

Comparative Analysis on Cutting Possibilities Derived from Different Allowable Cut Indicators in Slovakia

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Abstract: This paper examines the issue of forecasting growing stock development and cutting possibilities based on the actual regeneration period of individual forest stands. These cutting possibilities represent a harvest level that is sustainable in light of forest stand regeneration. A survey was conducted using two groups of forest stands taken from the Forest Management Plan database at the Training Forest Enterprise of the Technical University in Zvolen, Slovakia. We compare the growing stock and harvest levels estimated by considering the actual regeneration period with those estimated by the following indicators of allowable cut: analytical cutting percentage, empirical cutting percentage, 1/20 of standing volume of forest stands in the two oldest age-classes and older, and 1/30 of standing volume of forest stands in the three oldest age-classes and older. The results indicated that cutting possibilities estimated by considering the actual regeneration period can be used as the judging criterion for selecting the most suitable allowable indicator to the target forest management unit. For our experiments, the empirical cutting percentage outperformed the other indicators on the basis of suitability of the derived cutting possibilities.

1. Introduction

The prediction of growing stock development, age structure, and cutting possibilities is an important component of selecting allowable cut indicators for a particular forest management unit (FMU). The previous method for predicting growing stock development was based on the expected allowable cut without

considering some important silvicultural elements, which could influence forest harvest in Slovakia. Many researchers have tackled on developing a solution to these problems, and have proposed a new methodology for calculating the expected growing stock (see Kanka, 1983; Kanka *et al.*, 1983; Greguš, 1989; Marušák, 1998; Marušák, 1999; Burgan, 2002). The current method uses model increments represented by the expected growing stock coefficients to predict timber volume according to age-classes for individual tree species.

In today's practical forest management planning, forecasting growing stock development is indispensable for selecting allowable cut (harvesting) indicators. The current Slovak forestry Act number 453/2006 Coll., related to forest management and forest protection, stipulates that only one of five possible allowable cut indicators can be applied, so that the selection method for the indicators needs to be as objective as possible. The current allowable cut indicators are: (i) analytical cutting percentage, (ii) empirical cutting percentage, (iii) final mean increment, (iv) 1/20 of timber volume of forest stands in the two oldest age-classes and older, and (v) 1/30 of timber volume of forest stands in the three oldest age-classes and older.

Prediction of growing stock development and harvest levels determined by allowable cut indicators plays an important role in selecting the most suitable indicator. From the practical viewpoint, such an allowable cut indicator that ensures cutting sustainability and evenness should be selected and used. That is, the selected indicator should consider the age and growing stock structures in order to maintain equitable harvest levels over the longest possible period. Practically, when applying the indicator, the expected timber volume development needs to be favoured. The initial growing stock markedly affects the harvest level, and the harvest level conversely affects the expected growing stock. These two variables cannot be separated, as those expressly depend upon each other. It is commonly noticed that the analytical cutting percentage and the empirical cutting percentage are the most suitable for the calculation of the expected timber volume because they provide the expected harvest level in each age-class separately. Other allowable cut indicators determine the cutting amount as a whole.

The calculation of the expected timber volumes and harvest levels in Slovakia has historically been associated with the analytical cutting percentage. The analytical cutting percentage, however, assumes 100% cut in the oldest age-classes whose trees are generally older than the rotation period plus half the regeneration period, which violates the regeneration rules. Meeting this analytical cutting percentage is problematic because these age-classes also include forest stands that cannot be regenerated in the first decennium because of the silvicultural requirements. In other words, the regeneration of these forest stands would require two or more decennia in order to satisfy such silvicultural requirements as the regeneration element width and area cut in the applied silvicultural system and harvesting criteria.

