Biometric Traits of Wood and Quality of Timber Produced in Former Farmland

TOMASZ JELONEK, WITOLD PAZDROWSKI AND ARKADIUSZ TOMCZAK

The August Cieszkowski Agricultural University of Poznań, Department of Forest Utilisation
Wojska Polskiego 71A St, 60-625 Poznań, POLAND, Phone +48 61 8487754; Fax +48 61 8487755;
tjelonek@au.poznan.pl

Jelonek, T., Pazdrowski ,W. and Tomczak, A. 2008. Biometric Traits of Wood and Quality of Timber Produced in Former Farmland. *Baltic Forestry*, 14 (2): 138–148.

Abstract

Investigations were conducted on 48 Scots pines grown on former farmland and under typical forest conditions in northern Poland. It was attempted in the study to determine wood quality of pines grown in former farmland and typical forest conditions, based on the relationship between biometric traits of trees and the share of sapwood and heartwood in tree stems. Moreover, the analysis included the dynamics of heartwood formation and the dependence between crown volume of trees, the diameter at breast height and height, and volume and share of heartwood and sapwood in tree stems. Results show that the higher dynamics of heartwood formation and a higher share of heartwood and a lower share of sapwood are distinguished in stems of pines growing on former farmland in comparison with pines growing on typical forest soils. High values of coefficients of determination obtained for analyzed dependencies facilitate estimation of sapwood and heartwood volumes in stems of pines on the basis of their diameter at breast height or crown volume.

Key words: Scots pine, former farmland, biometric traits, sapwood, heartwood

Introduction

Forecasts concerning the development of forest resources in Poland predict increased demand for wood at the simultaneous reduction of globally harvested timber volume. This situation is going to result in the deficit of timber, which may be aggravated as a consequence of destructive phenomena in the natural environment.

Expansion of the raw material base may be achieved using the following methods:

- management of afforested former farmland and wasteland,
- intensification of management in private forests and state forests managed by other government departments,
- utilisation of afforestation potential,
- intensification of timber production in forest areas.

As far as the possible solutions given above are concerned the best results may be obtained by developing former farmland and wasteland for afforestation (Fonder 1991, Głaz 1996).

Increasing the area of forests by afforestation of former farmland is also connected with the enhancement of their advantageous effect on the entire natural environment and first of all on living conditions for the local population and natural conditions of agricultural production (Łonkiewicz 1990).

The problem of ecological succession and the reconstruction of forest ecosystems in former farmland was also investigated by Szujecki (1990) and Szwagrzyk (2004).

In spite of growth conditions rather adverse for trees, occurring in former farmland, Ważyński (2000) on the basis of conducted investigations found that stands growing under the conditions found on former farmland exhibit sufficient quality.

Wood structure is determined by species-specific and individual traits, while at the same time several paremeters of wood properties are modified by external conditions such as *e.g.* geographical location, climate and soil conditions.

Sapwood and heartwood are essential elements of wood macrostructure having a decisive effect on the quality and properties of timber. Considerable variation in physical, chemical and mechanical properties of sapwood and heartwood frequently determines the possible applications and utilisation of both types of wood.

Most trees in their cross stem sections have regular heartwood, similar in shape to stem girth. In some species heartwood may be irregular in shape, which does not correspond to the boundary of annual rings (Hillis 1987)

Duda and Pazdrowski (1975), and Pazdrowski and Spława-Neyman (1996) showed that the share of sapwood and heartwood is closely correlated with age of trees and site fertility. The share of heartwood increases with age of trees and site fertility, at the expense of the share of sapwood.

The quality of raw material base may be preliminarily assessed on the basis of phenotypic traits of individual trees, i.e. their height and crown structure (Zawierucha 1978). Dependences between crown size as well as other biometric traits and elements of wood structure and growth dynamics of trees were also analyzed by Smith (1953), Meyer (1959), Lemke (1966a, 1966b), Assmann (1968), Dudek (1969), Pazdrowski (1994a, 1994b), Dean (1999), Amarasekara and Denne (2002), and Jelonek and Pazdrowski (2004).

The crown, its shape, morphology and its effect on increment dynamics was discussed at length by Assmann (1968). The last author characterized tree crowns using simple and universal indexes.

In the extensive literature on the subject numerous items may be found describing timber quality, its biological aspects and relationship with biometric traits of trees. However, there is no in-depth analysis facilitating quality appraisal of timber produced on former farmland and the determination of the strength and trend of the dependence between external factors modifying growth conditions and biometric traits of trees, and wood structure.

The aim of the study was to determine the effect of former farmland on quality of timber produced in pine stands in northern Poland.

Methodological assumptions

Investigations were conducted in northern Poland in production pine stands (Figure 1). A total of 48

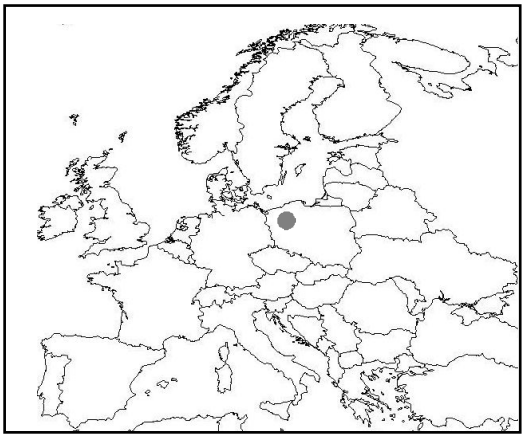


Figure 1. Location of conducted investigations http://geography.about.com/library/blank/blxeurope

Pinus sylvestris L. trees were used in the study, aged between 32 and 114 years, grown on former farmland and on typical forest sites (Table 1). Compared stands were similar in terms of many possible taxation conditions, *i.e.* site conditions, age, height, breast height diameter, and the area occupied by one tree (Table 1).

