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ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2008
Volume 11
Issue 2
Topic
FORESTRY

JELONEK T. , PAZDROWSKI W., TOMCZAK A., SZABAN J. 2008. THE EFFECT OF SOCIAL POSITION OF A TREE IN THE STAND AND SITE ON WOOD QUALITY OF SCOTS PINE *(Pinus sylvestris* L.), EJPAU, 11(2), #10.
Available Online http://www.ejpau.media.pl/volume11/issue2/art-10.pdf

THE EFFECT OF SOCIAL POSITION OF A TREE IN THE STAND AND SITE ON WOOD QUALITY OF SCOTS PINE (*Pinus sylvestris* L.)

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ABSTRACT

The study was an attempt to determine technical quality of pine wood coming from mature stands growing in fresh coniferous forests (Bśw) and fresh mixed coniferous forests (BMśw). This assessment was based on the share of conventional knotless elements in the total number of conventional elements in 5-meter butt logs [2].
Analyses indicate a significant effect of growth and development conditions (the site) as well as the social position of the tree in the stand on wood quality manifested in the share of knotless wood.

Key words: Scots pine, social position, technical quality of timber, knot incidence, fresh coniferous forest, fresh mixed coniferous forest

INTRODUCTION

Heterogeneity of wood structure together with natural flaws (defects) of the stem determines the quality and value of timber, and thus its possible applications or utilization [20].

Wood structure resulting from the stadial growth of entire stands as well as individual trees is characterized by the incidence of knots in tree stems, from the point of view of physiology being natural elements of wood structure, remnants of dead occluded branches.

Branches play a very important role in the life of a tree. They incorporate the entire assimilation apparatus, used – among other things – for respiration and CO_2 assimilation.

Not all branches remain on the stem over the entire life of a tree. Crown expansion results in a situation when lower branches are increasingly more shaded, as a result of which the process of assimilation is gradually inhibited. Finally shading becomes so strong that branches are not supplied any assimilates, thus they cease to grow and begin to die. Thus, dying back of branches is the first stage in the process of self-pruning [8].

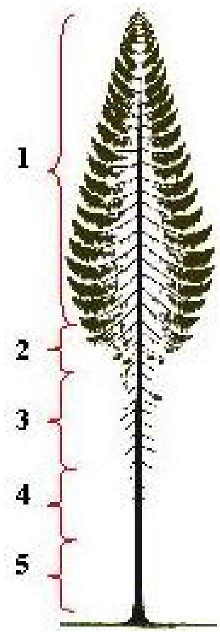
The rate and course of this process is connected, among other things, with individual variation of trees. The following zones may be distinguished on tree stems in closed properly tended stands (Fig. 1):

1 – crown zone,
2 – zone of dying branches,
3 – zone of broken branches and occlusion of their bases,
4 – healing zone over occlusions,
5 – zone of deep knots.

For the user the most valuable part of a healthy tree, from which timber of superior quality may be obtained, is the fifth zone. However, it usually constitutes a small part of the stem [6].

From the point of view of wood industry, the most advantageous wood type would be wood from cylinder-shaped stems, with a uniform annual ring distribution and texture parallel to the longitudinal axis and at the same time knotless [11]. It is only an abstract model of wood with no defects, making it possible to define the concept of defects.

Fig. 1. Zones of self-pruning, quoted after Giefing 1999



The effect of defects on use value of wood and their practical importance is clearly manifested in the fact that the type of defects, their location and rate of incidence constitute the basis for wood quality classification and determine its potential applications [12]. Commonly used methods to determine technical quality of timber, based on an analysis of its macrostructure (i.e. sapwood width, annual ring width, the share of late wood) as well as physical and mechanical properties of wood, are not comprehensive enough to reflect the entire complexity of wood quality.

Wood quality in case of coniferous trees depends on several factors, among which an essential role is played by the number, size and location of knots [8,13,10,18,20]. Knots are one of the main defects from the point of view of wood industry and to a considerable degree determine, already at the stage of quality control estimates, the quality classification of all wood assortments. The fact that they are natural elements of wood structure and are found in all tree species only emphasizes their importance and scale of incidence [11,18].

Knots have a significant effect on the deterioration of individual technical and strength properties, wood material service life as well as workability and processability. Wood with knots is more difficult to process, which results in faster wear of wood-working machine parts and manufactured products usually being of less value than those produced from knotless wood [8].

Among trees there is a natural individual variation in terms of branching. It is advisable to introduce ecotypes adapted to sites, characterized by good self-pruning and producing good quality wood [18]. Dziewanowski [4] – using the conventional element method – showed the variation in terms of knottiness of saw timber, caused by the age of the tree, social position in the stand, stand quality, site type of forest and the location of wood in relation to the cardinal points of the compass in the growing tree, as well as the effect of the shape of cross stem section on its quality.

Within the chain of individual branches of wood industry sawmill industry is the one which processes the biggest amounts of wood. At the same time a constant increase is observed in prices of best quality wood [3]. As a consequence this should lead to an improvement of quality of produced timber thanks to appropriate evaluation and selection, aiming at the production of timber of superior quality and pre-determined utilization.

The aim of the study was to determine technical quality of wood coming from mature pine stands in view of the social class of tree position in the stand as well as site quality.

