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Natural loss of trees, recruitment and increment in stands of primeval character in selected areas of the Bieszczady Mountains National Park (South-Eastern Poland)

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ABSTRACT: In three investigated stands the highest increment (8.8 m^3/ha per year, i.e. 1.5% of the actual stand volume, measured at the end of the control period) was reached by Jawornik I stand in the initial period of the growing up stage, and Tworylczyk stand in the advanced growing up stage (7.4 m^3/ha per year, i.e. 1.2% of the actual stand volume). Jawornik II stand, in the optimum stage, the aging phase, had the lowest increment (3.9 m^3/ha per year, i.e. 0.7% of the actual stand volume). The process of a natural volume loss was the most intensive in Tworylczyk stand (7.6 m^3/ha per year), a little less intensive in Jawornik II stand (7.1 m^3/ha per year), and the least intensive in Jawornik I stand (5.8 m^3/ ha per year). The analysis of tree loss, recruitment, and increment, and the relations between these processes, can form the basis for a conclusion that stable stands developed in the Carpathian primeval beech forests in the years 1988–1998. Such steady processes can be used for the development of a stable, multifunctional model of the forest managed by the selection system, or the Swiss irregular shelterwood system in the Carpathian beech stands of a similar structure.

Keywords: Eastern Carpathians; *Abies alba; Fagus sylvatica;* developmental stages and phases; selection forest

The stability and permanence of primeval forest ecosystems in a tree layer, expressed by a definite stand volume, are the result of three natural, separate, and partially antagonistic processes: natural loss, recruitment and increment (Dziewolski, Rutkowski 1987). Their values can be measured and expressed by the number of trees or volume units. In forests of primeval character their extent can be determined by two measurements taken at the beginning and end of the control period.

The investigations carried out in primeval forests of the Eastern Carpathians in the past (Mauve 1931; Korsuň 1938) were based on a single measurement, thus they do not contain data describing the three processes mentioned above. The data on the increment of primeval mountain forests of the Western Carpathians (Dobroč and Badín in Slovakia) can be found in Korpeľ s (1995) monographic work. It also includes data on the increment of primeval beech forests in the Slovak Eastern Carpathians (Vihorlat). Studies of this type were also carried out in Poland in the National Parks of the Western Carpathians situated in the Gorce and Pieniny Mountains (Dziewolski, Rutkowski 1987, 1991). These papers contain data on the loss, recruitment, and increment in stands with fir and beech in their species composition, expressed by the number of trees and volume units.

Similar investigations were undertaken by the authors of this paper in the Bieszczady Mountains National Park situated in the Polish part of the Eastern Carpathians (the Western Bieszczady Mountains). Their objective was to determine the loss, recruitment, and increment in beech stands of primeval character, and also determine the characteristics of trees that died during the control period (1988–1998).

STUDY AREA AND REMARKS ON THE METHODS

A description of three permanent sample plots where the measurements were carried out can be found in the paper of Jaworski et al. (1991), and in the paper prepared for publication (Jaworski et al. 2002) (compare Table 1). But it should be mentioned that according to Korpeľ (1982, 1995) the stands under investigations represent the growing up stage, storeyed structure phase (Tworylczyk stand), the initial phase of the growing up stage (Jawornik I stand), and the growing up stage in the aging and regeneration phase (Jawornik II stand) (Table 1).

Investigations carried out on three permanent sample plots in 1988 and 1998 included the measurements of $d_{1.3}$ and height of all trees permanently numbered with marked places of diameter measurement ($d_{1.3}$ ≥ 6 cm), and the evaluation of vitality and growth tendency according to IUFRO classification (Leibundgut 1966). The trees that reached the size of merchantable timber

Table 1. Location of sample plots and their site and stand characteristics

Plot (Forest Range)	Jawornik I (Suche Rzeki)	Jawornik II (Suche Rzeki)	Tworylczyk (Suche Rzeki)
Location (compartment)	99a	99a	151a
Size (ha)	1/3	1/2	1/2
Exposure	N–NW	N–NE	W–NW
Slope	13–17°	18–23°	18–25°
Elevation (m)	780–800	780–810	720
Plant association	*Dentario glandulosae-Fagetum lunarietosum*		*Dentario glandulosae-Fagetum*
Developmental stage and phase acc. to KORPEĽ (1995)	growing up stage, phase of storeyed structure with aging symptoms in upper storey	optimum stage, phase of aging and regeneration	growing up stage, phase of storeyed structure

($d_{1.3} \geq 8$ cm) during the control period were included in the category of recruitment while the trees that died during that period to the category of loss. The trees 6–7.9 cm in $d_{1.3}$ were qualified as the advanced upgrowth and are not taken into consideration in this paper.

