Target Diameter Models for Leuce Poplar Stands Growing on Sandy Soils

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Abstract – The fact that certain ecological factors fundamentally influencing tree growth have become unfavourable in Hungary in recent years, has led to the more extensive use of white poplar (and its hybrids) in afforestation and forest regeneration. An intensive integrated research and development work has been carried out on the growth of Leuce poplars on sandy soils, including primarily the white poplar (*Populus alba*) and its natural hybrid the grey poplar (*Populus x canescens*). The research revealed several factors influencing stand growth. The study presents a new, simplified tending operation model for Leuce poplar stands, as well as age, growing space and target diameter models suitable for qualitaty log production and for mass assortments. The simplicity of these practice-oriented models may foster the qualitative development of Leuce poplar management in Hungary.

Leuce poplars / tending operation models / growing space regulation

Kivonat – Homoki Leuce-nyár állományok célátmérő modelljei. A homoki Leuce-nyárakkal, döntően a fehér nyárral (*Populus alba*) és természetes hibridjével, a szürke nyárral (*Populus x canescens*) kapcsolatos kutatómunka intenzívebbé tételét több tényező indokolja. A fatermesztést alapvetően befolyásoló ökológiai tényezők egy részének kedvezőtlenebbé válása előtérbe helyezte e fafaj (és hibridjeinek) egyre kiterjedtebb alkalmazását az erdőtelepítések, illetve erdőfelújítások során. A tanulmány a nemzetközi szakirodalomban is hézagpótlónak tekinthető módon közli a fehérnyárasok új, egyszerűsített erdőnevelési modelljét, illetve a minőségi rönktermesztésre, valamint a tömeg-választékok előállítására alkalmas fehérnyárasok kor-növőtér-célátmérő modelljeit. A közölt gyakorlatorientált modellek egyszerűségüknél fogva nagyban segíthetik a Leuce- nyár termesztés minőségi fejlesztését Magyarországon.

Leuce-nyárak / erdőnevelési modellek / növőtér szabályozás

1 INTRODUCTION

Leuce poplars, primarily white poplar (*Populus alba*) and its most important natural hybrid the grey poplar (*Populus* x *canescens*), are tree species native to Hungary (Kopecky 1962, Szodfridt – Palotás 1973, Kopecky 1978, Rédei 1991). Due to their favourable silvicultural and growth characteristics, as well as the possibilities for the utilisation of their wood, the area they occupy is increasing continuously. The most important task facing Hungarian poplar

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growers is improving the quality and increasing the quantity of poplar stands for wood production (Rédei 2000).

The area occupied by the two species in 2006 was 65 000 ha (3.2% of the total forest area), with a standing volume of 9.8 million m^3 (163 m^3 ha^{-1}) (Führer et al. 2009). Their importance will continue to increase across the large areas of marginal land not suitable for the cultivation of hybrid poplars but able to accommodate these native species (Rédei 1991, 1994, 2000).

Other species that may be used for plantation forestry in addition to these poplar species are black locust, red oak and black walnut. Common walnut plantations may also play a role, but the silvicultural significance of this tree species is negligible.

From among the above listed tree species, the models for tending operations and the tables for age-growth space-target diameter models are suitable for production of large, quality wood material as well as mass assortments produced in white and grey poplar stands.

2 MATERIALS AND METHODS

The models we developed are based on a yield table for white and grey poplars. It was constructed from data gathered from 50 permanent and 40 temporary forest inventory sample plots (500–1000 m^2). The stands sampled were located in the vicinity of N 46° 31' 10" and E 19° 26' 46". The age of the stands varied between 5 and 45 years.

During the stand surveys, the key stand characteristics were measured. Stem volume was estimated using the following volume function (Sopp – Kolozs 2000):

$$v = 10^{-8} d^2 h^1 (h/[h-1.3])^2 \left[-0.4236 d\, h + 12.43 d + 4.6 h + 3298\right] \quad (1)$$

where v is stem volume (m^3), d is diameter at breast height (cm) and h is tree height (m).

The regression analyses were calculated using a computer-based statistics programme. The expected height values of the stands at the reference age (25 years) according to the yield classes are: 24.2 m, 21.6 m, 19.0 m, 16.4 m, 13.8 m and 11.2 m. On the basis of the guide curve and the reference age (100%), a percentage value was calculated at any age and for any yield class. The yield table was constructed using the following formulae and coefficients; (a detailed dataset is available from the authors):

1. Age of stand (A)
2. H_m = average height of stand (height of dominant and co-dominant trees) in m:
   $H_m = 1.21592 \times (1\text{-}e^{-0.09236A})^{1.8334}$
3. D_m = average DBH of stand in cm:
   $D_m = 1.58356 + 0.73502 \times H_m + 0.01571 \times H^2_m$
   with $R^2 = 0.886$
4. V_m = volume of stand in m^3 ha^{-1}
   $V_m = BA_m \times H \times F_m$, where
   $H \times F_m$ = form-height quotient
   $H \times F_m = 1.96791 + 0.40778 \times H_m$
   with $R^2 = 0.923$
5. BA_m = basal area of stand in m^2 ha^{-1}:
   $$BA_m = \frac{D_m^2 \times \pi}{4 \times 10000} \times N_m$$

6. N_m = stocking density of stand in trees ha^{-1}:
   $N_m = e^{8.75483-0.83879 \ln Dm}$
   with R^2=0.826

3 SIMPLIFIED TENDING OPERATION MODEL FOR LEUCE POPLAR STANDS

Leuce poplars are fast-growing species. Seedlings quickly emerge from competition with weeds. In-line and inter-row weeding is required in the first years after plantation establishment by means of seeding, as is the removal of failed plants. During tending operations, it is important to take into consideration the fact that plantations consist of trees of varied genetic make-up (genotype). In terms of the demand for light, it is worth remembering that Leuce poplar reacts extremely strongly to light availability. It also tolerates shade very well (Tóth 1996, Führer et al. 2009).

