

Tree species growth in mixed spruce, fir and beech stands*

Igor Štefančík

Forest Research Institute, T. G. Masaryka 22, 960 92 Zvolen, Slovak Republic,
e-mail: stefanci@fris.sk

Abstract

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The paper presents a comparison of tree species growth on four research plots in Slovakia. The plots are situated in mixed spruce, fir and beech stands where no interventions were carried out in the last 30 years. The results showed that in the initial stage of research had fir the second highest proportion in tree species composition over three of the plots and/or on one of them even the highest one. After 30 years, the highest proportion of beech was found over the plots overall and/or the following total decrease (according to the number of trees) was registered: 76–89% for fir, 46–93% for spruce and 36–73% for beech. After 30 years, beech reached the upper crown layer, while fir together with spruce constituted the medium crown layer. As for mean crown width, differences between individual tree species were low and statistically insignificant ($P > 0.05$). The highest mean annual diameter increment was registered for spruce and the lowest for fir.

Key words

mixed stand, spruce-fir-beech, growth parameters

Introduction

Mixed spruce, fir and beech stands are important stand type of higher situated mixed forest complexes in the Alps and Carpathians Mountains. In Slovakia, the mentioned stands cover an area of one-fourth of the total forest area, i. e. more than 461,000 hectares, mainly within the 4th to 6th altitudinal forest zones. Nowadays, the advantage of mixed stands is generally recognized in comparison to unmixed ones, especially in view of their stability and/or resistance to injurious factors.

In Slovakia, research on tending of mixed spruce, fir and beech stands started at the end of the 60's of the last century. For this reason, four permanent research plots (17 partial plots) were established in the 5th and 6th altitudinal forest zones situated in the natural range of mixed spruce, fir and beech forests in Slovakia in both the Veľká Fatra Mountains and the Low Tatra Mountains. The first results of research on the mentioned

problems were published in 1977 (L. ŠTEFANČÍK 1977). An assessment of the 30-year tending effect on stand condition was already carried out on the three-plot series (I. ŠTEFANČÍK, L. ŠTEFANČÍK 2003).

The aim of this paper is to ascertain and compare the growth of individual tree species in mixed spruce, fir and beech stands in the 30-year period of study.

Material and methods

As the object of our research was chosen several series of permanent research plots (PRP) located in the 5th and 6th forest altitudinal zones of Central Slovakia, established in the past by Prof. Ing. L. Štefančík, DrSc., for the research on production relations in mixed spruce, fir and beech stands. The area of plots ranges from 0.20 to 0.50 hectare, their arrangement depends on field conditions, and they are isolated by 10 m wide tree belts. The trees on all the plots have been numbered and measurement

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points at the breast height 1.3 m marked out. Complex biometrical measurements were carried out on the numbered trees in 5-year intervals, in accordance with standard methods (L. ŠTEFANČÍK 1977). Since the establishment of PRP, seven biometrical measurements have been carried out on all plots focused on quantitative parameters – breast height diameter, tree height and crown size at horizontal projection.

A more detailed description of research plots is presented in Table 1. The data were processed by common biometrical and statistical methods according to standard research methods. To find out the significance of influence of tree species on diameter increment and crown width, the analysis of variance (ANOVA) was used.

The background of the methodical procedure in processing of the results was to compare between the biometrical values on the partial plots at their establishment and after the last measurement, what represents a period of 30 years. To exclude the influence of management on development of the investigated parameters, we took into account only control plots, where no interventions were carried out.

Results and discussion

Fig. 1 presents the tree species composition on partial plots in the initial stage of research and after 30 years. As for spruce, fir and beech, it can be seen that at the beginning was fir the second most abundant tree species and on the Motyčky PRP even the most abundant one. After the 30-year period, conspicuous changes were ascertained because the highest proportions were found for beech on all the plots. It can be seen that the mentioned increase caused a decreased proportion of fir on all the plots while increases were found for the other tree species. It is in accordance with the values of the total decrease in the individual tree species during the investigated period. To provide an objective comparison, the values were expressed as a percentage from the

number of trees of the corresponding tree species in the initial stage of the research (Fig. 2). Almost on all the plots was the highest decrease recorded for fir; on the contrary, it was the lowest for beech. An exception was found on the Hrable PRP, where the decrease in spruce was higher in comparison with the other tree species. This plot is located in the Spiš region with a marked worsening of spruce health condition and decline caused by air pollutants, reported already from the past (L. ŠTEFANČÍK, I. ŠTEFANČÍK 1993; B. KONÓPKA et al. 1997).