In the renewal process of the forest management plan, the remaining regeneration period (RRP) for each forest stand is determined by the number of years required for regeneration on the basis of the harvesting regime. Based on the regeneration rules, regeneration has to be completed by the year of the rotation period plus half of the regeneration period. In theoretical terms, with a rotation period (RP) of 110 years and a regeneration period (ReP) of 30 years, given 10 years for one age-class, regeneration has to be completed within the age range from 95 to 125 years. Thus, regeneration starts for forest stands with age 95 years in age-class 10. Since forest stands in age-class 10 are from 91 to 100 years old, they should have RRP of 25-30 years, while forest stands in age-class 11 should have RRP of 15-20, in age-class 12 they should have RRP of 5-10 years, and those in age-class 13 have RRP less than 5 years. There should not be any forest stands in higher age-classes (14 and higher in this example). In reality, however there are still some forest stands remained with RRP over 5-10 years, even in these higher age-classes.

Given the mean regeneration period, it is possible to determine cutting possibilities in each age-class. This information can also be used to select an appropriate allowable cut indicator by comparing the derived cutting possibilities with the planned cutting amount estimated by the selected allowable cut indicator. It is subsequently possible to decide if the selected allowable cut indicator is feasible

for FMU.

When the cutting possibilities for FMU become greater than the planned harvesting level, the harvesting requirement is fulfilled. If there is a large surplus for the cutting possibilities, the regeneration period must be extended. In the opposite case, when the planned harvesting level is greater than the cutting possibilities, the mean regeneration period must be shortened. Otherwise, this could result in violation of the area cut limits required by the silvicultural system.

The objective of this work is two-fold; (1) to estimate cutting possibilities based on the regeneration period established by the actual requirements from the forest stand management and (2) to compare the derived cutting possibilities with the harvest level derived by allowable cut indicators in order to judge which allowable cut indicator is the most realistic and suitable.

2. Materials and Methods

The development of cutting possibilities using the remaining regeneration period was assessed in two groups of forest stands, created from the original primary management group of stands at the Training Forest Enterprise of the Technical University in Zvolen, Slovakia. The first group represents state-owned forest stands (3,252.82 ha) and the second group consists of forest stands owned by multiple non-state owners (919.16 ha). In both cases, the mean rotation period and the regeneration period are 110 and 30 years, respectively. Hereafter, these stands are designated by FMU1 and FMU2, respectively. Databases of two groups were retrieved from the original forest management plan database prepared for the period 1993-2002.

The calculation of cutting possibilities was conducted with the mean value of the remaining regeneration period calculated for individual forest stands, as specified by the forest management plan (FMP) on the basis of the established regeneration procedures. To estimate possible harvest levels easier, let the remaining regeneration period (o) be expressed in tens of years. By using the mean remaining

regeneration period, o_{ti} , for age-class i in period t , the corresponding harvest level, T_{ti} , is calculated by,

$$[1] \quad T_{ti} = \frac{V_{ti}}{o_{ti}}$$

where V_{ti} is the timber volume from age-class i in period t . The mean remaining regeneration period in equation [1] is the weighted average of RRP, where the target harvesting area is used as weighting.

The mean remaining regeneration period for the second decennium, (o_{2i}), is calculated in a similar manner. Only forest stands with the remaining regeneration period greater than 10 years at the beginning of the first planning period are included in the calculation. For the third decennium, the mean, (o_{3i}), is calculated using forest stands with the remaining regeneration period greater than 20 years. The mean regeneration period for each planning period is calculated by,

$$[2] \quad o_{ti} = \frac{\sum_{j=1}^n TP_{ji} \cdot (o_{1j} - k)}{\sum_{j=1}^n TP_{ji}} \quad \text{for } i = 1 \dots m, \quad k = t - 1$$

where o_{ti} is the mean regeneration period in period t of age-class i , TP_{ji} is the harvesting area of the j -th forest stand in the i -th age class, and o_{1i} is the regeneration period of the j -th forest stand in period 1.

