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Effect of long-term tending on qualitative and quantitative production in mixed stands of spruce, fir and beech on Motyčky research plot

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ABSTRACT: The paper is a contribution to research on thinnings in mixed (spruce-fir-beech) stands situated in the fifth forest altitudinal zone in the central part of Slovakia. Three plots were tended by free crown thinning while one plot was left without any planned silvicultural treatment (as a control). Dynamic changes in tree species composition, stand structure and quantitative production were evaluated for a period of 30 years. A special attention was paid to development of crop trees that are the main bearers of stand quality and quantity. The changes were compared with respect to differences between plots with long-term silvicultural treatments and control plot (without treatments).

Keywords: thinnings; crop trees; static stability; mixed stands; spruce – fir – beech

The advantage of mixed stands in comparison with unmixed ones, especially from the aspect of their stability and/or resistance to injurious factors, has been known since the end of the 19th century. However, it is generally known that management of mixed forests is more complicated in comparison with unmixed stands. Besides the site conditions it is necessary to take into account also ecological requirements and/or properties of individual tree species in their management. The principal problems for silviculture of mixed stands including management goals were published by ŠTEFANČÍK L. (1977).

Mixed spruce, fir and beech stands are an important stand type of mixed forest complex in higher locations in the Alps and the Carpathian Mountains. In Slovakia, the mentioned stands occur mainly from the 4th to 6th forest altitudinal zone. VLADOVIČ (1998) stated that the management set of stand types for spruce-fir beechwoods took up the area of 14.13% out of the forests in Slovakia but its typologically suitable distribution should increase up to 24.85%.

Owing to the complexity of silvicultural problems in spruce, fir and beech stands the knowledge of their tending methods is also scarce in comparison with unmixed stands. Within the framework of tending only few papers dealt with cleanings (KÖSTLER 1952; HOCKENJOS 1968; ŠTEFANČÍK L. 1977; PAUMER 1978). More papers were focused on thinnings and/or long-term effects of tending on their structure, production and stability (ASSMANN 1961; MOLOTKOV 1966; LEIBUNDGUT et al. 1971; ŠTEFANČÍK L. 1977, 1990; HLADÍK 1992; ŠTEFANČÍK I. 1999; ŠTEFANČÍK I., ŠTEFANČÍK L. 1998, 2001, 2002).

In Slovakia, research on the tending of mixed spruce, fir and beech stands started at the end of the 60's of the last century. For this reason four series of permanent research plots (17 partial plots) were established located in natural areas of mixed spruce, fir and beech forests in Slovakia. The first research results of the mentioned problems were published in 1977 (ŠTEFANČÍK L. 1977). Assessment of 30-year tending effect on the stand condition was already carried out on two series (ŠTEFANČÍK I., ŠTEFANČÍK L. 2001, 2002).

The aim of this paper was to find and assess the changes in tree species composition, stand structure, static stability, qualitative and quantitative production of mixed spruce, fir and beech stand on the Motyčky PRP in a 30-year period of its systematic tending.

MATERIAL AND METHOD

The mixed spruce, fir and beech stand at the growth stage of pole-stage stand up to thin high forest on permanent research plot (PRP) Motyčky was chosen as an object of our research. This PRP is located inside the zone of the Forest District Staré Hory, Branch Forest Enterprise Slovenská Ľupča, and was established in 1971 for research on the silviculture-production relations in mixed spruce, fir and beech stands. The series of PRP Motyčky consists of four partial plots (PP) – three with an area of 0.20, 0.25 and 0.30 ha (designated as H), where free crown thinning is applied (ŠTEFANČÍK L. 1984) and one plot with an area of 0.20 ha was left without treatment – control plot (designated as O). The plots are isolated

Table 1. Basic characteristics of permanent research plot (PRP) Motyčky

Characteristic	Motyčky PRP
Establishment of PRP (year)	1971
Age of stand (years)	spruce 46, fir 41, beech 48
Geomorphologic unit	Veľká Fatra Mts.
Exposition	NE
Altitude (m)	810–870
Inclination (degree)	30
Parent rock	Dolomite
Soil unit	Rendzic Leptosol/Calcaric Cambisol
Forest altitudinal zone	5th fir-beech
Ecological series	B/C
Management complex	55
Management complex of forest types	511 fertile fir-beechwoods
Forest type group	*Fageto-Aceretum (FAc)* n.st.
Forest type	5401 mercury-beech maplewoods n.st.
Average annual temperature (°C)	5.8
Average annual precipitation sum (mm/year)	1,085

from each other and from another stand by a 10 m wide tree belt. A more detailed description of research plots is presented in Table 1.

The trees on all plots are numbered and measurement points at breast height 1.3 m are marked out. Complex biometrical measurements are carried out in 5-year intervals in accordance with standard methods that were developed for long-term research on silviculture-production problems of thinnings (ŠTEFANČÍK L. 1977) on all plots. Within their framework, besides the quantitative parameters (breast height diameter, tree height, crown size at horizontal projection), the trees were also evaluated according to the silvicultural and commercial classification with orientation on the trees of selective quality (promising and crop trees). Since the establishment of PRP, seven biometrical measurements have been carried out and simultaneously thinning treatments have always been performed. From a rationalization point of view, the method of promising trees and later crop trees (ŠTEFANČÍK L. 1984), which is focused on individual tending of trees of selective quality, was applied on the treated plot (H).

Experimental material was processed by common biometrical and statistical methods according to presented standard methods for research on thinnings (ŠTEFANČÍK L. 1977). Statistical significance of differences in arithmetical means of values was tested by Student's *t*-test.

In this paper we assessed the first measurement carried out at the time of PRP establishment in 1972 (at stand age of 41–48 years) and the last measurement in 2002 (at stand age of 71–78 years) in order to compare dynamic changes of investigated parameters on the partial plots for the period of 30 years. The results of the first four measurements were already published in the past (ŠTEFANČÍK L. 1990).

RESULTS AND DISCUSSION

Tree species composition

Percentage proportions of tree species according to the basal area (G) on Motyčky PRP are presented in Fig. 1. At the initial stage in 1972 the proportion of coniferous trees ranged from 44% to 68%. According to the tree species (except for plot IV), the highest proportion was found for fir (37–52%), followed by beech (24–51%), spruce (7–16%) and sycamore maple (4–7%). Pine is characterized as an admixed tree species with proportion of 1–5% only. The proportion of other species (European mountain ash, whitebeam, willow, Scotch elm and European hazel) was negligible. After 30 years, the proportion of coniferous trees on all plots markedly decreased, the most on control plot (24%) while a decrease by 6–18% was found on tended plots. This decrease was caused especially by fir whose proportion decreased to 23–30%, that means a reduction by 14–22%. On the contrary, an increased proportion was recorded for other tree species for the 30-year period. The proportion of spruce on treated plots increased by 1–6%, beech by 6–15% and sycamore maple by 1% and 3%. On control plots, there was an increase in the proportion of spruce by 4%, beech by 21% and also sycamore maple by 4%. The proportion of pine was almost the same on all plots. It can be concluded that the greatest changes in the investigated period of 30 years were found for fir in favour of the other tree species (spruce, beech, sycamore maple).

We stated after 15-year investigations into the development of tree species composition on this PRP that under the given natural condition the following proportion of tree species seems to be suitable: 30–40% for fir and

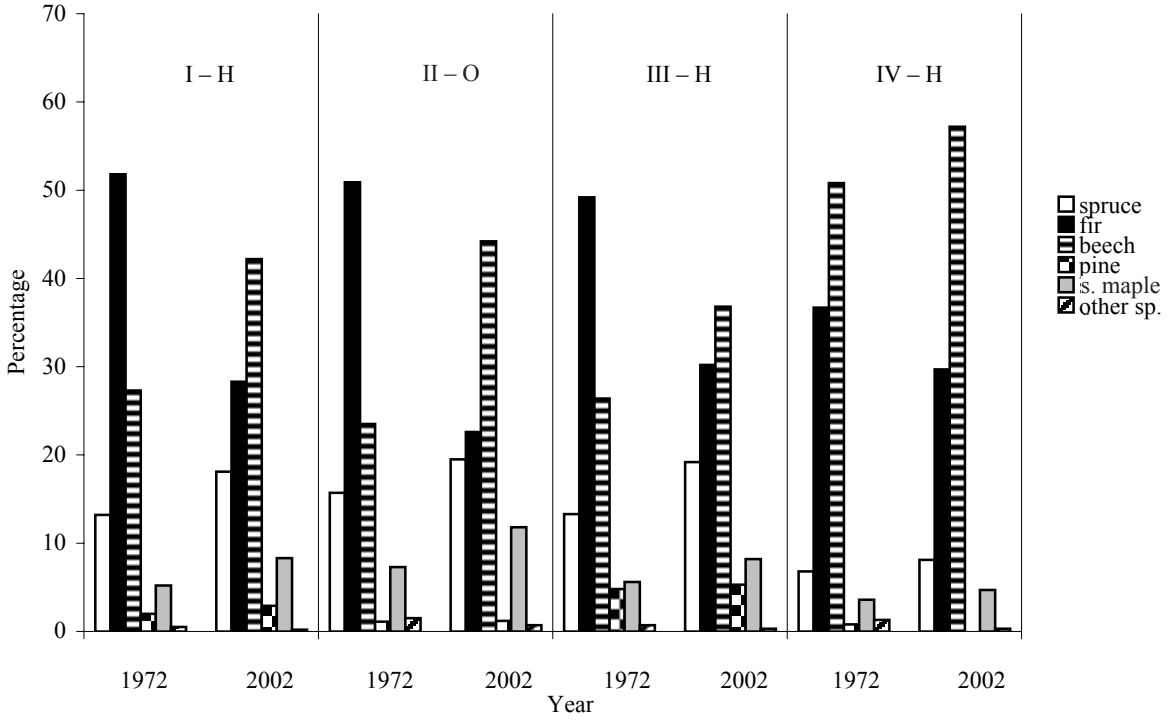

Fig. 1. Percentage proportions of tree species according to basal area on Motyčky PRP

beech, 10–20% for spruce and 10% for sycamore maple (ŠTEFANČÍK L. 1990). It can be seen that after 30 years the actual tree species composition almost corresponded to the assumed one. Similarly, a comparison of tree species composition with developmental goals according to HANČINSKÝ (1972) showed that all plots slightly differed from the required composition, especially on plot IV by a higher proportion of beech to the detriment of spruce and valuable broadleaved trees (sycamore maple, Scotch elm).