The volume of trees was computed using the original computer program "Zasoby" based on GRUNDNER and SCHWAPPACH (1952) volume tables. In order to determine the stand volume on the basis of 1988 measurements and the volume loss during 1988–1998 a stand height smooth curve was drawn according to Michajlov's function (KORF et al. 1972) while the stand volume in 1998, including the volume of recruitment, was determined on the basis of this curve for 1998 data (BRUCHWALD 1995).

First, the computations included the control of the number of trees:

$$N_{98} - N_{88} + N_L - N_R = 0$$

where: N_{88} – number of trees at the beginning of the period (1988),
N_{98} – number of trees at the end of the period (1998),
N_L – number of trees that died (loss) during 1988–1998,
N_R – number of trees qualified as the recruitment during 1988–1998.

The current periodic increment (I_V) was computed according to the formula:

$$I_V = V_{98} - V_{88} + V_L - V_R \quad (\text{m}^3/\text{ha per 10 years})$$

where: V_{88} – volume at the beginning of the period (1988),
V_{98} – volume at the end of the period (1998),
V_L – volume of trees that died (loss) during 1988–1998,
V_R – volume of trees qualified as the recruitment during 1988–1998.

Table 2. Loss, recruitment, and volume increment during 1988–1998 in three stands areas in the Bieszczady Mountains

Species	No. of trees N_{88} (trees/ha)	Volume V_{88} (m^3/ha)	No. of trees N_{98} (trees/ha)	Volume V_{98} (m^3/ha)	Loss 1988–1998 No. of trees N_L (trees/ha) per 10 years	Loss 1988–1998 Volume V_L (m^3/ha) per 10 years	Recruitment 1988–1998 No. of trees N_R (trees/ha) per 10 years	Recruitment 1988–1998 Volume V_R (m^3/ha) per 10 years	Increment 1988–1998 $I_V = V_{98} - V_{88} + V_L - V_R$ (m^3/ha) per 10 years
Jawornik I									
Fagus sylvatica	144	447.68	150	483.46	9	34.98	15	0.32	70.44
Abies alba	39	99.57	39	94.27	3	23.34	3	0.02	18.02
Total	183	547.25	189	577.73	12	58.32	18	0.34	88.46
Jawornik II									
Fagus sylvatica	156	631.41	152	599.71	18	71.33	14	0.23	39.40
Abies alba	4	0.09	6	0.14	–	–	2	0.04	0.01
Total	160	631.50	158	599.85	18	71.33	16	0.27	39.41
Tworylczyk									
Fagus sylvatica	278	583.74	280	579.89	34	75.82	36	0.62	71.35
Abies alba	10	27.71	8	30.14	2	0.17	–	–	2.60
Total	288	611.45	288	610.03	36	75.99	36	0.62	73.95

RESULTS

LOSS, RECRUITMENT AND INCREMENT

In Jawornik I stand, 12 trees (3 firs and 9 beeches) died during the control period on the area of 1 ha. Their volume amounted to 58.32 m^3/ha. The recruitment consisted of 18 trees/ha (3 firs and 15 beeches) of the total volume 0.34 m^3/ha (Table 2). The mean annual loss in numbers in the case of fir was 0.8%, and in the case of beech 0.6% (Table 3). The value of the fir annual loss was 2.5% of the fir volume in 1998, and that of the beech loss 0.7%, and the volume of the total annual loss was 1% of the actual (1998) stand volume (Table 3). The average volume of a single dead fir (7.78 m^3) was higher than that of beech (3.89 m^3). The volume increment reached 88.46 m^3/ha per 10 year (Table 2).

In Jawornik II stand, 18 beech trees of the total volume of 71.33 m^3 (Table 2) died during the control period, i.e. annually 1.2% of all beech trees on average. The average volume of a dead beech was 3.96 m^3. The mean annual loss amounted to 1.2% of the actual stand volume (Table 3). The recruitment consisted of 14 beeches (0.23 m^3) and only 2 firs (0.04 m^3) (Table 2). The volume increment was 39.41 m^3/ha per 10 year (Table 2).