For the purpose of comparison with other allowable cut indicators, the mean remaining regeneration period in the first three periods, o_{1i} , o_{2i} and o_{3i} was calculated in the percentage term as in equation [3].

$$[3] \quad p_{ti} = \frac{100}{o_{ti}} = 100 \cdot \frac{\sum_{j=1}^n TP_{ji}}{\sum_{j=1}^n TP_{ji} \cdot (o_{1j} - k)}$$

where p_{ti} is the cutting possibility in period t of age-class i with considering the regeneration period. In forecasting, it was assumed that age-classes for regeneration in the second or third decennium would be subject to cutting 1/3 (33%) of the timber volume in each decennium. Such an age-class in our case was currently age-class 9

in the second and third decennium, where $o_{2,9} = 3$ ($p_{2,9} = 33$), $o_{3,9} = 3$ ($p_{3,9} = 33$), and age-class 8 in the third decennium, where $o_{3,8} = 3$ ($o_{3,8} = 33$).

The expected timber volume was calculated through predicting the growing stock of individual tree species with the corresponding increment percentage (Marušák 1999, 2001). The harvest levels by other allowable cut indicators were also predicted. The estimated cutting possibilities from allowable cut indicators were: (1) analytical cutting percentage (denoted by CP), (2) empirical cutting percentage (denoted by ECP), (3) 1/20 of the growing stock of forest stands in the two oldest age-classes and older (denoted by 1/20), and (4) 1/30 of growing stock forest stands in the three oldest age-classes and older (denoted by 1/30). Note that prediction by these indicators did not consider incidental harvesting due to difficulty of objectively determining it within FMU.

3. Results

3.1. Assessing the share of regeneration periods in mature age-classes

Table 1 shows the number and area of forest stands with respect to RRP and age-class in FMU1. The total of 88 stands was considered as mature (older than age-class 10), and it covered 522.50 ha. Only 18 forest stands out of them covered 173.31 ha (33%) (expressed by bold in the table), and they could be regenerated in time with the stated rotation period (RP) and the regeneration period (ReP). RRP in age-class 12 has to be 10 years, while it should be no more than 20 years in age class 11, and 30 years in age-class 10. They were in the first mature age-class. Regeneration could be completed earlier in 11 stands (41.54 ha (8%)), and the remaining 59 stands (307.65 ha (59%)) needed more time to regenerate than required.

FMU2 was also dominated by forest stands with a long RRP (Table 2). There were 32 stands covering 216.37 ha in the mature age-classes. Seven forest stands, covering an area of 82.95 ha, 38 % (expressed by bold in the table), were going to be regenerated in time based on the given RP and ReP and age-class. One stand with

10.14 ha (5 %) needed less time to regenerate than required, while the remaining 24 stands with 123.28 ha (57 %) required more time for regeneration.

Table 1. The number and area of forest stands with respect to the remaining regeneration period and age-class in FMU1

Age class	Remaining Regeneration Period (years)												Total	
	10		15		20		25		30		40			
	#	ha	#	ha	#	ha	#	ha	#	ha	#	ha		
10	1	0.47	1	1.28	4	24.61	1	8.11	15	163.31	4	39.01	26	237.49
11	3	6.93	1	8.25	1	5.50	-	-	6	51.87	1	11.13	12	83.68
12	2	4.50	-	-	7	32.77	1	16.68	-	-	-	-	10	53.95
13	2	3.89	3	7.55	10	44.95	1	5.70	1	8.30	2	18.50	19	88.89
14	6	11.33	1	1.3	5	29.24	-	-	-	-	1	1.34	13	43.21
15	4	5.13	-	-	4	40.15	-	-	-	-	-	-	8	15.28
Total	18	32.25	6	18.38	31	147.22	3	31.19	22	223.48	8	69.98	88	522.50

Table 2. The number and area of forest stands according to remaining regeneration period and age-class in FMU2

Age class	Remaining Regeneration Period (years)											
	10		15		20		25		30		Total	
	#	ha	#	ha	#	ha	#	ha	#	ha	#	ha
10	-	-	-	-	1	10.14	-	-	6	79.62	7	89.76
11	-	-	-	-	-	-	-	-	3	30.31	3	30.31
12	1	3.33	-	-	3	11.66	-	-	-	-	4	14.99
13	2	3.89	1	3.36	4	22.30	1	5.70	1	8.30	9	43.55
14	3	7.77	-	-	4	26.22	-	-	1	1.34	8	35.33
15	1	2.43	-	-	-	-	-	-	-	-	1	2.43
Total	7	17.42	1	3.36	12	70.31	1	5.70	11	119.57	32	216.37