From the presented development of tree species composition we consider the fir decrease as especially important; it was caused by numerous reasons. One of them is the fact that the mentioned stands were neglected from silvicultural aspects at young and middle age. It is a well-known fact that fir suffers very much from tending treatments at older age, especially after the previous lack of silvicultural treatments it causes its increased mortality (KORPEĽ, VINŠ 1965). Such fir decrease confirmed its known overall decline in forest stands during the last decades (MÁLEK 1983; VLADOVIČ et al. 1998).

Our results related to fir decline in mixed stands also correspond with those found on other PRP Hrable and Korytnica where we conducted our research (ŠTEFANČÍK I., ŠTEFANČÍK L. 2001, 2002) and with knowledge published by other authors (KANTOR, PAŘÍK 1998; KLÍMA, HUBENÝ 2002).

Stand structure

Stand structure was expressed by relative frequency according to the growth (tree) classes. Thus, the proportions of trees at crown level of the stand (1^{st} + 2^{nd} growth class) and suppressed level of the stand (3^{rd} to 5^{th} growth class) is important from the silvicultural aspect, we present them in Fig. 2 in the initial stage of our research (in 1972) and at the last measurement in 2002. The results showed that in the initial stage on all plots the proportion of spruce, fir, beech, sycamore maple and other broadleaved tree species at crown level of the stand was lower than at suppressed level of the stand. An exception is pine with markedly higher proportion at crown level of the stand in comparison with suppressed level of the stand.

After the 30-year period (except for beech) the proportion of spruce, fir, sycamore maple and pine at crown level of the stand on all plots increased in comparison with initial stage of our research. A considerable proportion of pine and a little higher proportion of spruce (except for plot IV) were found at crown level of the stand, contrary to fir and beech characterized by an opposite tendency. The proportion of sycamore maple was higher at crown level of the stand on two plots while it was vice versa on the remaining two plots. Other broadleaved tree species (European mountain ash, whitebeam, Scotch elm) composed only the suppressed level of the stand. A comparison of 30-year development on control plot (II – O) showed that spruce, pine and sycamore maple had higher proportions at crown level of the stand contrary to beech, fir and other broadleaved tree species that occurred more frequently at suppressed level of the stand.

Although the stand structure (classification according to the growth classes) depends on site, tree species, age and tending measures (ŠEBÍK, POLÁK 1990), except for beech these results suggest a slight increase in the propor-

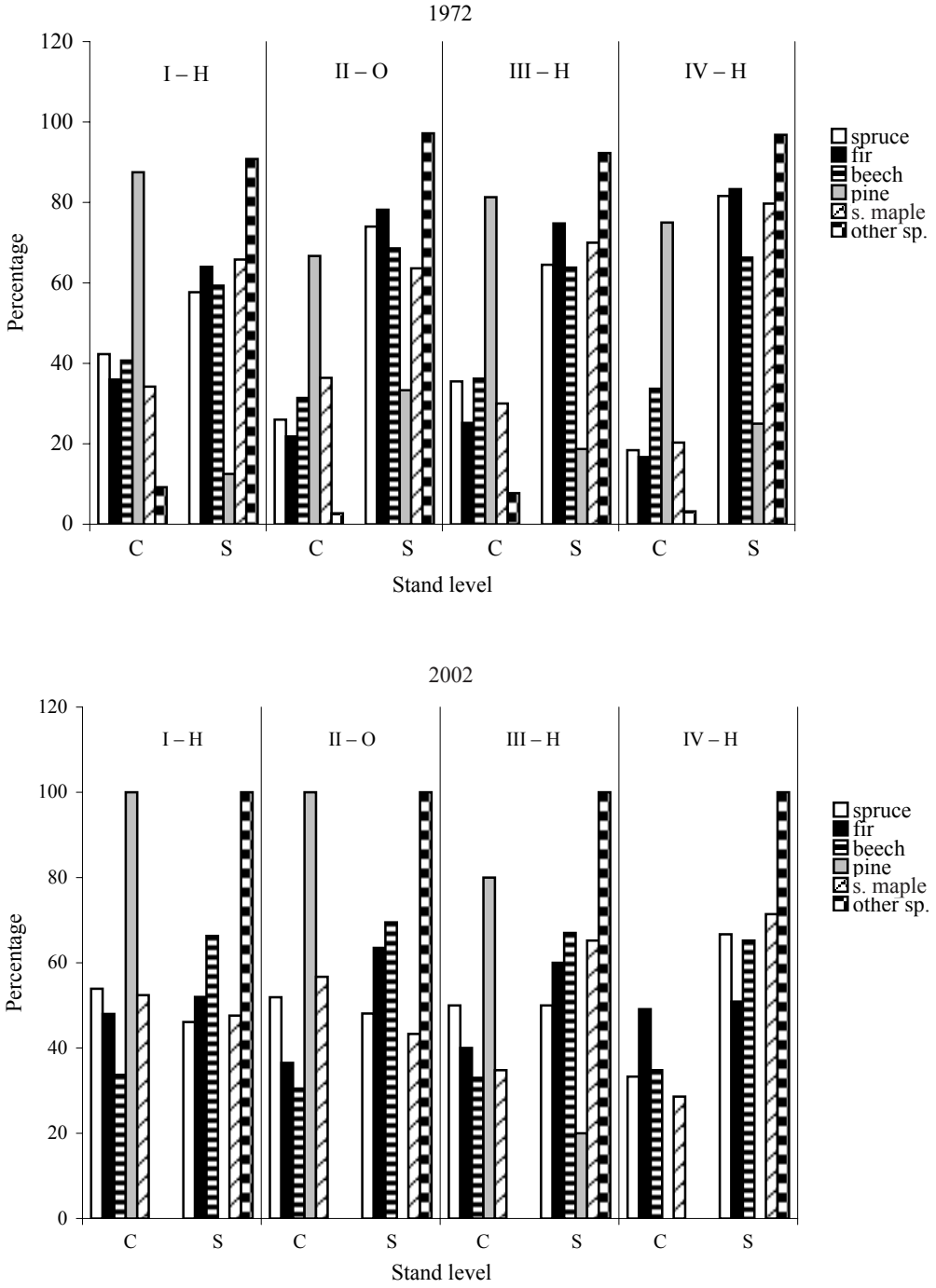

Fig. 2. Relative frequency of trees according to the level of the stand (C – crown level of the stand; S – suppressed level of the stand) at the first measurement (in 1972) and at the 7th measurement (in 2002)

tion of crown level of the stand within the framework of stand structure for all main tree species (spruce, fir, pine, sycamore maple) during the period of 30 years. Similar development was also found on other PRP in mixed spruce, fir and beech stands (ŠTEFANČÍK I., ŠTEFANČÍK L. 1998, 2001, 2002).

Development of qualitative production by the method of crop trees

Table 2 presents the development of crop trees, the main bearers of stand quality and quantity. It can be seen that in the initial stage of Motyčky PRP the number of promising

Table 2. Development of crop trees

Plot	Age (years)	Number of trees (per 1 ha)	Basal area		Volume of timber to the top of 7 cm o.b.	
			(m^2/ha)	(% out of main stand)	(m^3/ha)	(% out of main stand)
I – H	41–48	308	7.55	30.6	64.90	38.0
	71–78	208	14.57	53.3	168.14	58.5
II – O	41–48	220	6.94	23.4	66.33	33.3
	71–78	145	11.02	28.9	136.14	32.2
III – H	41–48	295	7.26	27.1	59.66	36.0
	71–78	230	15.68	50.6	182.26	56.6
IV – H	41–48	213	6.48	22.4	61.37	29.9
	71–78	203	15.15	48.7	188.26	54.1

Explanatory notes: H – plots with free crown thinning, O – plot without treatment (control)

trees (future crop trees) ranged from 213 individuals per hectare to 308 individuals per hectare, with the proportion out of the growing stock from 30% to 38%. After the 30-year period the number of crop trees decreased, so their number ranged from 203 individuals per hectare to 230 individuals per hectare on tended plots, while there were 145 individuals per hectare on control plots. The proportion of crop trees in growing stock was from 54% to 58% on the tended plots, and only 32% on control plots. Tree species composition of crop trees at the last measurement in 2002 is presented in Fig. 3. On all plots (except for plot IV) the highest proportion out of all crop trees was found for fir (35–45%), beech (28–48%) and spruce (10–20%).

