# Basic density of wood in different forest type

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**Abstract** The aim of this work is to determinate an average tree ring width and basic density of Norway spruce (*Picea abies* /L./Karst.) growing in different vegetation forest zones. Norway spruce is the most important commercial specie in Czech republic and its portion of forest stands is 53 %. The typological system of forest stands consists of horizontal (edaphic categories) and vertical (vegetation zones) zonation. There are statistically significant differences between the values of basic density and tree ring width according to vegetation zones and edaphic categories, however , statistically significant differences between the values of tree ring width can be observed only for $4^{th}$- $6^{th}$ vegetation zones. Differences between values of basic density and tree ring width according to edaphic categories are statistically highly significant especially for $5^{th}$ and $6^{th}$ vegetation zones. We can observe close relation between tree ring width and basic density, with increasing basic density tree ring width decrease. In summary, results of this study provide evidence of the influence of growth conditions to wood formation.

**Key words:** *basic density; tree ring; vegetation zone; edaphic category; Norway spruce*

## Introduction

Wood is important renewable raw material for energy generation, building, veneering, furniture making. Its mechanical and physical properties make the wood one of the most important structural materials, because of its big stiffness and strength and relatively low density. We can't omit its desirable acoustical properties. All physical and mechanical properties are defined by structure and density of wood, i.e. by amount and distribution of structural elements.

Wood structure and thus its properties are determined during tree ontogeny. Anatomical structure reflects all environmental (abiotic and biotic) and genetic factors operated on a tree during its life. The influence of the stand (growing conditions) on wood properties is to be examined for a long period.

The one year increment of wood compounds from the layer of earlywood, created during the initial period of growing season and typical by the wide cells with thin cell wall, and latewood, that is created during and at the end of growing season and is characterized by substantially thicker cell wall but narrower radial dimensions than earlywood (Vavrčík 2002). The radial dimensions of a cell and dimension of cell wall is influenced by temperature and water availability. Increasing temperature during earlywood formation period causes shortage of phase of radial expansion of young wood cells and therefore the radial dimensions of cells are smaller than normal. If the tree experiences higher temperatures during latewood formation period, the phase of radial expansion is prolonged. The maturing period extends if the temperature of environment is high for both earlywood and latewood. That leads to the significantly thicker cell wall.

Precipitation affects positively the radial growth period and maturing period and causes prolongation of these (Vavrčík 2002). The thickness of cell walls in newly foramted wood depends on the carbohydrates stock, and is therefore indicator of metabolic proceeds of a given year (Larcher 1988).

The wood density is one of the most basic parameters of wood quality. It affects substantially mechanical properties of wood. Due to different density of early- and latewood the treering width is very important factor of wood quality, because the portion of earlywood increases with increasing treering width. The early wood have lower density, lower strength and stiffness and have smaller shrinkage during moisture change (Horáček 1998).

## Materials and methods

Trial areas were selected and assessed by the typological classification of forest zones of Forest Management Institute (Plíva 1971). The typological system consists of horizontal and vertical division of zones. There are 9 forest vertical vegetation zones: (1) the oak zone, (2) the beech with oak zone, (3) the oak with beech zone, (4) the beech zone, (5) the silver fir with beech zone, (6) the Norway spruce with beech zone, (7) the beech with spruce zone, (8) the Norway spruce zone and (9) the mountain pine zone. The horizontal zonation applies to each one vertical vegetation zone. The zoning is based on general characteristics of soil environment, soil nutriens content and sometimes on the topography of the region. Primarily recognized are series, next on the basis of more detailed soil characteristics each series is subdivided into edaphic categories (tab.1). The age of stands in chosen areas was 70-100 years.

On each trial area 20 trees were randomly selected, the wood cores have been token using increment borer from each tree. The Ericson's procedure (Ericson 1959) was applied to calculate basic density for the whole stem radius. Basic density of wood was determined by the method of Olesen (1971).

Basic density is defined as

$$_{k} = \frac{m_0}{V_w}$$

where $\rho_k$ is basic density of wood, $m_0$ is mass of wood at moisture content 0 % and $V_w$ is volume of wood above saturation point.

Finely, the average tree ring width for each sample was determined as length of core/number of tree rings.

## Results and discussion

The influence of environment on wood properties have been statistically proved. The assumption of decrease of wood density with increasing tree ring width has been validated (fig.1). This is caused by increasing portion of thin walled early wood in wide tree rings of gymnosperms. The statistically significant differences between basic density values of samples from different vegetation zones and edaphic factors have been found. These are listed in the table 1 (according to vegetation zones) and table 2 (according to edaphic factors).