3.2. Development of cutting possibilities

The mean remaining regeneration period was calculated for the nearest three decennia (o_{1i}, o_{2i}, o_{3i}). These values, as well as their percentage expression for FMU1 are presented in Table 3 along with analytical cutting percentage (denoted by CP) for the comparison purpose. From the results in Table 3, it is noted that with respect to the mean remaining regeneration periods, the planned cutting measures were only associated with the balanced withdrawal of growing stock in the current age-class 10. On the contrary, over-mature age-classes 14 and 15+, and age-class 13 that represented the last mature age-class, required more than one decennium for additional harvesting. In age-class 13, it was possible to harvest only 45 % in the first decennium because the age-class contained 17 stands with the remaining regeneration period over 10 years (Table 1). The mean remaining regeneration period of these stands was 2.2 decennia in the first planning period, and it would be reduced to 1.4 decennium in the second period. The calculation of the remaining regeneration period would include forest stands with the regeneration period of 10,

15, 20, and 30 years (forest stands with the regeneration period of 20, 25, 30, and 40 years at the beginning of the first period). In the third period, it still would not be possible to harvest the remaining forest stands because the remaining regeneration period in two stands would become 20 years. These were forest stands with the remaining regeneration period of 40 years at the beginning of the calculation, which would require justification of values for o_{1i} , o_{2i} , and o_{3i} in other age-classes.

Table 3. Values o_{1*} , o_{2*} , and o_{3*} for individual age-classes in FMU1 (%)

Age class	Period								
	1			2			3		
	o_{1*}	%	CP	o_{2*}	%	CP	o_{3*}	%	CP
10	2.9	34	30	1.9	53	50	1.1	91	88
11	2.4	42	50	2.0	50	88	1.2	83	100
12	2.0	50	88	1.1	91	100	0.5	100	100
13	2.2	45	100	1.4	71	100	1.4	71	100
14	1.6	63	100	1.1	91	100	2.0	50	100
15	1.5	67	100	1.0	100	100	0	0	100

Values o_{1i} , o_{2i} , and o_{3i} in FMU2 are presented in Table 4. As in FMU1, age-class 10 in Table 4 was the most favourable for the even-withdrawal of timber volume. Forest stands in age-class 12 at the beginning of the first decennium required two decennia to regenerate, and stands in age-classes 13 and 14 would regenerate in three decennia. Unlike FMU1, forest stands in age-class 15+ would be harvested in the first decennium.

Table 4. Values o_{1*} , o_{2*} , and o_{3*} for individual age classes in FMU2 (%)

Age class	Period								
	1			2			3		
	o_{1i}	%	CP	o_{2i}	%	CP	o_{3i}	%	CP
10	2.8	36	30	1.9	53	50	1.0	100	88
11	3.0	33	50	2.0	50	88	1.0	100	100
12	1.6	63	88	1.0	100	100	0	0	100
13	2.0	50	100	1.3	77	100	1.0	100	100
14	2.1	48	100	1.4	71	100	1.0	100	100
15	1.0	100	100	0	0	100	0	0	100

The amount of the possible cutting (PC) was used as the basis for realistic suitability of the indicators. It was calculated in each age-class with the corresponding mean regeneration period, which represented the cutting possibilities of forest stands with respect to the determined regeneration procedure. The results are shown in Table 5. In the first period, the cutting possibilities by PC in FMU1 amounted to the total amount of 126,843 m³, the lowest value calculated for any of the allowable cut indicators. In the event that harvest levels for FMU1 were

determined by one of these allowable cut indicators, the prescribed cut would exceed the capacity of individual stands. Assuming that the cutting possibilities need to meet certain regeneration procedures, increasing the harvest level would become only possible by violating the area cut limits required by the silvicultural system. Therefore, the analytical cutting percentage (CP) with a value of 179,153 m³ became unrealistic for FMU1. This was also observed for the results in Table 6, which showed the values through PC and CP in each age-class. It showed that the cutting possibilities by PC were much lower than those by CP in most age-classes. A similar result can be seen in the allowable cut indicator of (1/20). The empirical cutting percentage (ECP) with a value of 131,576 m³ was lower by 3.7% from those of PC. With comparison of PC with each allowable cut indicator in the second and third decennium, we can conclude that ECP was the best allowable cut indicator for FMU1 because it best mimicked the cutting possibilities of the forest stands derived by PC. The next appropriate indicator is (1/30).