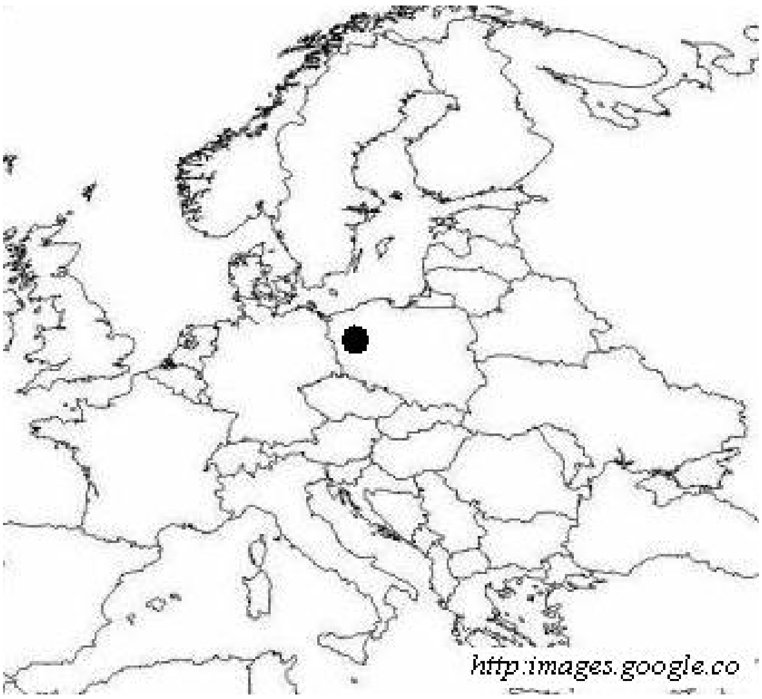
MATERIAL AND METHODS

In the study the analyzed wood came from Scots pines *(Pinus sylvestris L.)* growing under site conditions typical of fresh coniferous forest (Bśw) and fresh mixed coniferous forest (BMśw) in the Miastko Forest District, the Regional Directorate of State Forests in Szczecinek (Table 1, Fig. 2).

Table 1. Age and diameter at breast height of model trees

Site type of forest	Kraft's class	Age [years]	diameter at breast height 1.3 [cm]
Fresh coniferous forest	I	102	42
	II	100	36
	III	99	30
Fresh mixed coniferous forest	I	96	48
	II	90	40
	III	90	36

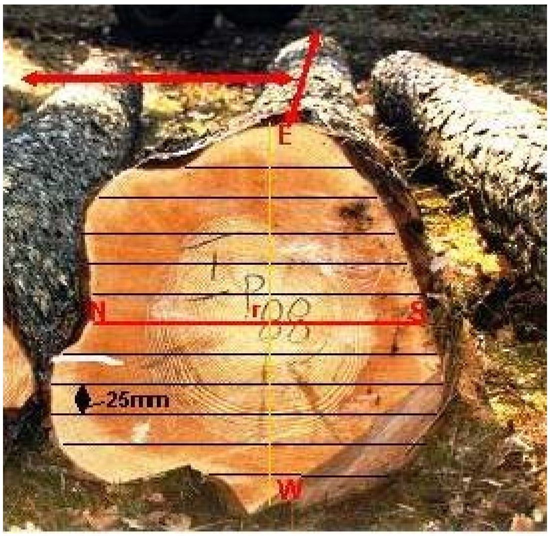
Fig. 2. Location of the Miastko Forest District



Studies were conducted in two mature pine stands, where in the established 0.5 ha mean sample plots, representative for each stand, diameter at breast height and heights were measured in all trees in proportion to their number in the adopted (2 cm) diameter subclasses.

Based on the recorded diameter and height characteristics of trees a total of 6 model trees (3 for each mean sample plot) were selected using the Urich II method [7]. At the same time model trees were selected so as to represent the fist three biological classes according to Kraft's classification.

Fig. 3. Sawing design of 5-meter butt ends



Model trees were felled, after which 5-meter butt logs were cut, marked on butt ends and sawn into unedged timber with a thickness of 25 mm parallel to the north-south direction (Fig. 3). Produced timber was numbered according to the east-west direction, which made it possible to identify the log from which it was produced. Next it was classified using the conventional element method [2].

Sections of 50x1000 mm and 25x500 mm were adopted as conventional elements.

The share of knotless elements was measured using two measures. The first one of 1 m length was divided into 10 sections, with a height of 50 mm each, while the other with a length of 0.5 m was divided into 20 sections with a height of 25 mm each.

Based on the measurements the share of knotless wood was determined and as a consequence – in logs coming from mean sample trees.

In order to estimate crown volume, assumed to be the volume of a cylinder [15], prior to the felling of mean sample trees their width was measured on the basis of their crown projection area. After model trees were cut down, the length of live crown, assumed to be the distance between the first living branch and crown top, was measured.

RESULTS

Empirical material collected during laboratory testing was used for further analyses. First technical quality of wood was analyzed on the basis of the share of knotless wood in successive 1-meter sections of 5–meter butt logs.

Wood quality, expressed by the ratio of the number of knotless elements to the total number of elements, varied between individual trees (Table 1, Fig. 4).
Knotlessness of wood in butt logs of analyzed pines ranged from 32.5% to 58.4% and was on average slightly higher in logs of pines growing in a more fertile site type of forest (fresh mixed coniferous forest – 50.9%) in comparison to the poorer site (fresh coniferous forest – 47.8%) (Table 2, Fig. 4).

