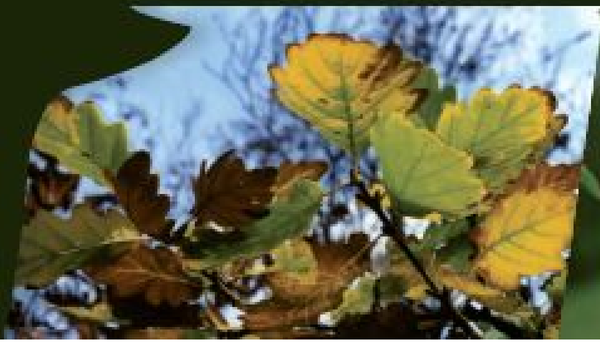
MGSZH Központ
Erdészeti Igazgatóság

Forest Monitoring and Observation System

Erdővédelmi Mérő-és Megfigyelő Rendszer

1988-2008



1. Foreword

While earlier some decades ago only few experts realised that the natural resources of the Earth are not available without restraint, nowadays environmental consciousness get more attention and more substance. As a consequence of continuous and consistent improvement of public perception and warnings of nature, humankind has realised that it is not possible to overrule nature. Similarly to nature's other components and elements, humans have to achieve a balanced and mutual contact with nature.

At the present time this endeavour is more and more visible starting from the reconsideration of consuming customs and the scale of values in the consumers' society, the more conscious utilisation of natural resources – like water, energy, etc. - to the modification of our relations to the different elements of the ecosystem.

It is not different in the case of forests. If we observe the expectations of society on forestry and the forestry sector in our homeland, Hungary we can conclude that both of them have changed considerably in the last decades. The former large scale, serial type forest management is disappearing. Where natural regeneration is possible clear-cutting methods are forced back and close to nature management methods are expanding. Nowadays not only a small group of committed experts but the whole society pays attention to the biodiversity of forests.

The tree main functions of forests – protection, economic, social – and the intention to harmonise them are emphasised more than ever in the new Forest Act. The understanding, creation and maintenance of these functions are essential for the society. On the one hand this harmony secure the protection, existence and possibility of recovery of the different components of nature, on the other the close to nature lifestyle unavoidably include the rational and sound utilisation of wood as raw material and as source of energy.

The Forest Monitoring and Observation System (FMOS) contributes to the maintenance and protection of this harmony by continuously recording the different effects on forests, observing the changes and operating the feedback system of result-based recommendations.

September 24, 2009

Károly Wisnovszky
Director General
CAO Centre Forestry Directorate

2. FMOS - general introduction

Forest ecosystems react differently to direct or indirect environmental changes. These changes – especially the anthropogenic ones – that have especially sped up generated an increasing demand for a more accurate determination of the direction and extent of these changes and led to new type of monitoring systems that focus on parameters sensitive to environmental alterations and use them as indicators.

One of the oldest environmental monitoring systems in Hungary is the Forest Protection Observation and Indicator System launched in 1961 and operated by the Forest Research Institute (FRI). The system is comprised of two sub-systems, the System of Forest Protection Indicator Sheets and the National Forest Light Trap Network.

The International Co-operative Programme (ICP Forests) launched in Europe in 1985 to assess the effects of air pollution on forests, recommended the set up and operation of a new monitoring system able to detect changes in forest condition. Hungary joined the programme with altogether 35 participating countries and in the same year established the "Complex Programme for Forest Protection" by the initiative of the Office on Forestry and Timber Industry of the Ministry of Agriculture and Food (MAF). In 1987 within the frame of the complex programme the Forest Management Service established the Forest Protection Network (FPN) focusing on forest damages.

In 1993 Hungary, having regard to the recommendations of the ICP Forests Manual started the implementation of the Increment Assessment Network (IAN) programme that aimed to assess the increment on the base of the inventory data and its temporal alterations. The IAN has a strong connection with FPM as the sampling network of IAN is based on the FPM net. Common plots of FPN and IAN network provide the common ground for complex analysis of data collected in the two systems.

First results on increment on county or regional level are available after the completion of the 5-year-long assessment, in the 6th year and more accurate results are available after 10 years due to the reliability of the system while the first analysis on the trends is possible only after the completion of the third assessment period, after 15 years.

After the democratic transformation the complex programme for forest protection launched in 1987 was extended with additional tasks, renamed as Forest Protection and Observation System (FPOS) and integrated into the new Forest Act No LIV of 1996 and into FM Regulation No 29/1997 of 29 April 1997 laying down detailed rules for the implementation of Forest Act. In the programme, covering the whole forest sector, the following tasks were designated to the Forest Management Planning Service (later State Forest Service and recently Central Agriculture Office Centre, Forest Directorate as legal successors):

1. Elaboration of methods and operation of national large-scale forest protection monitoring network with special attention to the effects of air pollution on forests.
2. Assessment of forest health condition of areas under forest management planning – annually 1/10th of the total forest area of Hungary – on forest compartment level.
3. Data processing and storage of the two assessments mentioned above.
4. Representation of Hungary in the relevant international co-operative programme and coordination of activities on national level.
5. Establishing and operating a target oriented monitoring system in case of damages or epidemics extended on relatively large forest areas.

National initiatives of the intensive monitoring network run by the FRI were the research sites in the 16x16 km network based on the 4x4 km large-scale monitoring plots established by the State Forest Service in 1987. Selection and establishment of the 16x16 km plots as well as the assessment methodologies started in 1989 by the Ecology Department of the FRI.

In the mid-nineties selection criteria of the intensive monitoring plots (Level II) were reconsidered and new monitoring plots were selected to fulfil the increasing demands set by the international monitoring programme as well as to select research areas where historical data were already available.

Majority of the monitoring sites were selected by the Ecology Department of the FRI from operational ecological research sites. On these sites water- and organic material cycles had already been measured earlier and these results could were valuable preliminaries for and had similar phenomena to measurements on intensive monitoring plots.

Within the FMOS additional, long term monitoring systems have been launched, like the "Assessment of Game Damages in Forests" and the "Forest Fire Database".

Moreover, among large-scale devastating diseases the damages caused by chestnut blight fungus (Cryphonectria) and gipsy moth were monitored and assessed carefully by tailor made systems.

The system has been developed and refined continuously on the base of the experiences gained at national level and in international cooperation.

3. Forest Protection Network (FPN)

3.1. FPN – history and objectives

From the 1980s the deterioration of forest health condition was observed all over Europe and in Hungary as well. As a consequence of continuously intensifying harmful environmental effects on forests it became necessary to establish a continuous and systematic observation system and a framework programme focusing on forest damages.

Hungary – having realised the problem of topical interest – joined the international program (*International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests*, shortly *ICP Forests*) in an early stage that has been established on the third meeting of the *Executive Body for Convention on Long-range Transboundary Air Pollution* in 1985. The main role of ICP Forests is to monitor the air pollution effects on forests with harmonised methods in Europe. ICP Forests also tries to identify the main causes of damages, to reveal factors and their correlation on a long run.

On the base of the international programme mentioned above the elaboration of the national forest condition monitoring programme started in 1987. The series of annual surveys and data processing started in 1988 and with the exception of the year 2007[1] the whole network was assessed every year. Based on the experience gained during the surveys and data analysis, the system has continuously been developed and improved.

The main objectives of the surveys were the assessment of forest health condition and different forest damages, furthermore the determination of the extent and spatial pattern of damages based on the information collected in the network.

Above the annual health condition, periodic observations also enabled us to detect the temporal and spatial changes and the structural alterations of health condition. In the forest as a natural ecosystem in case of any changes being out of the range of natural processes the cause-and-effect relationship, the biotic and abiotic factors and the anthropogenic impacts with negative effects on ecosystems have to be identified. After the detection of damages and identification of causes, preventive, protective and restoring measures – if needed – have to be implemented.

Compared to the international methodology – mainly focusing on changes in crown condition due to air pollution affects – the national assessment method is extended with a complete, detailed and comprehensive survey implemented in two levels.

Level I - Large scale assessment

Goals: Comprehensive annual collection and distribution of data based on systematic samplings to assess the development and spatial variation of damages and diseases, to detect their changes and to submit data to be compared on European level.

Started in: 1987.

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[1] *Due to lack of financial resources, only 78 sample plots were assessed in 2007 that only enabled Hungary to fulfil her international obligations. The above fact has to be considered when analysing the diagrams in the report. Also in relation to this fact 2006 should be considered as a reference year.*

Level II - Intensive monitoring

Goals: Assessment of the effect of air pollution and other damaging factors on the dominant forest ecosystems in the country through the exploration of processes in ecosystems and the research on possible triggering factors and their interrelation.

Started in: 1993.

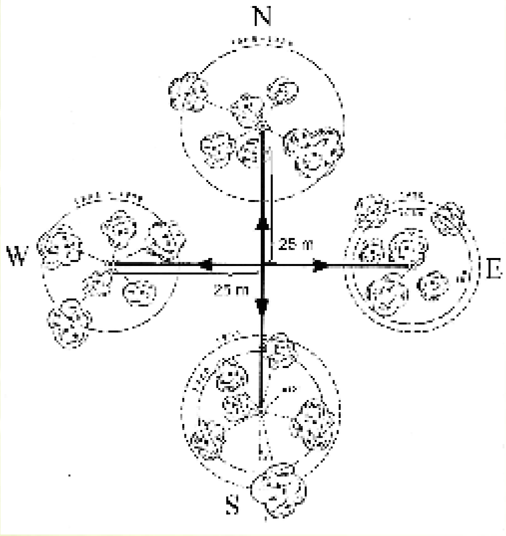
Level I is implemented by the forestry experts of the Central Agriculture Office (CAO) while level II is managed by the researchers of FRI. Description of level I forest damage assessment in the 4x4 km network is detailed below. Data collected in the frame of the international monitoring system have been submitted to ICP Forests for more than 20 years.

3.2. Methodology of Level I of FHM

3.2.1. Sampling grid

The implemented level I large-scale forest condition monitoring programme is based on systematic sampling. A systematic 4x4 km virtual grid - covering the entire area of the county – was set to select sample plots and in case the intersection point of the horizontal and perpendicular lines of the grid was on forest land, a sample plot was installed. (Within the 4x4 km grid the less dense 16x16 grid is used to link the national system with 78 plots to the international monitoring network.)

Within the sample plots four sample circles and 6 sample trees in each circle are selected (see below).



Plot design

In case the trees on the plot do not meet the minimum dimensional requirements determined in the methodology (characteristic of reforestations and young stands) stand level description of the same tree species is applied instead of the selection of individual sample trees.

The health condition of the sample trees – or the stands – is assessed by damages or damage factors and their intensity on the different parts of the tree.

3.2.2. Harmonised damage classes

The assessment of damage intensity - in accordance with the ICP Forests Manual – is based on 5% classes (10% steps until 2006), ranging from 0% to 100% as follows:

ICP damage classes		Categories
0 - 10%	not damaged	healthy
11 – 25%	endangered	slightly damaged
26 – 60%	medium damaged	considerably damaged
61 – 99%	strong damaged	considerably damaged
100%	dead	considerably damaged

In this publication the class of "dead" trees is divided into two sub-classes, trees died in the year of assessment, and trees died before the year of assessment. For instance a tree that died in 1990 is classified as "died in the actual year" in the first year and from the next year on as "tree dead for more than a year" and remains in that class until it falls down.

3.2.3. Survey parameters – characteristics and classification

Parameters of the assessment are in line with the internationally agreed methodology for the assessment of long range transboundary air pollution effects on forests and also meet the requirements set by the great variety of forest types in Hungary.

Forest health can be affected by a variety of factors that fall into three groups:

- Abiotic factors

  They are mainly caused by meteorological and climatic factors. Occasional occurrences may result in sudden calamities on large areas. (dryness/ drought, fire, wind, floods, inland waters, snow, ice etc.)

- Biotic factors
  - Under natural conditions in close to nature stands they are continuously present, but the forests stand usually quickly recovers from these damages (fungi and insects).
  - In artificial monocultures planted on large areas the presence of biotic damages is a natural phenomenon. In these even aged stands with low species diversity (individual trees have similar vitality) trees are more susceptible to devastating agents and their mass proliferation (e.g. caterpillar gradations or other epidemics)
  - Natural forest types are also endangered by mass proliferation of diseases (see the recent gradation of Gipsy moth), but these catastrophes are usually the coincidental effects of different unfavourable triggering factors.

- Anthropogenic factors
  - Artificially well-stocked with game – game damages
  - Not carefully performed silvicultural activities – e.g. bark damages, crown brakes, soil compaction, damages by trampling on seedlings.

The improper selection of sites (e.g. English oak planted on hilltop, spruce on dry sites, alder on stagnating water, etc.) may strengthen the above mentioned damages and result in spontaneous dieback in forest stands.

The three main groups above are divided into additional groups according to the occurrence of damages on the tree, so systematically all parts of a tree - the crown (leaves and branches), stem (bark), root swelling (including the soil in its vicinity) - are assessed as detailed below.

1. Crown assessment (cumulative data)

   a. Defoliation (cumulative data, includes leaf loss, crown breakage, top drying, chewing damage, abnormally small leaves, negative effects of air pollution emission, twig damages, plant leaf fungus, galls, necrotic spots, other leaf damages of unknown origin)

   b. Abnormal leaf discoloration

   c. Crown dieback

2. Damage types (specific list giving full particulars)

   a. Crown damages: leaf chewing insects, caterpillars, sucking insects, top drying, mistletoe, twig distortion and damage, galls, abnormally small leaves, plant leaf fungus, crown dieback, air pollution emission, other crown damages.

   b. Stem damages: tinder fungus, goitre (knob on tree), cancerous wounds, decayed knots, cankers, deformation, tree bark-louse, scale insects, woodborers, resin bleeding, frost rib, lightning damage, sucker, others.

   c. Bark damages: anthropogenic and other bark damages.

   d. Root swelling diseases: rotten root swelling, identifiable fungus in the root swelling, other damages.

   e. Soil damages: erosion, high groundwater level, stagnating water, soil pollution, soil compaction, ground water draining, other soil damages.

   f. Other damages: fire, wind throw, fall, stem breakage, drought, heat wave, oak disease, improper silvicultural management, leaf chewing insects in spring, gipsy moth egg masses, other damages.

   g. Game damages: hindering of natural regeneration, damages related to acorn planting, bud, twig and leaf chewing, bark stripping, chewing, rubbing, other game damages.

The Crown

Crown assessment has a key importance regarding that the crown sensitively reflects the state of health of a tree. Defoliation, discoloration and crown dieback considered as suitable, complex, visually assessable symptoms to indicate changes in tree health condition are determined as the complex effect of identified and not identified crown damages beside the damage-related crown assessment.

Ongoing natural processes in the crown have to be identified and distinguished from abnormal processes. Leaf loss due to natural processes should not be classified as defoliation. Different colour of shadow leaves, natural loss of old needles and branches have to be identified and differentiated from abnormal processes. However all abnormal observations have to be registered regardless of problems in linking symptoms to causes.

There is a slight difference between the national and the international definition of defoliation. The national definition refers to the total leaf loss, regardless of the cause, while the international definition refers to the leaf loss due to unknown causes exclusively. To avoid any contradictions the following definitions are applied.

Defoliation **is the significant loss of leaf assimilation surface in percentage in relation to a reference tree of similar species, origin and age, with crown considered optimal and grown on similar site.**

Reduced defoliation **is defined as the loss of leaf assimilation surface due to unidentified causes.** This is the internationally adopted definition in damage assessment in Europe. Compared to definition of defoliation defined above, it does not include the loss of leaf assimilation surface related to crown breakage, leaf chewing, leaf sucking as listed below:

- Leaf chewing insects, caterpillars, louse sucking;
- Shoot and chewing damages (game damages are not included);
- Crown breakage (e.g. wind, snow, rime, ice)

(These damage types however are recorded separately among crown damages in the national system.)

Discolouration is defined as the yellowing of leaves regardless of the cause. The intensity **is determined on a green to yellow scale.** Other colouration, like red, brown, lilac, etc. are not classified as discoloration in this context.

Crown dieback is measured as the percentage of dead branches compared to the whole crown. However, in making this measurement branches that are dead due to shading or competition are not included because they are dead due to normal processes of tree growth. Dead branches and branch stubs not due to natural processes of tree growth are assessed as crown dieback.

The Stem

In the assessment of stem wounds, damages caused by insects and fungi, abnormal development and mechanical damages are recorded. It is a guiding principle that the effects of damages not on the mechanical, but on the physiological strength of a tree have to be considered.

__The buttress roots/root collar/flare and the root system__

Decay, identifiable fungus damages, wind throw, some biotic infections and other damages on the root collar/flare are recorded. When damage intensity is assessed, its physiological effect has to be considered primarily.

__The Soil__

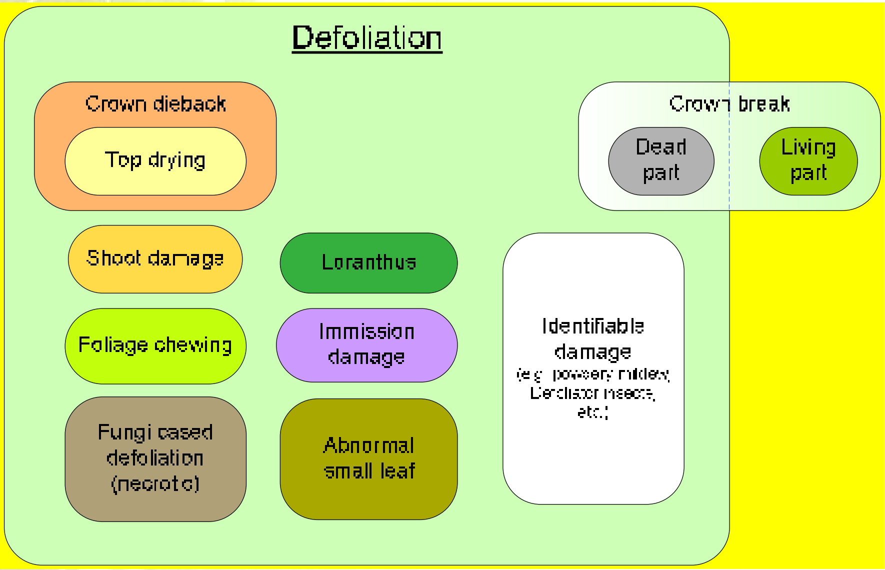
Soil damages also affect tree condition. Soil erosion has to be recorded at the soil information on trees if the tree in question stands on erosion affected site and the caused damage is proportional to the soil erosion rate. Soil contamination, soil compaction, groundwater level and stagnating water also have effects tree condition.

__Other damages recordable on the site__

Other, direct effects on all part of the trees, like draught, fire, wind throw, stem breakage, symptoms of oak wilt causing general deterioration, improper silvicultural practices or other damages can be recorded. Since 2004 the chewing damage caused by caterpillars in spring and the occurrence of egg masses have to be recorded here.

__Game damages recordable on the site__

Even in stands of seedlings and in old-growth stands chewing damages, bark stripping and rubbing have to be recorded if they make acorn planting and natural regeneration difficult.



Damages resulting in defoliation

3.2.4. Quality Assurance (QA)

Quality Assurance is essential in forest monitoring to promote, achieve and maintain data quality. In order to ensure the objective and harmonised field assessment to be carried out experts have to participate in field training courses every year. Training courses are occasions at which experts are familiarized with the methods requested to be applied. An inter-comparison round after the field assessment in summer is the occasion where the performance of individual observers is compared against data collected in randomly selected plots by independent experts (field check). Systematic data control activities are carried out in order to test the validity of recorded data.

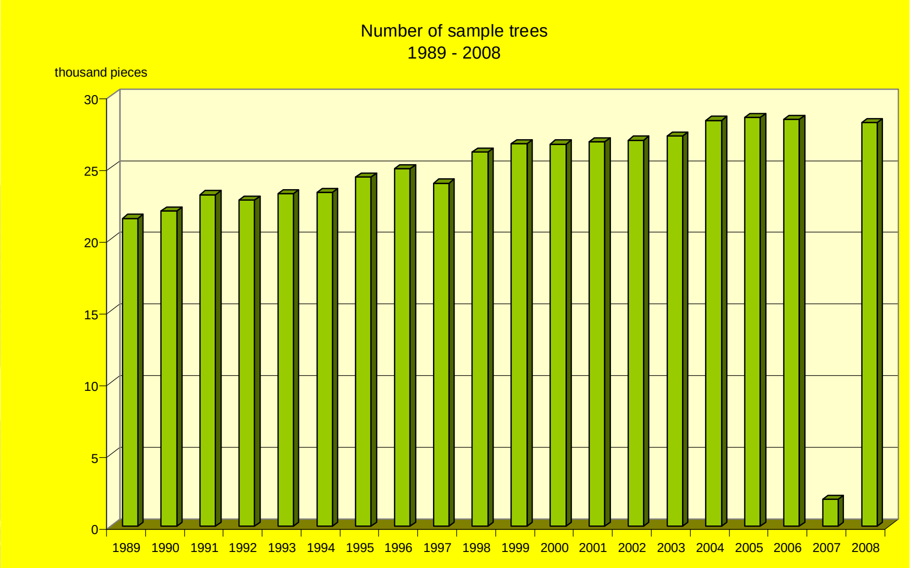
3.3. Data analysis

The annual analysis of collected data provides the basis for a comprehensive knowledge on the present status and long-term trends of forest health in Hungary.

Data are analysed by the distribution of main tree species applied in Hungary as follows:

Hard broadleaved tree species	**Soft broadleaved tree species**	**Conifers**
– English Oak (Quercus robur, Quercus pedunculata) (KST)	– Poplars (Populus) (NY)	– Scotch pine(EF)
– Sessile oak (Quercus petraea, Quercus sessiliflora) (KTT)	– Other soft broadleaved tree species (ELL)	– Austrian pine(FF)
– Other oaks (ET)		– Spruce(LF)
– Turkey oak (CS)		– Other pine (EGYF)
– Beech(B)		
– Hornbeam (Carpinus betulus) (GY)		
– Black locust(A)		
– Other hard broadleaved tree species (EKL)		

Number of sample trees during the 20 year assessment period.



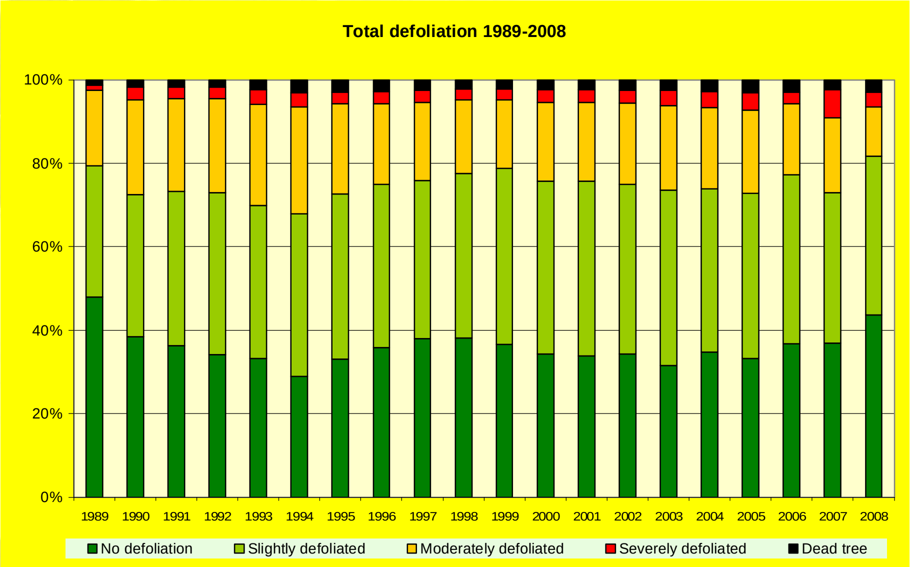
Annual trend in the number of sample trees

3.4. Changes in the past – time series

Results of the annual assessments are summarised in reports by directorates and in a national report. Reports including maps, charts and diagrams demonstrating the actual state of forests and its temporal variations in Hungary have been available since 2005 on the homepage of the CAOCFD.

3.4.1. Changes in total defoliation

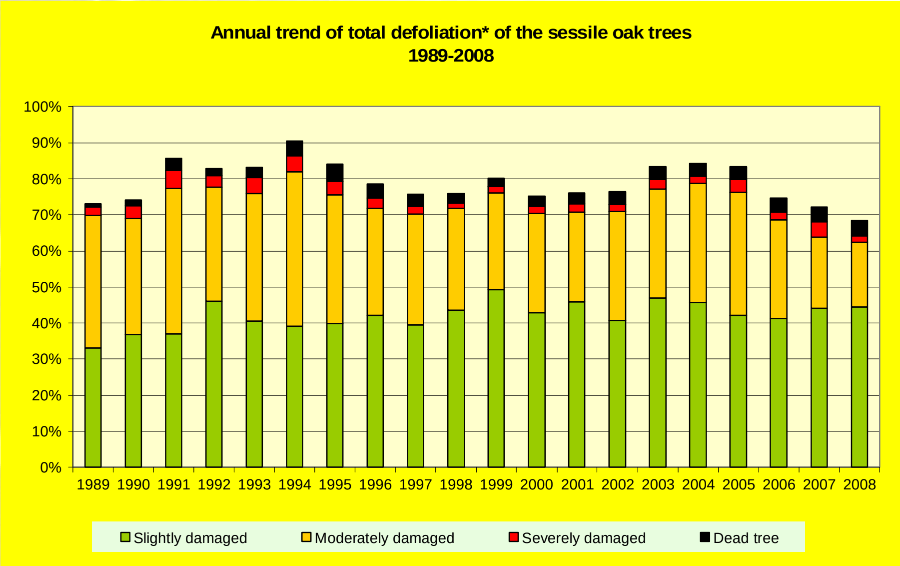
After the first survey in 1988 sessile oak seemed to be the most endangered tree species mostly due to root and root flare damages that considerably weakened coppice stands. Special attention was paid to oaks from the start of the surveys, especially to their crown damages in view of oak wilt symptom, gypsy moth attacks and top drying due to water shortage. The worst observed years of defoliation were in 1994 and 2003 when the health condition of all tree species deteriorated to the lowest rate ever recorded due to extreme weather conditions (especially drought) and increased biotic damages. Diagrams on defoliation of all tree species in 2003-2006 reflect the presence of gypsy moth, the invasive forest pest all over Hungary. The high level of damages was predicted by assessment results in previous years.



Total defoliation of the trees

Cyclic damage can be observed on the diagram showing defoliation percentage of sessile oak. In 1989 less than 30% of sessile oaks and 40% of other tree species were observed healthy. The percentage of undamaged sessile oak was considered significant in comparison with the mean value of observations over the past 20 years.

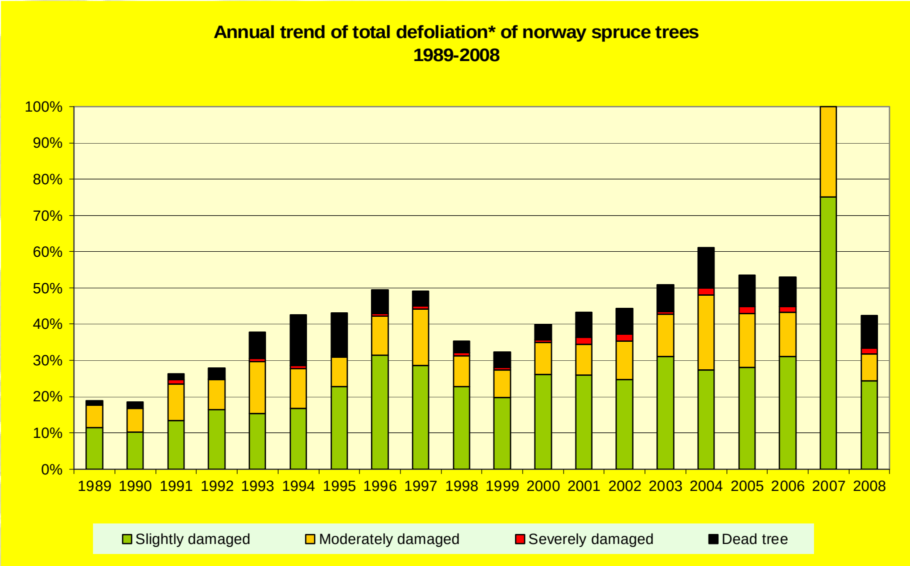
The growing deterioration of forest health was observed until the mid-nineties with a dip in 1994-1996. At the beginning of the new millennium the degree of deterioration increased especially on native deciduous tree species but the downward course did not reach the previously observed low rate.



*The diagram shows only damage categories to emphasize changes in the rate of deterioration. Undamaged trees are not included, that would be the complementary percentage up to 100%..

Damage rate of sessile oak trees affected by defoliation

Mention must be made of the bark beetle attack as the regional problem of Győr-Moson-Sopron and Vas counties. As a consequence of unsuitable site conditions and the lack of precipitation in preceding years trees as usual became highly susceptible to secondary damage-causing agent such as bark beetles. In order to reduce destructive effects and to avoid similar damages in the region, the area of spruce stands is decreased or pure spruce stands are replaced by mixed stands as laid down in guidelines for nature conservation.



*The diagram shows only damage categories to emphasize changes in the rate of deterioration. Undamaged trees are not included, that would be the complementary percentage up to 100%.

Damage rate of norway spruce trees affected by defoliation

The occurrence of extreme water stress (drought in (2000-2003 and in; 2007) might explain the forest stagnation or the deterioration in forest health condition observed all over Hungary. Monocultures especially under unfavourable climatic conditions are more susceptible to biotic disturbances as occurred in 2007-2008 when gall midge caused considerable damages in the Northern Great Plain and in the region between the Danube and Tisza rivers.

The comparison of tree health among tree species shows that in almost every year the health condition of oaks and black locust was in the worst condition while that of beech and spruce was the best with slight difference in percentage considering annual rates.

The following table presents the comparison results of tree species and conditions over the last 10 years. The list starts with tree species with the best health condition.

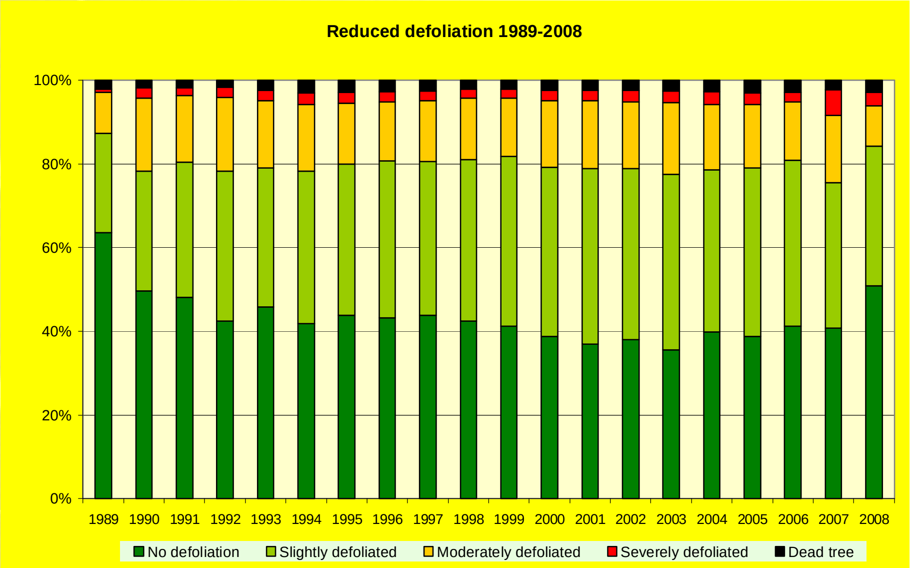
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2008
1.	S	S	S	BP	B	B	B	OSB	B	S
2.	H	BP	B	S	S	S	BP	BP	BP	B
3.	BP	H	H	OSB	BP	BP	P	S	S	BP
4.	B	B	BP	OHB	OHB	H	OSB	B	P	H
5.	OSB	OSB	OSB	B	OSB	OHB	H	P	H	P
6.	OC	P	OHB	H	H	OSB	BL	OHB	OHB	OC
7.	SP	SP	TO	TO	TO	P	OHB	OC	OSB	OHB
8.	TO	OHB	P	P	P	TO	S	BL	OC	OSB
9.	OHB	TO	SP	BL	OC	OC	OC	H	TO	TO
10.	P	BL	OC	OC	BL	BL	TO	SP	SP	BL
11.	BL	OO	PO	SP	SP	SO	SP	TO	BL	SO
12.	OO	OC	BL	PO	PO	OO	OO	PO	PO	SP
13.	PO	PO	SO	OO	OO	SP	SO	OO	SO	PO
14.	SO	SO	OO	SO	SO	PO	PO	SO	OO	OO

Oaks — Hard broadleaved trees

Pines — Soft broadleaved trees

The explanation of the abbreviations is located in annex I.

3.4.2. Changes in reduced defoliation



Rate of the reduced defoliation by damage categories

The proportion of undamaged trees (trees that did not show any symptoms of damage) – similarly to defoliation – had been continuously decreased until 1992. After a slight improvement the deterioration stopped in 1993. Until the beginning of the new millennium the proportion of damage did not exceed 60%. In 1997 the deterioration of forest health condition started to increase again and in 2003 the proportion of damaged trees was almost as high as 65%. Since 2004 an improvement in health condition has been observed.

When comparing tree species results are different. The most damaged tree species were oak, black locust and from 1990 Scotch pine and other conifers due to the increase in the proportion of damaged trees up to 50-60%. While the rate of damaged broadleaved trees species exceeded 70% the rate of damaged other tree species remained below 60% with the exception of Scotch pine. Between 2000 and 2003 a downward course was observed in the health condition of Scotch pine and the proportion of damaged trees was almost 80%.

Undamaged trees were most abundant among beech, hornbeam and Turkey oak samples – the proportion of damaged beech scarcely was above 40% with the exception of the year 2001 when it increased up to 62% in the endangered and medium damaged classes. Austrian pine and spruce were among the healthiest tree species with the proportion of healthy trees above 50% during years with more precipitation. It has to be mentioned that the number of spruce sample trees are relatively low, 5-10% of them fall into the class of dead trees and into the sub-class of “dead for more than a year”.

3.4.3. Changes in discolouration

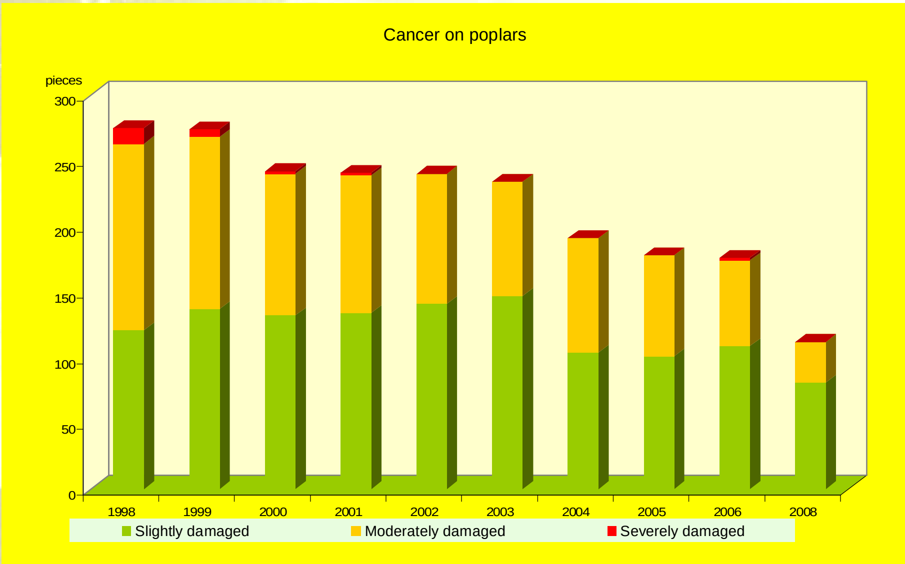
The damage rate of discolouration is low. While earlier discolouration level was high, it has decreased considerably and has remained below 5% for the past 15 years. None of the tree species have shown high level of decolouration. Yellow discolouration is typical of broadleaved tree species such as English oak, black locust while conifers exhibited different colour cast (the symptoms of Lophodermium needle cast disease) indicating the presence of infection. Lowest discoloration was recorded in 2008 that can be explained by favourable weather conditions, especially high precipitation.

3.4.4. Other damages

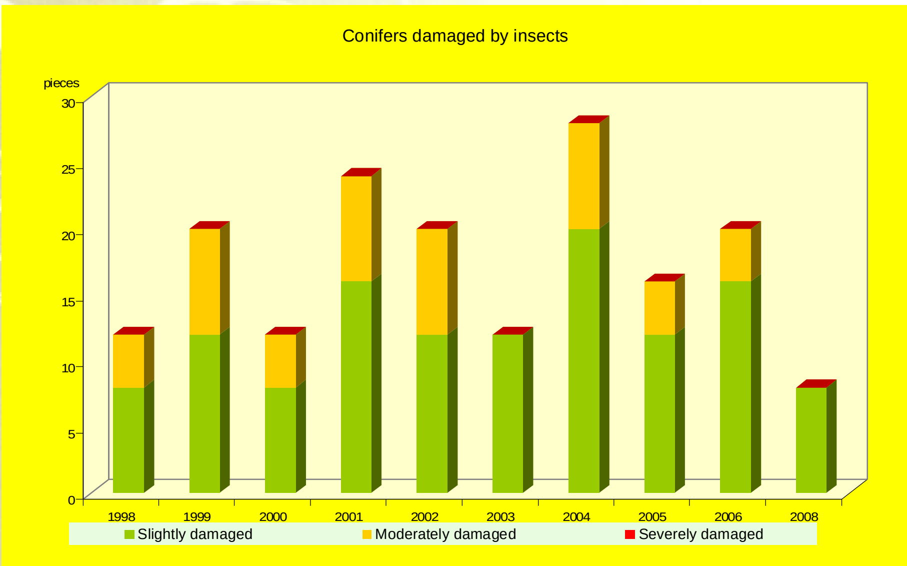
Beside the above detailed key indicators additional damage indicators are recorded that are essential to management.

For the right interpretation of the following diagrams it has to be stated that damage symptoms visible for more than a year (frost ribs) are repeatedly recorded year after year. Therefore a recorded damage does not mean that a fresh damage occurred to the tree (as in the classification of dead trees detailed above).

In Hungary the proportion of poplars in the forests is more than 8%. Poplars are generally planted to be widely used as industrial wood. Attack by destroying fungi and boring insects has decreased wood quality from timber plantations in Hungary for the last 10 years as shown below.

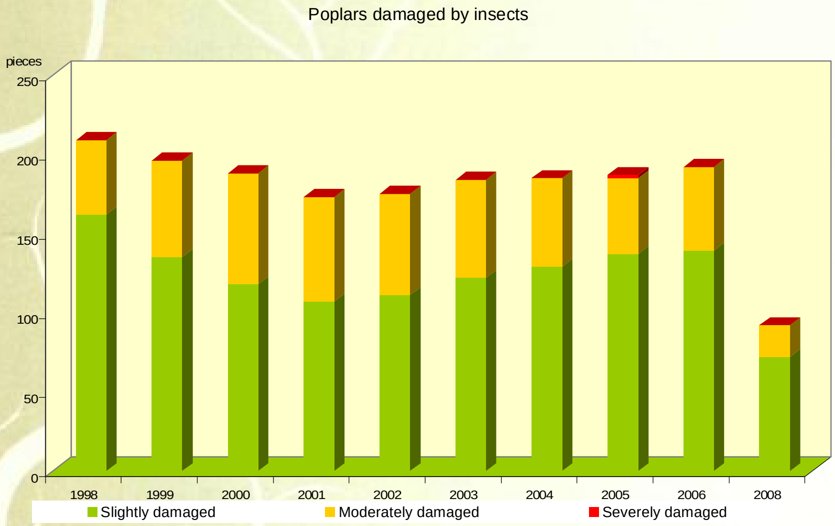


Number of poplars damaged by cancer



Number of conifers damaged by insects

Wood being an organic material is liable to be attacked by biological agencies. One of the principal agencies of wood deterioration is insects. The stem is attacked by boring insects in coniferous stands. In addition to bark beetles as mentioned above (proliferation in 2004-2006) citrus Mealybug (***Planococcus citri***), white pine weevil or Engelmann spruce weevil (*Pissodes strobi*) and longhorn beetles (Cerambycidae) decrease the quality of timber.

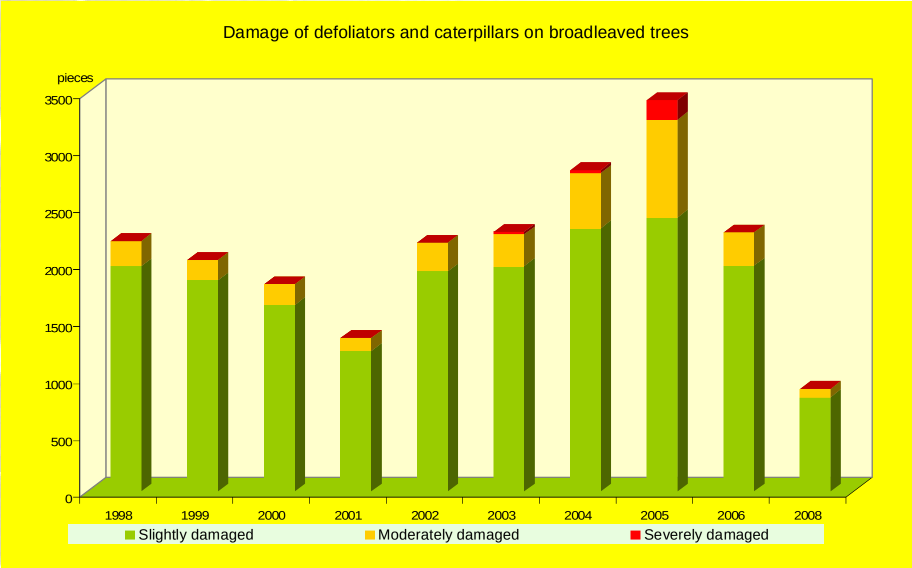


Number of poplars damaged by insects

Leaf chewing is the most prominent example of the loss of assimilation surface. As a consequence of mass proliferation of gipsy moth, the number of trees with damage caused by foliage-eating pests increased dramatically.

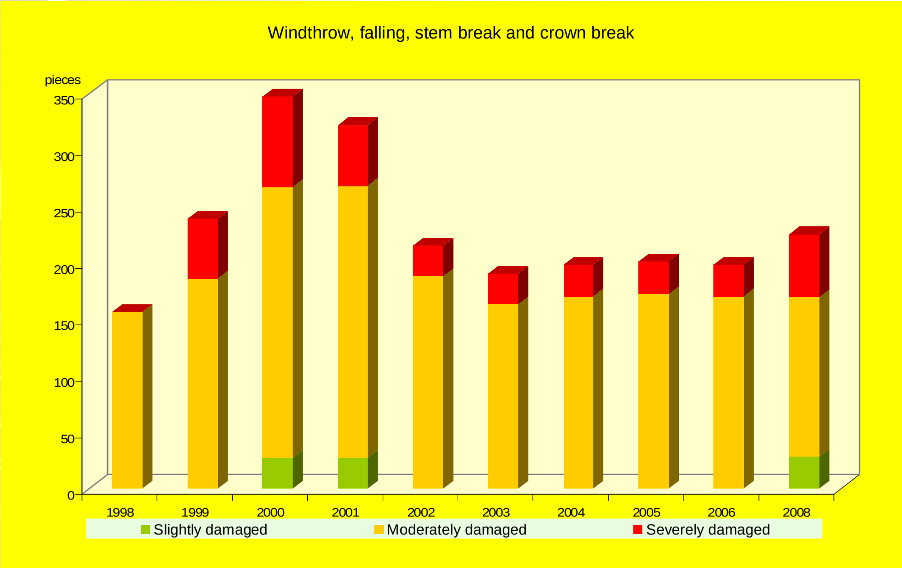
Number of trees damaged by direct human impact

The rate of damage related to felling and human activity in forests has not changed considerably, moreover has been slightly increased since 1998. Although the forest technology development continues the role of humans in causing damages is still considerable and extensive.



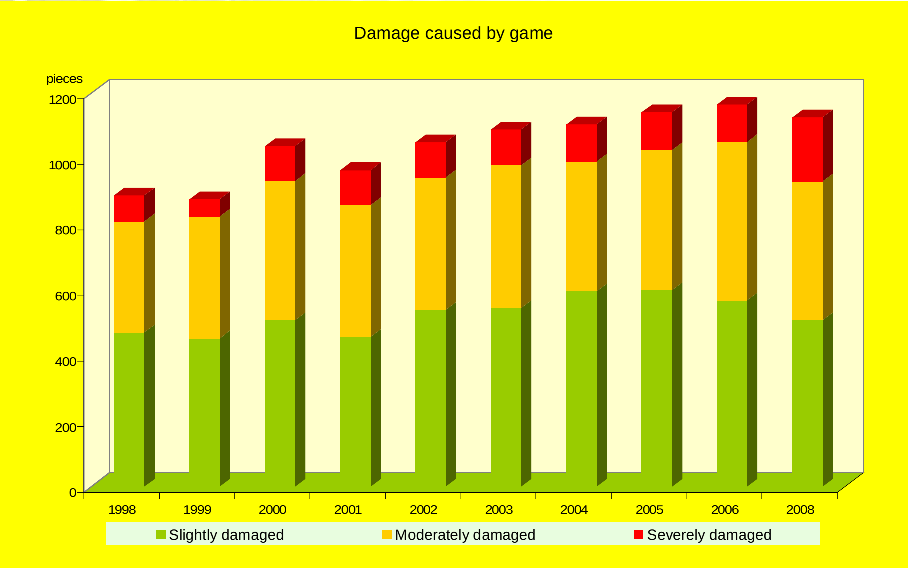
Number of trees damaged by defoliators

Tree death from fall, crown breakage with the exception of extreme storms is an, an element of natural processes in the life of a tree. Structural instability caused by previous deterioration, infection or damage may cause tree death. As a consequence of extreme weather conditions in recent years there were more fallen and windthrown trees all over Hungary.



Number of sample trees affected by windthrow and windfall

Damage caused by hoofed game browsing and bark stripping in natural and acorn plantations is a serious problem, one of the most serious problems in forestry. Game damages, the constant problem of silvicultural management can be quite successfully reduced locally. The primary intent is to curtail game damage mostly caused by an overpopulation of game that cannot sufficiently be supplied with fodder by the current forest vegetation. Such damage can be avoided or limited by balancing the forest vegetation against the game population. Kind, size and appropriation of protective measures are stipulated by the forest proprietor on the basis of negotiations with the beneficiary user of the range (game manager). Management activities that lead to minimizing game damages in the forest are fencing-in of fields, arranging for game feeding, clearings.



Number of sample trees damaged by game

4. FRI intensive monitoring

From the late 1970s on, the condition of tree crowns was observed to deteriorate in several forest areas of Europe. As a result of this decline being originally ascribed mainly to air pollution, the United Nations Economic Commission for Europe (UNECE) under its Convention on Long-range Transboundary Air Pollution (CLRTAP) established in 1985 the International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests). ICP Forests was launched by the initiative of the Executive Body for CLRTAP due to the growing public awareness of possible adverse effects of air pollution on forests.

Hungary joined the programme that has been developed into one of the world's largest bio-monitoring networks by signing the agreements on ministerial level. The *National Focal Centre (NFC)* of the program is the Central Agriculture Office Centre Forestry Directorate (CAOFD), (formerly Forest Management Planning Service and after 1 January 1997 State Forest Service). Level I monitoring network is operated by the CAOFD and the Forest Research Institute is responsible for intensive monitoring (Level II). Before the accession of Hungary to the European Union as a member state the monitoring activities were implemented in accordance with the Forest Focus Regulation.

According to the standardised data submission system, until 2003 Level II data were submitted by the NFC to the Forest Intensive Monitoring Coordinating Institute (FIMCI), an institute established for data processing and analysis. In 2003 the tasks of FIMCI was designated to the European Joint Research Centre (JRC, Ispra) and a new, internet based platform was developed for data submission.

4.1. Establishment of intensive monitoring in Hungary

*16*16 km forest protection network*

The 16x16 km grid that resides on the national 4x4 km network established by the Forest Management Planning Service in 1987 was the pioneer of the intensive monitoring network. Selection of sample plots and elaboration of methodology started in 1989 by the Unit of Ecology of FRI. Based on the results and experiences of the previous 5 years the system was revised, modified and the final sampling net including 71 sampling plots (64 sub-compartments) was designed.

After the final sampling plots had been selected first assessments were performed. Beside stand, vegetation and soil profile surveys botanical surveys were conducted by well-known Hungarian experts such as Tibor Simon, András Horánszky, István Isépy invited by FRI. On the base of previous national surveys and in accordance with recommendations of the international programme the systematic soil sampling was carried out in 1991 (On each plot 16 profiles are sampled and at each location the adequate soil sampling is done with attention to the mandatory depth intervals.)