Table 5. Values of cutting possibilities derived by each allowable cut indicator for 3 periods by tree species groups (m³)

Allowable cut indicator	Period	FMU 1			FMU 2		
		Conifers	Broadleaves	Total	Conifers	Broadleaves	Total
PC	1	28,622	98,221	126,843	12,758	41,342	54,100
	2	37,037	112,698	149,735	16,505	38,753	55,258
	3	46,151	124,391	170,542	18,157	27,994	46,151
CP	1	35,467	143,685	179,153	17,390	63,718	81,109
	2	39,708	98,552	138,260	15,633	25,751	41,384
	3	46,767	120,697	167,464	16,007	23,154	39,161
ECP	1	31,519	100,056	131,576	13,724	38,819	52,542
	2	38,089	110,376	148,465	14,946	33,025	47,971
	3	42,417	123,213	165,631	15,210	28,154	43,364
1/20	1	36,323	112,971	149,294	14,062	42,601	56,663
	2	40,326	116,804	157,130	15,887	36,465	52,351
	3	42,363	124,224	166,588	14,658	25,340	39,999
1/30	1	34,170	101,194	135,365	14,025	34,235	48,260
	2	37,382	110,498	147,880	14,016	28,943	42,958
	3	38,709	119,345	158,054	13,807	26,721	40,528

Table 6. Comparison of possible cutting (PC) and analytical cutting percentage (CP) in the mature age-classes of FMU1 (m³)

Allowable cut indicator	Tree species	Age class						
		9	10	11	12	13	14	15+
PC	Conif.	-	14,296	6,946	3,063	2,277	1,897	143
	Broad.	-	31,693	15,091	9,593	21,299	15,262	5,283
	Total	-	46,622	21,762	12,403	23,148	17,052	5,426
CP	Conif.	1,195	12,609	8,232	5,284	4,919	3,016	214
	Broad.	3,106	27,953	17,883	16,546	46,006	24,267	7,925
	Total	4,300	40,562	26,115	21,829	50,925	27,283	8,139

In FMU2, CP became inconvenient because its value for the first decennium was 81,109 m³ (Table 5), 50% more than that determined by PC (54,100 m³). This trend can also be seen in CP by most age-classes in Table 7. The 1/20 allowable cut indicator exceeded PC in the first decennium by 5% and its value in the following two periods was lower than those of PC. Allowable cut indicators ECP and 1/30 exhibited lower values than PC in all three periods, implying that they can be achieved and are suitable for FMU2.

Table 7. Comparison of possible cuts (PC) and analytical cutting percentage (CP) in the mature age-classes of FMU2 (m³)

Allowable cut indicator	Tree species	Age class						
		9	10	11	12	13	14	15+
PC	Conif.	-	5,347	3,046	430	2,290	1,573	73
	Broad.	-	8,383	3,208	4,899	10,746	12,384	1,721
	Total	-	13,730	6,254	5,329	13,036	13,957	1,794
CP	Conif.	398	4,491	4,569	605	4,580	2,674	73
	Broad.	700	7,042	4,812	6,898	21,492	21,053	1,721
	Total	1,098	11,533	9,381	7,504	26,072	23,727	1,794

3.3. Development of expected timber volume

The planned harvest levels affect the predicted timber volume. Using CP and 1/20 allowable cut indicators in FMU1, the timber volume expected in the following decennia became 5% lower than that predicted by PC on average using high values for these indicators (Figure 1). Conversely, the expected timber volume development using the ECP and 1/30 allowable cut indicators was very similar to that predicted by PC, implying that these allowable cut indicators would be suitable for FMU1.