Very interesting results were found by a comparison of the actual proportion and/or number of crop trees with a general model developed for spruce, fir and beech stands (ŠTEFANČÍK L. 1990; ŠTEFANČÍK I., ŠTEFANČÍK L. 2001) that was elaborated for stand age 100 years in three variants depending on the proportion of beech (30%, 40%, 50%). The following variants were determined for partial plots: plot I – variant 1 (30% beech proportion), plot III – variant 2 (40% beech proportion) and plot IV – variant 3 (50% beech proportion). As for the number of crop trees, the cited model assumed 200 to 260 individuals per hectare in relation to the variants. It can be stated that the model values were achieved on all plots except for plot I, where a little lower number of coniferous crop trees was found in comparison with the above-mentioned model. On the other hand, the tree species composition determined by the model was already achieved at stand age 71 to 78 years, but as for the target diameter of main tree spe-

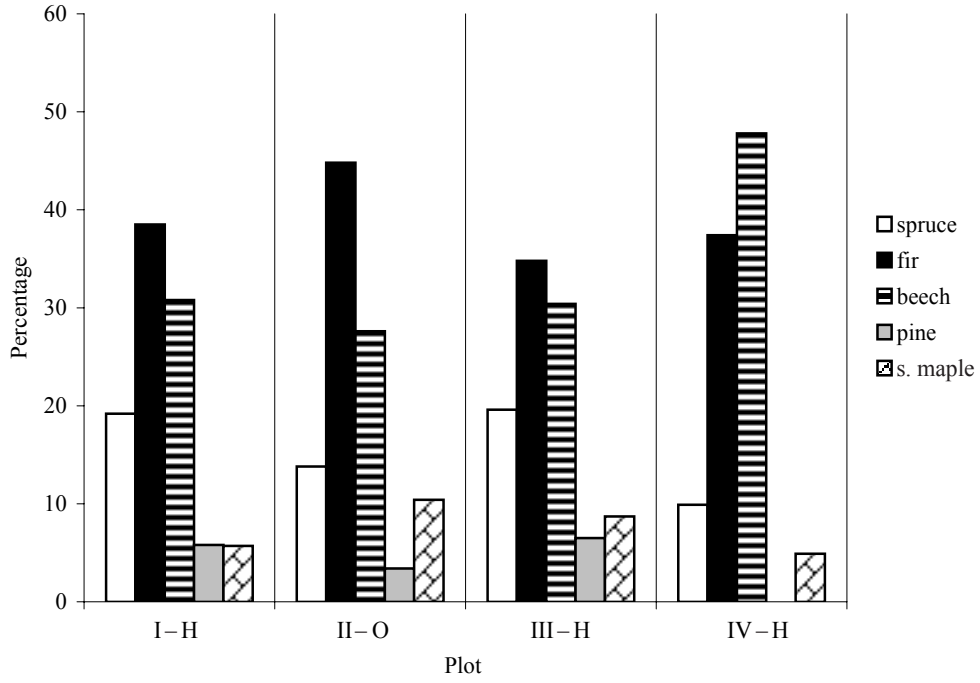

Fig. 3. Tree species composition of crop trees after the 7th measurement in 2002

Table 3. Growth parameters of crop trees

Plot	Tree species	Age (years)	Diameter $d_{1,3}$ (cm)		Height (m)		Crown width (m)		Crown length (m)		Proportion of crown length in total height of tree (%)		Slenderness coefficient	
			$\bar{x}$	s_x%	$\bar{x}$	s_x%	$\bar{x}$	s_x%	$\bar{x}$	s_x%	$\bar{x}$	s_x%	$\bar{x}$	s_x%
H	spruce	46	20.4	22.6	18.1	13.3	3.8	18.1	8.1	28.6	44.2	22.0	0.91	12.7
	fir	41	18.5	27.5	16.5	20.9	3.8	20.2	5.8	39.6	34.4	27.6	0.92	14.1
	beech	48	15.9	24.4	18.5	17.4	4.7	24.2	7.3	27.0	39.7	21.3	1.20	17.7
	pine	–	18.1	16.1	17.2	8.4	3.3	21.0	5.3	15.0	31.1	12.6	0.98	21.1
	s. maple+	–	14.4	19.9	16.3	1.5	3.9	19.5	6.8	3.7	41.6	5.2	1.18	18.4
O	spruce	46	24.1	25.2	21.6	13.7	4.1	20.6	10.2	25.7	46.6	15.1	0.93	17.5
	fir	41	18.2	28.4	16.9	16.9	3.7	27.5	5.5	34.7	32.3	26.9	0.96	14.3
	beech	48	16.0	31.3	17.9	19.8	4.5	40.1	6.6	40.3	35.6	27.3	1.18	19.5
	pine+	–	22.1	–	19.0	–	4.0	–	8.0	–	42.1	–	0.86	–
	s. maple+	–	16.9	–	19.0	–	6.0	–	10.0	–	52.6	–	1.13	–
H	spruce	76	33.1**	18.7	25.5**	10.9	4.8**	15.9	13.7**	17.8	53.7**	12.3	0.79**	13.3
	fir	71	29.1**	25.0	22.3**	15.1	4.9**	22.7	9.1**	33.9	40.6**	24.6	0.79**	12.6
	beech	78	29.1**	19.2	24.9**	11.7	6.0**	26.6	13.9**	20.5	56.0**	15.4	0.87**	13.6
	pine	–	30.6**	8.1	23.7**	7.1	4.6**	10.9	8.3**	15.6	34.9^N	14.0	0.78*	8.6
	s. maple	–	22.7	15.8	20.1	6.9	5.1	15.6	10.1	15.9	50.5	17.3	0.91	15.5
O	spruce	76	38.6*	22.5	28.5**	9.2	5.3*	13.9	13.3^N	19.3	46.3^N	12.4	0.76*	11.7
	fir	71	29.7**	21.1	24.0**	11.7	4.7*	22.1	9.2**	26.3	37.9*	15.7	0.82**	12.1
	beech	78	28.5**	17.0	25.8**	10.2	5.9^N	15.2	15.0**	14.5	57.9**	7.4	0.92*	9.6
	pine+	–	34.0	–	25.0	–	5.5	–	8.5	–	34.0	–	0.74	–
	s. maple+	–	25.4	7.0	22.8	5.7	5.4	6.5	11.3	4.2	49.8	5.7	0.90	2.5

Explanatory notes: H – plots with free crown thinning, O – plot without treatment (control), $\bar{x}$ – arithmetical mean, s_x% – coefficient of variance, *N* – statistically insignificant difference ($P > 0.05$), * – statistically significant difference ($P < 0.05$), ** – statistically significant difference ($P < 0.01$)

+ – insufficient number of individuals for statistical evaluation

cies, the model value has not been achieved until now, as we expected. However, we can assume on the basis of the present growth trend that it can be achieved earlier than at stand age of 100 years. The same development was also found on other PRP located in mixed spruce, fir and beech stands (Korytnica, Hrable) where, on some partial plots and/or tree species, the assumed diameter of crop trees was already achieved at the age of 80–90 years (ŠTEFANČÍK I., ŠTEFANČÍK L. 2001, 2002).

The tending of crop trees is important not only from silvicultural and/or qualitative production aspects but also in terms of static and ecological stability. It was confirmed by research that the most favourable results were achieved in stands with long-term tending by the method of crop trees (KONÔPKA 1992; ŠTEFANČÍK I. et al. 1999; ŠTEFANČÍK I., ŠTEFANČÍK L. 2001). Growth parameters of the crop trees of three tended plots in total (designated as H) and/or control plot (designated as O) and their development are presented in Table 3. It is obvious that changes in the course of 30-year research were always significant on tended plots contrary to the control plot. Comparison of the growth parameters of crop trees for spruce according to the models developed by KONÔPKA (1992) showed little favourable results for tended plots in comparison with control plot. We explain it by the fact that silvicultural treatments started very late since it is well-known that it is decided about the static stability of stand at younger growth stages.

It can be concluded that contrary to delayed tending (at the age of 45–50 years) the results were always more favourable in comparison with plot without treatment. Of course, neither quantitative nor qualitative losses due to neglected tending could be compensated. This fact was confirmed by our findings from other PRP with mixed spruce, fir and beech stands (Korytnica, Hrable) (ŠTEFANČÍK I., ŠTEFANČÍK L. 2001, 2002).

