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Relationship between crown characteristics and the radial increment of beech (*Fagus sylvatica* L.) in the Świętokrzyski National Park (Poland)

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ABSTRACT: The objectives of this study are to determine the relationship between crown characteristics and the radial increment of beech (*Fagus sylvatica* L.) and to specify the characteristics of beech trees with the radial increment above the average in the Świętokrzyski National Park. The following relationships have been found: the radial increment of beech increases as the degree of the freedom of the light part of the crown from neighbouring trees increases, and the increase in the relative crown length causes a significant increase in the radial increment. Most of the best growing beech trees are characterized by the light part of the crown confined in an area of up to about 55%, and the relative crown length spanning the range of 55% (trees 61 to 80 years of age at b.h.) to 76% (trees 21 to 40 years of age at b.h).

Keywords: *Fagus sylvatica*; type of top; crown deformation; crown freedom; defoliation; relative crown length; radial increment; thinning; Świętokrzyski National Park

Beech (*Fagus sylvatica* L.) is one of the principal forest tree species of the lower-mountain zone in the Sudetes, Carpathians, and the Świętokrzyskie Mountains. It grows in pure or mixed stands together with silver fir (*Abies alba* Mill.), Norway spruce (*Picea abies* [L.] Karst.), sycamore maple (*Acer pseudoplatanus* L.) and mountain elm (*Ulmus glabra* Huds.). These stands are very stable and highly productive. Under the best site conditions the stands of primeval character with beech in their species composition, growing in strictly protected reserves in some Polish national parks, reach stand volume of about 600–800 m^3/ha. One of the beech stands in the Bieszczady National Park, being in the stage of growing up and the phase of storeyed form, has the volume of 619 m^3/ha, while the beech-fir-spruce stand in the optimum stage in the Gorce National Park has the volume of 759 m^3/ha (JAWORSKI 1997).

The importance of beech in mixed stands of the lower-mountain zone is increasing in connection with the phenomenon of the silver fir decline leading to the replacement of silver fir by beech. In the Carpathians, Sudetes, and the Świętokrzyskie Mountains since about 1950, and especially since about 1960, the number of fir trees was decreasing while the number of beech trees was increasing (JAWORSKI 1982). A particularly conspicuous fir decline was observed in stands situated near the northern boundary of its range, in the Świętokrzyskie Mountains (JAWORSKI et al. 1988). The scale of this process is manifested, among other things, by the number of dead standing fir trees and trees lying on the ground in some stands of the Świętokrzyskie Mountains. In the study area established in 1992 in the Święty Krzyż strictly protected reserve there were 315.23 m^3/ha of dead standing and lying fir timber, which was as much as 155.28% of the volume of the stand growing there. This stand was in a transitional stage between the stage of breakup and the stage of growing up, and in an intermediate phase between the phase of regeneration and the phase of storeyed form (JAWORSKI et al. 1999). The analysis of the species composition of regeneration carried out in the Świętokrzyskie Mountains confirmed the replacement of silver fir by beech (the number of fir trees decidedly decreased in favour of beech as the age of young natural regeneration and upgrowth increased) (JAWORSKI et al. 1999).

The data presented above indicate an increasing importance of beech in stands of the lower-mountain zone in the Carpathians, Sudetes, and the Świętokrzyskie Mountains. Similar trends occur in the mountain mixed stands with silver fir and beech in their species composition in Germany, Czech Republic, Slovakia, Austria, and France (e.g. SPIECKER et al. 1996a,b).

In the circumstances, studies on the ecological requirements and silviculture of beech are particularly important since only the satisfactory knowledge of these problems permits to grow vigorous and stable stands with beech in their species composition.

A correct execution of tending operations (especially thinnings) requires the knowledge of those morphologi-

cal characteristics of beech crown that determine its vitality. The crown characteristics of beech correlating with its diameter and volume increments have a fundamental importance during the selection of crop trees securing high quality and stability of stands.

The objectives of this study are to determine the relationship between crown characteristics and the 10-year current radial increment at breast height of beech from 1985 to 1994, and to specify the characteristics of trees with the radial increment above the average in the Świętokrzyski National Park.