In FMU2, with cutting possibilities by PC higher than some allowable cut indicators, the highest increase in the timber volume was predicted through ECP and 1/30 indicators (Figure 2). The highest values were achieved by the 1/30 indicator with the expected timber volume higher at the end of the predicted period (at the beginning of the fourth decennium) than that calculated by PC. The difference was 8% using ECP.

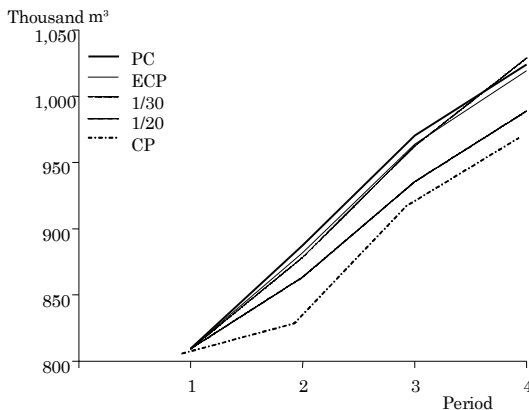


Figure 1. Expected timber volume development using different allowable cut indicators in FMU1

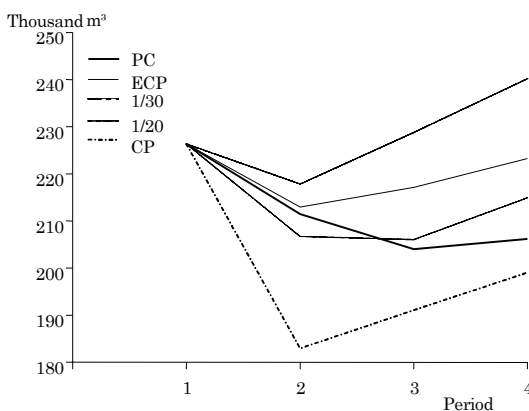


Figure 2. Expected timber volume development using the allowable cut indicators in FMU2

4. Conclusion

Predicting the expected growing stock and cutting amounts becomes an increasingly important practical activity in forest management planning in Slovakia. The prediction of the growing stock provides information on the expected timber volume in the nearest ten-year periods, from which the expected cutting possibilities can be derived. Similarly, based on the cutting possibilities of each mature stand, it is possible to predict the cutting amounts, meeting the needs of these forest stands right at the beginning of the planning period. For these purposes, this paper

investigated the use of the remaining regeneration period for calculating the cutting possibilities or possible cutting for each age class in order to select the most suitable allowable cut indicator. The method takes into account the possibilities of individual forest stand under the regeneration requirements, so that the resultant cutting possibilities (amounts) as a harvest level can be regarded as an upper bound for possible cutting in each age class. Exceeding these values would not satisfy the regeneration procedures.

We compared cutting amounts predicted by possible cutting and four allowable cut indicators in two forest management units. The amount by possible cutting was calculated in each age-class with the corresponding mean regeneration period, which represent the cutting possibilities of forest stands with respect to the determined regeneration procedure. Our comparison on the calculated cutting amounts and timber volume indicated the following three findings: 1) the calculation of cutting possibilities by possible cutting (PC) is needed to judge whether the particular allowable cut indicator can be applied in the target forest management unit without violating the requirements from the silvicultural system as to area cut and regeneration element width, so that we could select the most suitable allowable cut indicator, 2) with the calculation of cutting possibilities by possible cutting (PC), we can distribute cutting possibilities derived by the allowable cut indicators 1/20 and 1/30 over different age-classes, which is very important in predicting the growing stock by age-class, and 3) ECP was the best allowable cut indicator for FMU1 because it best mimicked the cutting possibilities of the forest stands derived by PC, while ECP and the allowable cut indicator 1/30 were suitable for FMU2 due to their lower values of cutting possibilities than those by PC.

