FOLIA FORESTALIA POLONICA
Seria B, zeszyt 33, 2002

THE DENSITY AND LENGTH OF TRACHEIDS OF DOUGLAS FIR (*Pseudotsuga menziesii* FRANCO) IN RELATION TO THE BIOSOCIAL POSITION OF A GIVEN TREE IN THE STAND[1]

by Ewa Fabisiak and Waldemar Moliński

Department of Wood Science, Agricultural University of Poznań

The wood density was found to increase with the distance from the pith, irrespective of the biosocial position of a given tree. This increase is the most pronounced in the suppressed trees, and also the wood density of this kind of trees is the highest. The length of tracheids increases from the pith to a certain distance towards the circumference at which it reaches a maximum, and then gets stabilized.

Key words: Douglas fir, density wood, length of tracheids, biosocial position

INTRODUCTION

An important factor affecting the dynamics of wood tissue production is the biosociological position of a given tree in the stand. The problem of the dependence of the annual ring size on the degree of tree development in a stand of the same age has been a subject of interest since the early 60s of the last century. According to some authors e.g. Dinwoodie (1961, 1963), Schultze-Dewitz (1961), Bannan (1965) the wood tissue of dominant trees was characterized by longer tracheids than that of the suppressed trees, while others e.g. Panshin and de Zeeuw (1980), claim the opposite. The source of the controversy is the individual and population variation of wood characteristics. It has been established that wood from the same tree species growing in different regions of the country or in a different habitat can show significantly different characteristics (e.g. Duffild 1964, McKimmy 1966, Niedzielska 1995).

One of the most important features influencing the wood structure is the state of development of a tree crown. The advancement of its development has direct influence on cambial processes so also on the size of annual rings, and can serve as a good criterion when making comparisons among threes in a given stand (e.g. Larson 1962).

---

[1] Short-version of the paper has been presented during the 15th Conference Wood Technology SGGW "Wood as the material of the 21st century" Warszawa 13-14 November 2001

For a few years the Department of Wood Science of Agricultural University of Poznań, has been conducting research aiming at determination of variation of some structural features of wood of the tree species preferred for afforestation of post-agricultural land. These structural features are important from the point of view of the wood quality as raw and construction material. This paper reports results of a study on the variation of the length of tracheids and wood density of Douglas fir (*Pseudotsuga menziesii* Franco) from dominant, intermediate and suppressed trees from the stand of the same age trees.

METHODS

The trees to be studied were cut down from a uniform 50-year old stand (according to relevant documentation) of Douglas fir trees in the Forest Range Stęszewko LZD – Murowana Goślina, an experimental area of Agricultural University of Poznań. Three trees were cut to represent the dominant, intermediate and suppressed trees (Table 1). At the length corresponding to ¼ of their height 3 disks about 3 cm thick were cut out. From the disks in the north-south direction 3 slabs of 20 mm in thickness were cut out. The first slab was used for analysis of the width of annual rings and determination of the contribution of late wood in particular rings. The second slab was divided into samples covering 3 annual rings counting from the pith, which were

Table 1

Tabela 1

Characterization of the experimental trees

Charakterystyka drzew doświadczalnych

Tree characteristics Charakterystyka drzew	Tree signature – Sygnatura drzewa		
	A	B	C
Tree age* (years) Wiek drzewa* (lat)	50	50	52
Diameter outside bark (cm) Średnia pierśnica w korze (cm)	41	27	19
Tree height (m) Wysokość drzewa (m)	30	25	21
Crown height (m) Długość korony żywej (m)	13	9	6
Crown index** Wskaźnik korony**	0.43	0.35	0.29

* Number of growth rings on the butt-end cross-section,

*Liczba przyrostów na przekroju odziomkowym

**Ratio of crown length to tree height

** Stosunek: długość korony/wysokość drzewa used for determination of the basic density of wood. The third slab was used for measurements of changes in the tracheid length along the north radius of the tree. For this purpose samples of early and late wood was collected from the annual rings number 3, 6, 9, 12, 15 and then from every fifth ring. The samples were subjected to maceration in a mixture of acetic acid and 30% of hydrogen dioxide solution (at the 1:1 ratio). The process was carried out at 60°C for 24 hours. Then with the help of a computer image analyser the lengths of 30 tracheids from the samples of early and late wood were measured.

