Structure and dynamics of stands of primeval character in selected areas of the Bieszczady National Park

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ABSTRACT: The investigations carried out in 1988 and 1998 on three permanent sample plots in stands of the East Carpathian beech forest *(Dentario glandulosae-Fagetum*) showed that in the growing up stage, the storeyed structure phase (Jawornik I stand), the stand volume increased from 547 m^3/ha to 578 m^3/ha while in the optimum stage, the ageing and regeneration phases (Jawornik II), it decreased from 631 m^3/ha to 600 m^3/ha, and in the growing up stage, the storeyed structure phase (Tworylczyk), from 611 m^3/ha to 610 m^3/ha. In all three stands beech dominated in the upgrowth. During the 10-year period the volume of dead trees (standing and lying ones) increased in Jawornik II and Tworylczyk stands while in Jawornik I stand it decreased. The beech stands of the Bieszczady Mountains have a largely differentiated structure, from one-storey structure in the optimum stage, the ageing phase to many-storeyed structure in the growing up stage. This creates an opportunity for forming the complex stand structure, also the selection forest structure, in managed beech forests of the Carpathians.

Keywords: East Carpathians; *Abies alba; Fagus sylvatica;* developmental stages and phases

STUDY OBJECTIVES

The Western Bieszczady Mountains, the westernmost range of the North Eastern Carpathians, are the mountains of medium height with Tarnica as their highest mountain of 1,348 m above sea level (Fig. 1). They are situated in the flysch outer Carpathians. The bedrock is mainly composed of Krosno and inoceramus sandstones and menilite layers. The ridges are most often built of sandstones while schists, very susceptible to weathering, prevail in valleys. Such a structure resulted in so called lattice system of the river network and ridge-and-valley configuration corresponding to it. Thanks to this morphological structure

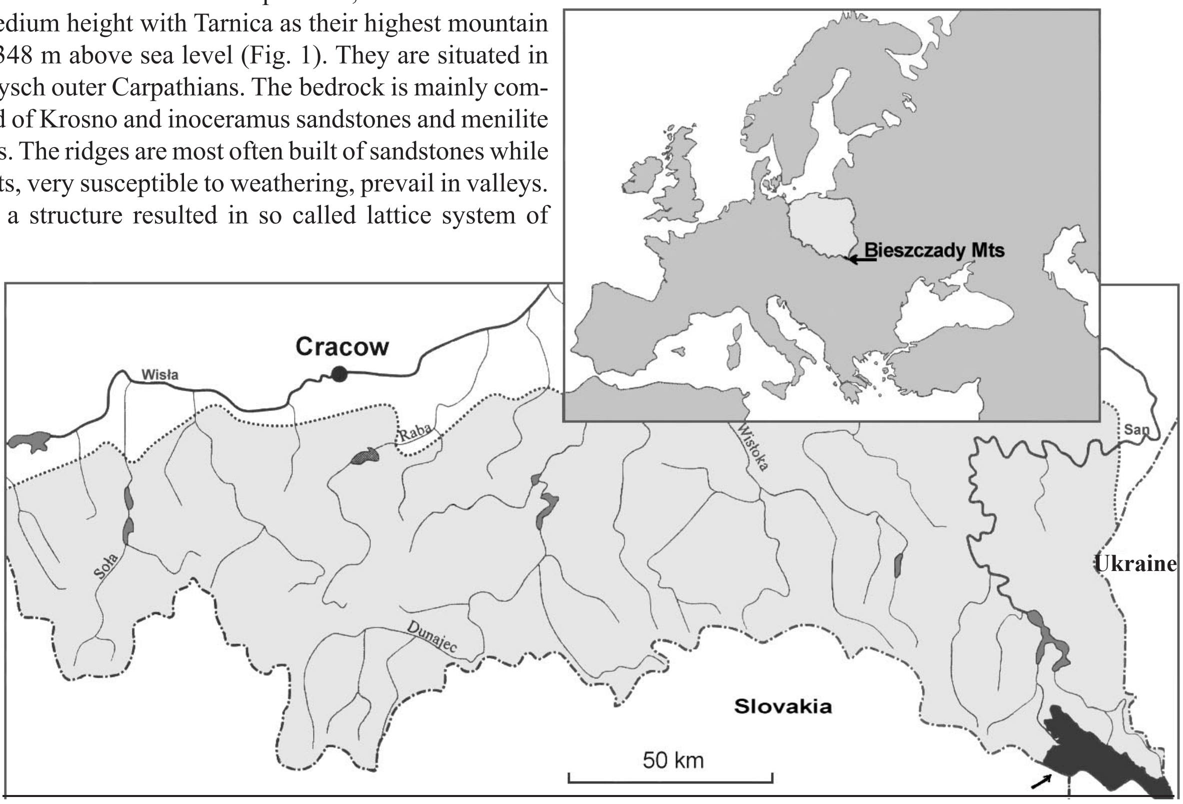

Fig. 1. Location of study area

Table 1. Climatic zones in the Bieszczady Mountains and their characteristics (data according to NOWOSAD 1995)

Climatic zone	Terrain configuration convex forms elevation (m)	Terrain configuration concave forms elevation (m)	Average annual air temperature (°C)	Length of growing season (days)	Average annual total precipitation (mm)
Temperate warm	below 650	below 520	+6 to +8	200–214	900
Temperate cold	650–1,075	520–850	+4 to +6	192–199	900–1,200
Cold	above 1,075	above 850	+3 to +4	181–192	1,200–1,300

many lowland plant species, e.g. hornbeam, found their way into the mountains (ZARZYCKI 1963).

Brown soils prevail in the Bieszczady Mountains. They occupy 85–90% of the area of the Bieszczady Mountains National Park. Acid brown soils are little more abundant than typical and leached brown soils (SKIBA et al. 1998).

The Bieszczady Mountains National Park and its surroundings lie in a moderately cold climatic zone (Table 1). The average annual air temperature ranges from +4°C to +6°C there. Parts of the Park's surroundings situated at the lowest elevation lie in a moderately warm climatic zone with the average annual air temperature from +6°C to +8°C. The cold climatic zone is characterized by the average air temperature from +3°C to +4°C (NOWOSAD 1995). The average total annual precipitation ranges from about 900 mm (moderately warm zone) to 1,200–1,300 mm (cold zone). The growing season lasts for 200–214 days in the moderately cold zone, and 181–192 days in the cold zone. The minimum absolute temperature drops to –37°C while the maximum reaches about +32°C (Table 2).

The Bieszczady Mountains are characterized, among other things, by the absence of forest cover in their highest parts and of the layer of the upper mountain forests. The upper limit of the lower mountain forests, composed of crooked beech and sycamore maple trees, runs at the elevation of 1,050–1,200 (l,260) m, and at present it is the upper forest limit. Above it there is a layer of mountain meadows (poloninas) with groups of *Alnus viridis* and *Sorbus aucuparia*. The present upper tree line has undoubtedly been lowered at many places by the activities of man, and therefore it is of economic character. It is supposed that originally there was a narrow belt of spruce forest at least at some places, and the difference in elevation between its lower and upper limits was 50 m at the most. This spruce belt was destroyed by man. The tops of the highest mountains, especially steep and rocky ones, have always been devoid of forest cover (ZARZYCKI 1963).

Among the 10 natural forest associations distinguished in the Bieszczady Mountains National Park (MICHALIK, SZARY 1997) large complexes of old stands, beech, beech-sycamore maple, beech-fir (*Dentario glandulosae-Fagetum* and *Luzulo nemorosae-Fagetum typicum*), beech-sycamore maple and sycamore maple-beech (e.g. *Aceri-Fagetum*), are of a particular biological value. Natural spruce-fir (*Abieti-Piceetum montanum*) and hornbeam-lime (*Tilio-Carpinetum*) forests are very rare. The forests where beech is a dominant species cover an area of 17,722.11 ha, i.e. 79.3% of the total forest area of the Bieszczady Mountains National Park. The two-species stands: beech-fir, beech-sycamore maple, and beech-spruce are also characterized by a considerable proportion of beech, and they cover 2.3% of the forest area of the Park. The remaining stands (18.4%) have no or very little beech (PRZYBYLSKA, KUCHARZYK 1999). About 14% of the Park's forest area is covered by secondary forest communities composed of spruce, stands of mixed species composition, and also alder forests (*Alnus incana*) as a result of spontaneous succession of this species on abandoned farm land (PRZYBYLSKA, KUCHARZYK 1999).

Due to the unique natural qualities of this fragment of the Eastern Carpathians, the only one in Poland, and the need of its protection the Bieszczady Mountains National Park, 5,587 ha in size, was declared in 1973. This Park has gradually been enlarged to reach the area of 27,834 ha in 1996, and it is presently the largest mountain national park in Poland. As a biosphere reserve it has become an internationally important area in the program of nature conservation in the Eastern Carpathians.