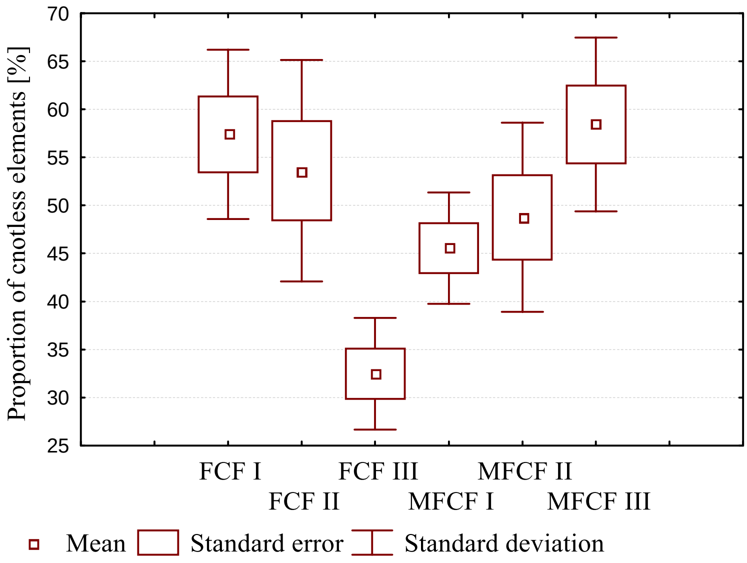
Both standard deviations and coefficients of variation of analyzed characteristics were higher in case of logs coming from the site type of fresh coniferous forest (Table 2, Fig. 4). This would indicate a less homogenous wood structure in terms of knottiness in trees growing in that site in comparison to those from fresh mixed coniferous forest.

When investigating the social class of tree position in the stand, the best technical quality of the analyzed part of the stem was found for a codominant tree growing in the fresh mixed forest, where knotlessness was 58.4%. In turn, the lowest quality was found in case of a codominant pine in the stand growing in the fresh coniferous forest, where knotlessness was as low as 32.5%.

Table 2. Wood quality (expressed by the ratio of the number of knotless elements to the total number of elements in suc cessive 1-meter sections) of butt logs coming from Scots pines growing under site conditions of fresh coniferous forest and fresh mixed coniferous forest types

Statistical characteristic	Share of knotless elements [%]					
	Fresh coniferous forest			Fresh mixed coniferous forest		
	Kraft class			Kraft class		
	I	II	III	I	II	III
mean	57.4	53.6	32.5	45.6	48.8	58.4
Standard deviation	8.8	11.5	5.8	5.8	9.8	9.1
Coefficient of variation [%]	15.4	21.5	17.9	12.7	20.2	15.5
mean	47.8			50.9		
Standard deviation	14.1			9.6		
Coefficient of variation [%]	29.5			18.9		

Fig. 4. Share of conventional elements with a length of 1m in butt logs of mature pines growing under site conditions of fresh coniferous forest and fresh mixed coniferous forest



Fresh coniferous forest I – share of conventional elements in the log coming from a tree of Kraft class I growing in fresh coniferous forest
Fresh coniferous forest II – share of conventional elements in the log coming from a tree of Kraft class II growing in fresh coniferous forest
Fresh coniferous forest III – share of conventional elements in the log coming from a tree of Kraft class III growing in fresh coniferous forest
Fresh mixed coniferous forest I – share of conventional elements in the log coming from a tree of Kraft class I growing in fresh mixed coniferous forest
Fresh mixed coniferous forest II – share of conventional elements in the log coming from a tree of Kraft class II growing in fresh mixed coniferous forest
Fresh mixed coniferous forest III – share of conventional elements in the log coming from a tree of Kraft class III growing in fresh mixed coniferous forest

Table 3. Results of LSD test for the share of knotless conventional elements in butt logs of mature pines established on the basis of 1 m sections

STL	Kraft class	Fresh coniferous forest			Fresh mixed coniferous forest		
		I	II	III	I	II	III
Fresh coniferous forest	I		0.336756	**0.000181**	0.107679	0.308686	0.399760
	II	0.336756		**0.000007**	**0.011841**	0.050887	0.904568
	II	**0.000181**	**0.000007**		**0.020602**	**0.004153**	**0.000010**
Fresh mixed coniferous forest	I	0.107679	**0.011841**	**0.020602**		0.545594	**0.016099**
	II	0.308686	0.050887	**0.004153**	0.545594		0.066004
	III	0.399760	0.904568	**0.000010**	**0.016099**	0.066004	

Results are significant at $p \leq 0.05$

On the basis of results of analysis of variance and the LSD test (Tukey test) statistically significant differences were found in the share of knotless elements (of 1m length) in 5-meter butt logs of pines from different social classes of tree position in the stand, growing in the site type of fresh coniferous forest and fresh mixed coniferous forest (Table 3). Statistically significant differences in the share of knotless conventional elements were found between Kraft classes I and II, and Kraft class III in fresh coniferous forest and between Kraft classes I and III in fresh mixed coniferous forest. Moreover, differences were found between Kraft class II in fresh coniferous forest and Kraft class I in fresh mixed coniferous forest, as well as Kraft class III in fresh coniferous forest and all the analyzed biological classes in fresh mixed coniferous forest.