RESULTS

Macro structural analysis has confirmed the well-known relation that the worse the biosociological position of a tree in a stand the narrower the annual rings and the greater the contribution of late wood in the rings. The greatest differences in the contribution of late wood were noted in the juvenile wood zone, e.g. in the juvenile zone of suppressed trees the contribution of late wood was almost twice greater than in the dominant trees. The contribution of late wood in mature zone of suppressed trees was only 10% greater than in the wood of the dominant trees. The results of basic density measurements in wood of particular trees are shown in Fig 1.

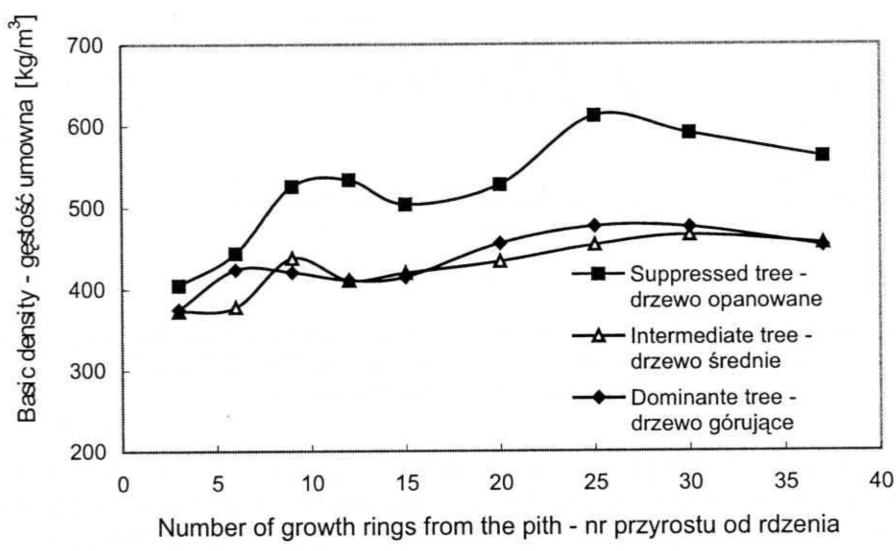

Fig. 1. Changes in the basic density of wood along the northern ray at ¼ of the tree height in wood of Douglas fir trees (*Pseudotsuga menziesii* Franco)

Rys. 1. Zmiany gęstości umownej drewna jedlicy zielonej wzdłuż promienia północnego na ¼ wysokości badanych drzew daglezji zielonej (*Pseudotsuga menziesii* Franco)

As follows from the figure, the wood density increases with the distance from the pith, irrespective of the biosociological position of a tree in a stand. This increase is the most pronounced in the wood samples from suppressed trees. Moreover, the density of wood from suppressed trees is considerably greater than that from intermediate and dominant trees. An interesting fact is the lack of significant differences in the basic density of wood from dominant and intermediate trees. It can be explained by a close contribution of late wood in the annual rings of these trees. Moreover, at the same contribution of the late wood in the annual rings, the wood density of the trees studied was different. This is illustrated in Fig. 2 showing the basic density of wood versus the mean contribution of late wood in particular samples. The data presented in Fig. 2 clearly indicate that the worse the biosociological position of a tree in a stand the greater the tightness of the wood.

