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Thinning and final cutting control in black locust (*Robinia pseudoacacia* L.) stands: a methodological approach – Short communication

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SUMMARY

Planning, implementing and inspecting forestry operations require more extent application of certain assessment methods. These methods may need to be improved and, in some cases, their simplification is necessary in order to ease their usage in practice. Knowledge and application of auxiliary tables and functions, data on volume and methods to estimate yields are needed for the planning of any kind of forestry operations, depending on the level of planning. The main purpose of this paper is to propose relatively rapid and simple methods to estimate the volume at thinning and final cutting, and the gross above ground volume at the harvest of black locust (Robinia pseudoacacia L.) stands, as well as to introduce tending operation models tailored for black locust. All these measures could be beneficial to forest authorities and foresters who are responsible for planning and production.

Keywords: *tending operation models; volume; Robinia pseudoacacia, silviculture*

INTRODUCTION

Forest tending is a forestry activity which shall be carried out following successful forestation or reforestation until the final cutting of the forest stand. The purpose of forest tending is to meet the economic and social requirements of sustainable forestry by taking into account the ecological conditions. Considering such expectations, site productivity shall be managed effectively by producing high quality timber with maximum yields and with an economical manner, while simultaneously maintaining the other functions of the forests, such as protection and recreation (Rédei, 2009).

The purpose of the tending cuttings is to decrease the number of stems of the forest stand in a comprehensive system according to our goals, until the final cutting. The first task is to form the most favourable stand structure by maintaining the optimal (required) number of stems, and the second task is to obtain wood material from tending cuttings (Nicolescu, 2018). In order to achieve good quality hardwood production, the desirable trees are selected (Kim et al., 2005; Nicolescu et al., 2020). The before-mentioned optimal number of stems means the number of trees per hectare on a given site, with the given species and age of the stand. This number of stems has to be maintained between each of the tending cuttings following each other, with respect to the required basal area to reach the goals of the forest tending. In case the stand grows without any disturbance, the tending cuttings shall serve to reach the required number of stems by decreasing the number of trees.

The tending cuttings (cleaning, thinning) has to be planned for the phases of the forest planning, as well as for the whole life-span of the stand in a comprehensive manner. The technology of implementation also has to be determined. To realize these tasks, it is advised to use forest tending tables.

Based on the yield table of the given species, forest tending model tables determine the tending cuttings according to the yield class, some important data on the stand structure of the remaining stand (main stand) following the tending cuttings and the age of final cutting. The volume of the tending cutting depends on the difference of the number of stems and basal area of the given stand, and of the respective values of the model table in terms of number of stems to be retained, and/or the basal area to be maintained. As the first step to use the model table, the yield class of the stand has to be determined of which we plan to implement the tending cutting. This is done according to the age and height of the stand which then determine the tending cutting based on the table's pre-determined values for the given age and the respective number of stems. (Rédei, 1989, 2009; Kollár et al., 2018). The volume of the tending cuttings is defined by the above-mentioned parameters and it will be introduced in the following pages.

Black locust (*Robinia pseudoacacia* L.) is one of the most important stand-forming tree species in Hungary, covering approximately 23% of the forested area and providing about 21% of the annual timber output of the country (NLC, 2024). In black locust stands mostly selective thinning is to be carried out. Selective thinning is a thinning in which trees are removed or retained on their individual merits. The shape and size of the trees are determined not only by the species and the variety, but also by the site quality, the composition of the stand, its density, the age, and by the management of the stand (Horn, 1971; Rédei et al., 2015). Intermediate cutting is the most widely applied type of selective thinning. It means that most of the suppressed and sub-dominant trees are removed, and also the opening up of the canopy by breaking up groups of competing dominant and co-dominant trees (Forestry Commission, 2015). Zheng et al. (2019) found that after thinning of black locust plantations photosynthesis of the remaining trees

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increases already from the first year following the operation. This encourages the development of the better trees and leaves an open and fairly uniform stand.

The most common way to estimate the intermediate yield is based on determining the volume of the mean tree and the number of rejected trees. There are several methods to define the beforementioned factors. Intermediate thinning decision can also be based on classifying tree forms (Kim et al., 2005). In this study we explain those methodologies which are easy to implement in practice and are relatively rapid.

METHODS AND RESULTS

1. Estimating the volume of intermediate thinning in case of selective thinning

v_{cut} = volume of the average tree to be rejected, based on the arithmetic averages of the height (h) and of the diameter at breast height (dbh) of 5 trees which are considered representative, derived from volume tables or determined by simplified volume function (see below).