Development of quantitative production

Fig. 4 shows the number of trees per hectare (*N*) at the first biometrical measurement in 1972 as well as at the last one carried out in 2002. When the research started, the order of tree species on all plots was as follows: fir, beech, spruce and sycamore maple. An exception was plot IV only, where beech had the highest number of trees. After the 30-year period of research only one alteration related

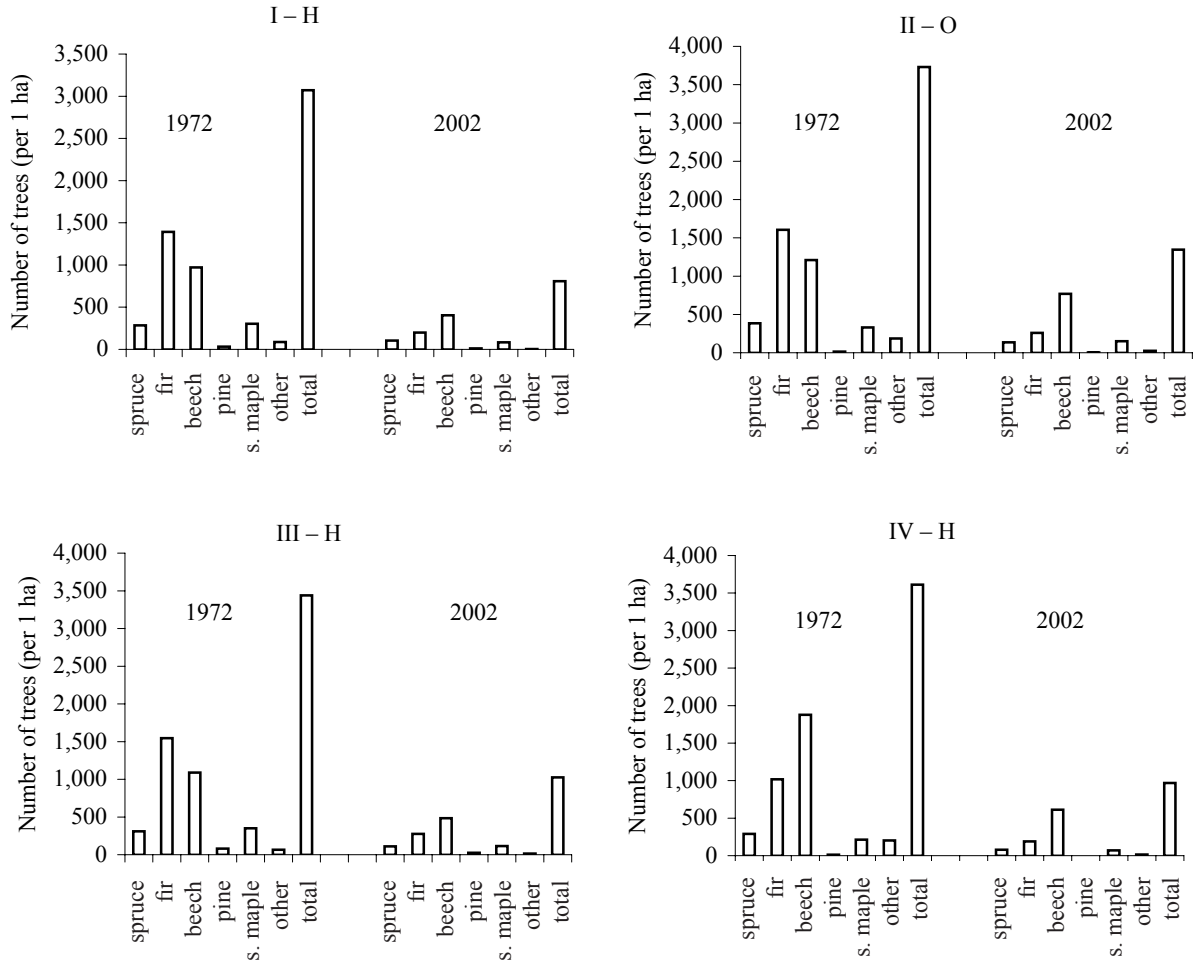

Fig. 4. Number of trees per hectare on partial plots at the first measurement (in 1972) and at the 7th measurement (in 2002)

to the above-mentioned order was recorded in the case of beech and fir. Of course, the highest number of trees occurred on control plots (1,345 individuals per hectare) while it ranged on tended plots from 808 individuals per hectare (plot I) to 1,025 individuals per hectare (plot III). The same trend was found for basal area (G) (Tables 4 and 5) and the volume of timber to the top of 7 cm o.b. (V_{7b}). The highest values were found for control plot 38.13 m^2 per hectare and/or 423.21 m^3 per hectare, respectively, and the lowest values for plot I (27.32 m^2 per hectare and 287.23 m^3 per hectare). The mentioned values are lower than those in similar mixed spruce, fir and beech stands Korytnica and Hrable PRP due to different age. It is higher on these plots on average by 8 years and/or 34 years, respectively.

Consequential values of quantitative production after the 30-year period depend especially silvicultural treatments (thinning intensity) as well as on self-thinning and/or other decreases (stem break, windthrow). On tended plots H, totally for all tree species, 7.3–14.1% of N, 9.6–16.3% of G and 10.1–16.2% of V_{7b} was removed by the first thinning. After 30-year tending 1.0–2.3% according to N, 1.1–2.2% according to G and 1.0–1.9% according to V_{7b} was removed by the 7th thinning.

Similar results were also found on other plots in mixed stands (Korytnica, Hrable) where the intensity of the first treatment (thinning of living trees) according to V_{7b} ranged from 11.0% to 15.0% on Korytnica PRP (ŠTEFANČÍK I., ŠTEFANČÍK L. 2002) and 24.9% on Hrable PRP (ŠTEFANČÍK I., ŠTEFANČÍK L. 2001). Our results also correspond with the recommendations by MOLOTKOV (1966), who published the thinning intensity of 15–30% of the growing stock and for later thinnings 10–20% for spruce, fir and beech stands of the Carpathian region in Ukraine.

Apart from the removal of trees by thinnings a decrease due to natural mortality (self-thinning) is also important from the aspect of stand development. Table 6 presents its development during the 30-year period of investigation with decrease expressed by percentage of total production (TP). The highest decrease in N by self-thinning amounting to 62.9% of total production was found on the control plot while it was 39.3% to 45.3% on tended plots. According to the tree species by an absolute expression of the

Table 4. Basal area and its decrease on the plots in 1972

Plot	Age (years)	Tree species	Total stand	Decrease (secondary stand)					Main stand
				thinning of living trees	dead trees	other* decrease	treatment intensity		
			(m^2/ha)	(%)	(%)	(%)	(m^2/ha)	(%) total	(m^2/ha)
I – H	46	spruce	3.89	16.4	–	–	0.64	16.4	3.25
	41	fir	15.29	15.5	–	0.1	2.38	15.6	12.91
	48	beech	8.07	16.9	–	0.1	1.37	17.0	6.70
		pine	0.61	16.4	–	–	0.10	16.4	0.51
		s. maple	1.54	22.7	–	–	0.35	22.7	1.19
		others	0.14	7.1	–	–	0.01	7.1	0.13
		total	29.54	16.3	–	0.1	4.85	16.4	24.69
II – O	46	spruce	4.64	–	–	–	–	–	4.64
	41	fir	15.10	–	–	–	–	–	15.10
	48	beech	6.97	–	–	–	–	–	6.97
		pine	0.34	–	–	–	–	–	0.34
		s. maple	2.16	–	–	–	–	–	2.16
		others	0.43	–	–	–	–	–	0.43
		total	29.64	–	–	–	–	–	29.64
III – H	46	spruce	3.94	4.1	–	–	0.16	4.1	3.78
	41	fir	14.57	5.4	–	–	0.78	5.4	13.79
	48	beech	7.82	20.8	–	–	1.63	20.8	6.19
		pine	1.44	–	–	–	–	–	1.44
		s. maple	1.65	12.7	–	–	0.21	12.7	1.44
		others	0.21	28.6	–	–	0.06	28.6	0.15
		total	29.63	9.6	–	–	2.84	9.6	26.79
IV – H	46	spruce	2.28	6.6	–	–	0.15	6.6	2.13
	41	fir	12.26	4.3	–	–	0.53	4.3	11.73
	48	beech	16.98	21.1	–	0.2	3.61	21.3	13.37
		pine	0.26	–	–	–	–	–	0.26
		s. maple	1.19	10.1	–	–	0.12	10.1	1.07
		others	0.44	22.7	–	–	0.10	22.7	0.34
		total	33.41	13.4	–	0.1	4.51	13.5	28.90

* – stem break or windthrow

number of trees, the following order was found: fir, beech, spruce, sycamore maple, other broadleaved tree species. According to the percentage of total production (expressed by G and V_{7b}) the highest decrease was recorded for fir and other broadleaved tree species. The same trend related to the highest natural mortality for fir was already found on this PRP after a 15-year period of investigation (ŠTEFANČÍK L. 1990). In total mortality on individual plots (according to V_{7b}) the share of fir was 85–98%. Nowadays, after 30 years, it was 84.4–97.5%. Similar results were also found on Korytnica PRP (ŠTEFANČÍK I., ŠTEFANČÍK L. 2002) and they are also in accordance with results published by other authors (KANTOR, PAŘÍK 1998; KLÍMA, HUBENÝ 2002).

Evaluation of total decrease (Table 7) over 30 years according to N showed the highest reduction on plot IV, which is in accordance with thinning intensity that was highest just on this partial plot after the four treatments (ŠTEFANČÍK L. 1990). The order according to tree species was the same as for a decrease due to self-thinning. Total decrease according to V_{7b} was 32–38% on tended plots and 17% on control plot. These values are only a little lower than on Korytnica PRP with mixed stand that is by 10 years older (ŠTEFANČÍK I., ŠTEFANČÍK L. 2002).