Starting in 1994 the soil profile surveys and with the participation of András Horánszky botanic survey were conducted again. More plots were installed and relevant stand parameters were listed. After a lapse of 5 years in 1999 the complementary assessments of stands were performed.

In order to gain a better knowledge on the hydrological regime of soil, the assessment of soil physical parameters started in 1994. Soil water retention characteristic was determined on 15 plots by frame irrigation method while on 55 other plots adequate undisturbed soil samplings within the soil profile was done. Beside the surveys above two researchers of the Hungarian Geological Institute, László Kuti and János Kalmár were invited by FRI to determine geological characteristic of sampling plots.

In addition to the climate classification of sites applied in forestry, a detailed meteorological classification was prepared based on data collected on the nearby meteorological stations of the National Meteorological Service. On climate diagrams, referring to the hydrologic year, water cycle periods by Járó (period of accumulation, main water utilization and maintenance) are also presented, with special emphasis on the negative deviations from the mean value of 50 years average.

The defoliation and discolouration of numbered trees, the rate of abiotic and biotic damages, and the health status of numbered sample trees was assessed annually (in August and September) by the experts of the Department on Forest Protection.

After the transformation of the intensive monitoring as– described below activities on the 16x16 km network were not stopped immediately. In natural and close to nature forest stands stand assessments and meteorological data collections were completed in 2000. Forest condition assessments were continued until 2003.

Intensive monitoring

At the beginning of nineties, proposals relating to intensive monitoring plots were drawn up for the reconsideration of the intensive monitoring (level II) concept. New sampling plots meeting (or easy to upgrade to meet) the continuously increasing requirements of the programme, moreover with available historical assessment data were selected.

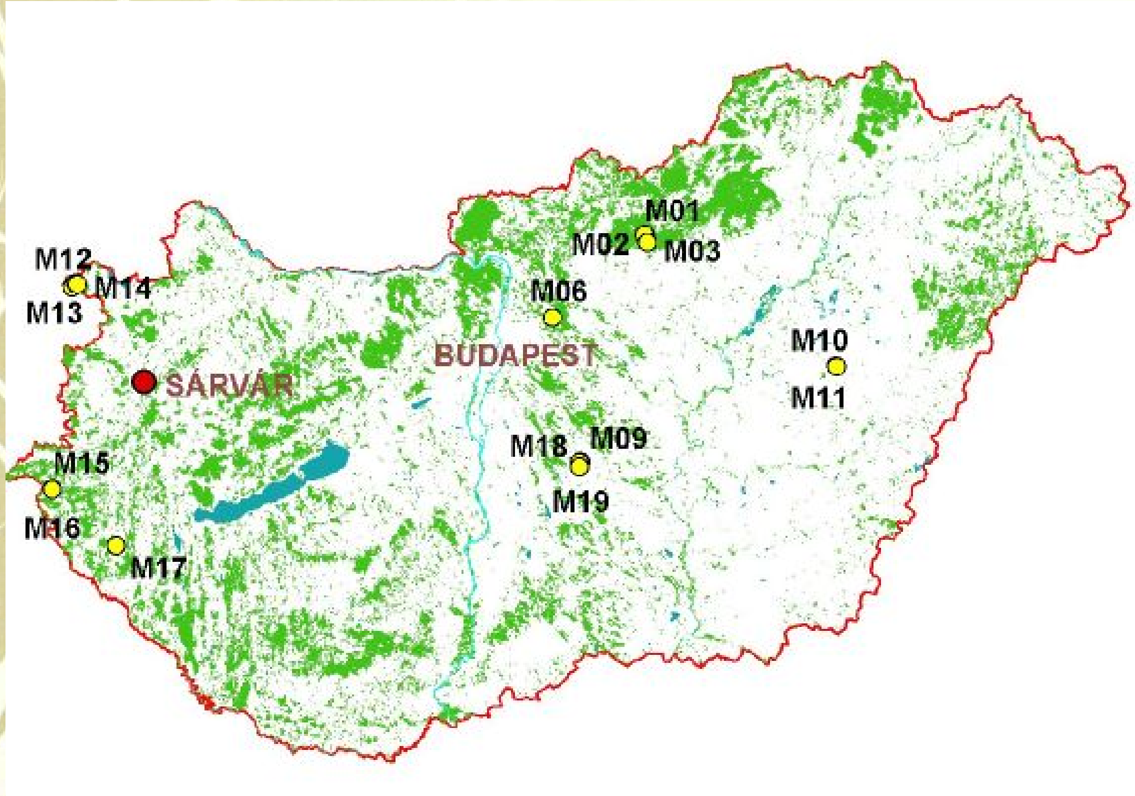
Majority of the new sampling plots were operating ecological base sites. On these plots the ongoing water and nutrient cycle measurements were very similar to the activities defined in the monitoring system and could be used as preliminaries. Above continuity practical questions, like accessibility, operability, availability of experts in the vicinity as well as the location of research stations and the structure of the institute were also considered. Sample plots were not selected at the same time therefore alterations in forest and research policy are mirrored in the final setup. Consequently sample plots do not fully represent the distribution of forest types however due to the low number of sample plots good representation of natural conditions cannot be expected.

Selection of a sample area in spruce stand in the Mátra Mountain was connected with the forest dieback in West Europe in the eighties. In addition the economic importance of spruce was well above the importance by area in Hungary. Establishment of additional sample plots in Mátra Mountain are attributed to the fact, that the Academy of Sciences declared this region of the Mátra to an area endangered by air pollution in relation to the vicinity of the power plant in Visonta.

On the Great Plain, east from the Tisza river English oak is important tree species in forestations. This is behind the selection of sample plots in Püspökladány. For similar reasons Scotch pine, Austrian pine, white poplar and black locust plots were selected in the region between the Danube and Tisza rivers.

The rest of the plots were selected for the economic importance of species (beech, sessile oak, Scotch pine).

Enlargement of sample plots, marking of border lines, numbering sample trees, installing new measuring facilities started in 1996. Initially 14 intensive monitoring plots had been established, that were extended by a white poplar plot (M18) in 2001. Though the number of plots has been stabilised, a Scotch pine plot (M8) close to Kecskemét was given up in 2004 due to a snow break and substituted by a black locust plot (M19). Plot location can be seen on the map below main characteristics are described in table "Basic characteristics of intensive monitoring plots (2007)".



Intensive monitoring sample plots (ICP- Forests, Level II) in 2007.

Main goal of the intensive monitoring is to characterise forest health condition and to detect changes in condition. To achieve these goals, it is indispensable to reveal the ongoing processes in forest ecosystems (water and nutrient cycles) and to get to know cause-effect relationships.

This is not the goal but an important result of the intensive monitoring that thanks to the detailed data collection the monitoring is a source of important information to other, like climate change, biodiversity, carbon sequestration projects.

Consequently intensive monitoring is not only the recording of consecutive states but also include analysis covering precedents, triggering factors realistic considerations on the effects of changes in the environment.

Species distribution of sample plots may change in the future. Changes have already occurred like the inclusion of black locust and white poplar plots. Long term approach is assumed in monitoring therefore establishing new plots is feasible when an old plot have to be closed (e.g. due to severely damaged). Considering the great variability of site and stand conditions, intensive plots maximized in 15 will never meet strict criteria on representativeness. However, plot design worth to be revised repeatedly.

Basic data of the intensive monitoring plots (2007)

Nr.	***ID***	***Municipality, forest subcompartment***	***Altitude*** *m*	***Aspect***	***Slope*** *°*	***Climate***	***Hidrology***	***Genetic soil type***	***Area*** *ha*	***Fenced area*** *ha*	***Start date***	***Main tree species***	***Associate tree species***	***Age*** *(2000)*
1	M01	Gyöngyössolymos 39A	560	NW	5	Beech	Seepege water	Ranker soil	0,25	0,09	1989.05.01	B	SO, H	89
2	M02	Gyöngyössolymos 32C	560	NE	3–5	Beech	Seepege water	Ranker soil	0,25	0,04	1987.03.01	S		35
3	M03	Gyöngyössolymos 66C	660	SE	5–10	Hornbeam-oak	Free-draining	Ranker soil	0,25	0,20	1986.04.01	SO	B, TO, H	63
4	M06	Gödöllő 142A	240	Plain		Sessile oak	Free-draining	Rusty brown	0,25		1973.05.01	SP		35
5	M08[2]	Kecskemét 7C	120	Plain		Forest steppe	Free-draining	Humic sand	0,25	0,10	1987.12.01	SP	HP	30
6	M09	Kecskemét 12E	120	Plain		Forest steppe	Free-draining	Humic sand	0,25	0,10	1994.01.01	BP	HP, SP	62
7	M10	Püspökladány 21F	90	Plain		Forest steppe	Free-draining	Solonetz meadow	0,25	0,04	1988.04.01	PO		72
8	M11	Püspökladány 24C	90	Plain		Forest steppe	Free-draining	Meadow solonetz	0,25	0,04	1988.04.01	PO	TO, E, A, OHB	67
9	M12	Sopron 151A	460	SE	5	Beech	Free-draining	Lessivated brown soil	0,25	0,11	1981.03.01	B	B, La, SO, S, H	96
10	M13	Sopron 125A	470	SE	0–5	Hornbeam-oak	Free-draining	Ranker soil	0,25	0,18	1987.05.01	SO	La, BP, S, Li, H	96
11	M14[3]	Sopron 135A	340	NW	5	Hornbeam-oak	Free-draining	Brown forest soil	0,25	0,16	1987.05.01	S	SP, SO, La, H, Li	3
12	M15	Őriszentpéter 19B	260	Plain		Hornbeam-oak	Water-logged	Brown soil with surface water gley	0,30	0,30	1995.02.01	SP		48
13	M16	Bajánsenye 6B	260	Plain		Hornbeam-oak	Water-logged	Brown soil with surface water gley	0,28	0,28	1995.02.01	SO	SP, H	72
14	M17	Szentpéterfölde 21A	240	W	0–10	Beech	Free-draining	Lessivated brown soil	0,25	0,16	1990.09.01	B	SO, H	69
15	M18	Kecskemét 7D	120	Plain		Forest steppe	Free-draining	Humic sand soil	0,25	0,16	2001.06.15	HP		31
16	M19	Kecskemét 221F	120	Plain		Forest steppe	Free-draining	Humic sand	0,25	0,25	2004.03.22	BL		20

[2] Sample plot terminated due to snow breaking.
[3] The spruce stand was harvested because of bark beetles damage, the area was reforested with beech and mainly broadleaved associated tree species

Sub-tasks

Frequency and experts listed by sub-tasks

sub-tasks	frequency	experts
health condition assessment	yearly	Koltay András
deposition assessment	weekly	Sitkey Judit
soil solution[4]	weekly	Sitkey Judit
ozone damage assessment	twice a year	Sitkey Judit
increment (stand level)	every five years	Illés Gábor
increment(circumference)	continuous	Manninger Miklós
annual ring analysis	once (initial)	Csókáné Szabados Ildikó
foliage analysis	every two years	Manninger Miklós
meteorology	continuous	Manninger Miklós
biomass measurement	monthly	Kurucz György
phenology	weekly	Kurucz György
soil assessment (base)	once (initial)	Manninger Miklós
soil physics	once (initial)	Szendreiné Koren Eszter
vegetation	every two years	Tobisch Tamás
air chemistry [5]	continuous	Horváth László (OMSZ)

Open air meteorological station (Mátra)

Beech sample plot in Matra (M01)

[4] The soil water assessment started in 2005 in the M01 sample point with the launch of the collecting system.
[5] Air chemistry assessment is performed only at one place that is close to Mátra sampling plots (M01, M02, and M03).

4.2. Results

Results of the diversified and consecutive surveys are represented by the following assessments:

4.2.1. Health condition assessment

The assessment of forest health condition reflects changes within the ecosystem. Symptoms of damages in the crown stem and root collar are indicators of the quality of the environment. The primarily aim of annual surveys is to provide information, a periodic overview on the actual heath condition of forest stands. Assessments contribute to the determination of qualitative and quantitative data on damage types and symptoms. Surveys provide a periodic overview of the spatial and temporal variation in a range of attributes to forest condition. Since the range of monitoring variables collected on Forest Protection observation plots meet the information requirements and the collection, validation, evaluation and storage of monitoring data and aggregation of national data are harmonized data comparability across participating countries and proper data processing is ensured (data can be evaluated in combined analysis of international and national data and used in the further development of national and other monitoring assessments).

Monitoring has been carried out since 1996 to collect data on forest condition, and the attributes to be measured are typically those able to describe tree health. All monitoring activities are harmonized among the participating countries and performed according to the methodology agreed upon by and applied in European countries. Assessments are conducted once a year in the first half of August. The number of sample trees per plots is different ranging from 50 to 200. Overall, 123 indices are assessed yearly to describe the condition of trees growing in Hungary. Measured variables are concerned with the forest condition and attributes are typically those able to describe tree health. During surveys each part of a tree (foliage, branches, twigs, trunk and buttress roots) is evaluated. Data on discolouration, defoliation, branch dieback, stem and root flare damages are collected annually that includes cause-effect relations. Each year a photo is taken of the reference tree in each sampling plot. As part of the annual survey of forest health, the condition of trees is assessed by comparing the actual health state of a tree with standard photographs. Two standards of comparison have been used: (1) an “ideal” or “perfect” tree representing the healthy tree, and (2) a tree representing the unhealthy (damaged) tree. These are referred to as the healthy and unhealthy (damaged) reference trees respectively.

By means of computer data processing all data collected are entered, summarized, analysed or otherwise converted into usable information on the actual health condition of forest, damages and cause-effect relations.

4.2.2. Results of health condition assessment

The results of assessment indicate that on the whole our forests in Hungary in a relatively good health condition. There are no vast area of dead or dying trees and long lasting epidemics. At the same time in each stand type abiotic and biotic damages are present. Gypsy moth is an invasive forest pest that is one of the most damaging tree defoliators. During the recent outbreak in 2003-2005, gypsy moth quickly spread and caused severe damages across Hungary. They are voracious eaters and can defoliate entire trees. High defoliation values and damages caused by secondary damage-causing agents were associated with gypsy moths. Gypsy moth caterpillars feed on a huge number of host trees, making them a serious threat to our forest. Their preferred foods are the leaves of oak and beech. According to recently conducted surveys the health condition of beech stands is much better in Northern Medium Mountains (Northern Hills) than in the western and south-western part of Hungary where the dry weather in 2000 and 2003 explains the significant deterioration of beech stands

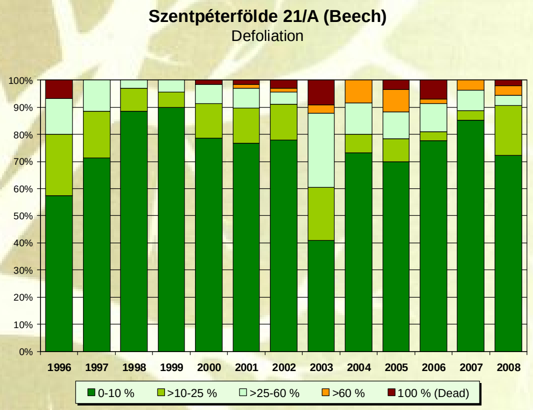
In coniferous stands the needles and shoots had been infected by pathogens. Spruce stands had been damaged by bark beetles and storm. Needle cast seemed to thrive when conifers are under stressful conditions to include drought. Drought conditions do influence the occurrence of forest fires as well.

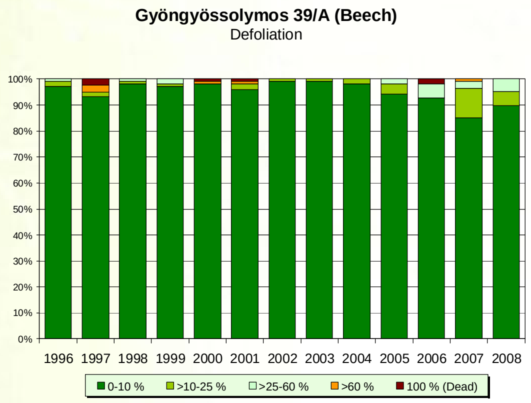
4.2.3. Health condition of main tree species

Beech stands

In the years of surveys conducted the health condition of beech stands in the Northern Hills was good. The annual average defoliation rate remained below 5% with the exception of the year 2005 due to the consumption of gypsy moth when the defoliation rate increased up to 7% especially in the case of suppressed trees.

In Western Transdanubian beech stands the average rate of defoliation was a bit higher, varied between 5-10%, whereas comparable data for the South-Western Transdanubia were 15-20% in 2003-2005 due to the heavy increase in the number of trees with medium and strong defoliation damages. Besides, the mortality rate increased, especially in 2003. All these changes unambiguously can be associated with warming, drought stress together with the mass proliferation of secondary damaging agents, mostly xylophages organisms.





Defoliation by damage classes in beech stands (1996-2008)

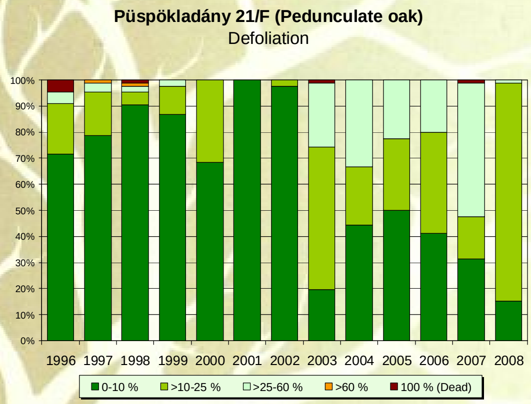
Sessile oak stands

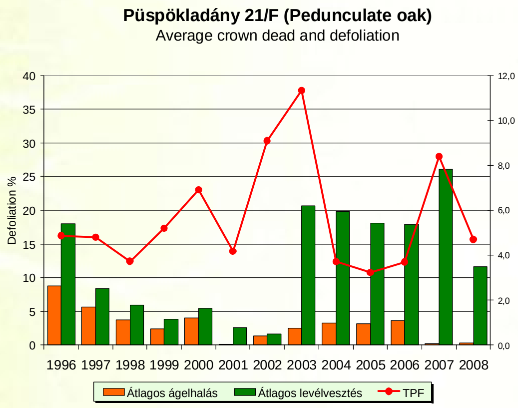
In recent years the health condition of sessile oak stands in the Northern Hills was good. Until 2003 the annual average defoliation rate remained below 5%. In 2003-2005 the defoliation rate continuously increased due to the gypsy moth invasion started in 2003 with a peak in 2005 when defoliation rate was 21% in South-Western Transdanubia.

The health condition of oak stands in Western Transdanubia is considered to be good despite of the gypsy moth invasion in 2003-2005. The health condition of sessile oak stands in South-Western Transdanubia is good with a higher level of annual defoliation (10%). The main damage type is the acute oak decline, but leaf-chewing caterpillars and cockchafers play a key role in defoliation damages. Suppressed trees are more susceptible to be damaged.

Pedunculate oak, English oak stands

The health condition of pedunculate oaks in the Great Plain varied according to the temporal variation of damages caused by insects. The average rate of defoliation was 10-20%. Higher level of defoliation occurred in 2003-2005 due to growing gypsy moth population. As a consequence of deterioration trees became predisposed to secondary agents such as fungi and disease. Deterioration of heath was recorded not only in the groups of suppressed trees, but in the groups of emergent (outstanding) and dominant trees. In contrary to pedunculate oaks Turkey oaks showed no symptoms of disease, except for the damages caused by the widespread forest defoliator (gypsy moth), but a substantial recovery was seen in few weeks.





Defoliation and branch dieback in English oak stand, Püspökladány (M10), (1996-2008)

Conifers

The general health condition of spruce stands in the Northern Hills is good. The annual rate of needle loss is 2-7%. Damages caused by bark beetles in 2000 and 2002 and by storm in 2005 induced increase of tree mortality rate. Despite of the overall presence of Heterobasidion annosum in stands no damage has been recorded. In Western Transdanubia there were more damaged trees in spruce stands. As a consequence of bark beetle attacks that were explained by unfavourable weather conditions, especially drought the level of deterioration increased considerably.

The health condition of Scotch pine stands on sandy soil in Central Hungary is adequate. The annual defoliation rate is around 30% due to the continuous presence of damaging agents on needles and shoots. Environmental stresses, such as drought and hot temperature, caused greater-than-normal loss of older needles.

On the contrary the health condition of Scotch pine stands in South-Western Transdanubia are excellent. In the last years the average defoliation rate was only 3-4%. In 2000 and 2002 the oldest needles fell due to the extreme warm temperature with no effect on the health condition of forests. The health condition of black pine stands on the sandy soil of Great Plain is considered good and epidemics were recorded only locally. The average defoliation rate was only 1-2%. Damages recorded on needles and shoots were caused by causative agents.

Native poplars and black locust

The health condition of native poplars and black locust, the characteristic tree species of the Great Plain has not changed considerably. The results of survey reflect the good state of health, epidemics only occur rarely and locally. The average level of defoliation was 5-10%. In the case of black locust, it was believed that early leaf loss was directly attributable to exceedingly dry weather. The periodic increase of the leaf-miner population has no effect on crown condition.

In the last years heavy damages were recorded due to Extreme weather condition caused heavy damages in poplar stand, but not in black locust stands.

4.2.4. Deposition monitoring

Atmospheric deposition is the process by which airborne particles and gases are deposited to the earth's surface either through precipitation (rain, snow, clouds, and fog), known as wet deposition or as a result of complex atmospheric processes such as settling, impaction, and adsorption, known as dry deposition. Deposition can include a wide variety of natural and anthropogenic pollutants, including inorganic elements and compounds (e.g., nitrogen, sulphur, basic cautions, mercury and other metals) and organic compounds (e.g., pesticides and herbicides). Once deposited, pollutants can have a variety of ecosystem effects. Nitrogen and sulphur compounds, for example, can result in acidification of freshwaters, loss of aquatic species, and vegetation changes.

The relative quantity of precipitation enters the soil. Vegetation often modifies the intensity and distribution of precipitation falling on and through its leaves and woody structures. The most obvious effect plants have on falling precipitation is interception. Interception can be technically defined as the capture of precipitation by the plant canopy and its subsequent return to the atmosphere through evaporation or sublimation. The amount of precipitation intercepted by plants varies with leaf type, canopy architecture, wind speed, available radiation, temperature, and the humidity of the atmosphere.

Precipitation that is not intercepted can be influenced by the following processes:

Stemflow is the process that directs precipitation down plant branches and stems. The redirection of water by this process causes the ground area around the plant's stem to receive additional moisture. The amount of stemflow is determined by leaf shape and stem and branch architecture. In general, deciduous trees have more stemflow than coniferous vegetation.

Canopy drip - some plants have an architecture that directs rainfall or snowfall along the edge of the plant canopy. This is especially true of coniferous vegetation. On the ground, canopy drip creates areas with higher moisture content that are located in a narrow band at the edge of the plant canopy.

Throughfall describes the process of precipitation passing through the plant canopy. This process is controlled by factors like: plant leaf and stem density, type of the precipitation, intensity of the precipitation, and duration of the precipitation event. The amount of precipitation passing through varies greatly with vegetation type.

The quantitative and qualitative analysis of precipitation contributes to the understanding of water and organic matter cycles of the different forest stands.

Surveys are conducted according to the three parts of a tree's growth cycles (within a year), such as the dormant period (November – April), the main growing or utilisation period (May – July) and the post-growing period (August – October) corresponding to the respective organic matter and water utilization cycles of forests.

Samples are collected using a standardized protocol and are analysed in a central laboratory using uniform techniques and procedures. The network provides information based on weekly precipitation samples that are analysed for several chemical constituents, such as acidity (pH), sulphate, nitrate, ammonium, and calcium.

The ultimate aim is to establish general relationships between ions, and between conductivity and ions, with relative confidence limits, which can be used as a comparison with those established in single laboratories.

4.2.5. Distribution of precipitation, interception

Forests come in all shapes and sizes. The many different types of forest are generally classified according to location and climate. Climate types are based on the annual and monthly averages of temperature and precipitation. The following table shows data on the annual turnover of water over 7 hydrological years of Sopron beech stand felled in 2008.

As precipitation falls, some of it evaporates immediately. Some of it soaks into the ground. This is called groundwater. Groundwater is used by trees immediately. The water taken up by the trees will be used in photosynthesis and respiration and this is a significant amount, considering the number of trees present in a forest. The water will eventually be passed out from the leaves of the plants as water vapour. This can be influenced by the amount and intensity of the light received, the humidity levels, temperature and so on.).

Trees in fall are in a state of serious change and reorganization. The tree is becoming dormant. In the dormant period the amount of precipitation that gets to the ground (after passing through the tree canopy) is 50% and the relative quantity of precipitation entering the soil is 35%. The amount of stemflow is 13%. The total amount of precipitation entering the soil is 48%.

In the main growing period when the formation of organic compound are the amount of precipitation that gets to the ground is 40% due to evaporation and the amount of stemflow is 13%. The total amount of precipitation entering the soil is 43%.

In the post-growing period (when the formation of organic compounds is over) the amount of precipitation that gets to the ground is 40% and the amount of stemflow is 20%.

Distribution of precipitation in Sopron beech stands according to water utilization (2001-2008)

months	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	annual average
period	dormant						main growing			post-growing			total annually
T (ºC)	5,1	-0,6	-0,4	1,2	4,7	9,8	15,0	18,3	20,1	19,2	14,2	10,3	9,8
	3,3						17,8			14,6			
SZT (mm)	51,5	38,8	42,9	38,0	63,2	43,2	72,8	75,5	77,6	105,4	80,2	57,9	**747,0**
	277,6						**225,9**			**243,5**			
ÁT (mm)	26,2	19,5	23,5	20,6	28,6	19,7	26,5	31,0	33,3	43,1	29,0	25,2	326,2
	138,1 (50 %)						**90,8 (40 %)**			**97,3 (40 %)**			**44 %**
TL (mm)	7,1	4,2	2,7	1,7	13,0	7,5	11,1	12,1	9,5	18,2	18,5	11,4	117,0
	36,3 (13 %)						**32,7 (14 %)**			**48,1 (20 %)**			**16 %**
A+5 (mm)	14,3	8,8	14,7	18,6	29,0	11,3	14,6	28,2	22,7	35,1	26,5	17,9	241,7
	96,7 (35 %)						**65,5 (29 %)**			**79,5 (33 %)**			**32 %**

It can be concluded that during the 7 year long survey the average precipitation entering the soil was 48%.

The highest precipitation rate was recorded in 2006-2007 when out of the 867 mm 544 mm (43%) entered the soil. This is the amount of water that can be taken up by trees and used in photosynthesis and respiration. The lowest precipitation rate was recorded in 2002-2003 (hydrologic year) with 607 mm of rain when only 222 mm (37%) of rain entered the soil.

The average stemflow over 7 years at beech stands was 117 mm (16%). The redirection of water by the stemflow process causes the ground area around the plant's stem to receive additional moisture. The amount of stemflow is determined by leaf shape and stem and branch architecture. For instance on June 29, 2002 11,9 mm of rain fell. Whilst from outstanding trees 287 litre stemflow reached the ground, from suppressed trees only 12 l.

4.2.6. Air pollutants (open air measurements)

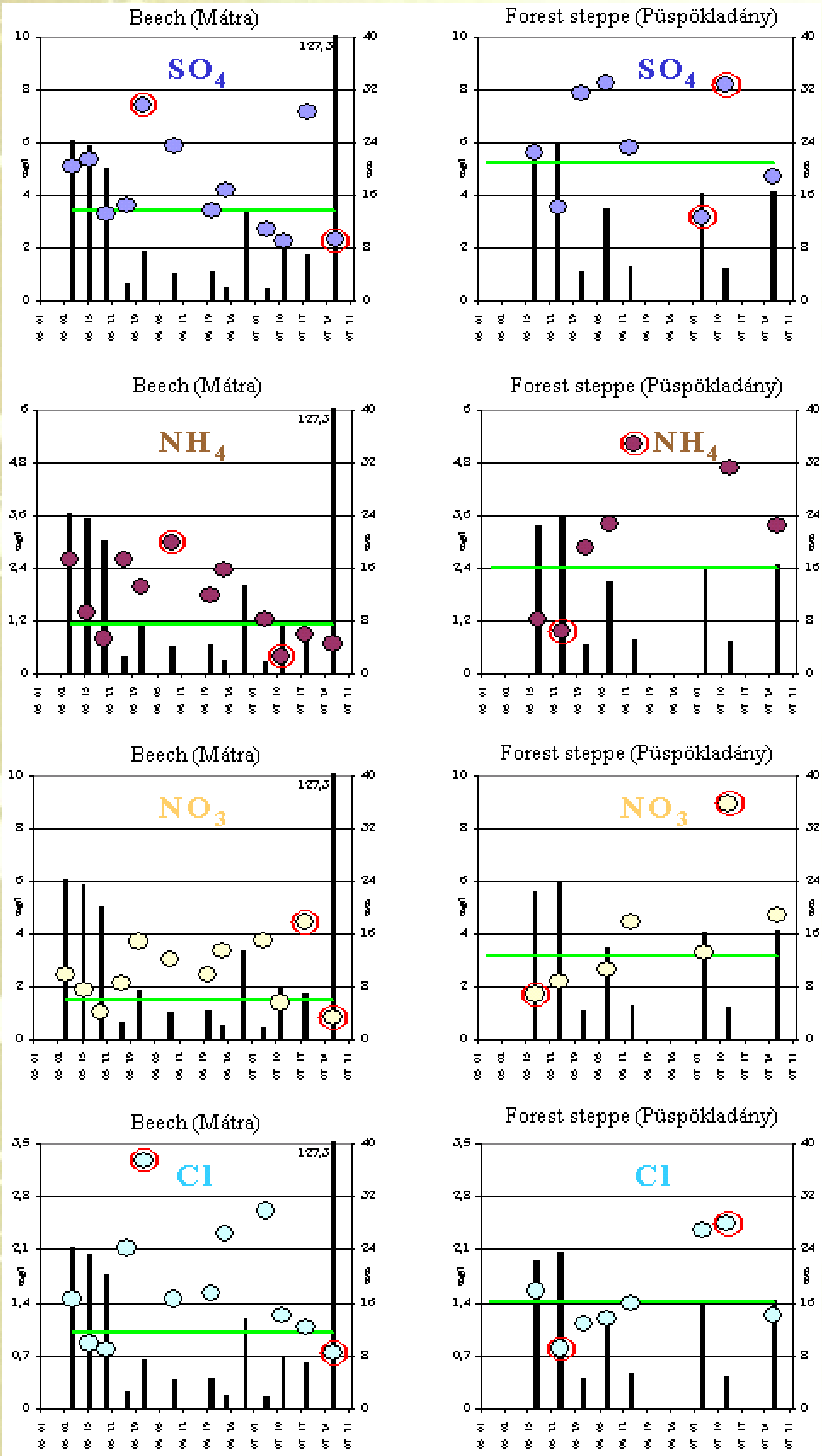
The number of samples depends on the amount of precipitation. Within the range of beech forest climate 32-47 and within the forest-steppe climate 20-30 water samples are collected. Data are presented in terms of concentration and deposition. Concentration data, expressed in milligrams per litre (mg/L) of precipitation are useful in determining spatial and temporal trends because they are not dependent on the amount of precipitation at each site, which can vary substantially from year to year. Wet deposition, expressed in kilograms per hectare (kg/ha) is calculated by taking into account both the amount of precipitation and the concentration at each location. Years with higher amounts of precipitation will yield higher levels of wet deposition. Wet deposition data provide the total amount of pollutants actually deposited on the ground by rain and snow and quantify the pollutant input to ecosystems.

Concentration of sulphate, ammonium, nitrate and chloride ions during the main growing period in beech and forest steppe climate in 2002-2003 (hydrologic year) and the amount of precipitation relating to the mean values of air pollutant concentration is shown in the following table and figure, respectively.

Concentration depends on the amount of precipitation: the two variables (the amount of precipitation and the ionic concentration) are inversely proportional.

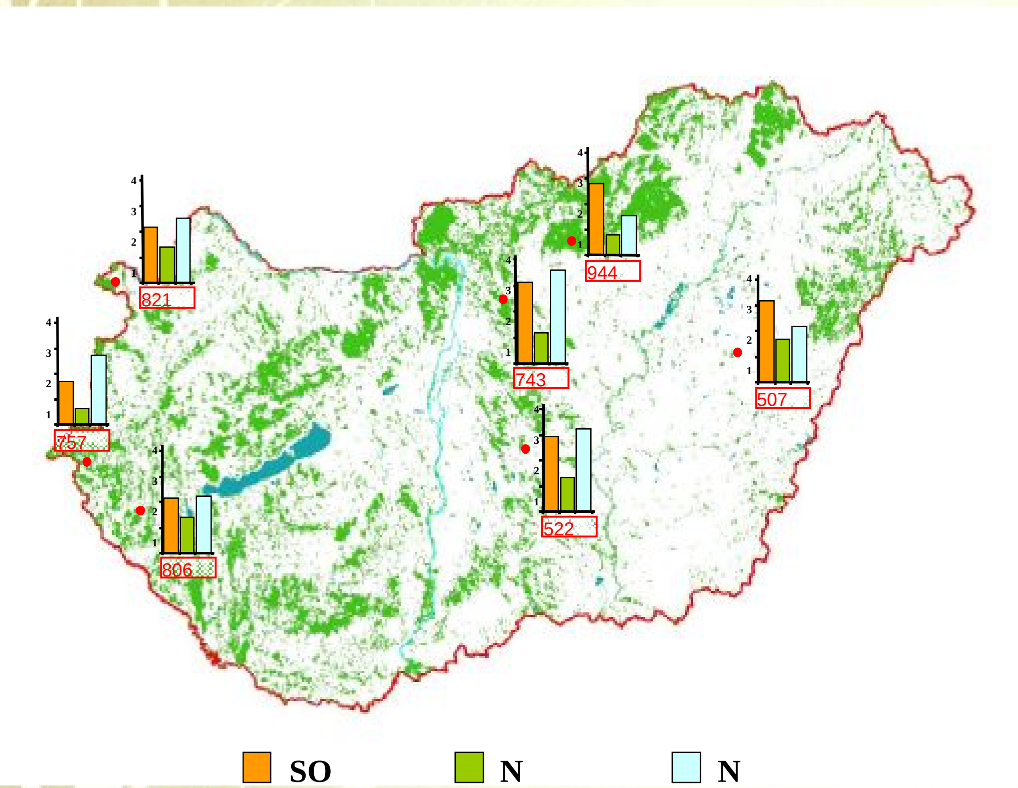
Concentration of air pollutants in 2003

	beech stand (Mátra)				forest-steppe (Püspökladány)			
	SO_4	**NH_4**	**NO_3**	**Cl**	**SO_4**	**NH_4**	**NO_3**	**Cl**
Average concentration mg/l	3,44	1,14	1,49	1,01	5,24	2,38	3,17	1,43
Maximum concentration mg/l	7,43	2,60	4,43	3,27	8,17	5,21	8,94	2,44
Precipitation mm	**7,6**	**24,4**	**7,1**	**7,6**	**4,9**	**5,4**	**4,9**	**4,9**
Minimum concentration mg/l	2,31	0,69	0,86	0,74	3,19	0,98	1,74	0,80
Precipitation mm	**127,3**	**127,3**	**127,3**	**127,3**	**16,1**	**23,7**	**22,4**	**23,7**



Changes in the concentration of sulphate, ammonium, nitrate and chloride ions during the main growing period in beech and forest steppe climate in 2003

Long range air pollution cannot be detected in Hungary. Spatial distribution of the open air measurements is shown by the results of 2005-2006.



Amount of precipitation and mean concentration of air pollutants in 2006 (mg/l)

Concentration differences are due to the amount of precipitation and annual concentration are connected to the amount of precipitation characteristic of the climate. Whilst ionic concentration is lower in beech forest climate (Mátra, Sopron Mountains) with high rate of precipitation (700 mm), it is higher in forest-steppe climate (region between the Danube and Tisza rivers, outer zone of Hortobágy) with only 500 mm of annual precipitation. In comparison with values recorded in Mátra, the annual mean concentration of precipitation in 2005-2006 (hydrologic year) in Püspökladány the annual mean concentration of precipitation was higher with 10, 51 and 26% for sulphate, ammonium and nitrate, respectively.

Air pollutants may have direct effects on health of forests, biodiversity and ecosystem processes. They may also have indirect effects on forests by promoting secondary stresses such as bark beetle infestations or toxicity of heavy metals in soils. Air pollution composition and distribution vary significantly in time and in space due to changes of climate and human activities, as well as environmental and physiographic changes with elevation. This temporal and spatial variability is difficult to quantify. Therefore, monitoring of air pollutants (atmospheric elements or pollutants collected from precipitation, chemical constituents deposited from the atmosphere via precipitation) for better understanding of its ecological effects has to be designed as a long-term activity, and location of monitoring sites must be chosen carefully. Average 1-year and 5-year long concentrations of air pollutants are monitored and concentrations of sulphate, ammonium, nitrate and chloride are measured. Concentration data are expressed in milligrams per litre (mg/L) of precipitation. A comprehensive record of precipitation chemistry, including all major ions and therefore air pollutants for base areas was recorded. Data of two selected sites (Mátra with beech forest climate and Püspökladány with forest-steppe climate) were compared.

For Mátra the average precipitation for the period 2000 through 2005 was 824 mm similar to the average value for nearby Kékes (Hungary's highest mountain for the period 1953 through 2001. Annual precipitation averages varied between 630 and 958 millimetres.

The average precipitation for the pedunculate oak stand in the edge zone of Hortobágy determined for the period 2000 to 2005 was 577 mm; almost 70 mm higher than the average precipitation for the period of 1901 to 1950 for the local Püspökladány. Annual precipitation averages varied between 402 and 728 millimetres.

It is worth to be noted that the precipitation was higher in Püspökladány (728 mm in 2000-2001) than in Mátra (630 mm in 2002-2003).

Annual and 5 year minimum and maximum mean concentrations (mg/l)

year		**beech forest climate (Mátra)**					**forest steppe climate (Hortobágy)**				
		csapadék	**SO_4**	**NH_4**	**NO_3**	**Cl**	csapadék	**SO_4**	**NH_4**	**NO_3**	**Cl**
2000-2001		800	3,29	1,23	1,67	1,14	728	3,69	1,59	2,40	0,87
2001-2002		958	3,33	1,22	2,07	0,71	402	4,62	1,85	3,89	1,06
2002-2003		630	3,74	1,23	2,03	1,15	436	4,78	1,96	3,34	1,68
2003-2004		785	3,17	0,82	2,20	1,10	608	3,08	1,23	4,55	1,47
2004-2005		950	2,33	0,86	1,88	1,10	710	3,30	0,95	3,17	1,44
2001-2005	max. *(prec.)*		33,45 *(2,9)*	9,77 *(3,8)*	14,7 *(3,1)*	6,83 *(2,9)*		27,60 *(2,8)*	17,47 *(2,8)*	18,26 *(2,7)*	6,17 *(2,7)*
	mean	**824**	**3,13**	**1,07**	**1,97**	**1,03**	**577**	**3,76**	**1,45**	**3,39**	**1,29**
	min. *(prec.)*		0,55 *(74,1)*	0,23 *(124,3)*	0,75 *(26,7)*	0,31 *(70,1)*		1,06 *(65,3)*	0,10 *(52,6)*	0,39 *(70,2)*	0,33 *(30,8)*

Sample plots were selected in forests away from populated areas with no direct air pollution effects. Concentration data can be considered as reference data in the comparison with data for air polluted areas.

Additionally, concentration values for air pollutants such as sulphate, ammonium, nitrate and chloride obtained from deposition data were below the critical values for forests neither in international nor in national reports.

One of the Dicotyledons leaf tissues is epidermis that covers the upper and lower surfaces. The epidermis is the outer layer of cells covering the leaf and coated on the outer side with a waxy cuticle that prevent water loss. In addition to its function as a permeability barrier for water and other molecules, the micro and nano-structure of the cuticle confer specialized surface properties that prevent contamination of plant tissues with external water (such as precipitation), dirt and microorganisms. The waxy sheet of cuticle also functions in defence, forming a physical barrier that resists penetration by virus particles, bacterial cells, and the spores or growing filaments of fungi.

Physiological effects of ionic concentrations are without visible means of support. Maximum concentrations of sulphate, ammonium, nitrate and chloride ions are so small that with the exception of ammonium they do not even meet the value requirements for drinking water quality.

Standards for drinking water quality, limit values of category "adequate"

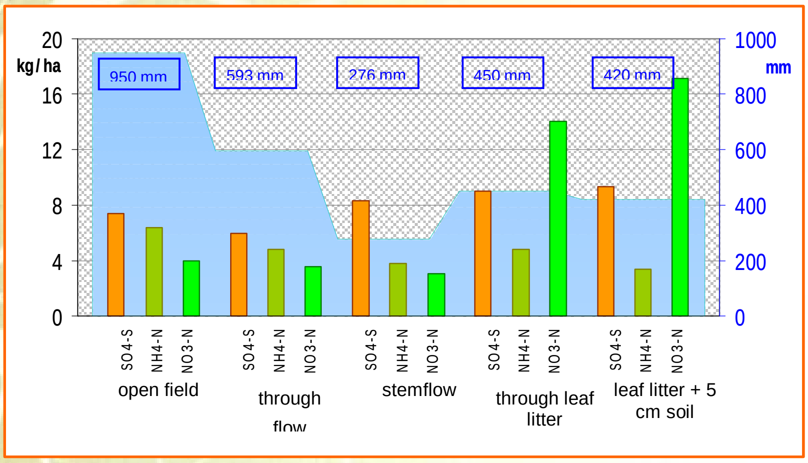
	"adequate"(mg/l)	maximum value measured (mg/l)
sulphate	200	33,45
nitrate	20	18,26
chloride	80	6,83

4.2.7. Deposition

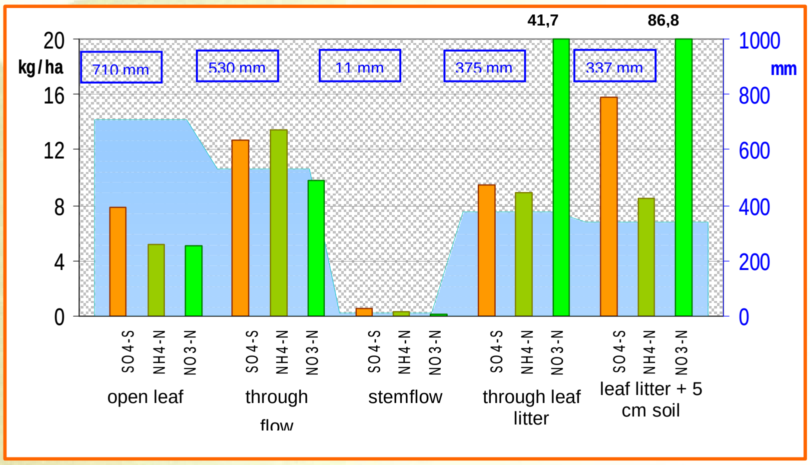
Where vegetation is present, precipitation consists of gross rainfall measured above the canopy or in openings in a forest, throughfall, dripping and stemflow. Therefore, interception significantly reduces precipitation intensity as water is first temporarily sorted and much is lost. Interception loss is that part of the precipitation on the canopy that doesn't reach the ground, because it evaporates from the canopy (canopy interception loss) and from near-ground plants and leaf litter (litter interception loss) or, to a lesser extent, is absorbed by plants. Interception usually results in a net loss of water available to the basin hydrological cycle and influence the pattern of deposition and concentration.

Deposition data in Mátra beech stands and in Püspökladány pedunculate oak stands in 2004-2005 (hydrologic year) with relatively high amount of precipitation are presented on the following figures/diagrams.

Despite the difference in the amount of precipitation depositions are quite similar.



Distribution of precipitation (mm) and deposition (kg/ha), Mátra beech stands, 2004-2005 (hydrologic year)



Distribution of precipitation (mm) and deposition (kg/ha) Püspökladány pedunculate oak stands 2004-2005 (hydrologic year)

In the hydrologic year measured there was no significant difference between the rates of precipitation that reached the ground (beech 47%, pedunculate 52%). 30-40 mm of the precipitation is retained by the top 5 cm high layer of soil. Precipitation that enters the soil, and is not retained by the soil moves downward to groundwater. This is called effective precipitation.

Dry deposited gases and particles can be washed from trees and other surfaces by rain. Solid particles and dissolved carbon from leaves, shrubs, herbaceous plants, leaf litter affect soil chemistry and weathering processes and increase the ionic concentration and amount of deposition as recorded in Mátra and Püspökladány.

We found that the increasing N deposition leached to the groundwater was 20,5 kg/ha for beech and 95,3 kg/ha for pedunculate that is explained by the effects of soil.

Stemflow fluxes of sulphur and nitrogen to forest soil was compared at the two sites. At the beech stands in Mátra the annual 276 mm stemflow is important. Total nitrogen flux to the forest soil was 6,9 kg/ha and SO_4-S flux was 8,3 kg/ha. On the contrary at the pedunculate stands the annual stemflow was only 11 mm, total nitrogen and SO_4-S flux to the forest soil was only 0,4 kg/ha 8,3 kg/ha, respectively.

We can conclude that the presence of dissolved organic matters in soil appears to be relatively low. The mobility of these organic matters explains their variations. Monitoring like measurements of the dissolved organic matters are of high importance in order to get a better understanding of ecological processes.

4.2.8. Increment measurements

Sampling, data processing

The efficient use, preservation and management of forest resources require continuous collection of information about forests because the forest system is dynamic. The way this information is collected is a function of the nature of the resources themselves, the available technology and labour, existing knowledge of the forest and relationships between parameters.

The information needed includes quantitative data about the trees and under-storey layer of the forest. Quantitative information comes from measurement. It is important to effectively and efficiently measure and quantify parts of the forest as required. Structural characteristics of the forest stand are determined from survey data (diameter, tree height, crown height, crown projection). After data processing other relevant data are available, such as:

- diameter at breast height (dbh) ($d_{1,3}$), the mean value as the representative size of the two measurements equally distant above and below the nominated height,
- tree basal area (the cross-sectional area (over the bark) at breast height measured in metres squared (m^2),
- tree height (A stand height curve is a representation of the correlation between tree height (total or bole) and tree diameter (dbh) or basal area (g). The curve can be presented as a plot of height against diameter, or in equation form. A stand height curve can be used to predict the height of a tree when only the dbh is measured.),

- tree volume calculated by Király tree volume equation. The input variables to the equation include diameter (at breast height and other heights) and tree height.

Main stand, by-stand and total stand level characteristics can be derived from inventory data, such as:

- D_g: mean diameter of stand derived from basal area,
- H_g: weighted mean height of stand derived from basal area,
- G: sum of basal areas per hectare (basal areas of all trees in a hectare),
- N: total number of stems per hectare,
- V: total volume of all trees per hectare (volume of all trees in a hectare).

Growth rate of sample plots in general

Structural characteristics of the total forest stand on monitoring plots are shown in the following table, including data for both main and mixed tree species.