Table 2. Characteristics of thermal conditions in the Bieszczady Mountains (data according to NOWOSAD 1995)

Meteorological station	Elevation (m)	Average air temperature (1956–1970) annual	January	July (°C)	Absolute (1956–1975) minima	maxima
Ustrzyki Górne	700	–	–5.3	14.8	–36.8	–
Brzegi Dolne	438	6.0	–	–	–36.4	32.5
Komańcza	470	6.3	–4.5	16.1	–35.6	31.9
Baligród	450	7.1	–3.4	16.6	–	32.1

The first detailed investigations in the Western Bieszczady Mountains were carried out in the 1950s and 1960s, including floristic (JASIEWICZ 1965), phytosociological and soil investigations (ADAMCZYK, ZARZYCKI 1963; ZARZYCKI 1963). The latter publications contain the characteristics of forest stands. Recently, comparative phytosociological (MICHALIK, SZARY 1997) and soil (SKIBA et al. 1998) studies were conducted there. The investigations concerning the Carpathian forests of primeval character, initiated in 1980 by the Department of Silviculture, Agricultural University of Cracow, also included the Bieszczady Mountains in 1988. In spite of the continuous exploitation of different intensity since the 14th century, the stands in this part of the Carpathians preserved their primeval character in some inaccessible areas. At the present time such forests cover 7.6% of the forest area of the Park, i.e. 1,703 ha (PRZYBYLSKA, KUCHARZYK 1999).

The name "forests or stands of primeval character" indicates the forest complexes where men did not interfere directly (the stands were not exploited, or single trees, usually the biggest ones, were felled) but where changes could take place due to air pollution, road construction, etc.

A series of three permanent sample plots was established in the Bieszczady Mountains National Park in 1988. They were selected because the characteristics of their structure corresponded to the developmental stages of primeval forest. Control measurements were carried out on these plots in 1998. The objectives of this study were to determine the changes in some stand characteristics (stand volume, $d_{1.3}$ distribution, vertical structure) that took place during the 10-year period, and to get information on the dynamics of stands representing different developmental stages of beech forests of primeval character in the Eastern Carpathians. The analysis of the recruitment, loss, and increment was presented in another publication.

METHODS

On each sample plot the trees were permanently numbered, and also the places of $d_{1.3}$ measurement were marked on the bark. To get information on the structure of stands measurements were carried out in 1988 and in 1998 again using the same methods. The $d_{1.3}$ and height measurements included all trees (6 cm $d_{1.3}$ and above). Moreover, the measurement of dead trees (lying and standing – whole and broken ones) was carried out.

Each living tree was classified to one of the development classes of trees (ŘEHÁK 1964) and to a layer of the stand according to IUFRO classification (LEIBUNDGUT 1966). On each plot the timber lying on the ground was measured taking into consideration the degree of its decomposition, and transect plots were established of the following dimensions: Jawornik I – 10 m × 66 m, Jawornik II – 10 m × 70 m, and Tworylczyk – 10 m × 62 m, in order to study the stand structure and to describe regeneration. The work conducted on each transect plot included:

– measurement of the situation of all living trees, and also standing and lying dead trees using the method of rectangular offsets; the crown projection of living trees was measured,

– determination of regeneration numbers with division into young natural reproduction (up to 0.5 m in height) and upgrowth (above 0.5 in height and $d_{1.3}$ up to 5.9 cm). In order to determine the numbers of the young natural reproduction a belt 2 m wide running along the longer side of the transect plot was used while the upgrowth was counted on the entire transect plot.

On the basis of the characteristics of stand structure and criteria assumed by KORPEL' (l982, 1995) the developmental stages and phases of primeval forest were determined. Using the data acquired during measurements of trees above 8 cm in $d_{1.3}$ (trees 6 – 7.9 cm in $d_{1.3}$ were considered to be overgrown upgrowth), the characteristic parameters of the $d_{1.3}$ and height distributions were computed. Among other things, they enabled to determine the type of Pearson's distribution (ZIELIŃSKI 1972). The statistical and volume computations (using GRUNDNER-SCHWAPPACH tables [1952]) were carried out according to "Zasoby" original computer program. It should be mentioned that Michajlov's equation was used for the tree height curve fitting (KORF et al. 1972).

CHARACTERISTICS OF STUDY AREAS

A complex of stands put under strict protection where sample plots Jawornik I and II are situated is located in the Suche Rzeki Protection Area. It includes compartments 97 to 101, 197 ha in total area, situated below the Wetlina mountain grassland. The optimal stage in the ageing phase dominates in these stands, primeval in character, and composed of beech with an admixture of single fir and sycamore maple trees while smaller areas are occupied by the growing up stage in one-storey or many storeyed phases, and still smaller ones by the break-up stage associated with the regeneration phase. The upgrowth and young natural regeneration of beech occur singly or in groups. The age of trees in the lower storey is about 50–60 years while in the upper storey 140–160 years, and single specimens of beech are 180–200 years old, and of fir over 200 years. In compartment 99a where sample plots Jawornik I and II are situated, the average stand volume is 270 m^3/ha (data from the statistical-mathematical inventory) (Protection Plan… 1996).

The Tworylczyk plot is also located in the Suche Rzeki Protection Area, namely in the "Puszcza Bieszczadzka nad Sanem" Reserve, which occupies an area of 498.78 ha and is under strict protection. The stands (compartments 148–152 and 145–157) adjacent to compartment 151a, 315 ha in size, form a mosaic of all developmental stages of primeval forest, with predominance of the optimal stage in the ageing phase. The average age of the stand forming the upper storey is 160–170 years, but the oldest beech trees are 200 years of age. The growing up and optimal stages dominate in compartment 151a. Beech trees reach the age of 60–70 years in the lower storey, 100–110 years in the middle storey, and 150–160 years in the upper storey. The stand volume is 381 m^3/ha (data from the

Table 3. Location of study areas and their site and stand characteristics

Sample plot (Protection area)	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 ageing symptoms in upper storey	optimum stage phase of ageing and regeneration	growing up stage phase of storeyed structure

statistical-mathematical inventory) (Protection Plan… 1996).

Two study plots (Jawornik I and Jawornik II) are situated in stands of a moist subassociation of the Carpathian beech forest with *Lunaria rediviva* (*Dentario glandulosae-Fagetum lunarietosum*), and the third plot (Tworylczyk) in the association of a fertile beech forest (*Dentario glandulosae-Fagetum*) (Table 3). This forest association, distinguished in the *Eu-Fagion* suballiance, has three characteristic species: *Dentaria glandulosa, Symphytum cordatum,* and *Polystichum braunii.*

From a geographical point of view the beech forests of the Bieszczady Mountains are included in the East Carpathian variety with some species of the East Carpathian character, e.g. *Aposeris foetida* and *Festuca drymeja* (MICHALIK, SZARY 1997). Typical brown soils which developed in the area under investigation (SKIBA et al. 1998) created the most favourable conditions for the growth of beech which reaches stand quality class I–II according to the Schwappach's tables (JAWORSKI et al. 1991).

RESULTS

STAND VOLUME, NUMBER OF TREES, BASAL AREA AT BREAST HEIGHT AND SPECIES COMPOSITION

Jawornik I

During the 10-year period the stand volume increased from 547 m^3/ha to 578 m^3/ha (Table 4). The total number of trees ($d_{1.3} \geq 8$ cm) increased slightly (from 183 to 189 trees/ha) similarly like the stand basal area (from 31.56 m^2/ha to 32.96 m^2/ha). During the period of investigations the species composition determined on the basis of volume did not basically change since the beech proportion increased from about 82% to 84%, and that of fir decreased from 18% to 16% (Table 4).

Jawornik II

During the period of investigations the stand volume decreased from 631.5 m^3/ha to 600 m^3/ha while the total

Table 4. Changes in species composition determined on the basis of the number of trees, basal area at breast height and volume on sample plots during 1988–1998

Species	1988						1998					
	No. of trees		basal area b.h.		volume		No. of trees		basal area b.h.		volume	
	(trees/ha)	(%)	(m^2/ha)	(%)	(m^3/ha)	(%)	(trees/ha)	(%)	(m^2/ha)	(%)	(m^3/ha)	(%)
Jawornik I												
Fagus sylvatica	144	78.7	24.75	78.4	447.68	81.8	150	79.4	26.58	80.6	483.46	83.7
Abies alba	39	21.3	6.81	21.6	99.57	18.2	39	20.6	6.38	19.4	94.27	16.3
Total	183	100.0	31.56	100.0	547.25	100.0	189	100.0	32.96	100.0	577.73	100.0
Jawornik II												
Fagus sylvatica	156	97.5	33.33	99.9	631.41	100.0	152	96.2	32.52	99.9	599.71	100.0
Abies alba	4	2.5	0.03	0.1	0.09	0.0	6	3.8	0.04	0.1	0.14	0.0
Total	160	100.0	33.36	100.0	631.50	100.0	158	100.0	32.56	100.0	599.85	100.0
Tworylczyk												
Fagus sylvatica	278	96.5	33.77	95.1	583.74	95.5	280	97.2	33.09	94.5	579.89	95.1
Abies alba	10	3.5	1.74	4.9	27.71	4.5	8	2.8	1.93	5.5	30.14	4.9
Total	288	100.0	35.51	100.0	611.45	100.0	288	100.0	35.02	100.0	610.03	100.0