Total production (Table 8) during 30 years of investigation on tended plots ranged from 3,072 to 3,612 individuals per hectare, 49.77 m^2/ha to 55.93 m^2/ha (according to G) and 460.3 m^3/ha to 541.00 m^3/ha (according to V_{7b}). The

Table 5. Basal area and its decrease on the plots in 2002

Plot	Age (years)	Tree species	Total stand	Decrease (secondary stand)					Main stand
				thinning of living trees	dead trees	other* decrease	treatment intensity		
			(m^2/ha)	(%)	(%)	(%)	(m^2/ha)	(%) total	(m^2/ha)
I – H	76	spruce	5.11	2.7	0.4	–	0.16	3.1	4.95
	71	fir	7.97	–	3.0	–	0.24	3.0	7.73
	78	beech	11.66	1.1	–	–	0.13	1.1	11.53
		pine	0.80	–	–	–	–	–	0.80
		s. maple	2.35	3.4	0.4	–	0.09	3.8	2.26
		others	0.05	–	–	–	–	–	0.05
		total	27.94	1.2	1.0	–	0.62	2.2	27.32
II – O	76	spruce	7.70	–	3.4	–	0.26	3.4	7.44
	71	fir	8.68	–	0.9	–	0.08	0.9	8.60
	78	beech	16.94	–	0.6	–	0.10	0.6	16.84
		pine	0.46	–	–	–	–	–	0.46
		s. maple	4.80	–	4.2	1.9	0.29	6.1	4.51
		others	0.34	–	17.6	–	0.06	17.6	0.28
		total	38.92	–	1.8	0.2	0.79	2.0	38.13
III – H	76	spruce	6.10	2.1	0.5	–	0.16	2.6	5.94
	71	fir	9.65	1.6	1.2	–	0.27	2.8	9.38
	78	beech	11.62	1.6	0.2	–	0.21	1.8	11.41
		pine	1.87	12.3	–	–	0.23	12.3	1.64
		s. maple	2.56	–	0.4	–	0.01	0.4	2.55
		others	0.06	–	–	–	–	–	0.06
		total	31.86	2.2	0.6	–	0.88	2.8	30.98
IV – H	76	spruce	2.54	–	1.2	–	0.03	1.2	2.51
	71	fir	9.34	–	1.2	–	0.11	1.2	9.23
	78	beech	17.94	0.6	0.1	–	0.13	0.7	17.81
		pine	0.25	100	–	–	0.25	100	–
		s. maple	1.47	–	0.7	–	0.01	0.7	1.46
		others	0.11	–	18.2	–	0.02	18.2	0.09
		total	31.65	1.1	0.6	–	0.55	1.7	31.10

For explanations see Table 4

values on control plot were as follows: 3,730 individuals per hectare, 52.37 m^2/ha and 512.20 m^3/ha, respectively. As for the trend of total production of particular tree species over 30 years we have found the highest values for beech and sycamore maple and the lowest for fir.

According to total current annual volume increment we recorded the following decreasing order on all plots: beech, fir and spruce, which is the same order found on Hrable PRP and similar to those on Korytnica PRP, where it was beech, spruce, fir and sycamore maple.

Silvicultural analysis of thinnings

Table 9 presents a silvicultural analysis of free crown thinning at the first treatment in 1972. By the first thinning the most intensive treatment was carried out at crown level of the stand (53.8–96.3% according to *G*), followed by treatment at a suppressed tree level (2.8–18.2%), except for plot IV, negative stem selection (6.5–25.1%) and finally sanitary selection (0.9–5.4%). These values evidently confirmed that until the establishment of research plot the stand was neglected from silvicultural aspects. A similar character of the first thinning was also found on Hrable PRP and Korytnica PRP (ŠTEFANČÍK I., ŠTEFANČÍK L. 2001, 2002) where no silvicultural intervention was carried out until the start of research. Differences were only in the thinning intensity of the first treatment. The first thinning on Hrable PRP was carried out at the age of 80 years while on Korytnica PRP at the age of 50 years. The respective thinning intensity of the first treatment on Hrable

Table 6. A decrease of trees by self-thinning throughout 30 years

Plot	Tree species	Decrease by self-thinning					
		number of trees		basal area		volume of timber to the top of 7 cm o.b.	
		(per ha)	(% of TP)	(m^2/ha)	(% of TP)	(m^3/ha)	(% of TP)
I – H	spruce	92	32.4	0.24	3.4	0.62	0.8
	fir	828	59.5	7.89	0.4	59.20	34.6
	beech	140	14.4	0.19	1.1	0.03	0.1
	pine	4	12.5	0.09	8.0	0.66	6.4
	s. maple	84	27.6	0.16	4.5	0.18	0.6
	others	60	68.2	0.09	52.9	–	–
	total	1,208	39.3	8.66	17.4	60.69	13.2
II – O	spruce	250	64.9	1.21	14.0	6.71	7.0
	fir	1,320	82.2	10.68	54.4	72.99	42.9
	beech	435	36.0	0.75	4.2	0.91	0.5
	pine	5	33.3	0.03	4.8	0.11	1.8
	s. maple	175	53.0	0.51	10.0	1.90	3.8
	others	160	86.5	0.38	58.5	0.83	26.7
	total	2,345	62.9	13.56	25.9	83.45	16.3
III – H	spruce	120	38.7	0.41	5.2	4.21	4.8
	fir	1,085	70.2	7.85	39.7	48.23	29.7
	beech	190	17.4	0.43	2.5	0.57	0.3
	pine	20	25.0	0.27	9.4	1.71	6.4
	s. maple	120	34.3	0.28	7.1	0.47	1.5
	others	25	38.5	0.10	29.4	0.56	30.9
	total	1,560	45.3	9.34	18.0	55.75	11.7
IV – H	spruce	157	54.1	0.74	19.2	3.45	9.9
	fir	701	68.9	6.37	37.0	44.56	27.0
	beech	387	20.6	0.82	2.6	1.77	0.6
	pine	6	46.2	0.05	10.2	0.20	4.2
	s. maple	81	38.0	0.29	12.5	1.37	7.2
	others	102	50.5	0.31	51.7	1.42	67.6
	total	1,434	39.7	8.58	15.3	52.77	9.8

TP – total production

PRP was 28.6% and on Korytnica PRP 12.7–15.8% according to *G* and 11.0% to 15.0% according to V_{7b}. On Motyčky PRP it was 9.6–16.4% according to *G* and 10.1–16.2% according to V_{7b}, which is in accordance with the statement of MOLOTKOV (1966). He recommended the thinning intensity of the first treatment performed in mixed spruce, fir and beech stands to be 15–30% of the growing stock and subsequent interventions with intensity of 10–20%.

Based on the comparison we state that the intensity of the 7th thinning ranged from 1.1% to 2.2% according to *G* and from 1.0 to 1.9% according to V_{7b}. These values are also similar to those on Hrable PRP and Korytnica PRP (ŠTEFANČÍK I., ŠTEFANČÍK L. 2001, 2002).

On the basis of an assessment of thinning intensity (according to *G*) during the 30-year period of investigations (Fig. 5) we found a similar dependence like on Korytnica PRP: every second treatment was more intensive than the previous ones (with some exceptions). It is clear from the results that one more intensive treatment (15–25%) could be enough for a period from 7 to 10 years, as for the thinning intensity and interval. These results are also in accordance with recommendations by KORPEĽ (1995), who suggested that across the thinning methods the variants of crown thinning with positive selection (method of waiters or crop trees) should be consistently carried out. As for the thinning intensity the cited author states that thinning intensity lower than 10% of the growing stock with thinning interval of 5 years results in equalization of stand structure and/or one-layer constitution of stand within strong horizontal canopy,

Table 7. Total decrease of trees throughout 30 years

Plot	Tree species	Number of trees		Basal area		Volume of timber to the top of 7 cm o.b.	
		(per ha)	(% of TP)	(m^2/ha)	(% of TP)	(m^3/ha)	(% of TP)
I – H	spuce	180	63.4	2.16	30.4	19.09	25.3
	fir	1,192	85.6	12.25	61.3	91.32	53.3
	beech	568	58.4	6.34	35.5	53.73	30.7
	pine	20	62.5	0.32	28.6	2.14	20.9
	s. maple	220	72.4	1.26	35.7	6.80	24.5
	others	84	95.5	0.12	70.6	–	–
	total	2,264	73.7	22.45	45.1	173.08	37.6
II – O	spuce	250	64.9	1.21	14.0	6.71	7.0
	fir	1,345	83.8	11.04	56.2	75.76	44.6
	beech	440	36.4	0.84	4.8	1.76	0.9
	pine	10	66.7	0.17	27.4	1.21	19.7
	s. maple	180	54.5	0.60	11.7	2.72	5.4
	others	160	86.5	0.38	58.5	0.83	26.7
	total	2,385	63.9	14.24	27.2	88.99	17.4
III – H	spuce	200	64.5	1.88	24.0	17.72	20.3
	fir	1,270	82.2	10.39	52.6	67.02	41.3
	beech	605	55.5	5.89	34.0	48.20	29.2
	pine	55	68.8	1.24	43.1	9.98	37.2
	s. maple	235	67.1	1.38	35.2	8.45	26.9
	others	50	76.9	0.28	82.4	1.58	87.3
	total	2,415	70.2	21.06	40.5	152.95	32.2
IV – H	spuce	210	72.4	1.35	35.0	7.60	21.8
	fir	827	81.3	8.00	46.4	57.65	34.9
	beech	1,264	67.3	13.62	43.3	115.99	36.8
	pine	13	100	0.49	100	4.71	100
	s. maple	143	67.1	0.86	37.1	5.52	28.9
	others	186	92.1	0.51	85.0	1.63	77.6
	total	2,643	73.2	24.83	44.4	193.10	35.7

For explanation see Table 6

as well as in a decline up to dying out of admixed tree species, especially fir.