$n_{cut.} = n_s - n_m$, where

n_s = number of stems in the sample area; n_m = number of trees of the given yield class of the tending operation model, proportionate to the sample area (based on *Table 1*).

Table 1. **Tending operation models of black locust stands according to the yield class (Rédei and Gál, 1985; Rédei, 2006)**

Age (yr)	Height growth of main stand according to the yield class (m)						Tending operation model according to the yield class					
	I	II	III	IV	V	VI	I	II	III	IV	V	VI
							age (yr) number of stem (pcs ha^{-1}) basal area (m^2 ha^{-1})					
5	8	7	6	5	4	3	C5	C6	C7	C8	C9	C10
							2500	2500	2700	3000	3000	3500
10	14	12	11	9	8	6	7	7	7	8	7	7
							C9	C10	C12	C13	C15	(C15)
15	18	16	14	12	10	8	1700	1700	1800	2000	1500	(2000)
							13	13	14	15	9	(8)
20	21	19	17	14	12	9	ST12	ST15	ST17	ST19		
							900	900	1100	1000	-	-
25	24	21	19	16	14	10	12	14	16	13	-	-
							ST18					
30	25	22	20	17	15	11	600	-	-	-	-	-
							17					
35	26	23	21	18	16	12	IST25	IST22	IST22			
							400	550	700	-	-	-
40	27	24	22	19	16	12	18	17	17			

Yield class is determined by the age and of the height of the main stand. The tending operation models specify the factors of the forest stand structures after the given (planned) tending operation. C=cleaning; ST=selective thinning; IST=increment stimulating thinning.

1.1. If the expected height of the rejected trees are (H) ≤ 8 m and their expected diameter at breast height (DBH) are ≤ 8 cm

v_{cut} = v $V_{cut/ha} = v_{cut} \times n_{cut/ha}$, where

v_{cut} = for individual black locust trees with h ≤ 8m and dbh ≤ 8 cm, see *Table 2*.
$n_{cut/ha}$ = in samples areas of 25 × 40 m the number of stems × $10n_s$

Table 2. **Volumes of the individual black locust trees to be cut down in case of h ≤ 8m and dbh ≤ 8 cm (based on Sopp and Kolozs, 2013)**

Tree height (m)	Diameter at breast height (cm)		
	5	6–7	8
5–8	0.01	0.02	0.03

1.2. If the expected height of the part of the stand to be cut down is (H) > 8 m and its expected diameter at breast height (DBH) is > 8 cm, but the criteria for measuring basal area is not met

$V_{cut/ha} = v_{cut} \times n_{cut/ha}$, where,

$v_{cut} = 0.35 \times dbh^2(h+3)$, on base of volume table for black locust (Sopp and Kolozs, 2013),
dbh and h are determined by simplified volume function based on the arithmetic averages of the height (h) and of the diameter at breast height (dbh) of 5 trees which are planned to be cut down

Example: According to an inventory of a sample area of a 17-year-old black locust stand, in yield class III, there are 1550 stems per hectare. Based on the tending operation model after increment stimulating thinning, the number of stems is: 1100 pcs ha^{-1}.

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Therefore n_{cut} =1550-1100 = 450 pcs ha^{-1}. Values of 5 trees which are planned to be cut down: h = 12 m; dbh = 10 cm. $v_{cut} = 0.35 \times dbh^2(h+3) = 0.053 m^3$, $V_{cut//ha} = 0.053 \times 450 = 23.9\ m^3\ ha^{-1}$.

1.3. The part of the stand to be cut down meets the requirements of simple basal area measurement (DBH ≥ 10 cm)

$V_{cut./ha} = (BA-BA_t) \times HF$ where,

BA – basal area of the whole stand ($m^2\ ha^{-1}$) (see number of sampling point in *Table 3*),

BA_t – total basal area based on the tending operation model according to the yield class (see *Table 1*).

Values of HF as a function of H. (see *Table 4*).

Note that it is a top priority to define the total basal area to be able to apply and inspect the tending operation models, and there are several measuring devices available (Fadgyas, 1980).

Table 3. **Number of sampling points in case of relascope assessment (±10% error) (Rédei, 1989)**

Size of the area (ha)	1	3	5	8	10	15	20
In uniform stands	4	6	7	9	10	12	13
In variable stands	4	6	9	12	15	18	20

2. Estimating the volume of intermediate thinning in case of increment stimulating thinning

$V_{cut./ha} = (BA-BA_t) \times HF$. In others, follow instructions in section 1.3.