MATERIAL AND METHODS

CHARACTERISTICS OF THE STUDY AREA

The investigations were carried out in the Święta Katarzyna, Święty Krzyż, and Chełmowa Góra Forest Divisions of the Świętokrzyski National Park (geographic coordinates: 50°50'–50°58' N, 20°48'–21°08' E).

Typical brown and grey brown podzolic soils predominate in the investigated area (KOWALKOWSKI 1991), which led to the development of the following associations: *Dentario glandulosae-Fagetum*, *Abietetum polonicum*, and *Pino-Quercetum* (the association names are given according to MATUSZKIEWICZ, MATUSZKIEWICZ 1966).

The data obtained during a long-term observation period (1955–1994) in the meteorological station situated on the top of Święty Krzyż Mt. (575 m above sea level) in the Świętokrzyskie Mountains showed that the mean annual temperature was +5.9°C (the mean temperature of January was –5.2°C, and July +15.9°C), mean annual precipitation was 923 mm, and the growing season lasted for about 182 days.

FIELD WORK

The research was conducted between 1993 and 1995. In the Święta Katarzyna, Święty Krzyż and Chełmowa Góra Forest Divisions of the Świętokrzyski National Park, a total of 251 permanent study points were selected at random in the P_2 areas (975 m × 1,030 m) of the network of SINUS System of Information on Natural Environment (CIOŁKOSZ 1991).

In the surroundings of each permanent study point the nearest beech tree from about 30 to about 90 years of age was selected. However, there were no beech trees near some of the study points, and therefore 203 trees were selected in total. The selected sample trees belonged to dominant trees (Kraft class II in one-storeyed stands) or they represented the upper storey (according to IUFRO – 100, in stands of complex structure).

The selected trees were marked, and their d.b.h. (two crosswise measurements, the first one from the side of the slope), height and length of the crown were measured. The crown characteristics were described according to the following classification:

A) the type of top (ZAWADA et al. 1981; JAWORSKI et al. 1988):
   1. narrow-conical;
   2. broad-conical;
   3. paraboloidal;
   4. flattened;

B) the degree of crown deformation (JAWORSKI et a1. 1991):
   1. regular crown – up to about 10% loss;
   2. slightly deformed crown – from about 10% to about 25% loss;
   3. moderately deformed crown – from about 25% to about 50% loss;
   4. strongly deformed crown – above about 50% loss;

C) the degree of crown freedom – for the light and shaded parts separately (JAWORSKI et a1. 1991):
   1. free crown;
   2. crown confined in an area up to about 25%;
   3. crown confined in an area from about 25% to about 50%;
   4. crown confined in an area from about 50% to about 75%;
   5. crown confined in an area above about 75%;

D) defoliation – the percentage of foliage missing within the upper half of the existing crown, compared with the expected mass in that crown part if the tree were healthy, and given its social status, effects from neighbouring trees, and the site and stand factors. To evaluate the damage degree the classification of European monitoring studies was used (BORECKI, KECZYŃSKI 1992):
   0. trees without damage – foliage loss up to about 10%;
   1. slightly damaged trees – foliage loss from about l0% to about 25%;
   2. moderately damaged trees – foliage loss from about 25% to about 60%;
   3. strongly damaged trees – foliage loss above about 60%.

During the evaluation of all analysed characteristics the intermediate classes were used as required, e.g. 2/3.

In the winter of 1994–1995 two increment cores were taken at b.h. from each sample tree. One core was extracted from the side of the slope, and the other perpendicularly to the first one.

DATA ANALYSIS

Cores were first visually crossdated with reference to prominent pointer or marker years. The cores were measured to the nearest 0.01 mm, and then the mean annual increments and the 10-year current radial increment at b.h. were computed for the last measured decade from 1985 to 1994. For each sample tree the age at b.h. was determined. Beech in the Świętokrzyskie Mountains requires from 8 to 16 years (12 years on average) to reach the breast height (JAWORSKI 1995), and therefore this number of years had to be added to the age at b.h. in order to obtain the actual age of the trees.

