called FM area) changes are not only a consequence of registered afforestation and deforestation but also due to mapping methodology reasons.

Transition from analog to digital maps took place between 2004 and 2006 and resulted in a database with no map sheets. ***Currently, all forests that were subject to forest planning (figures of which are published in various brochures) are mapped.*** Forest mapping accuracy criteria are summarized in Table 2. It has to be noted that the real accuracy is far better than the required as presented in the table. Furthermore, the listed requirements are being improved nowadays (which means that the maximum acceptable error values will be decreased).

Table 2. Forest mapping accuracy requirements.* Error means the maximum distance between the actual point and the measured one.

Point group	Error (m)*
Breakpoints of administrative boundaries of municipalities	1
Boundary points of land parcels covered by forests under forest planning	3
Boundary points of forest subcompartments	6
Points of objects helping orientation	15

Digital mapping are applied in forest planning and forest inspection. As a part of the planning process, maps are created for all forests that are to be planned in the given year. Most of the time it only means the updating of the existing maps, and new maps are only rarely created (i.e., in forests that had not been previously planned – including the so-called found forests – which originated most frequently from spontaneous or artificial but non-registered afforestation).

For digital mapping, the following documents are obtained by forest planners:

- site orthophotos (from the Institute of Geodesy, Cartography and Remote Sensing);
- land registry maps (cadastral maps), from the competent Land Registry Office; and, if necessary,
- maps created at the previous planning 10 years earlier (and that have been modified by forest inspection since then).

Based on field measurements, the maps are either updated or new ones are created.

During digital data processing, forest subcompartments are displayed as polygons (by DigiTerra Map v. 3. software). Polygons are uploaded to the NFD and checked whether their total area is within the area of the given municipality. Overlap higher than 5 % is not possible. Further validation is carried out by NFD software to check if the polygon meets specific requirements, including comparisons of areas of polygons of NFD with polygon areas calculated from areas of land parcels, checking of breakpoints (angles), etc. A forest subcompartment is officially recorded in NFD only if a polygon is assigned to it. Thus, number of forest subcompartments without polygons or with faulty polygons has been drastically decreased since the beginning of digital mapping. The polygon can be visualized directly on the user surface of NFD.

Displaying of boundary objects (e.g. numbered trees, stakes, etc.) is mandatory, whereas that of furher information (such as bigger roads, rivers, geographical names) is optional. The latter information is mostly imported from other databases. All of the field and imported topographical data are uploaded to the NFD. As an annex to their forest management plan, forest managers receive maps for free showing the forests they manage (Figure 19).

Forest inspection activities include modification of maps related to official issues (e.g. land use conversion, afforestation, division of forest area). Mapping process is the same as with forest planning, but input data from the Land Registry might be different (not only land registry maps, but land registry plan, list of coordinates) and input data can be obtained by other ways, too (e.g. purchased digital mapping information). Mapping activities of forest inspection work are checked during the next forest planning.

2.2.4. Coherent annual statistics of NFD

The coherent annual statistics of NFD for a given year is the statistics that show the situation on 31 December of that year which reflect changes related to forest inspection activities in that year. Due to methodological reasons, the coherent annual statistics is calculated only in the following April-May.

Forest management plans for the following 10 years that are effective on one-tenth of the forest area of Hungary are nominally uploaded on 1 January. Furthermore, during the so called 'closing operation' volume increments of the *following* year from data of yield tables are calculated and added to the volume of the previous year, and the age of stands are also increased (one year is added to the age of previous year). The resulted database is called 'NFD of 1 January'.