CONCLUSION

The evaluation of 30-year changes in the tree species composition, stand structure, qualitative and quantitative production of more than 70-year mixed spruce, fir and beech stand, located in the 5th forest altitudinal zone on a fertile site brought the following results:

– In the initial stage in 1972, the proportion of coniferous trees ranged from 44% to 68%. According to the tree species (except for plot IV) the highest proportion was found for fir (37–52%), followed by beech (24–51%), spruce (7–16%) and finally sycamore maple (4–7%). After 30 years, a marked decrease in the proportion of coniferous trees was found on all plots, the highest on control plot (by 24%) while it was by 6–18% on tended plots. This decrease was caused especially by fir whose proportion decreased by 14–22%. On the contrary, an increased proportion for spruce on tended plots by 1–6%, beech by 6–15% and sycamore maple by 1% and 3% was found. On control plots there was an increase in the proportion of spruce by 4%, beech by 21% and also sycamore maple by 4%.
– In the initial stage, the proportion of spruce, fir, beech, sycamore maple and other broadleaved tree species at crown level of the stand on all plots was lower than at suppressed level of the stand while for pine it was vice versa. After the 30-year period (except for beech) the proportion of spruce, fir, sycamore maple and pine at crown level of the stand on all plots increased in

Table 8. Total production of the stand throughout 30 years

Plot	Tree species	Number of trees	Basal area		Volume of timber to the top of 7 cm o.b.	
		(per ha)	(m^2/ha)	index of total stand	(m^3/ha)	index of total stand
I – H	spruce	284	7.11	1.828	75.36	2.415
	fir	1,392	19.98	1.307	171.33	1.593
	beech	972	17.86	2.213	175.27	3.231
	pine	32	1.12	1.836	10.24	2.381
	s. maple	304	3.53	2.292	27.81	4.182
	others	88	0.17	1.214	0.30	4.286
	total	3,072	49.77	1.685	460.31	2.256
II – O	spruce	385	8.65	1.864	95.41	2.333
	fir	1,605	19.65	1.301	169.98	1.654
	beech	1,210	17.68	2.537	187.36	4.658
	pine	15	0.62	1.824	6.13	2.472
	s. maple	330	5.12	2.370	50.20	4.142
	others	185	0.65	1.512	3.12	3.805
	total	3,730	52.37	1.767	512.20	2.570
III – H	spruce	310	7.82	1.985	87.34	2.894
	fir	1,545	19.77	1.357	162.45	1.781
	beech	1,090	17.30	2.212	165.20	3.594
	pine	80	2.88	2.000	26.84	2.689
	s. maple	350	3.92	2.376	31.45	4.929
	others	65	0.34	1.619	1.81	3.068
	total	3,440	52.03	1.756	475.09	2.578
IV – H	spruce	290	3.86	1.693	34.85	2.296
	fir	1,017	17.23	1.405	165.28	1.714
	beech	1,877	31.43	1.851	314.96	2.699
	pine	13	0.49	1.885	4.71	2.617
	s. maple	213	2.32	1.950	19.10	2.885
	others	202	0.60	1.364	2.10	2.958
	total	3,612	55.93	1.674	541.00	2.279

comparison with initial stage of our research. Other broadleaved tree species (European mountain ash, whitebeam, Scotch elm) composed only the suppressed level of the stand. On control plot (II – O) spruce, pine and sycamore maple had higher proportions at crown level of the stand contrary to beech, fir and other broadleaved tree species which occurred more frequently at the suppressed level of the stand.

– At the time of Motyčky PRP establishment, the number of promising trees (future crop trees) ranged from 213 individuals per hectare to 308 individuals per hectare, with the proportion out of the main stand growing stock from 30% to 38%. After a 30-year period, the number of crop trees decreased, so their number ranged from 203 individuals per hectare to 230 individuals per hectare on tended plots while there were 145 individuals per hectare on control plots. The proportion of crop trees out of the growing stock was from 54% to 58% on tended plots, and only 32% on control plots. On all plots (except for plot IV) the highest proportion out of the total number of crop trees was found for fir (35–45%), followed by beech (28–48%) and spruce (10–20%).
– After 30 years the highest number of trees occurred on control plots (1,345 individuals per hectare) while on tended plots it ranged from 808 individuals per hectare (plot I) to 1,025 individuals per hectare (plot III). The same trend was also found for basal area (G) and the volume of timber to the top of 7 cm o.b. (V_{7b}). The highest values were found for control plot 38.13 m^2 per ha and 423.21 m^3 per ha, respectively, and the lowest values for plot I (27.32 m^2 per ha and 287.23 m^3 per ha).
– On tended plots H, for all tree species, 7.3–14.1% of N (number of trees), 9.6–16.3% of G (basal area)

Table 9. Silvicultural analysis of free crown thinning (felling of living trees) on treated plots H by the first thinning in 1972

Plot	Measured parameter	Tree species	Selection						Thinning treatment intensity
			positive			negative		other* decrease	
			at crown level (%)	at suppressed level (%)	stem (%)	sanitary (%)	maturity (%)	(%)	(%)
I – H	*G*	spruce	100.0	–	–	–	–	–	16.4
		fir	65.5	19.7	3.2	11.1	–	0.5	15.5
		beech	85.4	11.1	2.3	–	–	1.2	17.0
		pine	100.0	–	–	–	–	–	17.0
		s. maple	34.1	10.2	55.7	–	–	–	22.6
		others	–	–	100.0	–	–	–	8.3
		total	74.0	13.5	6.5	5.4	–	0.6	16.4
	V_{7b}	spruce	100.0	–	–	–	–	–	17.7
		fir	69.9	19.0	2.9	8.2	–	–	14.7
		beech	91.7	8.3	–	–	–	–	17.5
		pine	100.0	–	–	–	–	–	17.7
		s. maple	45.6	4.9	49.5	–	–	–	22.1
		others	–	–	100.0	–	–	–	–
		total	80.8	11.7	3.6	3.9	–	–	16.2
III – H	*G*	spruce	100.0	–	–	–	–	–	3.9
		fir	92.4	7.6	–	–	–	–	5.4
		beech	98.5	–	–	1.5	–	–	20.8
		pine	–	–	–	–	–	–	–
		s. maple	95.2	4.8	–	–	–	–	12.8
		others	100.0	–	–	–	–	–	28.6
		total	96.3	2.8	–	0.9	–	–	9.6
	V_{7b}	spruce	100.0	–	–	–	–	–	3.4
		fir	95.3	4.7	–	–	–	–	5.7
		beech	99.1	–	–	0.9	–	–	24.0
		pine	–	–	–	–	–	–	–
		s. maple	100.0	–	–	–	–	–	17.7
		others	100.0	–	–	–	–	–	45.8
		total	98.2	1.3	–	0.5	–	–	10.1
IV – H	*G*	spruce	100.0	–	–	–	–	–	6.4
		fir	51.3	29.1	1.3	18.3	–	–	4.3
		beech	53.3	15.8	30.0	–	–	0.9	21.3
		pine	–	–	–	–	–	–	–
		s. maple	48.6	42.8	8.6	–	–	–	9.8
		others	25.0	46.9	28.1	–	–	–	24.0
		total	53.8	18.2	25.1	2.2	–	0.7	13.5
	V_{7b}	spruce	100.0	–	–	–	–	–	8.5
		fir	62.0	20.0	–	18.0	–	–	4.4
		beech	58.6	11.7	29.7	–	–	–	22.3
		pine	–	–	–	–	–	–	–
		s. maple	69.1	30.9	–	–	–	–	8.2
		others	44.2	55.8	–	–	–	–	24.6
		total	60.9	12.8	23.9	2.4	–	–	13.6

Explanatory notes: *G* – basal area, V_{7b} – volume of timber to the top of 7 cm o.b. per 1 ha, * – stem break or windthrow

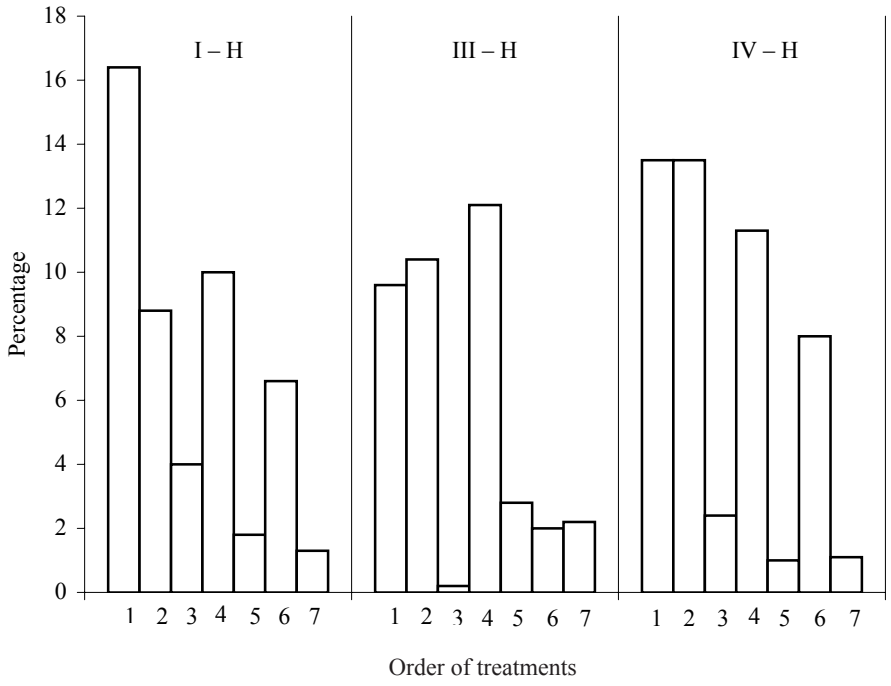

Fig. 5. Comparison of thinning intensity (according to basal area) during the 30-year period of investigation on tended plots Motyčky

and 10.1–16.2% of the volume of timber to the top of 7 cm o.b. (V_{7b}) were removed totally by the first thinning. After the 30-year period of tending, 1.0–2.3% of *N*, 1.1–2.2% of *G* and 1.0–1.9% of V_{7b} were removed by the 7th thinning.