The relationship between the crown characteristics and the current radial increment at b.h. from 1985 to 1994 was analysed by a general linear model (GLM) (NELDER, WEDDERBURN 1972; TIMM 1975). After carrying out the first part of the analysis within the general linear model – the analysis of variance, the second part of the analysis was carried out using Scheffé's test for categorical factors (multiple comparison procedure).

For beech trees with the 10-year current radial increment at b.h. between 1985 and 1994 higher than the average, the distribution of the analysed morphological characteristics was developed, and the mean relative crown lengths were computed. Only those characteristics that significantly affected the radial increment as shown by the analysis carried out earlier within a general linear model (GLM) were taken into consideration. The average increment included the mean increment ± 0.5 of standard deviation, and the radial increment higher than the average represented the values above the upper limit of the average increment interval. The level of a given characteristic including at least 50% of all trees taken into account was assumed to be the characteristic of a tree with radial increment higher than the average. If there was not such a level there, the neighbouring levels were brought together in order to assure that the total number of trees in these levels amounted to at least 50% of all trees.

RESULTS

A RELATIONSHIP BETWEEN CROWN CHARACTERISTICS AND RADIAL INCREMENT OF BEECH

Statistical analysis based on a general linear model (GLM) and taking into account the total effect of categorical factors such as: type of top, degree of crown deformation, freedom degree of the light and shaded parts of the crown, defoliation, and the quantitative factors such as relative crown length and age at b.h. has shown a statistically significant dependence between at least one of the factors and the 10-year current radial increment at b.h. from 1985 to 1994 ($F_{24.178} = 5.13$; $P < 0.001$) (Table 1).

The values of the critical significance levels computed for each factor taken into consideration proved that from all the factors the following ones significantly affected the 10-year radial increment of beech trees (Table 1):

A) the degree of the freedom of the light part of the crown ($P < 0.01$): the radial increment of the trees with the crowns confined in an area from about 20% to about 30% (higher increment) significantly differed from the radial increment of trees with the crowns confined in an area from about 50% to about 80% (lower increment). A general tendency was as follows: the more confined the light part of the crown, the lower the radial increment of beech (Fig. 1);

B) the relative length of the crown ($P < 0.001$): an increase in the relative length of the crown caused a significant increase in the radial increment of beech;

C) the age at breast height ($P < 0.001$): the radial increment significantly decreased as the age at b.h. increased.

THE CHARACTERISTICS OF BEECH TREES WITH RADIAL INCREMENT HIGHER THAN THE AVERAGE

In the description of the crown morphological characteristics of trees characterized by the radial increment above the average, only those elements were taken into consideration that may be controlled by tending cuttings,

Table 1. The analysis of the effect of the age at breast height and crown characteristics on the 10-year current radial increment at breast height of beech between 1985 and 1994, carried out using a general linear model (GLM) – the results of analysis of variance

Source of variation	Sum of squares	Degrees of freedom	Mean square	*F*-ratio
Model	8,954.4500	24	373.1020	5.13***
Residual	12,948.1000	178	72.7420	
Total (corrected)	21,902.5000	202		
Categorical factors:				
Type of top	42.1759	3	14.0586	0.19
Degree of crown deformation	244.4520	3	81.4842	1.12
Degree of freedom of the light part of the crown	1,429.3100	7	204.1880	2.81**
Degree of freedom of the shaded part of the crown	200.2920	4	50.0731	0.69
Defoliation	178.6520	5	35.7304	0.49
Quantitative factors:				
Relative crown length (%)	1,986.0900	1	1,986.0900	27.30***
Age at b.h.	1,047.8000	1	1,047.8000	14.40***
Residual	12,948.1000	178	72.7420	
Total (corrected)	21,902.5000	202		