In Tworylczyk stand, the loss in tree numbers was equal to the recruitment and amounted to 36 trees/ha (Table 2). The recruitment during a 10-year period consisted of beech only (36 trees and 0.62 m^3) while among the dead trees there were 34 beeches (75.82 m^3) and 2 firs (0.17 m^3) (Table 2). The annual loss was 1.3% of the actual number of living firs and beeches together (Table 3). The annual mortality of beech trees amounted to 1.2% of the total number of trees of this species while in the case of fir it was 2.5% (Table 3). The average volume of a single dead beech (2.23 m^3) was much higher than that of fir (0.085 m^3). The volume increment was 73.95 m^3/ha per 10 year (Table 2).

The basal area increment at breast height in three study areas Jawornik I, Jawornik II, and Tworylczyk was 4.47 m^2/ha per 10 year, 2.89 m^2/ha per 10 year, and 3.68 m^2/ha per 10 year, respectively (Table 4).

CHARACTERISTICS OF TREES THAT DIED

Jawornik I

The only dead fir tree came from the upper storey and reached 75 cm in $d_{1.3}$ (Table 5). In 1988 it belonged to weakened trees, vitality index 30 according to the IUFRO classification, and had a low growth tendency, index 3 (Table 5).

The beeches that died (3 trees on a sample plot 1/3 ha in area) were weakened (index 30) or of normal vitality (20) and of a slow (3) or normal (2) growth rate (Table 5). The largest number of beeches (6 trees/ha) died in the highest layer, making 8% of all beech trees and 6.9% of all trees in this layer. In the middle layer (200) 3 beech trees died per hectare (Table 6). The low stand density in the lower and middle layers, and favorable light conditions due to a sparsely stocked stand, developed as a result of the break-up stage that terminated 10–20 years ago, did not cause mortality among beech trees in the lower storey.

Jawornik II

Only beech trees (18 trees/ha) (Table 2) died in this stand during the control period, and most of them (77.8%) came from the upper layer (100) (Table 6). In the two remaining layers only 2 trees/ha died in each of them, i.e. in each layer 11.1% of the total number of dead trees (Table 6). Considering the ratio between the number of dead trees and the total number of trees in a given stand layer, the highest loss in numbers (16.7%) occurred in the middle layer (200), then (12.7%) in the upper layer (100), and the lowest loss (5.6%) occurred in the lower layer (300) (Table 6). The dead beech trees represented all diameter classes

Table 3. Annual loss, recruitment, and increment in relation to actual growing stock

Plot	Species	Ratio between the loss in numbers and actual number of trees in stand (%)	Ratio between volume loss and actual stand volume (%)	Ratio between tree recruitment in numbers and actual number of trees in stand (%)	Ratio between volume increment and actual stand volume (%)
Jawornik I	*Fagus sylvatica*	0.6	0.7	1.0	1.5
	Abies alba	0.8	2.5	0.8	1.9
	Total	0.6	1.0	1.0	1.5
Jawornik II	*Fagus sylvatica*	1.2	1.2	0.9	0.7
	Abies alba	–	–	3.3	0.7
	Total	1.1	1.2	1.0	0.7
Tworylczyk	*Fagus sylvatica*	1.2	1.3	1.3	1.2
	Abies alba	2.5	0.1	–	0.9
	Total	1.3	1.2	1.3	1.2

Table 4. Loss, recruitment, and increment of stand basal area at breast height during 1988–1998

Plot	Species	Stand basal area G^1_{88}	G^2_{98}	Loss 1988–1998 $G_L{}^3$	Recruitment 1988–1998 $G_R{}^4$	Increment 1988–1998 $I_G{}^5 = G_{98} - G_{88} + G_L - G_R$
				(m^2/ha per 10 years)		
Jawornik I	*Fagus sylvatica*	24.76	26.58	1.85	0.10	3.57
	Abies alba	6.81	6.38	1.34	0.02	0.89
	Total	31.56	32.96	3.19	0.12	4.47
Jawornik II	*Fagus sylvatica*	33.33	32.52	3.78	0.08	2.89
	Abies alba	0.03	0.04	0.00	0.01	0.00
	Total	33.36	32.56	3.78	0.09	2.89
Tworylczyk	*Fagus sylvatica*	33.77	33.09	4.35	0.20	3.47
	Abies alba	1.74	1.93	0.02	0.00	0.21
	Total	35.51	35.02	4.37	0.20	3.68

$G_{88}{}^1$ – stand basal area at the beginning of the period (1988)
$G_{98}{}^2$ – stand basal area at the end of the period (1998)
$G_L{}^3$ – basal area of dead trees (loss)
$G_R{}^4$ – basal area of trees in recruitment
I_G – stand basal area increment

with the exception of class one. Weakened beeches with slow growing rate dominated among the dead trees (Table 5).