Table 1. Statistical characteristics of model trees

Type of soil	Statistical characteristic	Age (years)	Tree height (m)	Crown length (m)	Crown volume (m^3)	DBH (cm)	Stand basal area (m^2)
Forest site	Mean	66.7	21.8	7.4	54.3	24.0	20.2
	Standard deviation	24.0	4.7	2.5	51.7	7.2	6.9
	Coefficient of variation [%]	36.0	21.6	33.1	95.2	30.1	34.3
	Maximum	110.0	28.3	11.9	168.2	37.0	30.3
	Minimum	32.0	11.8	3.1	2.1	12.0	9.7
Former farmland	Mean	71.1	21.2	7.1	54.3	24.5	21.4
	Standard deviation	27.5	3.2	1.8	39.6	8.3	7.6
	Coefficient of variation [%]	38.7	15.2	25.9	72.8	33.9	35.4
	Maximum	114.0	27.1	10.8	141.4	37.2	33.3
	Minimum	32.0	15.0	2.9	5.3	8.5	11.2

Moreover, sample plots were established in stands located close to one another in order to limit the effect of microclimate on the forming wood tissue. The other factors composing sets of growth and development conditions for individual trees and entire stands were considered to be constant.

In each analyzed stand a representative sample plot of 0.5 ha was established, in which the diameter at breast height (DBH) was measured for all trees and height in proportion to the number in adopted (2 cm) diameter sub-classes.

Based on the diameter and height characteristics of the stand in each plot three model trees were selected using the Urich II dendrometric method (Grochowski 1973), which represented the first three classes according to the Kraft classification (1884).

Prior to felling of each model tree its crown projection was performed in order to establish its diameter. All stems of felled model trees were divided into sections, from the centres of which discs with a thickness of approx. 3 cm were cut perpendicularly to the longitudinal axis of the stem. The first disc was cut from the kerf plane of the tree, the next at a distance of 1 m and successive from the centres of assumed 2 m long sections.

After slight drying and thorough sanding sapwood ring width and heartwood diameter were measured on cut discs in two perpendicular diameters oriented along the north-south and east-west axes.

On the basis of these measurements sapwood ring volume and heartwood cylinder volume were calculated in each 2-m section of individual model trees, which as a result made it possible to calculate total volume and the share of both types of wood in each analyzed model tree. The share of both types of wood in stem volume was expressed in relative values (%), assum-

ing stem volume as 100%. Moreover, the number of annual diameter increments found in the sapwood and heartwood zones was calculated in each cut disc, which was next used to determine the dynamics of heartwood formation. Obtained numerical values characterizing selected biometric traits of trees and selected traits of their wood macrostructure facilitated an analysis of their interdependencies. An attempt was made to determine to what extent individual biometric traits of trees determine the size and variation in selected characteristics of wood macrostructure. In the presented study these relationships were characterized using regression curves and coefficients of determination.

Results

Both sapwood and heartwood are important elements of pine wood macrostructure. Varied properties of both types of wood frequently determine their potential applications and utilisation of produced raw material. Thus during its assessment the share of sapwood and heartwood are frequently analyzed together with their ratio in logs and tree stems.

The share of sapwood and heartwood in pine stems, grown on former farmland and typical forest soils is presented in data given in Table 2 and in Figures 2 and 3.

Table 2. Characteristics of selected macroscopic wood structure characteristics of Scots pine *(Pinus sylvestris* L.*)* trees growing on former farmland and typical forest soils

Statistical characteristic	Forest			Former farmland		
	heartwood volume [m³]	sapwood volume [m³]	dynamics of heartwood formation	heartwood volume [m³]	sapwood volume [m³]	dynamics of heartwood formation
Mean	0.143	0.402	3.63	0.154	0.356	3.10
Standard error	0.1321	0.2486	2.05	0.1256	0.1941	1.57
Coefficient of variation [%]	92.0	62.0	56.5	81.7	54.5	50.52
Maximum	0.526	0.875	8.542	0.458	0.843	7.13
Minimum	0.001	0.017	1.469	0.007	0.062	1.28
Percentage of volume / area [%]	26.3	73.7		30.2	69.8	

Pines growing on former farmland soils on average exhibited a higher heartwood volume (0.154 m³) and lower sapwood volume (0.356 m³) than pines growing on typical forest soils, where these values were 0.143 m³ and 0.402 m³, respectively (Table 2, Figures 2 and 3).

Higher coefficients of variation for analyzed traits, *i.e.* volumes of sapwood and heartwood, were found in pines growing on forest soils, amounting to 92% for heartwood volume and 62% for sapwood volume, while for pines from former farmland soils these values were 82% and 55%, respectively (Table 2).

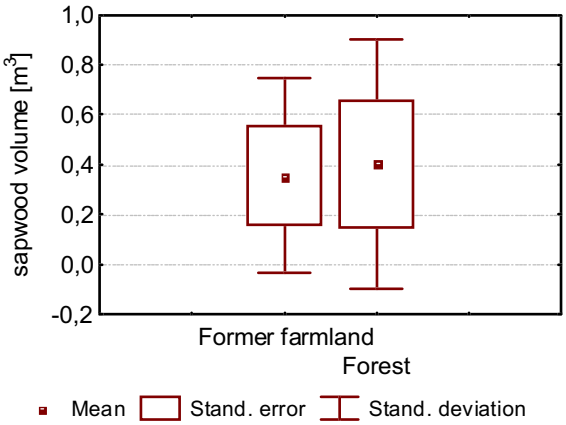


Figure 2. The share of sapwood in stems of Scots pines *(Pinus sylvestris* L.*)* growing on former farmland and typical forest soils

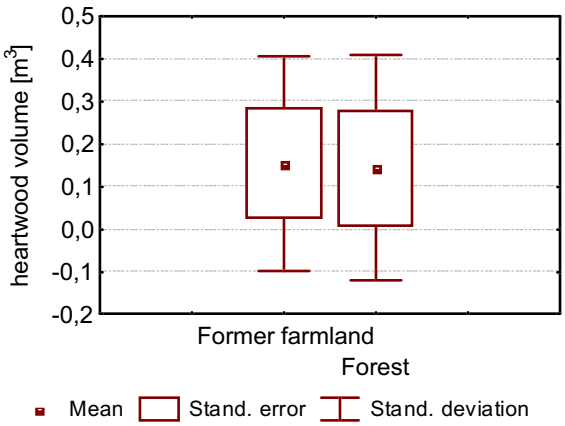


Figure 3. The share of heartwood in stems of Scots pines *(Pinus sylvestris* L.*)* growing on former farmland and typical forest soils