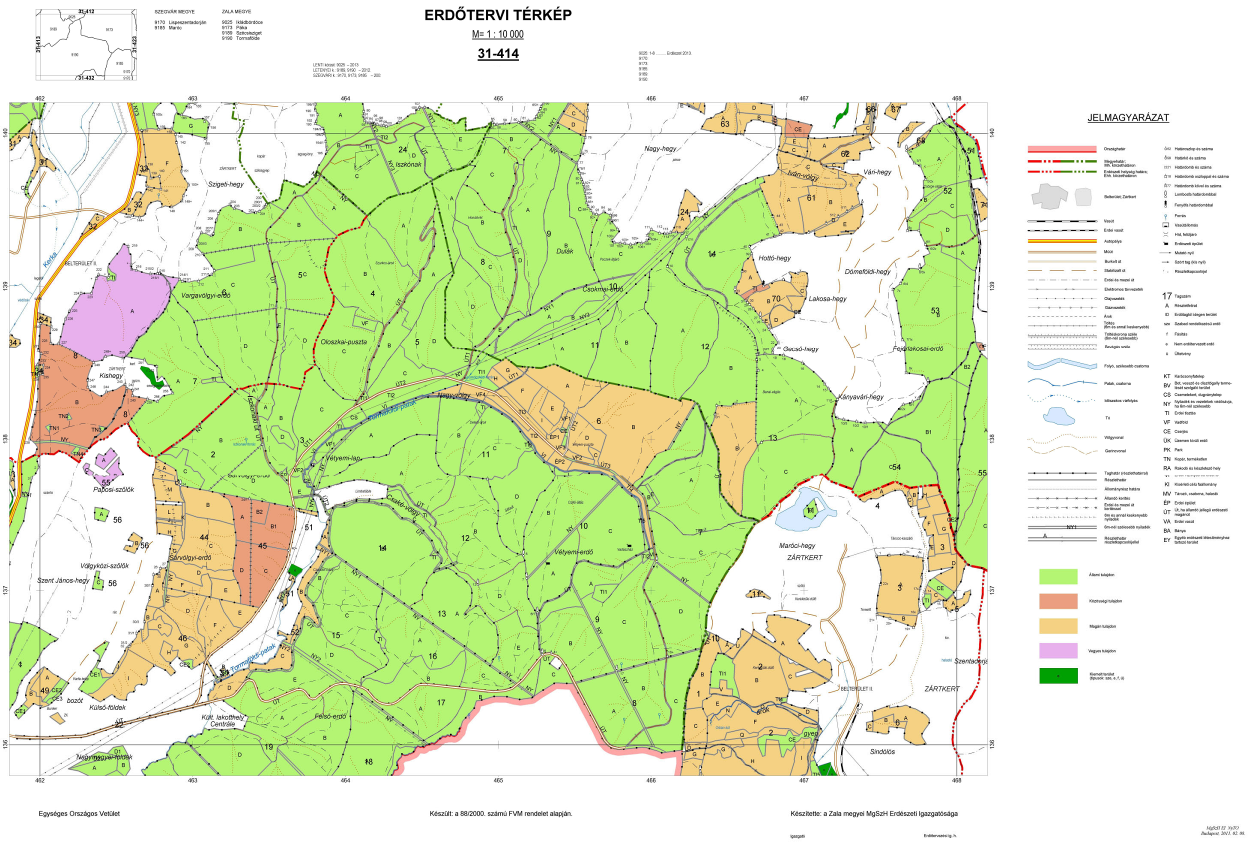


Figure 19. An example for forest management maps.

2.3. Structure of NFD

As mentioned above, forest management planning and forest inspection are the main sources of NFD data (Figure 18). As a consequence of the former, NFD data are referred to forest subcompartments *(stand-based inventory)*. Currently, altogether more than 300 raw and derived data are stored in the NFD by subcompartments. The main data groups are the following (Figure 20):