Tworylczyk

Dying of trees occurred in all stand layers, but it was most severe in the middle layer (44.4% of dead trees, i.e. 21.1% of the total number of trees in this layer) (Table 6). An equal number of trees died in the upper and lower layers (10 trees/ha, i.e. 27.8% in each layer), which amounted to 8.2% and 11.1% of the actual number of trees in each layer respectively (Table 6). Most of the dead beech trees (41.2%) belonged to the 8–15.9 cm diameter class, and nearly 24% to the 16–23.9 cm class (Table 5). Before death most of these beeches had weakened vitality (30) and slow growth rate (3) (Table 5).

DISCUSSION

The highest increment (8.8 m^3/ha per year, i.e. 1.5% of the actual stand volume) was reached by Jawornik I stand in the initial period of the growing up stage. The next was Tworylczyk stand (7.4 m^3/ha per year, i.e. 1.2% of the actual stand volume) being in an advanced phase of this stage. Jawornik II stand, being in the optimum stage, the aging phase, had the lowest increment (3.9 m^3/ha per year, i.e. 0.7% of the actual stand volume) (Tables 2 and 3).

In the primeval forests of Slovakia, composed of fir and beech, the current annual volume increment in the Dobroč reserve ranged from 7.1 to 12.1 m^3/ha, and in Badín 4.7 and 8.6 m^3/ha (KORPEĽ 1995). In the Peručica reserve in Bosnia (the Sutjeska National Park) this increment was 6.4–8.8 m^3/ha per year (PINTARIČ 1978). In stands of the Babia Góra National Park (Poland) it was 3.5–8.6 m^3/ha per year (JAWORSKI, PALUCH – unpublished). In beech forests of Vihorlat (the Kyjov reserve) growing under very favorable site conditions the current volume increment of merchantable timber reached 3–12 m^3/ha per year (KORPEĽ 1995). Therefore it can be concluded that beech stands investigated in the Bieszczady Mountains reached the increment similar to that of other European primeval forests composed of fir and beech. Only the stands in the Dobroč and Kyjov reserves in Slovakia were better in this respect than the investigated stands.

The data concerning the volume increment in the Bieszczady Mountains stands investigated, especially of a complex structure in the growing up stage (Tworylczyk and Jawornik I) are worth comparing with the current volume increment of beech selection forests in Germany. It is 7.2 m^3/ha per year in the forest of Langula (mean for the period 1974–1988) (GEROLD, BIEHL 1992), and 4.6 m^3/ha per year in the forest of Keula (LANDBECK 1952). This increment is close to that found in the Bieszczady Mountains, which, however, is much lower than the increment reached in a long term thinning experiment in Fabrikschleichen 015 where it was 12–14.5 m^3/ha per year in the stand 140–160 years old during 1960–1980 (PRETZCH 1992, 1996). This increment increase need not be connected with faster growth caused by thinning because it was also observed in experimental areas where thinning was moderate. A similar tendency of the increasing productivity of sites was observed in most regions of Central Europe where beech occurs (SKOVSGAARD, HENRIKSEN 1996; UNTHEIM 1996).

The trend of increasing growth could be caused by one factor, combination of factors or by regionally changing factors that finally had similar effects on growth. The land use history, forest management, natural disturbances, climate, including nitrogen deposition and increased CO_2 content in the atmosphere, or other factors are among the

Table 5. Characteristics of dead trees (loss) (1988 measurements and classification)