*** $P < 0.001$, ** $P < 0.01$

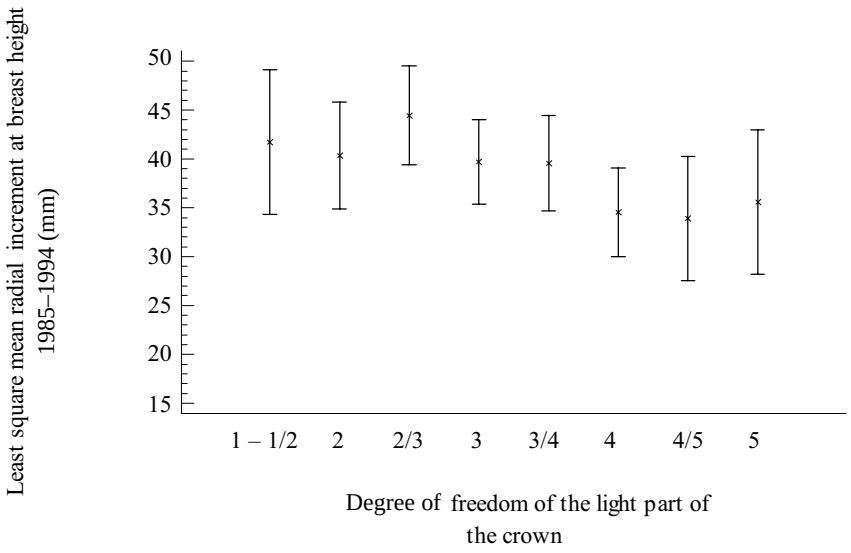

Fig. 1. The mean radial increment and Scheffé's intervals (P = 0.05, general linear model) in individual classes of the degree of freedom of the light part of the crown

significantly affecting the radial increment. These characteristics were selected with the help of a general linear model (GLM).

The beech trees with the 10-year current radial increment at b.h. between 1985 and 1994 higher than the average were characterized, depending on age, by the following morphological characteristics:

A) trees 21 to 40 years of age at b.h. – the 10-year current radial increment at b.h. between 1985 and 1994 higher than 49.04 mm:
   i) the degree of the freedom of the light part of the crown up to 3/4 (the crown confined in an area up to about 55%), these classes of the degree of the freedom of the light part of the crown included almost 71% of beech trees characterized by the radial increment higher than the average;
   ii) the mean relative length of the crown: 76%;
B) trees 41 to 60 years of age at b.h. – the 10-year current radial increment at b.h. between 1985 and 1994 higher than 43.45 mm:
   i) the degree of the freedom of the light part of the crown up to 3/4 (the crown confined in an area up to about 55%), these classes of the degree of the freedom of the light part of the crown included almost 75% of beech trees characterized by the radial increment higher than the average;
   ii) the mean relative length of the crown: 71%;
C) trees 61 to 80 years of age at b.h. – the 10-year current radial increment at b.h. between 1985 and 1994 higher than 35.70 mm:
   i) the degree of the freedom of the light part of the crown up to 3/4 (the crown confined in an area up to about 55%), these classes of the degree of the freedom of the light part of the crown included 75% of beech trees characterized by the radial increment higher than the average;
   ii) the mean relative length of the crown: 55%.

DISCUSSION

The analysis of the relationships between the selected crown characteristics and the radial increment of beech has shown a significant importance of the relative length of the crown and the degree of the freedom of the light part of the crown as factors closely correlated with the radial increment. It is easy to evaluate both these characteristics during stand tending operations, and this is why they should be among the basic criteria employed during the selection of crop trees, which is the requisite of high vitality and stability of stands with beech trees in their species composition.

The relative crown length of silver fir and Norway spruce, the species which together with beech form stands in the lower-mountain zone, also significantly correlates with the diameter increment (JAWORSKI et al. 1988; SKRZYSZEWSKI 1995). In the case of silver fir the crown longer than about 55% of the tree height assured the radial increment higher than the average while the crown length equal to about 40% of the tree height assured a normal diameter and volume increment of large timber, even in the period of a strong decrease in silver fir vitality from 1960 to 1980 (JAWORSKI 1982; JAWORSKI, PODLASKI 1989; PODLASKI 1999). The formation of long crowns, especially during late cleanings and early thinnings, should be an essential silvicultural goal in stands of the lower-mountain zone with beech, silver fir

and Norway spruce in their species composition (SKRZYSZEWSKI 1995; JAWORSKI, PALUCH 1998; PODLASKI 1999).