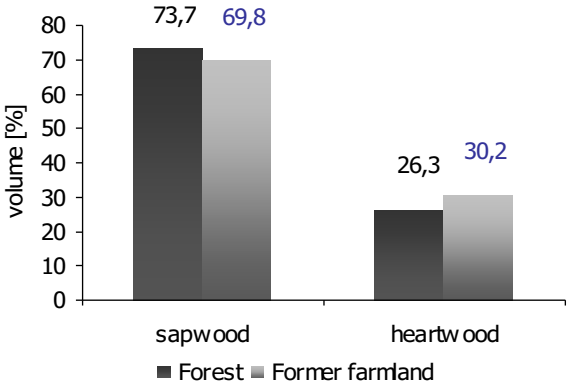
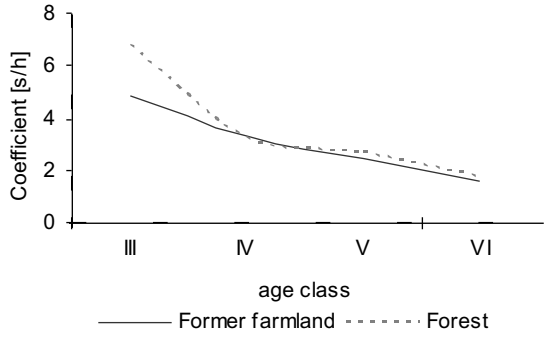


Figure 4. The share of sapwood and heartwood in stems of Scots pines *(Pinus sylvestris* L.*)* growing on former farmland and typical forest soils

The percentages of sapwood and heartwood volume were also analyzed in relation to total stem volume. A graphic presentation of this share is found in Figure 4. On average the share of heartwood in stem volume in pines growing on former farmland soils was higher by approx. 4% than in pines growing on typical forest soils.

Dynamics of heartwood formation defines the rate of transformation of sapwood (containing parenchymal cells) into heartwood devoid of parenchymal cells, serving mainly mechanical functions.



s/h – the number of rings within sapwood zone to the number of rings in heartwood zone

Figure 5. Dynamics of heartwood formation in stems of Scots pines *(Pinus sylvestris* L.*)* growing on former farmland and typical forest soils

Most frequently the dynamics of heartwood formation is defined on the basis of the ratio of the number of annual sapwood rings to the number of rings contained in heartwood. At the same time it needs to be stressed that the range of heartwood in the cross stem section does not have to coincide with the boundary of the annual ring.

Generally trees growing on typical forest soils are characterized by higher sapwood: heartwood ratio of 3.63, a higher standard deviation (2.05) and coefficient of variation (56.5%). In turn, trees growing on former farmland soils had values of 3.10, 1.57 and 50.5%, respectively (Table 2).

Results indicate that in trees coming from forest soils the process of heartwood formation was less intensive (especially in age class III) and occurred with a higher variability than in trees coming from former farmland soils (Table 2, Figure 5).

Statistically significant differences were found in the dynamics of heartwood formation between pines of age class III growing on former farmland and typical forest soils.

In the production of highest quality timber a crucial issue is to know interrelationships between some easily measurable biometric traits of trees and the share of sapwood and heartwood in stems.

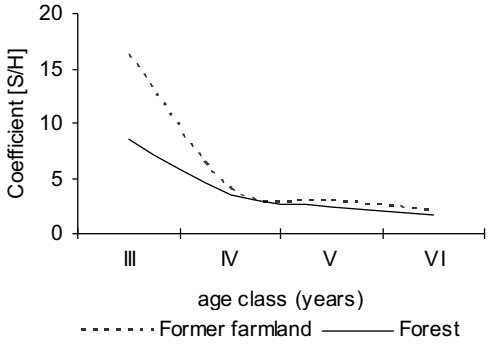
In order to analyze in detail the share of heartwood and sapwood in stems the ratios of volumes of both wood types were also analyzed.

Table 3. Statistical characteristic coefficient [H/S] and [S/H]

Statistical characteristic	Forest		Former farmland	
	Coefficient [H/S]	Coefficient [S/H]	Coefficient [H/S]	Coefficient [S/H]
Mean	0.29	6.39	0.38	4.09
Stand. error	0.17	6.77	0.21	2.98
Coefficient of variation [%]	58.6	105.9	55.3	72.9

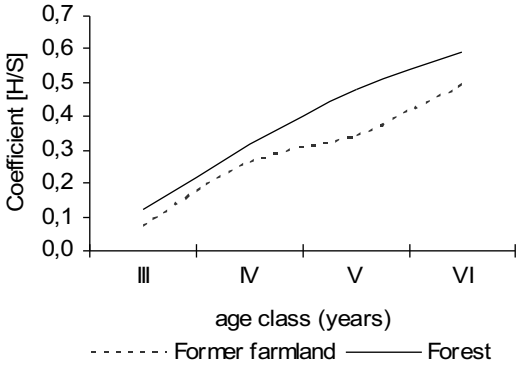
Pines growing on former farmland soils had higher [H/S] ratios and lower [S/H] ratios than pines growing on typical forest soils.

Higher coefficients of variation for the analyzed ratios were recorded for trees coming from forest soils.



[S/H] – sapwood volume : heartwood volume ratio

Figure 6. [S/H] ratio in stems of pines from former farmland and typical forest soils in terms of age



[H/S] – heartwood volume: sapwood volume ratio

Figure 7. [H/S] ratio in stems of pines from former farmland and typical forest soils in terms of age

It may be assumed that such fluctuations of the S/H and H/S ratios in case of pines coming from former farmland soils may be caused by a different course of the tree aging process, resulting from varied growth and development conditions on former farmland in comparison to forest soils.

In this study it was attempted to analyze the dependency between selected elements of wood macrostructure and selected biometric traits of trees.

Both sapwood and heartwood volumes depend, among other things, on the size of the tree crown. Figures 8 to 23 present the dependence of volume and share of sapwood and heartwood and the dynamics of heartwood formation in tree stems on crown volume, the height and the diameter at breast height. Interdependencies were characterized using the coefficients of determination and regression equations. Analyzed dependencies are curvilinear in character and calculated coefficients of determination reached high values.

For pines from typical forest soils the coefficient of determination R^2 of the dependence of sapwood volume on crown volume was 0.88, while that of the dependence of heartwood volume on crown volume was 0.83. The values of this coefficient for trees from former farmland were lower, amounting to 0.81 and 0.57 (Figures 9 and 11). The results show that dependent variables (volumes of sapwood and heartwood) are determined by analyzed independent variables (crown volume) in approx. 88% and 83% for typical forest soils and 81% and 57% for former farmland soils.