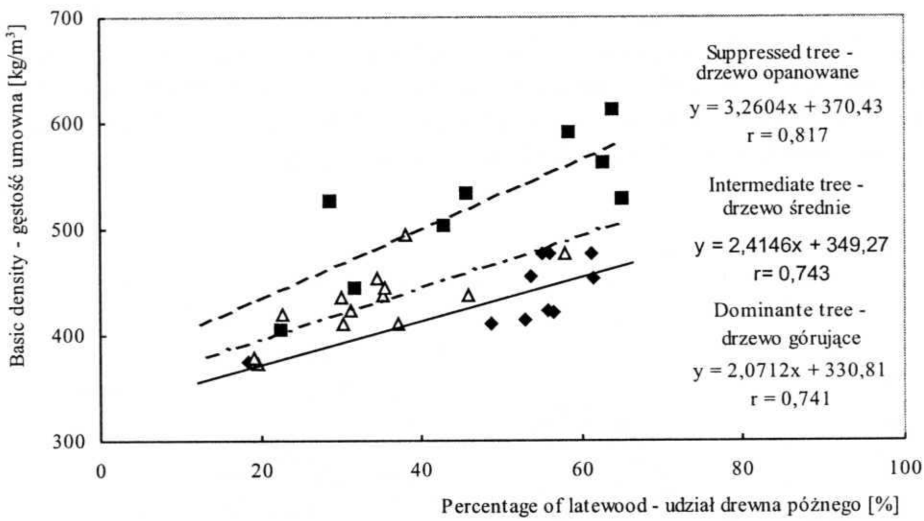

Fig. 2. The basic density of wood of the Douglas fir tree studied versus the contribution of the late wood
Rys. 2 Zależność gęstości umownej drewna badanych drzew daglezji zielonej w zależności od udziału drewna późnego

The results of tracheid length measurements as a function of cambial age in trees from different groups are shown in Fig. 3. As follows from the results, the length of tracheids in the cross-section of a tree trunk increases in the direction from the pith to the circumference to a certain maximum value and then gets stabilized. The lowest values of tracheid length were found in the cells of the early wood, irrespective of the biosociological position of a tree.

The period of the juvenile growth of trees determined on the basis of the length of tracheids is different in trees of particular biosociological positions. In the suppressed