Table 5. Characteristics of $d_{1.3}$ distribution

Year	Species	No. of trees in sample[1]	$D_{1.3}$ min. (cm)	max. (cm)	mean (cm)	Standard deviation (cm)	Coefficients of variation	asymmetry	excess	Parameters of Pearson's distribution β_1	β_2	Type of distribution acc. to Pearson
						Jawornik I						
1988	*Fagus sylvatica*	46	9.0	99.5	41.1	24.1	0.59	0.69	–0.52	0.48	2.48	*I*(*J*)
	Abies alba	13	8.5	112.0	38.2	×	×	×	×	×	×	×[2]
	Total	59	8.5	112.0	40.4	24.9	0.62	0.89	0.05	0.80	3.05	*I*(*J*)
1998	*Fagus sylvatica*	49	8.0	102.5	40.5	25.5	0.63	0.74	–0.42	0.55	2.58	*I*(*J*)
	Abies alba	13	8.0	117.5	35.7	×	×	×	×	×	×	×
	Total	62	8.0	117.5	39.5	26.3	0.66	0.96	0.27	0.93	3.27	*I*(*J*)
						Jawornik II						
1988	*Fagus sylvatica*	76	8.0	103.0	48.4	21.0	0.43	0.10	–0.11	0.01	2.89	*I*
	Abies alba	2	8.0	10.0	9.0	×	×	×	×	×	×	×
	Total	78	8.0	103.0	47.4	21.6	0.46	0.08	–0.22	0.01	2.78	*I*
1998	*Fagus sylvatica*	76	8.0	105.5	46.2	24.3	0.53	0.06	–0.59	0.00	2.41	*I*
	Abies alba	3	8.5	11.0	9.7	×	×	×	×	×	×	×
	Total	79	8.0	105.5	44.8	24.8	0.55	0.10	–0.69	0.01	2.31	*I*
						Tworylczyk						
1988	*Fagus sylvatica*	136	8.0	106.5	32.1	23.0	0.72	0.87	0.10	0.70	3.10	*I*
	Abies alba	5	12.0	65.5	43.0	×	×	×	×	×	×	×
	Total	141	8.0	106.5	32.5	23.0	0.71	0.82	0.01	0.67	3.01	*I*
1998	*Fagus sylvatica*	135	8.0	100.0	31.5	23.4	0.74	0.77	–0.44	0.59	2.56	*I*(*J*)
	Abies alba	3	36.0	73.0	56.8	×	×	×	×	×	×	×
	Total	138	8.0	100.0	32.1	23.5	0.73	0.72	–0.54	0.52	2.46	*I*(*J*)

Notes: [1] broken trees were not taken into account (Jawornik I in 1988 *Fagus sylvatica* 2 trees; in 1998 *Fagus sylvatica* 1 tree; Jawornik II in 1988 *Fagus sylvatica* 2 trees; Tworylczyk in 1988 *Fagus sylvatica* 3 trees; in 1998 *Fagus sylvatica* 5 trees; *Abies alba* 1 tree)
[2] parameters and distribution type were not determined because of the small number of trees in a sample

number of trees slightly decreased from 160 trees/ha to 158 trees/ha (Table 4). The stand basal area decreased by 0.8 m^2/ha. The species composition by volume remained the same. This is a beech stand with sporadic proportion of fir (Table 4).

Tworylczyk

During the 10-year period of investigations the stand volume did not change very much, decreasing by about 1.5 m^3/ha from the initial volume of 611 m^3/ha in 1988 (Table 4). The total number of trees remained the same (288 trees/ ha) and stand basal area decreased from 35.51 m^2/ha to 35.02 m^2/ha (Table 4). The percentage of beech volume decreased while that of fir increased by 0.4% (Table 4).

$D_{1.3}$ DISTRIBUTION

In all study areas the maximum $d_{1.3}$ of beech reached 100 cm and more (Table 5). Mean $d_{1.3}$ values slightly changed during the study period. However, the maximum beech $d_{1.3}$ increased on two plots (Jawornik I and II) while in Tworylczyk it decreased due to the death of the biggest beech tree. It should be mentioned that fir tree 117.5 cm in $d_{1.3}$ (Jawornik I) was the biggest tree in the investigated areas.

Jawornik I

The $d_{1.3}$ differentiation of beech, and all tree species together, expressed by the coefficient of variation, increased (Table 5). $D_{1.3}$ distribution curves did not change during the 10-year period retaining *I*(*J*) type of Pearson's distribution (unimodal distribution with weakly marked mode in the lowest diameter classes) found in 1988 (Table 5, Fig. 2).

Jawornik II

The beech $d_{1.3}$ differentiation expressed by the coefficient of variation increased during the controlled period. During 10 years the $d_{1.3}$ distribution did not change retaining *I* type of Pearson's distribution (unimodal distribution with mode near the middle diameter class (1988) and mode in the lowest diameter class (1988) (Table 5, Fig. 2).

Tworylczyk

During the 10-year period the values of $d_{1.3}$ coefficient of variation increased. The type of $d_{1.3}$ distribution of all

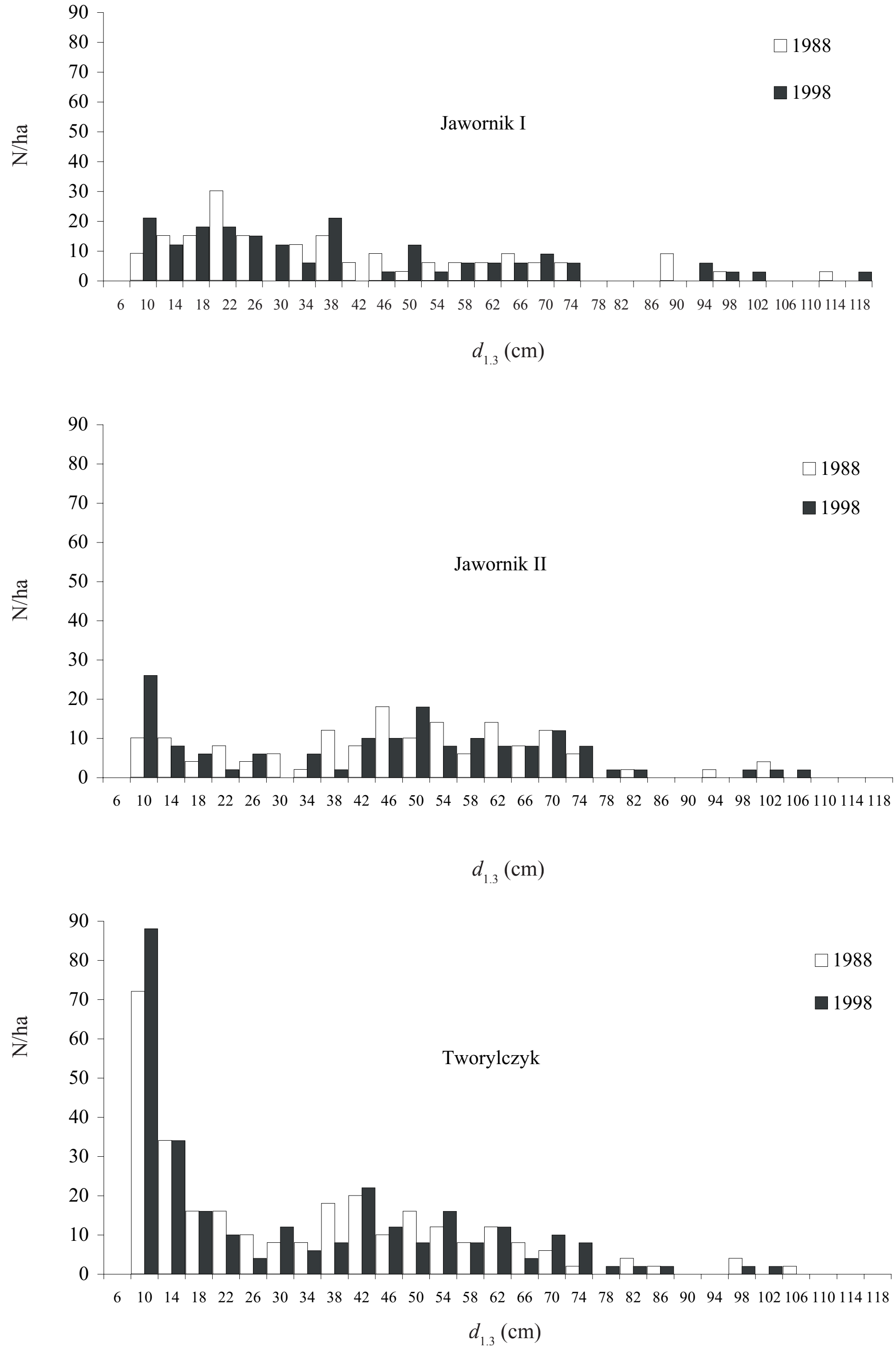

Fig. 2. $D_{1.3}$ distribution of all tree species together in 1988–1998

tree species together also changed from *I* to *I*(*J*) type of Pearson's distribution (unimodal distribution with mode in the lowest diameter class) (Table 5, Fig. 2).

CHARACTERISTICS OF HEIGHT DISTRIBUTION AND STOREYED STRUCTURE OF STAND

Jawornik I

In the period of investigations the beech and fir retained their maximum height, 40 and 41 m respectively (Table 6), but the height differentiation of beech as well as all the tree species together increased. The type of beech height distribution did not change while the height distribution of all tree species together changed from *I*(*J*) type (basically a transition type between the unimodal *I*(*J*) and bimodal *I*(*U*) types) to *I*(*U*) (Table 6, Fig. 3).