On the basis of regression curves describing dependencies of sapwood volume on crown volume it may be stated that in case sapwood volume is identical, pines from former farmland soils have bigger

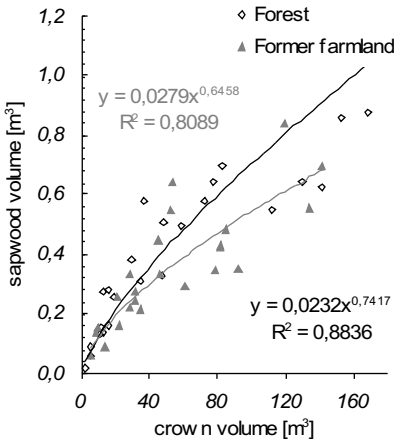


Figure 9. Correlation between sapwood volume and crown volume of pine trees growing on former farmland and typical forest conditions

crowns than pines from typical forest soils (Figure 9). In contrast, since heartwood volume depends on crown volume it was observed that at a crown volume of approx. 80m^3 a similar heartwood volume is found in stems of pines from typical forest and former farmland soils (Figure 11).

Figures 8 and 10 present dependencies of sapwood and heartwood volumes on the diameter at breast height. Both sapwood and hardwood volume depend on the diameter at breast height. Higher coefficients of determination R^2 were obtained for pines growing on typical forest soils (0.72 and 0.64) as compared to former farmland soils (0.69 and 0.42).

In case of the dependence of sapwood volume on the diameter at breast height it was observed that af-

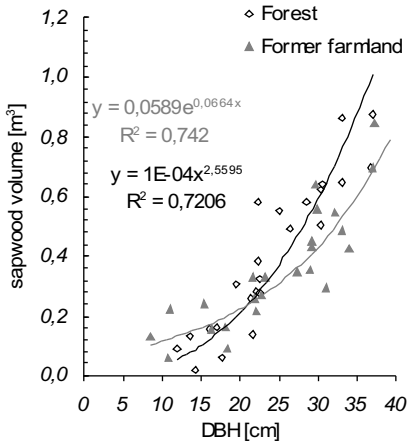


Figure 8. Correlation between sapwood volume and the diameter at breast height of pine trees growing on former farmland and typical forest soils

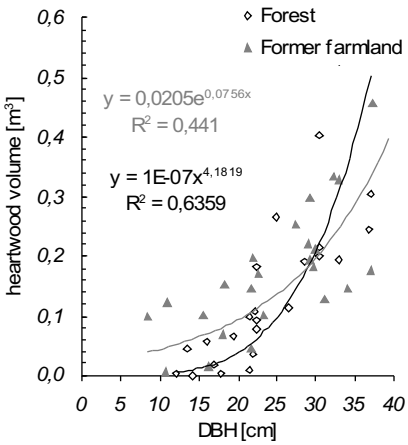


Figure 10. A correlation between heartwood volume and the diameter at breast height of pines growing on former farmland and typical forest soils

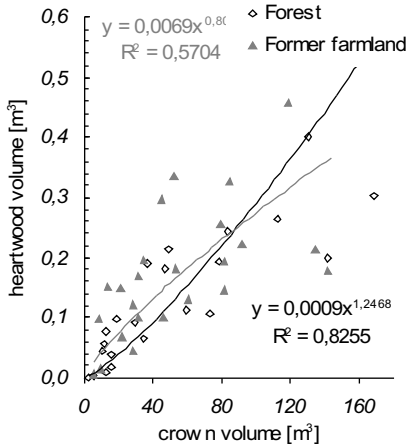


Figure 11. A correlation between heartwood volume and crown volume of pines growing on former farmland and typical forest soils

ter the diameter at breath height had exceeded approx. 20 cm an intensive sapwood increment was found in pines growing on typical forest soils than in these on former farmland. Also in case of the dependence of heartwood volume on the diameter at breast height a similar correlation was observed with one difference, as a more intensive heartwood increment in pines from typical forest soils occurred after the diameter at breast height had exceeded 30cm.

Successive figures (Figures 12 to 15) present dependencies of sapwood and heartwood volumes on crown length and tree height. Trends of analyzed dependencies were similar in pines from former farmland and typical forest soils; however, higher coefficients of determination were reported for trees growing on forest soils.

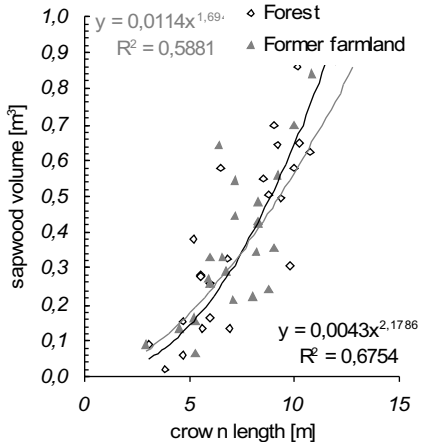


Figure 12. A correlation between sapwood volume and length of live crown in pines growing on former farmland and typical forest soils

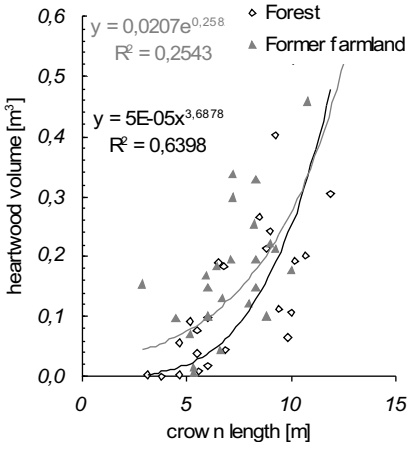


Figure 13. A correlation between heartwood volume and length of live crown in pines growing on former farmland and typical forest soils

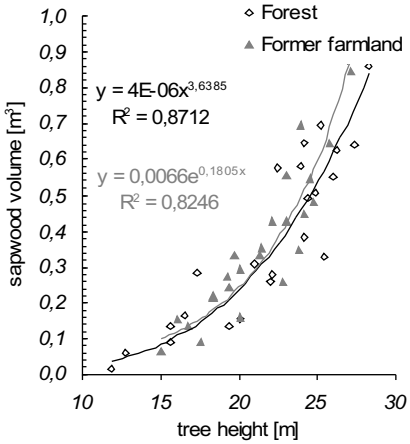


Figure 14. A correlation between sapwood volume and tree height of pines growing on former farmland and typical forest soils