The statistically significantly lowest knotlessness was found for a tree from class III according to the Kraft classification growing under the conditions typical of fresh coniferous forest site type (Table 3, Fig. 4).

Fig. 5. Share of knotless elements in butt logs of pines in terms of social classes of tree position in the stand depending on location in the log - Fresh coniferous forest

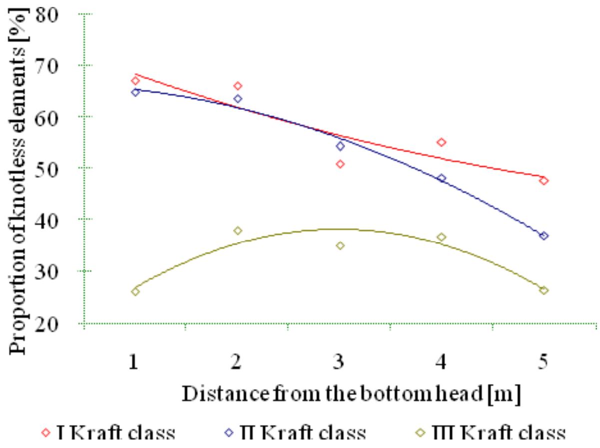
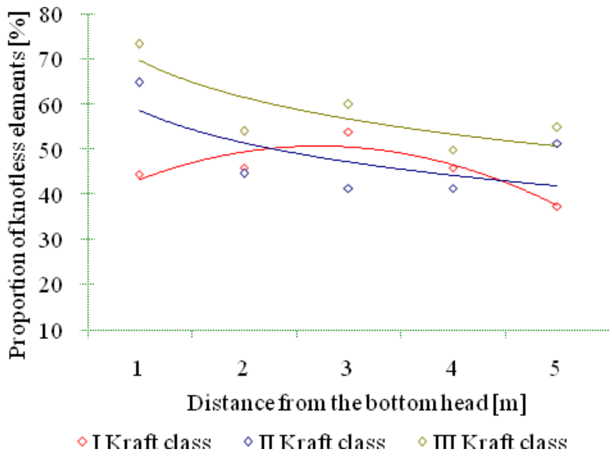


Fig. 6. Share of knotless elements in butt logs of pines in terms of social classes of tree position in the stand depending on location in the log - Fresh mixed coniferous forest



Moreover, technical quality of wood along the longitudinal axis was analyzed in logs coming from model trees (Figs. 5, 6).

For each of the 1-meter blocks of individual logs the percentage of knotless elements was calculated in relation to the total number of elements in this block.

In most analyzed cases knotlessness of wood decreased with an increase in the measurement on the stem, reaching its minimum in the top part of the log.

An atypical trend in knotlessness was only observed in a codominant pine growing in fresh coniferous forest and a predominant pine growing in fresh mixed coniferous forest. In both cases knotlessness increased up to the height of approx. 3 m, and then decreased.
This fact may be explained by the rate of self-pruning.

It may be assumed that these trees as saplings could have been growing at a changing position (with a different closure), being the effect of performed tending interventions. Since light deficit (determining the branch dying rate) in the lower part of the crown in this light demanding species occurs early and is manifested markedly in trees in case of dense canopy it should be assumed that each tending intervention may to a certain degree disturb the rate of self-pruning and determine timber quality. At the same time it needs to be remembered that such a course of self-pruning may also be affected by individual variation.

In order to increase the accuracy of determination of the share of knotless wood and knothy wood at the next stage of measurements 0.5-meter sections were used. The application of such half-meter sections provides improved accuracy and accounts for interverticil zones, thus the generated knotlessness indexes were higher in comparison to the values obtained during the analysis of 1-meter sections.

Table 4. Wood quality (expressed by the ratio of the number of knotless elements to the total number of elements in successive 0.5-meter sections) of butt logs coming from Scots pines growing in site types of fresh coniferous forest and fresh mixed coniferous forest

Statistical characteristic	Share of knotless elements [%]					
	Fresh coniferous forest			Fresh mixed coniferous forest		
	Kraft class			Kraft class		
	I	II	III	I	II	III
mean	78.9	81.9	66.7	74.0	75.8	81.5
Standard deviation	6.1	5.8	7.4	5.9	8.9	6.3
Coefficient of variation [%]	7.7	7.1	11.1	7.9	11.7	7.8
mean	75.8			77.1		
Standard deviation	9.1			7.6		
Coefficient of variation [%]	12.0			9.9		

