The Role of the Hungarian National Forest Inventory in Meeting Sustainability Goals

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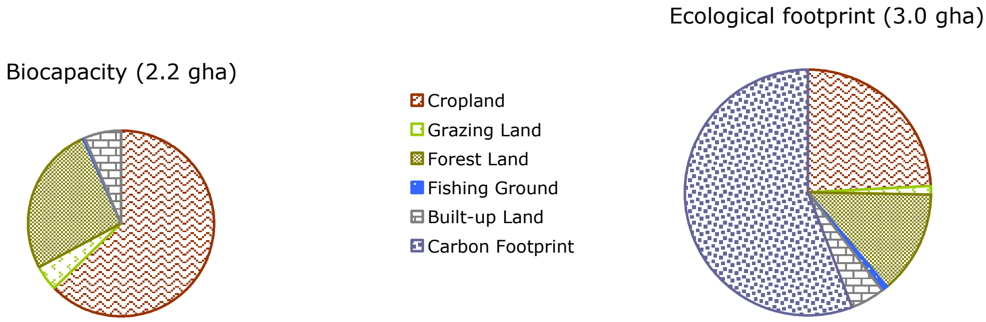
Abstract – Having signed international treaties, Hungary has entered into a commitment to continue with sustainable development. In our paper we want to show how the Hungarian government can meet these obligations using the Forestry Database.

Keywords: forestry database / climate change / carbon sequestration

1. NECESSITY FOR REDUCING ECOLOGICAL FOOTPRINT

When investigating the changes of the ecological footprint we can detect an obvious fact. While most of the components haven't changed during the last 50 years, one of the components has grown nearly fivefold. This component is the carbon footprint resulting from energy consumption. According to data of the Global Footprint Network, none of the components (cropland, grazing land, forest land, fishing ground) of Hungary's ecological footprint has exceeded its biocapacity (EL vs. BC = 1.18 gha vs. 2.09 gha).



Source: EWING et al.

Figure 1. Hungary's biocapacity and ecological footprint
(The circular segmented areas match the values of the ecological footprint)

The deficit of 0.8 gha in the final account results from our carbon footprint of nearly 1.5 gha. If we can reduce this component, we will get closer to sustainability. If we switch to technologies causing less carbon-dioxide emission (gross reduction), and to technologies taking up and storing carbon-dioxide (net reduction), we can reduce our ecological footprint.

In the 1980s, the World Meteorological Organization (WMO) published a study on the risks of the climate change and global warming. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was set up by WMO to coordinate the research activities related to climate change all over the world. The United Nations Conference on Environment and Development held in 1992 in Rio de Janeiro was also of great importance in the process of meet-

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ing the global challenges. The member states signing the Earth Summit Agreements have committed to reduce their net emissions of carbon dioxide.

There are different ways to meet commitments. The most crucial factor in choosing which method to use is cost efficiency. It has to be considered how much the sequestration of a carbon dioxide unit costs. One of the possibilities is forest management which is capable of managing carbon to a great extent or even completely. Forests play a crucial role in the carbon cycle for several reasons: long production cycle, production safety, high intensity of photosynthesis, forest soil carbon storage capacity, cost efficiency even on less productive soils and wood products with a long life cycle.

2. REPORT PREPARATION METHODOLOGIES TO FULFIL OBLIGATIONS

International obligations such as reporting to the Forest Resources Assessment of Food and Agriculture Organization of the United Nations (FAO 2006), to the Ministerial Conference on the Protection of Forests in Europe (MCPFE 2007) and to the United Nations Framework Convention on Climate Change (UNFCCC) concerning Land Use, Land-Use Change and Forestry (LULUCF) (IPCC 2003), are based on formation of forestry database.

Since 1995, Hungary has annually prepared its greenhouse gas inventory. The national GHG inventory follows the methods adopted and controlled by the United Nations. The main principles specified in the UNFCCC reporting guidelines on annual inventories are:

- transparency (clearly explained methodologies),
- accuracy (systematically exact estimates),
- consistency (estimates based on the same methodologies and consistent data sets year by year),
- comparability (reports prepared according to the same methodologies in each reporting country),
- completeness (full coverage of emission sources and sinks also from a geographical point of view).