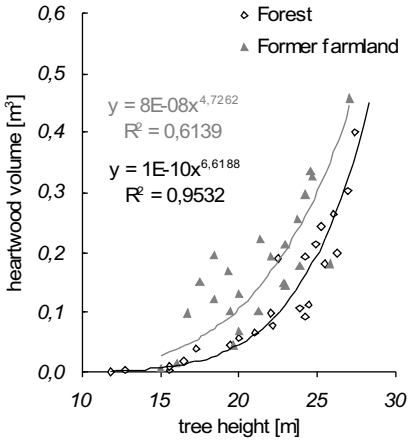


Figure 15. A correlation between heartwood volume and tree height of pines growing on former farmland and typical forest soils

Dependencies of the share of both wood types (sapwood, heartwood) in stem volume on crown volume and the diameter at breast height were also analyzed (Figures 16 to 19).

In pines from former farmland the share of sapwood was approx. 40% depending on the crown volume and 54% depending on the diameter at breast height, while in pines from forest soils those were approx. 50 and 34%, respectively (Figures 16 and 18). Analysis of the dependence of the share of heartwood in stem volume on crown volume and the diameter at breast height shown that the share of this wood in pines from former farmland depends on the crown volume approx. 50% and on the diameter at breast height 64% (Figures 17 and 19).

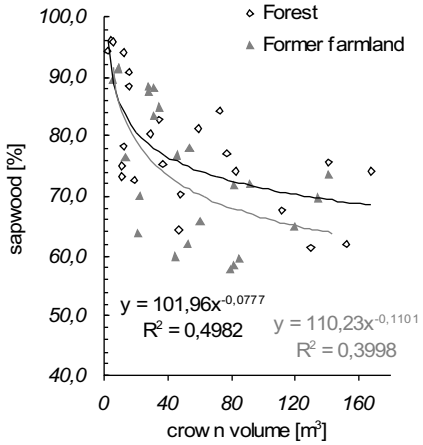


Figure 16. A correlation between dynamics of heartwood formation and crown volume in pines growing in former farmland and typical forest soils

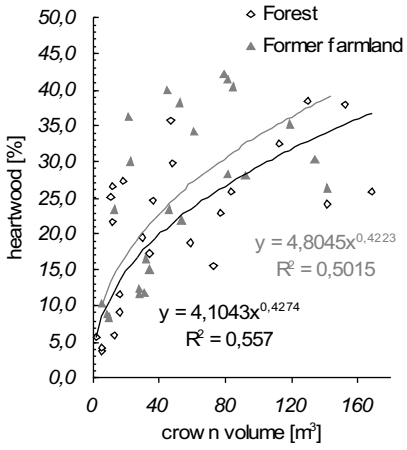


Figure 17. A correlation between dynamics of heartwood formation and the diameter at breast height of pines growing on former farmland and typical forest soils

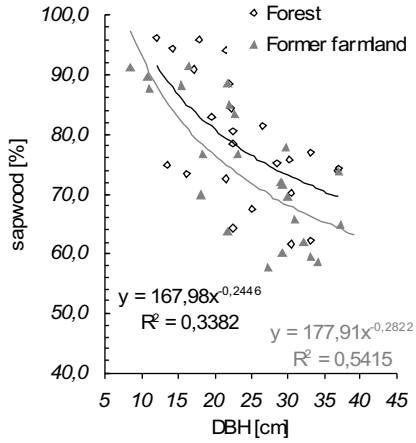


Figure 18. A correlation between the share of sapwood in stem volume and the diameter at breast height in pines growing on former farmland and typical forest soils

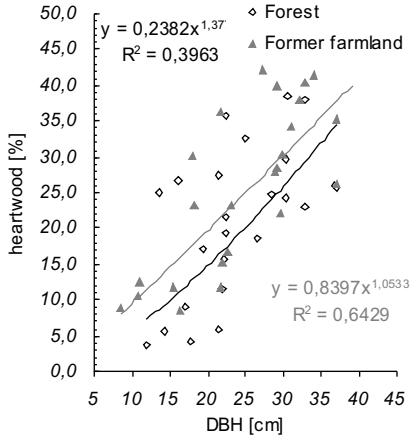


Figure 19. A correlation between the share of heartwood in stem volume and the diameter at breast height of pines growing on former farmland and typical forest soils

Figures 20 and 21 present the dependence of heartwood formation dynamics on crown volume and the diameter at breast height. A slightly stronger relationship, defined on the basis of coefficients of determination, links the dynamics of heartwood formation and crown volume in pines from forest soils than these from former farmland. It was the opposite when the diameter at breast height was the independent variable and in this situation a stronger relationship between the analyzed traits was found in pines from former farmland.

On the basis of regression curves describing dependencies presented in Figures 20 and 21 it may be stated that with an increase in crown volume and the diameter at breast height dynamics of heartwood formation increased in a curvilinear manner. The transformation from sapwood to heartwood was more intensive in pines growing on former farmland soils.

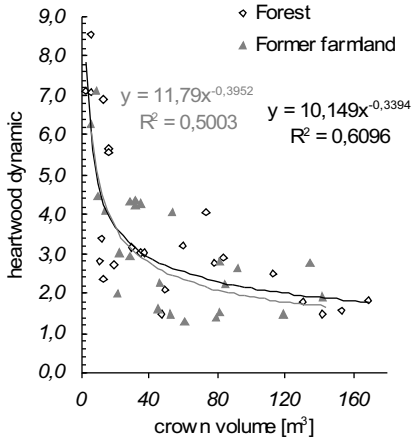


Figure 20. A correlation between dynamics of heartwood formation and crown volume in pines growing in former farmland and typical forest soils

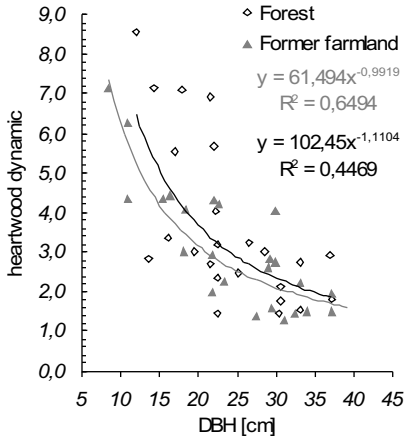


Figure 21. A correlation between dynamics of heartwood formation and the diameter at breast height of pines growing on former farmland and typical forest soils

Dependencies of three variables, *i.e.* crown volume, sapwood volume and age of trees, were also analyzed in the compared groups of trees. Higher coefficients of multiple correlation R(z/xy) were recorded in pines from typical forest soils (0.89) (Figure 22) than these from former farmland soils (0.86) (Figure 23).