– The highest decrease in *N* by self-thinning was found on control plot – 62.9% of the total production while it was 39.3–45.3% on tended plots. According to the tree species expressed by an absolute number of trees, the following order was found: fir, beech, spruce, sycamore maple, other broadleaved tree species but according to percentage of total production, the highest decrease according to V_{7b} was recorded for fir (84.4–97.5%) and other broadleaved tree species.
– Assessment of total decrease for 30 years showed the highest reduction according to *N* on plot IV, which is in accordance with thinning intensity that was the highest after four treatments just on this partial plot. The order according to tree species was the same as for a decrease due to self-thinning. Total decrease according to *G* from total production on tended plots was 40–45%, and 27% on control plot. Total decrease according to V_{7b} on tended plots was 32–38% and 17% on control plot.
– Total production during 30 years of investigation on tended plots ranged from 3,072 to 3,612 individuals per hectare, 49.77 m^2/ha to 55.93 m^2/ha (according to *G*) and 460.3 m^3/ha to 541.00 m^3/ha (according to V_{7b}). The values on control plot were as follows: 3,730 individuals per hectare, 52.37 m^2/ha and 512.20 m^3/ha, respectively. As for the trend of total production of particular tree species over 30 years we have found the highest values for beech and sycamore maple and the lowest for fir.
– According to total current annual volume increment we recorded the following decreasing order on all plots: beech, fir and spruce.
– The silvicultural analysis showed that the most intensive treatment was carried out by the first thinning at crown level of the stand (53.8–96.3% according to *G*), followed by a treatment at the suppressed tree level (2.8–18.2%), except for plot IV, then negative stem selection (6.5–25.1%) and finally sanitary selection (0.9–5.4%). These values unambiguously confirm that the stand was neglected from silvicultural aspects until the time of research plot establishment.

References

ASSMANN E., 1961. Waldertragskunde. München – Bonn – Wien, BVL Verlagsgesellschaft: 490.

HANČINSKÝ L., 1972. Lesné typy Slovenska. Bratislava, Príroda: 307.

HLADÍK M., 1992. Vývoj štruktúry a produkcie zmiešaného smrekovo-jedľovo-bukového porastu pri uplatňovaní zásad výberného hospodárskeho spôsobu. Acta Fac. For. Zvolen., *34*: 205–220.

HOCKENJOS F., 1968. Waldbauliche Erfahrungen im Fichten--Tannen-Buchenwald des Westschwarzwaldes. Allg. Forst-Jagdztg, *139*: 13–18.

KANTOR P., PAŘÍK T., 1998. Produkční potenciál a ekologická stabilita smíšených lesních porostů v pahorkatinách – I. Jehličnatý porost s příměsí buku na kyselém stanovišti ŠLP Křtiny. Lesnictví-Forestry, *44*: 488–505.

KLÍMA S., HUBENÝ D., 2002. Vliv výchovy na růst jedle ve smíšeném porostu. In: Současné trendy v pěstování lesů. Praha, ČZU, LF: 63–68.

KONÔPKA J., 1992. Modely cieľových stromov smreka z hľadiska statickej stability. Sbor. ČAZV ČSFR č. 153. Praha, ČAZV ČSFR: 106.
KORPEĽ Š., VINŠ B., 1965. Pestovanie jedle. Bratislava, SVPL: 340.
KORPEĽ Š., 1995. Zásady a pestovné metódy v horských a vysokohorských lesoch Slovenska. In: OTT E. et al., Pestovanie horských lesov Švajčiarska a Slovenska. Zvolen, ÚVVP LVH SR: 57–122.
KÖSTLER J.N., 1952. Ansprache und Pflege von Dickungen. Hamburg – Berlin, Verlag P. Parey: 80.
LEIBUNDGUT H., AUER C., WIELAND C., 1971. Ergebnisse von Durchforstungsversuchen 1930–1965 im Sihlwald. In: Mitt. Schweiz. Anst. Forstl. Vers.-Wes., *47*: 257–389.
MÁLEK J., 1983. Problematika ekologie jedle bělokoré a jejího odumírání. Studie ČSAV č. 11/83. Praha, Academia: 112.
MOLOTKOV P.I., 1966. Bukovyje lesa i chozjajstvo v nich. Moskva, Izd. Lesn. Prom.: 224.
PAUMER V., 1978. Výškové a hrúbkové členenie jedľovo-smrekovo-bukových húštin. Ved. Práce VÚLH Zvolen, *27*. Bratislava, Príroda: 143–158.
ŠEBÍK L., POLÁK L., 1990. Náuka o produkcii dreva. Bratislava, Príroda: 322.
ŠTEFANČÍK I., 1999. Vplyv snehovej kalamity na vývoj zmiešanej smrekovo-jedľovo-bukovej žrďoviny na výskumnej ploche Stará Píla. Lesn. Čas. – Forestry Journal, *45*: 181–204.
ŠTEFANČÍK I. et al., 1999. Vplyv antropogénnych a abiotických škodlivých činiteľov a ochrana proti nim. [Záverečná správa.] Zvolen, LVÚ: 214 + prílohy.
ŠTEFANČÍK I., ŠTEFANČÍK L., 1998. Zhodnotenie vplyvu výchovy na zachovanie biodiverzity zmiešaných smrekovo-jedľovo-bukových porastov. Lesn. Čas. – Forestry Journal, *44*: 485–501.
ŠTEFANČÍK I., ŠTEFANČÍK L., 2001. Assessment of tending effect on stand structure and stability an mixed stands of spruce, fir and beech on research plot Hrable. J. For. Sci., *47*: 1–14.
ŠTEFANČÍK I., ŠTEFANČÍK L., 2002. Assessment of long-term tending in mixed stands of spruce, fir and beech on research plot Korytnica. J. For. Sci., *48*: 100–114.
ŠTEFANČÍK L., 1977. Prečistky a prebierky v zmiešaných smrekovo-jedľovo-bukových porastoch. Lesn. Štúd. č. 25. Bratislava, Príroda: 92.
ŠTEFANČÍK L., 1984. Úrovňová voľná prebierka – metóda biologickej intenzifikácie a racionalizácie selekčnej výchovy bukových porastov. Ved. Práce VÚLH Zvolen, *34*. Bratislava, Príroda: 69–112.
ŠTEFANČÍK L., 1990. Vplyv prebierok na štruktúru a stabilitu zmiešaných smrekovo-jedľovo-bukových porastov. Ved. Práce VÚLH Zvolen, *39*. Bratislava, Príroda: 111–128.
VLADOVIČ J., 1998. Aktuálny stav súborov porastových typov v lesných oblastiach ako súčasť hodnotenia ich ekologickej stability. Lesn. Čas. – Forestry Journal, *44*: 23–56.
VLADOVIČ J. et al., 1998. Prehodnotenie cieľového zloženia lesných drevín s dôrazom na využívanie prirodzenej obnovy. [Záverečná správa.] Zvolen, LVÚ: 53.

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Vplyv dlhodobej výchovy na kvalitatívnu a kvantitatívnu produkciu zmiešaného smrekovo-jedľovo-bukového porastu na výskumnej ploche Motyčky

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ABSTRAKT: Práca je príspevkom k výskumu problematiky prebierok v zmiešaných (sm-jd-bk) porastoch 5. lesného vegetačného stupňa v oblasti stredného Slovenska. Na troch plochách sa aplikovala úrovňová voľná prebierka a jedna plocha sa ponechala bez úmyselného zásahu ako kontrolná. Vyhodnotili sa dynamické zmeny drevinového zloženia, porastovej štruktúry a kvantitatívnej produkcie za obdobie 30 rokov. Osobitná pozornosť sa venovala vývoju cieľových stromov, ktoré sú hlavnými nositeľmi kvalitatívnej i kvantitatívnej produkcie porastu. Zistené zmeny sa porovnali aj z hľadiska rozdielov medzi dlhodobo vychovávanými plochami a kontrolnou plochou (bez zásahu).