Trees from the highest layer (100) prevailed (54.1%) in this area in 1988. The proportions of trees in the middle and lower layers were 27.9% and 18%, respectively. During the 10-year period the proportion of trees in the upper layer decreased to 46% while that in the middle and

Table 6. Characteristics of height distribution

Year	Species	No. of trees in sample[1]	Height min.	Height max. (m)	Height mean	Standard deviation	Coefficients of variation	Coefficients of asymmetry	Coefficients of excess	Parameters of Pearson's distribution β_1	Parameters of Pearson's distribution β_2	Type of distribution acc. to Pearson
Jawornik I												
1988	*Fagus sylvatica*	46	9.0	40.0	27.7	8.8	0.32	–0.55	–0.86	0.30	2.14	*I*(*J*)
	Abies alba	13	5.5	41.0	22.8	×	×	×	×	×	×	×[2]
	Total	59	5.5	41.0	26.6	9.8	0.37	–0.49	–0.97	0.24	2.03	*I*(*J*)
1998	*Fagus sylvatica*	49	5.7	40.0	26.1	10.3	0.40	–0.52	–0.95	0.27	2.05	*I*(*J*)
	Abies alba	13	5.9	40.7	20.4	×	×	×	×	×	×	×
	Total	62	5.7	40.7	24.9	10.8	0.44	–0.37	–1.19	0.14	1.81	*I*(*U*)
Jawornik II												
1988	*Fagus sylvatica*	76	7.8	40.0	31.6	9.1	0.29	–1.54	0.94	2.38	3.94	?[3]
	Abies alba	2	6.0	8.8	7.4	×	×	×	×	×	×	×
	Total	78	6.0	40.0	31.0	9.8	0.32	–1.42	0.50	2.02	3.50	?
1998	*Fagus sylvatica*	76	5.8	39.5	28.5	11.5	0.40	–0.97	–0.75	0.95	2.25	*I*(*U*)
	Abies alba	3	6.0	9.1	7.3	×	×	×	×	×	×	×
	Total	79	5.8	39.5	27.7	12.0	0.43	–0.84	–1.04	0.70	1.96	*I*(*U*)
Tworylczyk												
1988	*Fagus sylvatica*	136	6.5	40.0	23.7	10.3	0.44	–0.10	–1.47	0.01	1.53	*I*(*U*)
	Abies alba	5	12.5	38.0	28.0	×	×	×	×	×	×	×
	Total	141	6.5	40.0	23.9	10.3	0.43	–0.11	–1.46	0.01	1.54	*I*(*U*)
1998	*Fagus sylvatica*	135	5.7	40.2	22.7	11.0	0.49	–0.01	–1.56	0.00	1.44	*I*(*U*)
	Abies alba	3	11.0	39.0	34.0	×	×	×	×	×	×	×
	Total	138	5.7	40.2	22.9	11.1	0.48	–0.04	–1.56	0.00	1.44	*I*(*U*)

Notes: [1, 2] see Table 5
[3] does not fit to the types of Pearson's distribution

lower layers increased to 30.2% and 23.8%, respectively (Table 7).

The characteristics presented above document a many-storeyed structure of this stand (cf. Fig. 4).

Jawornik II

During the 10-year period the maximum heights of beech did not change very much (Table 6), however the height differentiation distinctly changed, which is indicated by an increased value of the coefficient of variation. In 1988 the height distribution did not fit to the types of Pearson's distribution. During 10 years a bimodal type of height distribution (Pearson's *I*(*U*) type) developed. This is connected with considerable mortality of trees in the height class of 39 m (Fig. 3). Furthermore, the number of trees in the height class of 7 m considerably increased.

In this stand in 1988 the upper layer dominated including 76.2% of the total number of trees. In the middle and lower layers this percentage was 10% and 13.8%, respectively (Table 7). In 1998 the proportion of trees in the upper layer decreased to 69.6%, and in the middle layer to 7.6%, while in the lower layer it increased to 22.8% (Table 7). This characteristic indicates a tendency towards the formation of two-storeyed stand (cf. Fig. 5).

Tworylczyk

During 1988–1998 the height of the highest beech trees did not change while that of fir increased from 38 m to 39 m (Table 6). The differentiation of heights also increased, which is indicated by an increase in the value of coefficients of variation. The height distribution type retained its character of a bimodal curve – *I*(*U*) Pearson's type (Table 6, Fig. 3).

At the beginning of the control period the trees of the upper storey accounted for the highest proportion (45.9%) while this percentage in the middle and lower storeys was 32.6% and 21.5%, respectively (Table 7). In 1998 the proportion of trees slightly decreased to 42.4% in the upper storey and to 26.4% in the middle storey while it increased to 31.2% in the lower storey (Table 7). During the 10-year period, the storeyed structure was retained, with tendency to increase the percentage of trees in the lower storey (Table 7, Fig. 6).

VOLUME OF TREES LYING ON THE GROUND AND DEAD STANDING TREES

The volume of dead trees lying on the ground increased in all study areas. The greatest volume was present in

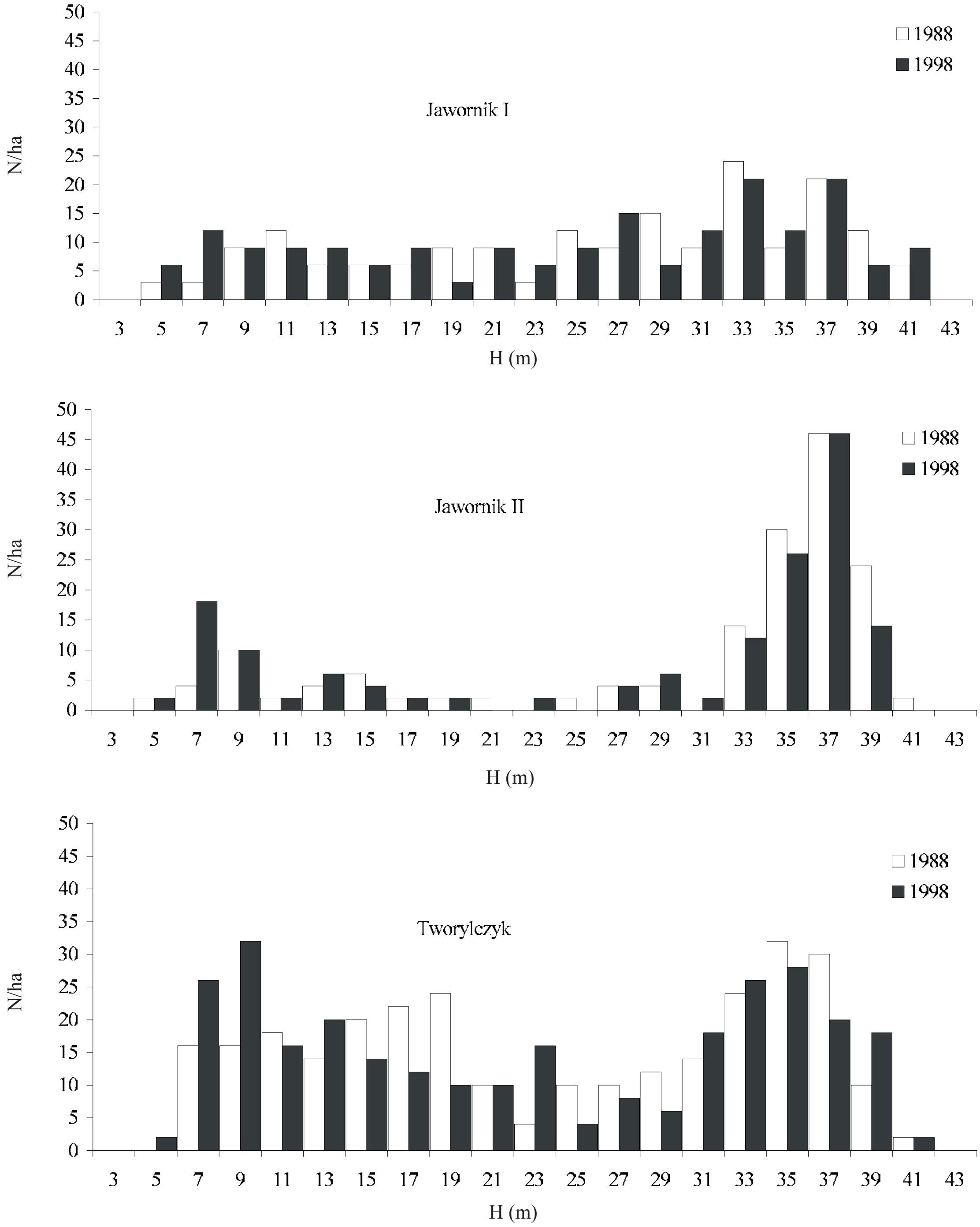

Fig. 3. Height distribution of all tree species together in 1988–1998

Jawornik I stand (205 m^3/ha in 1988 and 226 m^3/ha in 1998). In Jawornik II the volume of dead trees on the ground more than doubled (from 57 m^3/ha to 130 m^3/ha) while in Tworylczyk it increased by about 62% (from 55 m^3/ha to 89 m^3/ha) (Table 8).