Discussion

An increase in the area of forests is a permanent element of national spatial development, ecological and economic policy. The need to increase the areas of forests is presented in the most decisive manner in the State Forest Policy (1997) as one of its essential goals. The realization of the State Forest Policy (Puchnialski 200) should lead to an increase in the total area of forests to 30% in 2020 and 33% after 2050, the arrangement of the farmland-forest boundary in a manner beneficial for landscape value, as well as efficient functioning of forests and agriculture.

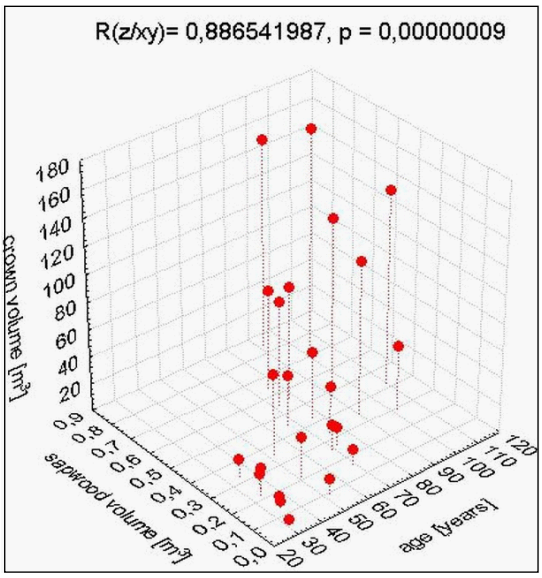


Figure 22. An interdependence between sapwood volume, crown volume and age of pines growing on typical forest soils

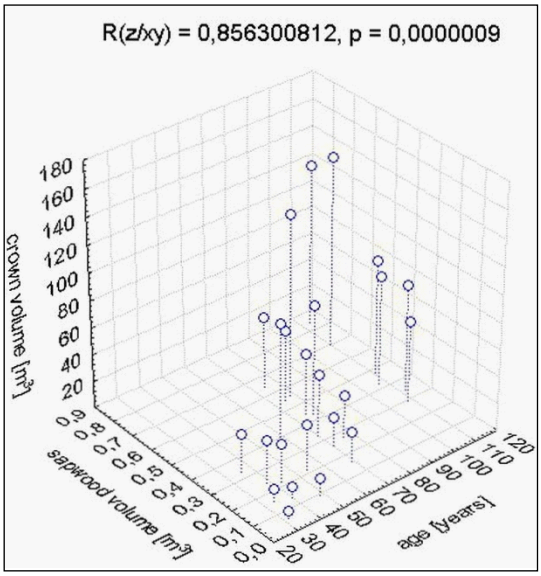


Figure 23. An interdependence between sapwood volume, crown volume and age of pines growing on former farmland soils

Forest on former farmland is one of the most important problems of contemporary forestry. The natural life cycle of trees, the effect of the environment and hereditary characters, as well as quality attributes of wood are closely interrelated and to a considerable degree depend on soil conditions. Atypical, extreme

conditions for forest production, found on former farmland, most probably affect directly the formation of wood tissue. At the same time it needs to be remembered that these conditions change throughout the life cycle of trees, which contributes to fluctuations of the quality of timber produced at individual stand development phases.

Thus it is necessary to solve several problems connected with the common goal, i.e. the generation of a strong, stable forest ecosystem, capable of producing high quality timber of versatile use.

The literature on the subject describes extensively the specific character and properties of former farmland (Fonder 1991, Głaz 1996, Puchnialski 2000), as well as the effect of various factors on the forming wood tissue (Wagenführ 1966, Smith 1968, Kolman and Wilfred 1968, Krzysik 1978, Winandy 1994, Thörnqvist 1993, Person *et al*. 1995, Hannrup and Ekberg 1998, Plomion *et al.* 2001, Schmidt 2001, Hejnowicz 2002, Hokka and Ojansuu 2004). However, there seems to be no comprehensive analysis of the effect of conditions generated by former farmland on modifications of wood quality.

Conducted investigations (Jelonek *et al*. 2005) showed that pure density of pines growing on former farmland soils was significantly higher than that of wood in pines from typical forest soils. This pertains both to sapwood and heartwood. We need to place emphasis on the fact that heartwood of pines growing on former farmland soils exhibited different properties than the wood of trees growing on forest soils. At high density this wood showed a much lower ultimate compressive strength parallel to the grain. Moreover, this wood did not exhibit differences in macrostructure, which suggests that changes were generated in wood tissue at the level of cell walls.

This study was an attempt to determine timber quality based on selected wood macrostructure properties in stems of Scots pines growing under varied conditions. The main factor differentiating this quality was the type of soil (forest, former farmland) and age. In the compared groups differences were observed in the share of sapwood and heartwood in stem volume and a different (at young age) dynamics of heartwood formation. A higher share of heartwood and a faster rate of heartwood formation in trees assigned to younger age classes of stands growing on former farmland soils would indicate a different course of the ageing process of wood tissue and the death of parenchymal cells than it is the case in pines growing on typical forest soils. It is also likely that in pines growing on former farmland soil cavitations could have been formed (especially at an older period in life), in the opinion of Assmann (1966) contributing to parenchymal cell death and heartwood formation in stems. It may also be assumed that the rate of heartwood formation and heartwood volume will be affected by tree height, crown size, and primarily water availability in soil.

Moreover, as it was shown in the course of investigations, there is a close correlation between heartwood formation dynamics and crown size or the diameter at breast height in a tree. Thus, it seems feasible to determine the dynamics of heartwood formation for a given specimen on the basis of crown size and the diameter at breast height by using respective reference distribution patterns. Hence, this would be a non-invasive method to estimate heartwood formation dynamics of trees and whole stands.