Species	$d_{1.3}$ (cm)	Diameter class*	Height (m)	Stand layer	Vitality index	Index of growth tendency
				according to IUFRO classification		
			Jawornik I (1/3 ha)			
Abies alba	75.0	VI	39.0	100	30	3
Fagus sylvatica	14.5	I	15.5	200	30	3
Fagus sylvatica	46.5	IV	32.0	100	30	2
Fagus sylvatica	74.0	VI	37.0	100	20	2
			Jawornik II (0.5 ha)			
Fagus sylvatica	21.5	II	9.5	300	30	3
Fagus sylvatica	24.0	III	20.5	200	30	3
Fagus sylvatica	34.5	III	27.0	100	30	3
Fagus sylvatica	37.5	IV	34.5	100	30	3
Fagus sylvatica	50.5	IV	35.5	100	30	3
Fagus sylvatica	54.0	V	34.5	100	30	3
Fagus sylvatica	58.5	V	36.0	100	30	2
Fagus sylvatica	75.0	VI	40.0	100	20	2
Fagus sylvatica	77.0	VI	38.0	100	30	3
			Tworylczyk (0.5 ha)			
Abies alba	12.0	I	12.5	300	30	3
Fagus sylvatica	8.0	I	11.3	300	30	3
Fagus sylvatica	8.5	I	11.3	300	30	3
Fagus sylvatica	9.5	I	14.0	200	30	3
Fagus sylvatica	11.0	I	10.5	300	30	3
Fagus sylvatica	11.5	I	17.5	200	30	2
Fagus sylvatica	11.5	I	18.3	200	30	2
Fagus sylvatica	13.5	I	16.5	200	20	2
Fagus sylvatica	18.5	II	20.5	200	30	2
Fagus sylvatica	20.5	II	9.3	300	30	3
Fagus sylvatica	22.5	II	20.5	200	30	3
Fagus sylvatica	22.5	II	17.0	200	30	3
Fagus sylvatica	27.0	III	19.0	200	30	3
Fagus sylvatica	41.5	IV	31.0	100	30	3
Fagus sylvatica	45.0	IV	37.5	100	30	3
Fagus sylvatica	53.5	V	37.0	100	20	2
Fagus sylvatica	80.5	VI	37.0	100	30	3
Fagus sylvatica	106.5	VI	33.0	100	30	3

* diameter classes: I 8.0–15.9 cm; II 16.0–23.9 cm; III 24.0–35.9 cm; IV 36.0–51.9 cm; V 52.0–71.9 cm; VI 72.0–91.9 cm; VII ≥ 92.0 cm

possible causes. The significance of each factor possibly varies in space and time. Growth responses to the influencing factor are modified by site and stand conditions (SPIECKER et al. 1996).

To make a comparison between the increment in managed forests and that in forests of primeval character is not fully correct because the silvicultural activities of the forest manager generally aim at maximum utilization of the growth potential of trees and stands while in the primeval forests the increment depends on natural changes not always fulfilling our expectations. These data are quoted to stress the changes in productivity of beech forests in Central Europe that have not been observed in the primeval beech forests of South-Eastern Poland at the present time. This has been indicated by a not very high increment in stands investigated in the Bieszczady Mountains (3.9–8.8 m^3/ha), generally close to the current volume increment of the primeval stands during the last three decades, the values of which are given above.

Table 6. Total number of trees and number of trees lost in individual stand layers

Stand layer acc. to IUFRO classification	Species	Total number of trees		Number of lost trees		Ratio between number of dead trees (loss) and actual number of trees in a layer (1988)	
						of given species	of all species together
		(trees/ha)	(%)	(trees/ha)	(%)	(%)	
				Jawornik I			
100	*Fagus sylvatica*	75	39.7	6	50.0	8.0	6.9
	Abies alba	12	6.3	3	25.0	25.0	3.4
200	*Fagus sylvatica*	48	25.4	3	25.0	6.3	5.3
	Abies alba	9	4.8	–	–	–	–
300	*Fagus sylvatica*	27	14.3	–	–	–	–
	Abies alba	18	9.5	–	–	–	–
	Total	189	100.0	12	100.0	–	6.3
				Jawornik II			
100	*Fagus sylvatica*	110	69.6	14	77.8	12.7	12.7
	Abies alba	–	–	–	–	–	–
200	*Fagus sylvatica*	12	7.6	2	11.1	16.7	16.7
	Abies alba	–	–	–	–	–	–
300	*Fagus sylvatica*	30	19.0	2	11.1	6.7	5.6
	Abies alba	6	3.8	–	–	–	–
	Total	158	100.0	18	100.0	–	11.4
				Tworylczyk			
100	*Fagus sylvatica*	116	40.3	10	27.8	8.6	8.2
	Abies alba	6	2.1	–	–	–	–
200	*Fagus sylvatica*	76	26.4	16	44.4	21.1	21.1
	Abies alba	–	–	–	–	–	–
300	*Fagus sylvatica*	88	30.5	8	22.2	9.1	8.9
	Abies alba	2	0.7	2	5.6	100	2.2
	Total	288	100.0	36	100.0	–	12.5