Table 1 contains a simplified tending operation model for Leuce poplar (white and grey poplar) stands. The table was compiled using data obtained from 70 long-term yield and

experimental tending operation plots. The choice of the most suitable spacing depends on the quality of the planting material and the particular site conditions. In this table, all of the data are presented in six yield classes. The mean tree height is the most important model factor because it determines the timing of the particular tending operation. Thinnings (to expand the available growing space) must be carried out when the stocking density approaches the stem number quoted in the table.

In plantations planted at spacings of either 3 x 3 m or 3 x 2 m, there is no need for thinning, except where the sapling growth is unstable. With initial spacings narrower than 3 x 1 m or 2.5 x 1 m, one or two thinnings are recommended for plantations established with white poplar clones.

Table 1. Simplified tending operation model for Leuce poplars (white and grey popla) stands

Tending operation					Stocking density (stems ha^{-1})	
	Number	To be carried out in year…	To be carried out at H_m (m) and yield class…		Tending operation	
					before	after
Cleaning	1	5–10	6	I–VI	>3000	3000
	2	11–14	8–11	I–VI	3000	1300–1800
Thinning	1	15–20	12–17	I–V	1300–1800	650–1200
	2	21–25	16–23	I–IV	650–1200	350–600
Final cutting		40		I–II		350–400
		30–35		III–IV		500–600
		25–30		V		800–900
		20–25		VI		1000–1100

Remarks for the use of the tending operation model:

- When planning the thinning operation, the better the estimated yield class, the lower the stem number value after thinning to be applied.
- White poplar stands in yield classes V–VI are not suitable for quality wood production.

4 AGE, GROWING SPACE AND TARGET DIAMETER MODELS FOR LEUCE POPLAR STANDS

In plantation forestry, *the timing of the expansion of the available growing space* is significant for reaching the target assortments by maintaining the near optimal stocking density per hectare (growth space). The ecological factors of the site essentially define the target assortments; for example, whether the opportunity for the production of sizeable, quality wood material (panel log, saw-log) exists or merely thinner wood assortments (cutting, pallet and box basic material), pulp, fibre, chippings and basic wooden board materials.

The data in *table 2* show that an opportunity for the production of quality, *sizeable logs is possible in white and grey poplar stands classified yield class I-III.* For white and grey poplar stands in yield class IV – assuming an average harvesting age of 30 years – a target diameter of 18 to 20 cm can be planned with great certainty. The sustainable stocking density per hectare depending on the yield class varies from 320 to 560 stems.

Table 3 shows that stands of yield classes IV and V are suitable for the production of mass assortments, and possibly even white and grey poplar stands of yield class VI with a target diameter of 10 to 12 cm. However, the management of stands characterised by these two lowest yield classes are usually loss producing and so are unsuitable for plantation forestry.

White and grey poplar stands growing under unfavourable ecological conditions also have an earlier harvesting age (generally between 25–30 years). The sustainable stocking density varies between 620–920 stems ha^{-1} depending on the yield class. In these stands, the reduction in stem number (thinning) carried out at age 15–17 does not lead to a significant increase in diameter growth.

Table 2. Age-target diameter model for Leuce poplars (white and grey poplar) stands targeted for quality log production

Planned target diameter (DBH) (cm)	Yield class	Years required to reach target diameter	Stocking density (stems ha^{-1})
18	I	14	560±5%
18	II	17	
18	III	21	
18	IV	28	
20	I	16	515±5%
20	II	18	
20	III	23	
20	IV	32	
25	I	21	425±5%
25	II	25	
25	III	37	
30	I	28	365±5%
30	II	42	

Table 3. Age-target diameter model for Leuce poplars (white and grey poplar) stands targeed for the production of mass assortments

Planned target diameter (DBH) (cm)	Yield class	Years required to reach target diameter	Stocking density (stems ha^{-1})
10	IV	11	
10	V	14	920±5%
10	VI	19	
12	IV	13	
12	V	17	790±5%
12	VI	25	
14	IV	15	
14	V	24	690±5%
14	VI	–	
16	IV	20	
16	V	31	620±5%
16	VI	–	

5 CONCLUSIONS

White and grey poplar plantation management for improved growth is becoming ever more significant in lowland forestry. This fact was taken into account in the conception of this study, and fed into the novel planning tools developed to help increase the value of the material produced in Leuce poplar stands. In recent decades, growth models based on stand level data have gradually been replaced by stand growth models predicated on stem number frequencies and individual tree growth models. Nevertheless, traditional tending operation models will remain very useful tools for forest management and forest inventory. The published models can be widely used in Leuce poplar management and forest inventory, such as:

- harvest scheduling for Leuce poplar stands,
- volume estimations,
- further development of silvicultural (tending operation) models for Leuce poplar stands,
- development of guidelines for local policies promoting native species, and
- growth analysis of Leuce poplar stands.

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