Structural characteristics of the total forest stands on monitoring plots

sample plot	tree species	year of assess-ment	age (year)	stand parameters				
				D_g	H_g	N	G	V
				cm	m	db/ha	m^2/ha	m^3/ha
M01	B	1996	86	33,1	27,7	416	35,9	561,8
M01	B	2000	89	34,4	28,8	416	38,7	631,8
M01	B	2005	94	35,9	30,8	412	41,8	728,5
M02	S	1977	11	6,4	5,1	2408	7,8	33,1
M02	S	1983	17	11,2	9,9	2408	23,7	162,8
M02	S	1996	30	15,1	16,1	2368	42,3	426,8
M02	S	2000	35	20,1	19,9	1180	37,5	452,8
M02	S	2005	40	22,2	22,6	932	36,1	479,8
M03	H	1996	59	13,5	13,7	132	1,9	17,5
M03	H	2000	63	14,0	14,0	132	2,0	19,3
M03	H	2005	68	14,4	15,3	132	2,2	21,9
M03	SO	1996	59	20,9	20,7	776	26,7	321,2
M03	SO	2000	63	22,3	20,4	748	29,1	349,1
M03	SO	2005	68	23,8	22,9	708	31,6	420,6
M06	SP	1996	30	15,6	14,7	1660	31,6	270,7
M06	SP	2000	35	16,8	15,3	1572	34,9	306,5
M06	SP	2005	40	18,2	17,7	1564	38,9	374,8
M08	SP	1996	26	15,2	12,6	1692	30,9	240,9
M08	SP	2000	30	16,1	13,0	1612	32,9	262,3
M09	BP	1996	58	27,7	21,7	680	40,9	503,6
M09	BP	2000	62	28,3	20,9	652	41,1	492,3
M09	BP	2005	67	29,3	22,9	604	40,7	521,4
M10	PO	1996	70	26,7	21,2	356	19,9	232,3
M10	PO	2000	74	28,1	22,4	356	22,1	271,7
M10	PO	2005	79	29,7	22,4	340	23,5	290,6
M11	A	2000	67	14,7	11,7	148	2,5	19,6
M11	A	2005	72	15,9	11,8	136	2,7	21,3
M11	TO	2000	67	28,6	18,5	88	5,7	57,5
M11	TO	2005	72	29,6	19,1	88	6,0	63,5
M11	PO	2000	67	23,8	15,8	232	10,3	96,4
M11	PO	2005	72	25,1	16,3	196	9,7	93,6
M11	E	2000	67	13,6	12,5	180	2,6	21,3
M11	E	2005	72	14,7	12,8	168	2,9	23,7
M12	B	1996	92	44,1	31,0	188	28,7	513,2
M12	B	2000	96	46,0	32,3	188	31,3	586,8
M12	B	2005	101	48,4	33,2	164	30,2	582,7
M12	SO	1996	92	39,3	29,0	48	5,8	100,0
M12	SO	2000	96	40,1	29,4	48	6,0	105,5
M12	SO	2005	101	43,9	31,7	20	3,0	56,8
M12	La	1996	92	35,9	31,3	76	7,7	117,0

sample plot	tree species	year of assess-ment	age (year)	stand parameters				
				D_g	H_g	N	G	V
				cm	m	db/ha	m^2/ha	m^3/ha
M12	La	2000	96	36,6	31,9	76	8,0	123,7
M12	La	2005	101	38,4	33,1	32	3,7	59,8
M13	Li	1996	92	18,0	20,1	64	1,6	19,8
M13	Li	2000	96	19,0	20,9	64	1,8	22,6
M13	Li	2005	101	19,6	19,7	60	1,8	21,6
M13	SO	1996	92	34,5	25,2	392	36,7	551,4
M13	SO	2000	96	36,0	26,0	392	40,0	619,0
M13	SO	2005	101	37,2	24,5	344	37,4	554,2
M13	La	1996	92	34,8	26,6	20	1,9	23,9
M13	La	2000	96	36,1	27,7	20	2,0	26,6
M13	La	2005	101	36,2	26,8	20	2,1	25,8
M14	S	1996	72	29,8	28,5	612	42,8	673,3
M15	SP	1995	43	24,9	21,6	790	38,3	424,2
M15	SP	2000	48	26,3	22,5	760	41,3	470,7
M15	SP	2005	53	27,9	24,7	726	44,3	539,9
M16	SO	1995	67	31,4	24,6	314	24,3	353,2
M16	SO	2000	72	32,7	23,4	307	25,9	362,7
M16	SO	2005	77	35,2	24,8	268	26,1	386,2
M17	B	1994	63	33,6	29,5	395	34,9	578,6
M17	B	2000	69	34,6	29,1	412	38,8	640,1
M17	B	2005	74	38,1	31,1	352	40,2	708,8
M18	HP	2001	30	26,7	22,7	80	4,5	48,7
M18	HP	2005	34	28,9	24,9	64	4,2	49,5
M18	HP	2001	30	26,6	22,6	292	16,3	183,7
M18	HP	2005	34	29,4	24,0	268	18,2	216,0
M19	BL	2005	25	12,9	14,9	1952	25,7	224,8

The explanation of the abbreviations is located in annex I.

Sample plot were grouped in increment classes as shown in the table below:

Mean annual increment of total production and site classes

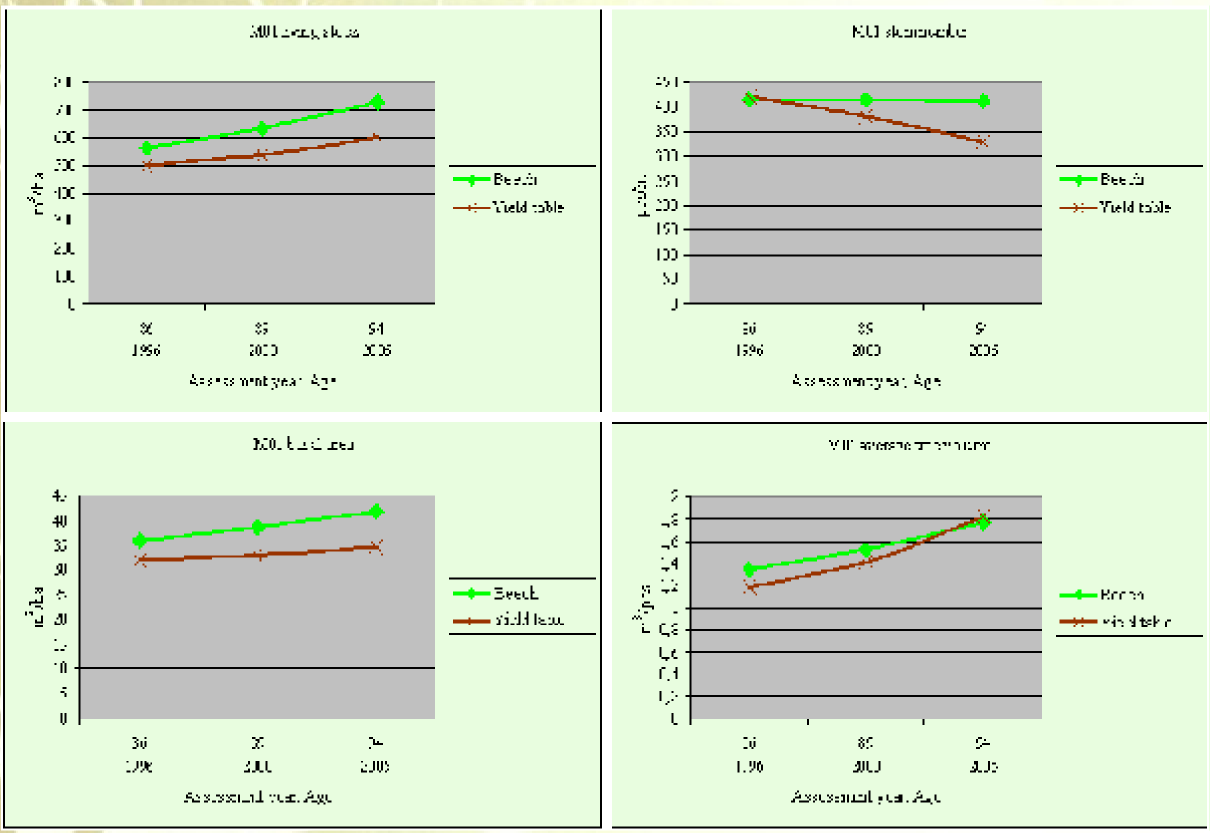
sample plot	main tree species	increment classes		
		I-II.	III-IV.	V-VI.
		mean annual increment of total production (m^3/ha/year)		
		good	medium	poor
M01	B		10	
M02	S	15		
M03	SO		8	
M06	SP	11		
M08	SP		8	
M09	BP	11		
M10	PO		6	
M11	PO			4
M12	B	12		
M13	SO		8	
M14	S	14		
M15	SP	11		
M16	SO	9		
M17	B	14		
M18	HP	15		
M19	BL			7

The explanation of the abbreviations is located in annex I.

The results, which are shown in the table above, indicate that more than half of the sites are in good site class considering mean annual increment values. Only one site is in poor site class.

Comparison with volume table data

In the following table stand structural parameters are compared with volume table data.



Stand structural parameters and volume table data of beech stand in Mátra (M01) (main stand)

Considering stand structural parameters it can be concluded that compared to volume table data as control values the values recorded for the total growing stock, basal area and number of stems are greater. Therefore the volume of sample trees on monitoring areas is not as great as the expected volume in the relevant volume tables that in the long run might result in self-thinning as the population reaches the self-thinning curve. However, trends in general reflect expectations of volume table data and there is no supporting evidence of direct effects of such factors as air pollution, epidemic insects and disease outbreaks, and other factors on level II monitoring areas and growth potential of stands.

4.2.9. Growth (circumference) measurements

Annual information on the percentage of radial growth can be obtained by measurement with permanently fixed tapes or electronic devices. The two most common instruments used to measure DBH are a girthing (or diameter) tape and callipers.

The circumference, or girth, is obtained using a flexible tape measure (Liming tape measure improved by Járó). On each plot 10 sample trees are selected from the main tree species that appear typical of the stand (height, thickness classes are considered). Normally permanent diameter measurements are aiming at the assessment of changes with an accuracy 1/10 of mm. Usually a permanent girth band tightened by a spring, a scale (with nonius reading) enables this precision when permanently fixed on the tree to avoid variation due to differing measurement positions. Continuous circumference measurements are performed on a sub-sample of trees from the beginning of April to the end of November with digital calliper. The Digital Calliper is a precision instrument that can be used to measure internal and external distances extremely accurately. Installation of girth bands takes place in April. Reading of girth bands is carried out at weekly intervals. For increment calculations, the reference values are the ones that were recorded in April (when the girth bands were installed).

The UMS product Strain-Gage Clip-Sensor is designed for continuous high-resolution and automated measuring of circumferential variation of trees. Small in dimension and weight, the clip-sensor can easily be fixed on the trunk without any damage to the bark or disturbance of growth. The complete sensor device is tightened like a belt and kept in position by a spring. Variations in tree-dimensions are conducted directly to the sensor for recording the trees immediate reactions to environmental influences, swelling of the bark, level in water conduits or cell division. The trees dimensional changes are conveyed to the clip by a cable tied around the trunk and are transformed into a corresponding resistance change in strain gages, which are fixed on top and bottom of the clip, wired into a full Wheatstone bridge. The cable's dependence on temperature is extremely low (1 ppm). A special Teflon-layer is placed between cable and bark to reduce the friction of the cable and to protect it from icing, resin or callusing.

Results obtained by measurement with permanently fixed tapes

Growth is the biological phenomenon of increase in size with time. Growth involves the formation, differentiation and expansion of new cells, tissues or organs. The sudden increase in tree diameter often observed after rain is not due to growth but reflects the effects of bark swell.

Increment is the quantitative increase in size in a specified time interval due to growth. The terms growth and increment are not interchangeable.

The following factors generally have important effects on growth in most plantations: initial spacing and treatment, silvicultural treatment, artificial thinning and pruning, site conditions (including nutrition) and climatic conditions. The increment is determined by the pattern and rate of growth of the tree and varies with: species, internal conditions (genetic and physiological) and external conditions (climatic, edaphic, biotic).

Generally, increment is based on a period of one year, smoothing out the intra-seasonal variations in increment.

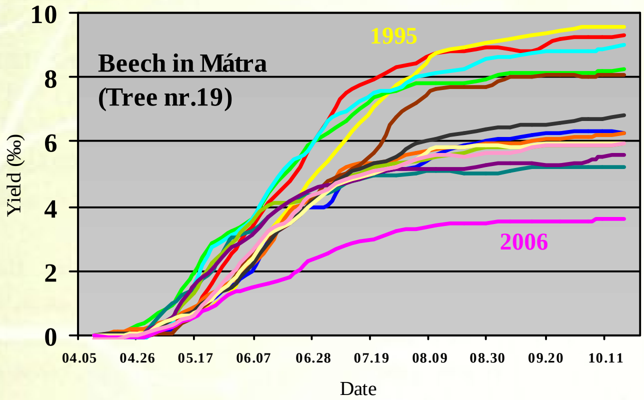
Current annual increment (CAI) is the increment over a period of one year at any stage in the tree's history. The CAI varies from year to year being affected by seasonal conditions and treatment. For this reason, it is common practice to express the increment as a mean over a period of years, termed as periodic mean annual increment (PAI). Annual increment is often expressed as PAI over a number of years to smooth out the between year variation.

Nevertheless, the average increment figure must still be related to the general weather conditions which prevailed during the period in question.

Increment data must also be related to tree age or size. The data are meaningless otherwise. One can use the age or size at the beginning or end of the period. It doesn't matter which as long as it is specified.

The annual increment recorded in Mátra over the period 1994 through 2007 reflect the between year variation mentioned above. The maximum rate of grows is almost three times more than the minimum rate of growth. The main growing period typically starts between mid-April to the beginning of May and end between July and September.

Automatic (above) and manual (below) girth band



Changes in annual growth (Mátra, 1994-2007)

Individual growth pattern varied significantly from tree to tree, therefore increment and precipitation data shall be compared on stand level. In the period 1996 to 2005 both the Mátra beech stand and the pedunculate oak stand maintained a steady growth rate, but the time of maximum and minimum growth rates differ for the two tree species.

Increment and precipitation (Mátra, beech stand)

year	increment of a stand	periodic precipitation (Mátra, beech stand)				
		dormant (d)	main growing (m)	d+m	post-growing	hydrologic year
	‰	mm				
1996	7,51	264	187	451	229	680
1997	7,98	155	219	374	62	436
1998	6,82	216	242	458	248	706
1999	6,82	237	376	613	127	740
2000	5,65	232	94	326	106	432
2001	10,66	264	213	477	65	542
2002	7,74	136	472	608	159	767
2003	5,38	182	279	461	29	490
2004	7,58	264	290	554	153	708
2005	7,02	264	436	700	75	775

Based on the circumference measurements for each tree species separately the beginning and the end of (dormant, main growing, post-growing) periods and the amount of precipitation were determined. The amount of precipitation and the available precipitation maximum calculated from the water capacity of soil are compared. When the periodical amount of precipitation was higher than the available precipitation maximum, the latter was used since that is the available amount of precipitation at the beginning of the main growing period.

According to survey data the available precipitation in the dormant period was adequate in amount to supply the soil with enough water. Available water capacity is the amount of water that a soil can store that is available for use by trees. This water is necessary to sustain the plants between rainfall events or periods of irrigation. The soil effectively buffers the plant root environment against periods of water deficit.

Increment and available amount of precipitation (Mátra, sessile oak stand)

year	increment of a stand	periodic amount of precipitation (Mátra, sessile oak stand)				
		dormant (d)	main growing (m)	d+m	post-growing	hydrologic year
	‰	mm				
1996	5,66	196	138	334	200	534
1997	6,66	144	226	370	84	454
1998	5,16	192	247	439	251	690
1999	14,13	196	466	662	54	716
2000	5,48	196	99	295	103	398
2001	8,03	196	174	370	64	434
2002	6,10	132	373	505	167	672
2003	6,46	144	238	382	171	553
2004	6,12	196	319	515	165	680
2005	6,89	150	494	644	89	733

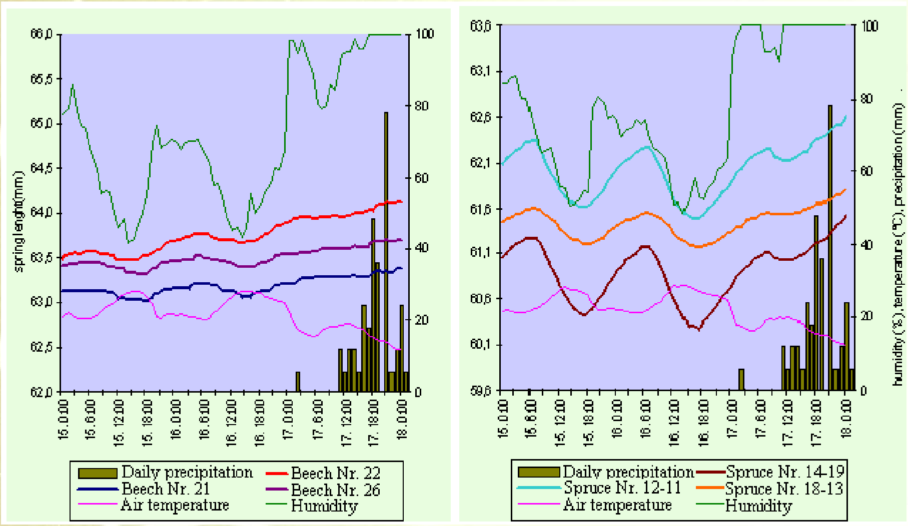
Presumably average increment is in connection with the amount of precipitation both in the main growing and in the main growing and dormant period (generally from November to April), but there is no strong correlation between the yearly sum of precipitation and the periodic increment, so the yearly sum of precipitation itself does not explain the variation in increment.

Automatic circumference measurements (Mátra sampling plots)

Data on the variation of trees circumference measured by automatic instruments are presented on the following diagram. Average daily data (mm) are derived from hourly recorded girth data and from data on temperature and relative humidity measured every half hour. Daily precipitation data were collected by the Hungarian Meteorological Service (OMSZ).

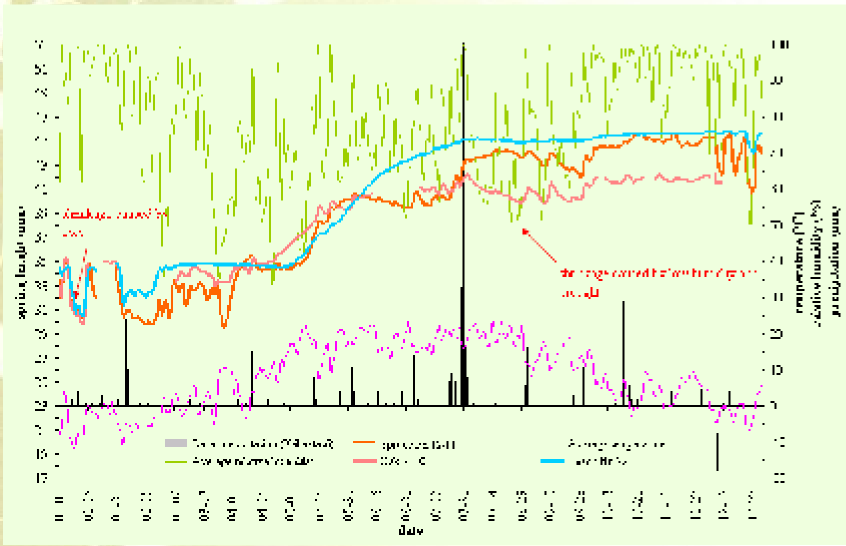
As the aim of the growth assessment is to derive tree related estimates the information on tree is essential. When selecting trees, due regard was given to increment measurement data over the previous years. Trees with the highest increment rate presumably respond faster to changing environmental conditions. Representativeness was enhanced since the selected beech, spruce and sessile oak (altogether three) trees represented the state of other selected trees. The corresponding increment measurement data had the same values (with negligible differences) as the selected three trees. Changes in environmental conditions such as precipitation, temperature and humidity have no significant effect on increment. Differences were detected in the beginning and end of growing and in the rate of increment.

Automatic measurement results confirmed previous measurement results. Whilst growth rate for beech and spruce was steady (even in the year of 2003 with the lowest rate of growth during the period of 1996 through 2005 when electronic devices were not used for measurements), sessile oak trees exhibited worst growth several times (even within a year).



Changes in circumference during the day for the three sample plots in Mátra in 2003

Measured values are providing information on changes in circumference or on the radial expansion/shrinkage. The variation in tree dimension <u>during the day</u> is strongly influenced by changes in water saturation and temperature. Both in the main and post-growing period there is typical day pattern - expansion in the morning and shrinkage in the late afternoon.



Changes in circumference in the main growing period in the beech and spruce stands of Mátra) 15-17 July, 2001)

Spruce is more susceptible to changes in weather condition (winter frost), drought (rainless) conditions, and periods with low humidity. Winter frost explains shrinkage. 4-5 mm and 2-3 mm (6-7‰ and 2-3‰ in comparison to the previously measured circumference) frost-induced shrinkage was measure in spruce and beech, respectively. Thaw expansion reverses the frost shrinkage at times of increasing air temperature above a minimum temperature of approximately 0°C. The thaw and frost dynamics are temperature induced and have, therefore an inverse day/night-time pattern: the radius expands during the day when the temperature is increasing and contrast happens during the night. Similarly to frost shrinkage, this process is temperature-induced as well.

The day/night-time pattern is influenced by dry/rainy days, but the effect on the two tree species is different. The shrinkage/expansion is primarily a function of tree species. Whilst in the main growing period beech is continuously growing regardless of the changes in weather condition, spruce responds with stem circumference changes to extreme weather conditions, drought-induced shrinkage and moister-induced expansion were observed. In the post-growing period spruce responds with the same physiological process (with lower amplitude values). On the contrary beech is slightly influenced by weather condition (precipitation, drought).

Sessile oak is also sensitive, but less susceptible to changes in weather condition than spruce. Automatic circumference measuring has been carried out since 2001, but due to its thick bark further measurements have to be performed to properly answer the question of shrinkage/expansion.

4.2.10. Vegetation assessments

Objectives of assessment:

1. the study of the composition, diversity, and structure of vegetation,
2. the study of vegetation dynamics (biodiversity changes). Vegetation changes will allow describing, explaining and modelling dynamical processes, by analysis of pathways, causes and mechanisms (including natural and anthropogenic environmental factors), and
3. the estimation of the status and changes in the diversity of plant communities at the monitoring plots (within monitoring sites).

Sampling

At the monitoring sites cover and abundance of vascular plants were visually assessed during the spring and summer surveys. Separate record was made for each species in the different vertical strata (herb, shrub and tree layers). A minimum of two people formed a working team and assessed all of the sampling units at each sampling date (with the exception of the year 2001) to overcome subjectivity.

Data processing

Seven sampling units with the least human and natural disturbances (M01, M03, M09, M11, M13, M15, M16) were selected from the surveyed sampling plots. Assessment was performed five times within the fenced areas of the selected sampling units.

Global (collected in spring and summer surveys) data on herb layer were processed. Results at different dates were not merged, but the higher percentage of the variable recorded either in the spring survey or in the summer survey was taken into consideration. The composition of vegetation and the vegetation dynamics in the herb layer were analysed with multivariate statistical methods (principal components analysis and correspondence analysis) with environmental variables incorporated. Species were grouped according to their ecological requirements (as determined by Borhidi) with respect to relative groundwater and soil moister requirements). Further assessments were performed to determine correlation between the temporal variation of cover and weather conditions (matrix correlation analysis between distance matrices of ecological groups and weather condition parameters).

Structural changes in vegetation of sampling plots

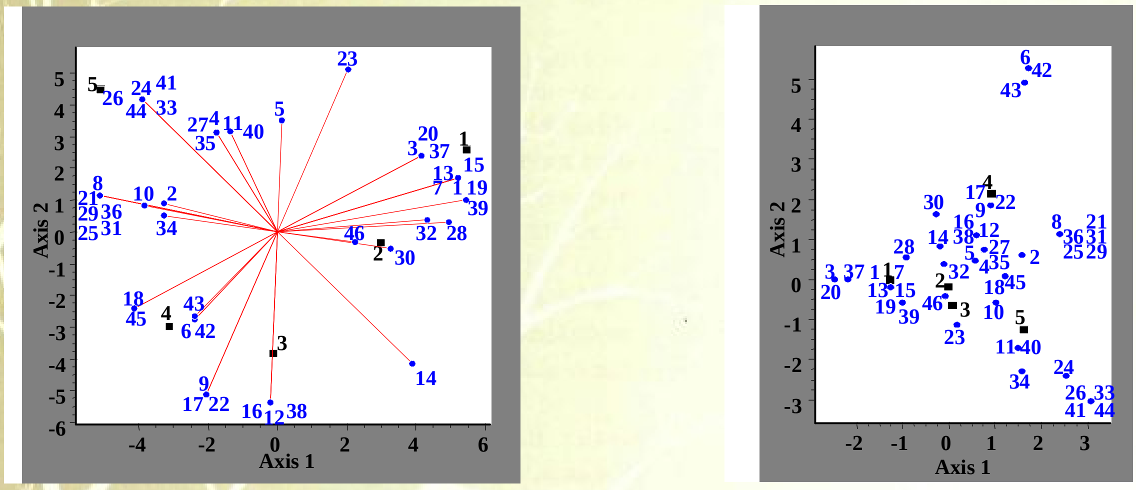
Principal components analysis and correspondence analysis revealed the gradual trends of vegetation change only in two cases (M03 and M13).

The hornbeam-oak stand in the M03 sampling plot has double canopy. Whilst in the upper lever we have sessile oak, in the lower lever we find hornbeam and beech. The selective thinning of the lower level allowed more light to penetrate through the canopy resulting in a more abundant ground and shrub layer (increased light level encouraged growth of ground and shrub layers).

During the five surveys we recorded 19 species in the shrub layer. Hornbeam is the dominant tree (with 20% of the canopy cover). The herb layer is reach in species as well (82 species were recorded). Dominant species are the coralroot bittercress (*Cardamine bulbifera*), wood bluegrass (*Poa nemoralis*), Sweet woodruff (*Galium odoratum*), *Carex pilosa* and wood violet (*Viola silvestris*). In the period 1996 through 2005 the cover of coralroot bittercress (*Cardamine bulbifera*) and Sweet woodruff (*Galium odoratum*) increased from 1% to 25% and to 15%, respectively. In the same period the cover of wood bluegrass (*Poa nemoralis*) decreased from 20% to 1% and the cover of *Carex pilosa* from 10% to 3%.

The M13 sampling plot has double canopy. Whilst in the upper lever we have sessile oak, in the lower lever we find hornbeam and large-leaved lime. Both shrub and herb layer is rich in species. Large-leaved lime is the dominant tree in the shrub layer (with 30% density), but we found 19 other species. In the herb layer the total of 68 species were recorded. Dominant species are the *Carex pilosa* and Wood Melick (*Melica uniflora*). Acid soil is explained by the presence of wavy hairgrass (*Deschampsia flexuosa*), oakforest woodrush (*Luzula luzuloides*), bilberry (*Vaccinium myrtillus*), Korean feather reed grass (*Calamagrostis arundinacea*) and common cow-wheat (*Melampyrum pratense*).

In the period of surveys the density of few dominant species decreased, such as Common Privet or European Privet (*Ligustrum vulgare,* No 28.), Wood Melick (*Melica uniflora,* No 32.) and shrubby blackberry (*Rubus fruticosus,* No 39.), on the contrary the density of other species increased, such as *Carex pilosa* (No 10.). We found species that gradually disappeared from the site, for instance *Abies alba* (No 1.), *Campanula persicifolia* (No 7.), *Euphorbia amygdaloides* (No 19.), others appeared, such as *Fallopia dumetorum* (No 21.), *Pulmonaria officinalis* (No 36.), and there were species that appeared and after a while disappeared from the site (e.g. *Cardamine bulbifera,* (No 9.), *Rhamnus catharticus* (No 38.)).



PCA(left) and CoA (right) ordination in the M13 plot, based on the vegetation data. The first two axes explain 67,8% and 83,5% of the total variance. The sampling occasion is marked with black, the ID of the trees is marked with blue.

Correlation between weather condition and changes in herb layer

In sampling plots we assessed fluctuating weather conditions that have the potential to shape long-term vegetation composition and dynamics. The study conducted in M01 sampling plot is detailed below. In the beech stand we found beech and hornbeam regrowth. Herb cover was greatly reduced and species poor. During the five plot surveys conducted we found 41 species. The average density of dominant species, Wood Melick (*Melica uniflora*) and *Carex pilosa* was 5-10%.

On the base of matrix correlation of calculated distance matrices calculated from herb layer data we can conclude that fluctuating weather conditions (difference in the amount of precipitation and in air temperature) have no effect on vegetation composition. There was no correlation neither between fluctuating weather conditions and ecological groups.

Canonical correspondence analyses help to determine the susceptibility of species to changes in weather condition. For instance when the amount of precipitation was higher as usual between 1 November and 31 March (in 1996 and 2001) the species richness (density) of *(Carex pilosa*) increased up to 10 and 15%, respectively. On the contrary Wood Melick (*Melica uniflora*) is not susceptible to changes in the amount of precipitation. Canonical correspondence analyses did not detect any evidence in correlation between species richness (density) and changes in air temperature.

4.2.11. Atmospheric chemistry assessments

On the ecological site of the Forest Research Institute in Mátra (Névtelen-bérc) the following measurements are performed:

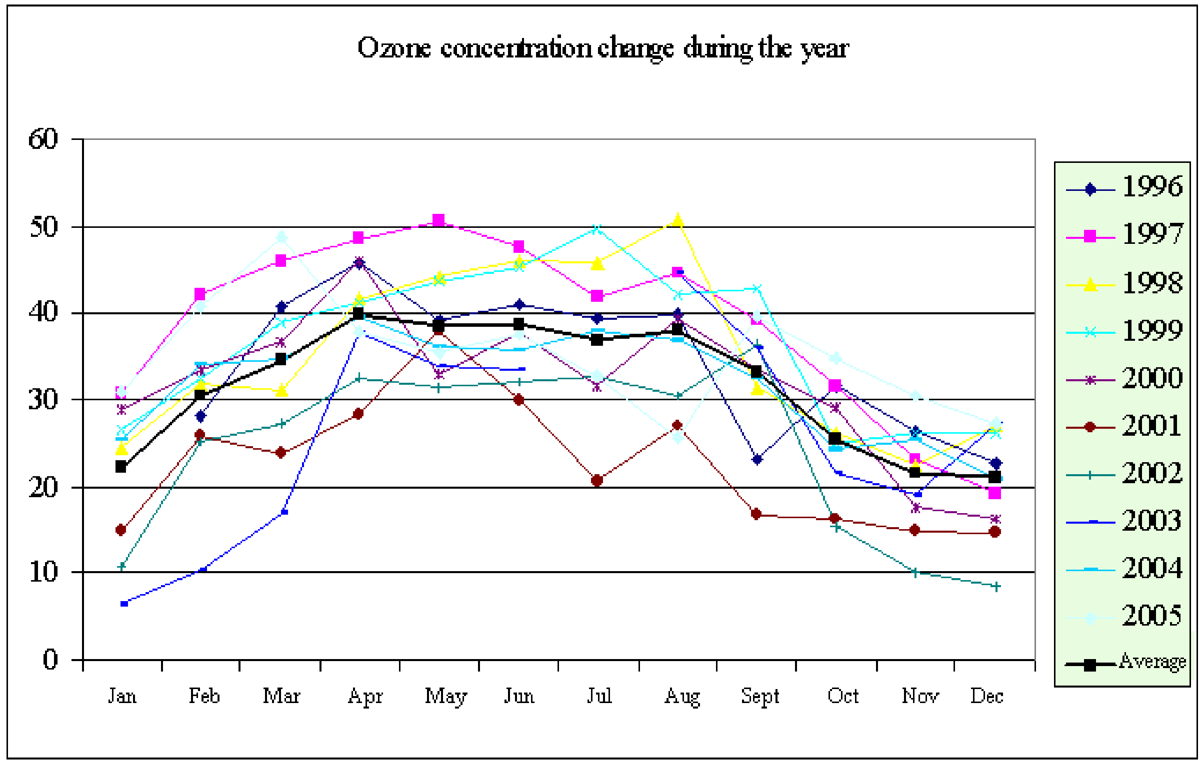
- Ozone concentration, yearly and long-range trends, critical levels for ozone, the exceeding of critical load, via AOT40 (Accumulated Ozone Exposure over a threshold of 40 Parts Per Billion).
- Acid concentration (sulphur and nitrogen compounds), exceeding of critical load.

- Dry, wet and total deposition of acids (sulphur and nitrogen compounds), comparison with critical level, long-range trends.

Measurements were carried out according to the standard recommended methods for sampling and chemical analysis for the EMEP measurement network. (EMEP, 1996: EMEP co-operative programme for monitoring and evaluation of the long-range transport of air pollutants in Europe. EMEP manual for sampling and chemical analysis. EMEP/CCC-Report 1/95, NILU, Kjeller, Norway).

Ozone mixing ratios

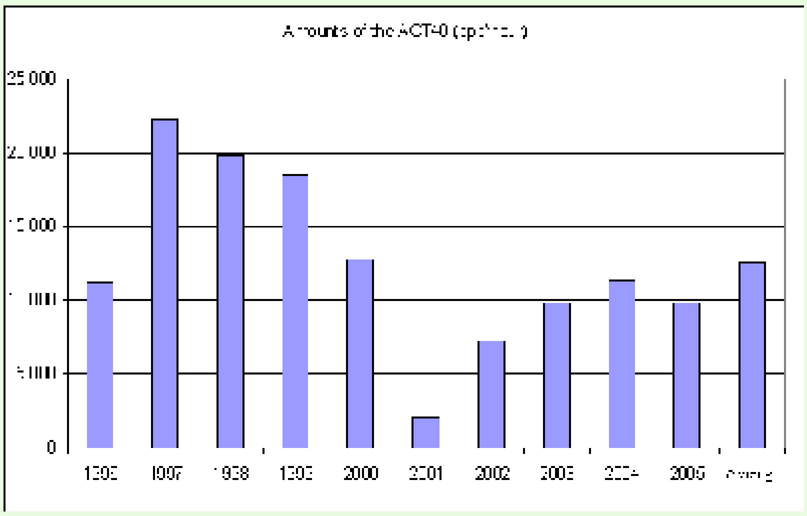
Between 1996 and 2005 ozone mixing ratios were 32 ppb, relatively low in Europe. The *following diagram* shows the monthly ozone mixing ratios in each year.



Change of ozone concentration during the year (ppb)

In the vegetation period (mostly in spring and summer) ozone concentration is higher. Highest data are recorded in April due to effect of ozone from the stratosphere. The presence of ozone in the troposphere is explained by downward transport of ozone-rich stratospheric air masses in the vicinity of tropopause foldings, cut-off lows and storms. Higher ozone concentration can be observed in May and in August as well. The atmospheric chemistry involved in ozone formation is complex. It takes time for the ozone to accumulate as the chemical reactions involved are quite slow. Peak ozone formation takes place downwind of precursor sources in sunny weather with low wind speeds. There is correlation between the ozone production mechanism and warmer days (radiation). With higher temperature, we can expect higher ozone levels. As higher radiation intensity explains faster ozone formation, ozone production is more intensive in the vegetation period (in the summer).

Despite several criticisms, ozone (O3) AOT40 (O3 accumulated over a threshold 40 ppb, remains the basis for estimating the potential risk of forests due to O3 and for setting environmental quality objectives. The knowledge about AOT40 values at forest monitoring sites is of considerable interest. The AOT40 is defined as the sum of the hourly O3 concentration exceeding the threshold of 40 ppb over the period 1 April 30 September (the definition considers the vegetative period, which varies according to the species and the geographical location). Only the daylight hours are considered when global radiation > 50 W/m2. The AOT40 level of 12,500 ppb.h (in the period of 1996 through 2005) is an average level on European level. Considerable deviation in concentration is observed over the whole period and within each year as well.

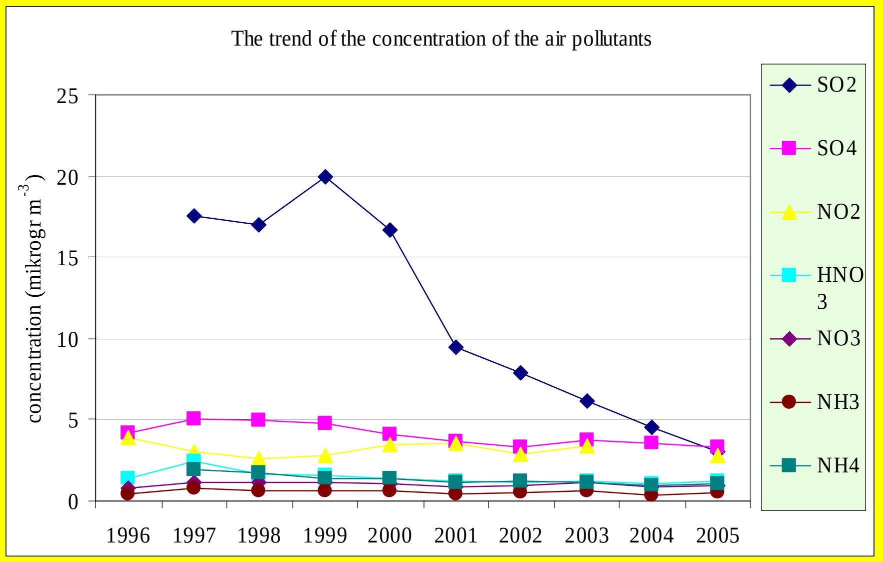


*The amounts of the AOT40 (ppb*hour)*

Concentration of sulphur and nitrogen compounds

Analysis of daily concentration data only revealed relatively high concentration of sulfur dioxide. Concentration reached the critical value (when the daily mean value was 125 μg/m^3) only few times during the survey period (1997-2000).

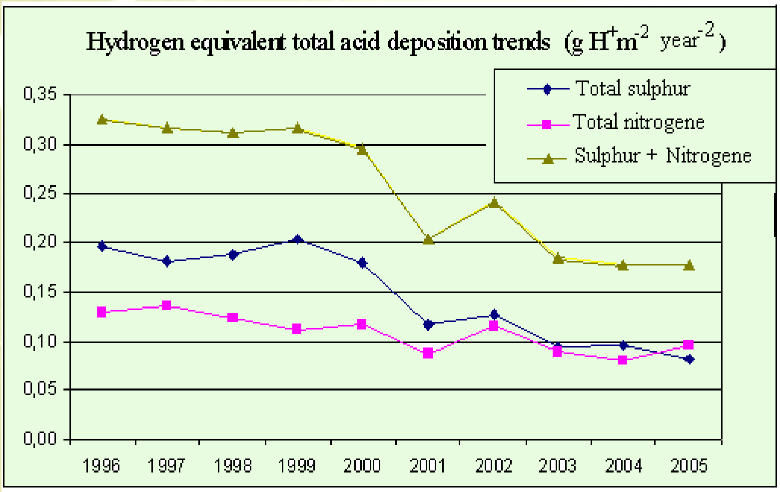
Annual mean concentration of sulphur and nitrogen compounds is presented in the following graph. Most sulphur dioxide is produced by burning fuels containing sulphur or by roasting metal sulphide ores, although there are natural sources of sulphur dioxide. The thermal power plant in Visonta burning high-sulphur coal is the main source of anthropogenic sulphur dioxide emissions resulting in the relatively high concentration level of sulphur dioxide on national level. Lower concentration level has been achieved since 2000 due to the installation of desulphurizing equipment. Annual mean concentration of nitrogen dioxide is below the limit (maximum) value. Other compounds (nitric acid, ammonia, nitrate, sulphate, and ammonium particles) have low concentration levels, far below the permissible limits. Decreasing trend can be observed at sulphur dioxide and sulphate particles. Long-term changes are not recorded for nitrogen compounds.



The trend of the concentration of air pollutants

Deposition of sulphur and nitrogen compounds, total acid deposition

Acidic substances in the atmosphere are deposited on the earth's surface by two mechanisms: wet and dry deposition, therefore both dry and wet deposition is taken into account when considering total acid deposition. At the beginning of the survey sulphur deposition was much higher than nitrogen deposition. Sulphur and nitrogen deposition reduction was observed, especially at the end of the survey when the total deposition was below the critical load expressed in hydrogen equivalent. Calculation of critical thresholds has different methods. According to one RIVM report (RIVM, 1995: Calculation and mapping of critical thresholds in Europe, Report No. 259101004) the critical loads of deposition in the region is high above the observed values (0,15 g $H^+/m^2/yr$). Due to the reductions achieved ecosystems in the region are not subject to risk of danger.



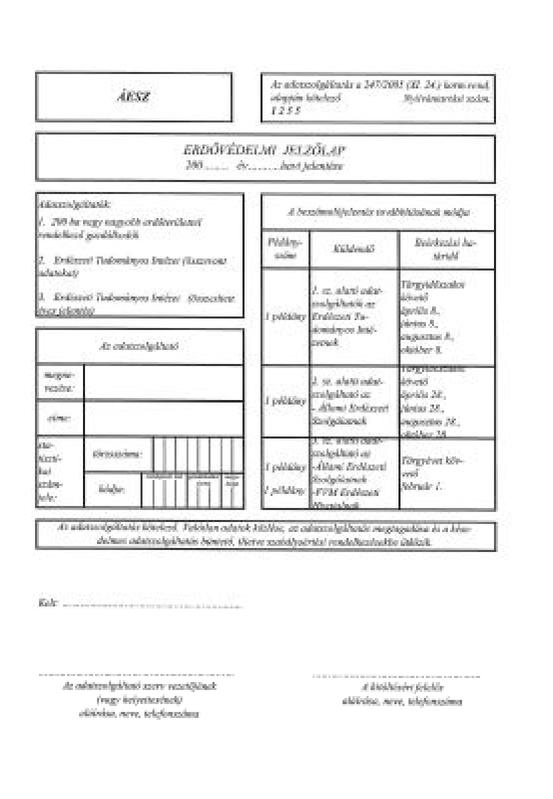
Hydrogen equivalent total acid deposition trends ($gH^+m^{-2}year^{-2}$)

5. Forest Protective Monitoring-Forecasting System

In response to widespread concern that reliable information on forest health condition is essential for modern forest management, the Forest Protection Observation and Monitoring System was established in 1961. Since that the system has been continuously developed and improved to face emerging forest protection problems and timely demands. The System of Forest Protection Monitoring Sheets and the National Forest Light Trap Network are the keystones of the system operated by the Forest Research Institute (FRI).

5.1. System of Forest Protection Monitoring Sheets

Four times a year forest managers managing more than 200 hectares of forest land are obliged to report on the type, intensity (low/medium/high) and time of damage occurred and on protective attempts and measures taken to recover from the damage.



ÁESZ

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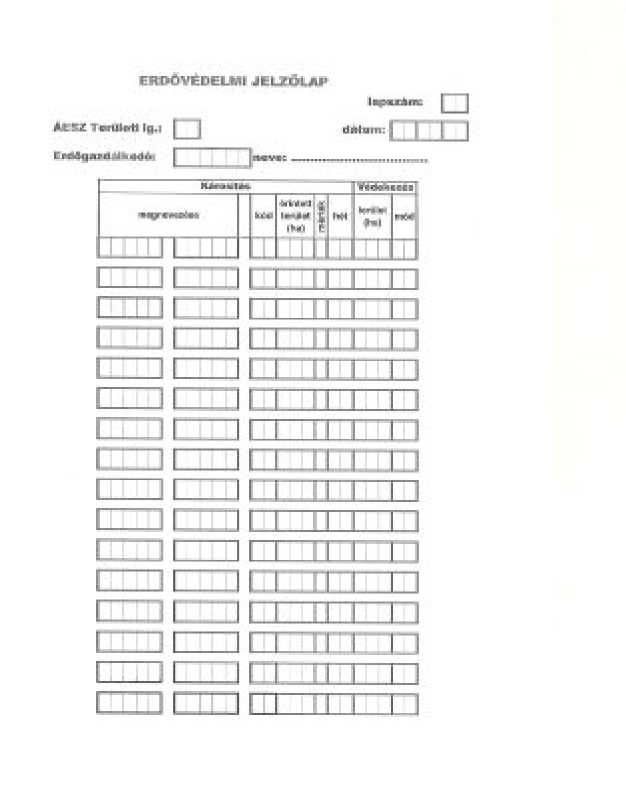

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Forest protection monitoring sheet

Once data is collected, it is processed to convert it into useful information. After completing data processing, output is generated. The main purpose of data processing is to get the required result. The generated output is used to prepare annual prognoses. A manual documenting the harmonized methods for reporting was adopted in 2006. Data submission form, code lists and explanatory manual are provided for forest managers in order to meet the reporting requirement.

Manual with pictures and codes

Interactive web helpdesk will be soon available for forest managers to identify damages on FRI homepage of the FRI (www.erti.hu).

5.2. Forest Light Trap Network

5.2.1. Review of the history of the light trap network

Only two countries known worldwide where there is an existing national light trap network >50 stations, that has been operating for decades. One is in Hungary (Hungarian Light Trap Network). Simultaneous samplings with such networks of light traps can be carried out according to landscape, or even at a larger spatial (regional, national) scale to forecast insect pest densities. The national light trap type designed and first operated by Professor Jermy was installed in 1952 and has been used by the National Light Trap Network ever since. After 6-year-experience of trapping and managing the caught insect material from six different sites in the country, a nation-wide network of light traps started to operate in Hungary in 1958. The network, established with the intention of forecasting for plant protection purposes, grew to more than 100 traps a decade later, and even today about 60 stations are operating. In 1961-62, a forest light trap network with 12 stations was established. The Plant Protection Identification Group had also processed catches of these forest traps until 1971. By that time 25 forest traps had been operating, which are still successfully operated today. It is evident that the data series, with decades-long observation, are eventually becoming more valuable in monitoring such large-scale processes as effects on climate change on bioindication of species and diversity changes.

Traps of the Forest Light Trap Network in 2009

5.2.2. Operation of the light trap operation, collected insect material, identification handling and future of the trapped insects

Jermy-type light traps are operated in the Forest Light Trap Network on everyday basis. Insects are collected from early evening hours until the radical decrease of their flight at dawn from the beginning of March until the end of December. The collections are stored daily for later processing.

Light trap in Püspökladány

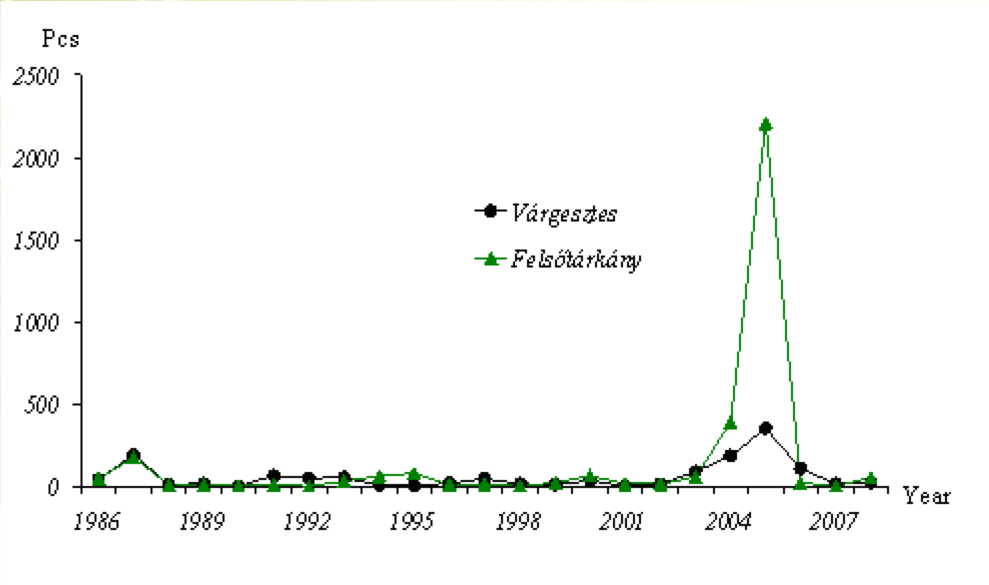
The collected insect material of traps was processed centrally in the Department of Zoology of the Hungarian Natural History Museum by its Identification Group. The scope of duty of the Group was the daily selection, complete and reliable identification and registration of all collected materials. The Plant Protection Identification Group also processed catches of forest traps until 1971 when identification of forest and agricultural light trap materials was separated locally. Experts of Forest Protective Monitoring-Forecasting Service in the Forest Research Institute processed the collections of the forest light trap network with the aid of outside professional and amateur entomologists. The complete Lepidoptera collection was processed again from the mid-1970s. From the collected insect material of traps a comparative collection of approximately 20 thousand specimens was compiled consisting more than 95% of macro-moths that can be found in Hungary.

One box from the comparative collection of macro-moth

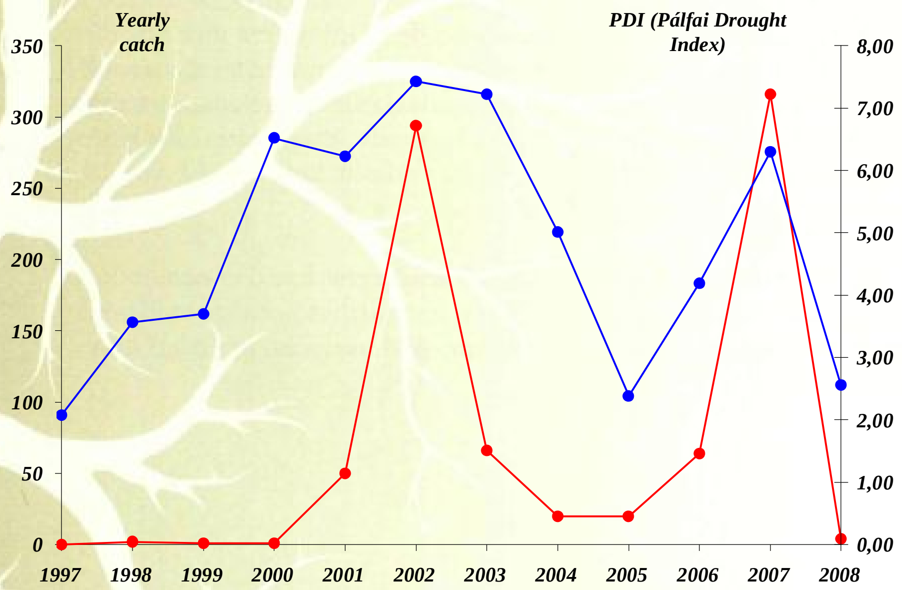
5.2.3. Objectives of forest light trapping

The use of different trapping methods has an important role in field samplings of insect populations and assemblages. Light trapping is one of the most frequent and most popular sampling methods. Hundreds of light traps are working around the world to forecast agricultural and forest pests. The possible uses of data on the identified species from these collections are wide ranging, and may serve forest protection, taxonomic, faunistic, zoogeographic, ecological and environmental studies.