Example: The basal area of a black locust stand aged 22 from yield class III. is = 22 $m^2\ ha^{-1}$ (BA). Basal area according to the tending operation model is =17 $m^2\ ha^{-1}$ (BA_t). The average height of the part of the stand (H) to be cut down is = 14 m, and HF=7.82. $V_{cut/ha}$ = (22-17) ×7.82 = 39.1 $m^3\ ha^{-1}$.

The above-mentioned methods can be used to pre-estimate the yield of the planned tending operations in about 10–15 per cent of a specific unit (forest district, forestry). Based on the acquired data it is possible to modify the management plans of other black locust stands which grow in similar ecological conditions and which have similar stand structure.

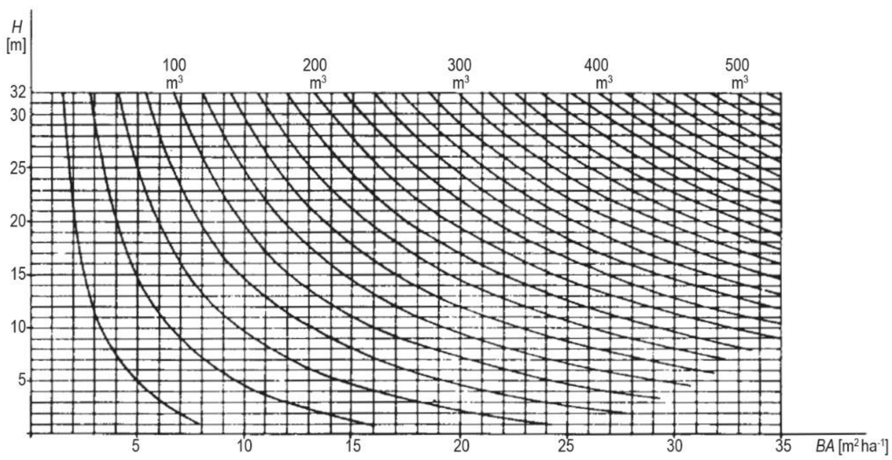
3. Estimating the volume of final cutting

To rapidly estimate the yield of the black locust stands which are planned for final harvest the above introduced V = BA × HF formula can be used (*Table 3–4*). Total gross above ground volume of black locust stands can be determined based on *Figure 1*. as a function of H and BA. It is beneficial to use this graph when planning re-afforestation by coppicing, as the volume of the living stand serves as the basis of choosing the method of re-afforestation (Rédei et al., 2020; Honfy et al., 2021).

Table 4. **Values of HF as a function of H (edited by Rédei, 1989)**

H_{cut} (m)	HF	H_{cut} (m)	HF
8	5.35	20	10.29
9	5.76	21	10.70
10	6.18	22	11.12
11	6.59	23	11.53
12	7.00	24	11.94
13	7.41	25	12.35
14	7.82	26	12.76
15	8.23	27	13.18
16	8.65	28	13.59
17	9.06	29	14.00
18	9.47	30	14.41
19	9.88		

Figure 1. **Total growing stock of black locust stands per hectare as a function of height (H) and basal area (BA) (edited by Rédei, 1989, 2006)**



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Example: A black locust stand planned for final cutting at age 32. The average height is (H) = 23 m and the total basal area (BA) = 24 m^2 ha^{-1}. According to the graph the total volume per hectare is cca. 275 m^3.

Note that in case of calculating the average of DBH of the sample stand, the total volume per hectare of the given part of the forest stand can be estimated by the algorithm V (m^3 ha^{-1}) = 40.24784+0.36919 DBH^2.

CONCLUSIONS

The estimating methods introduced and suggested in this paper cannot replace the rules of framing the forest management plans (Kolozs and Facskó, 2012). Nonetheless it contributes to the extent use of tending operation models and helps to define the total volume of the secondary stand. Furthermore, the above-discussed method can be used to estimate the yearly harvest, and for any other management plans and execution that is based on tree yield (volume) estimation. Also, it can be applied to choose the method of re-afforestation of black locust stands on the basis of total growing stock.

REFERENCES

Fadgyas, K. (1980): Szögszámláló mintavétel alkalmazása az erdőrendezésben. *Az erdő*, 29(6), 261–265. (in Hungarian)

Forestry Commission (2015): *Thinning Control*, 4th ed.; Forestry Commission: Edinburgh, UK, 1–56.