The loss of trees, being a result of natural mortality, was most severe in Tworylczyk stand representing the advanced growing up stage and the phase of storeyed structure. In this stand 36 trees/ha died during the period of 10 years (Table 2). The loss of trees was twice as low in the stand being in the optimum stage and the initial aging phase (Jawornik II) (Table 2). The smallest number of trees (12 trees/ha per 10 year, i.e. 0.6% of the actual number annually) died in Jawornik I stand representing the initial phase of the growing up stage (Tables 2 and 3).

In Jawornik I stand, where the break-up process had been finished 10–20 years ago (JAWORSKI et al. 2002), the tree mortality have decreased and presently it takes place in the upper layer, and less frequently in the middle layer (Tables 5 and 6). In the case of large diameter trees ($d_{1.3}$ above 70 cm) the mortality is a result of reaching the natural (biological) life end. These specimens are most likely the remnants of the oldest tree generation. Other two trees probably died due to competition or other forms of harmful effects of surrounding trees. There were no external disease symptoms on these trees.

In Tworylczyk stand, representing the growing up stage and having a storeyed structure, the loss in tree numbers was the highest in the middle layer while in the upper and lower layers it was much lower (Tables 5 and 6).

The process of natural mortality in stands with complex storeyed structure (Jawornik I and Tworylczyk) resembles the removal of trees mature for cutting in the selection system. The dead trees in the upper stand layer, above 70 cm in $d_{1.3}$, correspond to the "crop harvesting", but in the latter case it concerns living trees of weakened vitality and slower growth. The dead trees in the same layer but of smaller diameters, and the dead trees in the middle layer (200) correspond to a known rule of entering with selection cuttings to all stand layers.

The natural selection taking place in these stands seemingly plays a role of selection cutting carried out by the forest manager, but mainly in a negative direction (sanitation cuttings), although frequently in connection with other aims of selection cutting (LEIBUNDGUT 1966; SCHÜTZ 1997). However, additional studies are required to determine how much "the aims of the nature" approximate the aims of the man under definite conditions.

The losses in Jawornik II stand also consisted of trees of the older generation from the highest storey (Tables 5 and 6), but the dying of these trees cannot be compared to selection cuttings due to a little differentiated structure. They basically resemble a one-storey structure, single tree cuttings used in the Swiss irregular shelterwood system where the trees mature for cutting are removed.

The per cent of the annual loss in tree numbers and volume: 0.6% and 1% in Jawornik I stand, and 1.1% and 1.2% in Jawornik II, respectively, and the per cent of volume increment in these stands: 1.5% and 0.7%, respectively (Table 3), assure the permanence of the primeval ecosystem of the Carpathian beech forest. The extent of the loss and increment, determined in this study, can form the basis for a multifunctional model of the forest managed by the selection or Swiss irregular shelterwood system.

It should be stressed that the permanence of forest enterprise managed by the selection system can be assured if the difference between the intensity of the increment process and the intensity of the loss (exploitation) is the lowest possible (RÜESCH 1983; SCHÜTZ 2001). Similar assumptions were made for stands managed by the Swiss irregular shelterwood system (POZNAŃSKI 1999).

Tworylczyk stand, similarly like Jawornik I stand, indicates a possibility of forming the complex storeyed structure in beech forests. It is presently characterized by stability in respect of the loss, increment and volume (Table 2). This stand with complex structure and a high volume for the many-storeyed beech forest shows, however, a tendency to form a two-storeyed structure, which is indicated by a decrease in tree numbers in the middle layer (from 32.6% in 1988 to 26.4% in 1998) (JAWORSKI et al. 2002). The processes taking place do not favor the formation of many-storeyed structure. The formation of the complex storeyed structure requires a lower stand volume in the case of the beech forest. Among other things, it is indicated by data from some beech selection forests, e.g. in Keula with 408 m^3/ha (GEROLD, BIEHL 1992), and in Bleicherode with 548 m^3/ha (DITTMAR 1990). But GEROLD and BIEHL (1992) are of the opinion that the selection structure disappears at the stand volume above 500 m^3/ha.