References

- Burgan, K. (2002) Prognózy vývoja ťažieb (Aktuálne problémy a čiastkové výsledky riešenia), In *Vlastnícke a užívateľské vzťahy k lesu vo väzbe na hospodársku úpravu lesov* (Herich, I., Žihlavník, A. and Marušák, R. eds.), Zvolen, pp.61-66. (in Slovak).

- Greguš, C. (1989) Metodický postup odvedenia výhľadových a prognózovaných ťažbových etátov, *Lesnícky časopis*, 35, 1: 17-31. (in Slovak).
- Kanka, M. (1983) Prognóza vývoja ťažbových možností, KDP, LF VŠLD Zvolen, 127p. (in Slovak).
- Kanka, M., Kachnič, M., Burgan, K. and Bavlšík, J. (1983) Vývoj ťažbových možností na tri desaťročia-prognózy, *Lesoprojekt Zvolen*, 14p. (in Slovak).
- Laš, M., (2000) Regulácia ťažby pomocou plochových ťažbových ukazovateľov, In *Perspektívy rozvoja hospodárskej úpravy lesov v SR*, LF TU Zvolen, pp.53-58. (in Slovak).
- Majoroš, Š. (1999) Overenie možnosti adaptívnej regulácie obnovných ťažieb súboru podrastovo obhospodarovaných porastov, *Acta Facultatis Forestalis Zvolen*, XLI, pp.211-224 (in Slovak).
- Marušák, R. (1998) Problematika kalkulácie očakávaných zásob vo vzťahu k výpočtu výhľadových etátov, *Acta Facultatis Forestalis Zvolen*, XL, pp.131-144. (in Slovak).
- Marušák, R. (1999) Problematika výchovných ťažieb pri kalkulácii očakávaných zásob. *Acta Facultatis Forestalis Zvolen*, XLI, pp.225-238.
- Marušák, R. (2001) Prognózovanie zásob vo vzťahu k výberu ťažbového ukazovateľa. In *I. medzinárodné sympóziom, Súčasnosť a nové smery rozvoja HÚL - Problematika priestorovej a ťažbovej úpravy lesa v súčasnosti* (Žihlavník, A. and Marušák, R. eds.), Zvolen 11.-12.9.2001, pp.69-76. (in Slovak).
- Žihlavník, A. (1997) Problematika a možnosti použitia ťažbových ukazovateľov v lesných užívateľských celkoch, *Acta Facultatis Forestalis Zvolen*, XXXIX, s. pp.243-253. (in Slovak).
- Žihlavník, A. (1998) Využitie plochových ťažbových ukazovateľov v nepravidelných vekových štruktúrach lesa, *Acta Facultatis Forestalis Zvolen*, XL, s. pp.185-196. (in Slovak).
- Žihlavník, A. (1999) Ťažbová úprava lesa v lesných užívateľských celkoch. *Vedecké štúdie 4/1999/A*, TU Zvolen, 78p. (in Slovak).

Žíhla, A. (2000) Ťažbová regulácia v lesných užívateľských celkoch s podrastovým hospodárskym spôsobom, Acta Facultatis Forestalis Zvolen, XLII, s. pp.213-225. (in Slovak).

スロバキアにおける異なる許容伐採指標による伐採率に関する比較分析

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要約：本論文では、それぞれの林分に対し、実際の森林の更新期間に基づく林分蓄積と伐採率の予測について解析を行った。伐採率は森林の更新を考慮した場合に持続的となる伐採量でなくてはならない。ツボレン工科大学の演習林から得られる 2 つの管理ユニットを用いて、現行の 4 つの許容伐採指標(解析的伐採, 経験的伐採, 老齢林 1/20 伐採, 老齢林 1/30 伐採) から算出される伐採率と、更新期間を考慮して算出される現実的な率を比較し、対象とする森林に適した許容伐採指標の分析を行った。更新を考慮して算出される伐採率を最も良く模倣するものが、すなわち最も適当な指標と考えることができるが、本研究で取り扱った森林管理ユニットでは経験的な伐採率を用いた許容伐採指標が最も適していることが分かった。

キーワード：伐採率, 更新期間, 許容伐採指標