# The relative length and length of the crown of 35 -year-old pine trees and its relationships with growth space 

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#### Abstract

The paper presents the formation of length and relative length of the 35 -year-old pine trees crowns, depending on the biosocial position of a tree in a stand and growth space of a single tree. A crown width and its degree of deflection were used as measures of the growth of individual trees in the stand.

Growth space, crown ratio, crown length, pine


## Introduction

The size of the tree crown is an indicator of the tree growth energy. Burger and Badoux were the precursors of extensive research concerning the construction and shape of the crowns (Borowski 1974), and Lemke (1966) in Poland. The size of the crown can be described with different dimensional characteristics, including the length and relative lengths of the crown.

The length of tree crown indicates the viability of the tree and is taken in assessing the ability of trees to photosynthesis (Daniels and Burkhart 1975). Taking into consideration the fact that shoots and meristem growth, as well as initiation of roots growth, takes part in the crown, the relative length of the crown can be a good indicator of the tree ability to increment (Monserud 1975). The crown features - the length and its relative length - are both determinants of competition with respect to the use of the tree growth space potential (eg Monserud 1975, Daniels and Burkhart 1975).

Measuring the length of the crown may be difficult to implement especially in dense stands. Therefore, research began to focus also on the development of the crown length and crown relative length models.

The aim of the study is to describe shaping of the relative length and the length of 35 -year-old pine crowns depending on the biosocial their position and relationship with the space of a single tree. The crown width and its degree of deflection were used as measures of the growth space of the individual tree in the stand.

## Materials and methods

The research material was collected from 35-year-old pine stand growing on fresh coniferous forest (FCF) in Zielonka Experimental Forest District. There were 50 trees randomly selected from the stand. Biosocial position according to Kraft classification was established for each tree before harvesting. Breast height diameter with bark of standing trees was measured in two directions - NS and EC (accurate within $0,1 \mathrm{~m}$ ), and the arithmetic mean of these measurements was taken as the tree diameter at breast height ( $d_{l, 3}$ ). After cutting, the tree length (accurate within $0,01 \mathrm{~m}$ and adopted as tree height ( $h$ ) ) was measured, as well as the height of the crown base, to the first living branch considering as the basis of a crown closure. Crown length $l_{k}$ was calculated as the difference between the total height of the tree and the height of the
crown base. The relative crown length $l_{k} / h$ was calculated as the ratio of crown length to the tree height. The crown width and its degree of spread were adopted as growth measures of a single tree. Crown width - $d_{k}$ (in meters) was obtained from the crown projection area adopted from area of a circle. Crown projection area was based on the projection of tree crown characteristic points. Crown deflection coefficient was calculated as the ratio of the crown diameter to the tree height $d_{k} / h$.

## Results

The absolute mean and relative length of the analyzed pine crowns decreases with deterioration of trees biosocial position (Table 1, Fig. 1). The arithmetic mean obtained for all analyzed trees is similar to the mean for trees from $3{ }^{\text {rd }}$ Kraft class which, in the drawn sample, constitutes the largest group. The variability in both absolute and relative length of the crown is lower in Kraft classes than in the whole sample (Table 1).

Table 1. Statistical characteristics of tree crown traits in the biosocial classes

| Statistical traits | All <br> trees | Kraft's class |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | I | II | III | IVa | IVb | Va |
| Number of trees | 50 | 9 | 10 | 16 | 8 | 3 | 4 |
| Crown length $l_{k}[\mathrm{~m}]$ |  |  |  |  |  |  |  |
| The minimum | 2,80 | 5,39 | 4,57 | 3,68 | 2,95 | 3,09 | 2,80 |
| The maximum | 9,01 | 9,01 | 7,25 | 5,75 | 5,05 | 5,07 | 3,69 |
| The arithmetic mean | 4,92 | 6,62 | 5,59 | 4,64 | 4,03 | 3,88 | 3,15 |
| The standard deviation | 1,31 | 1,16 | 0,89 | 0,62 | 0,73 | 1,05 | 0,38 |
| The coefficient of variation | 26,59 | 17,50 | 15,99 | 13,28 | 18,10 | 27,03 | 12,19 |
| Crown ratio $l_{k} / h$ |  |  |  |  |  |  |  |
| The minimum | 0,23 | 0,37 | 0,33 | 0,28 | 0,23 | 0,26 | 0,26 |
| The maximum | 0,55 | 0,55 | 0,53 | 0,44 | 0,40 | 0,35 | 0,31 |
| The arithmetic mean | 0,37 | 0,44 | 0,40 | 0,35 | 0,33 | 0,31 | 0,28 |
| The standard deviation | 0,07 | 0,06 | 0,06 | 0,04 | 0,06 | 0,05 | 0,02 |
| The coefficient of variation | 19,04 | 13,37 | 16,03 | 12,70 | 18,38 | 16,49 | 8,33 |