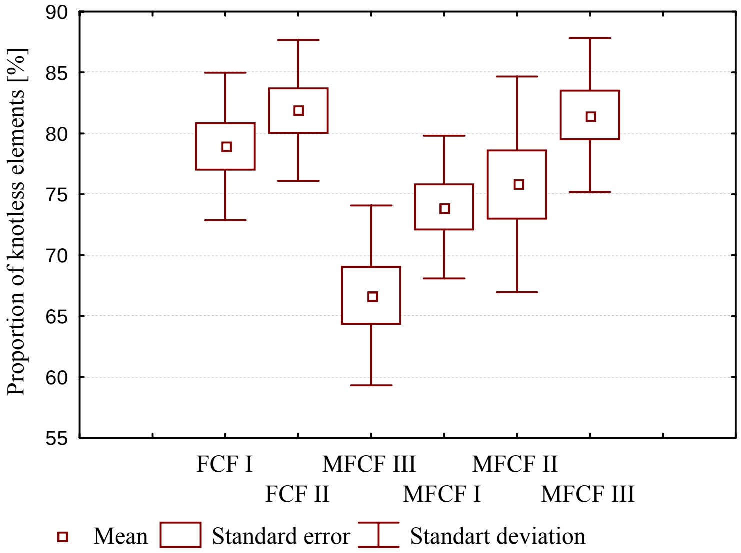
Wood knotlessness in butt logs of analyzed pines ranged from 66.7% to 81.9% and was on average slightly higher in logs of pines growing in the more fertile site (fresh mixed coniferous forest – 77.1%) in comparison to the poorer site (fresh coniferous forest – 75.8%) (Table 4, Fig. 7).

The codominant tree (representing class II according to Kraft's classification) growing in fresh coniferous forest had (in view of the social class of tree position in the stand) the highest (81.9%) technical quality of wood, determined on the basis of the share of knotless elements. The lowest technical quality was found for the codominant tree also growing in the fresh coniferous forest (Table 4, Fig. 7).
Variation in wood knotlessness of analyzed model trees ranged from 7.1% for a dominant tree representing Kraft class II in fresh coniferous forest to 11.7% for a dominant tree growing in fresh mixed coniferous forest. Generally, more homogenous wood in terms of the share of knotless wood was recorded for pines growing in the more fertile site, where the coefficient of variation for the analyzed characteristic in case of the adopted 0.5-meter sections was 9.9%, being by 2.1% lower than in case of butt logs coming from pines growing in fresh coniferous forest (Table 4).

The lowest variation in the share of knotless wood was observed in trees with a better technical quality of butt logs (with better self-pruning).

These included a representative of the dominant tree (Kraft class II) growing in fresh coniferous forest and a co-dominant tree growing in fresh mixed coniferous forest (Table 4)

Fig. 7 Share of knotless elements of 0.5 m length in butt logs of mature pines growing in site type of fresh coniferous forest and fresh mixed coniferous forest



Fresh coniferous forest I – share of conventional elements in the log coming from a Kraft class I growing in fresh coniferous forest
Fresh coniferous forest II – share of conventional elements in the log coming from a Kraft class II growing in fresh coniferous forest
Fresh coniferous forest III – share of conventional elements in the log coming from a Kraft class III growing in fresh coniferous forest
Fresh mixed coniferous forest I – share of conventional elements in the log coming from a Kraft class I growing in fresh mixed coniferous forest
Fresh mixed coniferous forest II – share of conventional elements in the log coming from a Kraft class II growing in fresh mixed coniferous forest
Fresh mixed coniferous forest III – share of conventional elements in the log coming from a Kraft class III growing in fresh mixed coniferous forest

Based on the results of analysis of variance and the LSD test (Tukey's test) statistically significant differences were found in the share of knotless elements in 5-meter butt logs of pines from different social classes of tree position in stands growing in sites of fresh coniferous forest and fresh mixed coniferous forest (Table 5).

Thus, in fresh coniferous forest statistically significantly higher knotlessness was found for the predominant tree than the codominant and dominant trees in relation to the codominant, while in fresh mixed forest statistically higher knotlessness was recorded for the codominant rather than the predominant tree.
A tree of Kraft class III growing in fresh coniferous forest exhibited statistically significantly lowest knotlessness among the analyzed logs.

It needs to be pointed out that there were no statistically significant differences between trees occupying identical positions in the forest community, but growing under different site conditions, apart from trees from class III according to Kraft's classification.

Table 5. Results of the LSD test for the share of conventional knotless elements in pine butt end logs established on the basis of 0.5m sections

STL	Kraft class	Fresh coniferous forest			Fresh mixed coniferous forest		
		I	II	III	I	II	III
Fresh coniferous forest	I		0.336756	**0.000181**	0.107679	0.308686	0.399760
	II	0.336756		**0.000007**	**0.011841**	0.050887	0.904568
	II	**0.000181**	**0.000007**		**0.020602**	**0.004153**	**0.000010**
Fresh mixed coniferous forest	I	0.107679	**0.011841**	**0.020602**		0.545594	**0.016099**
	II	0.308686	0.050887	**0.004153**	0.545594		0.066004
	III	0.399760	0.904568	**0.000010**	**0.016099**	0.066004	

Results are significant at $p \leq 0.05$

Technical quality of timber was analyzed along the longitudinal axis of analyzed logs coming from model trees (Figs. 8, 9).

For each 0.5-meter block of individual logs the percentage of knotless elements was calculated in relation to the total number of elements in this block.

Generally it may be assumed that in all analyzed logs coming from model trees the share of knotless elements was highest in the butt end part and decreased gradually with height.