In Jawornik I stand the volume of dead firs lying on the ground was particularly high. In 1988 the fir proportion in the species composition of the stand was 18.2% while its proportion in the composition of timber lying on the ground was over 45% (Tables 4 and 8). In 1998 the percentage of fir on the ground was much lower (9.6%), but this was probably due to the fact that wood of some firs was so decomposed that it was difficult to identify the species (Table 8).

In 1998 the ratio of the volume of lying trees to the stand volume ranged from almost 15% (Tworylczyk) to 39% (Jawornik I) (Table 8).

The volume of dead standing trees decreased during the control period (Table 9); in Jawornik I from 101 m^3/ha

Table 7. Proportion of living trees and their distribution in stand layers (according to IUFRO classification) in 1988–1998

Year	Species	Stand storey 100 (trees/ha)	100 (%)	200 (trees/ha)	200 (%)	300 (trees/ha)	300 (%)	Total (trees/ha)
				Jawornik I				
1988	*Fagus sylvatica*	81	56.3	45	31.2	18	12.5	144
	Abies alba	18	46.1	6	15.4	15	38.5	39
	Total	99	54.1	51	27.9	33	18.0	183
1998	*Fagus sylvatica*	75	50.0	48	32.0	27	18.0	150
	Abies alba	12	30.8	9	23.1	18	46.1	39
	Total	87	46.0	57	30.2	45	23.8	189
				Jawornik II				
1988	*Fagus sylvatica*	122	78.2	16	10.3	18	11.5	156
	Abies alba	–	–	–	–	4	100.0	4
	Total	122	76.2	16	10.0	22	13.8	160
1998	*Fagus sylvatica*	110	72.4	12	7.9	30	19.7	152
	Abies alba	–	–	–	–	6	100.0	6
	Total	110	69.6	12	7.6	36	22.8	158
				Tworylczyk				
1988	*Fagus sylvatica*	126	45.3	92	33.1	60	21.6	278
	Abies alba	6	60.0	2	20.0	2	20.0	10
	Total	132	45.9	94	32.6	62	21.5	288
1998	*Fagus sylvatica*	116	41.4	76	27.2	88	31.4	280
	Abies alba	6	75.0	–	–	2	25.0	8
	Total	122	42.4	76	26.4	90	31.2	288

Table 8. Volume of trees lying on the ground in 1988–1998

Species	Volume 1988 (m^3/ha)	1988 (%)	1998 (m^3/ha)	1998 (%)	Ratio of the volume of lying trees to the species volume (%) 1988	1998	Ratio of the volume of lying trees to stand volume (%) 1988	1998
				Jawornik I				
Fagus sylvatica	112.32	54.7	29.20	12.9	25.1	6.0	20.5	5.0
Abies alba	93.13	45.3	21.78	9.6	93.5	23.1	17.0	3.8
Decomposed wood	–	–	175.15	77.5	–	–	–	30.4
Total	205.45	100.0	226.13	100.0	–	–	37.5	39.2
				Jawornik II				
Fagus sylvatica	37.78	65.8	86.33	66.4	6.0	14.4	6.0	14.4
Abies alba	14.55	25.4	–	–	16,166.7	–	2.3	–
Decomposed wood	5.05	8.8	43.76	33.6	–	–	0.8	7.3
Total	57.38	100.0	130.09	100.0	–	–	9.1	21.7
				Tworylczyk				
Fagus sylvatica	52.92	96.6	30.10	33.9	9.1	5.2	8.6	4.9
Abies alba	1.87	3.4	3.24	3.6	6.7	10.7	0.3	0.5
Decomposed wood	–	–	55.52	62.5	–	–	–	9.2
Total	54.70	100.0	88.86	100.0	–	–	8.9	14.6

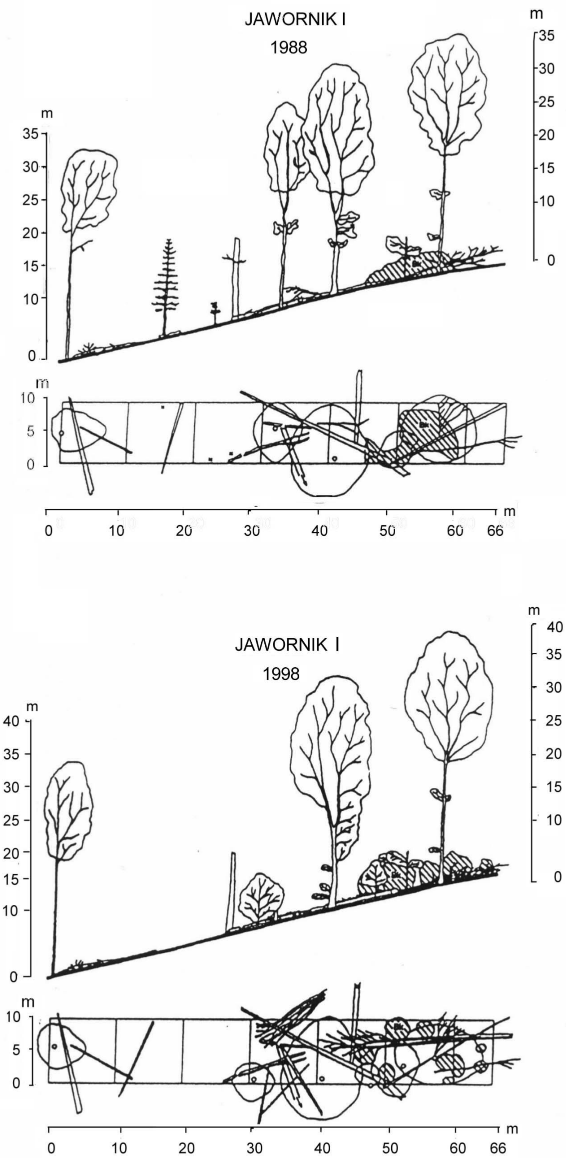

Fig. 4. Structure of stand on Jawornik I sample plot

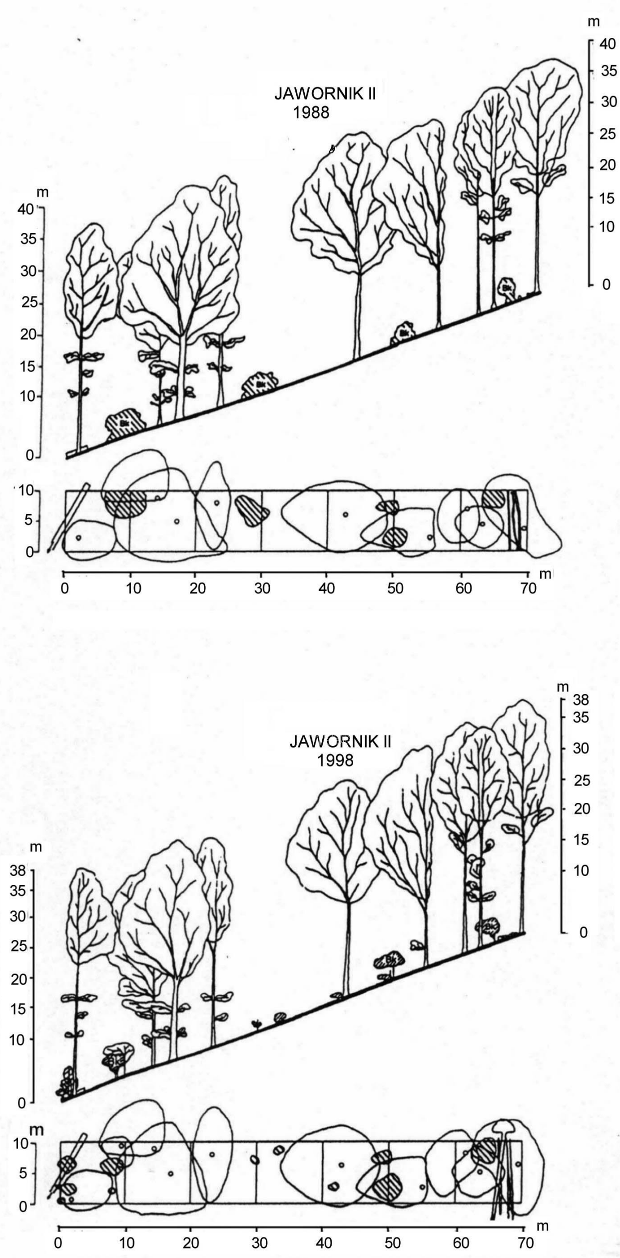

Fig. 5. Structure of stand on Jawornik II sample plot

to almost 63 m^3/ha. While in 1988 dead firs dominated among the dead standing trees (about 70%), in 1998 they accounted for 45% only. A considerable decrease in the volume of dead standing trees was also found in Tworylczyk (from 47 m^3/ha to almost 29 m^3/ha). In Jawornik II a decrease in the volume of dead standing trees at its small amount in 1988 was inconsiderable from 17 m^3/ha to 12 m^3/ha (Table 9).