Horn, H.S. (1971): *The Adaptive Geometry of Trees*, 3rd ed.; Princeton University Press: Princeton, New Jersey, USA, 144.

Honfy, V.; Ábri, T.; Juhász, L.; Rásó, J.; Keserű, Zs.; Rédei, K. (2021): A simplified method for application of natural regeneration in black locust (*Robinia pseudoacacia* L.) stands in Hungary. *J. For. Sci.,* 67(2), 66–70. https://doi.org/10.17221/147/2020-JFS.

Kim, J.H.; Kang, S.K.; Chung, S.H. (2005): A proposal of criteria for tending operation by quality grade of tree form in natural deciduous forests. *For. Sci.Technol*., 1(1), 27–32. https://doi.org/10.1080/21580103.2005.9656265

Kollár, T.; Veperdi, G.; Rédei, K. (2018): A NAIK Erdészeti Tudományos Intézet hosszúlejáratú fatermési, erdőnevelési és hálózati tartamkísérleteinek múltja, jelene és jövője. Erdészeti Lapok, 153(10), 306–310. (in Hungarian)

Kolozs, L.; Facskó. F. (2012): The Role of the Hungarian National Forest Inventory in Meeting Sustainability Goals. The Impact of Urbanization, Industrial and Agricultural Technologies on the Natural Environment: International Scientific Conference on Sustainable Development and Ecological Footprint, Sopron, Hungary, 26/03/2012; Neményi M, Heil B; Eds.; Nyugat-magyarországi Egyetem Kiadó.

Nicolescu, V.N. (2018): The practice of silviculture. Aldus, Brasov p. 254.

Nicolescu, V.N.; Rédei, K.; Mason, W.L.; Vor, T.; Pöetzelsberger, E.; Bastien, J.C.; Brus R.; Benčať T.; Đodan M.; Cvjetkovic B.; Andrašev, S.; La Porta, N.; Lavnyy, V.; Mandžukovski, D.; Petkova, K.; Roženbergar, D.; Wąsik, R.; Mohren, G.M.J;. Monteverdi, M.C.; Musch, B.; Klisz, M.; Perić, S.; Keça, L.; Bartlett, D.; Hernea, C.; Pástor, M. (2020): Ecology, growth and management of black locust (*Robinia pseudoacacia* L.), a non-native species integrated into European forests. J. For. Res, 31(4), 1081–1101, https://doi.org/10.1007/s11676-020-01116-8

Rédei, K.; Gál, J. (1985): Akácosok fatermése. *Erdészeti Kutatások*, 76–77, 195–203. (in Hungarian)

Rédei, K. (1989): Az akácállományok elő- és véghasználati fatérfogatának gyorsított becslése. Erdészeti Kutatások, 80–81, 101–105. (in Hungarian)

Rédei, K. (2006): *Az akáctermesztés fejlesztésének biológiai alapjai és gyakorlata*; Agroinform Kiadó: Budapest, Hungary, 128. (in Hungarian)

Rédei, K. (2009): Az akác ültetvényszerű termesztése. In: *Ültetvényszerű Fatermesztés 1*.; Führer E., Rédei K., Tóth B.; Eds.; Agroinform Kiadó: Budapest, pp. 126–158. (in Hungarian)

Rédei, K.; Keserű, Z.; Antal, B. (2015): Tending operation models for black locust (*Robinia pseudoacacia* L.) stands growing on sandy soils in Hungary. *Int. J. Hortic. Sci.*, 21 (3–4), 55–57.

Rédei, K.; Ábri, T.; Szabó, F.; Keserű, Z. (2020): Angle-count sampling method for estimating forest stand volume – a practical approach. Acta Agraria Debreceniensis, 2, 99–102. https://doi.org/10.34101/ACTAAGRAR/2/7900

Sopp, L.; Kolozs, L. (2013): *Fatömegszámítási táblázatok*; NÉBIH Erdészeti Igazgatóság: Budapest, Hungary, 69.

Zheng, Y.; Zhou, J.; Zhou, H.; Zhao, Z. (2019): Photosynthetic carbon fixation capacity of black locust in rapid response to plantation thinning on the semiarid loess plateau in China. Pak. J. Bot., 51(4), 1365–1374. https://doi.org/10.30848/PJB2019-4(40)