Fig. 8. The share of knotless elements in pine butt end logs in terms of social classes of tree position in the stand depending on the position in the log - Fresh coniferous forest

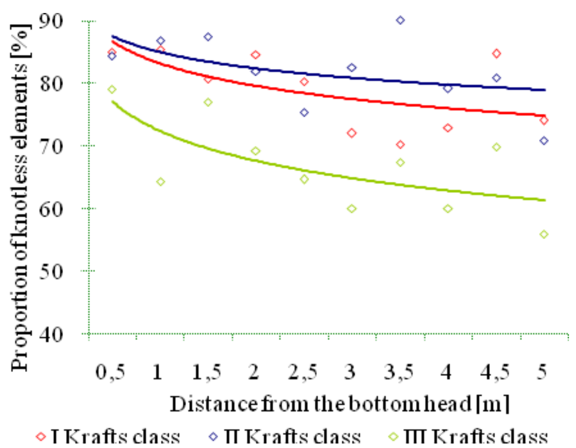
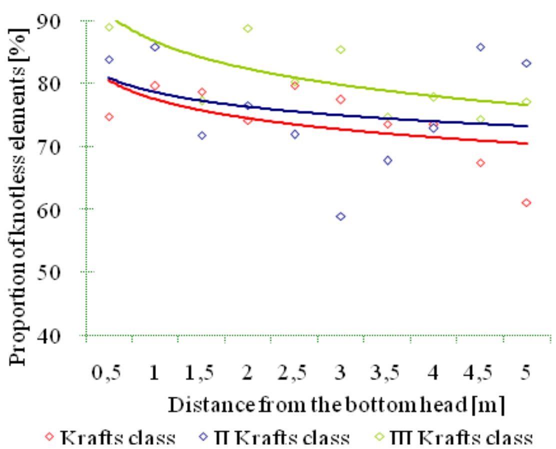


Fig. 9. The share of knotless elements in pine butt end logs in terms of social classes of tree position in the stand depending on the position in the log - Fresh mixed coniferous forest



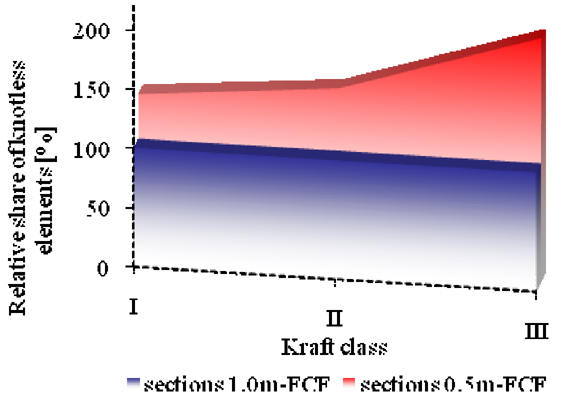
Differences between the proportions of conventional elements in the same butt end logs, determined based on the analysis of knotlessness in 1- and 0.5-meter sections, are presented in Figs. 10–12.

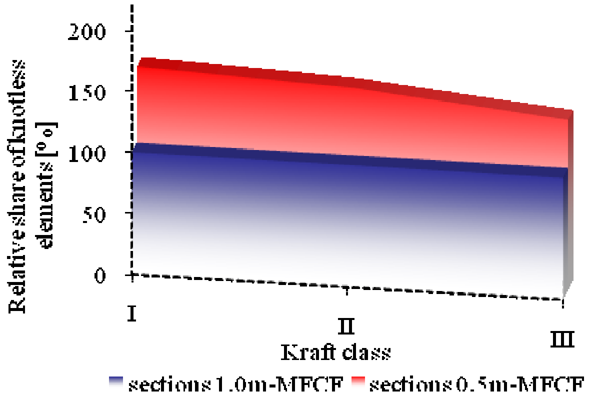
Figs. 10 and 11 present a comparison, in which the knotlessness index in butt end logs, resulting from the application of standard (i.e. 1-meter) sections, was adopted as the reference point (100%) for the knotlessness obtained as a result of the distribution of this trait in model logs in 0.5-meter sections.

Both in the richer and poorer sites this index was much higher for the adopted 0.5-meter sections, with this difference that in the fresh coniferous forest knotlessness increased with a deterioration of the social position of a tree in the stand, while in the poorer site knotlessness decreased with a deterioration of this position.

The presented trend resulting from the application of different sections (1.0 and 0.5 m) to determine knotlessness may suggest that the use of shorter sections (0.5 m) yields a more comprehensive picture of timber quality, as it takes into account the wood zone located between whorls.

Fig. 10. The share of knotless elements in butt end logs of mature pines growing in the fresh coniferous forest site in view of social classes of tree position in the stand	**Fig. 11. The share of knotless elements in butt end logs of mature pines growing in the fresh mixed coniferous forest site in view of social classes of tree position in the stand**

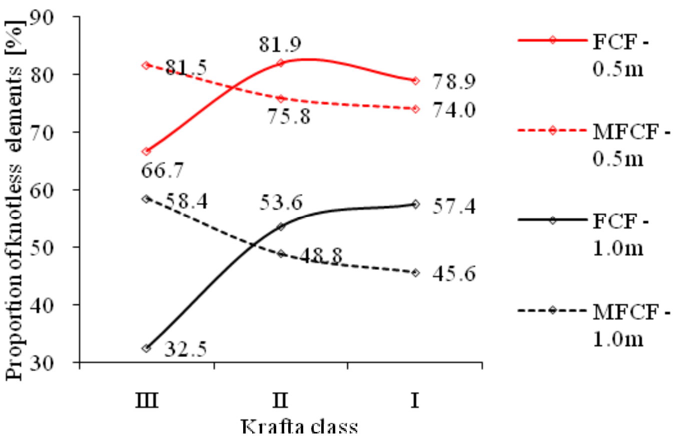




The following figure (Fig. 13) presents mean knotlessness in logs of compared trees, determined on the basis of adopted 1- and 0.5-meter sections, in terms of site conditions and social position of a tree in the stand.