The total volume of standing and lying dead trees ranged from 74 m^3/ha (Jawornik II) to 307 m^3/ha (Jawornik I) in 1988. The ratio of dead tree volume to stand volume ranged from 12% to 56% (Table 10).

In 1998 the total volume of both categories of dead trees increased on Jawornik II and Tworylczyk sample plots while in Jawornik I it decreased. Therefore, the proportion of dead tree volume in the stand volume increased to almost 24% and 19%, respectively, in Jawornik II and Tworylczyk, and decreased to 50% in Jawornik I (Table 10).

REGENERATION

Jawornik I

During the 10-year period the numbers of the younger natural reproduction (up to 20 cm in height) of fir increased by almost 5 times (from 1,045 to 5,150 seedlings/ha) while those of beech by more 16 times (from 545 to almost 8,940 seedlings/ha) (Table 11). In the older natural reproduction (21–50 cm in height) there was a relatively high number of beeches in 1998 (almost 3,900 seedlings/ha) while 10 years earlier such regeneration was very rare.

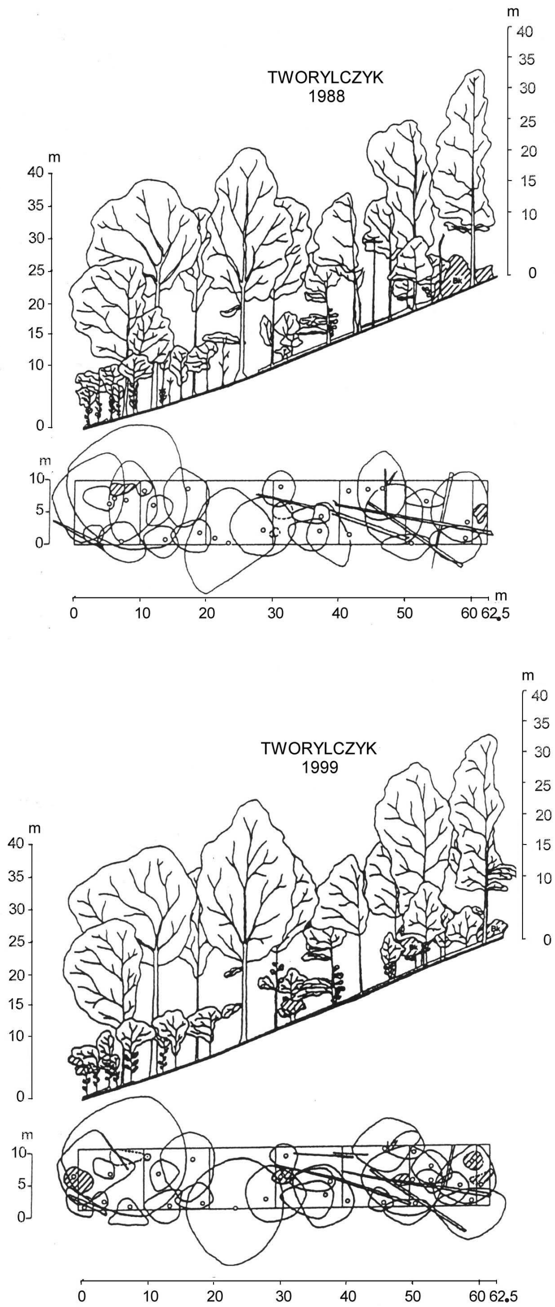

Fig. 6. Structure of stand on Tworylczyk sample plot

In 1998 sycamore maple reproduction was quite abundant (over 1,200 seedlings/ha) while this species was absent 10 years earlier (Table 11). In the species composition of the upgrowth (above 50 cm in height) beech dominated in 1998 (8.8%). The beech upgrowth numbers increased from 430 to almost 1,300 saplings/ha during 1988–1998 (Table 11).

Jawornik II

During the 10-year period, the numbers of the younger natural reproduction (up to 20 cm in height) of beech increased by almost 38 times (from 300 to 11,300 seedlings/ha), while those of the older natural reproduction (21– 50 cm in height) from 40 to 1,930 seedlings/ha. The numbers of the younger natural reproduction of sycamore maple increased 4 times (from more than 200 to about 930 seedlings/ha) (Table 11). Fir natural reproduction was scarce and occurred in the younger class only (about 60 seedlings/ha in 1988 and over 210 seedlings/ha in 1998).

Total numbers of beech upgrowth were small, and they decreased from more than 520 to about 480 saplings/ha over the l0-year period of time (Table 11).

Tworylczyk

During the 10-year period the numbers of the younger natural reproduction (up to 20 cm in height) of beech considerably increased (from 160 to almost 24,700 seedlings/ha). The older natural reproduction of this species occurred only in 1998 (about 160 seedlings/ha) (Table 11). The numbers of the younger natural reproduction of fir increased inconsiderably (from about 420 to over 560 seedlings/ha) (Table 11). The upgrowth at the beginning of the study as well as at its end was composed of beech only, and it was not abundant (about 550 saplings/ha in 1988 and 500 saplings/ha in 1998).

DEVELOPMENTAL STAGES AND PHASES

Jawornik I

Openings in the stand canopy (Fig. 4), large volume of dead standing (101 m^3/ha) (Table 9) and lying on the ground (over 205 m^3/ha) (Table 8) trees, domination of trees of the growing up generation (54.1%) (Table 12) and distinct storeyed structure (Table 7) indicated that in 1988 this stand was in the break-up stage, phase of selection forest or storeyed structure.

During the control period, however, the stand volume distinctly increased (from 547 to 578 m^3/ha), relatively large increment was produced (8.85 m^3/ha per year) (JAWORSKI, KOŁODZIEJ 2002), volume of dead lying trees increased only by about 21 m^3/ha (Table 8), and volume of dead standing trees decreased by about 38 m^3/ha (Table 9). The numbers of trees in the lower and middle layers also increased (Table 7). The changes that took place allow to conclude that this stand entered the growing up stage. It is supposed that the transition of the break-up stage into the growing up stage could take place even before the beginning of this study, thus in Jawornik I stand the initial period of the growing up stage began before 1988.

Jawornik II

A distinct domination of trees in the highest storey in 1988 (76.2%) (Table 7) indicated the optimum stage at the beginning of the control period while openings in the stand canopy and groups of regeneration signalled the ageing phase. A decrease in the stand volume from almost 632 to 600 m^3/ha during 10 years confirmed the developmental tendency of this stand determined in 1988 (Table 4). Besides, the following phenomena point to the optimum stage and ageing phase:

Table 9. Number and volume of dead standing trees in study areas in 1988–1998

Species	Numbers				Volume				Ratio of the volume of dead standing trees to the volume of			
	1988		1998		1988		1998		species (%)		stand (%)	
	(trees/ha)	(%)	(trees/ha)	(%)	(m^3/ha)	(%)	(m^3/ha)	(%)	1988	1998	1988	1998
Jawornik I												
Fagus sylvatica	24	29.6	15	31.2	30.55	30.2	34.50	54.9	6.8	7.1	5.6	6.0
Abies alba	57	70.4	33	68.8	70.61	69.8	28.31	45.1	70.9	30.0	12.9	4.9
Total	81	100.0	48	100.0	101.16	100.0	62.82	100.0	–	–	18.5	10.9
Jawornik II												
Fagus sylvatica	12	85.7	14	100.0	16.63	99.9	11.78	100.0	2.6	2.0	2.6	2.0
Abies alba	2	14.3	–	–	0.02	0.1	–	–	22.2	–	0.0	–
Total	14	100.0	14	100.0	16.65	100.0	11.78	100.0	–	–	2.6	2.0
Tworylczyk												
Fagus sylvatica	32	88.9	20	71.4	40.12	86.2	25.11	87.9	6.9	4.3	6.6	4.1
Abies alba	4	11.1	8	28.6	6.44	13.8	3.46	12.1	23.2	11.5	1.0	0.6
Total	36	100.0	28	100.0	46.56	100.0	28.57	100.0	–	–	7.6	4.7

– dominant proportion of trees with optimal growth (Table 12),
– decreasing number of trees (from 160 to 158 trees/ha) (Table 4),
– small volume increment (3.94 m^3/ha per year) (JAWORSKI, KOŁODZIEJ 2002),
– increase in the volume of dead trees lying on the ground (from 57 to 130 m^3/ha) (Table 8).

Tworylczyk

In 1988 this stand showed the structure characteristic of the growing up stage and many-storeyed phase. The results of the control measurements confirmed the stage and phase mentioned above, although the stability of stand volume (611 m^3/ha in 1988 and 610 m^3/ha in 1998) can indicate a stagnation in the development dynamics of this stand. The following phenomena point to the growing up stage and storeyed phase:
– storeyed stand structure (Fig. 6, Table 7) and all-generation structure of age that is reflected by the $d_{1.3}$ and height distributions (Figs. 2 and 3),
– high value of $d_{1.3}$ coefficient of variation which increased from 0.71 to 0.73 during the 10-year period (Table 5),
– high value of height coefficient of variation (0.43 in 1988 and 0.48 in 1998) (Table 6),
– relatively large volume increment during the control period (7. 40 m^3/ha per year) (JAWORSKI, KOŁODZIEJ 2002),
– very high proportion (over 42% in 1998) of trees in the lowest (8–14 cm) diameter class (Fig. 2),
– relatively small volume of dead lying (89 m^3/ha) and standing (29 m^3/ha) trees in 1998, 14.6% and 4.7% of stand volume, respectively (Tables 8 and 9),
– high percentage of trees in the growing up generation (Table 12).