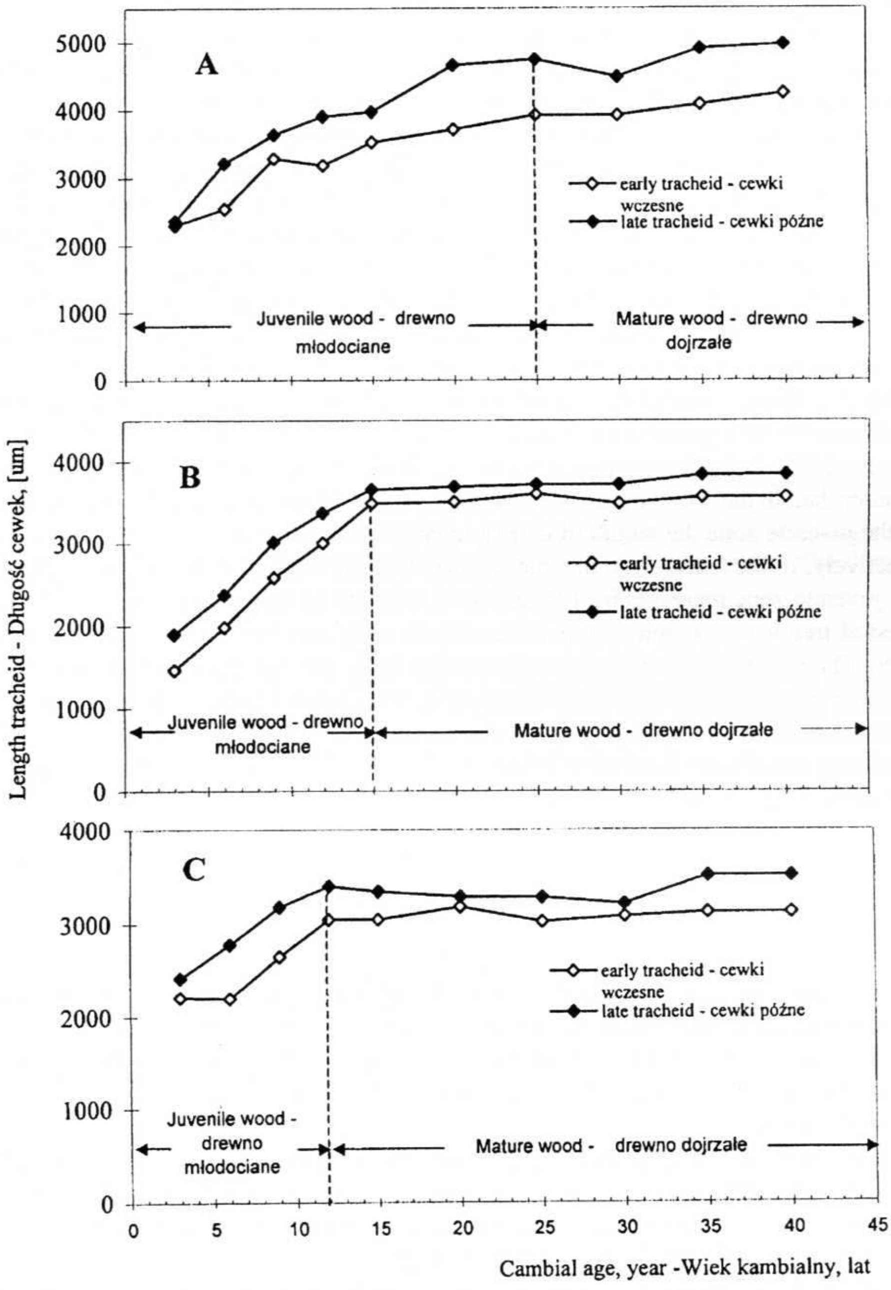

Fig. 3. Relationship between early and late tracheids length and age of growth rings of Douglas fir trees

Rys. 3. Zależność długości cewek wczesnych i późnych od wieku przyrostów drzew daglezji zielonej (*Pseudotsuga menziesii* Franco) tree (C) the length of tracheids gets stabilized from the 12th annual ring, in the intermediate (B) from the 15th and in the dominant (A) from the 25th. In the dominant tree the tracheid length increases even up to the 40th annual ring, which may suggest that the process of tracheid length increase has not ended yet in this tree.

Irrespective of the zone of the cross-section, the greatest length has been found for the early and late tracheids of dominant trees (A). The mean length of early tracheids in this tree was 3230 μm, while that of late tracheids – 3780 μm in the juvenile wood and the corresponding values for mature wood were 4040 μm and 4770 μm. The length of tracheids of the intermediate tree (B) was smaller; the mean length of early and late tracheids in the juvenile wood was 2470 μm and 2840 μm, respectively, while in the mature wood – 3020 μm and 3710 μm, respectively. In the wood sample from the suppressed tree (C) the mean length of early tracheids in juvenile and mature wood is 2530 μm and 2940 μm, respectively, while the mean length of late tracheids in juvenile and adult zone is 3080 μm and 3360 μm, respectively. Thus, the mean length of early and late tracheids in the suppressed trees is by ~30% and intermediate trees is by ~20 % smaller than in the wood of the dominant tree. In the wood sample of the dominant tree in the juvenile zone the length of early and late tracheids increases 70% and 100%, respectively. In the wood from the intermediate tree the corresponding tracheid length in the juvenile zone increases by 125 and 85%, whereas in the juvenile wood of the suppressed tree wood sample the increase of both early and late tracheid length reached 40%. The results of the study have shown that in the dominant tree the increase of the juvenile wood is greater than in the intermediate or suppressed trees. A similar observation based on the measurements of pine trees was published by Spława-Neyman et al. (1995), who suggested that an increase of the size of the assimilation apparatus of trees can be responsible for as much as 50% increase in the contribution of juvenile wood.