Results obtained for the stand growing in the fresh coniferous forest clearly show a reduction of technical quality of timber with the transition of trees to lower layers in the stand.

Fig. 12. The share of knotless elements in logs of model trees analyzed using 1- and 0.5-meter sections in view of different growth and development conditions of trees



A different situation was observed in the stand growing in the richer site (i.e. fresh mixed coniferous forest). In this site the proportion of mean knotlessness in butt end logs increased with the deterioration of growth conditions of a tree, defined on the basis of its social class in the stand.

This situation may be explained by the richness of the site and growth dynamics of pines. It should be assumed that in this light-demanding tree species predominant trees, growing in the rich site, produce wide crowns with thick branches, thus more difficult to self-prune.

In this case the deterioration of the social position of trees is most probably connected with limited access to light in case of lower and central sections of the crown and as a consequence the tree forming thinner branches, which die faster.

In an attempt to confirm the effect of crown size in the analyzed trees on technical quality of timber coming from butt end logs an analysis was performed concerning the dependence of knotlessness on selected measured elements of the crown (Figs. 13–15).

Knotlessness defined on the basis of the share of conventional elements (in 0.5 m sections) was analyzed in terms of its dependence on the volume, width and length of the crown in model trees.

All analyzed dependencies were curvilinear in character and were described by regression curves and coefficients of determination R^2 (Figs. 13–15).

Fig. 13. A dependence of knotlessness on crown volume

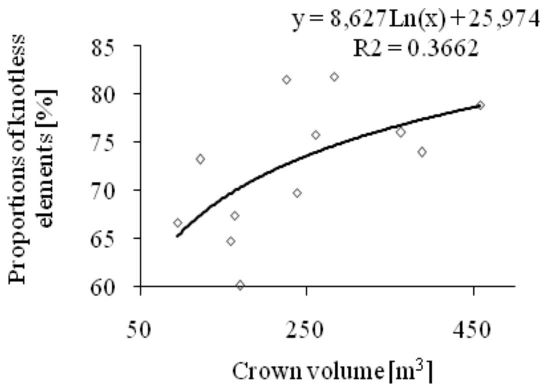


Fig. 14. A dependence of knotlessness on crown width

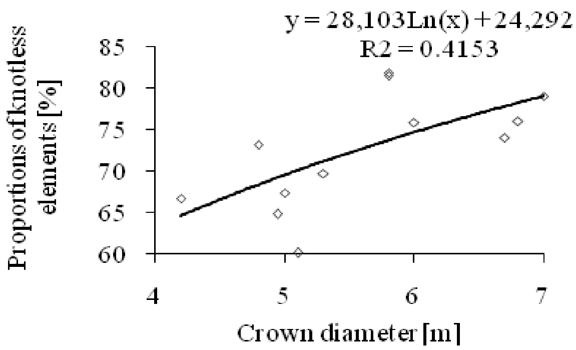
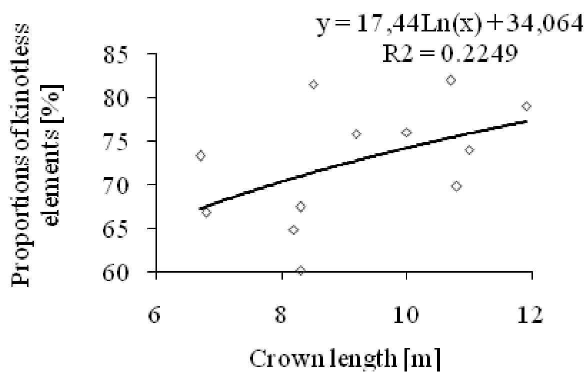


Fig. 15. A dependence of knotlessness on crown length



In the investigated case knotlessness depended in approx. 42% on crown width, in approx. 37% on crown volume and in only 22% on crown length.

Results indicate that a relationship exists between technical quality of timber defined by knotlessness on crown width. This emphasizes the effect of both the initial planting spacing and the position of trees in the later period on the modification of technical quality of Scots pine wood.

DISCUSSION

The natural life cycle of trees, the effect of the environment and hereditary traits and quality attributes of wood are strictly connected and in great measure depend on the site [5,14]. It needs to be mentioned here that the aim of this study was to investigate the problem and develop methodology. The study compared knotlessness defined using the standard method based on the analysis of logs in 1-meter sections as well as the analysis in 0.5-meter sections.

On the basis of the comparison it may be assumed that the method based on the analysis with the application of 0.5-meter sections yields more accurate and reliable results.

Literature describes extensively the effect of growth conditions on the rate and degree of self-pruning [4,8,17]. In spite of the fact that a natural individual variation exists among trees in terms of the rate of self-pruning, it needs to be assumed that a significant effect on the course and rate of this process is affected by several external factors creating growth and development conditions both for individual trees and entire stands. These include e.g. the site, quality class, social position of trees in the stand, or even the position of wood in relation to the points of the compass [4].