DISCUSSION

The species composition is a distinctive feature of the East Carpathian forest stands studied in the Bieszczady Mountains. Tworylczyk and Jawornik II stands represented a pure beech forest while Jawornik I stand had a 16.3% proportion of fir in the species composition of the stand in 1998 that decreased by about 2% in relation to 1988 (Table 4).

On all sample plots established in the Western Carpathians in the lower mountain forests of primeval character the

Table 10. Total volume of dead trees lying on the ground and dead standing trees and ratio of the volume of dead trees to stand volume in 1988–1998

Sample plot	1988				1998			
	dead lying trees (m^3/ha)	dead standing trees (m^3/ha)	total (m^3/ha)	ratio of the volume of dead trees to stand volume (%)	dead lying trees (m^3/ ha)	dead standing trees (m^3/ ha)	total (m^3/ ha)	ratio of the volume of dead trees to stand volume (%)
Jawornik I	205.45	101.16	306.61	56.0	226.13	62.82	288.95	50.0
Jawornik II	57.38	16.65	74.03	11.7	130.09	11.78	141.87	23.6
Tworylczyk	54.70	46.56	101.26	16.6	88.86	28.57	117.43	19.2

Table 11. Numbers and percentage of natural regeneration in sample plot areas in 1988–1998

Sample plot	Year	Species	Young natural reproduction: seedlings 1-year old (No./ha)	Young natural reproduction: height up to 20 cm (No./ha)	Young natural reproduction: height 21–50 cm (No./ha)	Young natural reproduction: Total (No./ha)	Young natural reproduction: Total (%)	Upgrowth: height 51 cm to 80 cm (No./ha)	Upgrowth: height 81 cm to 130 cm (No./ha)	Upgrowth: from 130 cm in height to 1.9 cm in $d_{1.3}$ (No./ha)	Upgrowth: diameter class in cm 2.0–3.9 (No./ha)	Upgrowth: diameter class in cm 4.0–5.9 (No./ha)	Upgrowth: diameter class in cm 6.0–7.9 (No./ha)	Upgrowth: Total (No./ha)	Upgrowth: Total (%)	Total (No./ha)	Total (%)
Jawornik I	1988	*Fagus sylvatica*	–	545	45	590	10.9	30	76	151	151	15	6	429	89.4	1,019	17.3
		Abies alba	3,712	1,045	–	4,757	88.0	–	–	15	15	–	6	36	7.5	4,793	81.4
		Acer pseudoplatanus	–	61	–	61	1.1	–	–	–	–	–	–	–	–	61	1.0
		Fraxinus excelsior	–	–	–	–	–	15	–	–	–	–	–	15	3.1	15	0.3
		Total	3,712	1,651	45	5,408	100.0	45	76	166	166	15	12	480	100.0	5,888	100.0
	1998	*Fagus sylvatica*	–	8,939	3,864	12,803	54.0	485	379	212	106	61	54	1,297	89.4	14,100	56.1
		Abies alba	3,788	5,151	–	8,939	37.7	–	–	–	–	–	3	3	0.2	8,942	35.5
		Acer pseudoplatanus	–	758	1,212	1,970	8.3	136	–	15	–	–	–	151	10.4	2,121	8.4
		Total	3,788	14,848	5,076	23,712	100.0	621	379	227	106	61	57	1,451	100.0	25,163	100.0
Jawornik II	1988	*Fagus sylvatica*	214	300	43	557	61.0	71	186	157	57	29	22	522	98.9	1,079	74.9
		Abies alba	71	57	–	128	14.0	–	–	–	–	–	6	6	1.1	134	9.3
		Acer pseudoplatanus	–	214	14	228	25.0	–	–	–	–	–	–	–	–	228	15.8
		Total	285	571	57	913	100.0	71	186	157	57	29	28	528	100.0	1,441	100.0
	1998	*Fagus sylvatica*	–	11,286	1,929	13,215	90.2	71	143	171	14	43	42	484	99.6	13,699	90.5
		Abies alba	214	214	–	428	2.9	–	–	–	–	–	2	2	0.4	430	2.8
		Acer pseudoplatanus	–	929	71	1,000	6.9	–	–	–	–	–	–	–	–	1,000	6.7
		Total	214	12,429	2,000	14,643	100.0	71	143	171	14	43	44	486	100.0	15,129	100.0
Tworylczyk	1988	*Fagus sylvatica*	806	161	–	967	61.9	64	32	97	129	129	98	549	100.0	1,516	71.8
		Abies alba	161	419	–	580	37.1	–	–	–	–	–	–	–	–	580	27.5
		Acer pseudoplatanus	–	16	–	16	0.7	–	–	–	–	–	–	–	–	16	0.7
		Total	967	596	–	1,563	100.0	64	32	97	129	129	98	549	100.0	2,112	100.0
	1998	*Fagus sylvatica*	–	24,677	161	24,838	92.8	32	129	65	48	113	108	495	100.0	25,333	92.9
		Abies alba	1,371	565	–	1,936	7.2	–	–	–	–	–	–	–	–	1,936	7.1
		Total	1,371	25,242	161	26,774	100.0	32	129	65	48	113	108	495	100.0	27,269	100.0

Table 12. Proportion of all tree species together in development classes determined on the basis of Řehák's classification (1988 and 1998)

Area	Year		Development classes and vitality x) of trees: old age generation (A)				optimum growth generation (B)				growing up generation (C)				Total
			A_1^1	A_2^2	A_3^3	**A**	B_1	B_2	B_3	B	C_1	C_2	C_3	**C**	
Jawornik I															
	1988	(trees/ha)	6	18	–	24	9	39	12	60	24	36	39	99	183
		(%)	3.3	9.8	–	13.1	4.9	21.3	6.6	32.8	13.1	19.7	21.3	54.1	100.0
	1998	(trees/ha)	6	9	3	18	18	42	9	69	30	51	21	102	189
		(%)	3.2	4.7	1.6	9.5	9.5	22.2	4.8	36.5	15.9	27.0	11.1	54.0	100.0
Jawornik II															
	1988	(trees/ha)	–	12	4	16	6	62	22	90	6	24	24	54	160
		(%)	–	7.5	2.5	10.0	3.7	38.8	13.8	56.3	3.7	15.0	15.0	33.7	100.0
	1998	(trees/ha)	6	10	4	20	4	66	14	84	4	28	22	54	158
		(%)	3.8	6.3	2.5	12.6	2.5	41.8	8.9	53.2	2.5	17.8	13.9	34.2	100.0
Tworylczyk															
	1988	(trees/ha)	4	4	4	12	14	76	10	100	24	82	70	176	288
		(%)	1.4	1.4	1.4	4.2	4.9	26.3	3.5	34.7	8.3	28.5	24.3	61.1	100.0
	1998	(trees/ha)	2	–	6	8	10	82	10	102	24	118	36	178	288
	1998	(%)	0.7	–	2.1	2.8	3.5	28.4	3.5	35.4	8.3	41.0	12.5	61.8	100.0

Vitality x): 1 – luxuriant, 2 – normal, 3 – weakened

percentage of fir decreased during 10–17 years. On Babia Góra Mt by 4–9% depending on the area, in the Pieniny Mts. by 8–14%, in the Beskid Sądecki Mts. (Łabowiec reserve) by 2–15% (JAWORSKI, KARCZMARSKI 1990b, 1991, 1994).

These changes were smaller in the Gorce Mts. (Łopuszna reserve) ranging from 0 to 3.2% (JAWORSKI, SKRZYSZEWSKI 1995). At the same time the percentage of beech increased. These processes caused a change in the species composition of the Carpathian forests.

The above data represent a period of time too short to draw final conclusions on the causes of these changes. The process of the fir retreat is connected with its mortality as well as with difficulties of regeneration, caused, among other things, by a destruction of young natural reproduction and upgrowth by deer. Some authors (FABIJANOWSKI, JAWORSKI 1996) connect the high dynamics of beech with warming up of the climate that favours this tree species (FELBERMEIER 1994). It should be supposed that further complex studies will allow to solve this problem.

The species composition distinguishes the investigated stands from the lower mountain primeval forests growing at similar sites in the Western Carpathians (Babia Góra Mt, Beskid Sądecki Mts. and Pieniny Mts.) where both beech and fir dominate; their proportion in the stand volume ranges from 18% to 93% in the case of beech and from 8% to 54% in the case of fir (JAWORSKI, KARCZMARSKI 1990a,b, 1991, 1994). The stands of Babia Góra Mt also include spruce in their species composition (1–28%) (JAWORSKI, KARCZMARSKI 1990a,b). A higher percentage of spruce (9–54%) occurs in the lower mountain stands of the Gorce Mts. while the percentages of beech and fir are 24–83% and 8–22%, respectively (JAWORSKI, SKRZYSZEWSKI 1995).