Kľúčové slová: prebierky; cieľové stromy; statická stabilita; zmiešané porasty; smrek – jedľa – buk

Cieľom práce bolo zistiť a zhodnotiť zmeny v drevinovom zložení, porastovej štruktúre, stabilite, kvalitatívnej a kvantitatívnej produkcii zmiešaného smrekovo-jedľovo-bukového porastu na výskumnej ploche Motyčky za 30-ročné obdobie systematickej výchovy.

Objektom výskumu bol zmiešaný smrekovo-jedľovo-bukový porast v rastovej fáze žrďoviny až tenkej kmeňoviny na trvalej výskumnej ploche (TVP) Motyčky, ktorá sa nachádza v obvode Lesnej správy Staré Hory, odštepný lesný závod Slovenská Ľupča. TVP bola založená v roku 1971 na výskum problematiky pestovno-produkčných vzťahov v zmiešaných smrekovo-jedľovo-bukových porastoch. Sériu TVP Motyčky tvoria štyri čiastkové plochy – tri s výmerou 0,20, 0,25 a 0,30 ha (majú označenie H),

kde sa aplikuje úrovňová voľná prebierka (ŠTEFANČÍK L. 1984), a jedna plocha s výmerou 0,20 ha je kontrolná s označením O. Podrobnú charakteristiku výskumných plôch uvádzame v tab. 1.

Na plochách sú stromy očíslované s označením meriska hrúbky vo výške 1,3 m. Na každej ploche sa pravidelne vykonávajú kompletné biometrické merania očíslovaných stromov v päťročných intervaloch v súlade so štandardnými metodikami, ktoré sú vypracované pre dlhodobý výskum pestovno-produkčných otázok prebierok (ŠTEFANČÍK L. 1977). V rámci nich sa okrem kvantitatívnych znakov (hrúbka $d_{1,3}$, výška stromu, rozmery koruny pri horizontálnej projekcii) hodnotili stromy aj podľa pestovnej a hospodárskej klasifikácie s orientáciou na pestovanie stromov výberovej kvality (nádejné a cieľové stromy). Od založenia plochy sa tu vykonalo sedem biometrických meraní a súčasne s meraniami sa vždy vykonal aj prebierkový zásah. Z hľadiska fytotechniky sa na zasahovaných plochách (H) aplikovala metóda nádejných stromov a neskôr metóda cieľových stromov (ŠTEFANČÍK L. 1984), ktorá sa zameriava na individuálnu výchovu tzv. stromov výberovej kvality.

V príspevku sme vyhodnotili prvé meranie (v roku 1972) vykonané pri založení plochy (vo veku porastu 41–48 rokov) a posledné meranie v roku 2002 (vo veku porastu 71–78 rokov), aby sme porovnali dynamické zmeny sledovaných znakov na čiastkových plochách za obdobie 30 rokov. Výsledky z prvých štyroch meraní boli publikované už dávnejšie (ŠTEFANČÍK L. 1990).

Vyhodnotenie 30-ročných zmien v drevinovom zložení, porastovej štruktúre, kvalitatívnej a kvantitatívnej produkcii vyše 70-ročného zmiešaného smrekovo-jedľovo-bukového porastu v 5. lesnom vegetačnom stupni na živnom stanovišti prinieslo nasledujúce výsledky:

– Pri východiskovom stave v roku 1972 sa podiel ihličnanov pohyboval od 44 % do 68 %. Podľa drevín mala okrem plochy IV najvyššie zastúpenie jedľa (37–52 %), potom buk (24–51 %), smrek (7 až 16 %), a napokon javor horský (4–7 %). Po 30-ročnom období sa podiel ihličnanov na všetkých plochách výrazne znížil, pričom najviac na kontrolnej ploche (o 24 %), kým na vychovávaných plochách bol pokles o 6–18 %. Toto zníženie bolo zapríčinené najmä jedľou, ktorej zastúpenie kleslo o 14–22 %. Naopak zastúpenie smreka sa na zasahovaných plochách zvýšilo o 1–6 %, buka o 6–15 % a javora horského o 1–3 %. Na kontrolnej ploche sa zvýšilo zastúpenie smreka o 4 %, buka o 21 % a tiež zastúpenie javora horského o 4 %.
– Pri východiskovom stave bolo na všetkých plochách zastúpenie smreka, jedle, buka, javora horského a ostatných listnatých drevín v úrovni porastu menšie ako v podúrovni, kým pri borovici to bolo opačne. Po 30-ročnom období sa okrem buka na všetkých plochách zastúpenie smreka, jedle, javora horského a borovice v úrovni zvýšilo v porovnaní so začiatkom výskumu. Ostatné listnáče (jarabina, mukyňa, brest horský) tvorili iba podúroveň. Na kontrolnej ploche (II – O) sa smrek, borovica a javor horský presadili v úrovni porastu, kým buk, jedľa a ostatné listnáče sa vyskytovali viac v podúrovni porastu.
– Pri založení TVP sa počet nádejných stromov (budúcich cieľových stromov) pohyboval od 213 stromov na ha do 308 stromov na ha, pričom na zásobe hlavného porastu sa podieľali v rozpätí 30–38 %. Po 30-ročnom období sa počet cieľových stromov znížil, takže na zasahovaných plochách sa ich počet pohyboval od 203 jedincov na ha do 230 jedincov na ha, kým na kontrolnej ploche to bolo 145 stromov na ha. Na zasahovaných plochách sa cieľové stromy podieľali na zásobe hlavného porastu v rozpätí 54–58 %, kým na kontrolnej ploche to bolo iba 32 %. Na všetkých plochách (okrem plochy IV) najvyšší podiel z celkového počtu cieľových stromov tvorila jedľa (35–45 %), potom buk (28–48 %) a smrek (10–20 %).
– Po 30 rokoch sme najvyšší počet stromov zistili na kontrolnej ploche (1 345 ks/ha), kým na zasahovaných plochách sa pohyboval od 808 ks/ha (plocha I) do 1 025 ks/ha (plocha III). Rovnaký trend bol aj pri kruhovej základni porastu (G) a objeme hrubiny (V_{7b}), keď najvyššie hodnoty boli na kontrolnej ploche 38,13 m^2/ha, resp. 423,21 m^3/ha a najmenšie hodnoty na ploche I (27,32 m^2/ha a 287,23 m^3/ha).
– Na zasahovaných plochách H sa prvou prebierkou súhrnne za všetky dreviny odstránilo z celkového počtu stromov N 7,3–14,1 %, z celkovej kruhovej základne G 9,6–16.3 % a z celkového objemu hrubiny V_{7b} 10,1–16,2 %. Po 30-ročnej výchove sa pri siedmej prebierke odstránilo podľa N 1,0–2,3 %, podľa G 1,1–2,2 % a podľa V_{7b} to bolo 1,0–1,9 %.
– Najväčší úbytok počtu stromov samoprerieďovaním sme zistili na kontrolnej ploche, a to 62,9 % z celkovej produkcie (CP), kým na zasahovaných plochách to bolo 39,3–45,3 % z CP. Podľa drevín pri absolútnom vyjadrení z počtu stromov bolo poradie jedľa, buk, smrek, javor, ostatné listnáče, ale pri vyjadrení percenta z CP podľa G a V_{7b} bol najväčší úbytok zaznamenaný u jedle (84,4–97,5 % podľa V_{7b}) a ostatných listnáčov.
– Pri vyhodnotení celkového úbytku za 30 rokov sa najväčší úbytok podľa počtu stromov zaznamenal na ploche IV, čo súvisí s intenzitou prebierok, ktorá tu bola po prvých štyroch zásahoch najväčšia. Poradie drevín bolo rovnaké ako pri úbytku samoprerieďovaním. Celkový úbytok na zasahovaných plochách podľa G tvoril 40–45 % z celkovej produkcie (CP), kým na kontrolnej ploche 27 %. Pri vyjadrení podľa V_{7b} to činilo na zasahovaných plochách 32–38 %, resp. na kontrolnej ploche 17 %.
– Celková produkcia (CP) sa za 30 rokov sledovania na zasahovaných plochách pohybovala pre N od 3 072 do 3 612 stromov na ha, pre G 49,77–55,93 m^2/ha , pre V_{7b} 460,3–541,00 m^3/ha. Na kontrolnej ploche to boli hodnoty pre N 3 730 stromov na ha, pre G 52.37 m^2/ha a pre V_{7b} to bolo 512,20 m^3/ha. Čo sa týka trendu CP jednotlivých drevín za 30 rokov, zistili sme, že najvyššie hodnoty dosahovali buk a javor horský a najnižšie jedľa.

– Podľa celkového objemového bežného ročného prírastku bolo na všetkých plochách poradie drevín buk, jedľa a smrek.
– Pestovná analýza prebierok ukázala, že pri 1. zásahu sa najviac zasahovalo v úrovni porastu (53,8–96,3 % podľa kruhovej základne), ďalej nasleduje podúrovňový zásah (2,8–18,2 %) okrem plochy IV, potom negatívny tvarový výber (6,5–25,1 %) a nakoniec zdravotný výber 0,9–5,4 %. Tieto údaje jednoznačne potvrdzujú, že do založenia výskumnej plochy bol porast pestovne zanedbaný, pričom na plochách so systematickou výchovou počas 30 rokov sa dosiahli vo všetkých ukazovateľoch oveľa priaznivejšie výsledky ako na ploche bez zásahov.

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