Forest protection prognosis: Data may be used as part of forest protection prognosis since such network of light traps enables making synoptic monitoring of spatial and temporal dynamics of complete insect assemblages. Such a long-term operating survey system is fundamental for the study of insect gradation. This network has contributed to the current knowledge of the gradation of forest pests, such as *Lymantria dispar*, *Euproctis chrysorrhoea, Malacosoma neustria, Thaumetopoea processionea, Tortrix viridana*, *Erannis defoliaria, Agriopsis aurantiaria, Operophthera brumata, Colotois pennaria,* etc. The outbreaks of these important pests begged for countrywide forecasting of pests. The foundation and the long-term operation of the forecasting system, with great spatial scale and different temporal scales have ensured the prevention of insect damage at the national and regional level.



Annual Gypsy moth catches in two light traps (1986-2008)



Annual Thaumetopoea processionea catches in the light trap in Acsád and Pálfai Drought Index(1997-2008)

The network contributes to the detection of pests (e.g. *Helicoverpa armigera*), that recently have no harmful effects on forest condition but may cause damage to forests in the future and to the identification of newly appeared pests such as the voracious Asian gypsy moth *(Lymantria dispar)* that is similar to the European gypsy moth. Light traps can be used to detect the presence of gypsy moth by attracting and catching adult male and even female moths since Asian gypsy moth females are active fliers, unlike the flightless female European gypsy moths.

Faunistic: Light traps help to describe the moth fauna in Hungary, to obtain an estimate of different insect population sizes, and to discover several moth species new to the Hungarian fauna and new to science (e.g. *Epirranthis diversata, Gravitarmata margarotana).* Light trap is proved to be useful to find species e.g. *Rhyacia lucipeta, Arytrura musculus* that have not been caught for decades.

Taxonomy: the science of naming things aims the identifying, describing and naming things. From the macro-moth materials of the Forest Light Trap Network for instance the following species and subspecies were described: Brachionycha syriaca decipulae Kovács 1966, Boarmia umbellaria matrensis Vojnits 1970, Eupithecia catharinae Vojnits 1969, Oligia versicolor vojnitsii Kovács 1967, Lycia hirtaria pusztaer Vojnits 1971, Gnophos pullata kovácsi Vojnits 1967, Apamea sicula tallosi Kovács et Varga 1969.

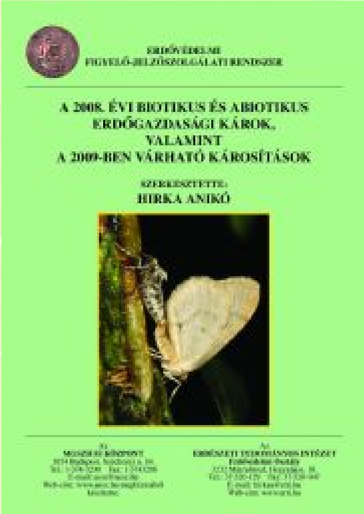
Ecology: Light trap catches are fundamental for phonological studies (life cycle events, dates of first occurrence of biological event in the annual cycle, such as the first flight and appearance, the dates of egg-laying, the timing of the development cycles, the time frame for any seasonal biological phenomena, the swarming of insects, the elevation and size of swarms, the physical conditions favourable for swarming; the swarming behaviour) and help to determine how life cycle events are influenced by seasonal and inter-annual variations of climate. This long-term monitoring system can be used for studying the impacts of global and regional environmental changes on living organisms such as forest pests. The several decade long data sets collected by the Hungarian light trap network can be used to monitor changes in insect populations.

The biological effects of climate change have an increasing importance. There are numerous predictions for expected influences of the increasing temperature ("global warming") on abundance, life cycle and phenology of insects, inter-specific relationship in food chains of insects, and geographical distribution of some pests.

The long-term data series of light trapping can also be implemented not only in the analysis of population dynamics but also in the description or characterisation of seasonal flight pattern of less abundant, rarer species.

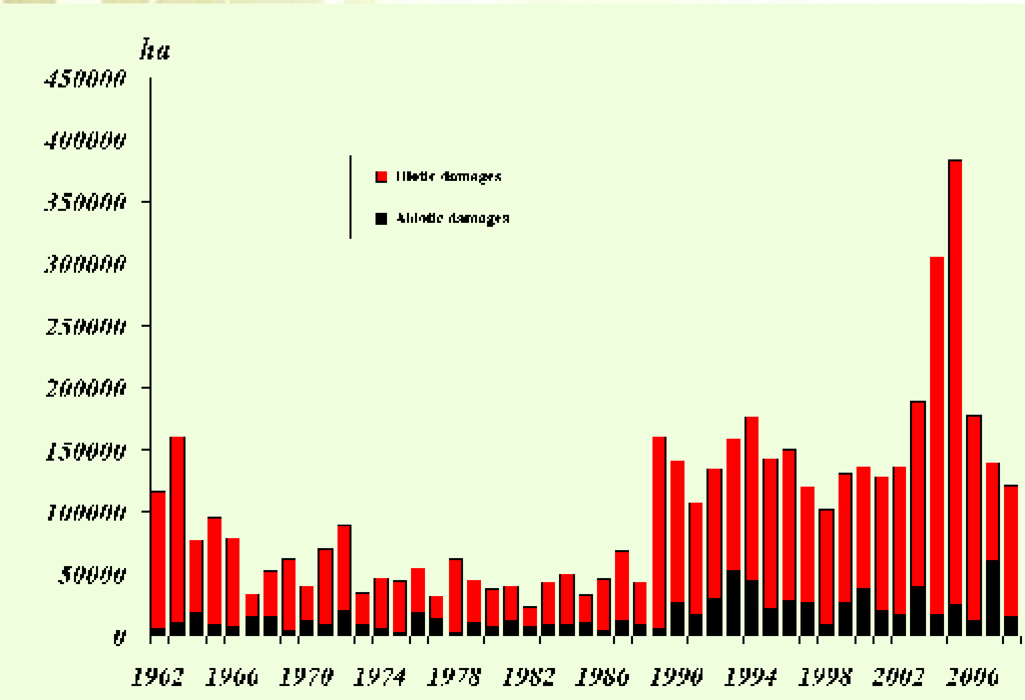
5.3. Forest Protection Prognosis

The Forest Protection Prognosis has been edited annually from data of the Forest Protection Monitoring-Monitoring System and has been published by the Unit of Forest Protection of the Forest Research Institute since 1962. The annual publication has been sent to forest mangers fulfilling their obligation to report on damages.



Forest Protection Prognosis

In the prognosis we can find the summery of damages occurred in the year in question, relevant meteorological data (in most cases explaining the rates of damages) and the damage types including regions effected by damages, short description of species causing damages, prognosis and recommendations on protection (how manage pest problems). New species causing damage are also described in the publication. At the end of the publication there is a photo guide to identify damages and damaging insects.



Biotic and abiotic damages (1962-2008)

Database processed from reports of forest managers is fundamental for studies and long-term forecasting. It became obvious that the increasing rate of abiotic and biotic damages in the last two decades can be explained by environmental factors (weather extremes). According to climate models more extreme weather events can be predicted. The forecasted weather phenomena that are at the extremes of the historical distribution, especially severe or unseasonal weather can cause more severe forest damages. According to the possible scenarios, the climate would become drier associated with more frequent droughty years in Hungary. Various hypotheses regarding direct and indirect effects of arid, warm climate on insects exit that may explain the insects' outbreaks.

6. BioSoil – Forest Focus demonstration project

6.1. Introduction - pilot-projects

In accordance with Article 6 of Regulation (EC) No 2152/2003 of the European Parliament and the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community (Forest Focus) for the realisation of the objective, the establishment of a Community scheme for broad-based, harmonised and comprehensive, long-term monitoring of the condition of forests to assess the requirements for and develop the monitoring of soils, carbon sequestration, climate change effects and biodiversity, as well as protective functions of forests could be carried out by means of studies, experiments, demonstration projects, testing on a pilot basis and establishment of new monitoring activities. The Commission could have, in cooperation with the Member States, developed the scheme, in particular to assess impacts of climate change on forests and other wooded land, including impacts on their biological diversity and their relationship with carbon sequestration and soil.

The BioSoil project, a demonstration project on forest soils and forest biodiversity that aimed to broaden the scope of previous forest monitoring activities (on atmospheric pollution and forest fires) to the fields of soil characteristics and biodiversity indicators was launched to perform survey on all Level I sites and some Level II sites. The scientific and technical aspects of sampling were developed by expert of EU Member States in cooperation with the European Commission Joint Research Centre.

The demonstration project comprises two main modules: Soil Module and Biodiversity Module. Both modules use a common site for sampling data, but sampling activities are separated. The locations of the sites make use of the existing network of sites for monitoring the forest environment under Forest Focus / ICP Forests.

In the following the two modules are reviewed separately.

6.2. BioSoil – Soil Module

6.2.1. Objective, sampling design

The purpose of the soil module of Biosoil is first of all the assessment of basic information on the chemical soil status and its change over time, and secondly the assessment of soil properties which determine the forest soil's sensitivity to air pollution. A third major objective of the survey is to allow **the evaluation of the forest soil condition across Europe**, **the understanding the role of forest soil in cause-effect relationships** and in ecosystem functions and services, in order **to draw conclusions at European level**.

Soil layers were sampled and analysed. Determination of soil characteristics and sampling were performed according to two classification systems.

Comparison at European level is based on WRB-classification (World Reference Base for Soil Resources). WRB became the official reference soil nomenclature and soil classification for European Commission and adopted by the International Union of Soil Sciences. One of the general principles on which the WRB is based is that the classification of soils is based on soil properties defined in terms of diagnostic horizons, properties and materials, which to the greatest extent possible should be measurable and observable in the field. The WRB is a comprehensive classification system that enables people to accommodate their national classification system. It comprises two tiers of categorical detail: the Reference Base, limited to the first level only and having **Reference Soil Groups** (RSGs); and the WRB Classification System, consisting of combinations of a set of prefix and suffix qualifiers that are uniquely defined and added to the name of the RSG, allowing very precise characterization and classification of individual soil profiles. (Tier 2 is the **combination of RSGs with qualifiers**, detailing the properties of the RSGs by adding a set of uniquely defined qualifiers.)

At the plot installation a detailed soil profile pit description complemented by sampling according to genetic horizons led to a detailed soil classification following the WRB.

6.2.2. Field sampling

Field sampling was carried out according to three aspects in order to implement the two types of classification.

According to the international requirement (BIOSOIL) disturbed soil samples are taken at five fixed depths (0-5 cm, 5-10 cm, 10-20 cm, 20-40 cm, 40-80 cm) and undisturbed soils are taken in dedicated cylinders with a volume of 100 cm^3 (repeated 3 times). The disturbed samples are taken to obtain data on soil physical and soil chemical parameters, the undisturbed samples are for the soil moisture measurements.

Cylinders with a volume of 100 cm3

Pedological characterization was accompanied by sampling of soil layers according to the national classification. The soil is sampled till the depth of 200 cm or till the depth of limiting indurated horizon (e.g. parent rock). Layers thicker than 50 cm were sampled separately even if they were homogenous. For every profile at least 4 samples were taken. Sampling was carried out according to the effective National Forest Management Planning Manual.

The organic layer is sampled with a frame of 30*30 cm according to the recommendations of BioSoil Manual.

The organic layer in aerated conditions may consist of one or more of the following organic subhorizons:

OL – horizon (Litter): this organic horizon is characterised by an accumulation of mainly leaves/needles, twigs and woody materials (including bark), etc. This sublayer is generally indicated as litter (decomposition state < 30%).

OF-horizon (fragmented and/or altered) is a zone immediately below the litter layer. This organic horizon is characterised by an accumulation of partly decomposed (i.e. fragmented, bleached, spotted) organic matter derived mainly from leaves/needles, twigs and woody materials. The material is sufficiently well preserved to permit identification as being of plant origin (no identification of plant species) (decomposition state 30-95%).

OH – horizon (humus, humification): characterised by an accumulation of dark, well-decomposed, amorphous organic matter (decomposition state > 95%).

Organic subhorizons are sampled separately only if they are thicker than 0,5 cm.

Average samples were made from soil samples that were taken from 3 depth layers (0-5 cm, 5-10 cm, 10-20 cm) in Vér-kind cylinders with a volume of 100 cm^3.

Vér-kind cylinder

6.2.3. Biosoil – Soil, laboratory analysis

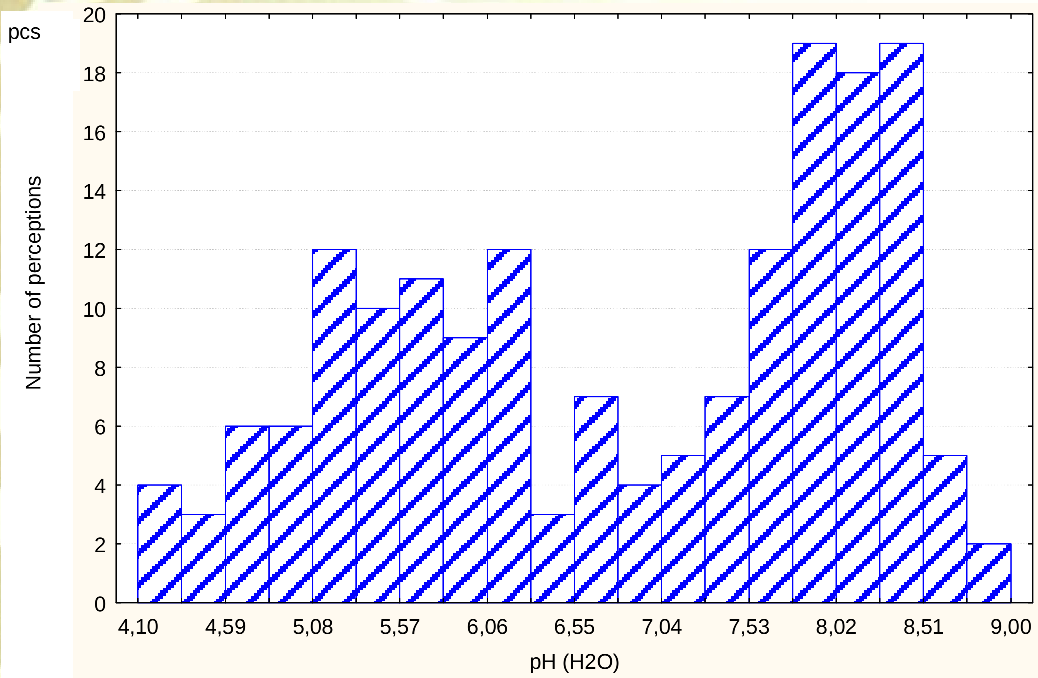
The laboratory analysis started in 2006 for the duration of 3 years (2006-2008) and was conducted by the Institute of Chemistry and Forest Sites, Faculty of Forestry, University of West Hungary. In order to provide a harmonised set of soil parameters, the laboratory has been participating in ICP-Forests „Soil Interlaboratory Test Programme" since 2004. Mineral and organic samples were analysed according to the given methodology.

Samples taken by different methods were analysed by different laboratory methods. Almost 800 disturbed and undisturbed samples were taken according to the BioSoil manual to determine physical characterization such as the mass of the organic layer and the particle size distribution (sand >63, silt 2-63, clay 2 µm). A The chemical and physical key soil parameters on samples taken at fixed depth were measured such as the pH ($CaCl_2$), total organic carbon, total nitrogen, carbonates, Aqua Regia extracted P, Ca, K, Mg, Mn, Cu, Pb, Cd, Zn, exchangeable cations (Ca, Mg, K, Na, Al, Fe, Mn), etc.

Layer samples separated by national methods were measured to determine soil physical characteristics (particle size distribution – clay, silt, fine and coarse sand, Arany-type water-saturation capacity), chemical characteristics ($pH_{(H2O)}$: $pH_{(KCl)}$, carbonic chalk, hydrolytic and exchangeable acidity), and available soil nutrients (humus, AL-soluble P, K, total nitrogen).

6.2.4. A Biosoil–Soil results

Field measurements and laboratory analyses resulted n a comprehensive database that are being evaluated at international level.
The following diagram illustrates soil sample distribution by pH in Hungary.



The aim of the evaluation is detailed below. There are questions to be answered related to the database such as whether the database can be used:

- to detect changes in soil by the two surveys and verify changes with statistical methods;
- to determine cause-effect relationships;
- to apply methodology of assessment all over Europe;
- to draw conclusions and determine trends at European level; and
- to build (develop and maintain) a soil information database at European level.

Further opportunities

Other surveys and measurements were conducted beside soil project (e.g. forest stand inventory) to allow further data comparisons. Soil Database can be updated and enriched with more exact site maps.

Since the aim of the database is to provide a harmonised set of soil parameters, covering Europe (the enlarged EU), to be used in modelling at regional, national, and/or continental levels, the database shall be extended to cover other countries. In addition to geographical extensions, the database shall experienced important changes that could include the introduction of a new extended list of parent materials. The database could be managed using associated relational databases.

6.3. Biosoil – Biodiversity Module

Many initiatives are currently taken to estimate the loss of biodiversity in Europe. Efforts to develop guidelines for assessing forest biodiversity have been under way for many years. Several processes like the MCPFE process (Vienna, 2003) and the Convention on Biological Diversity are presenting lists of indicators relevant to forest biodiversity. However, there is still a need to select and test simple and suitable indicators to measure and describe forest biodiversity at stand as well as at European level and there is still no large scale monitoring system of forest biodiversity in Europe.

The existing Level 1 survey of the monitoring programme represents an option for such a large scale monitoring system. The Level 1 survey is a systematic network based on a 16km x 16km transnational grid of sample plots and as such represents a statistically unbiased sampling tool for European forests and a unique opportunity to examine selected parameters of biological interest in forests at the European level.

6.3.1. Objectives of BioSoil Biodiversity

The overall objectives of the biodiversity component of BioSoil are to make an inventory of components of forest biodiversity such as forest structure and species diversity using the Level I systematic network.

The BioSoil project will provide data to support both international and national policy on forest biodiversity, by:

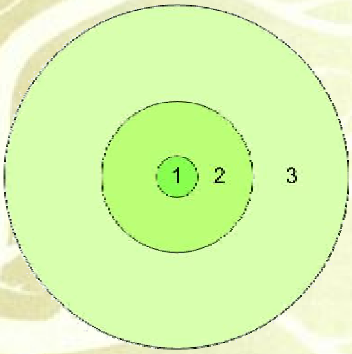
- Conducting a demonstration study to collect harmonised information relevant to forest biodiversity at the European level and demonstrate the use of the Level 1 network in this context;
- Presenting a European forest type classification of the Level 1 plots and provide a first attempt at habitat classification of the forests of Europe
- Testing selected, internationally recognised, robust and practical indicators of forest biodiversity on a large scale survey thereby to develop a practical methodology as a manual.
- Establishing an improved common baseline framework to integrate other information and ongoing projects (including the soil initiative of BioSoil) on forest biodiversity to achieve maximum added value;
- Designing a multi-scale hierarchical approach to quantify European forest biodiversity and monitor changes over time and space.

6.3.2. Methodology

The BioSoil initiative is a representative tool of European forests and to address other issues of relevance to European forestry such as forest biodiversity with the addition of a few assessment variables. The approach adopted is known as the stand structure approach, which assumes an increased potential for biological diversity with increasing complexity of the forest stand. This approach is complemented with the addition of biological data such as information on the ground vegetation community.

6.3.3. Data collection – sampling net and parameters

The existing Level 1 survey of the monitoring programme is a systematic network based on a 16km x 16km transnational grid of sample plots. The BioSoil initiative represents the opportunity to assess and demonstrate the efficacy of the Level 1 network, as a representative tool of European forests and to address other issues of relevance to European forestry such as forest biodiversity with the addition of a few assessment variables. Monitoring performed simultaneously on one of the four sub-points of FPN monitoring. The sub-point is selected centrally. The centre of the sample plot is the centre of the FPN sub-point.



Unit	Shape	Radius/ Area
Subplot (1)	circle	3,09 m (30 m^2)
Subplot (2)	circle	11,28 m (400 m^2)
Subplot (3)	circle	25,24 m (2000 m^2)

The basic BioSoil circular plot of 25.24 m radius consists of 3 subplots of different radii.

Overview of the BioSoil plot measurements:

<table>
<tr><th></th><th>Subplot 1</th><th>Subplot 2</th><th>Subplot 3</th></tr>
<tr><td>General plot description</td><td colspan="3">Yes</td></tr>
<tr><td>Forest type classification</td><td colspan="3">Yes</td></tr>
<tr><td>Diameter at breast height and species composition</td><td>$d_{1,3}$ > 0 cm</td><td>$d_{1,3}$ > 10 cm</td><td>$d_{1,3}$ > 50 cm</td></tr>
<tr><td>Top height and bottom of canopy layer</td><td colspan="3">5 trees selected from the dominant layer</td></tr>
<tr><td>Coarse woody debris, snags, and stumps</td><td>$d_{1,3}$ > 10 cm</td><td>$d_{1,3}$ > 10 cm</td><td>–</td></tr>
<tr><td>Canopy closure</td><td colspan="3">Yes</td></tr>
<tr><td>Tree layering</td><td colspan="3">Yes</td></tr>
<tr><td>Vascular plant species list (32x32 km grid points*)</td><td>Yes</td><td>Yes</td><td>–</td></tr>
</table>

** Designed from 16x16 km grid net by systematic selection*

The sampling approach of the biodiversity component of BioSoil includes additional surveys when compared to forest health surveys:

§ Forest type classification

Current forest type is determined by applying international classification.

§ Structural forest (forest stand structure) diversity

Parameters of forest stand: tree diameter and tree species composition; dominant layer, height of canopy bottom. Species composition (mixture rate) includes living and dead trees and excludes dead wood. The tree diameter and sometimes the decay state are recorded.

§ Coarse woody debris, snags, and stumps

Parameter includes all lying deadwood components with diameter greater than 10cm. For lying woody debris diameter, length and decay state are to be recorded.

§ Canopy closure and tree layering (number of tree layers)

Both parameters are included in the classical forest stand description and considered essential aspects.

§ Vascular plant species list

Species in the herbaceous layer were registered.

Data submission was performed according to the international requirements.

6.3.4. Data analysis

Since this is an international project, data analysis is conducted on international level. Although measurements were taken, observations were made using the sample plots and data were submitted the results are not available yet. Quality Assurance (QA) is essential in forest monitoring to promote, achieve and maintain adequate Data Quality (DQ). DQ results from a process in which each step of the investigation of concern is properly addressed, from the definition of the objectives to the comparability of the data in space and time, to data storage, processing and reporting. QA is a cross-cutting issue as it is of concern for all the investigations and for all the various steps within an investigation. Data validation/submission procedures are still under development, therefore results from surveys has been left to a later date.

Experience gained during monitoring can contribute to the improvement of the national system.

Data collected on 78 sample points (18,95ha) for Hungary are available.

Total number of trees	2495
Living tree	2435
Standing dead tree	57
Lying dead tree	3

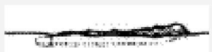
Coarse woody debris	30.43 m^3
Broadleaved tree species	19.60 m^3
Needle-leaved tree species	6.58 m^3
Unknown tree species	4.25 m^3

Tree sized tree species	36
Seedling sized tree species	15
Shrub layer species	14
Vascular plant species	162

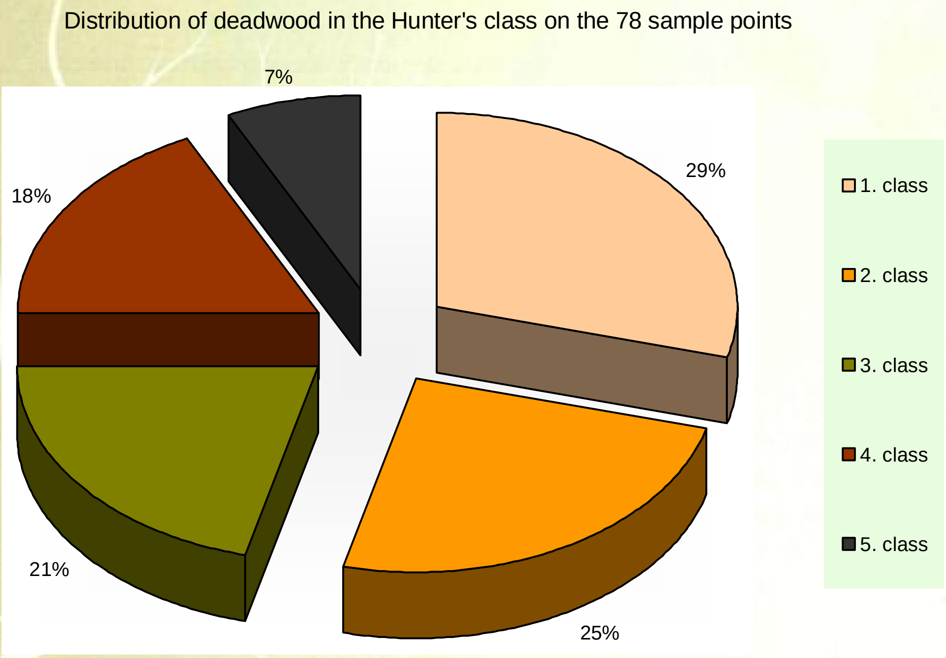
Among the 36 tree sized tree species there were ones such as Crack Willow (*Salix fragilis*) and Scots Elm (*Ulmus glabra*) –, that are not often registered as stand components since the rate of these tree species are below the 5% threshold level to be registered.

There are a wide variety of herbaceous perennials as well, such as Common Fleabane (*Pulicaria dysenterica*) or Columbine Meadow Rue (*Thalictrum aquilegifolium*).

The registration of coarse woody debris was the first in the history of the Hungarian forest monitoring. Registration was performed according to the different states of wood decomposition process by Hunter (1990).

Different states of wood decomposition process by Hunter				
1st phase	2nd phase	3rd phase	4th phase	5th phase
				

The diagram below illustrates the percentage distribution of dead wood among the different states of wood decomposition process.



Percentage distribution of dead wood in the 78 plots among the different states of wood decomposition process by Hunter

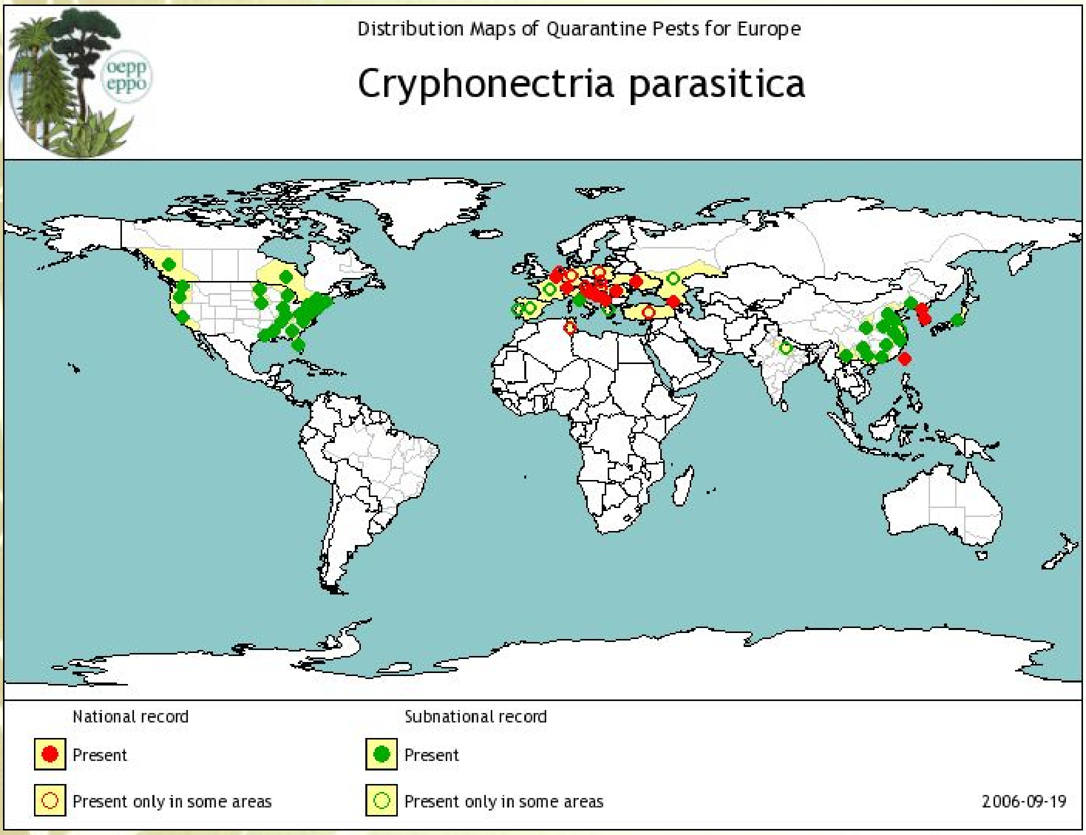
7. Chestnut blight

7.1. Occurrence and importance of the Chestnut blight

Distribution

The pathogenic fungus, Cryphonectria parasitica is the casual agent of chestnut blight, a devastating disease of sweet chestnut tree. The blight appears to have been introduced from either China or Japan. Japanese and some Chinese chestnut trees show some resistance to infection by Cryphonectria parasitica: they may be infected, but the fungus does not usually kill them. Introduced into North America from Asia before the turn of the 20th century, Cryphonectria parasitica spread throughout the natural range of the American chestnut tree, destroying hundreds of millions of mature trees within a 50-year period. In 1938, the pathogen was first discovered in Europe. Once again, the fungus spread very rapidly and most parts of Europe where chestnuts are cultivated were affected by the pathogen. The fungus was found on oak throughout its natural range in North-America and Europe too. The mass occurrence of the fungus on sessile oak trees in Hungary was recorded 1999.

Symptoms – cankers caused by Cryphonectria parasitica on sessile oak



Distribution and incidence of Cryphonectria parasitica

7.2. Symptoms on chestnut species

The fungus makes its entry at wounds and grows in and beneath the bark and this eventually kills the cambium all the way round the twig, branch or trunk. The first symptom is a small reddish area on the bark of a twig or branch. A sunken canker may form and the bark may split, and there may be a certain number of subsequent cracking of the outer bark. Orange-red stromata containing conidiomata break through the bark of the canker. Fan-shaped, buff-coloured mycelial wefts form in the inner bark and cambium. Reddish perithecia are produced in groups. Later, the dead bark falls off, the invaded tree dies. On branches and stems with thicker bark the discoloration is not visible, but the stromata and the mycelia under the bark are clear symptoms of the disease.

Symptoms of chestnut blight

Symptoms of chestnut blight

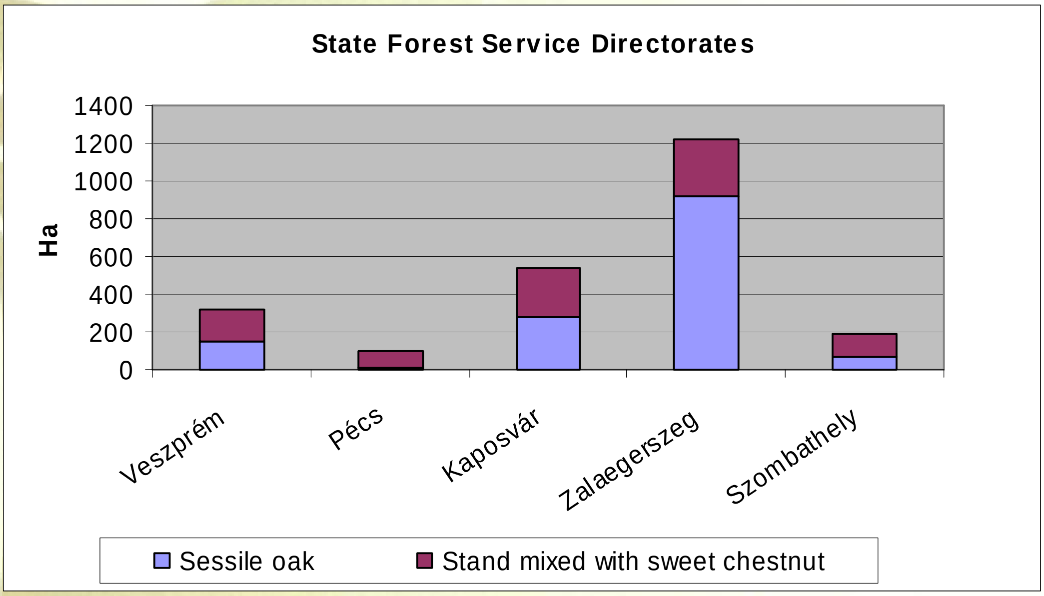
7.3. Symptoms on sessile oak

The pathogen causes mostly perennial cancer on sessile oak, causing distortions in the trunk and thicker branches. The orange-red stromatas can be well observed on the surface of the bark. Oak tree mortality rate is lower if compared to chestnut tree. Large extent of bark cancer and tree death is only observed on suppressed and weakened trees. Although the Cryphonectria parasitica does not directly kill the infected trees, the technical damage is significant due to the permanent distortion.


Stromatas on sessile oak trees

7.4. Distribution and incidence of the fungus on sessile oak

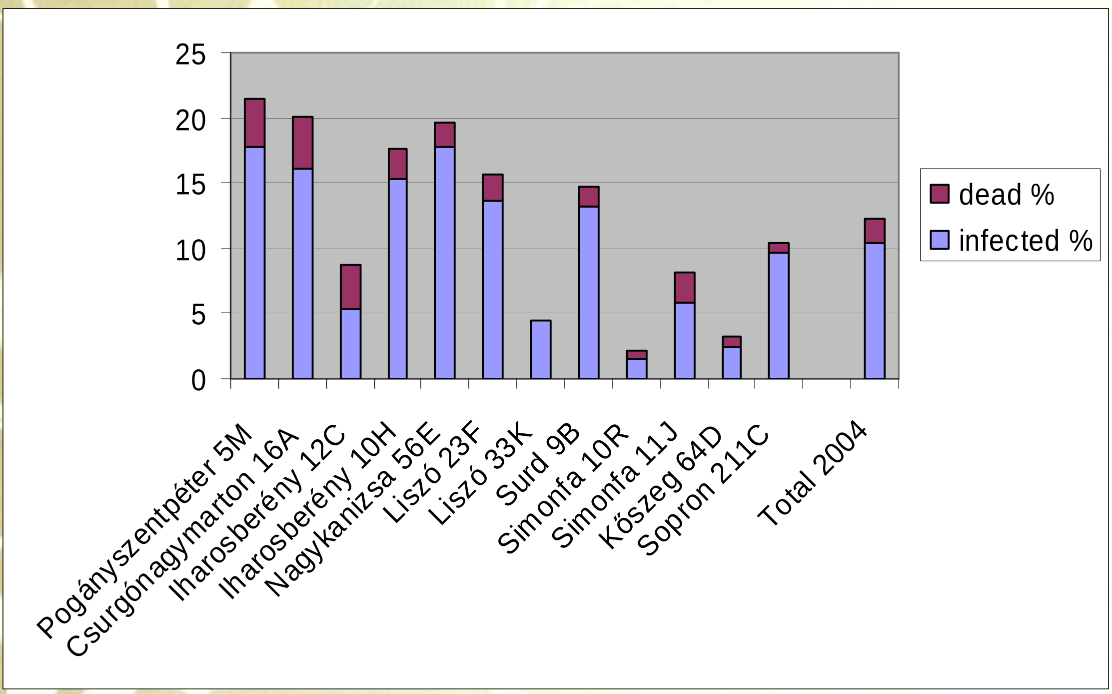
After the first detection of the pathogen on sessile oak the health condition of domestic oak trees with regard to the incidence of fungus were regularly evaluated. According to the preliminary surveys the 5-30 years old sessile oak stands were the most vulnerable. The aim of the evaluations that were carried out between 2003 and 2006 covering the sessile oak and the mixed chestnut and sessile oak stands was the detailed investigation to determine the distribution and incidence of C. parasitica, as well the extent and spread inside the infected stands.



Area of damaged sessile oak and chestnut mixed stands in the former SFS Directorates

The fungal infection occurred throughout the natural range of sessile oak within the following Directorates of the former State Forest Service: Veszprém, Pécs, Kaposvár, Szombathely and Zalaegerszeg. The diagram above illustrates the areal extent of infection reported in the Directorates.

The sessile oak mortality rate, the incidence of infection and the rate of spread were evaluated at selected plots in the infected stands. The distribution of infected and dead trees in the indicated forest sub-compartments in 2004 is indicated on the following diagram.



Rate of infected and dead trees in some forest sub-compartments

7.5. The life cycle of chestnut blight

Conidia and ascospores of Cryphonectria parasitica are spread in several ways, in wind and rain, but also transmitted by beetles and birds. The disease spread rapidly via nursery stock, nuts, and natural means. The transmission is significant with infected or contaminated seedlings and grafts. The rain washes down the spores from the crown to the direction of thicker branches and trunk. Spores are formed during the whole growing season and in frost-free periods of winter. The life cycle of chestnut blight begins when infection occurs through a wound in the bark. The fungus then begins to grow in the bark tissue, forming pale-coloured mycelial fans. The resulting canker expands when mycelial fans penetrate areas of wound periderm, becoming lethal when the vascular cambium is invaded. The stem or branch on which the lethal canker occurs dies, causing blighted branches, for which this disease is named. On the surface of these cankers, orange-yellow stromata break through the bark. Two structures can be found embedded in these stromata: perithecia and pycnidia. The perithecia contain ascospores, and the tendrils of pycnidia are made of conidia. Ascospores are primarily wind disseminated. Conidia, on the other hand, are commonly wash down trees or splash to nearby positions during rains. Although both types of spores can initiate infection, ascospores are more important in the chestnut blight life cycle. The Cryphonectria parasitica survives after it has killed the trees, produces mass of spores and can reinfect young sucker sprouts emerging from the root collar of infected and dying individuals. Thus, the bark of dead branches and trees are significant source of infection.

Sessile oak infection has similar symptoms with chestnut, but oak is more resistant and the cankers are more globosely. Therefore, trees may survive by forming callus around the infection to prevent the extension of necrosis. Since the pathogen is not destroyed, trees usually do not recover from the infection and perennial cancerous lesions are formed that thicken the trunks and branches and finally causing the distortion of the trunk.

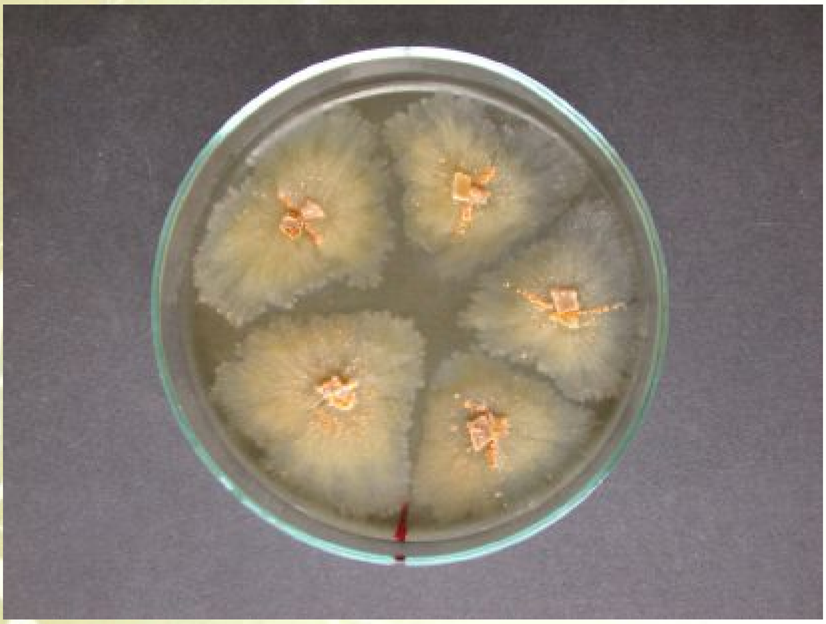
Orange-red stromata

Permanent distortion of trunk

7.6. Genetic variability of pathogens, vegetative compatibility

A number of vegetative compatibility (VC) is known about the pathogen. No hyphae is formed between the different types of VC strains (isolates), the colonies are separated. By current state of knowledge the compatibility is regulated by 7 pairs of alleles. These are combining during the generative propagation, thus the number of VC types increases in the area. The separation of VC types is possible in laboratory with compatibility tests. This knowledge is important for biological protection.

The national studies have shown that the number of VC types were 1-2 in sessile oak stands, in one case five different types of VC has been reported in a forest sub compartment.



Compatibility test: breeding pairs of virus strains. The lower left pairs are compatible, the other pairs are incompatible

7.7. Hypovirulence

Reduced infection capability strains can occur in Cryphonectria parasitica populations. Hypovirulence in Cryphonectria parasitica is defined as the inability of the fungus to cause the disease in its virulent form. The pathogenicity of the fungus is reduced and infection of the bark has less explicit symptoms. Hypovirulence is the basis for natural disease control. These were discovered when superficial, non lethal cancers appeared on chestnuts, causing spontaneous healing. On the trunk infected by such strains only superficial damage is visible, the cambium is not destroyed, the tree survives.

Hypovirulent (red-orange) Cryphonectria parasitica isolates

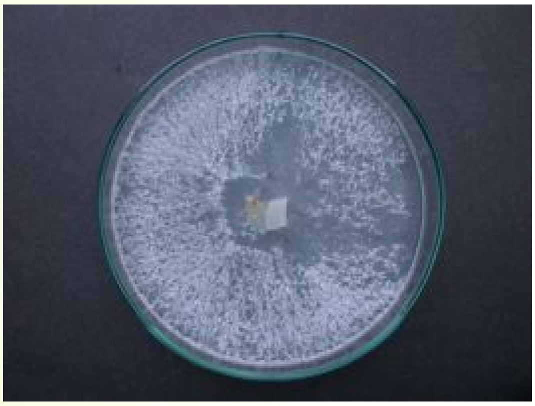
Distortion caused by hypovirulent strains

In virus culture the hypovirulent strains differ from the normal, virulent strains. While the virulent strain colonies are pigmented and formation of picnidium is observed, the colonies of hypovirulent strains are lightly pigmented or white, picnidium formation is not observed. In the cytoplasm of the hypovirulent strains double-stranded RNA (dsRNS) are located, which are actually viruses without protein-envelope (Cryphonectria hypovirus). The decrease in infectivity is related to their presence. The biological control of the virus is available with the use of hypovirulent strains.

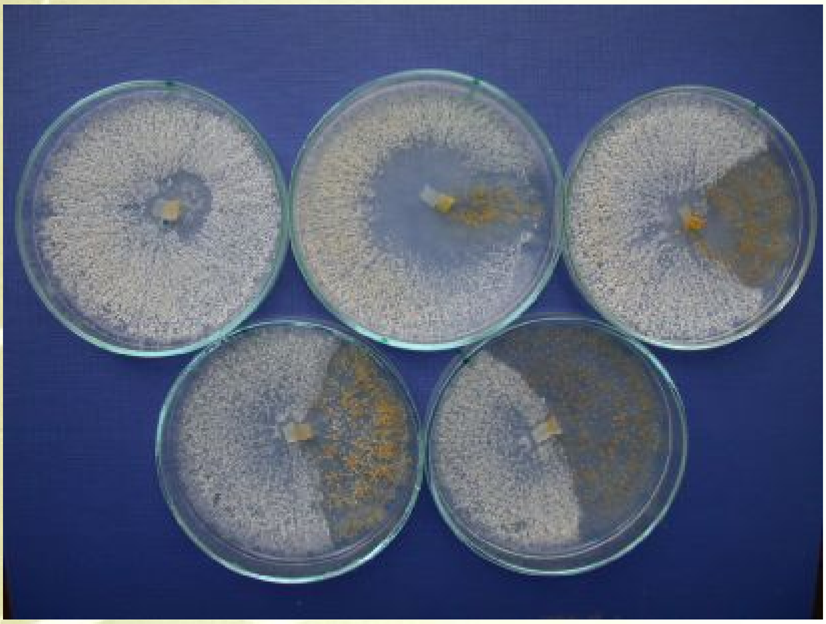
7.8. The principle of biological control

Laboratory tests have shown that the Cryphonectria hypovirus can be transmitted from hypovirulent strains to virulent strains, causing the latter become also hypovirulent. The condition of the transformation (conversion) is that the virulent and hypovirulent strains have to be compatible partners, which means that the hyphal bridges have to be formed between their colonies. In addition, the hypovirulent strain has to have good conversion capability which is the base for conversion.

Unsuccessful conversion: the strains Incompatible



Successful conversion: the strains are compatible



Different stages of conversion

7.9. Method and efficiency of the biological control, in case of chestnut

The first step in the biological control is to know the compatibility types of the agent in the area. This is followed by the selection of the common types of compatible hypovirulent strains, and conversion of the local virulent isolates in laboratory. The converted strains can be adapted for local biological control.

In a simpler case, where spontaneous healing occurs in the area, local hypovirulent strains are present. In this case they should be used. With the biological method the already infested chestnuts can be cured as well. The method is the ingestion of suitable (compatible) hypovirulent strains into the bark around the infested area. The strain causing necrosis is converted to the hypovirulent form with a hypovirulent strain. The tree can defend itself against converted strains that display decreased virulence and even heal.

Chestnut trees cured with biological method

7.10. Possibility of biological control in sessile oak

In inoculated young sessile oak trees the virulent strains caused bark necrosis, which subsequently and apparently healed, or developed into perennial cancer. In contrast, the hypovirulent strains caused only surface changes. In infected stands the treatment is time-consuming and difficult to implement, it is not cost-effective and the result is questioned, since the existing distortions do not disappear, so the mechanical damage persists.

In case of oaks it is appropriate to apply the preventive biological control. This means application and dissemination of hypovirulent populations. The applied hypovirulent strains can spread naturally and gradually transform the local virulent strains. If the population of hypovirulent strains become dominant compared to the virulent strains, the appearance of perennial cancer and tree mortality can be significantly reduced. The optimal method of application still needs to be developed.

Oak tree inoculated with hypovirulent strain

8. Gypsy moth and its damage

8.1. The Gypsy moth

8.1.1. Area of spread

Gypsy moth, *Lymantria dispar L.*, is one of Europe's, Asia's and North-America's most devastating forest pests. Gypsy moth is a native insect in Hungary where this defoliator is considered as the most important insect pest in the deciduous forest, but the exploits of the gypsy moth in 2005-2006 were recorded in beech stand in the Transdanubian and Northern Medium Mountains as well.

The species originally evolved in Europe and Asia and has existed there for thousands of years. In 1869, the gypsy moth was accidentally introduced near Boston, MA by E. Leopold Trouvelot. He had an amateur interest in entomology. His main interest was in identifying native silkworms that might be used for silk production. The exact reasons or circumstances are unknown, but in the late 1860's he returned from a trip to France with some gypsy moth egg masses. He was apparently culturing them on trees in back of his house when some of the larvae escaped. He understood the potential magnitude of this accident and notified local entomologists but no action was taken. About 10 years after this introduction, the first outbreaks began in his neighbourhood and in 1890 the State and Federal Government began their attempts to eradicate the gypsy moth. These attempts ultimately failed and since that time, the range of gypsy moth has continued to spread. Although Limantria dispar populations have declined significantly since 1990 when about 3 million ha were defoliated, this defoliator remains the most important insect pest in the deciduous forests of the eastern United States. In North America, the history of outbreaks is associated with the spread of Limantria dispar into new areas dominated by preferred species followed by the rapid expansion of populations in the absence of the gypsy moth's complex of natural enemies.

8.1.2. Description and biology

The taxonomic name of gypsy moth indicates the difference in the outer appearance of male and female moths. The Hungarian name is related to colour of the female's body hair. After mating, female moths lay an egg mass on the bark of a tree. The egg masses are buff coloured and are covered with a tan satin-like mass made from the female's body hair. Males can be distinguished by their brown coloration. Male moths vary in colour from light tan to dark brown. Front wings display black wavy bands and V-shaped markings. Hind wings are light brown trimmed with dark brown. Their wingspread is about 3-4 cm. Female moths are larger than males and predominantly white with a few faint, wavy brown or black bands and V-shaped markings on the front wings. Marginal dark spots are found on both front and hind wings. Female moths have a wingspread of 5-8 cm.