The above-mentioned development of tree species composition is remarkable especially for decrease of fir, which was, according to our opinion, caused by numerous factors. It is known that especially fir belongs to the most sensitive tree species what was also confirmed by the increased mortality on our research plots. The changes related to fir decrease confirmed the known fact of its overall decline in forest stands during the last decades (MÁLEK 1983; VLADOVIČ et al. 1998).

On the other hand, a considerable increase of beech proportion was found. This fact could be explained by a strong competitive ability of beech compared with other tree species under the given ecological conditions. After 30 years, beech reached the upper crown layer, while fir together with spruce made up the medium crown layer. It is noticeable that the same trend was registered on all the investigated plots.

From the point of view of growth space utilization, especially throughout the vertical profile of forest canopy, in addition to tree height, crown size and crown width of individual trees (tree species) are also considered to be very important parameters. Particularly, the crown size and the area of foliage together with other ecological factors influence the rate of physiological processes (photosynthesis, respiration) in the vertical canopy structure, which is reflected in biomass production of the given forest stand (MASAROVICHOVÁ et al. 1996; MAREK et al. 1997). Therefore, we

Table 1. Basic characteristics of permanent research plots (PRP) in mixed stands

Characteristic	PRP Motyčky	PRP Korytnica I, II, III	PRP Hrable
Establishment (year)	1971	1967	1968
Stand age (years)	spruce 46, fir 41, beech 48	spruce 58, fir 50, beech 50	spruce 80, fir 82, beech 74
Geomorphologic unit	the Veľká Fatra Mts.	the Nízke Tatry Mts. (west part)	the Volovské vrchy Mts.
Exposition	NE	NE	W
Altitude (m)	810-870	930-970	820-840
Inclination (degree)	30	30-35	25
Parent rock	Dolomite	Triassic Schist	phyllite and quartz-phyllite slope deposits
Soil unit	Rendzic Leptosol/Calcic Cambisol	Cambisol/Umbria Leptosol	Haplic Cambisol/Dystric Cambisol
Altitudinal forest zone	5 ^b fir - beech	6 ^a spruce-beech-fir	5 ^b fir-beech
Ecological rank	B/C	B/C	B
Management complex	55	65	55
Management complex of forest types	511 fertile fir-beechwoods	611 fertile beech-fir sprucewoods	511 fertile fir-beechwoods
Forest type group	Fageto-Aceretum (FAc) n.st.	Fageto-Aceretum (FAc) v.st.	Abieto-Fagetum (AF) n.st.
Forest type	5401 mercury-beech maplewoods n.st.	6402 fern-beech maplewoods v.st.	5301 low-herbaceous fir beechwoods n.st.
Mean temperature (°C)	5.8	4.2	6.0
Mean annual precipitation total (mm/year)	1,085	1,200	900

compared the values of mean crown width of the individual tree species. Differences between the species were low and statistically insignificant ($P > 0.05$). The crown size increased with the age of stand. It is known that crown size of trees can be influenced by silvicultural interventions, i. e. by removing undesirable individuals with the aim to release the crowns of remaining trees. However, on plots without interventions (as in our case), the crown size is a result of competitive relations between the tree species.

Consequently, our interest was focused on the crown width in relation to diameter increment of individual tree species – one of the most significant production parameters. By the method of correlation analysis, a statistically significant relation ($P < 0.01$) between crown width and mean annual diameter increment (correlation coefficient ranged from 0.795 to 0.864) was found for beech trees on all the plots. For fir ranged the coefficient value from 0.181 to 0.981, and on one plot was the mentioned relation found as insignificant ($P > 0.05$). Similar results were found for spruce with correlation coefficient 0.453–0.819, where the investigated relation was also statistically insignificant on two plots

in Korytnica ($P > 0.05$). These results suggest a favourable growth of beech under the given conditions and its prevalence in competitions with spruce and fir. It was also confirmed by the fact that spruce mean diameter was found the highest in comparison with fir and beech on the all plots. On the just opposite, the mean diameter of beech was the lowest. This species had, however, the highest diameter increment, although the differences between the tree species were neither high nor statistically significant ($P > 0.05$).