1. Maps (see Chapter 2.2.3.);
2. Data of forest subcompartments (L-sheets). On the L-sheets, the most important data of forest subcompartments are stored, such as:
   a. The name of the forest manager. Each forest manager has a unique identifier (forest manager code). Forest management plan provisions impose rights and obligations on the actual forest manager of the forest subcompartment.
   b. The area and the environmental status (protected/not protected) of, and the function of forest management in the subcompartment.
   c. Site characteristics, the most important of which are: climate type, exposure, degree of slope, aspect (direction), genetic soil type, physical soil attributes, rooting depth, amount and type of water in soil that is additional to water from precipitation, yield class, etc. Furthermore, the method applied for analyses of site conditions is given (i.e., direct method: soil sample is analyzed in laboratory or indirect method: soil attributes are assessed from cover of various site indicator plant species).
   d. Tree species records stored in a special form: not by species but by so called 'tree species rows'. Tree species rows are determined by three variables: tree species, layer and age (i.e., data of 100-year-old sessile oak trees in the upper tree layer form a row, however, data of 50-year-old sessile oak trees are stored in a separate row). Data of species proportion of which is less than 5 % are not stored. Data in a tree species row include the most important characteristics of the tree stand such as age, proportion by crown closure, origin (seed or sprout), mean height, mean diameter, standing volume, annual increment, area etc.. Similarly to the site description, the sampling method is indicated. The area of a tree species row is not simply the area of crown projection of certain trees, but a number calculated by a complex algorithm. Algorithm input data set includes: species proportion, density (relative to the site capacity estimated from yield tables), crown closure. The sum of areas of tree species rows equals the area of forest subcompartment irrespectively of the closure of the entire canopy. The area of tree species rows is used for forest planning and inspection activities related to harvests and regenerations.
   e. Data of the planned harvests. For the given 10-year-long planning period details of the prescibed harvests are summarized: timing (urgency), and degree of removal (volume to be cut by tree species).
   f. Forestation (regeneration, afforestation) prescriptions. If regeneration shall be started in the following 10 years, the regeneration method, expected stand type and deadline for completion of the regeneration are indicated. Species proportions are not indicated. The same data are presented for afforestation.
3. Records of harvests carried out (F-sheets, see Chapter 2.2.2.).
4. Records of regeneration/afforestation carried out (E-sheets, see Chapter 2.2.2.).
5. Detailed site data (T-sheets). Raw data of soil sampling with photos of soil profiles are included.

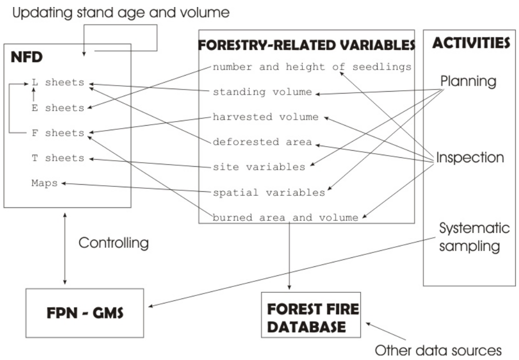


Figure 20. Build-up of forestry-related databases.

2.4. Hardware architecture of NFD

Data management practice of the Hungarian Forestry Administration within the State Administration has been outstanding, especially if previous technological difficulties (COCOM-list) are considered. Already at the beginning of development of civil informatics systems, when the first complete forest inventory was carried out, modelling and calculating functions (volume and age data calculation, forest subcompartment data calculation and validation) were already operating on computers.

The major steps of the development of the IT systems employed in the forestry authorities have been the following:

1. Centralized data processing: until about 1986
   - RAZDAN (Russian made, language FORTRAN, in 1970)
   - Siemens mainstream, and R-20 and R-30 (Russian copy of IBM 360, DOS operating system, *punched tape*)
   - VAX-VMS (PLIOPT, from 1992)
   - Forest planners received printed forms and recorded new or corrected field data by hand. Then, data were uploaded to the NFD by the coordinating organ. During checks error lists were compiled.

2. Data processing in local Personal Computers until about 2004
   - PC XT, AT, i286
   - Foxpro (a text-based procedural programming language) till 2004
   - Data processing was transferred to local computers, but data processing software programs were still written centrally. GIS, i.e. the digital mapping database was run in parallel. At the end of each year databases separated on the basis of competence were merged in order to establish the coherent annual statistics. Data storage media were used to physically move the separated databases for merging. Sheets to be used in the following year were printed from this database. Forest management plan completion was achieved by printing the plans, which were called „fizzy printing”.

3. Web-based online data processing running on the central server: since 2005
   - ESZIR is the Oracle g9 and g10 based system that was developed within the frame of a PHARE-project in 2005. Physical data medium is only used to upload input data. The introduction of centralized architecture has resulted in uniform methods of proceedings and higher data quality.

2.5 History of the administration of afforestation

As a result of Treaty of Trianon at the end of World War I, the forest area of Hungary decreased dramatically. By 1920, the forest area was reduced from 26% to 12%. As a consequence, an afforestation programme was launched to mitigate wood shortage. As a result of the programme, more than 800 thousand hectare has been forested since the 1930's and the forest area has been increased above 20%. This means that, on the average, about 10 thousand ha was forested annually.