In the production of highest quality timber it is essential to know interrelationships between certain, easily measurable biometric traits of the tree and the shares of sapwood and heartwood in the tree stem.

The determination of these interrelationships is important for two reasons. Firstly at the time timber is allocated specific purposes it facilitates its optimal utilization. Secondly, thanks to the action of breeding measures at individual phases of stand development it makes it possible to produce timber with advantageous, pre-determined traits and properties.

Finding universal indexes, easily measurable on site (not requiring the tree to be cut down), facilitating estimation of the quality, and thus the value of timber has been the objective of numerous studies (Dudek 1969, Pazdrowski and Spława-Neyman 1993, Pazdrowski 1994a,1994b, Jelonek and Pazdrowski 2004, Tomczak *et al.* 2005), including this one.

Both the volume and share of sapwood and heartwood in the stem are considerably dependent on crown volume and breast height diameter of a tree. In case of the dependence of sapwood as well as heartwood volume on crown volume and the diameter at breast height in the tree higher values of the coefficient of determination were recorded in pines from typical forest soils. The dependence of sapwood volume on tree height and the length of live crown was also stronger in pines from typical forest soils. This fact may indicate a higher lability of pine phytocenoses growing on former farmland.

Conclusions

On the basis of conducted investigations it may be assumed that tree growth conditions, obviously different in case of former farmland soils in comparison to forest soils, result in different growth dynamics and quantitative ratios of the analyzed elements of wood structure and their dependencies on biometric traits of these trees.

In order to rationally utilize timber from former farmland it would be necessary to conduct chemical analyses of wood and physico-mechanical properties of wood; however, at this stage it seems that it is a slightly inferior construction material than wood from pines growing under typical forest conditions. Thus when utilizing wood (from former farmland) for construction purposes larger sections of load-bearing elements need to be used than in case of wood from pines growing in typical forest soils. Moreover, the lower share of sapwood found in wood of pines from former farmland in comparison to these growing in forests has a negative effect on the value of timber and its potential applications, especially in terms of yield in pulp and paper industry and plywood industry.

References

Amarasekara, H. and Denne, M. P. 2002. Effects of crown size on wood characteristic of Corsican pine in relation to definitions of juvenile wood, crown formed wood and core wood. *Forestry* 75(1): 51-61

Assmann, E. 1968. Nauka o produkcyjności lasu [Forest yield science]. PWRiL, Warszawa, Poland, p. 50-70 (in Polish)

Dean, T. J. 1999. Using live-crown ratio to control wood quality: an example of quantitative silviculture. Paper presented at the Tenth Biennial Southern Research Conference, Los Angeles 1999

Duda, J. and Pazdrowski, W. 1975. Procentowy udział twardzieli i bielu w 100-letnich sosnach zwyczajnych (*Pinus sylvestris* L.) rosnących w różnych warunkach siedliskowych [Percentages of heartwood and sapwood in 100-year old Scots pines (*Pinus sylvestris* L.) growing under different site conditions]. *Sylwan,* 11: 57-64 (in Polish with English summary)

Dudek, A. 1969. Zależność intensywności przyrostu miąższości i przyrostu pierśnicy od wielkości korony [A dependence of volume increment and diameter breast height intensity on crown size]. *Folia Forestalia Polonica,* (A) 15: 149-169 (in Polish)

Fonder, W. 1991. Kierunki leśnego zagospodarowania gruntów porolnych i nieużytków przeznaczonych do zalesienia [Directions of forest management of afforested former farmland and wasteland]. *Przemysł Drzewny,* 12:16-20 (in Polish)

Grochowski, J. 1973. Dendrometria [Dendrometry], PWRiL Warszawa (in Polish)

Głaz, J. 1996. Strategia użytkowania lasu [A strategy of forest utilisation]. *Przemysł drzewny* 10: 12-15 (in Polish)

Hannrup, B., Ekberg, I. 1998. Age-age correlations for tracheid length and wood density in *Pinus sylvestris*. *Canadian Journal of Forestry Research*, 28(9): 1373-1380

Hillis, We. 1987. Heartwood and tree exudates, Springer series in wood science. Berlin. Heidelberg. New York

Hokka, H., Ojansuu, R. 2004. Height Development of Scots Pine on Peatlands: Describing Change in Site Productivity with A Site Index Model. *Canadian Journal of Forest Research*, 34(5): 1081-1093

Jelonek, T. and Pazdrowski, W. 2004. Correlation between breast height diameter of trees, their crown biometric elements and selected wood macrostructural traits of Scots pine (*Pinus sylvestris* L.). Annals Warsaw Agricultural University-SGGW. *Forest and Wood Technology,* 55: 263-267

Jelonek, T., Pazdrowski, W. and Tomczak, A. 2005. Share of sapwood and heartwood in stems of Scots pine trees (*Pinus sylvestris* L.) growing on forest soils and former farmlands as a basis for the evaluation of timber raw material. Warsaw Agricultural University-SGGW. *Forest and Wood Technology,* 56: 296-300

Kollman, F.F.P. and W.A. Cote, Jr. 1968. Principles of Wood Science and Technology 1: Solid Wood. Springer - Verlag New York Inc., p. 160-285

Kraft, G. 1884. Beiträge zur Lehre von den Durchforstungen. Schlagstellungen und Lichtungshieben. Hannover. Germany: Klindworth's.

Meyer, H. 1959. Der Einfluss der Kronenkürzungen an Fichten der II Altersklasse auf deren Hohen- und Starkenwachstum. *Archiv für Forstwesen*, 8, 9: 819-849

Lemke, J. 1966a. Korona jako kryterium oceny dynamiki wzrostowej drzew w drzewostanie sosnowym [The crown as the criterion in assessment of growth dynamics of trees in a pine stand], *Folia Forestalia Polonica* (A), 12: 185-211 (in Polish)

Lemke, J. 1966b. Korona jako jedno z kryteriów wyboru drzew próbnych przy oznaczaniu bieżącego przyrostu miąższości drzewostanu [The crown as a criterion in selection of mean sample trees when determining current volume increment of a stand], *Folia Forestalia Polonica* (A), 12: 237-247 (in Polish)

Łonkiewicz, B. 1990. Perspektywy zwiększania lesistości Polski w świetle planu przestrzennego zagospodarowania kraju [Prospects for increased share of forest areas in Poland in view of the country physical management plant]. *Sylwan,* 3-12: 9-22