In order to maintain a stable selection structure it is necessary to secure the continuity of regeneration, and an adequate number of trees in low diameter classes, and the transfer of these trees into higher classes, which is connected with the optimum stand volume. According to SANIGA (1998) this volume is 280–300 m^3/ha in Slovak beech selection forests (the Eastern Carpathians). Citing Schaeffer's investigations, SCHÜTZ (1992) is convinced that the maintenance of selection structure in beech forests is possible at the stand volume not higher than 200–250 m^3/ha. It should be remembered, however, that the optimum stand volume depends on the site, and the values cited above have only a guiding meaning.

Thus it can be assumed that the "cuttings" in Tworylczyk stand expressed by a natural volume loss are too weak to assure the many-storeyed structure. A higher tree loss in the highest layer would be favorable in this respect. A lower volume of Jawornik I stand (547 m^3/ha) in 1988 (Table 2) is more favorable for the maintenance of storeyed differentiation of the stand. In the managed forests where we wish to maintain a selection structure stronger cuttings would be more favorable that would permit to reach a stable stand volume of about 400–430 m^3/ ha. Such volume is reached by the primeval beech forests with selection structure also in the Bieszczady Mountains (JAWORSKI et al. 2000).

CONCLUSIONS

1. In forests of primeval character in the Bieszczady Mountains the tree loss, recruitment, and increment are closely connected with the developmental stages and phases of primeval forest.
2. For practical forestry the knowledge of the loss, recruitment and increment in forests of primeval character, expressed by the number of trees and volume units, can be a helpful tool in computation of the amount of cut securing the stability of a tree layer ecosystem in managed forests of similar site and stand conditions and managed by the selection or Swiss irregular shelterwood systems.
3. In spite of the fact that the primeval forests cannot be an uncritical model for forest management since not every stand (its developmental stage or phase) fulfils the postulate of a multifunctional forest, the stable forest ecosystems can serve as a model of the silvicultural procedure followed in the Carpathian managed beech forests of similar development and structure. However, further studies are necessary in this respect using a more ample study material.

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Přirozený úbytek stromů, dorůstání a přírůst v původních porostech vybraných partií Národního parku Bieszczady v jihovýchodním Polsku

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ABSTRAKT: Cílem studie je zjištění poznatků o úbytku stromů, resp. dřeva, dorůstání (doplnění) a přírůstu původních bukových porostů. Toto šetření je založeno na měřeních provedených na třech trvalých zkusných plochách v letech 1988 a 1998. Ze tří sledovaných porostů bylo nejvyššího přírůstu dosaženo u porostů Jawornik I v časném stadiu dorůstání (8,8 m^3/ha za rok, tj. 1,5 % stávající porostní zásoby, měřené na konci kontrolního období) a Tworylczyk v pokročilém stadiu dorůstání (7,4 m^3/ha za rok, tj. 1,2 % stávající porostní zásoby). Porost Jawornik II, který se nachází ve stadiu optima, vykazoval nejnižší přírůst (3,9 m^3/ha za rok, tj. 0,7 % stávající porostní zásoby). Přirozené objemové ztráty byly největší v porostu Tworylczyk (7,6 m^3/ha za rok) a o něco menší na lokalitě Jawornik II (7,1 m^3/ha za rok) a nejmenší v porostu Jawornik I (5,8 m^3/ha za rok). Studie umožňuje formulovat následující závěry: V lesích původního charakteru v NP Bieszczady jsou úbytek stromů, dorůstání a přírůst blízce spojeny s dynamikou růstových a vývojových stadií a fází původního lesa. Pro lesnickou praxi jsou poznatky o úbytku, dorůstání a přírůstu původních lesů vyjádřeny počty stromů a jednotkami objemu (porostní zásoby); mohou být užitečným nástrojem při výpočtu rozsahu těžebního zabezpečení a stability ekosystému v obhospodařovaných lesích podobných stanovištních a porostních poměrů – zejména jde o lesy obhospodařované jednotlivým či skupinovitým výběrem nebo způsoby. Navzdory faktu, že původní les nemůže obecně plnit roli modelu lesnického hospodaření, protože ne každý porost (vývojové stadium nebo fáze) splňuje požadavek víceúčelového lesa, stabilní lesní ekosystémy však mohou sloužit jako model pěstebních opatření v hospodářských lesích v podobných podmínkách prostředí.

Klíčová slova: východní Karpaty; *Abies alba*; *Fagus sylvatica*; vývojová stadia a fáze; výběrný les

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