The stands of the Bieszczady Mountains are very similar to the stands in Eastern Slovakia. In Stužica forest reserve, situated in the zone of beech and beech-fir forests, the percentage of beech ranges from 70% to 99% while that of fir from 0.5% to 30% (KORPEL' 1995).

The stand of the early growing up stage (Stužica DVF1) reached 564 m^3/ha in 1971 and 628 m^3/ha in 1991 (Table 13), which is close to the volume of Jawornik I stand (578 m^3/ha) .

Two Slovak beech stands in the advanced growing up stage (DVF 2 and 6 – Stužica) reached 564 and 709 m^3/ha in 1971, and 520 and 717 m^3/ha in 1991, respectively (Table 13) (KORPEL' 1995) and in the Havešová reserve 714 m^3/ha (KORPEL' 1989), thus stands in the Stužica (DVF 6) and Havešová reserves are superior to Tworylczyk, the best stand of the Bieszczady Mountains (610 m^3/ha).

Tworylczyk stand is also inferior in respect of the volume to stands of Babia Góra Mt (Jałowiecki Potok – 722 m^3/ha) (JAWORSKI, KARCZMARSKI 1990b) and of the Pieniny Mts. (Walusiówka – 681 m^3/ha) (JAWORSKI, KARCZMARSKI 1991).

The volume of Jawornik II stand (600 m^3/ha) is higher than the volume of Orawski Chodnik stand (535 m^3/ha) from Babia Góra Mt (JAWORSKI, KARCZMARSKI 1990b). However, it is much lower than the volume of stands in the Gorce Mts. (Łopuszna II – 689 m^3/ha and Łopuszna III – 759 m^3/ha) (JAWORSKI, SKRZYSZEWSKI 1995) and in the Pieniny Mts. (Przełęcz Sosnów – 650 m^3/ha) (JAWORSKI, KARCZMARSKI 1991). The beech stand in the Slovak reserve Havešová reached 720 m^3/ha (KORPEL' 1989). All

Table 13. Volume of selected stands of primeval character in lower mountain forests of the Carpathians

Stand name	Developmental stage	Volume (m³/ha)	Author
Stužica DVF 1 (1971 and 1991)	growing up	564 and 628	KORPEL' (1995)
Stužica DVF 2 (1971 and 1991)		564 and 520	KORPEL' (1995)
Stužica DVF 6 (1971 and 1991)		709 and 717	KORPEL' (1995)
Łopuszna I		603	JAWORSKI, SKRZYSZEWSKI (1995)
Solinka		529	JAWORSKI et al. (2000)
Beskidnik		226	JAWORSKI et al. (2000)
Tarnicki		430	JAWORSKI et al. (2000)
Jawornik III		423	JAWORSKI et al. (2000)
Łopuszna II	optimum	689	JAWORSKI, SKRZYSZEWSKI (1995)
Łopuszna III		759	JAWORSKI, SKRZYSZEWSKI (1995)
Stužica DVF 5 (1971 and 1991)		601 and 536	KORPEL' (1995)
Stužica DVF 3 (1971 and 1991)	break-up	529 and 559	KORPEL' (1995)
Stužica DVF 4 (1971 and 1991)		661 and 687	KORPEL' (1995)

these stands are characterized by a similar structure and optimum developmental stage. A higher volume of stands in the Western Carpathians results from the participation of fir at the first place, and sometimes of spruce in their species composition.

In spite of the relatively lower stand volume of beech forests in the Bieszczady Mountains there are some beech trees reaching large dimensions (40 m in height and 100–106 cm in $d_{1.3}$) (Tables 5 and 6) and high quality class (I–II) (JAWORSKI et al. 1991). They are better in this respect than beeches from Babia Góra Mt and the Pieniny Mts. whose maximum heights are: 36.5 m (Orawski Chodnik) and 39 m (Gródek-Pieniny). Higher beech trees (41–42 m) grow in the Beskid Sądecki Mts. (Łabowiec Reserve) (JAWORSKI, KARCZMARSKI 1994). In Slovak reserves Stužica and Havešová the largest beeches reach 40 and 49 m in height and 112 and 111 cm in $d_{1.3}$, respectively (KORPEL' 1995).

The investigated stands showed a very differentiated structure, from one-storey structure (Jawornik II) to many-storeyed and many-generation structure (Jawornik I and Tworylczyk). The differentiated structure of beech stands, including the selection forest structure, was indicated by studies carried out in other stands of primeval character in the Bieszczady Mts. (JAWORSKI et al. 2000).

The investigated beech stands Tworylczyk and Jawornik II had the lowest volume of dead standing trees (29 m³/ha and 12 m³/ha respectively) in 1998 in comparison with the West Carpathian stands, e.g. Babia Góra Mt stands: Orawski Chodnik – 150 m³/ha, Dolny Płaj IIIb – 117 m³/ha (JAWORSKI, KARCZMARSKI 1990b), and the Pieniny Mts. stands: Przełęcz Sosnów – 115 m³/ha, Walusiówka – 78 m³/ha, Gródek – 50 m³/ha (JAWORSKI, KARCZMARSKI 1991). In this study the volume of dead standing trees reached the highest level in Jawornik I stand amounting to 101 m³/ha in 1988 and 63 m³/ha in 1998 (Table 9). This is connected with the termination of the break-up stage 10–20 years ago, as well as with the participation of fir in the species composition of this stand. The volume of dead standing trees was largely affected by the mortality of fir, and this process concerned trees of all diameter classes and all developmental generations.

CONCLUSIONS

1. Beech stands in the Bieszczady Mountains vary much in their structure from one-storey stands in the optimal stage to many-storeyed stands in the growing up stage. This creates an opportunity to form the complex stand structure, including that of selection forest, in managed forests.
2. In respect of stand volume they are slightly inferior to the East Carpathian beech stands of the Stužica reserve in Slovakia, and largely inferior to the West Carpathian stands with beech, fir and spruce in their species composition.
3. Decline of fir which is not abundant and lack of upgrowth of this species indicate the transformation of the investigated stands into a pure beech forest, a similar process like in the Western Carpathians.

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Struktura a dynamika původních porostů ve vybraných partiích Národního parku Bieszczady

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ABSTRAKT: Předmětem studie bylo určit změny některých porostních charakteristik (porostní zásoba, rozmístění, struktura jednotlivých pater), ke kterým došlo během desetiletého období (1988–1998), a analyzovat dynamiku porostů reprezentujících rozdílná vývojová stadia bukových lesů původního charakteru ve východních Karpatech. Konkrétní analýzy poměrů dorůstání, úbytku stromů a přírůstu již publikovali JAWORSKI a KOŁODZIEJ (2002). Označení „lesy nebo porosty původního charakteru" označuje lesní komplexy, které nejsou přímo ovlivněny člověkem (v porostech v podstatě nebylo těženo, pouze ojediněle byly vykáceny jednotlivé stromy), ale k určitým změnám v těchto lesích dochází například v důsledku působení imisí nebo budování komunikací. Charakteristickým rysem tří porostů květnatých bučin (*Dentario glandulosae-Fagetum*) sledovaných v Národním parku Bieszczady je jejich druhové zastoupení. Porosty Tworylczyk a Jawornik II jsou čisté bučiny, zatímco lokalita Jawornik I měla v roce 1998 16% příměs jedle, což bylo téměř o 2 % méně než v roce 1988. Tyto porosty lze podle strukturních rozdílů charakterizovat jako jednopatrové (Jawornik II), tak i jako bohatě strukturované vícevrstevné s mnohagenerační strukturou (Jawornik I a Tworylczyk). Diverzifikovaná struktura bukových porostů včetně výběrného lesa byla zjištěna šetřeními provedenými také v ostatních porostech s původním charakterem v rámci NP Bieszczady (JAWORSKI et al. 2000). Během desetiletého období ve stadiu dorůstání s patrovitou strukturou (Jawornik I) porostní zásoba vzrostla z 547 m^3/ha na 578 m^3/ha, zatímco ve stadiu optima během obnovní fáze (Jawornik II) poklesla z 631 m^3/ha na 600 m^3/ha a ve stadiu dorůstání s patrovitou strukturou

(Tworylczyk) poklesla z 611 m^3/ha na 610 m^3/ha. Ve všech třech porostech v růstu dominoval buk. Během analyzovaného období vzrostl podíl odumřelých stromů (stojících i ležících na zemi) v porostech Tworylczyk a Jawornik II a poklesl na lokalitě Jawornik I. Studie umožňuje formulovat následující závěry: 1. Bukové porosty Beskyd ukazují značnou diverzitu porostní struktury od jednovrstevných porostů ve stadiu optima k mnohovrstevným porostům ve stadiu dorůstání. To poukazuje na možnost utváření složité struktury obhospodařovaných bukových lesů Karpat včetně charakteristik výběrného lesa. 2. Tyto porosty mají poněkud menší zásobu než bukové porosty rezervace Stužica na Slovensku (východní Karpaty) a mnohem horší než polské buko-jedlo-smrkové porosty v západních Karpatech. 3. Pokles podílu buku a nedostatky v jeho růstu (Jawornik II) umožňují se domnívat, že v Beskydech – podobně jako v západních Karpatech – dochází ke změnám v druhovém složení porostů nižšího horského vegetačního pásu; jedle je nahrazována dynamicky se šířícím bukem.

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

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