When analysing the relationship between various crown characteristics and the radial increment of beech, the degree of the crown freedom should be taken into account (ROLOFF 1999). The results of many studies did not show any significant correlation between the beech crown characteristics and its increment, which was most probably connected with the omission of the effect of the degree of the crown freedom (ROLOFF 1986; WAHLMANN et al. 1986; PERPET 1988; ATHARI, KRAMER 1989; INNES 1998).

This study showed a weak, insignificant correlation between the degree of foliage loss and the radial increment of beech in the Świętokrzyski National Park. Crown density assessments are subjective and have a low degree of precision (STRAND 1994; LECH 1995; SOLBERG 1999). However, in stands growing under the pressure of various strong factors causing stress, defoliation is the basic characteristic describing the crown condition (SCHÖPFER 1985; INNES, BOSWELL 1988, 1989; LANDMANN, BOUHOT-DELDUC 1995). The lack of a significant correlation between the degree of foliage loss and the radial increment of beech in the Świętokrzyski National Park could be caused by the relatively small defoliation of beech trees growing in the investigated stands (PODLASKI 1999).

The results suggest the possibility of thinnings taking into account the group distribution of beech trees. The beech trees growing in small groups close to one another, and having even very asymmetrical crowns but onesidedly free in their light part, do not slow down their diameter growth and are characterized by trunk higher quality in comparison with trees distributed more or less uniformly (KATÓ, MÜLDER 1992, 1998; ZAJĄCZKOWSKI 1994). It should be remembered, however, that it is necessary to assure a free fragment of the light part of the crown (at least 45%). Thinning should result in the formation of small groups of beech trees (2–4 trees) with asymmetrical but free crowns, growing at a certain distance from one another so the free development of crowns is possible in an area between groups.

The improved gradual nest cutting and partial cutting methods assure the proper conditions for beech development. Of special importance is the modification of the partial cutting method with partial cuttings in groups. It results in a smaller and spread silvicultural risk through formation of a stand with differentiated structure (large groups with a gentle transition from the middle to the edge of regeneration) (KORPEĽ 1991).

CONCLUSIONS

1. The radial increment at b.h. of beech significantly increased as the degree of the freedom of the light part of the crown and the relative crown length increased.
2. The majority of best growing beech trees was characterized by the light part of the crown confined up to 55% in an area, and the relative crown length from 55% (for trees 61–80 years of age at b.h.) to 76% (for trees 21–40 years of age at b.h.).
3. The relative length of the crown, a characteristic easy to determine during tending operations, is of great importance for selection of crop trees.
4. The beech trees dynamically growing in the Świętokrzyski National Park require a proper tending. The cuttings should result in the development of a long crown, free in its upper part. The trees growing in dense pure beech stands require a special tending.

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References

ATHARI S., KRAMER H., 1989. Problematik der Zuwachsuntersuchungen in Buchenbeständen mit neuartigen Schadsymptomen. Allg. Forst- Jagdztg, *160*: 1–8.

BORECKI T., KECZYŃSKI A., 1992. Atlas ubytku aparatu asymilacyjnego drzew leśnych. Warszawa, Agencja ATUT: 48.

CIOŁKOSZ A., 1991. SINUS – System informacji o środowisku przyrodniczym. In: MAZUR. S. (ed.), Ekologiczne podstawy gospodarowania środowiskiem przyrodniczym. Wizje – problemy – trudności. Warszawa, Wyd. SGGW-AR: 317–328.

INNES J.L., 1998. An assessment of the use of crown structure for the determination of the health of beech (*Fagus sylvatica*). Forestry, *71*: 113–130.

INNES J.L., BOSWELL R.C., 1988. Forest health surveys 1987. Part 2: Analysis and interpretation. Forestry Commission Bulletin 79. London, HMSO: 52.