Male gypsy moth

Female gypsy moth laying eggs

Females lay egg masses ranging from 15-40mm in length which contain up to 1000 eggs. Each egg is about 1 mm in length. The egg masses are buff coloured and are covered with hair from the female moth's abdomen. Overwintering gypsy moth eggs hatch in May. The new, few mm, hairy, black caterpillars have a small knob on each side of the head and are first seen near clusters of eggs. It takes up to a month for all the eggs to hatch. For this reason, it is common to find caterpillars of various sizes at the same time. The larvae soon crawl into treetops, where they spin down on lines of silk to be blown to other places.

Feeding by the young caterpillars on underside of leaves usually goes unnoticed. By the time they are half grown, entire leaves are eaten. At this stage, the caterpillars are mostly black, except for orange markings down their backs. As caterpillars grow, bumps develop along their backs along with coarse, black hairs. Each of the 11 sections of a developed caterpillar will have two coloured spots, the first five pairs, blue, and the last six, red. Mature caterpillars can be as long as 4-7 cm.

5-7 cm long caterpillars are easily distinguished by five pairs of blue spots on the front body segments and six pairs of red spots on the back body segments

8.1.3. Life cycle

Gypsy moths are univoltine, meaning that one generation occurs annually. They overwinter in the egg stage (for 9-10 months) and usually hatch from late April, early May. Once larvae hatch, they stay together for couple days soon and crawl into treetops, where they spin down on lines of silk to be blown to other places.

Larval dispersal occurs by spring “ballooning”: the small, hairy larvae assisted by long silk threads produced by special glands on their heads are blown by wind to new locations. Ballooning adds a lot of km per year to new infestations. As a consequence of ballooning the damaged area is always bigger in extent than the egg infested area.

Larval dispersal by spring ballooning: the 1.2 cm larvae assisted by long silk threads are blown by wind to new locations

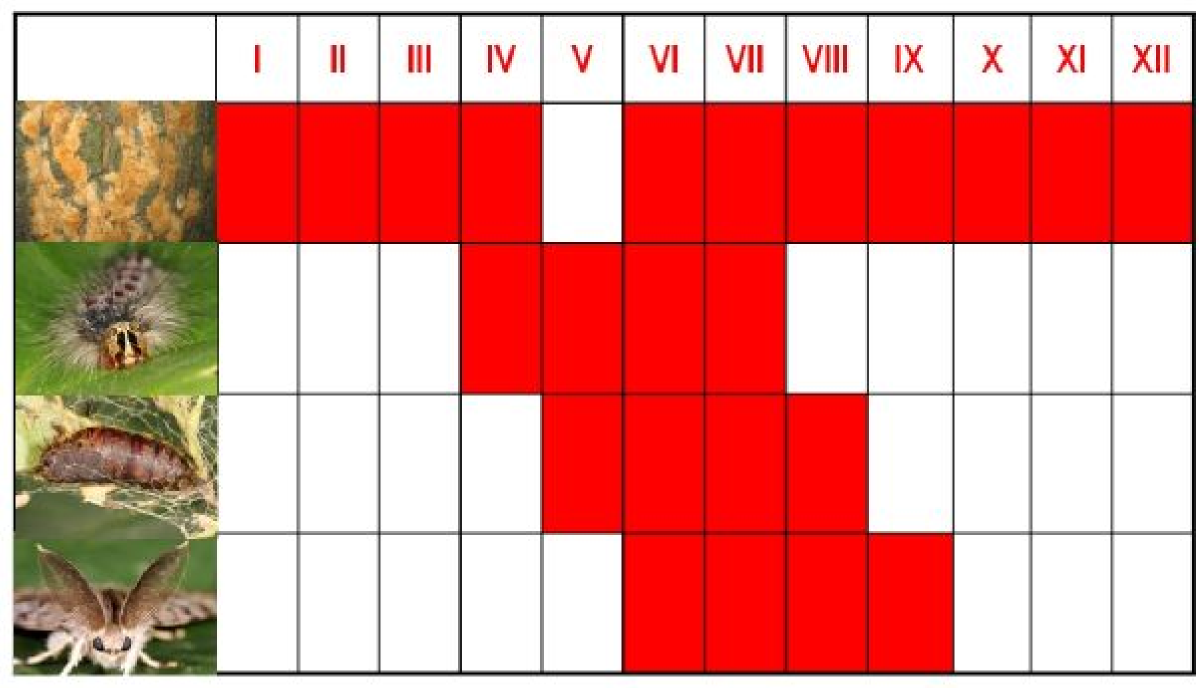
Once larvae hatch, they begin to eat foliage and grow fast. Caterpillars go through 4-5 growth stages. In the last larval instar they feed most heavily and on the widest range of vegetation. When population numbers are sparse, the movement of the larvae up and down the tree coincides with light intensity. When population numbers are dense, larvae feed continuously day and night until the foliage of the host tree is stripped. Then they crawl in search of new sources of food.

The larvae reach maturity between mid-June and early July. They enter the pupal stage. This is the stage during which larvae change into adults or moths. Pupation lasts from 3-4 weeks.

The male gypsy moth emerges first, flying in rapid zigzag patterns searching for females. When population numbers are sparse, pupation can take place under flaps of bark, in crevices, under branches, on the ground, and in other places where larvae rested. During periods when population numbers are dense, pupation is not restricted to locations where larvae rested. Pupation will take place in sheltered and non-sheltered locations, even exposed on the trunks of trees or on foliage of nonhost trees.

When heavy, egg-laden females emerge, they emit a chemical substance called a pheromone that attracts the males. Because they cannot fly, females do not move far from the pupation site to lay their few hundred eggs. The eggs are covered with a tan satin-like mass made from the female's body hair. Eggs are the stage in which the gypsy moth overwinters. Moths die soon after mating and egg laying.

Four to six weeks later, embryos develop into larvae. The larvae remain in the eggs during the winter. The eggs hatch the following spring.



Calendar: Life cycle of gypsy moth

8.1.4. Hosts

The poliphagous gypsy moth feeds on a wide range of tree genera and species. Gypsy moth larvae prefer hardwoods, but may feed on several hundred different species of trees and shrubs. During heavy infestations, competition for food will drive the caterpillar to attack almost any tree or shrub. In Hungary the gypsy moth has a preference for the leaves of deciduous hardwood trees such as Turkey oaks and pedunculate oaks. In Turkey oak and pedunculate oak stands gypsy moth grow faster and females lay more eggs.

During the outbreak in 2004-2006 beside the above mentioned preferred species total defoliation was recorded in sessile oak, hornbeam, beech, poplar, larch and spruce stands. Gypsy moths fed on apple, peach and cherry trees and even on walnut and vine leaves. Gypsy moths appear to dislike ashes, wild pears, wild privets, lilacs and yews. However, on the Balaton Highland defoliated agricultural lands next to forest areas were recorded.

8.1.5. Natural enemies of gypsy moth

Gypsy moth infestations alternate between years when trees experience little visible defoliation (gypsy moth population numbers are sparse) followed by 2 to 3 years when trees are visibly defoliated (gypsy moth population numbers are dense). Gypsy moth population numbers are dense after 8-10 year long dry-warm periods.

The natural enemy complex which consists of parasites, predators, and pathogens, does not normally control the gypsy moth in outbreak situations but does aid in maintaining certain sparse gypsy moth populations at low levels. It may also help to extend the period of years between outbreaks. Disease caused by a natural virus is the major factor in halting outbreaks, but unfortunately this occurs only after the full impact of gypsy moth defoliation has been realized.

Predation on gypsy moth life stages by birds generally appears low. The presence of extensive amounts of hair on body of the larva apparently makes them an undesirable bood item for birds with the exception of cuckoos. Many species of birds such as chickades and nuthatches that have been observed feeding on gypsy moth eggs and larvae are probably more important in sparse gypsy moth populations. Although predators destroy many life stages of the gypsy moth, their importance has probably been underestimated because they consume their prey quickly and leave few if any remains. Woodland mammals can consume large numbers of gypsy moth larvae and pupae in forested areas. Some mammals eat only one life stage of gypsy moth, while others may eat as many as three. Some mammalian predators of the gypsy moth include the mouse. The Calosoma sycophanta or forest caterpillar hunter is a large, bright green, metallic ground beetle. The species is a voracious consumer of gypsy moth caterpillars during both its larval stage and as an adult. Compsilura concinnata and Parasetigena agilis (Diptera: Tachinidae) are parasitic flies that attack gypsy moth larvae. Diseases caused by bacteria, fungi, or viruses contribute to the decline of gypsy moth populations, especially during periods when gypsy moth populations are dense and are stressed by lack of preferred foliage. Wilt disease caused by the areola-polyhedrosis virus (NPV) is specific to the gypsy moth and is the most devastating of the natural diseases. NPV causes a dramatic collapse of outbreak populations by killing both the larvae and pupae.

Predaceous immature ground beetle, the natural enemy of gypsy moth with the destroyed gypsy moth larvae.

8.2. Damage caused by gypsy moth

8.2.1. 1 Direct effects

Gypsy moth larvae can successfully feed on many species of plants that include trees and shrubs. Gypsy moth is native to Hungary, but we only talk about damage when gypsy moth densities reach high levels and large quantities of foliage are consumed and partial or total defoliation of the forest canopy may occur.

Depending on the degree of infestation, tree damage ranges from light to almost complete defoliation. One must see an episode of severe defoliation by the gypsy moth to appreciate fully the dramatic impact this insect can have. Most noticeable of course, is the great change in appearance of stands when winter appears to have arrived months ahead of time. Sometimes these visual effects are temporary, lasting but a few weeks until a new set of leaves is produced.

Winter scene in June

The effects of defoliation depend primarily on the amount of foliage that is removed, the condition of the tree at the time it is defoliated, the number of consecutive defoliations, available soil moisture, and the species of host. If less than 50 percent of their crown is defoliated, most hardwoods will experience only a slight reduction (or loss) in radial growth (approximately 40 to 60 percent). If more than 50 percent of their crown is defoliated, most hardwoods will refoliate or produce a second flush of foliage. Healthy trees can usually withstand one or two consecutive defoliations of greater than 50 percent. Trees that have been weakened by previous defoliation or been subjected to other stresses such as droughts are frequently killed after a single defoliation of more than 50 percent.

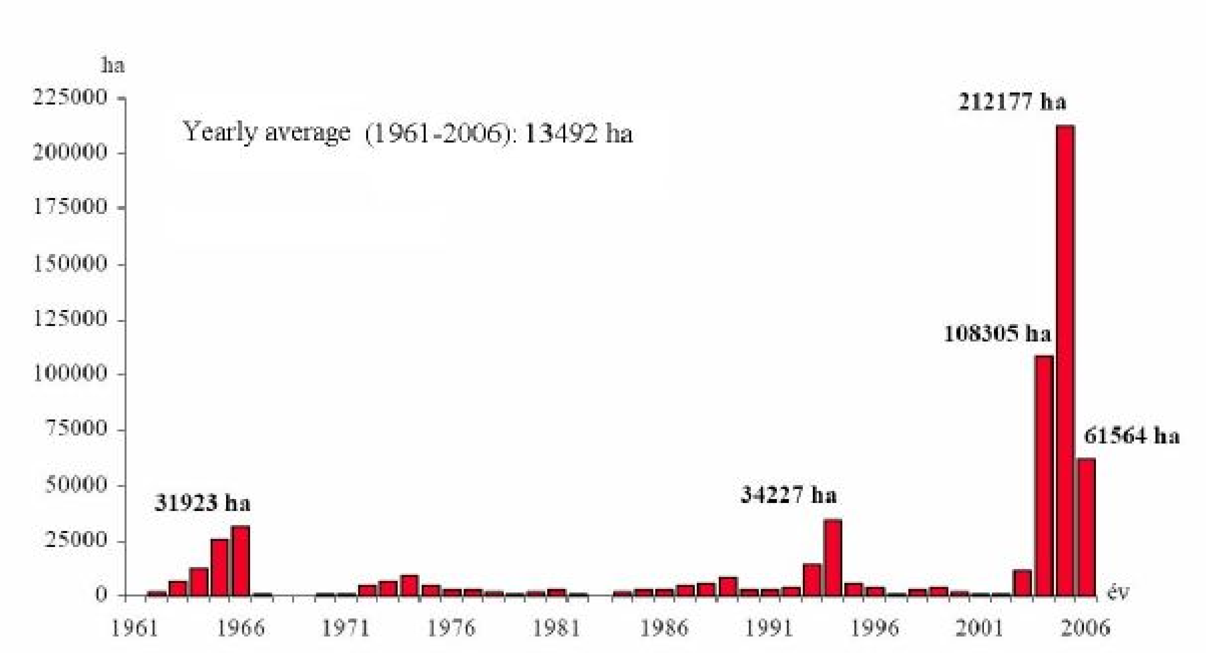
Trees use energy reserves during refoliation and are eventually weakened. Weakened trees exhibit symptoms such as dying back of twigs and branches in the upper crown and sprouting of old buds on the trunk and larger branches. Trees weakened by consecutive defoliations are also vulnerable to attack by disease organisms and other insects.

The effects of gypsy moth defoliation are more severe in Southern and South-Eastern Europe due to favourable climatic conditions and large areal extent of forest stands of preferred tree species. The exploits of the gypsy moth in Hungary are well known and have been well documented in the forestry literature. The extent of outbreaks has been registered since the establishment of Forest Protection Measuring and Monitoring System (FPMMS) in 1960.

Data on damages are derived not only from FPMMS but from Forest Monitoring and Observation System (FMOS) and surveys on sub-compartment level conducted by Directorates of the State Forest Service.

The outbreak started in Turkey oak and beech stands in Balaton Highlands and Southern-Bakony in 2004, and in 2005 it extended its range to the Northern Medium Mountains (Northern Hills), Somogy and Baranya Counties in 2005 when more thousands ha were damaged. In 2006 the insect spread to areas where the Eger, Budapest and Pécs Directorates of the State Forest Service are competent.

In 2004, 2005 and 2006 the gypsy moth defoliated 108.305 ha, 212.177 ha and 61.564 ha forested areas, respectively.



Annual defoliation caused by gypsy moth in Hungary, 1961-2006.

8.2.2. Tree condition and mortality causing organisms

Whether or not a tree succumbs of defoliation by the gypsy moth depends on three main factors: Tree condition, the number and severity of prior defoliations and the presence of organisms that attack and kill stressed trees.

Trees weakened by construction (by being wounded, by water being altered, or by sudden exposure to drying winds or bright, hot sun) or by other stress agents such as too little or too much water, frosts, lead diseases, or herbicides are likely to suffer more drastically from gypsy moth defoliation than healthy, nonstressed trees. But even healthy trees can suffer from defoliation if enough of their leaves are removed in successive years.

The final blow to most defoliated trees is dealt by opportunistic organisms that can successfully attack and kill trees stressed by defoliation. One of these organisms that can invade trees weakened by defoliation is the wood-boring beech splendour beetle (*Agrilus viridis*) according to the observations made by Győrfi (1941) causing the death of trees. During the outbreak in 2004-2005 in Balaton Highlands and Southern-Bakony the attack of beech splendour beetle was reported in Zala County that caused the death of oak trees. The attack of beech splendour beetle didn’t extend to the neighbouring beech stands in the Bakony, but caused tree death in pedunculate oak stands. There were trees that refoliated or produced a second flush of foliage by midsummer. Beech trees seemed to survive, but in the end were disappointing to grow because of devastation caused by oak powdery mildew disease. Powdery mildew, caused by the fungus Erysiphe cichoracearum, covered the leaves with white fungal growth and weakened affected trees. The powdery fungal growth on the shoots was fatal and led to the death of trees. After the heavy infestation of *Lymantria dispar L*. in 1994 in Devecser 300ha and in 2006 in the Bakonybél-Zirc region 150ha 80-90 year old beech trees had to be felled.

8.3. Control

8.3.1. Infestation survey

Gypsy moth eggs are laid in clusters called egg masses. The number and the average size of egg masses indicate the severity of damage that can be expected next year. To predict next year's potential level of defoliation during the FPN surveys the level of infestation is determined by estimating the number of egg masses found in each of the sampling plots. The level of infestation ranging from 0 to 9 is recorded in the database. In order to determine action threshold and decide on the necessity action that must be taken more detailed measurements are necessary. Survey results of the FPN are intended to inform the Forestry Authority determine if any further detailed monitoring need to be conducted on sites.

Severe egg mass infestation in the Southern-Bakony

During the detailed survey the following categories are used:

- Weak infestation if the number of egg masses is less than 500 per 0,1ha,
- Medium infestation if the number of egg masses is 500-1000 per 0,1ha,
- Strong infestation if the number of egg masses is more than 1000 per 0,1ha.

Practical experience shows that both medium and strong infestation results in complete defoliation. While medium infestation allows the completion of gypsy moth life cycle (that is the gypsy moth can pass through the egg, larva and pupa stage, strong infestation cause the death of gypsy moth in large number (before the complete developments of larvae) due to lack of new resources of food causing the collapse of gypsy moth outbreak in the following year.

Gypsy moth larvae emerging from egg masses

8.3.2. Managing the Gypsy Moth

Action must be taken immediately if mass gypsy moth infestation is noticed. For large tracts of forest land that is severely infested with gypsy moths, chemical control is not considered necessary, the only proper solution. Forest stands near-natural state and rich in tree species might be capable to reduce or eliminate gypsy moth populations, in which natural enemies play an important role. Control might be inevitable due to economic, forest protection and human health considerations.

Economic reasons might emerge in nurseries, young stands and naturally regenerating stands to protect nut crops. Activities related to economy based protection are part of the regular forest management. Forest protection based control is essential when gypsy moth population numbers are dense and trees that have been weakened by previous *Lymantria dispar L.* infestation and have been subjected to other stresses may be killed.

Hairs that coat the egg masses can cause allergic reactions, therefore The Gypsy moth may also cause a minor human health hazard because some individuals are allergic to the hairs shed by the caterpillars. This can be a human health reason for eliminating the gypsy moth in areas next to forests and where health, social and recreational institutions are located in forests.

Activities to prevent accumulating damage and those related to economy based protection are not part of the regular forest management.

8.3.3. Control initiatives

After the regular gypsy moth monitoring to count the number of egg masses in affected areas and on the basis of the above mentioned economic forest protection and human health considerations, the Forestry Authority can make initiatives to control gypsy moths that is not part of the regular forest management. Forest managers decide on protective actions related to economic consideration. When aerial application of pesticides is planned to be used the plant, environmental protection authority and the local government (authority) must be notified in order to obtain their approval.

In case of aerial application of pesticides a map on forest compartment level with aerial routs has to be generated from National Forest Stand Database with GIS. In the outbreak of gypsy moth in 2004-2006 the work of the National Gypsy Moth Expert Board and the data from the State Forest Service contributed to the efficient and cost effective implementation of preventive measures and they succeeded in ensuring availability and efficient utilization of adequate financial resources.

8.3.4. Control

For a small infestation, physical controls are recommended. In parks, orchards and lines of trees the destruction of egg masses is a tactic directed against the gypsy moth. However, physical removal of eggs is not feasible for larger area of infestation. In forest lands the use of pesticides against the gypsy moth is necessary. While for nurseries and forestations ground application, for large tracts of forest land aerial application of pesticides are used.

While most pesticides registered for caterpillar control will kill the gypsy moth, there are also concerns about the effects of these pesticide sprays on the environment as well as the human residents.

While the actual risk from registered pesticides is usually misunderstood and overemphasized, the fact that most people prefer to not come into contact with pesticides is understandable. So, how can people avoid coming into contact with synthetic pesticides, yet control the gypsy moth? One answer is to use products derived from a naturally occurring, soil dwelling bacterium, called *Bacillus thuringiensis* or BT for short.

The actual mode of action of BT is simple. The toxic crystal Bt protein is only effective when eaten by insects with a specific (usually alkaline) gut pH and the specific gut membrane structures required to bind the toxin. Not only must the insect have the correct physiology and be at a susceptible stage of development, but the bacterium must be eaten in sufficient quantity. When ingested by a susceptible insect, the protein toxin damages the gut lining, leading to gut paralysis. Affected insects stop feeding and die from the combined effects of starvation and tissue damage. Bt spores do not usually spread to other insects or cause disease outbreaks on their own as occurs with many pathogens.

The interesting thing about BT, is that only certain insects digest and are affected by the protein toxins. In most insects, as well as people, birds, fish, and other animals, the BT proteins have virtually no measurable effect.

Insecticides made from BT and its toxins are usually called microbial or biological insecticides. In general, BT and its toxins are destroyed within three to five days by sunlight and other microbes. Caterpillars killed by BT stop feeding, drop to the ground, and decay harmlessly. The BT applied in a spray does not multiply or accumulate in the environment.

Because of the way that caterpillars grow, only the young caterpillars have gut linings thin enough for the BT toxin to punch holes in it. For gypsy moth, once the larvae have gotten larger, they are rather difficult to kill with BT. Therefore, the best time to apply BT is after all the eggs have hatched and while the caterpillars are no larger than third instars. The third instar is the caterpillar stage that has molted two times after hatching.

Successful use of Bt formulations requires application to the correct target species at a susceptible stage of development, in the right concentration and at the correct temperature (warm enough for the insects to be actively feeding). Determining when most of the pest population is at a susceptible stage is key to optimizing the use of this microbial insecticide.

Compound collectively known as insect growth regulators are recognized as important insecticides. These compounds include chitin synthesis inhibitors. The most widely studied chitin synthesis inhibitor is diflubenzuron, also known as dimilin. Chitin is the major component of the tough outer covering, or cuticle, of insects. As insects develop from immature larvae to adults, thex undergo several molts, during which new cuticles are formed and old ones are shed. Diflubenzuron prevents successful development by inhibiting chitin synthesis, the finalenzyme in the pathway by which chitin is synthesized from glucose. Diflubenzuron is highly effective against larval stages of many species of nuisance insects, although affected larvae do not die until they molt (it could be 5-6 days). Chitin synthesis inhibitors, however, are not specific to insect pests. Theoritically, the inhibitors could also cause declines in the population of other species, but this might not necessarily occure in practice. Concerns about effects on other nontarget organisms have limited their use.

In 2005 success was achieved on sprayed pedunculate oak stands in Bakony. These trees were protected by spraving them when the buds began to break..

8.3.5. Communication

As mentioned above larval dispersal occurs by spring “ballooning” when the small, hairy larvae assisted by long silk threads produced by special glands on their heads are blown by wind to new locations. As a consequence of ballooning the outbreak of gypsy moths is not only a problem of foresters.

Silk spun by 1-2 cm larvae acts as a parasail, carrying the young larvae to new, uninfested trees

In order to prevent agricultural lands from being defoliated by an outbreak of gypsy moths damage and to avoid extreme reaction from society the efficient communication is inevitable. Efficient communication requires a message in plain language, honesty and adequate timing. If the predicted next year's potential level of defoliation is high the public shall be informed on the possible outbreak. It has to be explained that the outbreak is not the consequence of the improper forest management. The gypsy moth periodically becomes a serious pest of woodland and shade trees. Instructional publications that emphasize background instructional concepts on the history of the gypsy moth, the life cycle, impacts of defoliation, conditions that lead to to high levels of mortality following outbreaks of the pest and information on what can be done to reduce the spread of this pest (silvicultural prescription to minimize losses).

The reaction to gypsy moth invasions and tree defoliation ranges from complete horror to a total lack of interest. However, almost everyone has some level of concern when gypsy moth caterpillars cause noticeable defoliation of trees, drop their frass on everything under the trees, or when the hairy caterpillars begin to crawl over everything in sight. At this point, people and media demand immediately the elimination of these caterpillars from their daily routines. Here comes the communicator to stop yellow journalism and inform the public on the possibly approaching end of the outbreak.

9. Habitat change due to stock of game (VÉV)

9.1. Objectives and start of the monitoring

Data generated from the forest management database do not reveal wholly and completely the changes in the relationship between forest and wildlife. Processes that have harmful effects not only on the state of forest stands and the reforestation potential, but also on the economic indicators of forest management remain hidden. Interaction between wildlife and habitat was known before 2001, but without a uniform approach to specific, reproducible research to tie specific instructions to data analysis and experimental data so that the cause-and-effect relationship between habitat changes and stock of game can be better understood and assessed.

For the above reason the former State Forest Service made a proposal for the Forestry Office of the Ministry of Agriculture to establish a national-scale network in the framework of the existing Forest Protection Measuring and Monitoring System. The Office adopted the proposal and ensured the necessary conditions from 2001 to carry out measurements.

The main principles of the establishment of network and plot design were as follows:

- the assessment of the most important stands of young and regenerating native trees (beech, hornbeam oak, sessile oak, pedunculate oak and turkey oak);
- the assessment of regeneration (primarily natural regeneration and secondarily on artificial regenerations);
- the nationwide coverage, taking into account the spatial distribution of forest stands and the habitat characteristics;
- the sampling plot is to be established on habitat where the forest stand has a high predisposition to game damage (thus plot couldn't be established on areas protected with fencing or in forest in close proximity to populated areas).

Further principles related to the design and operation of the system:

- the application of the method of control fences, when the state of forest inside and outside the fence is evaluated;
- the assessment is carried out according to a nationally uniform methodology and by trained professionals;
- the survey period shall last for at least 10 years.

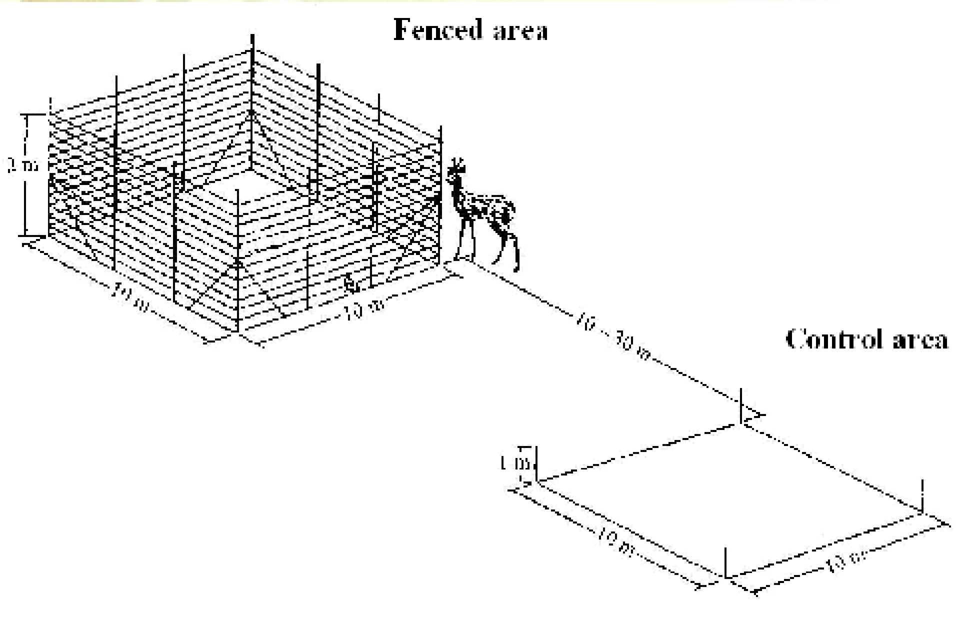
The system is designed to apply one of the methods of monitoring the activity of game, **to examine the** browsing and peeling **impact of ungulates on forest vegetation** (the method of control fences), **especially the impact on natural forest stands and their growth**. Furthermore Under the same habitat conditions the development of forest vegetation cover inside and outside of the fence is evaluated. **The assessment aims to find out whether a systematic difference can be detected in the development of forest vegetation cover inside and outside the fence.**

9.2. Methodology

The field monitoring started in 2002 on about 300 sample points, and, including 2008, it has been carried out five times so far.

At the start of the monitoring, similarly to the international method applied in several countries, in order to initiate an investigation into the impact of browsing and peeling on tree species, a 10 x 10m exclosure, along with a matched control in terms of habitat, climatic and forest stand conditions, was constructed by mutual agreement with the forest manager. Thus, the two plots established next to each other differed only in that one was fenced, while the other wasn't, thus ensuring the possibility of a comparative study.

The basic requirement to carry out a comparative study and not affect assessment validity is that the nursing and regeneration works to be conducted are the same on the established plots (fenced and control areas). At the beginning of the survey natural stands under regeneration were selected to ensure that the stands are or soon will be in seedling stage.



Area and location of the VÉV sample plots

As already mentioned, the surveys were carried out on nearly 300 sample points annually. The set of sample points, however, varied a little over the years due to changes in the plot condition. Sample plots which did not meet the requirement of selection criteria were not considered.. In 2002 the assessment started with 299 sample points, in 2008 there were only 284 points in the sample. It was possible to relocate plots or to establish new ones that meet the selection criteria in each year with the exception of the year 2008.

When the system was launched the developed field protocol was already available to provide (the achievement of) consistent methodology. Until 2006 the surveys were implemented according to the same methodology. From 2008 Due to significant increase in height and canopy closure recorded in stands in seedling ages, in parallel with the formerly used methodology the so-called "estimate methodology" was developed and introduced in 2008.

Despite changes in forest condition the newly developed methodology was designed to ensure efficient assessments.

The differences between the two methodologies will be discussed later.

At the design of the new – estimate – method it was important that the data obtained by a different method can be evaluated in an integrated system. The method to be applied is chosen by the surveyor according to the field protocol manual and the stand characteristics. The use of the estimate method is not binding, but if the average height of seedlings is above 1m, the surveyor can decide to do the assessment according to the new method. Further fundamental difference between the two methods is that while under the normal methodology the number of seedlings determines whether the survey is to be carried out on the total area or just on part of it, the new method requires the assessment of the total 10 x 10m area.

9.2.1. The normal methodology

The exact implementation of the recordings – **with the exception of artificial regeneration where the lines are clearly visible** – was ensure by the division of sampling areas into smaller square units, the so called plots (2 x 2m **quadrants**). The division of sampling area has threefold aims:

- it helps to accurately count seedlings and promotes visibility when the total area is assessed;
- it designates the sub-areas to be included in the assessment when the number of seedlings are high;
- it helps to estimate the canopy cover more accurately.

The total 10m x 10m area is divided into 25 2mx2m quadrants and metal stakes are emplaced to guide location of the quadrant corners. Thus before the annual field assessment the quadrants can be constructed by looping a string around the stakes to mark off the boundaries of the quadrant.

In order to optimize the loss off time and the expected accuracy of data the included plots are decided with a simple method. This depends on the average number of seedlings on a quadrant. The full number of seedlings is independent of tree species. All seedlings are taken into account even if the tree species are belonging to the target stand or the main tree species are present in small numbers. The number of included quadrants in the fenced and the control areas are determined by the current number of seedlings.

The number of quadrants in the fenced and the control areas are determined by the current number of seedlings within the quadrants.

Estimated average number of seedlings (Nr./ $4m^2$)	Included quadrant number (Nr.)
8	25
8,1-16	13
16,1-32	6
32,1-60	3
Over 60	2
Over 100	1

Number of quadrants to be assessed according to the estimated average number of seedlings

The number of quadrants to be assessed is determined separately for fenced and control areas; hence the number of quadrants may vary. This method allows the assessment of 100 to 200 seedlings even in regenerating forests that have high number of seedlings. The parameters – dimensions, damages – are assessed on individual level.

9.2.2. The estimate method

The sample area is divided into 4 equal, $25m^2$ squares. Estimation of parameters relating to seedlings and forest stands for assessment is carried out according to the estimation method that ensures the continuity of surveys and data evaluation even if the normal method was applied before.

Name of parameter	Recording of the parameter, traditional methodology	Recording of parameter, estimate methodology
Determining the area to be included	Number of seedlings in the quadrants	Total area (4 squares)
Height of the trees	Measurement of each tree	Estimation of each tree species
Canopy cover of the potential stand	Intercept method on each tree species	Estimation of each tree species
Damage assessment	Visual assessment of each tree	Estimation of each tree species

During the assessment the following plot related data are to be recorded:

- sampling plot identification data;
- general information;
- stand parameters effecting regeneration in fenced and control areas.

Other variables to be measured:

- height and cover of herbaceous layer;
- canopy cover of other tree species and shrubs;
- relative height of shrubs by species and browsing damage;
- canopy closure of target stand;
- seedlings appearing in large numbers;
- height, cover, mixture rate, number and damage of seedlings.

The VÉV examines the following damages:
- summertime browsing ;
- shoot tip browsing;
- cumulative damage caused by big game;
- damage caused by insects;
- fungal damage;
- trampling, breakage;
- bark peeling, bark rubbing;
- desiccation;
- water;
- competition with other plants;
- peeling;

- cutting back;
- other damages.

9.3. Data evaluation

9.3.1. Data evaluation process, methodology

For assessments a Forest Inventory Data Record Sheet is used, separately for fenced and control sites. After the field survey data input is inserted into a digital database. Before data processing the up-loaded data are screened carefully to ensure the quality of information being gathered meets the requirements to allow for a successful survey.

During the development of the new method it has been emphasized that data whatever data collection method is used can be displayed, interpreted and statistically analyzed together. Although the data cannot be analyzed in parallel, the evaluated data can be compared to each other and the conclusions have the same significance.

The difference between the two methodologies was resolved by separate and combined statistical tests and analyses. As a result, the impact of game damage on regenerating forest (of different height) can be measured.

Severely damaged seedling

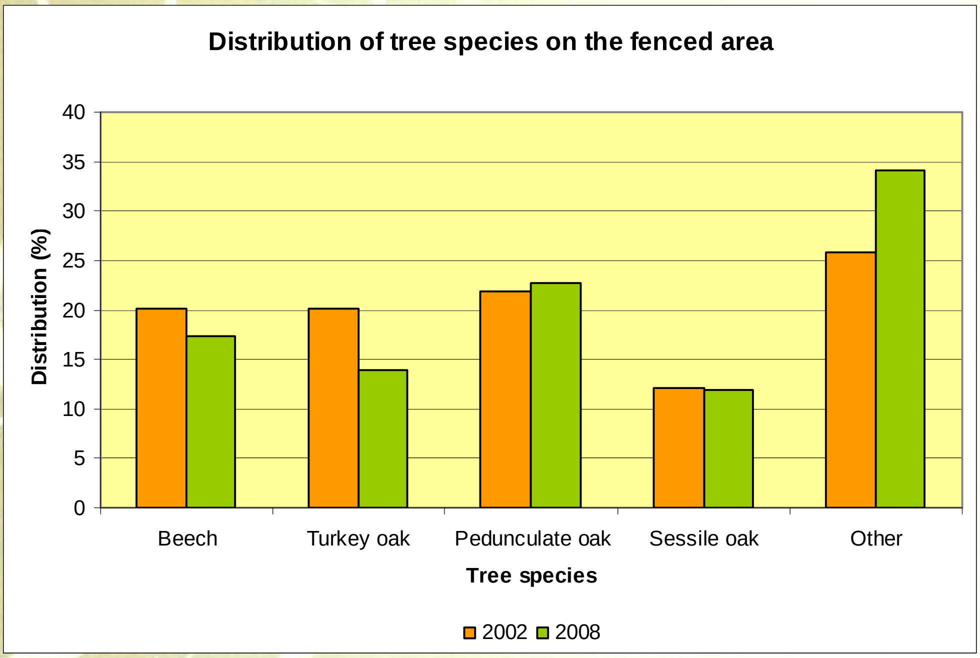
9.3.2. Number of assessed sampling points

It can be stated that over the total surveying period the number of sampling points was almost 300 due to the continuous replacement of sampling points not meeting the requirement of selection criteria. Data collected from all sampling points were evaluated.

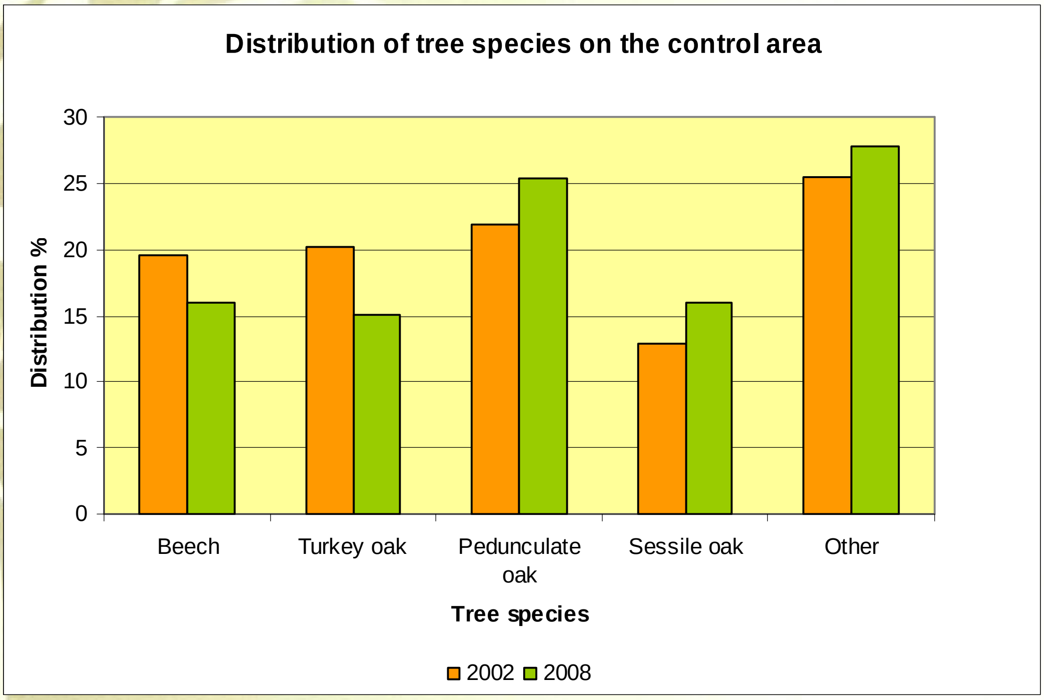
9.3.3. Distribution of tree species in fenced and unfenced control areas

When the monitoring system was set up in 2002 sampling points were selected in forests of native species that have regenerated naturally or in forest stands that were established artificially. These are typically forest stands with beech, turkey oak, pedunculate oak and sessile oak.

Forest cover development in the sampling areas over the so far 7 year survey period is reflected in data related to the changed tree species distribution both in fenced and unfenced control areas. On fenced areas the rate of other tree species increased and that of main tree species decreased. On fenced areas (that were protected against game damage) the conditions were favorable to hornbeam, ash, maple, and lime tree. Tree species distribution on fenced and unfenced control areas in 2002 and 2008 are presented on the following diagram.



Distribution of tree species on the fenced area in 2002 and 2008



Distribution of tree species on the control area in 2002 and 2008

The two figures illustrate clearly that when the sampling plots were selected (2002) the distribution of tree species in the fenced and unfenced control areas was the same, confirming the equal distribution at the beginning. When comparing 2002 data with 2008 data it can be stated, that over the 7 year survey period the distribution of main tree species decreased and that of other tree species increased on both sites (fenced and unfenced areas). As expected, the rate of increase was greater in the fenced areas in 2008 due to the smaller distribution of other tree species that are more attractive to game animals.

9.3.4. Difference in height between fenced and control areas

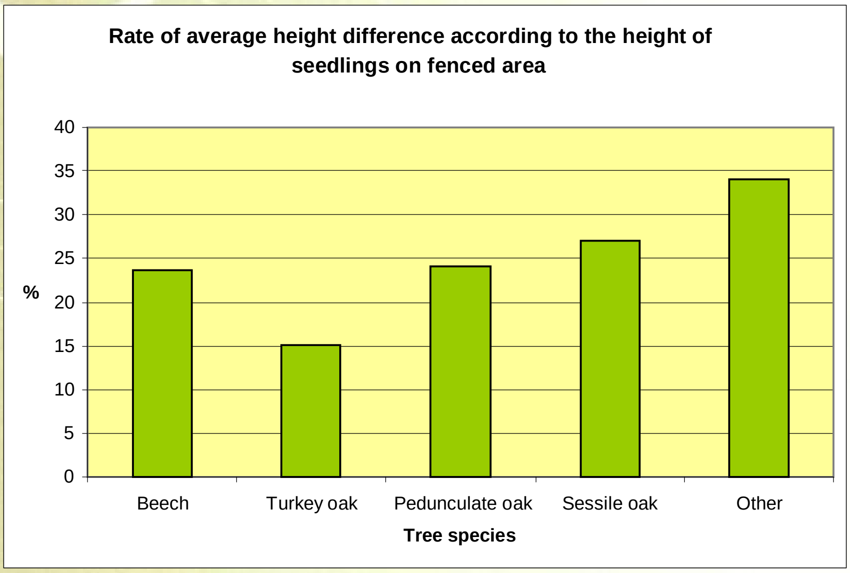
The monitoring system is based on the registration of the height of seedlings in the fenced and control areas. The damage caused by game can be expressed by the difference in height of the same species.

The monitoring system was designated so that the fence provides protection from game damage, thus the height growth of seedlings is undisturbed, while the control area is subjected to game pressure since fencing is not employed. The extent and the effect of game damage to regeneration over the survey period can be derived from the difference in height growth of seedlings. When monitoring started in 2002 the average height of seedlings in both (fenced and unfenced control) areas was similar.

The difference in average height growth in fenced and control areas is outstandingly obvious in 2008. Higher height growth of seedlings as in fenced areas results in an earlier completion of regeneration. This kind of forest regeneration seems to be essential for forest renewal success. Differences in height growth recorded in fenced and control areas are shown in the following table.

	Beech	Turkey oak	Pedunculate oak	Sessile oak	Other
Fenced area (cm)	127,9	114,3	118,7	182,4	160,3
Control area (cm)	97,9	97,0	90,2	133,0	105,6
Height difference (cm)	30,2	17,2	28,5	49,3	54,7

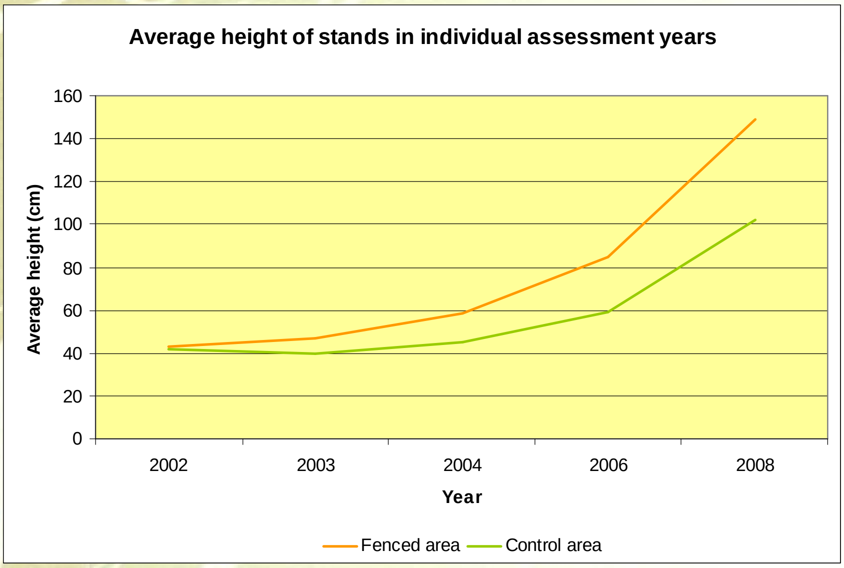
Average height of seedlings on the fenced and control areas in 2008



Rate of average height difference of the seedlings on the fenced and control area according to the average height on fenced area

Results obtained from measurements show that the average tree height in the fenced areas is higher than that in the control areas and explains both the significant height growth in fenced areas that are protected against game damage and the earlier completion of regeneration.

The most significant difference in the average height can be observed in the case of other tree species due to their rate of growth and attractiveness to game animals.



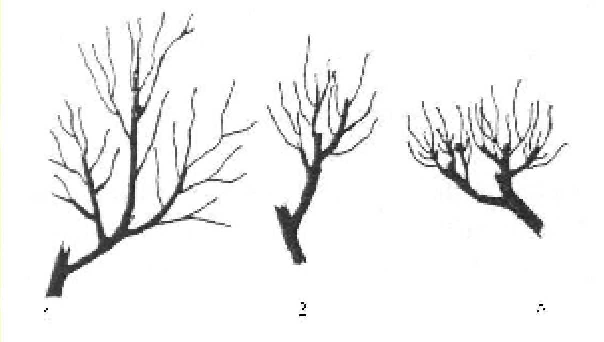
Development of average height on fenced and control areas in individual assessment years

When comparing fenced and unfenced areas the difference in height had become greater since 2004 with a peak in 2008 when the average difference in height was 47,2 cm that is the extra height growth over 7 years recorded for the fenced area .

9.3.5. Damage description ant trends on control areas

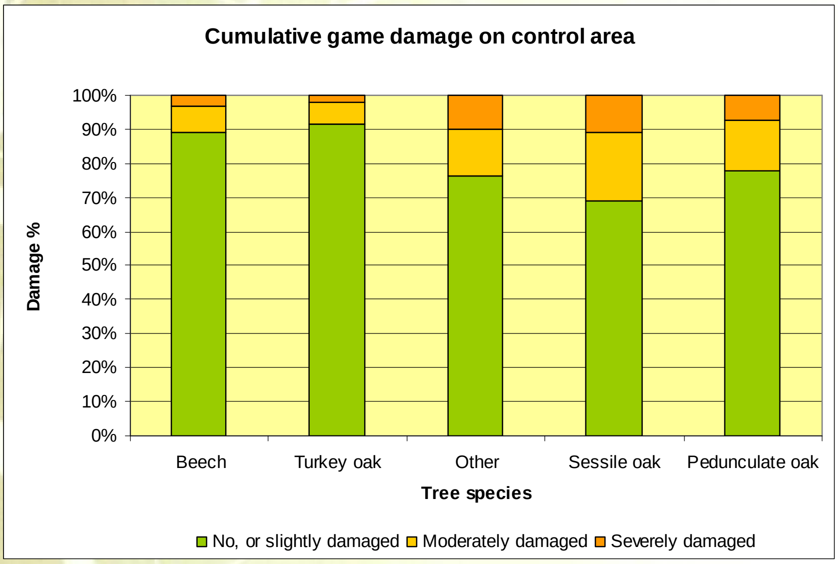
During the monitoring the following damage types and categories are separated:

- Summer time browsing:
  - No damage
  - Less than 1/3 damaged
  - 1/3-2/3 damaged
  - More than 2/3 damaged
- Shoot tip damage
  - Shoot tip not damaged
  - Shoot tip damaged
- Cumulative game damage
  - No, or slightly damaged (1)
  - Moderately damaged (2)
  - Severely damaged (3)



Damage symptom of cumulative game damage

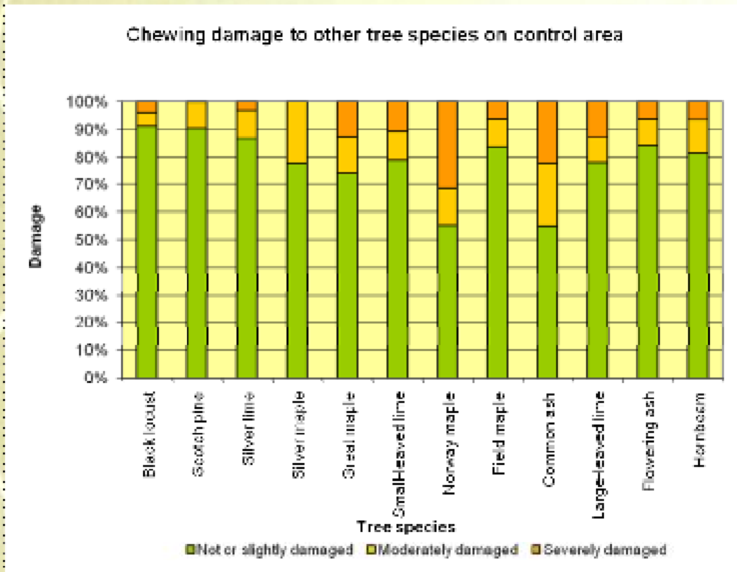
The assessment of cumulative damages is the most efficient method to trace browsing damages over 7 years. The cumulative damage is a symptom. The seedling population declines slowly as a result of continuous game pressure. The rate of damage can be determined by the deformation of shoots. The extent is stated by the deformation of shoots. According to 2008 data on cumulative damages the pedunculate oak, other tree species and sessile oak were the mostly affected tree species. On the contrary beech and turkey oak stands were only slightly and moderately damaged in 2008.



Categories of cumulative game damage on control areas

Within 'the cumulative damage caused by big games' the pedunculate oak and other tree species (such as common maple, great maple, Norway maple, common ash and lime trees, etc.) were categorized as severely damaged tree species in comparison with the remaining tree species.

Among the other tree species the most damaged tree species are maple, ash and lime. 30% of all the Norway maple trees is severely damaged. The wide range of tree species damaged by big games reflects the varied diet of big games. It can be concluded that the intensive appearance of other tree species in forestation not only improve biodiversity and forest stability, but also decrease the rate of game damage to the main tree species.