When fulfilling each of the above requirements, practicability (i.e. choosing the most effective and low-cost methods and practices) must also be taken into account.

GHG emissions and removals related to all land-use sectors are estimated and reported for the calendar year and for the whole country. Consequently, emissions and removals are not measured, but calculated from available statistical data and using formulas. The forest land sector takes up approximately one-fifth of Hungary’s surface area. Comprehensive statistical data on forest management are provided by the National Forest Database.

3. FOREST MANAGEMENT PLANNING IN HUNGARY AND THE NATIONAL FOREST DATABASE

3.1. Development of Forest Management Planning in Hungary

The Forest Management Planning (FMP) has a long tradition in Hungary. The first order, to survey and map Hungary’s forests, was decreed by Maria Teresa and came into force in 1769. The first forest act was issued in 1879. Treatment of the majority of forests had to be based on forest management plans. Sustainability was ensured based on existing age classes and a comparison between theoretically possible and actual cuts as it was ordered in 1920.

In 1935 the forest act ordered that forest owners had to manage their forest using forest management plans. Development of forest management plans has been supported by computerised data processing since 1970.

3.2. The data content of forestry database

Reference definitions developed during the COST Action E43 project ensure a common basis for more exact, harmonized, understanding of forest inventory related definitions across Europe. Mainly these definitions are used in the systematic forest inventory while the compartment wise inventory also gradually tend to use these definitions. Inventories in forest management units (forest stands or sub-compartments) of Hungary include data as follows:

Land-property
- Owner
- Municipality
- Sub-compartment ID
- Cadastral ID
- Responsible forest administration
- Actual forest area
- Primary forest function
- Restrictions (if any)
- Goal of wood production
- Game feeding potential
- Size of forest block
- Date of last management action

Site Data
- Topography: elevation, exposition, slope declination
- Climate
- Hydrology
- Genetic soil type, soil texture and depth of fertile layer
- Potential/optimal stand type with its estimated mean increment
- Canopy class
- Shrub cover

Stand Data
- Storey
- Tree-species, age, origin
- Species composition (by area), type of mixing
- Diameter at breast height dbh
- Height
- Stem quality
- Volume
- Basal area
- Current increment
- Method of volume measurement
- Dominant damage type, intensity

Management Data
- Planned rotation age
- Drain/removal
- Intensity (m^3/ha to be harvested)
- Type of felling (cleaning, thinning, selective cutting, etc.)
- Reforestation
- Reforestation method
- Tree-species composition

The information collected by the FMP is stored in the National Forest Database. This database is used for reporting national and international annual statistics on Hungarian forests too (KOLOZS-SZEPESI 2010). Detailed surveying and the comprehensive database containing statistics for the last 40 years help to meet the requirements of practicability.

4. CARBON SEQUESTERED IN THE BIOMASS OF HUNGARIAN FORESTS

4.1. Estimating carbon stock changes in biomass

There are two methods for estimating carbon stock changes in the biomass carbon pool. One of them is the so called stock-difference method: after calculating the carbon stocks for two different times from living biomass data, their difference will show the change:

$$\Delta C_b = \frac{C_{t_2} - C_{t_1}}{t_2 - t_1} \qquad (Eq.\ 1)$$

$$C_t = V_t \cdot \gamma \cdot (1+\rho) \cdot \varphi$$

where: ΔC_b = carbon stock change of biomass,
C_t = carbon stock at time t,
V_t = growing stock volume at time t,

t_2 = end of inventory year,
t_1 = end of previous inventory year,
γ = basic wood density,
ρ = root-to-shoot ratio,
φ = carbon fraction of (dry) biomass.

When applying the other method, changes in biomass are estimated and carbon stock change values calculated as follows:

$$\Delta C_b = \Delta V_b \cdot \gamma \cdot (1+\rho) \cdot \varphi \qquad (Eq.\ 2)$$

where: ΔC_b = carbon stock change of biomass,
ΔV_b = volume change of biomass,
γ, ρ, φ = as specified above.