INNES J.L., BOSWELL R.C., 1989. Monitoring of forest condition in the United Kingdom 1988. Forestry Commission Bulletin 88. London, HMSO: 54.

JAWORSKI A., 1982. Fir regression in Polish mountain areas. Eur. J. For. Path., *12*: 143–149.

JAWORSKI A., 1995. Charakterystyka hodowlana drzew leśnych. Kraków, Gutenberg: 237.

JAWORSKI A., 1997. Karpackie lasy o charakterze pierwotnym i ich znaczenie w kształtowaniu proekologicznego modelu gospodarki leśnej w górach. Sylwan, *141*: 33–49.

JAWORSKI A., PALUCH J., 1998. Wpływ czyszczeń późnych na kształtowanie się cech biomorfologicznych i budowy piętrowej podrostu jodły (na przykładzie powierzchni doświadczalnej w Brzozowie-Jahonce). Acta Agr. Silv. Ser. silv., *36*: 15–30.

JAWORSKI A., PODLASKI R., 1989. Wpływ cech biomorfologicznych korony na kształtowanie się przyrostu szerokości słoi, wysokości i miąższości grubizny jodeł. Acta Agr. Silv. Ser. silv., *28*: 17–32.

JAWORSKI A., PODLASKI R., SAJKIEWICZ P., 1988. Kształtowanie się zależności między żywotnością i cechami

biomorfologicznymi korony a szerokością słojów rocznych u jodeł. Acta Agr. Silv. Ser. silv., *27*: 63–84.

JAWORSKI A., PODLASKI R., WAGA T., 1999. Budowa i struktura drzewostanów o charakterze pierwotnym w rezerwacie Święty Krzyż (Świętokrzyski Park Narodowy). Acta Agr. Silv. Ser. silv., *37*: 27–51.

JAWORSKI A., SKRZYSZEWSKI J., KARCZMARSKI J., 1991. Wpływ różnej intensywności trzebieży selekcyjnej na kształtowanie się cech biomorfologicznych i przyrostu jodły i świerka (na przykładzie powierzchni trzebieżowych w LZD w Krynicy). Zesz. Nauk. AR. Kraków., Leśn., *20*: 203–238.

KATÓ F., MÜLDER D., 1992. Qualitative Gruppendurchforstung der Buche. Wertentwicklung nach 25 Jahren. Allg. Forst- Jagdztg, *163*: 197–203.

KATÓ F., MÜLDER D., 1998. Qualitative Gruppendurchforstung der Buche. Wertentwicklung nach 30 Jahren. Forst u. Holz, *53*: 131–132, 134–136.

KORPEĽ Š., 1991. Pestovanie lesa. Bratislava, Príroda: 465.

KOWALKOWSKI A., 1991. Analiza niektórych właściwości gleb Świętokrzyskiego Parku Narodowego. [Maszynopis.] Kielce, Zakład Geografii Gleb i Ochrony Przyrody WSP: 98.

LANDMANN G., BOUHOT-DELDUC L., 1995. Ground monitoring of crown condition of forest trees in the French Mountains. In: LANDMANN G., BONNEAU M. (eds.), Forest decline and atmospheric deposition effects in the French Mountains. Berlin, Springer: 3–40.

LECH P., 1995. Przydatność szacunkowej metody określania defoliacji drzew do badań stanu zdrowotnego lasu. Sylwan, *139*: 99–109.

MATUSZKIEWICZ W., MATUSZKIEWICZ J.M., 1996. Przegląd fitosocjologiczny zbiorowisk leśnych Polski. Phytocenosis, 8, Seminarium Geobotanicum 3: 79.

NELDER J.A., WEDDERBURN R.W.M., 1972. Generalized linear models. J. R. Stat. Soc. A, *135*: 370–384.

PERPET M., 1988. Zur Differentialdiagnose bei der Waldschadenserhebung auf Buchenbeobachtungsflächen. Allg. Forst- Jagdztg, *159*: 108–113.