Chewing damage of some other tree species on control areas in 2008

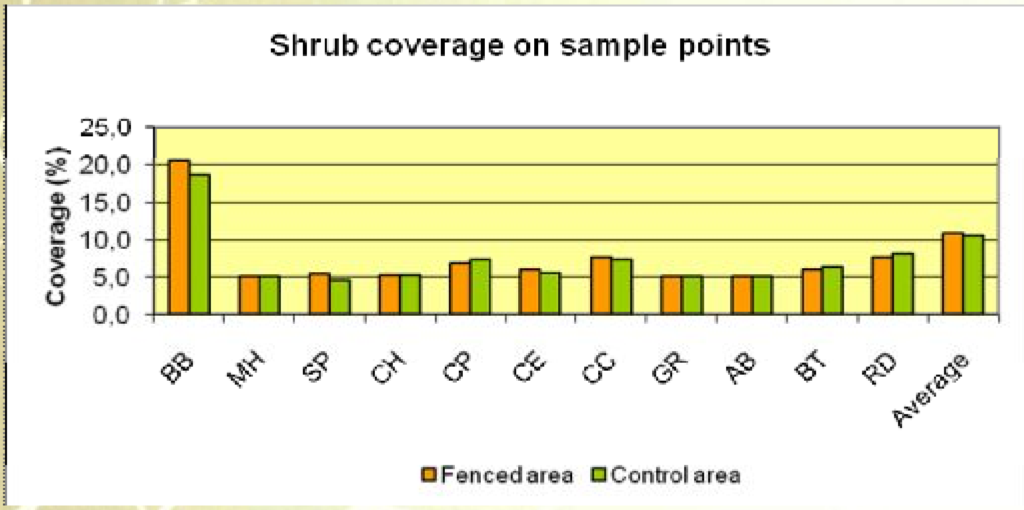
9.3.6. The cover of shrubs and herbaceous species on sample points, the frequency of browsing damage on shrubs

During the assessment a number of additional data is recorded beside data on browsing damage. The herb, shrub diversity, their distribution and cover can provide important information on the damage-dependent game carrying capacity of the forest. Forests poor in shrubs and herbs are more predisposed to game-caused forest disturbing factors. Diversity is very important as a game buffer food supply. Predisposition of seedlings to game damage can be reduced by certain forest features such as richness in shrubs and herbs.

Few indicative data on the cover and distribution of herbs are presented in the following table:

	Cover of herbs (%)	Distribution of monocotyledons (%)	Distribution of dicotyledons (%)
Fenced area	52	59	41
Control area	58	65	35

The table clearly shows that the herbaceous cover on the control areas is slightly higher. The more seedlings are browsed the better the condition is for shrubs to grow. Compared to shrubs in fenced area (where the canopy shading is dense, suppressing shrub growth) shrubs in unfenced area can consume more light, nutrients and water. The shrub coverage is similar (with slight difference) in fenced and unfenced areas. Results show that sometimes shrub cover is greater (more extensive) in the unfenced control area. Outstanding difference in shrub cover can be observed only for the dense-growing blackberry shrubs.



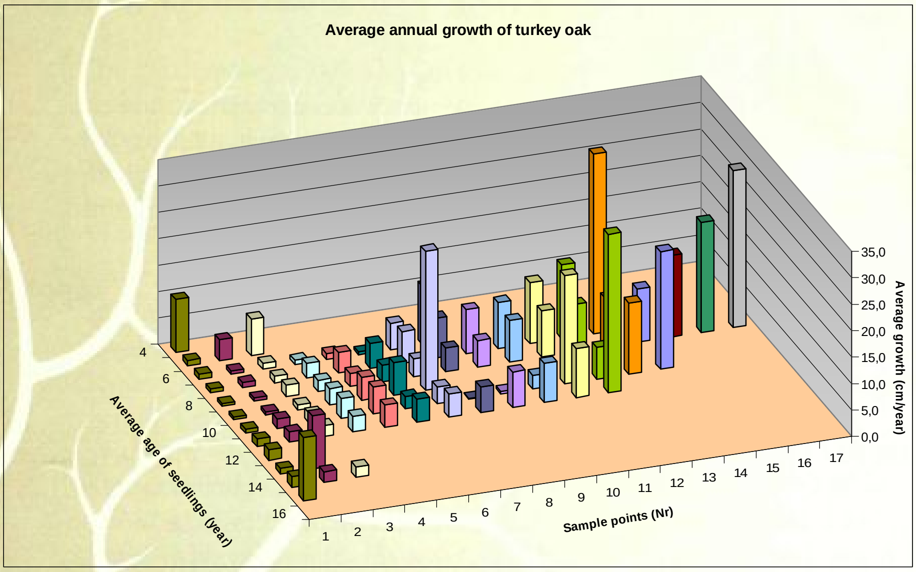
Coverage of main shrubs ont he fenced and control areas

Species on the diagram above:

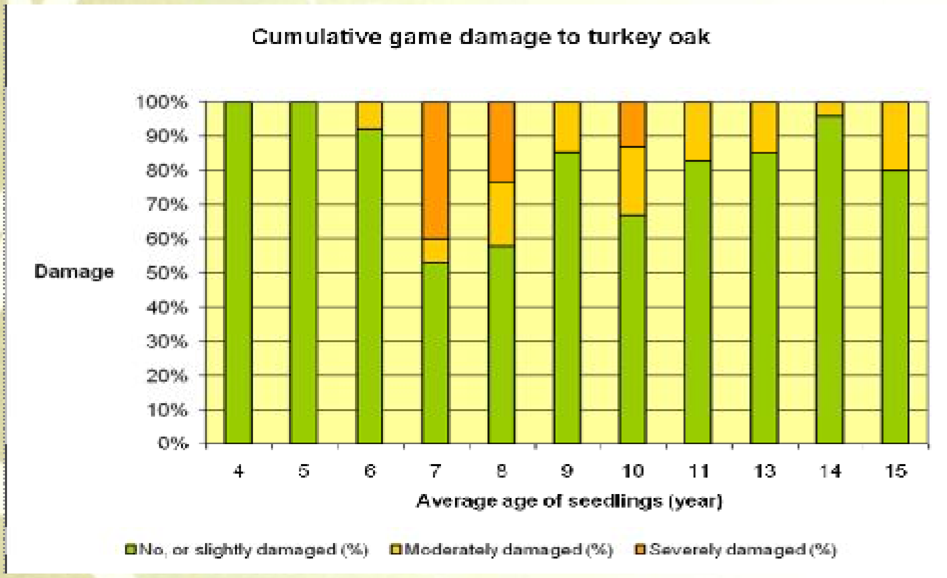
BB	Blackberry
MH	May hawthorn
SP	Spindle-tree
CH	Common hawthorn
CP	Common privet
CE	Common elder
CC	Cornelian cherry
GR	Guelder rose
AB	Alder buckthorn
BT	Blackthorn
RD	Red-branched dogwood

9.3.7. Statistical time-series

The analysis of time series can show the relationship between annual height increment and cumulative game damage. During the analysis the average height increment of native tree species on fenced areas compared to that on control areas was determined (($h_{fenced\ 2008} - h_{control\ 2008}$)/average age of seedlings).The difference in height growth between fenced and control areas plotted against (taken as a function of) seedling age. The cause-effect relationship between height growth and cumulative damage caused by big games is obvious. The third dimension of the diagram indicates the number of affected sampling points. The presentation of affected sampling point is essential because it can happen that within the same tree species regrowth of the same age might be present in several sampling points.



Average annual growth of turkey oak between fenced and control areas depending on the age of seedlings

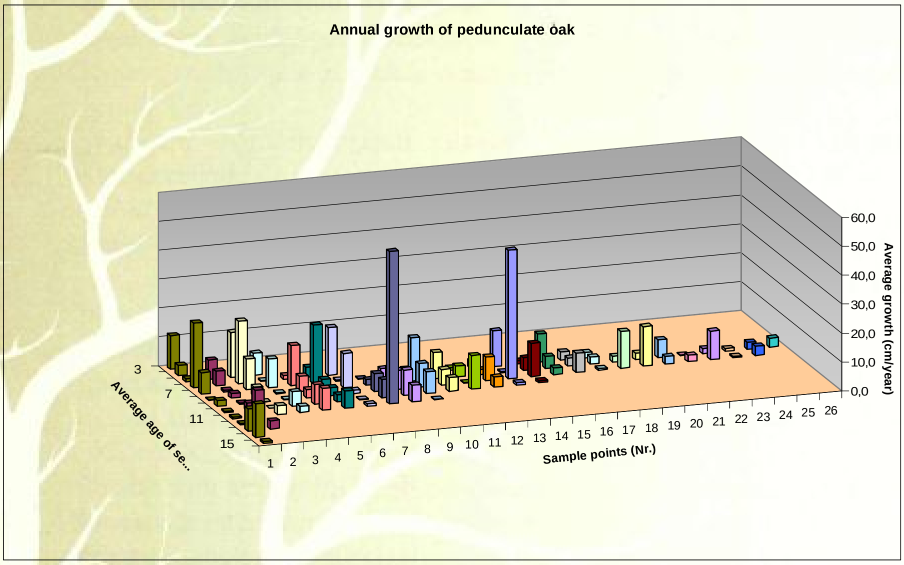


Distribution of cumulative damage on turkey oak trees

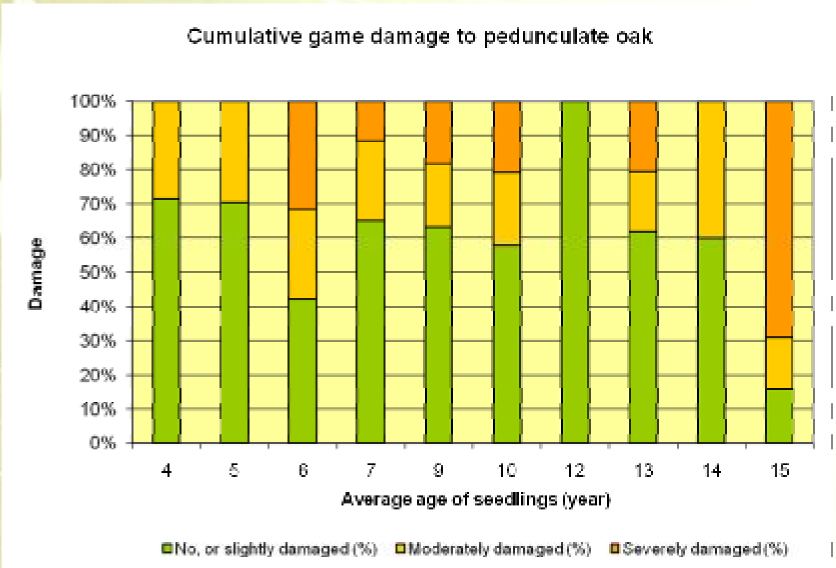
Consistent parameters values of the damage and height diagrams require the combined evaluation of diagrams. It shows clearly, that the largest difference in height growth between seedlings in fenced and control areas occurs in 7-11 year old turkey oak seedlings. In this age-class seedlings are more predisposed to cumulative game damage. Since the difference in height growth is related to game damage as the site is constant within the fenced and control areas of the sampling point, we can say that game damage caused to control areas, especially to 7-11 years old turkey oak seedlings reduced not only height growth but the success of regeneration as well.

Difference in height growth between seedlings both in fenced and unfenced areas in beech species occurs to the same age-class as in turkey oak species. A small number of 3 year-old beech seedlings are damaged by game. The rate of slightly and moderately chewed seedlings is smaller in beech than in turkey oak.

It can be concluded that sessile oak is the most susceptible tree species to game damaging factors when examining chewing damages and the difference in height growth. The height growth of sessile oak varies in a wide interval, but spreads evenly over the different ages (5-11) with observed peak values.



Average annual growth of pedunculate oak between fenced and control areas depending on the age of seedlings



Distribution of cumulative damage to pedunculate oak trees

The 10cm difference in the annual height growth in the 5 year old stands is explained by game damage. Serious cumulative game damage to sessile oak is observed in a wider interval, and moderate chewing damage occurs more often and to a greater extent when compared to turkey oak. The combined evaluation of diagrams explains the high correlation between height growth and chewing game damages

9.4. Future prospects for the monitoring

Since 2001when the system was launched seven years have passed. Evidence accumulated in those years has led to consensus by professionals about the indispensability of the system. The assessment of sampling point became difficult due to significant height growth of stands. New sampling points are to be selected to meet system requirements and to ensure sufficient system operation. Whereas the existing nearly 300 sample points are scattered all over the country, it is essential to rationalize sampling point selection. This means that on areas assigned for sampling more pairs of sampling points are planned to be set up in order to increase efficiency and to reduce the impact of game damage.

In addition to the operating system a new (independent) monitoring system is essential to focus on game damage. This could work in the framework of an existing system (e.g.: FNM), or separately when assessment would consider only forestation related sampling points. The objective of the separate system would be the detection and assessment of actual game damage. The availability and collection of such information is an essential prerequisite, from the professional point of view, for meeting related requirements, especially when considering forest administration trends (overburdened professional population, lack of control system of reforestation/ lack of procedures to ensure that reforestation has been completed) and the orientation of the new forest law are considered.

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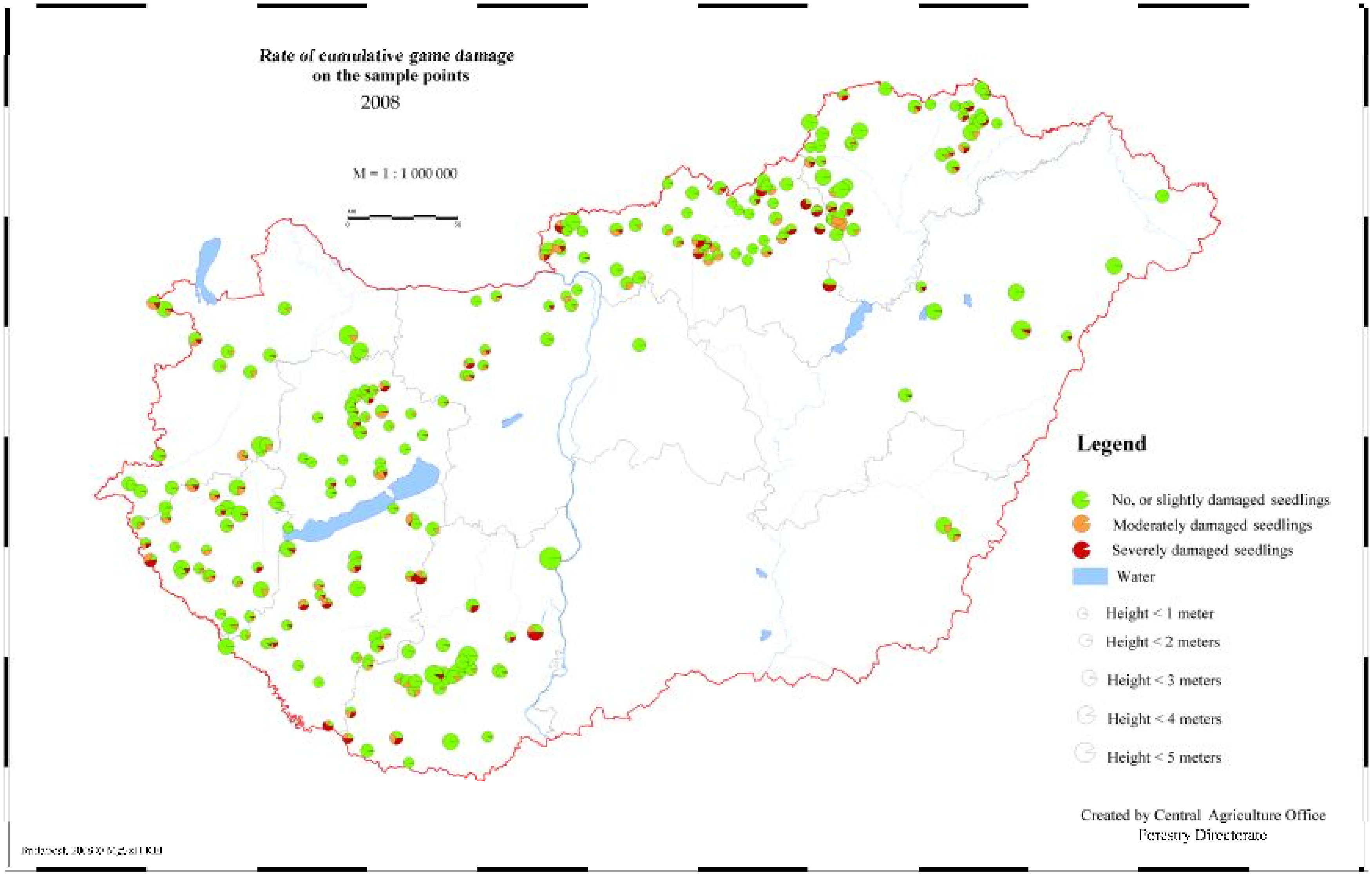

Rate of cumulative game damage
on the sample points
2008
M = 1 : 1 000 000
Legend
No, or slightly damaged seedlings
Moderately damaged seedlings
Severely damaged seedlings
Water
Height < 1 meter
Height < 2 meters
Height < 3 meters
Height < 4 meters
Height < 5 meters
Created by Central Agriculture Office
Forestry Directorate

10. Forest fires in Hungary

Large-scale uncontrolled vegetation fires like in the tropical and boreal regions don't occur in Hungary. In spring and summer the daily news reports regularly about small forest and vegetation fires, which occasionally cause great concern.

The use of fire in agriculture has lost its former function due partly to the use of chemicals in agriculture and partly to the prohibiting provisions of nature and environmental conservation laws. However, in some forest types logging residue is often burned after timber harvesting.

The relative frequency of forest fires increased in the recent decades due to climate extremes, less rainfall, higher average temperatures and the series of winters without snow cover. Climate change results in hotter summers when not the number of fires, but fire velocity and spread increase significantly. Thus, in some cases it is much more difficult to extinguish forest fires. Due to the extensive size and immense speed, forest fires can easily spread to vast areas.

Hungary is not a fire-prone country and natural forest fires do not occur very often due to climatic conditions and the composition of vegetation. Beside the negligible natural forest factors that cause forest fires, it has been found that most times human activities are responsible for causing forest fires in Hungary. It can be a result of human negligence and intention. During forest fires not only the trees, but the whole forest biome is endangered. After fires, depending on its form, the biome is able to regenerate only after a very long time.

10.1. Data collection method

For a better understanding of forest fires threatening forests it is essential to gather information about them. For this purpose the European Union requires Member States to collect data on forest fires since 1992. There is the European Forest Fire Information System (EFFIS) since 1994, which is run by the European Commission's Joint Research Centre. The previous year's forest fire statistics are available on the organization's Web site (effis.jrc.it or www.jrc.cec.eu.int) Hungary has been providing information for EFFIS since 2002.

In those European countries, where forest fires destroy large areas every year (Mediterranean countries and Germany, Poland), time series are available for decades about the damages.

In order to ensure data comparability at Community level data collection rules were standardized. This means that the core data for every forest fire, which has occurred in the territory of Member State during the preceding year, are to be collected and submitted as detailed in the Commission Regulation No 1737/2006/EC. Additional data for forest fires may be collected and submitted by Member States. Beside the EU Regulation national rules were adopted concerning the collection of data on forest fires (the 12/1997. (II.27.) BM Regulation and the amendment to it is the 4/2008. (VIII.1.) ÖM Regulation).

The forestry authority developed a modern forest fire database in 2006 to enable Hungary to fulfill Community and national obligations related to forest fires. From 2007 data for forest fires are submitted to and recorded in the new, integrated National Forest Fire Database. The fire-fighting crews, the National Directorate General for Disaster Management and the forestry authority submit data to the forestry authority-operated database.

Once the set of data on an extinguished fire is loaded into the database, the forest inspectorate is informed of the fire. The database makes fire-related tasks such as data recording, compilation of statistical and other reports, geographic/spatial information retrieval of forest fires much easier.

The incidence of forest fires appears to have accelerated since 2007. Data recorded from 2007 differ significantly from the average of previous years (see graphs and tables), which doesn't always indicate that there were more fires. It is mostly due to the clarification of data collection system that resulted in more recorded fires as compared to previous years.

A further reason for difference in the number of recorded forest fires is that data collection is carried out with respect to the definition of forest and forest fire in 1737/2006/EC Regulation.

The definition of forest in EU legislation is different from that in the Hungarian Forest Law, but similar to the FAO definition. Consequently in some cases fires in areas defined as non-forest areas in the Hungarian Forest Law fall under the above mentioned EC Regulation.

For the purpose of the Regulation, the definition applied for forest fire is that **forest fire** means fire which **breaks out and spreads** on forests and other wooded land or which breaks out on other land and spreads to forest and other wooded land.

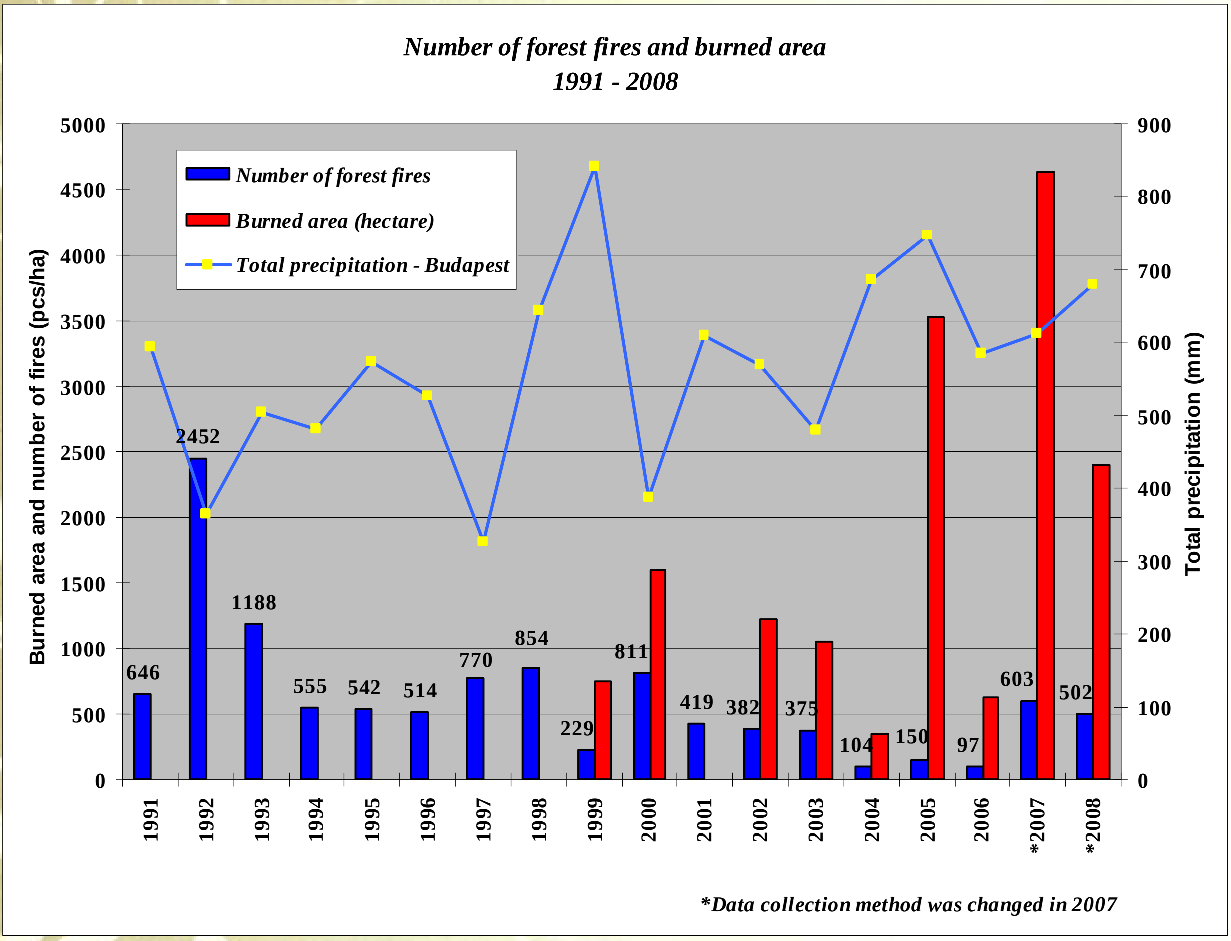
The definition of forest fire **excludes** prescribed or **controlled burning** that is necessary for a healthy forest, usually with the aim of reducing or eliminating the quantity of accumulated fuel on the ground.

The forest fire data are provided each year by Hungary to the EU Fire Database in order to have comparable information on forest fires at Community level. Fire on other wooded land, that is not defined as forest under national law in Hungary, is also included in the forest fire statistics, but as a separate category (fires in other wooded lands).

In the tables presented below burned area includes not only forest area but non-forest area as well. With this in mind, a 10 hectare burned are could mean 1 hectare of burned forest and 9 hectare of burned other area.

10.2. The number of forest fires and the extent of burned area

Before the establishment of the integrated forest fire database there had not been available data about the annual number of vegetation fires. Only those fires were registered that affected forest areas. Before 1998 the data collection was not uniform, thus historical data on fires are available only from records of fire departments and companies managing state forests.



The table presents data from the new integrated database.

Year	Total number of vegetation fires	Fires in forests and other wooded land		Other land
	Number of fires	Number of fires	Burned area (ha)	Number of fires
2007.	6691	603	4636	6088
2008.	6639	502	2404	6137

After the 2 year experience of the newly introduced data collection system we can state, that only 9-10% of the annual vegetation fires is forest fire. Although the number of forest fires that occurred is relatively low, but the damage they caused is much higher than the damage caused by low intensity grassland or stubble-field fires. Furthermore, considerable effort and more fire suppression activities are needed to extinguish forest fires.

As a consequence of the new method of data acquisition whereas fires on other wooded land are also recorded, the number of fires has increased.

The significant increase in the burned area is due to the connected databases. Data registered by the Forestry Authority can be compared to and modified by data on the areal extent of fires (from the database operated by the National Directorate General for Disaster Management) in order to have reliable information on affected areas. Growing number of fire departments have special instruments to determine the exact areal extent of fires.

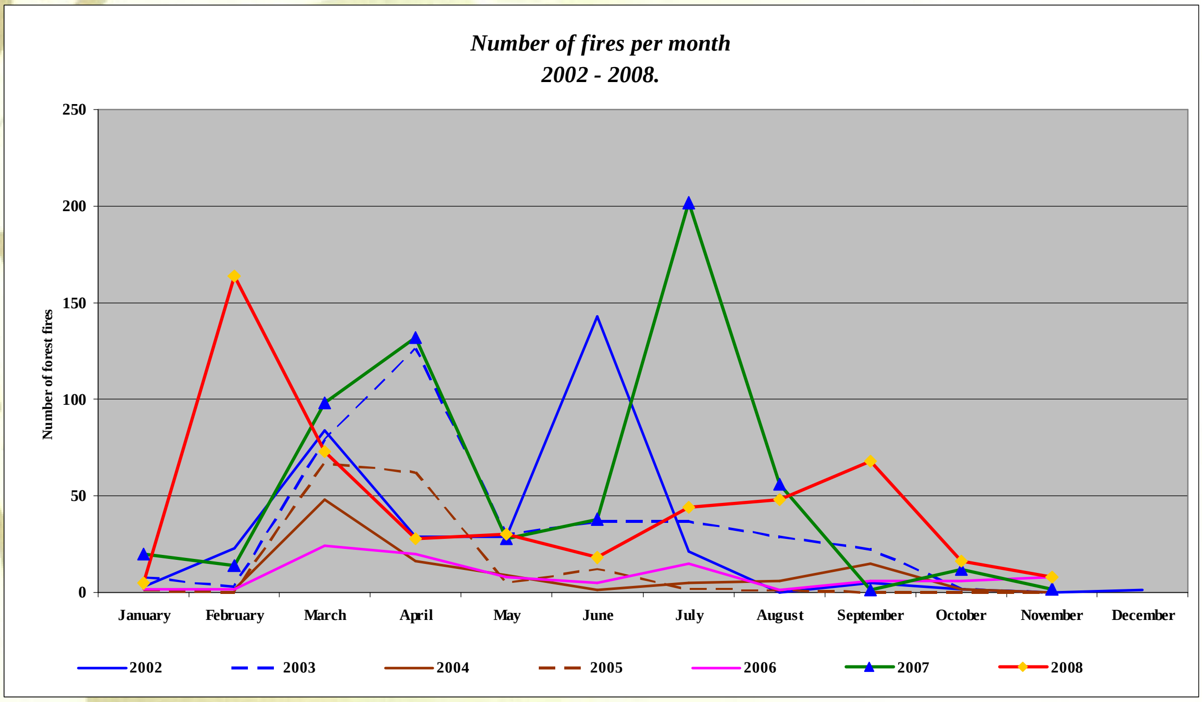
The diagram above clearly indicates how much the number of forest fires depend on meteorological conditions such as precipitation. Recent studies of biomass have tried to find out that how long it takes for thick and thin wood found in biomass levels in different forest stand types under given (different) weather conditions how long it takes to reach the combustible state.

The new data acquisition system groups burned areas according to the biomass consumed by fire comprising grassland, woody-shrub and forest biomass. Results of the classification explain and justify the assumption that a certain number of forest fires break out on other land and spreads to forest and other wooded land.

The figure shows the general trend of forest fires during the twelve months of the year over the period 2002-2008, indicating that fire risk is higher in two periods in Hungary.

Burning stubble (from February to April) is a traditional method of destroying any plants and insect pests left behind after harvesting. The principal aim of agricultural burnings is functional; they are not started simply for destructive purposes. But the agricultural or shrub land burning might start a fire (as a result of failure to comply with preventive measures) which can easily spread to forest and other wooded land. The systematic burning of stubble is carried out from February to April (depending on weather condition).

In a forest, a lot of flammable materials are present, such as deep duff, newly fallen dead leaves, clumps of grass, litters of dry twigs and branches, downed logs, low shrubs and many other types of materials which have a major influence on the spread rate of fire, especially in the prolonged periods of hot and dry weather and no precipitation, during July, August and September.



Comparing the yearly distribution of forest fires and the burned areas we can state, that 70-75% of forest fires break out in the above mentioned high fire risk periods. It worth to be noted that 40-45% of spring fires occurs typically in the Northern Hungarian region (Borsod-Abaúj-Zemplén, Heves, Nógrád) which indicates the high vulnerability of the region due partly to the underlying underlie socio-economic problems.

On the contrary, the large number of summer fires breaks out, in contrast to the spring period, arises particularly in the Great Hungarian Plain. Pine forests of Bács-Kiskun and Csongrád counties are affected by fires almost every year.

Spring and spring fires correspond to 30% and more than 50% of the total burned area, respectively.

10.3. The causes of forest fires

The use of results obtained with the fire cause origin investigation is important as a source of information for the definition of prevention strategies, namely for public awareness campaigns, and therefore contribute to decrease the number of ignitions and burned area. The causes of fires are also important parameters in fire prevention. This can be background of fire prevention campaigns and plan development in certain regions and counties.

Besides the natural factors that cause forest fires, it has been found that most times human activities are also responsible for causing forest fires. It is estimated that almost 99% (!) of the forest fires are caused by human activities (negligence or intentional burning). The assignment of a fire to a category according to the causative agent responsible for starting the fire, contradicts the classifications that are used for reporting national fire statistics, since in some cases the cause of fire cannot be properly determined, or because of the uncertain circumstances the fire is registered as a fire of unknown cause by the fire department.

Statistical data indicate that between 2002 and 2008 45% of the recorded forest fires were caused by negligent use (involuntary), accidental causes or arson (voluntary). Fires caused by these causative agents represent about 40% of the total burned area.

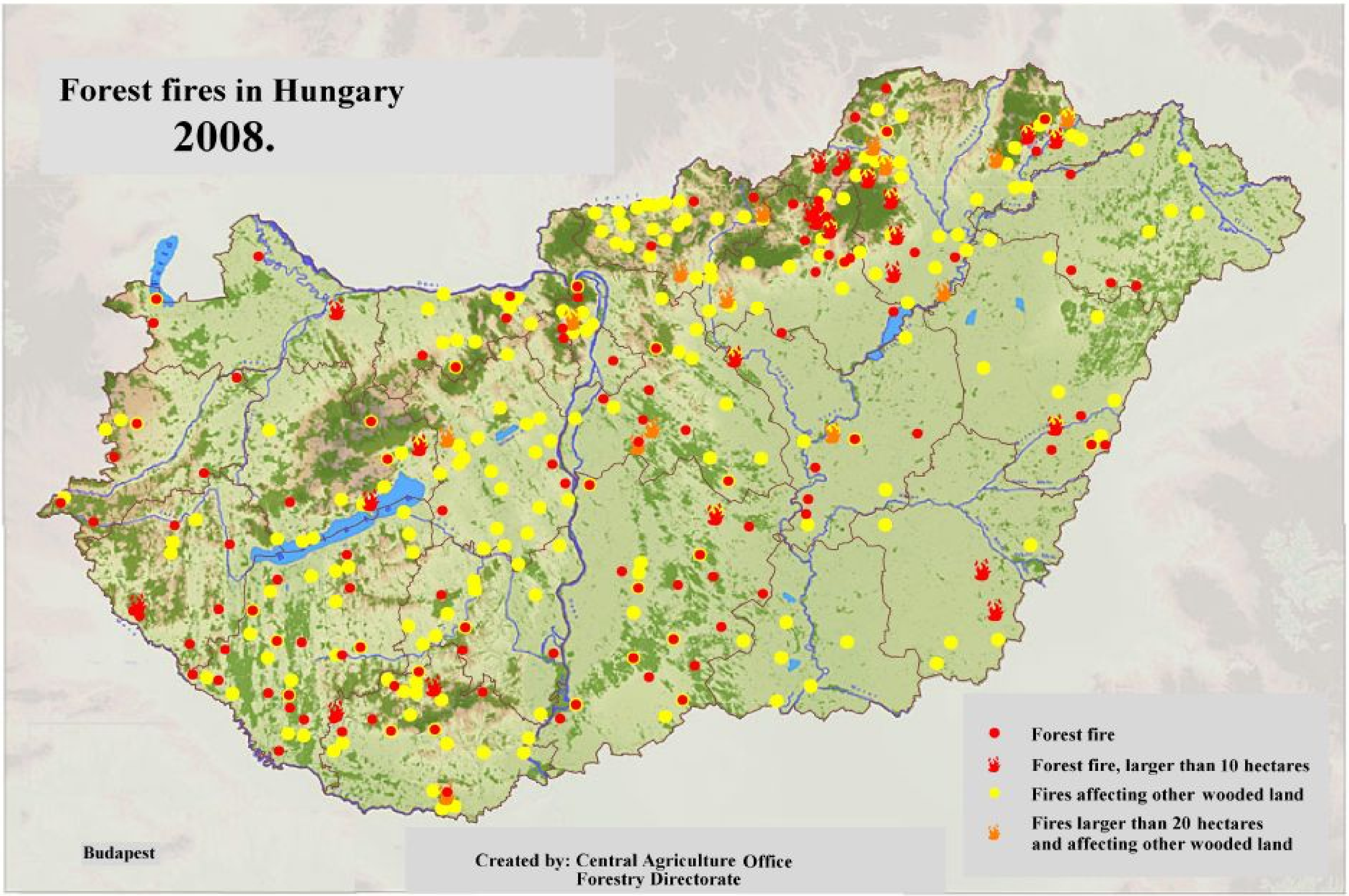
In Hungary under the given climatic and forest stand conditions natural factors are the less frequent motives (causative agents) and only a small percentage of natural fires contribute to the total amount of vegetation burned.

10.4. The type of fire

Considering the types of fires underground fire is less important in Hungary, but because of peat fires it is not completely unknown. Although peat has many uses for humans, it also presents severe problems at times. When dry, it can be a major fire hazard, as peat fires can burn almost indefinitely (or at least until the fuel is exhausted). Peat fires can even burn underground; reigniting after the winter, provided there is a source of oxygen. 95% of registered forest fires were aboveground fires in 2007 and 2008. Under the given forest stand conditions in Hungary aboveground fire is the most frequent type of vegetation fire representing about 70% of the total burned area.

Keen observation of variations in forest fuels is essential in reliably estimating fire behaviour. In a forest, great differences exist in the character of flammable materials such as deep duff, dead leaves, dry wigs and branches, and low shrubs with distinctive burning characteristics. The flammability of a particular fuel body is governed by the burning characteristics of individual materials by the combined effects of the various types of materials present. Fire intensity depends on the amount of flammable material. Crown fire is usually ignited by surface fire due to high fire intensity.

80% of crown fires broke out in coniferous forests, especially in the great Hungarian Plain. Crown fires are not common in deciduous forest stands with the exceptions of fires which spread from coniferous forests.


Forest fires in Hungary
2008.
Budapest
Created by: Central Agriculture Office
Forestry Directorate
Forest fire
Forest fire, larger than 10 hectares
Fires affecting other wooded land
Fires larger than 20 hectares
and affecting other wooded land

10.5. The areal extent of forest fires

In the period 2002-2008 the extent of burned areas (separately) was below 50 ha with few exceptions.

The percentage of small fires less than 1 hectare is 30%. The relatively high number of small fires indicate that the majority of fires that involve the following characteristics: low rate of fire intensity, surface fire (fire that burns loose debris on the surface, which includes dead branches, leaves, and low vegetation) is detected and extinguished, that is to say that the ignitions are controlled before spreading. The earlier they are reported the faster they are supressed by units of the state fire service (fire fighting crews). The average burned area of small fires is 0,2 hectare.

The percentage of 'medium sized' fires affecting an area between 1-50 ha is 60-65%, and the average burned area of these fires is 5,9 hectare. These are also surface fires, but with a little bit of higher intensity and greater extent of burned areas. These fires are common in coniferous, robinia and native poplar stands. The main cause of these fires is usually negligence.

10.6. Burned biomass caused by forest fires

The national forest fire data comparability and consistency are ensured by the uniform record sheet which has been used by the Forestry Authority and the Fire Service since 2007.

In a forest, great differences exist in the character of flammable materials which have distinctive burning characteristics. Fuel continuity describes the distribution of fuels in a given area. Fuel continuity is an important factor in fire behaviour because the distribution of fuels influences the potential area where a fire may spread, as well as the rate of speed. If a dangerous fuel is uniformly distributed over an entire area, a high potential exists for a complete burn to occur at a rapid rate of spread. If the fuel body is broken up by patches of bare ground or much less flammable material, both the potential area of the burn and the rate of spread are reduced. As the amount of flammable materials in a given area increases, the amount of heat a fire produces also increases. The hottest fires, as well as those most difficult to control, occur in areas containing the greatest quantity of fuel.

Fuel appraisal, the process of first describing the fuel type characteristics and secondly interpreting the fuel description in terms of potential fire behaviour on the basis of past experience, comparative methods and mathematical models is essential to make predictions and to determine effective suppression strategies.

The following vegetation types that are on the forest fire statistical data sheets are used for the comprehensive forest fire statistics and fire prevention analyses.

Flammable material model	Vegetation type	Burned are (ha) 2007.	Burned area (ha) 2008.
Other	Low grass vegetation	**1054**	**968**
	High grass vegetation	**672**	**327**
Forest	Deciduous plantation	**205**	**96**
	Coniferous plantation	**104**	**27**
	Deciduous forest stand	**770**	**249**
	Coniferous forest stand	**979**	**26**
Other wooded area	Shrub and brush land	**836**	**704**
	Juniper plantation	**18**	**8**
	Total:	**4638**	**2405**

It has to be noted that the burned forest areas represent only 44% of the total burned area and 80-85% of the total amount of biomass consumed by fire.

The above figures indicate that fires spreading to and from forests are to be considered when fire management services such as prevention and suppression are performed. Not only forests but grass vegetation, and shrub and brush rangelands are destroyed by forest fires.

Even in Hungary under the given environmental condition in attempting to control fire, fire-fighters and forest managers must have complex knowledge of standard fire program requirements, suppression tactics, methods and procedures, and skill to perform routinely assigned fire suppression assignments in various types of fuels and under a variety of weather and terrain conditions.

10.7. Forest fire prevention

Council Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire prescribes the development and implementation of forest-fire protection plans by Members States. Hungarian legislation adopted detailed rules for forest-fire protection, namely the Regulation of the Minister of Home Affairs 12/1997. on the protection of forests against fire.

The Council Regulation has been modified many times since 1992 due to relevant policy change. The European Forest Fire Information System (EFFIS) has been established by the Joint Research Centre (JRC) and the Directorate General for Environment (DG ENV) of the European Commission (EC) to support the services in charge of the protection of forests against fires in the EU and neighbour countries, and also to provide the EC services and the European Parliament with information on forest fires in Europe. Hungary has been submitted data to the huge EU fire database maintained by EFFIS since 2002.

Having regard to forest fires that cause enormous ecological and economical damage in the Southern most affected Member States, whereas the condition of forests can be seriously affected by human influences such as fires and such threats can seriously distort and even destroy forests, the need was stresses to protect the natural environment and the forest heritage, to manage forests sustainably and to support international and pan-European cooperation concerning the protection of forests, making reference to forest monitoring and the promotion of forests as carbon sinks the European Parliament and the Council developed Regulation (EC) No 2152/2003 of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community (Forest Focus) which succeeded related programmes.

Hungary has participated in the implementation of measures for fire protection against fire adopted by Forest Focus Regulation since 2004. The complex programme for fire prevention was based on the Phare project that contributed to the implementation of the programme.

In the framework of the programme **the following developments were carried out**:

- **The regulation** on the protection of forests against fire **has been amended**. Profound knowledge concerning forest fire suppression was inserted into and prescribed tasks of forest managers, and tasks of organizations and authorities relating to fire prevention and suppression were specified in the regulation.

- **The National Forest Fire Database** operated by Central Agricultural Office (CAO) **has been expanded and updated**. New technology has been incorporated in the database and database content was extended. Since January 1, 2007 up-to-date information is available on forest and vegetation fires due to the integrated database.

- **Classification method of territory according to the degree of forest fire risk**. The classification method based on the tree species, site and increment data at forest compartment level from the National Forest Fire Database operated by CAO.

- **The revision and update of national and country plans for prevention of forest against fire** were necessary to meet EU requirements and to adapt to changes in the structure of society and forest management and in ownership relations.

    - According to the Regulation of the Minister of Home Affairs (4/2008. (VIII.1.) ÖM rendelet) the forest managers are obliged to develop a plan for prevention of forest against fire and to have a fire equipment of cache (a pre-determined complement of tools and equipment in planned quantities for exclusive use in fire suppression) and a fire rescue team on standby (to take immediate action on detection of a fire).
    - Different types of plans are developed considering the administrative and forest management circumstances.
        - § **national** plan for prevention of forest against fire
        - § **county** plan for prevention of forest against fire
        - § **forest managing** plan for prevention of forest against fire
            - forest managers managing more than 100 ha forest area classified as areas of (medium/low) fire risk
            - simplified plan for prevention of forest against fire developed by small forest managers

- Hungary developed a public awareness campaign for forest fires prevention.
- The programme comprises measures **contemplated** for achieving the objectives as regards establishment or improvement of systems of prevention.
  - Measures to set up or improve systems of prevention, with particular emphasis on the launching of protective infrastructures such as forest paths, tracks, water supply points, firebreaks, cleared and felled areas, the launching of operations to maintain firebreaks, cleared and felled areas and preventive forestry measures within the framework of a global strategy for the protection of forested land against fire. (It will be specified in the Subsidy Regulation.)
  - Measures to set up or improve forest monitoring systems, including deterrent monitoring, with particular emphasis on the installation of fixed or mobile monitoring facilities and the purchase of communications equipment. Currently there are no available financial resources to cover these expenses.

From the year 2009 several actions were taken such as the **national awareness campaign** aiming to inform the public about forest fire prevention practices, changing attitudes and behaviour and creating awareness about fire prevention was undertaken. Through the campaign, students were informed as well about the importance of forests and the ways to protect them. Besides the natural factors that cause forest fires, it has been found that most times human activities are also responsible for causing forest fires. It is estimated that more than 90% of the forest fires are caused by human activities. In Hungary it has been observed that the majority of forest fires are initiated by negligence and intentional acts, but fire might break out when fire suppression actions are not conducted properly.

Forest fires are an anthropogenic phenomenon which exclusively and directly depend on social behaviour, whether voluntary (arson) or involuntary (negligence). Despite the progress in knowledge made with studying the physical facets of the phenomenon, causes and motives of human-related fire remain mostly unknown. The integrated data acquisition provides information on sociological factors - related to the negligent use of agricultural fires, particularly stubble burning – that are high in importance. Data on fires during the last two years indicate that fires that have been started on non-forest areas are bigger problems than forest fires. **In 2008 only 8% of the total vegetation fires were forest fires.**

It is obvious that approaches toward the prevention of fires face a complex set of constraints, like a general lack of awareness and concern about forest and land fires in all levels of the society; institutional constraints; available budgets at operational level insufficient; human-induced changes in vegetation cover resulting in the rapid spread of fire-prone vegetation types, which create hazards for future fires over large areas in the country. Such conditions make the prevention of fires a big challenge. Human-induced fires, however, are generally preventable. To reduce their occurrence, human resource and institutional development along with general awareness campaigns are the foremost tasks. Extension work, which includes awareness campaigns and the distribution of information materials, is the first essential step to plant “fire prevention seeds”.

Well-organized and carefully implemented programs are highly successful in North America and Western Europe. It is important to embrace the fact that, while past suppression tactics have been effective, fire prevention tactics and strategies have changed. No longer can we afford to invest all our resources in fire suppression force equipment and strategies. Reactive fire suppression programs must involve proactive fire management programs. The goal of fire prevention programs is to prevent unwanted human caused fires. New techniques and strategies for fire prevention education can be used in specific situation to capture the public interest and therefore understanding and to more effectively reduce the damages and risks from unwanted fires.

The overall strategy of the fire prevention plan developed by the Forestry and Fire Authority should focus on education and enforcement. Each of these activities is an important peace when reaching out to the public and ensuring that there is a strong understanding of the message that is being conveyed.

Sight after fire in a pine forest

Sight after fire in a juniper stand

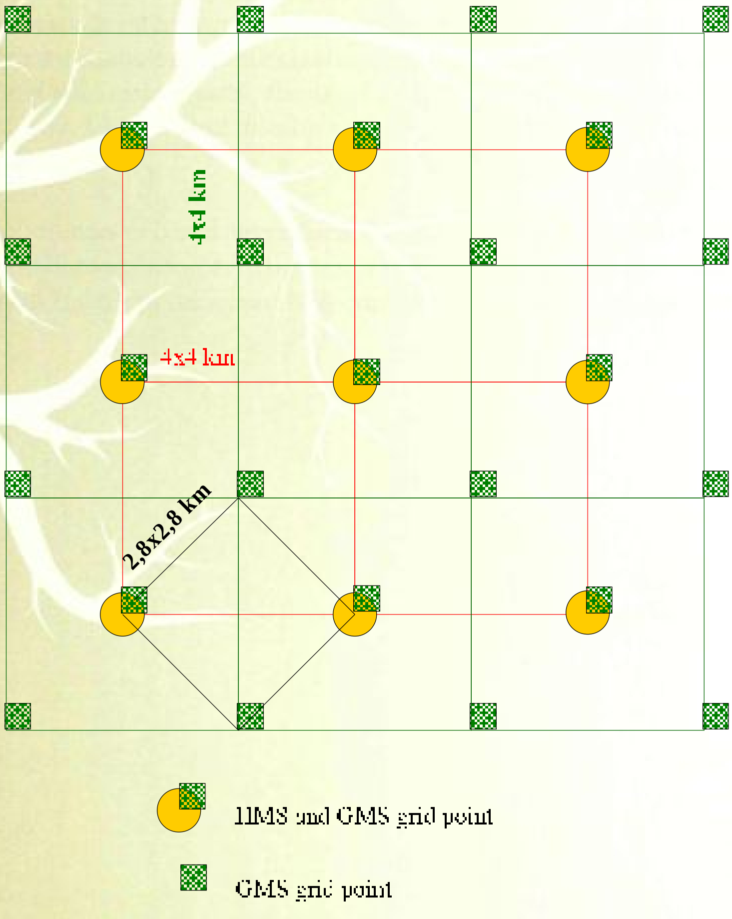
11. Growth Monitoring System

The Growth Monitoring System (GMS) was launched in 1993 in close connection with the formerly established Forest Protection Network (FPN). The main objective of the program is the monitoring of increment by measurements of all trees in the plots. Temporal variation in increment can be determined by longer time series of repeated measurements. A growth assessment over years (more periodic measurements on identical spot) provides information on more increment period, which is required before reliable information of increment change can be obtained.

Forest response to changes reflects processes of the ecosystem that are sensitive to the year-to-year variation in environmental conditions represented in the growth of trees longer time series of repeated increment measurements on identical trees reduce statistical errors since they tend to be less sensitive to individual measurements errors and enable corrections and/or filling of data gaps in the National Forestry Database (NFD) (later referred to as Database).