The afforestation programme was financed from national resources for a long time. The financial support depended on the size of the regeneration area, the target stand type and the stage of the afforestation (each step of the afforestation was subsidized separately). Furthermore, the payments were proportional to the development condition of afforestations which means that the development condition was annually checked by forest inspectors and where forests failed to meet specific conditions, the payments that forest managers had claimed might have been withdrawn. Although it was an area-based payment scheme and the condition of the afforestations was detectable from year to year, the strategic objective of the programme was not primarily the account for the received payments by subcompartment, rather, the support of forestry companies.

The Forestry Authority had 10 Directorates that were administratively independent and reported directly to the Ministry. Because of that, they were separated by their jurisdiction, and methods applied by them became different causing uncertainty as far as data are concerned. However, annual field reviews were general and compulsory. As the forest area has in fact increased, the administrative system can be considered effective.

There has been no national subsidy since 2005, only EU granted area-based payment is available for new afforestation plans. Afforestations that were on-going at that time are, however, still supported until the completion (obviously, the area of these afforestations is decreasing).

3. Forest Protection Network (FPN) Database

3.1. The objective of the establishment and the history of the FPN Database

The main objective of the establishment of the Forest Protection Network is to detect long-term trends in forest health condition and to identify their causes. By this way, the Forest Protection Network helps to develop adequate methods to prevent the deterioration of forest health condition.

Within the framework of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) with 35 participating countries, the Forest Protection Network was established in Hungary in the middle of 1980's. At the beginning, the objective of the project was the assessment of air pollution effects on forests, but later, air pollution as a possible cause of forest health deterioration was withdrawn and the continuous monitoring of forest health condition was emphasized.

3.2. Development of FPN Database (sampling)

The Hungarian Forest Protection Network employs data collection at two levels. Level I was implemented by the forestry experts of the Central Agriculture Office (CAO) and its predecessor institutions between 1987 and 2010, and from 2011 by the Hungarian Forestry Research Institute (FRI). Since 1993 Level II has been managed by the researchers of FRI.

By the Level I network countrywide data are obtained which are used for examination of large-scale (at least regional) cause-effect relationships. In Hungary, a grid of 4 x 4 km was established covering the entire area of the country. If the intersection point of the grid was on forest land, a sample plot was installed. Obviously, due to changes of forest area, it may vary in over time which points of the grid are on forest land and which points are not.. Thus, number and location of sampling plots are accordingly modified. That is, previously forested but in the year of the given sampling unforested plots are omitted and vice versa, previously unforested but in the year of the given sampling forested plots are sampled. On Level I plots, health-related tree stand characteristics are sampled annually (degree of defoliation, crown, stem, bark, root collar and game damages). Furthermore, soil damages (erosion, high groundwater, slack-water, soil compaction, etc.) are also recorded.

The number of sample plots of Level II network (so called ‘base areas’) is less, currently only eight. This number also varies depending on the available financial resources. As a consequence, it cannot be considered a real network. At the selection of Level II plots basic requirements included that the selected areas be representative of the Hungarian forest types and already have a research history (the more intensive the better). Level II data are suitable for revealing interactions at finer spatial scale (i.e., on forest subcompartment-level). Various forest attributes are sampled, such as crown condition and defoliation, increment, dry and wet aerial deposition, amount of precipitation, canopy interception, cover of ground vegetation species, ambient air quality. Sampling frequency depends on the variable measured, and varies from continuous electronic data collection to measurements only once in every five years.

4. The Growth Monitoring System (GMS) Database

4.1. The objective of the establishment and history of the GMS Database

The Growth Monitoring System (GMS) was launched in 1993. The main objective of the system is to monitor increment and its temporal variation in order to verify data in the National Forestry Database. GMS was an independent initiative, not directly connected to any international projects.