It results from studies conducted by Dziewanowski [4] that the highest proportion of knotless elements was found for wood coming from the upper layer of the stand (Kraft class I), while the lowest – for wood from the lower layer. He also showed that the poorer the site, the bigger the variation in quality in individual social classes of tree position, with the difference being smallest under conditions optimal for the production of high-quality pine wood (quality class II - fresh coniferous forest, fresh mixed coniferous forest).

These results are not completely consistent with those reported by Dziewanowski, who stated that technical quality of pine timber deteriorates with the transition of trees to a lower social class in the stand [4]. This statement seems justified, but only in case of a site optimal for pines (fresh coniferous forest). In trees growing in a richer site (fresh mixed coniferous forest) the situation was opposite.
As it was already mentioned, this phenomenon may be explained by the process of branch dying, which starts after the compensation point is reached, i.e. when dissimilation becomes more intensive than assimilation. In predominant and partly dominant trees growing in fresh mixed coniferous forest the deficit of light in lower parts of the crown is most probably compensated by site fertility, which as a consequence leads to the delay in the initiation of the process of branch dying back and causes an increase in the share of wood overgrown with knots in relation to knotless wood.

Axially the proportion of knotless elements in analyzed butt end logs decreased with height, which seems obvious, since the lower, thickest part of the stem as a rule has the smallest knots, set deepest as a result of dead branches being overgrown in the juvenile stage.

It results from studies by Chojnacki [1], Jackowski [9] and Pazdrowski [18] that the quality of wood in case of mature pines, manifested in knot incidence, is determined mainly at the juvenile stage of the stand, first of all seedling establishment and thicket stages. This is justified by growth dynamics of this forest-forming species, which at the juvenile stage, due to its ecological requirements, tends to utilize free space to the maximum, and thus to form thick branches and grow in all directions.

Intraspecific competition, being the most important interaction between trees both within a species and trees of different species, is closely related with this problem [16]. Silvicultural tending interventions aim at the alleviation of the effect of competition between individual specimens, at the simultaneous acceleration of radial and axial growth dynamics. Control and regulation of stand closure optimize growth increment of trees, increase the dimensions of produced timber as well as stand stability by regulating the tree stem diameter to fit the size of the tree crown [22,23].

Results partly confirm the presented hypotheses that the social position of trees in the stand, with which crown size is obviously connected, is also related with the quality of timber, defined in this study by the proportion of conventional knotless elements. This is confirmed by the high coefficients of determination describing the dependence between knotlessness and crown width.

A significant effect on the rate and course of the self-pruning process and timber quality is found for the forest economy and silvicultural procedures (the selection of species composition to fit site productivity conditions, as well as ecotypes adapted to local growth conditions) together with an appropriate selection in the course of silvicultural interventions. This fact stresses the role in modern forestry of the selection of ecotypes adapted to site and climatic conditions. This statement was proved to be justified by Schöpfer [20], who observed that pine ecotypes with thin branches and narrow crowns, even at a considerable reduction of stand density (the creation of gaps), do not develop thick branches or wide crowns.

Thus, consideration for timber production as the primary task of forest management is based on the knowledge and purposeful utilization of biological trends. The knowledge on processes of tree growth, causes of its disturbance, followed by the determination of dependencies of growth increment on tree species, the site and the type and intensity of cutting are necessary preconditions of rational forest management [19].

CONCLUSIONS

1. Timber quality defined by the share of knotless elements in view of the social class of tree position in the community was different in the richer site than in the poorer one.
2. The lowest share of knotless elements (determined on the basis of analyses of 1-meter sections) was recorded for codominant trees growing in fresh coniferous forest (32.5%), while it was the highest for codominant trees growing in fresh mixed coniferous forest (58.4%).
3. The highest share of knotless elements (determined on the basis of analyses of 0.5-meter sections) was found for dominant trees growing in fresh coniferous forest (81.9%), and codominant trees growing in fresh mixed coniferous forest (81.5%), while it was lowest (66.7%) for codominant trees growing in fresh coniferous forest.
4. On average a slightly highest rate of knotlessness (77.1% for 0.5-meter sections and 50.9% for 1-meter sections) and at the same time higher wood homogeneity in this respect was recorded for logs coming from pines growing in the richer site (fresh mixed coniferous forest) than it was the case for logs coming from pines growing in the poorer site, i.e. fresh coniferous forest.
5. The analysis of knotlessness using both 1-meter and 0.5-meter sections showed that the statistically significantly lowest technical quality of timber was found for trees classified as Kraft class III growing under site conditions typical of fresh coniferous forest.
6. The share of knotless elements in analyzed butt end logs was generally highest in the butt end part and decreased gradually with height.
7. It may be assumed that timber quality, defined on the basis of the proportion of conventional knotless elements, is – among other things - the function of site fertility and social class of tree position occupied by a tree in the stand.
8. The determination of the rate of knotlessness on the basis of the share of defect-free elements to the total number of elements in 1- and 0.5-meter sections yielded different results. On the basis of the performed comparison it may be assumed that the method based on the analysis of 0.5-meter sections yields more accurate results and presents a more comprehensive picture of trends found in this trait in tree stems.

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Accepted for print: 28.03.2008

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