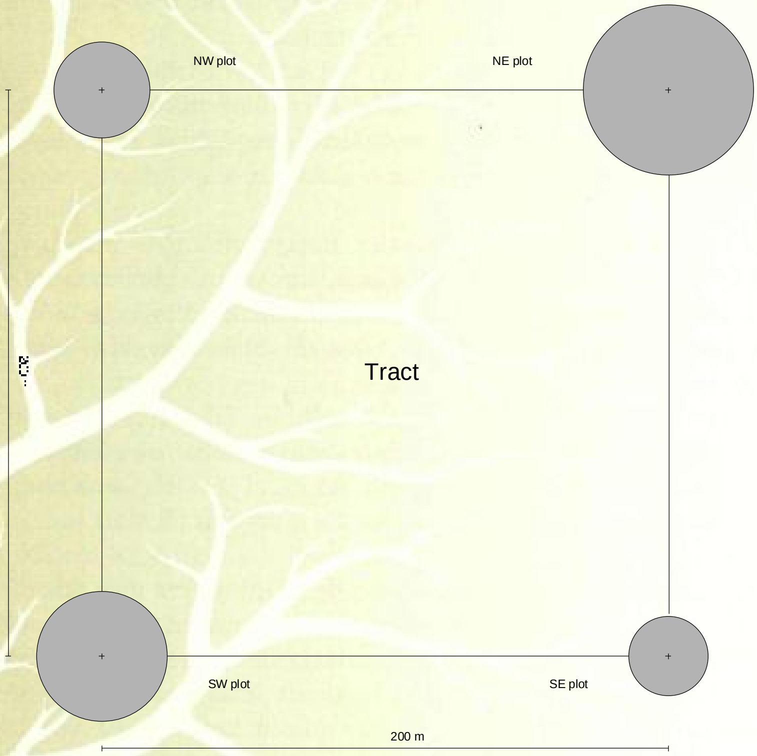
11.1. Grid, plot selection, sampling and representativity

The existing national (FPN) 4*4 km grid of sampling plots was adequate to establish permanent sample plots. Sample locations reside on the national 4*4 km network. The sampling intensity is the 2*2 km grid of sampling points that is nested within the national 4*4 grid as shown on the following figure. The distance between sampling points is 2,8km.



FPN and GMS grids of sampling points

The survey and assessment unit is the tract consisting of four circular plots, each which are arranged at the corners of the square with 200 m of side length. The south-western corner of the tract is the centre of sampling plot. Each tract that is assigned to one of the years of the 5-year-long inventory period is repeatedly assessed once every five years. On the following figure the four tracts with different radius are illustrated.



Tract and its four sample points

Each grid corner and tract plot represents approximately an 8 km2 (800 ha) and a 2 km2 (200 ha) area, respectively.

Potential sampling plots were drawn on forest maps (originally the image of the maps was plotted on deformation-resistant plastics (Astralon)). A plot that fell within a forest compartment and met requirements of selection criteria was selected as GMS sampling plot. Plot selection was not carried out by an independent inventory. Forest management planning data were used to select sampling plots and later to evaluate GMS during data processing.

Revision of sampling plots is carried out annually. While few selected plots that do not meet selection criteria are left out of the network, few others (previously potential plots, but not selected due to their land cover type) are selected as sampling plots due to changed land cover (they are registered as forests areas under forest management planning).

The main selection criterion for GMS was to ensure the required accuracy of growing stock estimation of the country’s forest resources, in other words, at the 95% confidence level the growing stock estimation on country and directorate level shall obtain 5% and 10% accuracy.

11.2. Survey methodology

The survey of the sample plot is carried out by using stand description or individual assessment method.

When trees within a plot do not meet selection criteria or they are inaccessible, therefore individual tree assessment is impossible; the so called stand description method is applied when beside the forest compartment description only few tree species related data are registered. Data were derived sometimes from field assessments and mostly from the Database.

During the individual assessment data collection is carried out within circular plots with a radius between 4 and 25 m. The size of the circular plot depends on the numbers of trees within the sampling plot. The circular plot of younger forest stands has a smaller radius and that of old-growth forest stands with lower density level is longer. The number of sample trees is between 15 and 25 to ensure more flexible working.. At regional or county level the lower threshold of the average number of trees is 20.

When GMS sampling plot lies within the FPN sampling plot or vice versa, sampling is carried out in the four FPN circular ('satellite') plots. In case of overlay sampling plot.

The most important attributes evaluated by field assessment are listed below:

General data of plot
Geographic coordinates, quarter
Survey method
Stand structure
Crown closure
Topography
Altitude
Aspect
Slope
Water management class
Site
Soil damage
Radius of circular plot
Occurrence of shrubs

Sampling trees data
ID
Tree species
Tree Origin
Age
Tree Diameter (minimum, maximum)
Cause and level of damage
Cutting year
Height class
Height of tree

Stand description parameters (when stand description method is applied)
Tree species
Origin
Mixture
Age Estimation
Crown closure

Average diameter
Average height
Stem Number per hectare
Damage

Expected accuracy of field measurement:

diameter:		
	individual method:	± 0.5 cm
	circular plot average:	± 0.25 cm
circumference (individual m.):		
	up to 150 cm:	± 6 mm
	above 150 cm:	± 10 mm
height (individual m):		
	up to 20 m:	± 0.5 m
	between 20.1 – 30 m:	± 0.75 m
	above 30 m:	± 1 m

Due to visibility conditions field measurements for tree height are carried out from late autumn to spring. The field assessment over 15 years (i.e. three periodic measurements) that was over in the spring of the year 2008 provided information on more periods, which is required before reliable information can be obtained.

The huge amount of data – mainly due to manual data collection – required comprehensive control and consistency analysis therefore data evaluation took longer time. This unique database offers further evaluation possibilities.

11.3. Data evaluation

Data collected over 15 years are stored and evaluated in relational database, in Visual FoxPro environment.

Field-Map is an integrated tool designed for computer aided field data collection. It's used mainly for mapping of forest ecosystems and for data collection during field examinations. This application is able to work with multi-level relational database and also provides smooth communication with external devices such as GPS, laser rangefinders and inclinometers. The Field-Map technology is currently used for national forest inventories in Hungary.

Field-Map Inventory Analyst is software application for evaluation of statistical forest inventories. It provides user with easy handling and processing of the databases of field data. Data can be completed, pre-processed and processed in order to obtain final statistical results and output. Automatically generated output consists of classified tables of results and graphs. As option the user may complete the result with methodological remarks, definition of the terms and comments.

Before data procession to ensure data quality and consistency certain tasks were performed, such as:

- To convert the four FHM satellites into one circular plot;
- To convert variable size plot radius into standard plot radius;
- To convert variable size plot area into standard plot area;

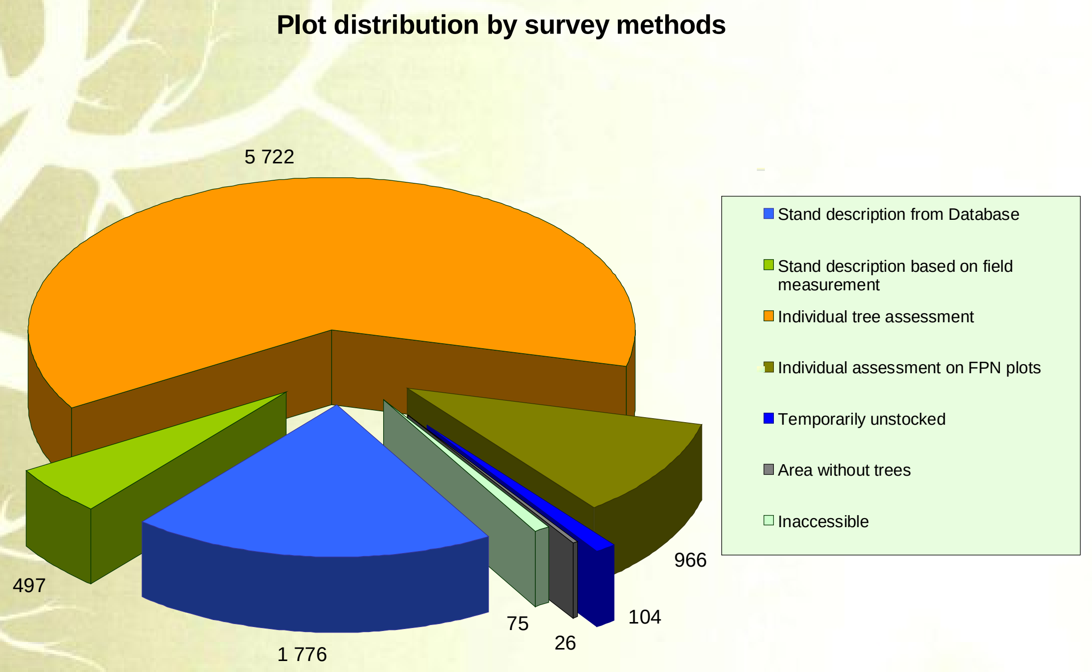
- To control and - if necessary – correct stand description data, fill data gaps;
- To integrate stand description data into the Field-Map database
- To assign other available data from the Database into the Field-Map;
- To itemize dead trees (Dead tree as a separate category was not included in the assessment, but sample trees that died during the assessment period were registered);
- To generate the average diameter
- To calculate the representative area of sample trees
- To generate height curves

11.4. Results of evaluation

In most cases evaluation data were compared with 5 year averages of Database data. (The average was calculated to ensure data comparability.)

11.4.1. Distribution by survey methods

The total number of sample trees assessed during the third measurement period was 155.965, an average of 23.,3 trees by sampling plots. The number of sampling plots was 9.166. The distribution of plots by survey methods is indicated on the following diagram.

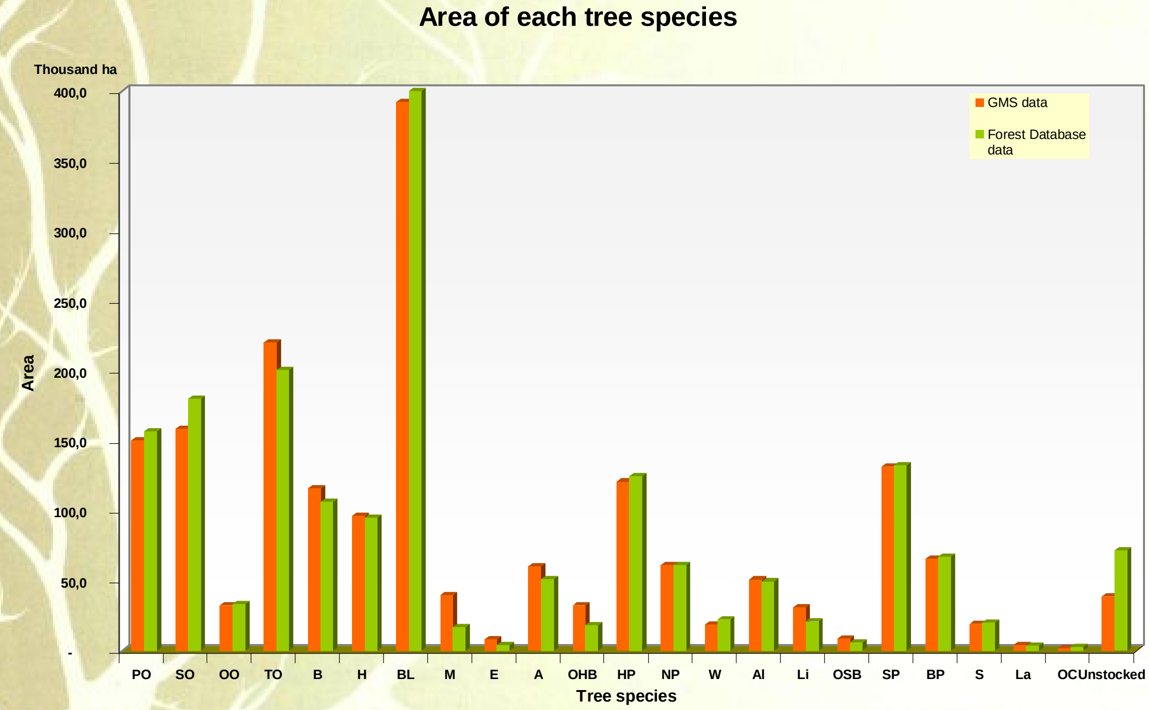


Distribution of the assessed sample points in the third measurement period by survey methods

11.4.2. Area distribution

In the following we compare the third measurement period data of GMS with related Database data. It has to be highlighted that data on temporarily unstocked areas and areas partly covered by trees or with incomplete canopy cover are included in GMS data, therefore in the Database as derived average data.

The following diagram illustrates the areal distribution data of main tree species according to GMS and Database data.



Comparison of the area of each tree species according to the GMS and Forest Database data

The comparison proved the representativity of GMS data even on tree species level as the areal distribution results from both Database and GMS data is almost the same.

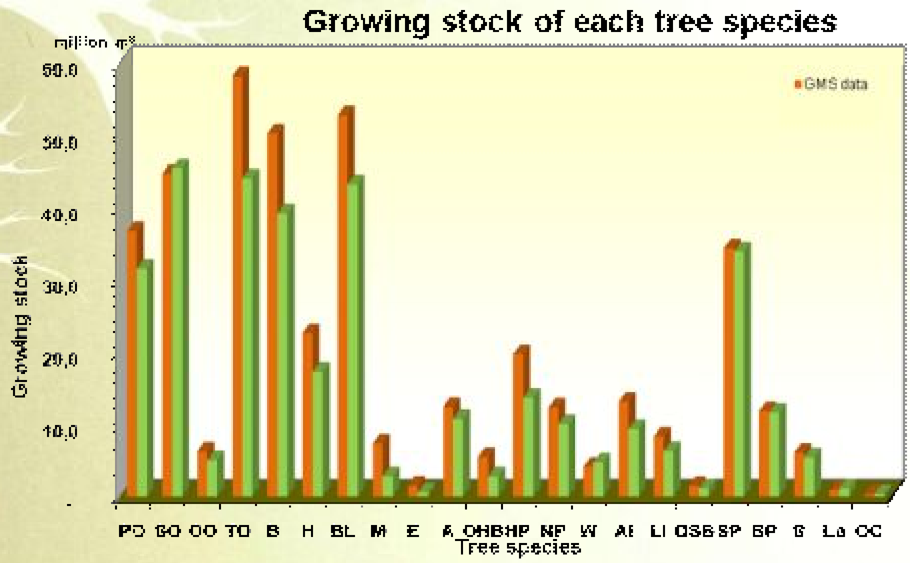
The following table indicates that the same information can be derived from the areal distribution of main tree species groups in percentage when Database and GMS data are compared. As it was expected the different tree species in Hungarian forests are detected more accurately by GMS due to the different method that works with individual trees instead of average stand description. Therefore the main tree species (e.g. pedunculate oak or sessile oak) are a little bit overrepresented in the Database and the so called mixture tree species (e.g. maple or ash) are under represented.

The areal distribution of tree species (e.g. Turkey oak or Beach) which generally constitute a pure stand is higher in GMS. These tree species appear in mixed stands with a canopy cover of 5-10%. The canopy cover above 10% is the threshold for being defined as a stand-alone specimen tree in stand wise inventory.

Tree species groups	GMS	Database
	area %	
Pedunculate oak	8,1	8,4
Sessile oak	8,5	9,7
Other oak	1,7	1,8
Turkey oak	11,8	10,8
Beach	6,2	5,7
Hornbeam	5,2	5,1
Black locust	21,4	22,2
Maple	2,1	0,9
Elm	0,4	0,2
Ash	3,2	2,7
Other hard broadleaves	1,7	1,0
Hybrid poplars	6,5	6,7
Native poplars	3,3	3,3
Willow	1,0	1,2
Alder	2,7	2,7
Lime	1,7	1,1
Other soft broadleaves	0,5	0,3
Scots pine	7,1	7,1
Black pine	3,5	3,6
Spruce	1,0	1,1
Larch	0,2	0,2
Other conifer	0,1	0,1
Unstocked	2,1	3,9
Total	100,0	100,0

11.4.3. Growing stock

The following diagram illustrates the comparison of growing stock data from the third GMS measurement period with related Database data.



Comparison of growing stock of each tree species according to the GMS and Forest Database data

The table below shows the above comparison expressed in figures with the respective confidence interval.

Tree species group	Database	GMS		
	Growing stock m3		Confidence interval *	
Pedunculate oak	**31 627 338**	**36 821 012**	*33 936 154*	*39 705 870*
Sessile oak	**45 561 519**	**44 763 593**	*41 975 536*	*47 551 650*
Other oak	**5 003 616**	**6 211 970**	*5 328 999*	*7 094 940*
Turkey oak	**44 114 287**	**58 245 623**	*54 976 705*	*61 514 540*
Beach	**39 292 680**	**50 349 397**	*46 160 323*	*54 538 471*
Hornbeam	**17 305 794**	**22 654 864**	*21 131 416*	*24 178 312*
Black locus	**43 304 812**	**52 884 406**	*50 375 559*	*55 393 253*
Maple	**2 791 230**	**7 353 375**	*6 636 305*	*8 070 444*
Elm	**569 238**	**1 496 359**	*1 088 198*	*1 904 520*
Ash	**10 735 493**	**12 404 988**	*11 107 168*	*13 702 809*
Other hard broadleaves	**2 766 909**	**5 493 088**	*4 850 827*	*6 135 349*
Hybrid poplars	**13 668 191**	**19 732 421**	*17 665 004*	*21 799 839*
Native poplars	**10 037 871**	**12 323 456**	*10 605 952*	*14 040 961*
Willow	**4 728 472**	**4 132 411**	*3 274 239*	*4 990 583*
Alder	**9 366 390**	**13 155 942**	*11 292 899*	*15 018 986*
Lime	**6 283 411**	**8 295 164**	*7 305 762*	*9 284 565*
Other soft broadleaves	**1 154 779**	**1 473 780**	*1 110 625*	*1 836 935*
Scots pine	**34 016 525**	**34 440 069**	*31 905 327*	*36 974 810*
Black pine	**11 643 649**	**11 843 730**	*10 485 336*	*13 202 123*
Spruce	**5 417 129**	**6 070 014**	*4 742 390*	*7 397 638*
Larch	**1 128 121**	**854 263**	*560 487*	*1 148 039*
Other conifer	**317 916**	**263 782**	*134 345*	*393 220*
Total	**340 835 370**	**411 263 707**	*404 397 824*	*418 129 589*

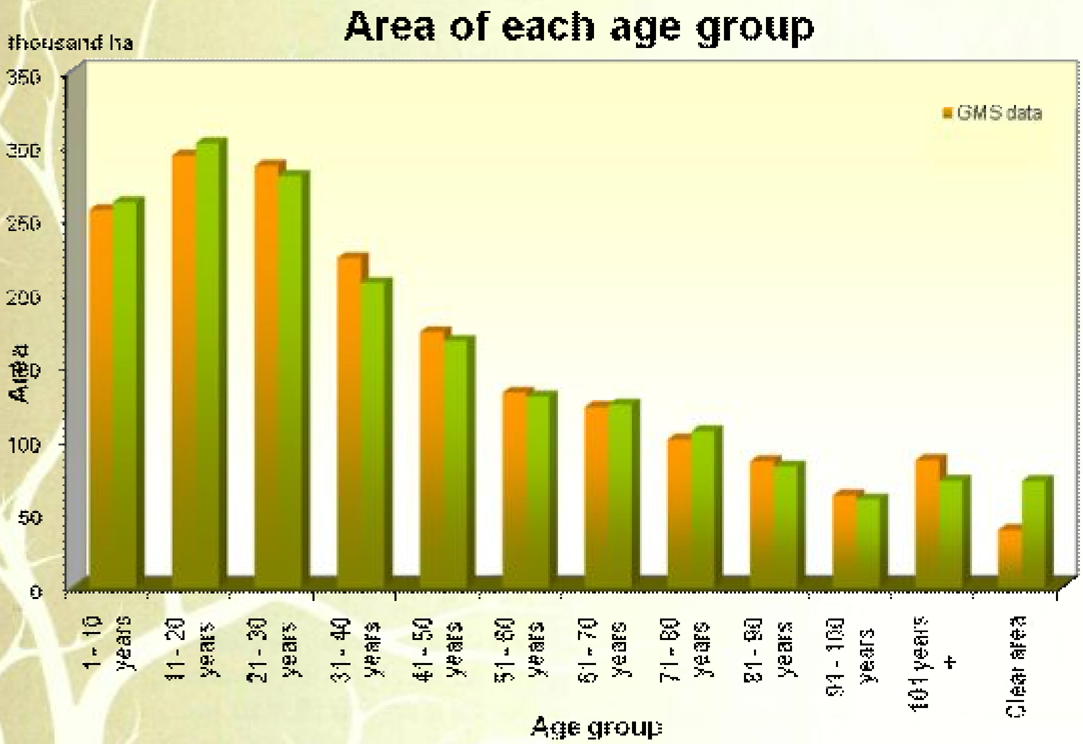
* $\alpha=0,05$

The almost 70 million m3 difference is considerable at first glance. However it has to be emphasized that **reliable conclusion requires more detailed result evaluation as the data collection methods of GMS and the Database are different**.

More analysis will be done at the evaluation of time series data.

11.4.4. Age class distribution

The following diagram illustrates the comparison of area data by age classes from the third GMS measurement period with related Database data.



Comparison of the area of each age groups according to the GMS and Forest Database data

The respective values of GMS and the Database are nearly the same with the exception of trees in the oldest (above 100 year) age class. Not only the remnant tree, but the related – sometimes overrepresented - area is included in GMS. On the contrary the area is not recorded in the Database. Further difference can be detected in empty area data. While an empty area is defined as a totally empty area in GMS; in the Database empty area includes areas of trees with incomplete canopy closure.

11.4.5. Tree species distribution

As it was mentioned above only tree species with a mixture rate above 5% are recorded in stand-wised inventory, while GMS method ensures more detailed information by recording tree species with a lower mixture rate. The following table of figures on the tree species distribution of Hungarian forests gives a more complete and detailed information about the diversity of Hungarian forest and the presence of rare tree species.

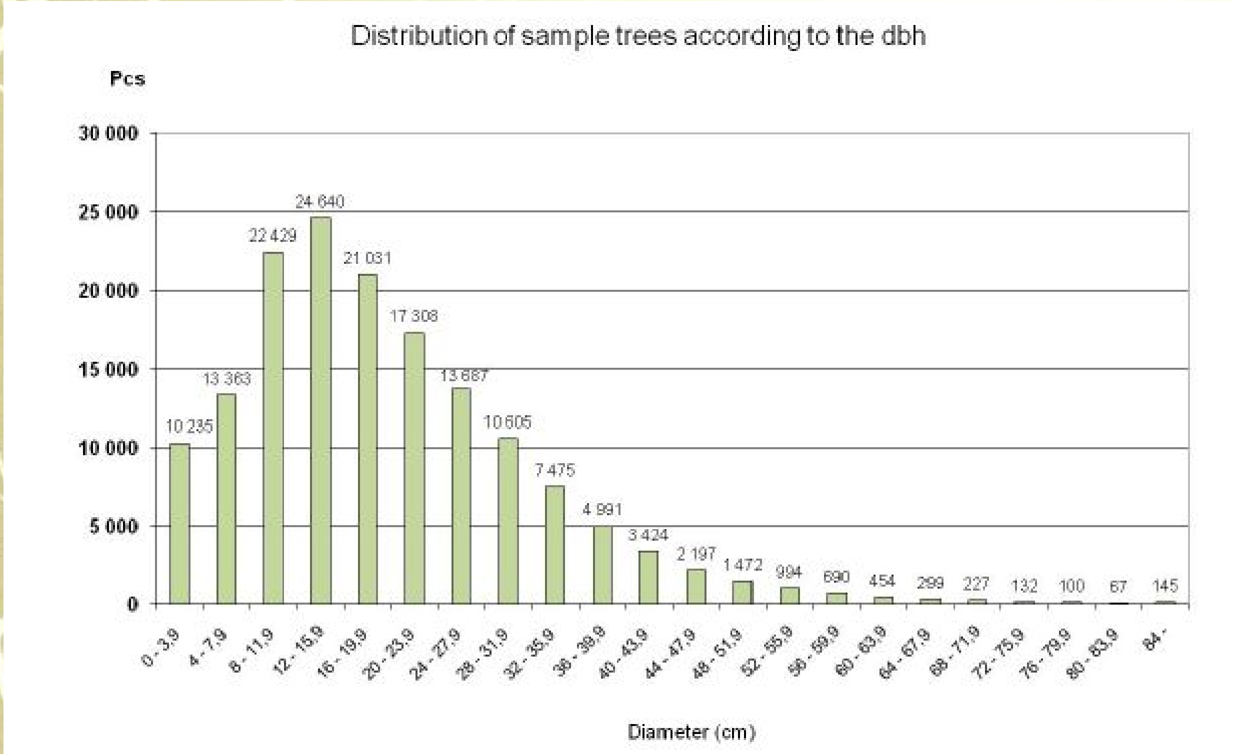
Tree species	Area				
	hectare	(a = 0.05)			%
Pedunculate oak	149 894	140 972	-	158 817	8.1
Slavonian oak	490	0	-	991	0.03
Sessile oak	158 709	150 184	-	167 233	8.5
Downy oak	20 148	17 358	-	22 938	1.1
Red oak	11 955	9 435	-	14 474	0.6
Swamp Spanish oak	15	0	-	40	0.0008
Other oaks	99	0	-	214	0.005
Turkey oak	220 265	210 241	-	230 288	11.8
Beach	116 201	108 382	-	124 020	6.2
Other beach	13	0	-	38	0.0007
Hornbeam	96 514	91 077	-	101 951	5.2
Other hornbeam	16	0	-	41	0.0009
Black locust	391 692	377 250	-	406 134	21.6
Appalachia black locust	30	0	-	74	0.002
Császártöltési black locust	19	0	-	46	0.001
Kiskunsági black locust	32	0	-	94	0.002
Nyírségi black locust	190	0	-	563	0.01
Zalai black locust	190	0	-	561	0.01
Kiscsalai black locust	2	0	-	5	0.00009
Great maple	6 044	4 708	-	7 379	0.3
Norway maple	4 397	3 345	-	5 449	0.2
Common maple	23 197	20 862	-	25 531	1.2
Manitoba maple	5 205	3 843	-	6 567	0.3
Silver maple	510	132	-	889	0.03
Tatarian maple	47	0	-	116	0.003
Other maple	442	291	-	592	0.02
Mountain elm	609	260	-	959	0.03
Field elm	4 469	3 515	-	5 422	0.2
Fluttering elmil	1 528	997	-	2 058	0.08
Siberian elm	1 738	859	-	2 616	0.09
Common ash	26 786	23 650	-	29 923	1.4
Hungarian ash	8 639	6 713	-	10 565	0.5
Red ash	7 380	5 592	-	9 169	0.4
Flowering ash	17 486	15 209	-	19 763	0.9
Black walnut	6 308	4 578	-	8 038	0.3
Common walnut	2 899	1 997	-	3 801	0.2
Wild cherry	4 470	3 634	-	5 306	0.2
Mahaleb cherry	553	193	-	913	0.03
Ground cherry	45	0	-	123	0.002
Hangberry	474	258	-	690	0.03
Black cherry	3 033	2 224	-	3 842	0.2
European Wild Apple	293	143	-	443	0.02
Wild pear	2 129	1 594	-	2 663	0.1
White mulberry	1 573	962	-	2 183	0.08
Mountain ash	155	0	-	408	0.008
Service tree	18	0	-	38	0.001
Common whitebeam	123	0	-	283	0.007
Wild service tree	2 511	1 877	-	3 145	0.1

Sweet chestnut	825	292	-	1 358	0.04
London plane	290	0	-	593	0.02
Oriental hackberry	106	0	-	275	0.006
Western hackberry	2 414	1 602	-	3 225	0.1
Honey locust	582	152	-	1 012	0.03
Honey tree	15	0	-	44	0.0008
Russian silverberry	2 026	1 104	-	2 948	0.1
Pride of India	21	0	-	54	0.001
Turkish Hazel	6	0	-	18	0.0003
Other hard broadleaves	1 652	793	-	2 512	0.09
Marilandica poplar	4 458	2 921	-	5 995	0.2
Serotina poplar	213	0	-	538	0.01
Robusta poplar	9 989	7 548	-	12 429	0.5
Italian poplar	26 270	22 095	-	30 444	1.4
Regenerata poplar	271	0	-	570	0.01
Gelrica poplar	9	0	-	24	0.0005
Other hybrid poplars	6 460	4 353	-	8 567	0.3
Blanc du Poitou poplar	206	0	-	604	0.01
BL poplar	2 110	963	-	3 257	0.1
Pannonia (H-490/3) poplar	46 410	40 749	-	52 072	2.5
Agathe F (OP-229) poplar	16 582	13 193	-	19 972	0.9
I-45/51 poplar	1 283	319	-	2 248	0.07
I-154 poplar	4	0	-	11	0.0002
I-273 poplar	285	0	-	702	0.02
H-328 poplar	410	0	-	973	0.02
S-611-c poplar	56	0	-	134	0.003
Tripló poplar	254	0	-	550	0.01
Kopecky (H-490/4) poplar	747	14	-	1 481	0.04
Favourite poplar	10	0	-	28	0.0005
I-58/57 poplar	2 653	1 435	-	3 871	0.1
White poplar	7 009	5 036	-	8 981	0.4
Grey poplar	47 146	42 196	-	52 097	2.5
Aspen	2 858	1 773	-	3 942	0.2
Black poplar	4 326	3 141	-	5 511	0.2
Lombardy poplar	52	0	-	151	0.003
Other poplars	2 227	1 041	-	3 414	0.1
Bédai willow	1 354	448	-	2 261	0.07
I-1/59 willow	203	0	-	601	0.01
Veliki Bajar willow	42	0	-	112	0.002
White willow	16 058	13 102	-	19 014	0.9
Weeping willow	94	0	-	238	0.005
Crack willow	86	0	-	223	0.005
Goat willow	587	326	-	849	0.03
Other willows	55	0	-	136	0.003
Common alder	50 760	45 123	-	56 397	2.7
Grey alder	137	21	-	254	0.007
Green alder	5	0	-	16	0.0003

Small-leaved lime	14 903	12 910	-	16 896	0.8
Large-leaved lime	3 799	2 711	-	4 887	0.2
Silver lime	12 514	10 273	-	14 756	0.7
Silver birch	5 147	3 742	-	6 551	0.3
Horse-chesnut	353	0	-	748	0.02
Ailanthus	3 037	1 950	-	4 124	0.2
Cigartree	3	0	-	8	0.0001
Other softbroadleaves	8	0	-	25	0.0004
Scots pine	130 798	122 255	-	139 341	7
White pine	1 000	243	-	1 758	0.05
Alföldi scots pine	33	0	-	68	0.002
European black pine	65 582	59 287	-	71 876	3.5
Jack pine	12	0	-	36	0.0006
Káli jack pine	33	0	-	78	0.002
Albertirsai jack pine	86	25	-	148	0.005
Norway spruce	19 125	15 811	-	22 439	1
Várbükki Norway spruce	6	0	-	15	0.0003
European larch	3 977	2 750	-	5 204	0.2
Douglas-fir	214	32	-	397	0.01
Rocky mountain Douglas-fir	199	0	-	589	0.01
Silver fir	41	0	-	96	0.002
Nordmann fir	5	0	-	15	0.0003
Common juniper	637	195	-	1 078	0.03
Red cedar	78	0	-	231	0.004
Lawson's cypress	241	0	-	636	0.01
Northern whitecedar	26	0	-	76	0.001
Other conifers	366	0	-	754	0.02
Unstocked	38 761	33 322	-	44 200	2.1
Total	1 860 127				100

11.4.6. DBH distribution

The GMS diameter data of individual sample trees ensured that the representative tree diameter distribution data are available for the country. The diagram below shows the tree diameter distribution data obtained by the individual method in the third GMS measurement period..

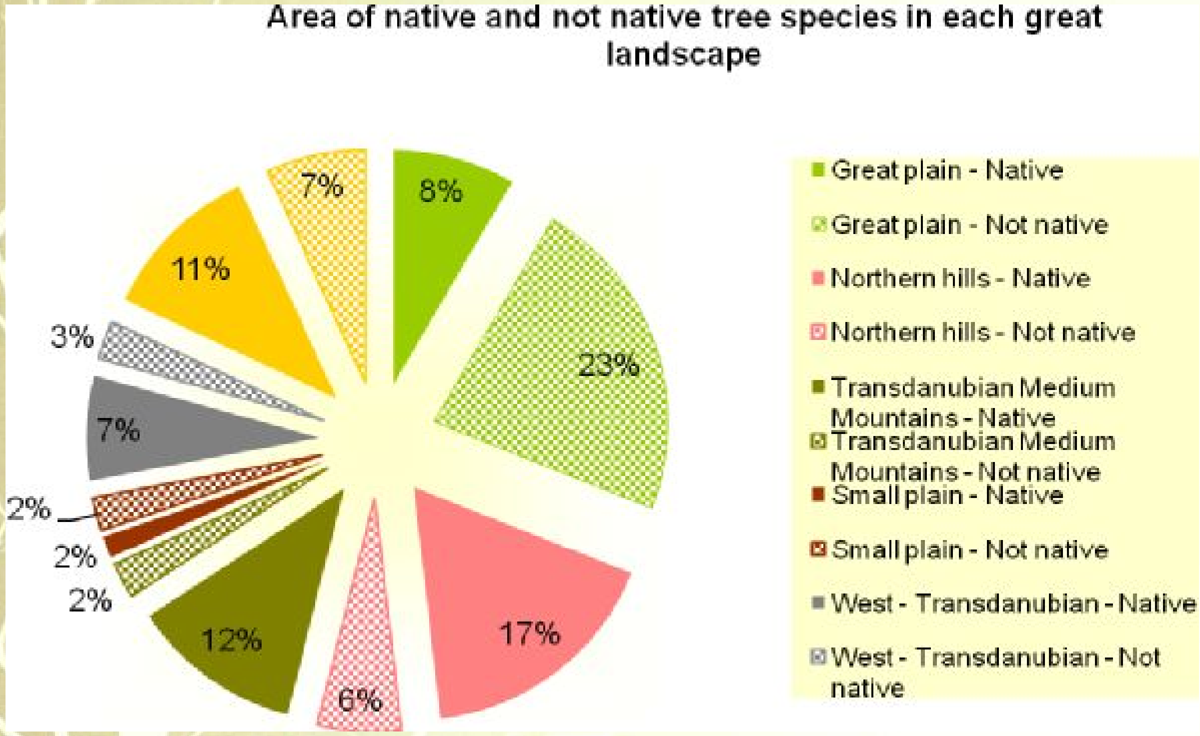


Number of sample trees in each dbh group

11.4.7. Indigenousness

The concept of naturalness or close-to nature became more emphasized and important recently. The indigenousness is one of the determining components of this concept. Classification of tree species is based on the classification of forest region developed by Dr. Bartha – Dr Standovár – Dr. Tímár. It can be stated that 58,5 % of the tree species in Hungary are native or to be more exact native not only to Hungary but to region as well.

The following diagram illustrates the areal distribution of native and non-native tree species grouped by forest regions. (It has to be noted that unstocked areas are included in non-native areas.)



Area of native and not native tree species according to the forest landscapes

The following table illustrates the areal distribution of native and non-native tree species. Unstocked areas are listed as well.

Tree species group	Not native ha	Not native %	Native ha	Native %
PO	490	0,07%	149 894	14,05%
SO	26	0,01%	158 683	14,87%
OO	12 252	1,63%	19 965	1,88%
TO	1 905	0,26%	218 360	20,46%
B	13	0,01%	116 201	10,90%
H	16	0,01%	96 514	9,05%
BL	392 154	51,84%	-	0,00%
M	7 296	0,97%	32 545	3,06%
E	1 738	0,23%	6 606	0,62%
A	10 917	1,45%	49 374	4,64%
OHB	21 591	2,86%	10 929	1,03%
HP	120 906	15,98%	-	0,00%
NP	677	0,09%	60 714	5,70%
W	1 782	0,24%	16 696	1,57%
A	19	0,01%	50 884	4,78%
Li	416	0,06%	30 800	2,89%
OSB	3 401	0,46%	5 147	0,49%
SP	95 995	12,68%	35 837	3,37%
BP	65 712	8,70%	-	0,00%
S	13 154	1,75%	5 976	0,57%
La	3 977	0,53%	-	0,00%
OP	1 137	0,16%	670	0,07%
Total	755 574	100,00%	1 065 795	100,00%
Empty area	*38 761*	4,9		

The abbreviations are explained in Annex I.

11.4.8. Shrubs

During field surveys in the third GMS measurement period the assessment of the understory layer was conducted. The detailed shrub layer description included not only shrubs but trees as well. From data obtained in field surveys only data on the species composition of shrub layer and the dominance of species are presented in the following table. Dominance value indicates the number of sampling plots that is composed of the given shrub species. (In case of italic letters the scientific name was used.)

English/ *Scientific* name	Dominance
Hoptree/ *Ptelea trifoliata*	1
Golden currant/ *Ribes aureum*	12
Spurge laurel/ *Daphne laureola*	24
Rough-stemmed spindle tree/ *Euonymus verrucosa*	159
Common ivy/ *Hedera helix*	208
Purple willow/ *Salix purpurea*	2
May hawthorn/ *Aestivalis*	242
Spindle tree/ *Euonymus*	583
Smoketree/ *Cotinus*	17
Common hawthorn/ *Crataegus monogyna*	2 987
Old man's beard os Traveller's Joy/ *Clematis vitalba*	323
Wild privet/ *Ligustrum vulgare*	1 996
Garland Flower/ *Daphne mezereum*	33
Black elder/ *Sambucus nigra*	1 916
Black honeysuckle/ *Lonicera nigra*	2
Black current/ *Ribes nigrum*	1
Deciduous Shrub Cytisus/ *Cytisus nigricans*	1
European dewberry/ *Rubus caesius*	564
European cornel/ *Cornus mas*	686
Green alder/ *Alnus viridis*	1
Italian Honeysuckle/ *Lonicera caprifolium*	11
Water elder/ *Viburnum opulus*	30
Alder buckthorn/ *Rhamnus frangula*	222
Indigo bush, False indigo/ *Amorpha fruticosa*	179
Basket willow/ *Salix viminalis*	1

English/*Scientific* name	Dominance
Thicket Creeper, Grape Woodbine *Parthenocissus inserta*	3
Blackthorn/ *Prunus spinosa*	1 045
Butcher's Broom/ *Ruscus hypoglossum*	2
Wild grape, grapevine of the woods/ *Vitis sylvestris*	2
Oregon grape/ *Mahonia aquifolium, Berberidaceae*	10
Common hazel/ *Corylus avellana*	384
Bladdernut/ *Staphylea trifolia*	36
Brambles/ *Rubus canescens*	1
Raspberry/ Rubus idaeus	85
Wayfaring tree/ Viburnum lantana	109
Common lilac/ *Syringa vulgaris*	4
Bladder senna/ *Colutea arborescens*	4
Grey willow/ *Salix cinerea*	2
Barberry/ *Berberis vulgaris*	238
Rosemary leaf Willow/ *Salix rosmarinifolia*	1
Common broom/ *Cytisus scoparius*	8
Butchers Broom, Ruscus/ *Ruscus aculeatus*	23
Blackberry/ *Rubus ursinus*	2 357
Snow Storm Spirea/ *Spiraea media*	1
Buckthorn/ *Rhamnus*	105
Common dogwood/ *Cornus sanguinea*	958
Gooseberry/ *Phyllanthus niruri L.*	400
Dog rose/ *Rosa canina*	1 713
Redcurrant/ *Ribes rubrum*	3
Fly honeysuckle/ *Lonicera canadensis*	3

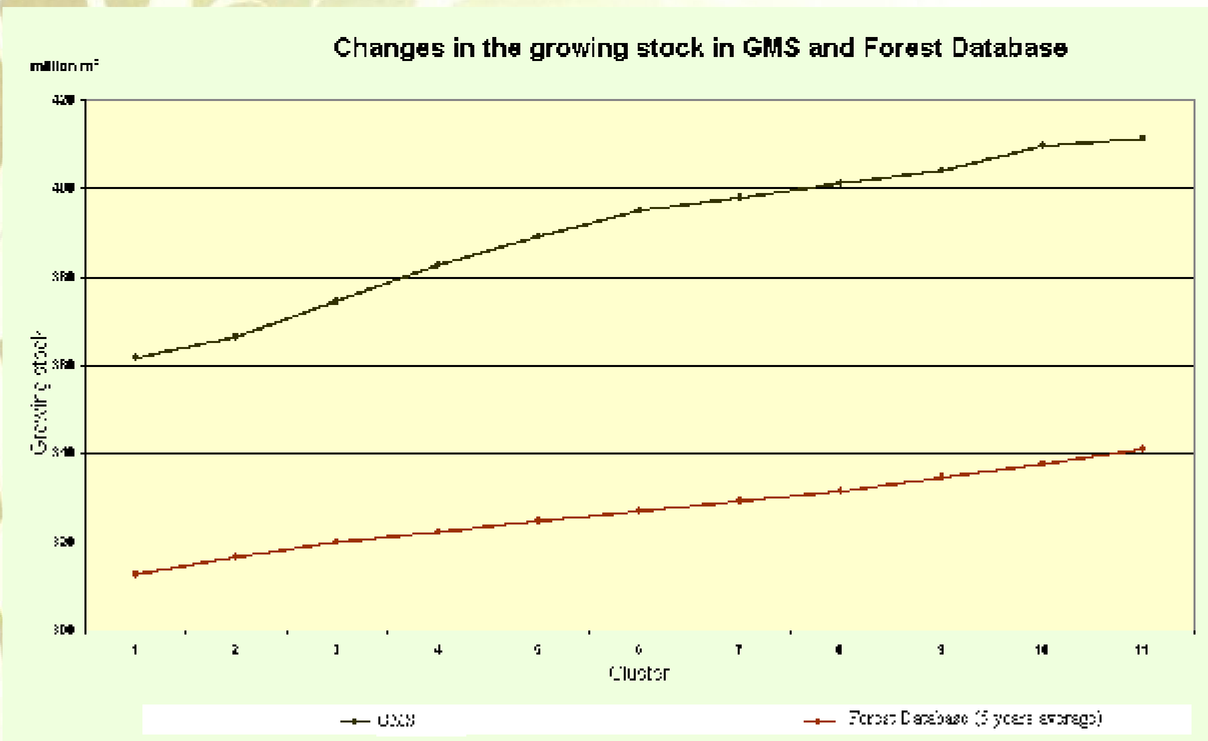
In the first GMS measurement period herbs were recorded too. The collected data provide useful information on the spread and dominance of herb species.

11.4.9. Time series – Growing stock change

The assessment (the three GMS measurement periods on plots) with the five-year interval of measurements over 15 years provide information on three increment periods, which is required before reliable information on increment change can be obtained. For 15 years inventory was conducted as a continuous forest inventory, therefore the longer time series of repeated measurements are more accurate with higher resolution in time and providing possibilities to reconstruct past development. The 15 years of continuous assessment enables the construction of eleven groups (periods of five years) by starting groups with each measurement year from 1993/1994 until 2003/2004, therefore to detect changes more accurately without the loss of representativity. The following table presents the periods.

Number of set	Period covered	1993/ 1994	1994/ 1995	1995/ 1996	1996/ 1997	1997/ 1998	1998/ 1999	1999/ 2000	2000/ 2001	2001/ 2002	2002/ 2003	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008
1	1993/1994 - 1997/1998															
2	1994/1995 - 1998/1999															
3	1995/1996 - 1999/2000															
4	1996/1997 - 2000/2001															
5	1997/1998 - 2001/2002															
6	1998/1999 - 2002/2003															
7	1999/2000 - 2003/2004															
8	2000/2001 - 2004/2005															
9	2001/2002 - 2005/2006															
10	2002/2003 - 2006/2007															
11	2003/2004 - 2007/2008															

The following diagram illustrates the growing stock change over 15 years of GMS.



Changes in growing stock in GMS and Forest Database

There is many different way of interpreting the significant difference in the growing stock values calculated from GMS and Database data and in the slope of curves. The most probable explanation is described below.

It is an **established fact in Europe that the calculated growing stock value is 10-30% higher in the so called systematic inventory than in the stand-wise inventory** due to fewer possibilities for subjectivity in individual tree measurement compared to assessment of the stand as a whole. Yield tables that are generally used for stand-wise inventory calculation have lower increment values than in reality and are unable to follow growth tendencies in forest stands.

Based on data above the calculated growing stock value is 20,66% higher in the so called systematic inventory than in the stand-wise inventory. Additional evaluation is required to find further evidence to support and accept without uncertainty the above mentioned explanations. Evidence-based explanations are very important because conclusions will be drawn based on findings. All necessary measures (e.g. the revision of application of yield tables (if necessary)) shall be taken to ensure reliability and validity in assessments.

Forests have been exposed to environmental changes. These can arise naturally or as a result of human activities. Natural environmental changes and human activities have altered forest growth for centuries. Recent long-term growth investigations indicate an increasing growth trend in European forests. The influences that may change forest ecosystems considerably are detected by some experts as the possible effects of atmospheric deposition as for example nitrogen, of changes in tropospheric air chemistry like the concentration of CO2, in radiation, in air temperature and in other site factors on forest ecosystems.

The long-term increase of growth is clearly indicated on the above curve based on GMS data.

The question of accelerating forest growth was raised many decades ago (e.g. related works of Heinrich Spiecker). As long as neither the causes of the observed growth changes are fully understood nor future development of the causing agents can be predicted the risks involved in these changes cannot be assessed in a reliable way. The amount and complexity of the scientific problems evolving from the observed forest growth trends show that solutions can only be developed by the cooperation of scientists covering various disciplines on a European or world-wide level.

Finally it has to be emphasized that though the revised yield tables were elaborated by Forest Research Institute, they have not been used yet. The application of these yield tables may result in more reliable survey results.

11.4.10. Increment

Additional time and work are necessary to obtain more reliable results on increment. However, based on the available assessment results the calculated increment values are higher in GMS than in the Database. Based on the available GMS data the net annual increment (the average annual volume over the given reference period of gross increment less that of natural losses on all trees) is about 7 million m3 and the annual felling (the average annual standing volume of all trees, living or dead, that are felled during the given reference period) is about 7 million m3, therefore the gross annual increment (the average annual volume of increment) is about 14 million m3.

Since there are many factors effecting forest growth, additional assessments are necessary to confirm the deduced 'truth' with the most subtle of arguments related to the current and future forest growth tendency.

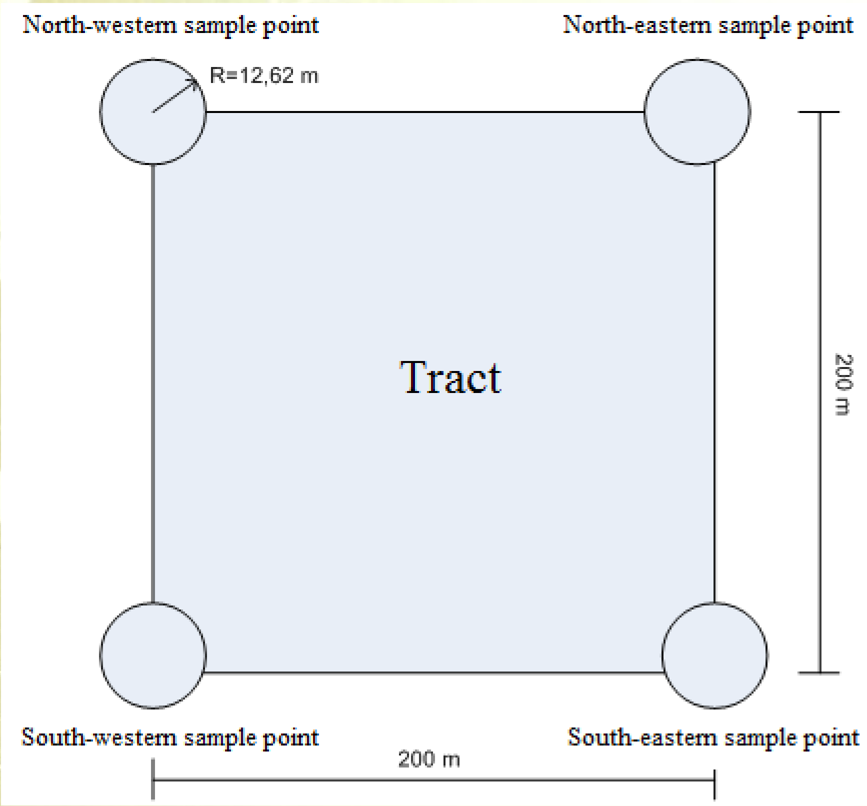
11.5. Future of the Growth Monitoring System

11.5.1. Fourth cycles of the GMS

In response to the conclusions that had been reached through the three GMS measurement periods and in order to meet national and international requirements the applied method of GMS was reconsidered and modified with bearing in mind the need and importance of continuity and consistency in data collection.