Pazdrowski, W. and Spława-Neyman, S. 1966. Budowa i fizyczna charakterystyka drewna sosny zwyczajnej (*Pinus sylvestris* L.) z drzewostanów w wieku przedrębnym, jako podstawa racjonalizacji przeznaczeń i wykorzystania surowca drzewnego [Wood structure and physical characteristics of Scots pine (*Pinus sylvestris* L.) from maturing stands as a basis for rationalization of allocation and utilisation of timber]. 10th Scietific Conference of the Faculty of Wood Technology. SGGW, Warszawa, p. 35-41 (in Polish with English summary)

Pazdrowski, W. and Spława-Neyman, S. 1993. Badania wybranych właściwości drewna sosny zwyczajnej (*Pinus sylvestris* L.) na tle klas biologicznych w drzewostanie [Studies on selected properties of wood of Scots pine (*Pinus sylvestris* L.) in terms of social classes of tree position in canopy]. *Folia Forestalia Polonica* B, 24: 133-145 (in Polish with English summary)

Pazdrowski, W. 1994a. Współzależność miżdzy niektórymi cechami ilościowymi koron drzew a makrostrukturą drewna sosen (*Pinus sylvestris* L.) wyrosłych w warunkach BMśw [An interdependence between selected quantitative traits of tree crowns and wood macrostructure of pines (*Pinus sylvestris* L.) grown in fresh mixed coniferous forest]. *Sylwan,* 11: 79-88 (in Polish)

Pazdrowski, W. 1994b. Korona drzewa jako kryterium oceny jakości drewna sosen z drzewostanów rębnych [Tree crown as a criterion in assessment of wood quality of pines from saw timber stands], Prace Komisji Nauk Rolniczych I Komisji Nauk Leśnych, vol. LXXVIII, p. 149-155 (in Polish)

Persson, B., Persson, A., Stahl, E. and Karlmats, U. 1995. Wood quality of *Pinus sylvestris* progenies at various spacings. *Forest Ecology Management*, 76: 127-138

Plomon, C., Leprovost, G. and Stokes, A. 2001. Wood Formation in Trees. *Plant Physiology*, 127: 1513-1523

Puchnialski, T. 2000. Krajowy program zwiększania lesistości. Poradnik od A do Z. Zalesienia porolne [National program

of increasing forest area. Guidelines form A to Z. Afforestation of former farmland] PWRiL, Warszawa (in Polish)

Tomczak, A., Jelonek, T., Pazdrowski, W. and Duma, M. 2005. Selected biometric traits of the Scots pine (*Pinus sylvestris* L.) stems as the basis for the assessment of the volume and proportion of mature wood. *Acta Scientiarum Polonorum*, 4(2): 113-121

Thörnqvist, T. 1993. Juvenile wood in coniferous tress, Swedish Council for Building Research. Stockholm

Smith, D.M. 1968. Wood quality of loblolly pine after thinning. U.S. Forest Service Research Pap. FPL- 89.

Shmit, H. 1953. Kronen und Zuwachsuntersuchungen an Fichten des bayerischen Alpenvorlandes. *Forstwissenschaftliches Centralblatt,* 72(9-10): 276-286

Szujecki, A. 1990. Ekologiczne aspekty odtwarzania ekosystemów leśnych na gruntach porolnych [Ecological aspects of reconstruction of forest ecosystems in former farmland]. *Sylwan*, 3-12: 23-40 (in Polish)

Szwagrzyk, J. 2004. Sukcesja leśna na gruntach porolnych; stan obecny, prognozy i wątpliwości [Forest succession in former farmland; current status, forecasts and reservations]. *Sylwan*, 4: 53-59 (in Polish)

Wagenführ, R. 1966. Anatomie des Holzes, Leipzig

Ważyński, B. 2000. Efekt zalesienia gruntów porolnych [The effect of afforestation of former farmland]. *Rocznik Akademii Rolniczej w Poznaniu. Leśnictwo,* 38: 145-162 (in Polish)

Winandy, J. E. 1994. Wood properties. Encyclopedia of Agricultural Science. Academic Press 4: 549-561, USDA-Forest, Forest Products Laboratory, Wisconsin

Zawierucha, E. 1983. Metody fenotypowej klasyfikacji drzew sosny zwyczajnej [Methods of phenotypic classification of Scots pine]. *Sylwan*, 7: 41-52 (in Polish)

Received 06 December 2007
Accepted 30 October 2008

БИОМЕТРИЧЕСКИЕ СВОЙСТВА ДЕРЕВА И КАЧЕСТВО ПРОИЗВОДИМОГО ДРЕВЕСНОГО СЫРЬЯ ИЗ ДЕРЕВЬЕВ, ВЫРАЩЕННЫХ НА ЗЕМЛЯХ, РАНЕЕ ИСПОЛЬЗОВАННЫХ В СЕЛЬСКОХОЗЯЙСТВЕННЫХ ЦЕЛЯХ

Т. Елёнэк, В. Паздровский и А. Томчак

Резюме

Исследования проводились на 48 соснах обыкновенных, выросших в условиях земель, после их использования в сельскохозяйственных целях и выросших на типичных лесных землях на севере Польши. В работе была предпринята попытка определить качество древесины сосен, взятых с земель, ранее используемых в сельскохозяйственных целях, и с типично лесных почв, на основе связи между биометрическими чертами дерева и долей заболони и ядра в стволах деревьев. Анализировались также, с одной стороны, динамика процесса образования ядра, с другой - зависимость между объемом кроны дерева, диаметром на высоте уровня груди, высотой ствола и объемом и долей в стволах ядровой и заболонной древесины. Полученные результаты свидетельствуют о том, что сосны, выросшие в условиях земель, после их использования в сельскохозяйственных целях, характеризуются более высокой динамикой образования ядра, более высокой долей ядра и более низкsой долей заболони в стволах деревьев, чем сосны, выросшие на типичных лесных землях. На основании ярко выраженных коэффициентов, полученных в результате проанализированных зависимостей, можно моделировать объемы заболони и ядра в стволах сосен по диаметру на высоте уровня груди либо по объему крон.

Ключевые слова: сосна обыкновенная, земли, ранее использованные в сельскохозяйственных целях, биометрические свойства, заболонь, ядро