Fig. 1. The arithmetic mean of pine trees crown length and relative crown ratio and their variability in the biosocial classes

The length of the 35 -year-old pine trees crown increases with the diameter at breast height and tree height, as well as with crown width and its degree of spread. It decreases with deterioration of tree biosocial position. A similar order of compounds strength was found in relation to the relative length of the crown, but its strength was weaker than in a case of the crown length. The crown length shows the strongest correlation with relative length (Table 2).

Table 2. The correlation diagram

| Tree traits | $l_{k} / h$ | Kraft's <br> class | $d_{l .3}$ | $h$ | $d_{k}$ | $d_{k} / h$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $l_{k}$ | 0.951 | -0.670 | 0.800 | 0.802 | 0.673 | 0.483 |
| $l_{k} / h$ |  | -0.575 | 0.655 | 0.589 | 0.593 | 0.476 |
| Kraft's class |  |  | -0.785 | -0.728 | -0.682 | -0.553 |
| $d_{l .3}$ |  |  |  | 0.845 | 0.780 | 0.594 |
| $h$ |  |  |  |  | 0.652 | 0.387 |
| $d_{k}$ |  |  |  |  |  | 0.948 |

Taking into consideration the fact that the measurement of the crown length can be difficult to make in the stand, a model to estimate the crown length was developed based on the knowledge of simple crown features, which are also measures of the growth space - crown width and its degree of spread.

$$
l_{k}=3,4653+4.4907 \cdot d_{k}-50.3829 \cdot d_{k} / h
$$

The equation estimated at the level of $69 \%$ describes the variability of crown length by the width variability and degree of the crown spread (Table 3).

Table 3. Multiple and partial correlation coefficients for the crown length dependence on crown diameter $d_{k}$ and degree of crown spread $d_{k} / h$

| $R_{\text {multiple }}$ | $100 R^{2}$ | $R_{\text {partial }}$ |  |
| :---: | :---: | :---: | :---: |
|  |  | $d_{k}$ | $d_{k} / h$ |
| 0.8307 | 69.01 | 0.7720 | -0.6582 |

## Discussion

Research by Svensson (1998) carried out on a large material of pine and spruce sample trees showed the necessity of taking into account the crown characteristics (crown relative length) in determining density increment.

Skrzyszewski (1995) showed the relationship of crown length with the current 10 -year increment in crosssectional area at the breast height in 11 out of a total of 15 analyzed spruce stands. The relative length of the crowns influences in a statistically significant way the tree growth in 9 out of a total of 15 stands. Author also found the relationship between these features in the case of larch trees. The crown length and width were significantly associated with increase in cross-sectional area at the breast height in 6 out of 7 stands. Relative crown length showed the same connection in 4 out of 6 stands. The relationship between these traits was stronger in larch than spruce (Skrzyszewski 1995).

Jaworski et al. $(1988,1995)$ have demonstrated the relationship between the crown relative length and the annual tree growth in younger fir stands with correlation coefficient at the level 0.579 , and 0.515 in elder stands.

The crown relative length was successfully used to estimate the tree growth. Monserud and Sterba (1996) showed a strong significant effect of relative crown length on the size of cross-sectional area increment for all forest tree species in Austria. Monserud (1975) found a significant effect of relative crown length on tree height increment in 11 out of 12 species tested, while on the DBH increment - in 9 out of 12 . Wykoff (1990) showed a high significance of the impact of this feature on the growth of cross- sectional area in all 11 surveyed conifer stands. Daniels and Burkhart (1975) used the relative crown length to determine the increase in DBH of pine plantations situated in South - East part of the USA.

Turski et al. (2012) showed that the average length of crowns decreased with decreasing trees Kraft class, and increases with their age. The average crow length of 92-year-old predominant stand was 1.2 times greater than that obtained in a 77 -year-old stand, and 1.3 times higher than in the 47-year-old one. In each of those three stands was also found a pattern where relative crown length was decreasing with the decline of tree biosocial position.