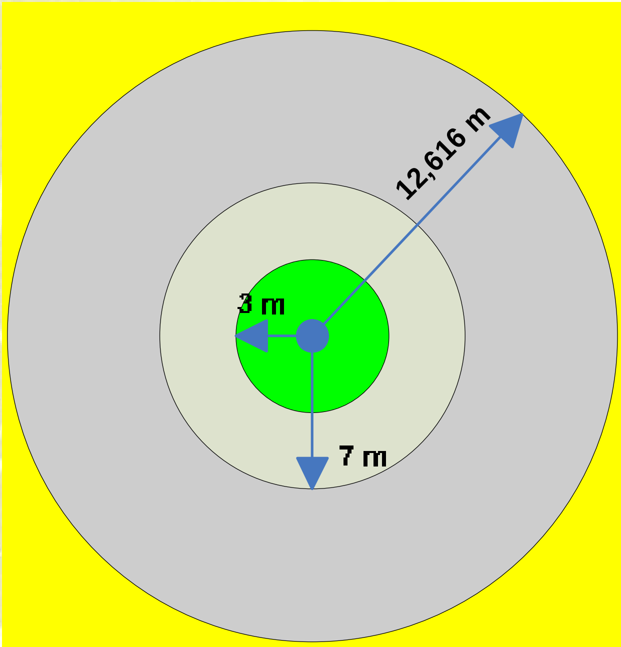
In the frame of a European Union funded project high technology including hardware and software products were purchased. The elements of the geographic information system (GIS) the system that captures, stores, analyses, manages, and presents data with reference to geographic location data, in the simplest terms, the merging of cartography, statistical analysis, and database technology were integrated into GMS. To make distinction between the previously and currently operating systems, they are later referred to as GMS1 and GMS2, respectively.

The sampling grid and the selection of sampling points have not been changed essentially. However, it is worth mentioning that in GMS2 concentric circles were assessed instead of the so called satellite circles.



Tract with its four constant radius sample points

Nevertheless changing the variable sized sampling into a fix, concentric cycle method is a significant modification.

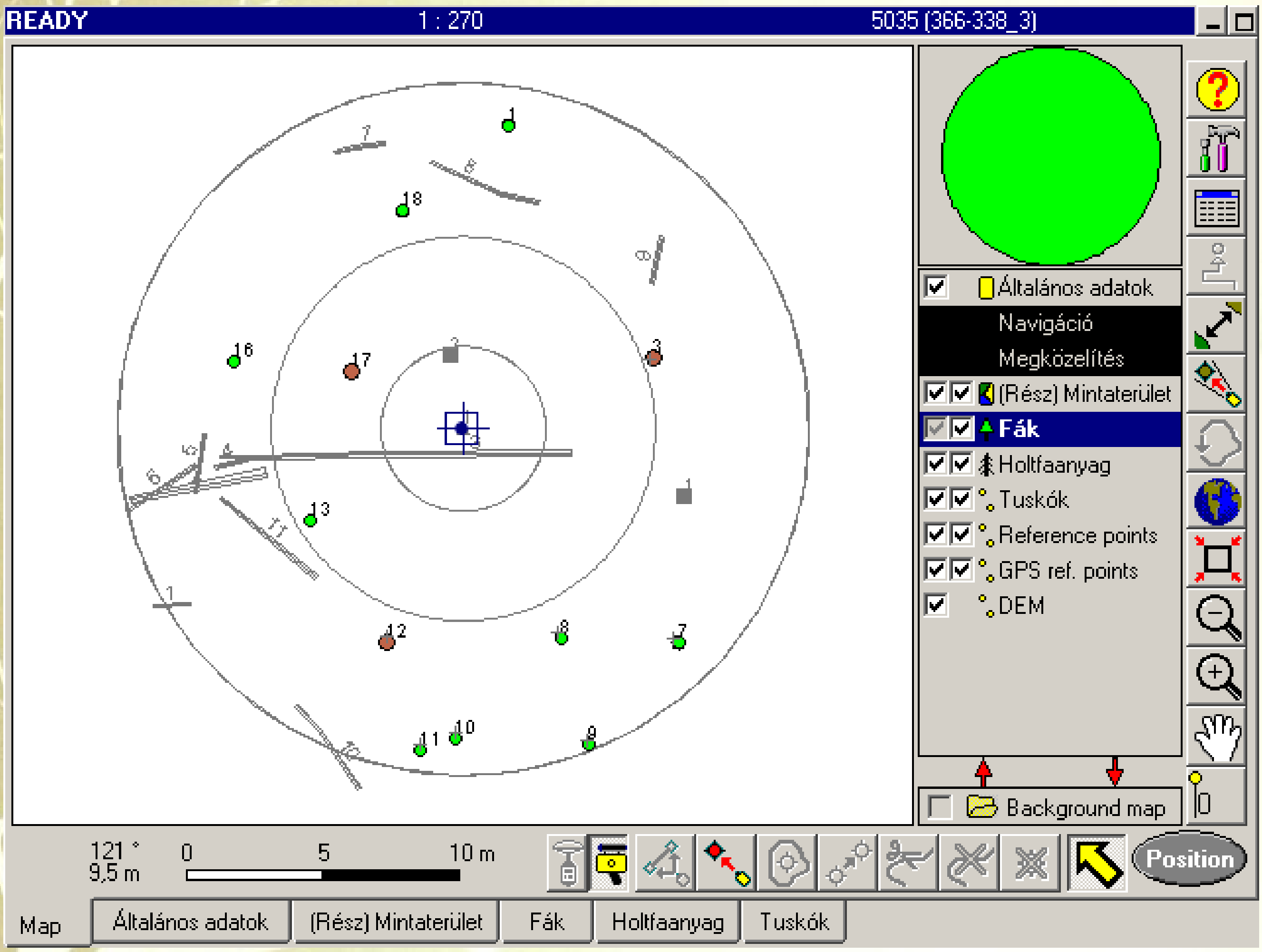


Segments in the 500m^2 sample point

	radius	area	DBH
	m	m^2	cm
1. cycle	3	28,3	> 7
2. cycle	7	154	> 12
3. cycle	12,616	500	> 20

In addition to the previously collected data the indicators of forest naturalness were emphasised. For assessment, different criteria such as the standing and lying dead trees, stumps and the actual and potential forest habitats were used. Point, line, and area data are all stored in a GIS shapefile that is a file format used for storing geographic information data.

Field-Map was used for computer aided field data collection. The picture below illustrates a map layer with the measured trees, lying deadwoods and stumps.



Map layer of the field assessment

Field-Map is based on efficient use of electronic or traditional devices such as

Hammerhead tablet PC
ForestPro laser rangefinder
Mapstar II electronic compass
GeoXH or SXBlue GPS

In the following pictures an SXBlue GPS, an assembled Field-Map hardware set of components, and the training of Field-Map technology for forest engineers can be seen.

SXBlue GPS

Field-Map hardware set

Field-Map training

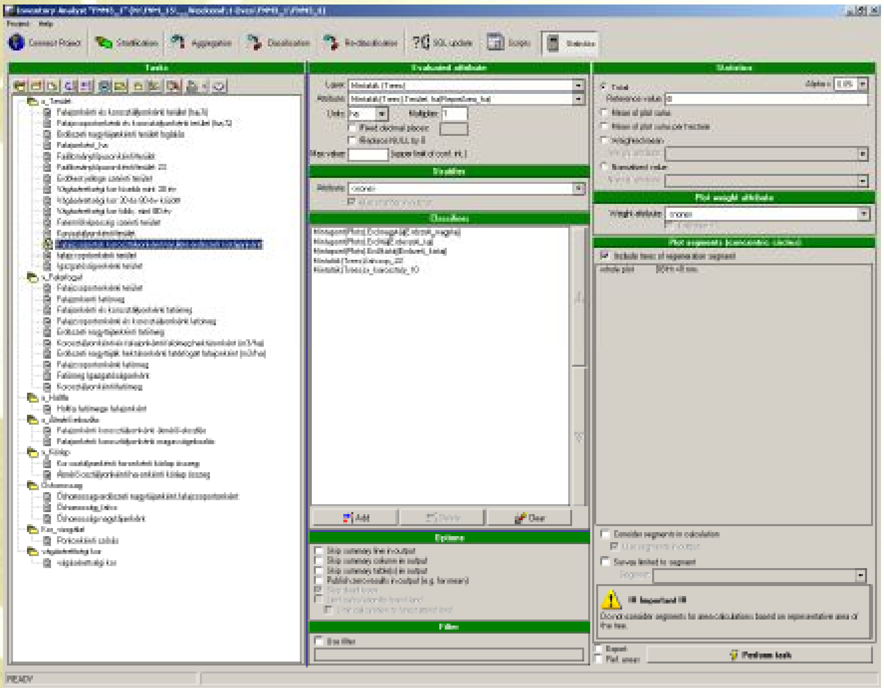
11.5.2. GMS2 data evaluation

The assessment of the first year of the fourth GMS2 measurement period was carried out in 2008-2009. The method of inventory was developed and the appropriate working environment was created to meet the above described requirements.

The evaluation of collected data is in process, but preliminary results are already available due to the computer aided field data collection. Field-Map, the combination of measurement devices with data storage and computing facilities of field computers enables users to obtain maximum effect from technology. Preliminary data should be interpreted with caution given only the one year assessment data.

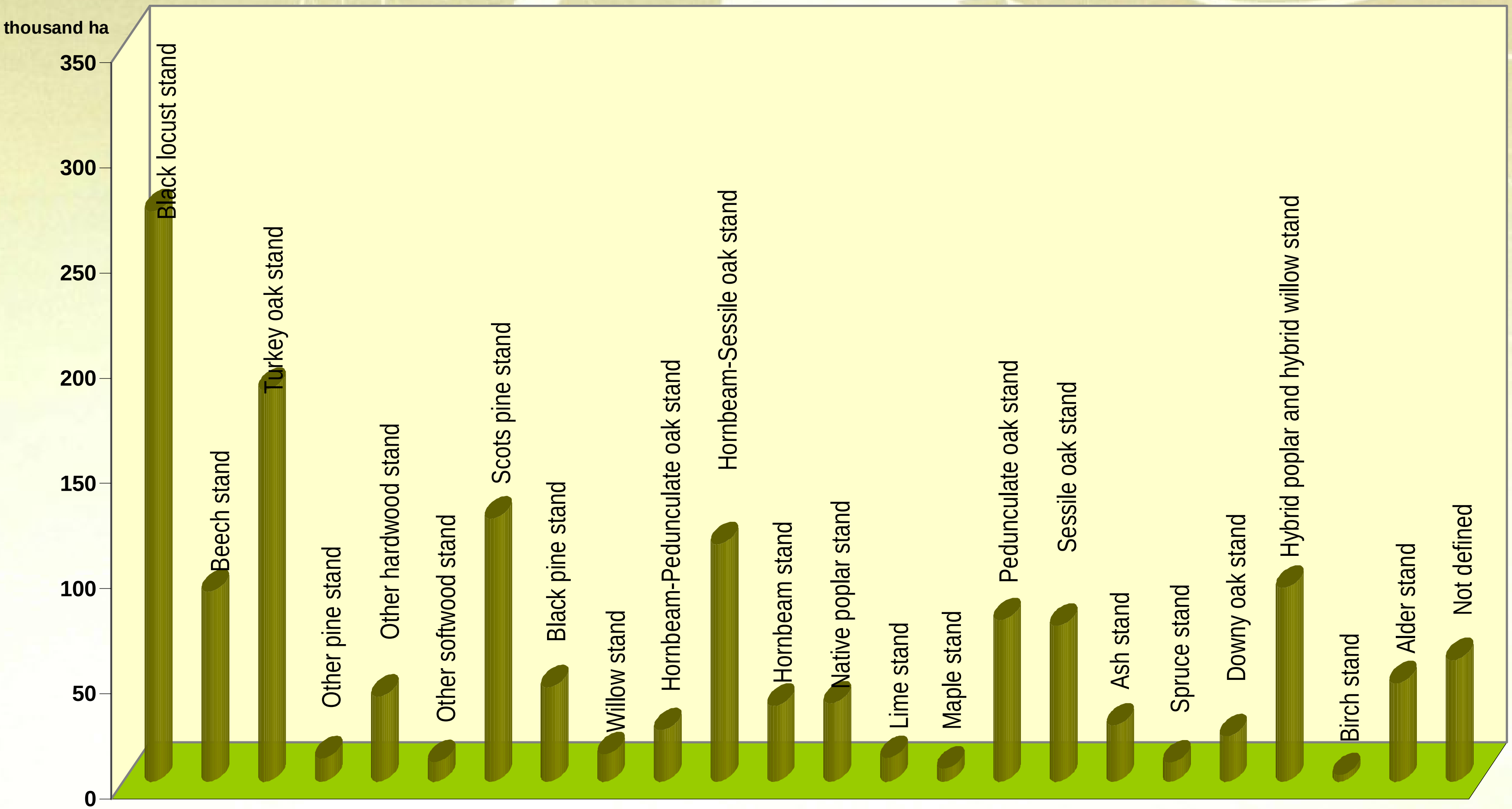
Distribution of the forest associations

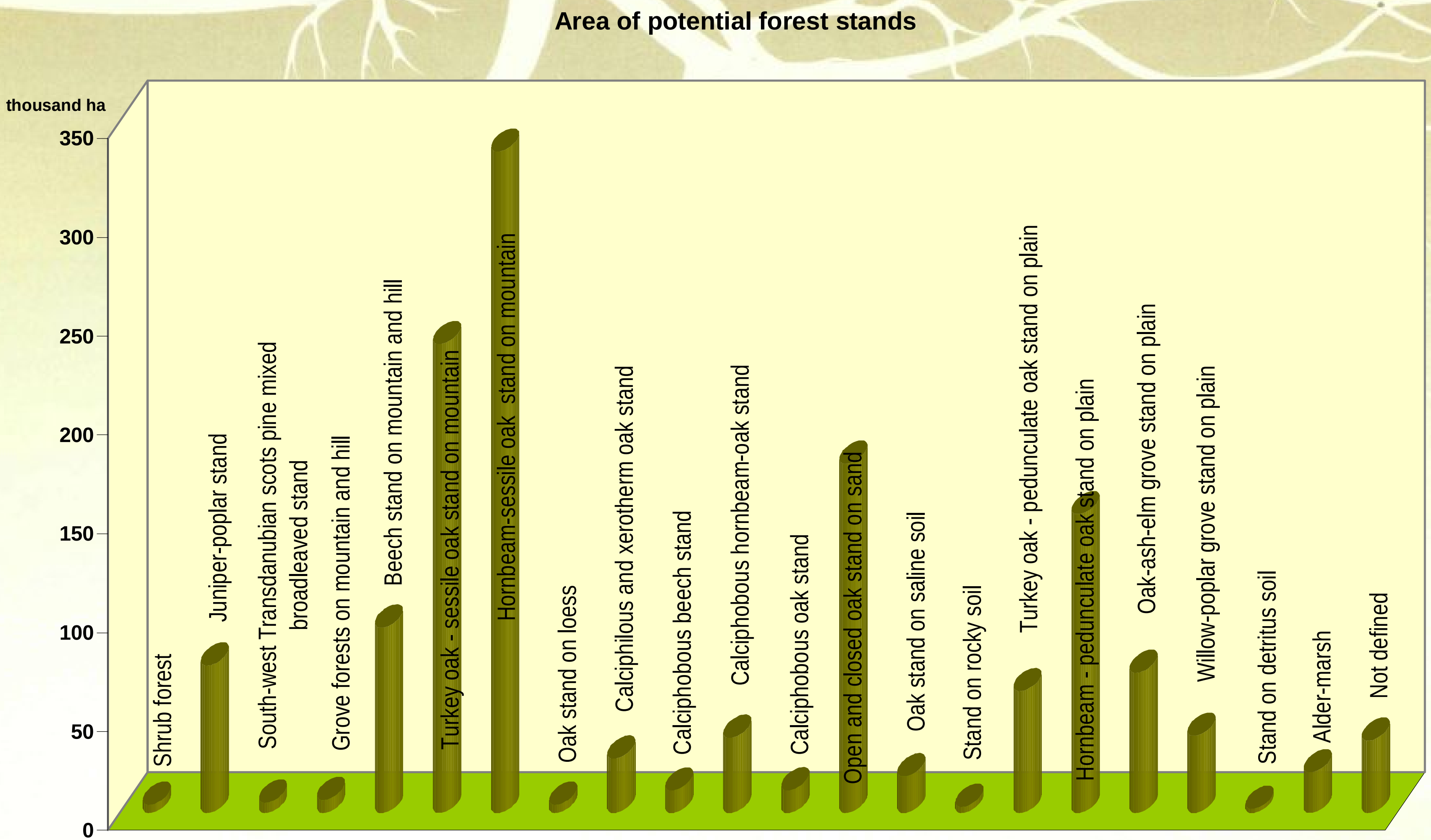
The actual and potential forest types described on each sample plots are presented on the following diagram.



FM Analyst statistics

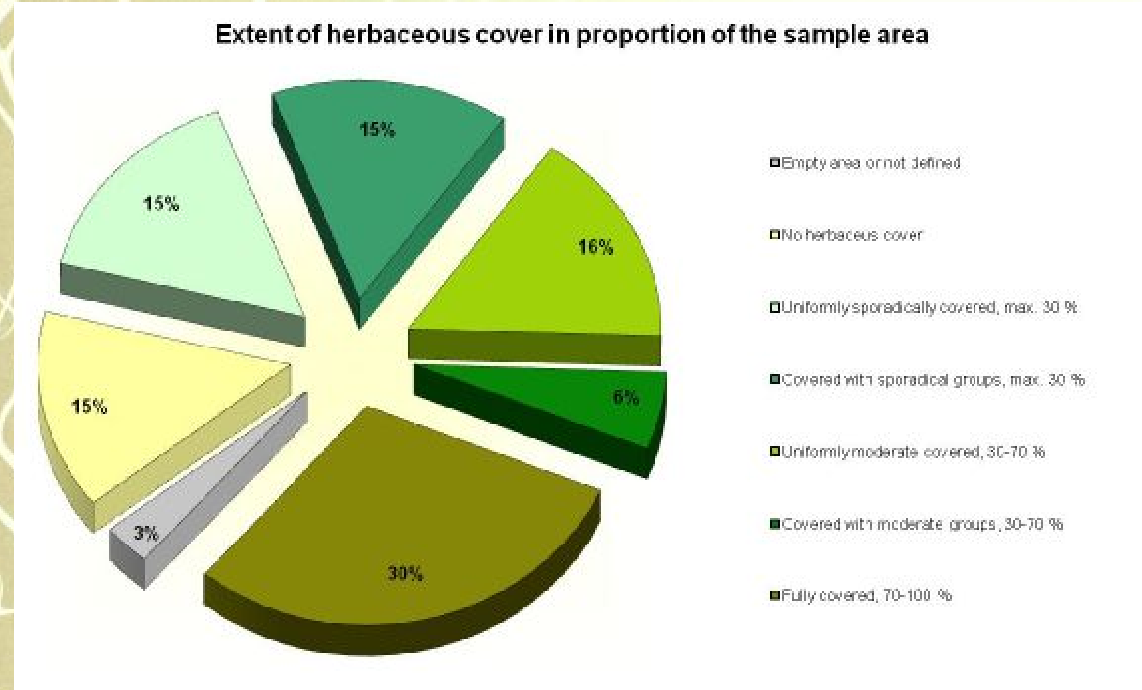
Area of actual forest stands




Area of potential forest stands
thousand ha
350
300
250
200
150
100
50
0
Shrub forest
Juniper-poplar stand
South-west Transdanubian scots pine mixed broadleaved stand
Grove forests on mountain and hill
Beech stand on mountain and hill
Turkey oak - sessile oak stand on mountain
Hornbeam-sessile oak stand on mountain
Oak stand on loess
Calciphilous and xerotherm oak stand
Calciphobous beech stand
Calciphobous hornbeam-oak stand
Calciphobous oak stand
Open and closed oak stand on sand
Oak stand on saline soil
Stand on rocky soil
Turkey oak - pedunculate oak stand on plain
Hornbeam - pedunculate oak stand on plain
Oak-ash-elm grove stand on plain
Willow-poplar grove stand on plain
Stand on detritus soil
Alder-marsh
Not defined

Herbaceous plant communities

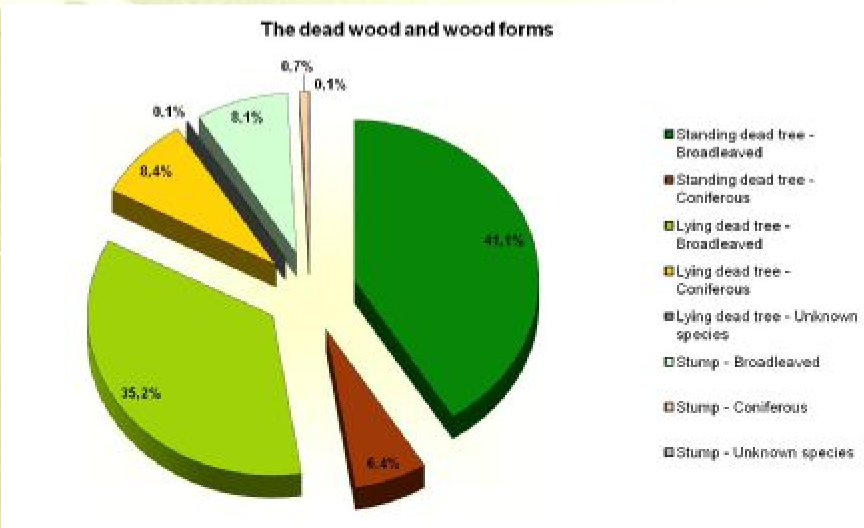
The forest inventory based herbaceous plant assessment provides reliable data on herbaceous communities demonstrated below. These plants are less conspicuous in forests but are the most important elements in the open habitats, where they frequently cover the entire ground and dominate the scene in number of both species and individuals.



Distribution of herbaceous cover

Distribution of deadwood

Hungarian national inventory did not monitor forest deadwood before GMS2. The figures obtained on this topic are for groups such as stumps, standing and lying deadwood. The distribution of about 17 million m^3 deadwood is indicated on the following diagram.

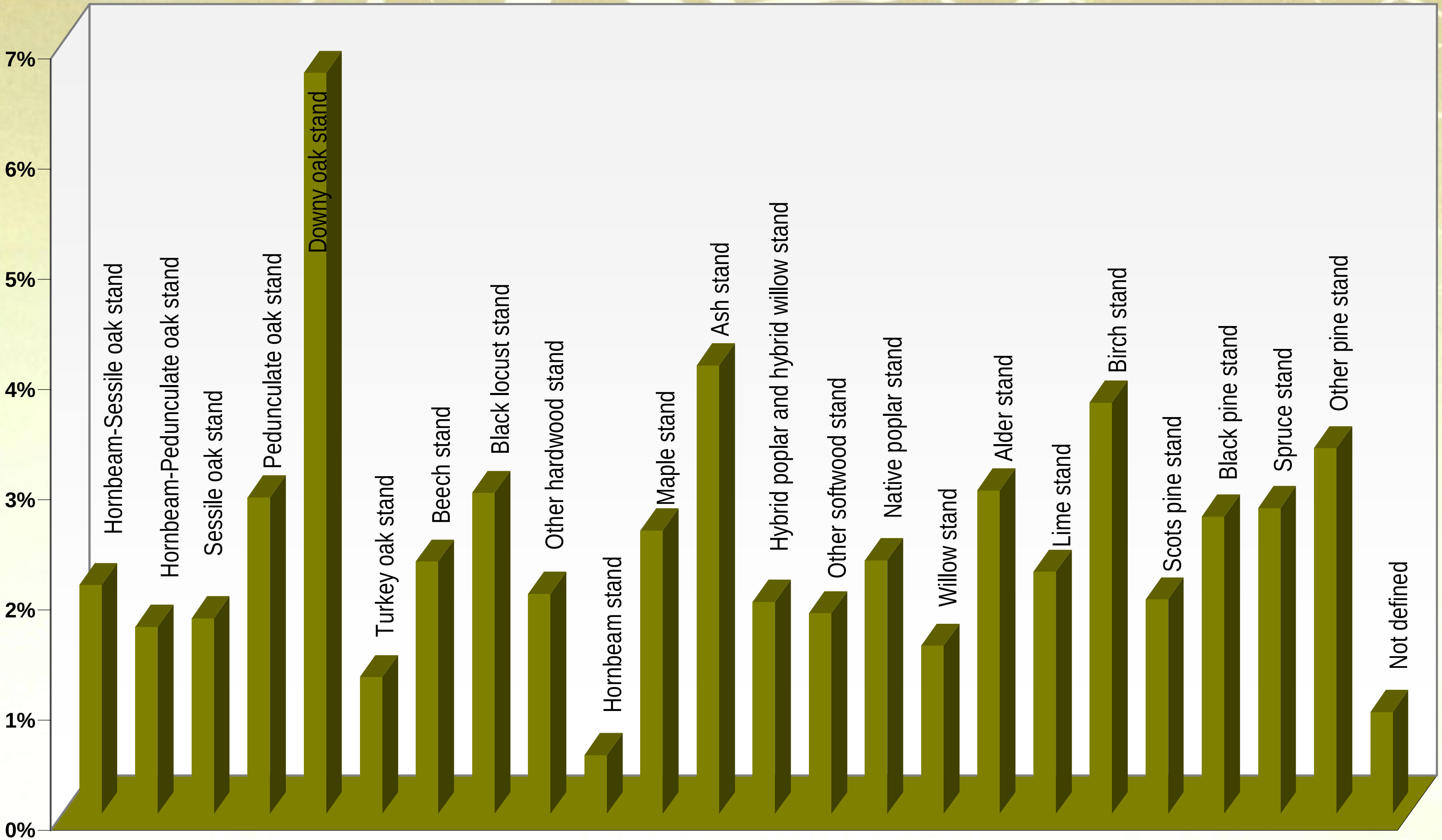


Distribution of dead tree forms

The photo below shows the Native forest in the Beech Mountain.

Standing dead tree

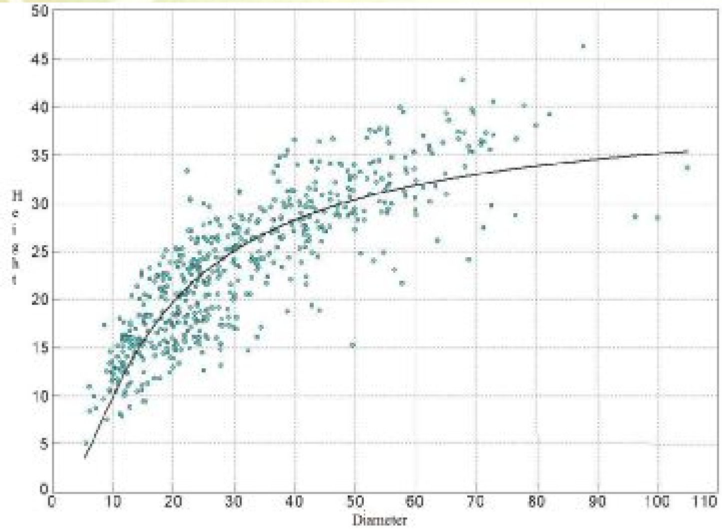
Rate of deadwood volume in each stands according to the total volume of growing stock



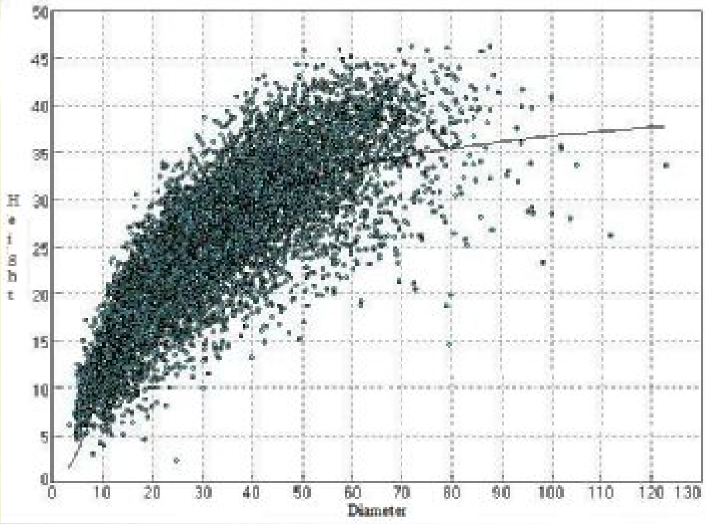
11.5.3. The further utilization opportunities of GMS data

The analysis of forest inventory data showed enormous deviation from the yield tables. Such differences most likely pose consequences for the use of information contained in these traditional tables for forest management in certain forest regions.

The use of correction factor (the ratio between stand yield table and observed data collected through forest inventory) to derive the potential growth of individual trees from the average yield table growth of trees in a stand with a given site index might be the solution for the problem of deviation mentioned above. The construction and development of yield tables (interregional, regional yield tables, local and site productivity tables) requires long-term measurements with special attention to the actual forest management practices in order to serve the main purpose of yield tables that is to provide estimates of present yield and future increment and yield. For the compilation of yield tables the GMS data are available and valuable. The following diagram illustrates the difference in forest growth trends for a given tree species when local and country data are compared.



Transformed curve from the set of points that represent height data for beech species in the region of Börzsöny (a mountain range in Northern Hungary)

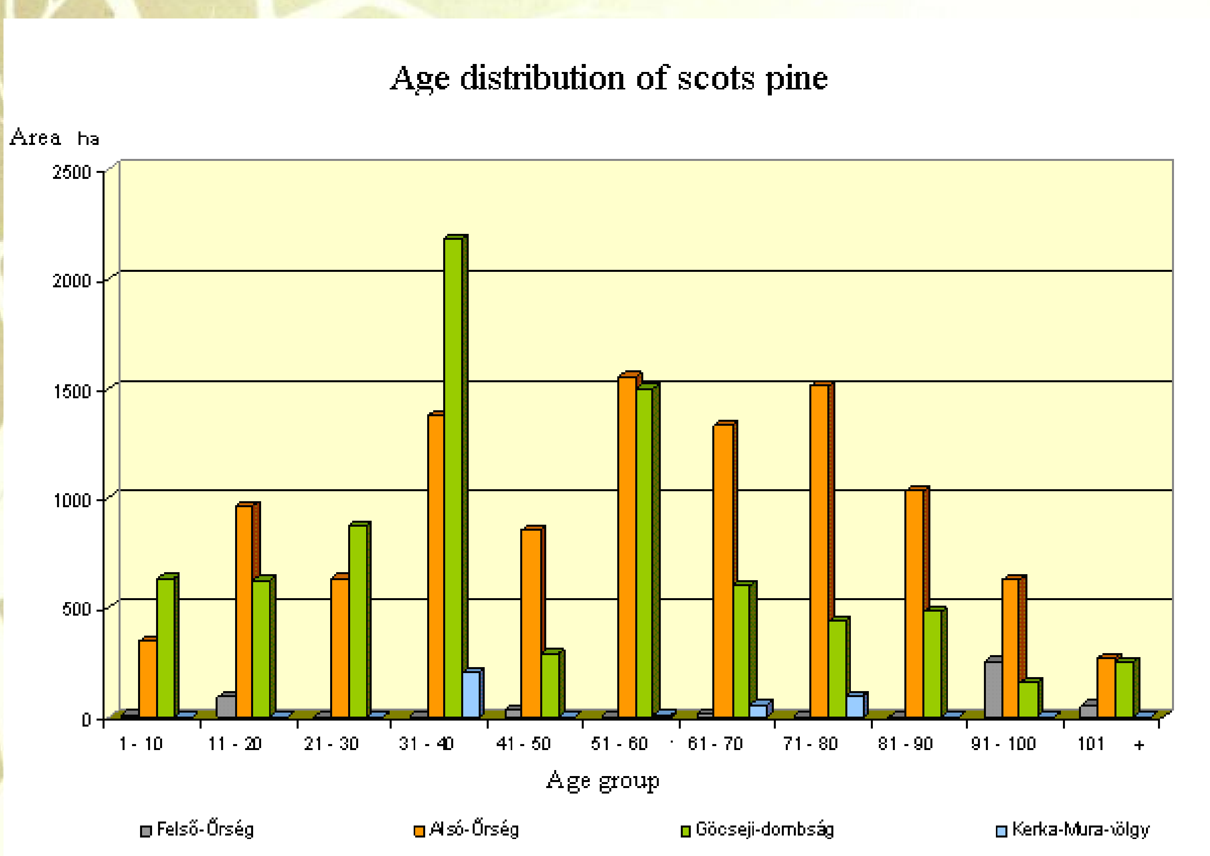


Transformed curve from the set of points that represent height data for beech species in the area of Hungary

The GMS assessment results may provide inventory data on forests where the selection cutting system is used.

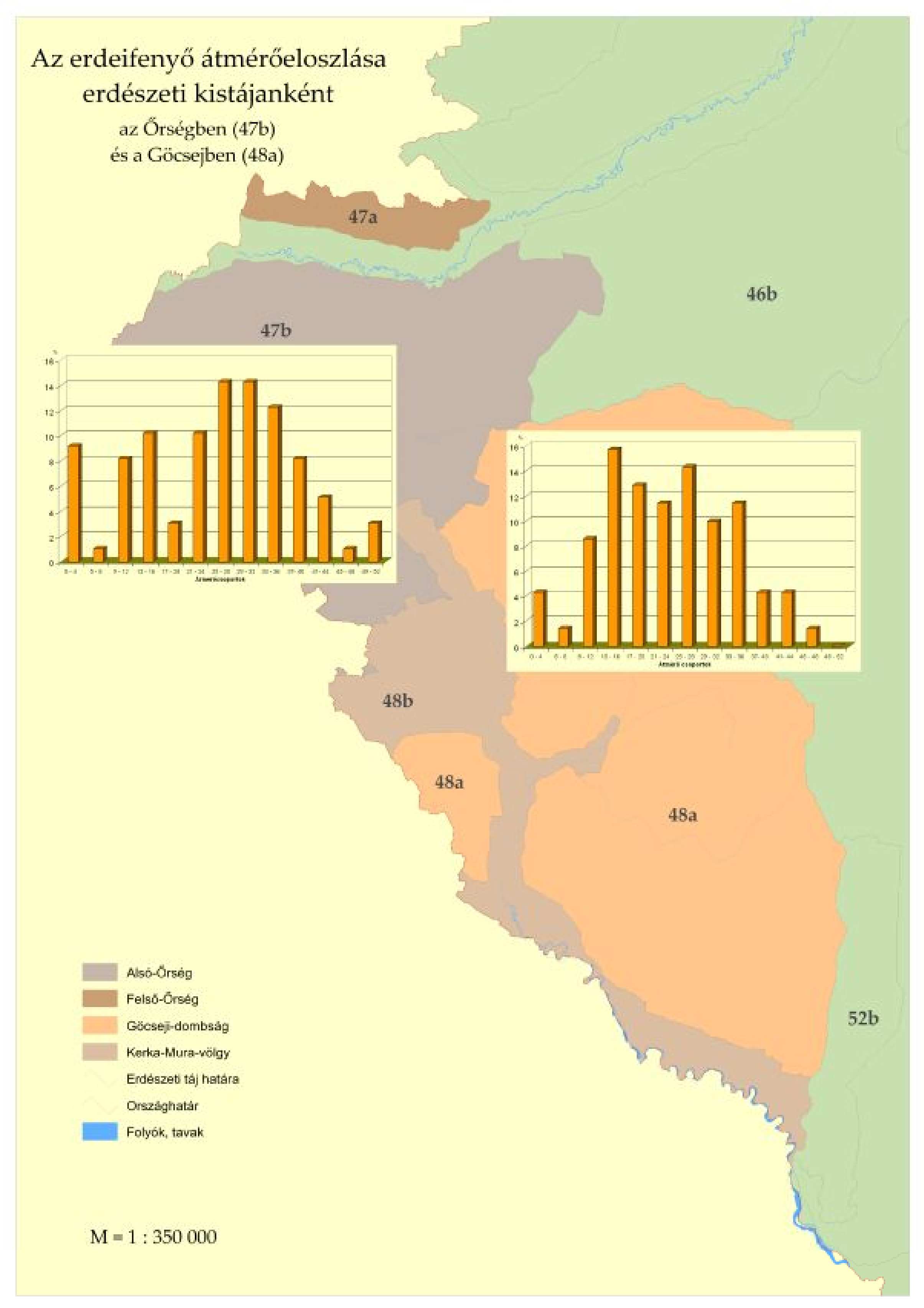
A volume tariff system is a ‘harmonized’ set of tree volume tables, with one independent variable, for estimating the volume of trees and stands of even-aged forests. A number of systems have been compiled empirically on the ‘volume line’ concept for different species and silvicultural conditions. They vary in structure. It is suggested that in order to increase inventory efficiency the measurement of height can be supplemented or completely replaced with the volume tariff systems that can be applied as a useful tool. (Supplementation means the minimization of height measurement.) For the compilation of local volume tables the GMS data are available and valuable.

GMS data can be used to find information on Hungary’s forests and its resources. The design of the database is aimed at providing forest resource information on forests that can be distinguished according to forest region, structure, site class, tree species and management system. As an example for Scotch pine, the distribution of age classes in four forest sub-regions may be retrieved from GMS data and presented in a diagram as follows.



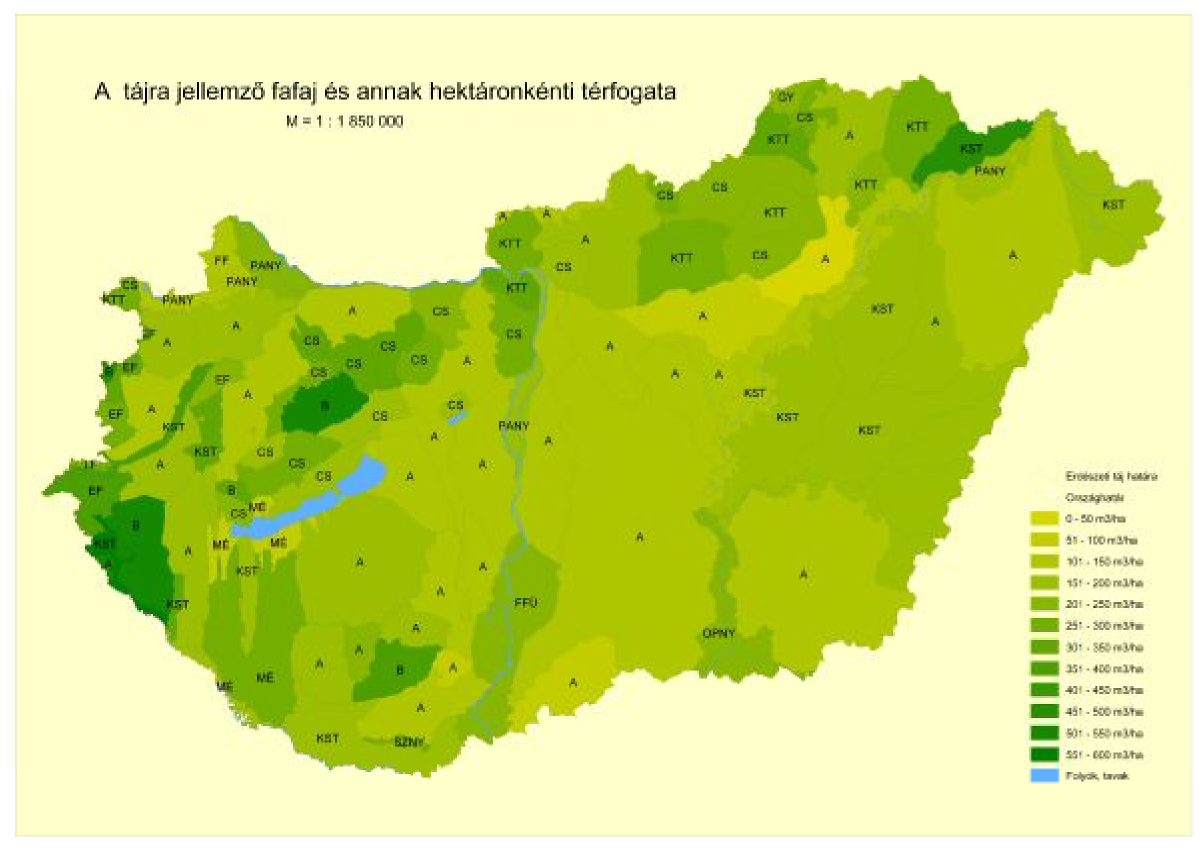
Age distribution of scots pine in four forestry microregion

The GMS data provide information to derive forest maps. The following map shows the DBH distribution in two forest sub-region (in Göcsej and Őrség in Western Hungary) for Scotch pine.



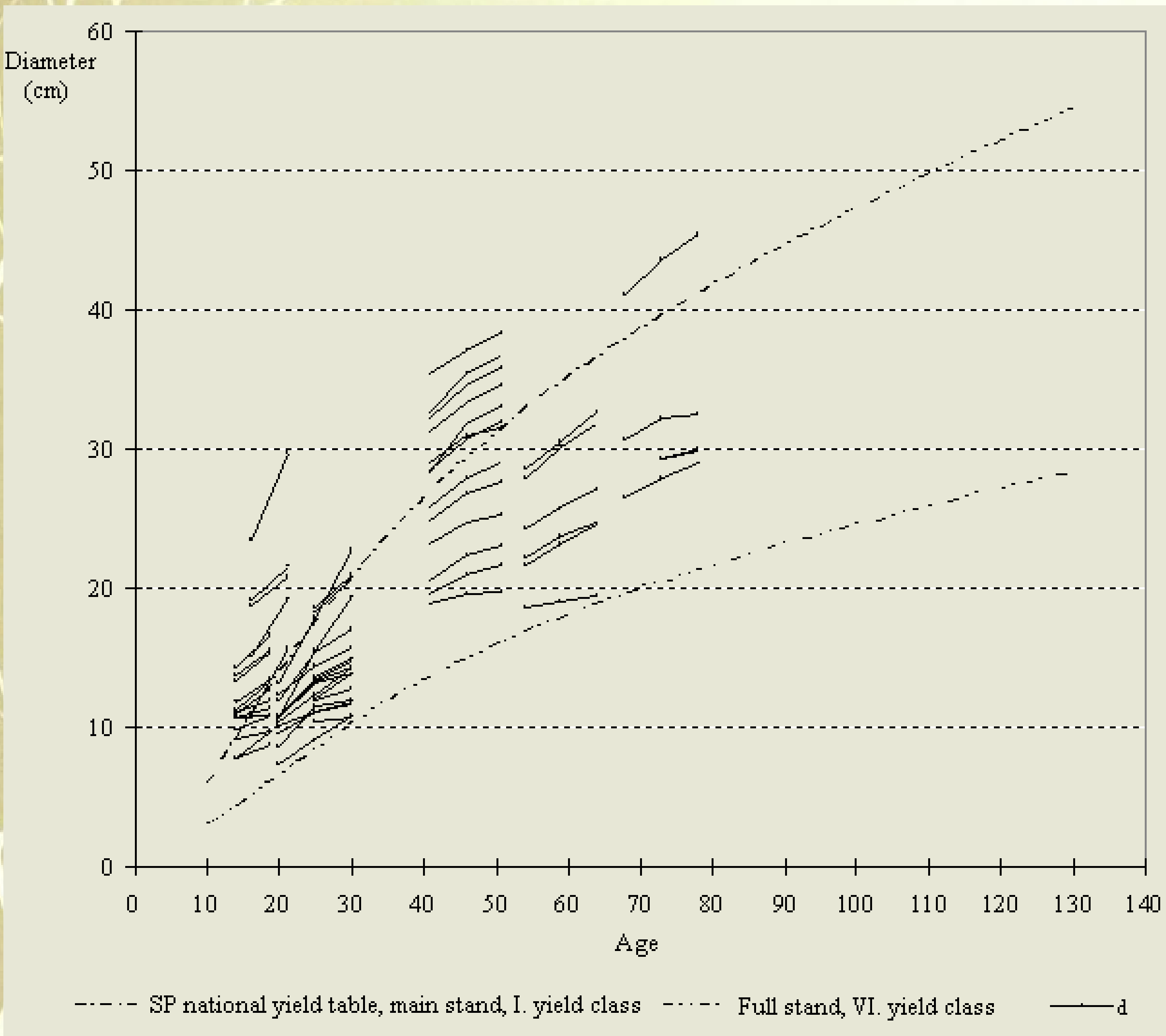
The figure above shows the diameter distribution of the scots pine in the Őrség and Göcsej forestry microregions

After the basic set-up a scenario is to be defined. Many options exist to create scenarios. They can include forest stand type or area of dominant tree species. Basic outputs may be the amount of dead trees or - as it is indicated on the following map - the volume of dominant tree species per hectare.



The figure above shows the region specific tree species and its volume per hectare

Furthermore, data provide information on tree condition over time, spatial and temporal variation of forest condition, long-term trends and dynamics. The following figure illustrates the diameter growth of Scotch pine in the third measurement period and the yield curves for Scotch pine in Hungary.



Individual yield of scots pine on some sample points in Zala county

11.6. Epilogue

Unfortunately, due to circumstance beyond our control, forest inventory cannot be carried out in 2009. Hopefully, continuous forest inventory will be carried out from 2010 again. The short interval shall be used to improve and optimize the efficiency of the system.

The large numbers of collected data and forest inventory experiences are proved to be useful. There are several local yield tables that have been already developed. (interregional, regional yield tables, local and site productivity tables) requires long-term measurements with special attention to the actual forest management practices in order to serve the main purpose of yield tables that is to provide estimates of present yield and future increment and yield. The compilation of local yield tables has been supported by the Forestry Authority

Forest experts using selection cutting processes are interested in the methodology and the sampling methods associated with forest inventory. For a number of motives including practicality, data quality, cost implications, the systematic sampling is chosen for forest and tree data collection. The systematic sampling in forest inventory is easily planned, gives better estimates of stands where the surveyed population is heterogeneous. The elaborated method shall be applied by forest owners and the forest authorities as well.

Since forestry was included in the Kyoto Protocol to the United Nations Convention on Climate Change as an options offered to countries for fulfilling their commitments to reduce net emissions to the atmosphere, activities related to GMS are to be concerned important in compliance with the Kyoto Protocol commitments. In order to provide the require information for the Kyoto purposes the inventory shall be extended to the whole county and additional parameters related to the estimation, measuring, monitoring and reporting on carbon stock changes, greenhouse gas emissions and effects of climate change shall be integrated into the system.

12. The future of EMMRE

Hopefully, the present publication has helped the reader to recognize the importance of EMMRE (Forest Protection Measurement and Monitoring System). Lessons learned from implemented forest monitoring in practice have led to a widespread perception – especially among experts who take an active part in the system - that the existing monitoring efforts and capabilities are essential, and the measuring, monitoring and research activities shall be continued.

The protection of forest is not only the interest of foresters but of society as well. Monitoring is designed to examine various aspects of forest ecosystems that have come to be seen as the most important component of the biosphere using forests as indicators of changes to the ecosystem.

The importance of annual and long-term monitoring is an undisputable fact. Monitoring provides a periodic overview of the spatial and temporal variation in forest condition in relation to anthropogenic as well as natural stress factors. It also contributes to the better understanding of the relationships between the condition of forest ecosystems and anthropogenic as well as natural stress factors, provides a deeper insight into the interactions between the various components of forest ecosystems, contributes to the calculation of critical levels/loads and their exceedance in forests and provides policy-makers and the general public with relevant information.

The monitoring and information reporting requirements are documented in hard low mechanism (new Forest Law and related regulations) and related tasks are assigned to the affected forest research institute and forest administration.

EMMRE as a national system is part of and therefore linked to the global monitoring of biosphere with an emphasis on the development and harmonization of monitoring activities. Existing sub-systems shall be integrated into a complex system to ensure higher efficiency and complex data evaluation.

The overall monitoring objectives, the operation of EMMRE and the data analysis on national and international level help to ensure sustainable forest management and contribute to the conservation of forests and ecosystems at local, national and international levels.

Annex I.

List of abbreviations

Name	Hungarian abbreviation	English abbreviation
Pedunculate oak	KST	PO
Sessile oak	KTT	SO
Other oak	ET	OO
Turkey oak	CS	TO
Beech	B	B
Hornbeam	Gy	H
Black locust	A	BL
Maple	J	M
Elm	Sz	E
Ash	K	A
Other hard broadleaves	EKL	OHB
Hybrid poplars	NNY	HP
Native poplars	HNY	NP
Willow	Fü	W
Alder	É	Al
Lime	H	Li
Other soft broadleaves	ELL	OSB
Scots pine	EF	SP
Black pine	FF	BP
Spruce	LF	S
Larch	VF	La
Other conifer	EGF	OC