4.2. The development of the GMS Database (sampling)

For GMS monitoring, a grid of 2.8 x 2.8 km is used which was established by placing new grid points in the 4 x 4 km grid of Level I network. That is, every point of the latter was moved 2 km eastwards and 2 km southwards. In this way, a new grid was obtained with a point distance of 2.8 km (which is $\sqrt{2^2 + 2^2}$). Thus, half of the points of the GMS grid are identical to Level I grid points. At each GMS grid point a so called tract was established which is a square of 200 x 200 m. The southwest corner of the tract is the grid point. At each corner of the tract, trees are sampled in concentric circles of various sizes. The diameter of the sampling circle depends on the diameter at breast height of the tree to be sampled. Each tract is assigned to one of the years of the 5-year-long inventory period and is repeatedly assessed once in every five years. Similarly to FPN, GMS sample plot locations may vary in time with the forest area. The diameter and height of each sample tree are measured, and if the tree is damaged, the cause and degree of damage are also assessed.

For the development of the GMS Database, the definition of forest by FAO has been applied since 2009. This definition is quite different from that applied in all the other databases (see Chapter 1.1.). According to FAO, forest is defined as lands of more than 0.5 hectares, with a tree canopy cover of more than 10 percent, and which are not primarily under agricultural or urban land use. The trees should be able to reach a minimum height of 5 meters in situ. Furthermore, the so called 'other wooded lands' are also recorded but trees are not sampled on them. These are stands area of which is larger than 0.5 hectares and the tree canopy cover is higher than 5 percent. Tree height as a criterion is not considered in this case. Before 2009, the definition detailed in Chapter 1.1. was used.

In 2010, FPN and GMS were merged and since then they have been operating with renewed data content (e.g. survey on dead trees and small trees are included) and new technology. The new system is called Forest Monitoring and Observation System.

5. National Forest Fire Database

5.1. The objective of the establishment and the history of National Forest Fire Database

Data collection and storage related to forest fires make it possible to analysis of causes of fire, to develop preventive measures, to estimate damage (property damage and goodwill value of damage) and to submit data to international databases (one of these is the Greenhouse Gas Inventory, since, at a global scale fires are sources of greenhouse gas emission in the atmosphere).

Hungarian Fire Service data on the number of forest fires have been available since 1991. The cooperation between the Forestry Directorate and the Fire Service was established in 1999, and since that, not only the number of forest fires, but also the size of the affected areas has been recorded by the Fire Service. The Forestry Directorate has been actively participating in data collection since 2002.

The European Forest Fire Information System (EFFIS: http://effis.jrc.it or http://www.jrc.cec.eu.int/) was established in 1994, which is run by the European Commission's Joint Research Centre. Hungary has been submitting data to EFFIS since 2002. The National Forest Fire Database was established by the Forestry Directorate in 2006. Data have been uploaded to the database since 2007.

On the EU-level, data collection is regulated by the Commission Regulation No 1737/2006/EC. This regulation defines forest fire as fire which breaks out and spreads in forests and other wooded lands or which breaks out on other lands and spreads into forests or on other wooded lands. This definition excludes prescribed or controlled burning which is used for eliminating slash from the harvesting area. Another consequence of the definition is the fact that the area of a forest fire may be larger than that of the burned forest if the fire crosses the boundary of the forest.

5.2. Development of the National Forest Fire Database (data collection)

National Forest Fire Database data are submitted by the Fire Service, the National Directorate General for Disaster Management and the Forestry Directorate. Data on fire area are checked in situ by forest inspectors in every case that ensures data quality.

The National Forest Fire Database includes, among others, the following data:

- fire incident identifier;
- year of fire incident;
- total (forested and non-forested) area affected, by the fire (these data are submitted to the EFFIS);
- forest area damaged by the fire (destroyed volume is estimated from the size of the affected area and the standing volume of the forest subcompartment as retrieved from the NFD);
- ratio of area of the affected woody vegetation and the biomass destroyed within that area (woody vegetation means stands that are not forests according to the Hungarian Forest Act, but are forests according to the internationally accepted definition (FAO); destroyed biomass ratio is calculated from the ratio of destroyed/total area);
- fire intensity on a 1-3 scale;
- fire type: aboveground (surface), underground and crown fire (crown fires can cause the total destruction of the tree stand, while the others distruct mostly dead leaves only that do not affect the assimilating surface of the trees).