Conclusion

The aim of this paper was to ascertain and compare the growth of tree species in four mixed spruce, fir and beech stands over a 30-year period. The results showed, that at the beginning of the experiment, fir was the second most abundant tree species on three plots and on one plot even the most abundant one. After 30 years, the highest proportion for beech was found over the all plots. The fir proportion decreased on all plots, while for the other tree species, an increase was observed. It is in accordance with the values of the total decrease, which were 76 to

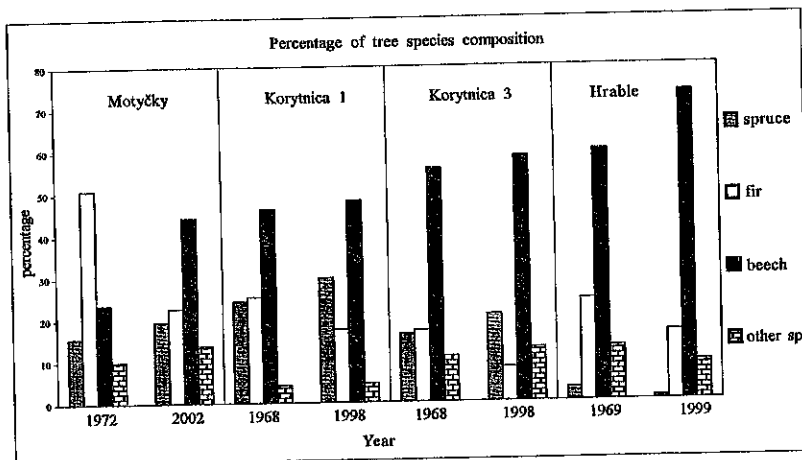


Fig. 1. Development of tree species composition on investigated plots for study period of 30 years

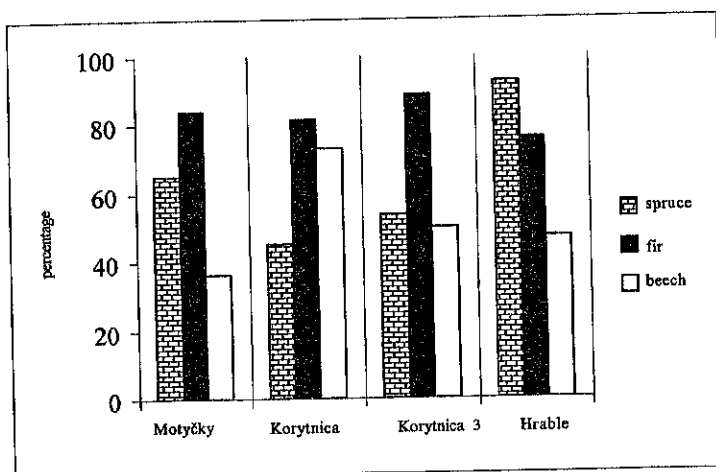


Fig. 2. Percentage of total decrease in individual tree species on investigated plots for study period of 30 years

89% for fir, 46–93% for spruce and the lowest were found for beech 36–73%.

On the contrary, beech was characterized by a very strong competitive ability against the other tree species under the given ecological conditions. After 30 years, the beech trees reached the upper crown layer, while fir together with spruce made up the medium crown layer. As for the mean crown width, differences between individual tree species were small and statistically insignificant ($P > 0.05$). The highest mean annual diameter increment was found for spruce and the lowest for fir.

These results suggest a favourable growth of beech under the given conditions and its prevalence in competitions with spruce and fir.

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Rast drevín v zmiešaných smrekovo-jedľovo-bukových porastoch

Súhrn

V príspevku sa hodnotí rast drevín na štyroch výskumných plochách Slovenska v zmiešaných smrekovo-jedľovo-bukových porastoch, kde sa nevykonávali žiadne zásahy za obdobie 30 rokov. Výsledky ukázali výrazný úbytok jedle, ktorý činil 76–89 % z počtu stromov. Naopak, najväčšie zastúpenie dosiahol na všetkých plochách za sledované obdobie buk, ktorý sa dostal do hornej vrstvy, kým jedľa tvorila spolu so smrekom strednú vrstvu. Čo sa týka priemernej šírky koruny boli rozdiely medzi jednotlivými drevinami malé a tiež štatisticky nevýznamné. Šírka koruny vo vzťahu s hrúbkovým prírastkom jednotlivých drevín bola najtesnejšia u buka pričom na všetkých plochách bola štatisticky významná ($P < 0,01$). Pri jedli a smreku sme zistili nižšie hodnoty korelačného koeficienta, pričom neboli vždy signifikantné. Najvyšší priemerný ročný hrúbkový prírastok mal smrek a najmenší jedľa. Tieto výsledky naznačujú, že buk sa v daných ekologických podmienkach vyznačuje silnou konkurenčnou schopnosťou voči ostatným drevinám.