CONCLUSIONS

The above-discussed results of the study permit drawing the following conclusions:

1. In the juvenile wood from the suppressed tree of Douglas fir the contribution of late wood can be even twice greater than in the dominant tree. The contribution of late wood in the mature wood from the suppressed tree is only 10% greater than in the dominant tree.
2. With decreasing biosociological position of trees the density of wood increases.
3. With increasing biosociological position of a tree in a stand the period of the juvenile wood formation increases. For the suppressed tree this period is 12 years, while for the dominant tree it increases to 25 years.
4. The mean length of tracheids in the wood from the suppressed trees is by ~30% and intermediate trees is by ~20% smaller than in that from the dominant tree.

Received in November 2001

REFERENCES

Bannan M.F. (1965): The length tangential diameter and length width ratio of conifer tracheids. Canad. Jour. of Bot., 43: 967-984.

Dinwoodie J.M. (1961): Tracheid and fibre length in timber. A review of literature. Forestry, 34: 125-144.

Dinwoodie J. M. (1963): Variation in tracheid length in *Picea sitchensis*. London Forest Products Research, Spec. Rep. No 16.

Duffild J.W. (1964): Tracheid length variation patterns in douglas-fir and selection of extreme variants. Tappi, 47(2): 122-124.

Larson P. R. (1962): A biological approach to wood quality. Tappi, 45: 443-448.

Mc Kimmy M.D. (1966): A variation and heritability study of wood specific gravity in 46-year-old douglas-fir from known seed sources. Tappi, 49(12): 542-549.

Niedzielska B. (1995): Zmienność gęstości oraz podstawowych cech makroskopowej struktury drewna jodły (*Abies alba* Mill.) w granicach jej naturalnego zasięgu. Zeszyty Nauk AR Kraków, 198: 1-75.

Panshin A., de Zeeuw C. (1980): Textbook of wood technology. McGraw-Hill Book Comp., New York.

Schultze-Dewitz G. (1961): Notes concerning the influence of the position of tree on its anatomical structure. Holzforschung, 15: 89-91.

Spława-Neyman S., Pazdrowski W., Owczarak Z. (1995): Biometryczne parametry budowy drewna sosny zwyczajnej (*Pinus sylvestris* L.) w aspekcie więźby sadzenia upraw. Folia Forestalia Pol. 26: 73-84.

GĘSTOŚĆ I DŁUGOŚĆ CEWEK DAGLEZJI ZIELONEJ (*Pseudotsuga menziesii* Franco) W ZALEŻNOŚCI OD STANOWISKA BIOSOCJALNEGO W DRZEWOSTANIE

W pracy przedstawiono promieniową zmienność gęstości umownej i długości cewek 50 letnich drzew daglezji zielonej (*Pseudotsuga menziesii* Franco) należących do klasy drzew górujących, średnich i opanowanych. Stwierdzono, że gęstość drewna niezależnie od stanowiska biosocjalnego drzewa w drzewostanie rośnie w miarę oddalania się od rdzenia. Wzrost ten jest najbardziej widoczny w przypadku drzew opanowanych. Również gęstość drewna drzew opanowanych jest wyższa od gęstości drzew średnich i górujących. Długość cewek na przekroju poprzecznym pnia wzrasta w kierunku od rdzenia ku obwodowi do pewnej maksymalnej wartości, a następnie stabilizuje się. Przeciętna długość cewek wczesnych i późnych w drewnie drzew opanowanych jest o około 30%, a średnich o 20% mniejsza niż w drewnie drzew górujących. Strefa drewna młodocianego obejmuje w drzewie opanowanym 12, w drzewie średnim 15, a w drzewie górującym 25 przyrostów rocznych.

Authors' address
Dr inż. Ewa Fabisiak
Prof. dr hab. Waldemar Moliński
Katedra Nauki o Drewnie
Akademia Rolnicza w Poznaniu
60-627 Poznań, ul. Wojska Polskiego 38/42
POLAND