In Hungary, the first method is used, since the NFD provides annual living biomass statistics specifying stands of different tree species and ages. These data can be used for preparing the carbon stock inventory. Many of the systematical errors disappear when data of consecutive years are deducted from each other, while under- or overestimation can alter the results when using the second method. (Both formulae are based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 – Agriculture, Forestry and Other Land Use, Chapter 2.)

Growing stock volume (*V*) can be calculated from data available in the NFD (tree species, height, diameter at breast height – $d_{1.3}$) using Király's growing stock volume equation (*Eq. 3*) based on Sopp's volume tables.

$$V = (p_1 + p_2 \cdot d_{1,3} \cdot h + p_3 \cdot d_{1,3} + p_4 \cdot h) \cdot \left(\frac{h}{h-1,3} \right)^k \cdot \left(\frac{d_{1,3}^2 \cdot h}{10^8} \right) \qquad (Eq.\ 3)$$

where: V = growing stock volume (m³),
$d_{1,3}$ = diameter at breast height (at 1.3 m) (cm),
h = height (m),
p_1, p_2, p_3, p_4, k = species-specific parameters.

When using this equation, we get the total aboveground volume of trees, so we don't need the biomass expansion factor.

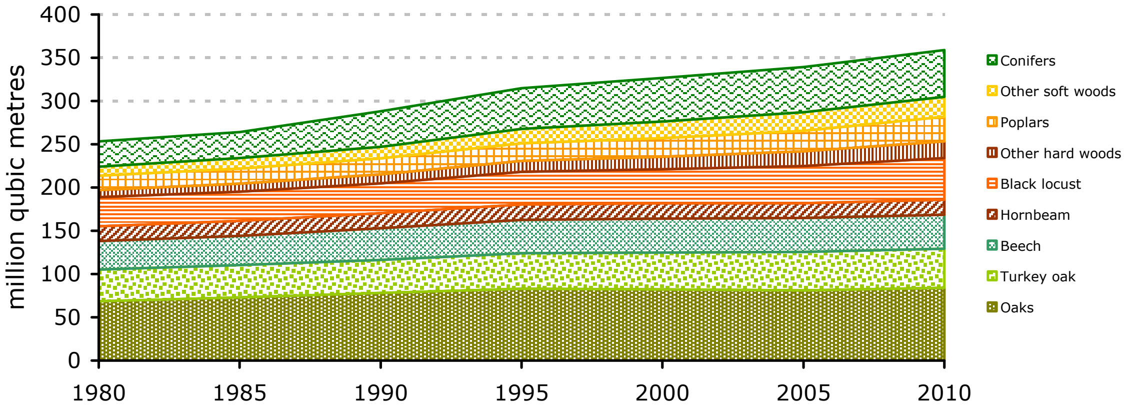
We have data on base density available for different tree species and groups of tree species. In 2008, investigations on base density were run in the Hungarian Forest Research Institute in order to eliminate doubts about overestimating its values in the first years of annual reports. Results indicate that real values are on average by 17% lower than those published in earlier references (SOMOGYI 2008). In accordance with statistical properties of the new investigations, corrected parameters were calculated for all tree species in the NFD.

For estimations of the underground biomass, the dimensionless root-to-shoot ratio of 0.25 is used for all tree species in general. (IPCC has recommended the use of a higher value, but having relatively young forests, we have chosen the conservative estimation method and use this low value.) The measurements recorded in Hungary are between 20% and 37%, but these values can not be considered reliable due to the low number of samplings.

According to IPCC recommendations, the value of 0.5 is used for estimating tree biomass carbon content. It coincides with measurements recorded in Hungary revealing values between 50.1% and 52.3%

4.2. Carbon sequestered in Hungarian forests

By 1970, all forests in Hungary had valid forest management plans. From this year onwards, computerized storage of forest management data has been prescribed by the Manual for Forest Inventory and Management Planning issued by the CAO Forestry Directorate or its predessedors. Computerization has allowed updating of data recorded at different times that is their projection for a given time-period. The availability of the complete digital database covering up the whole country since 1980 makes investigation of forest stand characteristics and species diversity possible. *Figure 2* shows changes of stand volume and species composition over the last thirty years. From the data shown on *Figure 2* we have calculated the amount of carbon sequestered in Hungarian forests over the past three decades using equation *1*.