Very interesting conclusions were reached by larch tree researchers from China (Jiang and Liu 2011). The crown relative length was used to model the longitudinal tree cross-section. The equation based on this tree feature received coefficient of determination on level of $98 \%$. These studies confirm the results of work on the influence of crown dimensions on the longitudinal tree cross-section (Muhairwe 1994; Sharma and Zhang 2004; Jiang et al. 2007).

## Conclusions

1. The absolute mean and relative crown length of analyzed pines decreases with deterioration of biosocial position of a tree in the stand.
2. The crown length is most strongly correlated with its relative length.
3. The crown length increases with the increase of diameter at breast height and the tree height.
4. The crown length is also growing with the increase of the crown width and its degree of spread.
5. Tree crown length decreases with the deterioration of the biosocial position of tree in a stand.
6. The crown length of 35 -year-old pines can be estimated with $69 \%$ accuracy, on the basis of the crown width and its degree of spread measured:

$$
l_{k}=3,4653+4.4907 \cdot d_{k}-50.3829 \cdot d_{k} / h
$$

## List of Literature

1. BOROWSKI M. 1974. Przyrost drzew i drzewostanów. PWRiL, Warszawa.
2. DANIELS R.F., BURKHART H.E. 1975. Simulation of individual tree growth and stand development in managed loblolly pine plantations. College of Forestry an Wildlife Resources. Virginia Technical Institute, Blacksburg.
3. JAWORSKI A., KACZMARSKI J., PACH M., SKRZYSZEWSKI J., SZAR J. 1995. Ocena żywotności drzewostanów sosnowych w oparciu o cechy biomorfologiczne koron i przyrost promienia pierśnicy. Acta Agraria et Silvestria series Silvestris, vol. 33.
4. JAWORSKI A., PODLASKI R., SAJKIEWICZ P. 1988. Kształtowanie się zależności między żywotnością i cechami biomorfologicznymi korony a szerokością słojów rocznych u jodeł. Acta Agraria et Silvestria series Silvestris, vol. 27.
5. JIANG L, BROOKS JR, HOBBS GR. 2007. Using crown ratio in yellow-poplar compatible taper and volume equations. Northern Journal of Applied Forestry 24: 271-275.
6. JIANG L., LIU R. 2011. Segmented taper equations with crown ratio and stand density for Dahurian Larch (Larix gmelinii) in Northeastern China. Journal of Forestry Research 22(3): 347-352.
7. LEMKE J. 1966. Korona jako kryterium oceny dynamiki wzrostowej drzew w drzewostanie sosnowym. Folia Forestalia Polonica, seria A 12: 185-236.
8. MONSERUD R.A. 1975. Methodology for simulating Wisconsin Northern hardwood stand dynamics. Ph.D. Thesis. University of Wisconsin, Madison.
9. MONSERUD R.A., STERBA H. 1996. A basal area increment model for individual trees growing in even- and uneven-aged forest stands in Austria. Forest Ecology and Management: 80: 57-80.
10. MUHAIRWE CK. 1994. Tree form and taper variation over time for interior lodgepole pine. Canadian Journal of Forest Research 24: 1904-1913.
11. SHARMA M, ZHANG SY. 2004. Variable-exponent taper equations for jack pine, black spruce, and balsam fir in eastern Canada. Forest Ecology and Management 198: 39-53.
12. SKRZYSZEWSKI J. 1995. Charakterystyka przyrostowa oraz kształtowanie się zależności pomiędzy wybranymi cechami drzew a przyrostem promienia na pierśnicy świerka i modrzewia. Acta Agr. Silv. Ser. Silv. Vol. 33.
13. SVENSSON S.A. 1998. Estimation of annual stem volume increment. SUAS, Dept. of Forest Survey Report 46, Umea.
14. TURSKI M., JASZCZAK R., DEUS R. (2012): Wybrane charakterystyki koron drzew i ich związek z pierśnica oraz wysokością w drzewostanach sosnowych różnych klas wieku. Sylwan 156 (5): 369-378.
15. WYKOFF W.R. 1990. A basal area increment model for individual conifers in Northern Rocy Mountains. Forestry Science 36: 10771104.

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Summary

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