PODLASKI R., 1999. Kształtowanie się zależności pomiędzy żywotnością, cechami morfologicznymi korony, a przyrostem promienia pierśnicy jodły, buka i sosny w wybranych drzewostanach Świętokrzyskiego Parku Narodowego. [Maszynopis.] Kraków, Katedra Szczegółowej Hodowli Lasu, AR: 133.

ROLOFF A., 1986. Morphologie der Kronenentwicklung von *Fagus sylvatica* L. (Rotbuche) unter besonderer Berücksichtigung möglicherweise neuartiger Veränderungen. Göttingen, Ber. Forschungszentr. Waldökosysteme: 177.

ROLOFF A., 1999. Tree vigour and branching pattern. J. For. Sci., *45*: 206–216.

SCHÖPFER W., 1985. Das Schulungs- und Kontrollsystem der terrestrischen Waldschadensinventuren. AFZ Wald., *40*: 1353–1357.

SKRZYSZEWSKI J., 1995. Charakterystyka przyrostowa oraz kształtowanie się zależności pomiędzy wybranymi cechami drzew a przyrostem promienia na pierśnicy świerka i modrzewia. Acta Agr. Silv. Ser. silv., *33*: 141–158.

SOLBERG S., 1999. Crown density changes of Norway spruce and the influence from increased age on permanent monitoring plots in Norway during 1988–1997. Eur. J. For. Path., *29*: 219–230.

SPIECKER H., MIELIKÄINEN K., KÖHL M., SKOVSGAARD J.P., 1996a. Conclusions and summary. In: SPIECKER H., MIELIKÄINEN K., KÖHL M., SKOVSGAARD J.P. (eds.), Growth trends in European forests. Berlin, Springer: 369–372.

SPIECKER H., MIELIKÄINEN K., KÖHL M., SKOVSGAARD J.P., 1996b. Discussion. In: SPIECKER H., MIELIKÄINEN K., KÖHL M., SKOVSGAARD J.P. (eds.), Growth trends in European forests. Berlin, Springer: 355–367.

STRAND G.H., 1994. The geography of changing crown vigour in Norwegian Conifer Forests. Ambio, *24*: 280–285.

TIMM N.H., 1975. Multivariate analysis with applications in education and psychology. Monterey, Brooks/Cole: 689.

WAHLMANN B., BRAUN E., LEWARK S., 1986. Radial increment in different tree heights in beech stands affected by air pollution. IAWA Bull., *7*: 285–288.

ZAJĄCZKOWSKI J., 1994. Biogrupy drzew w drzewostanach – możliwości i celowość ich wykorzystania przy prowadzeniu trzebieży. Pr. IBL, *778*: 5–38.

ZAWADA J., TWARÓG J., WIDERA S., 1981. Badania przyczyn i hodowlanych następstw regresji jodły w górach. Kraków, Sprawozdanie Naukowe IBL, Zakład Gospodarki Leśnej Regionów Górskich IBL: 36.

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Závislost mezi vlastnostmi koruny a radiálním přírůstem u buku (*Fagus sylvatica* L.) v Národním parku Świętokrzyski v Polsku

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ABSTRAKT: Cílem této studie bylo stanovení závislosti mezi vlastnostmi koruny a radiálním přírůstem u buku (*Fagus sylvatica* L.) a podrobnější charakteristika stromů buku s nadprůměrným radiálním přírůstem v Národním parku Świętokrzyski. Zjistili jsme tyto závislosti: radiální přírůst buku se zvyšuje s vyšším stupněm volnosti osvětlené části koruny, přičemž

nárůst relativní délky koruny vede k významnému zvýšení radiálního přírůstu. Většinu nejlépe rostoucích buků charakterizuje osvětlená část koruny vymezená na ploše do 55 % a relativní délka koruny v rozpětí 55 % (stromy ve věku 61–80 let při dosažené výčetní výšce) až 76 % (stromy ve věku 21–40 let při dosažené výčetní výšce).

Klíčová slova: *Fagus sylvatica*; typ koruny; deformace koruny; volnost koruny; odlistění; relativní délka koruny; radiální přírůst; probírka; Národní park Świętokrzyski

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