Source: CSÓKA et al. 1997, BÁN et al. 2002, KOTTEK 2008

Figure 2. Growing stock and species composition of Hungarian forests

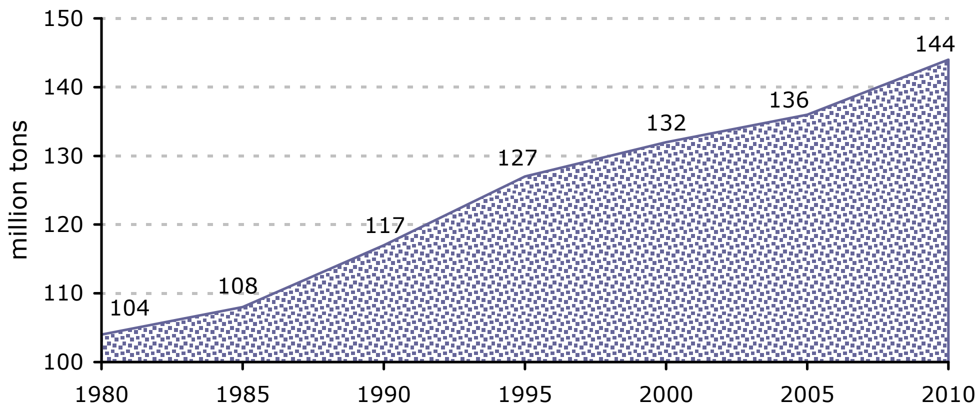
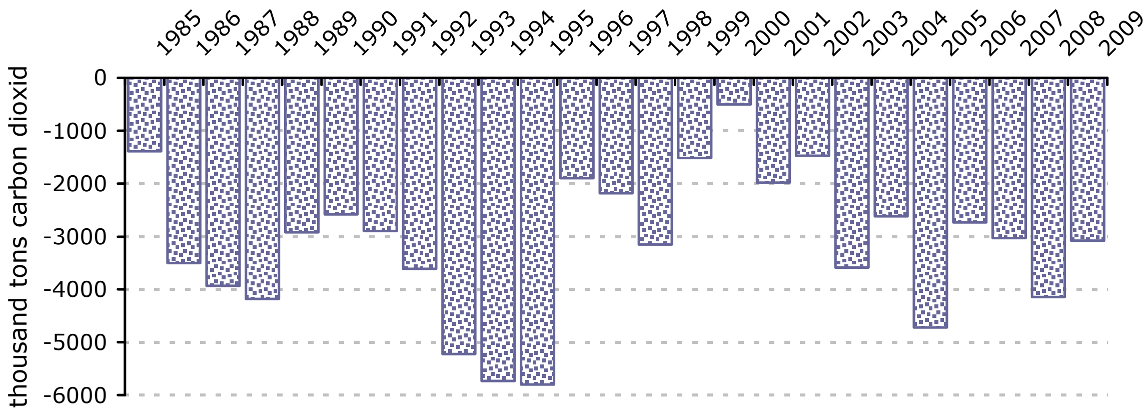


Figure 3. Amount of carbon sequestered in Hungarian forests

Burning of logging scraps and forest fires reduce the gross amount of carbon sequestered, but their share is so small that they can be eliminated: 15 thousand tonnes vs. 140 million tonnes, which gives a ratio of 0.01%. *Figure 4* shows the net amount of carbon sequestered during the years 1985–2009. (In similar statistics, positive values indicate emissions, negative indicate removals.)



Source: LULUCF report of Hungary 2010

Figure 4. Average net CO_2 emission (+) / seqestration (-) of Hungarian forests

Regardless of the different absorption values (CO_2 removals), the diagram reveals that Hungarian forests have always served as carbon sinks during the past twenty-five years.

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