The highest value of basic density has been found for fourth (beech) vegetation zone – 445 kg·m$^{-3}$ Together with that, the smallest average tree ring width 1.57 mm has been found for this group. After Tukey test of multivariate comparison there are statistically significant differences between sub-categories of edaphic series gleyic and between and between sub-categories P and B. Interesting is basic density of wood in sub-category P (462 kg·m$^{-3}$) and generally higher values of basic density on stands with lower pH.

Similarly high values of basic density and small average tree ring widths are typical for second (beech with oak) vegetation zone (444 kg·m$^{-3}$, 1.65 mm) and third (oak with beech) vegetation zone (438 kg·m$^{-3,}$ 1.69 mm), whereas the difference between values of basic density and average tree ring width in vegetation zones 2 – 4 are not statistically significant.

High values of basic density can be caused by effect of high temperatures and by longer vegetation period. If the tree experiences high temperature, the phase of radial growth of earlywood tracheids is shorten and of latewood tracheids is prolonged, simultaneously the phase of maturing is prolonged. The production of latewood is therefore boosted up and the earlywood tracheids have thicker cell wall and smaller radial dimension the those growing in colder environment.

On the other hand, the smallest values of basic density can bee observed in eighth (spruce) vegetation zone (374 kg·m$^{-3}$), where is, however, narrow tree ring width (1.59 mm). It can be caused by production of latewood tracheids with thin cell wall, or perhaps by decreased production of latewood caused by lower average temperature during vegetation period in higher elevation. In the seventh vegetation zone (beech-spruce), on the contrary, the low value of basic density (378 $kg \cdot m^{-3}$) seems to be caused by raised portion of earlywood, because the average tree ring width is big (1.76 mm). There is significant difference between basic density in N and T edaphic category and others.

Economically the most important is fifth (beech with fir) vegetation zone, that takes 30 % of the total forest area. The average value of the basic density is 414 $kg \cdot m^{-3}$, and the average tree ring width is 1.81 mm. Statistically significant differences between edaphic categories can be found for M-I categories of acid series, where the values of the basic density higher, one exception is category gleyic – nutrient-poor with average value of basic density 460 $kg \cdot m^{-3}$. Similar to the pattern of results of 5$^{th}$ vegetation zone are results of sixth (spruce with beech), where the average value of basic density is 392 $kg \cdot m^{-3}$ and simultaneously the highest value of the average tree ring width 1.99 mm.

| Mean (n, stat. dev.) | oak with beech | beech with oak | beech | beech with fir | beech with spruce | spruce with beech | spruce | Mean |
|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| Basic Density (kg.m-3) | 443.98 *(200; 37.29)* | 437.57 *(340; 41.87)* | 445.00 *(282; 35.96)* | 413.98 *(589; 43.96)* | 392.34 *(465; 37.33)* | 377.66 *(219; 34.37)* | 374.14 *(400; 36.13)* | 409.61 *(2495; 47.17)* |
| Tree ring width (cm) | 0.165 *(200; 0.046)* | 0.169 *(340; 0.051)* | 0.157 *(282; 0.041)* | 0.181 *(589; 0.058)* | 0.199 *(465; 0.048)* | 0.176 *(219; 0.044)* | 0.159 *(400; 0.068)* | 0.175 (2495; 0.055) |

Tab. 1 Results according vegetation zones

Tab. 2 Results according edapfic categories

| edaphic factor | | | basic density ($kg.m^{-3}$) | tree ring width (mm) |
|---|---|---|---|---|
| extreme | xerothermal *(xerothermica)* | X | | |
| | scrub *(humilis)* | Z | 378.57 *(40; 35.30)* | 1.49 *(40; 0.36)* |
| | skeletal *(saxatilis)* | Y | | |
| acid | nutrient-poor *(oligotrophica)* | M | 454.89 *(181; 36.36)* | 1.22 *(181; 0.36)* |
| | acidic *(acidophila)* | K | 403.19 *(429; 49.6)* | 1.54 *(429; 0.64)* |
| | stony-acidic *lapidosa acidophila)* | N | 427.34 *(121; 37.0)* | 1.56 *(121; 0.37)* |
| | compacted-acid *(illimerosa acidophila)* | I | 440.34 *(120; 41.22)* | 1.65 *(120; 0.36)* |
| rich in nutrients | fresh, nutrient-medium *(mesotrophica)* | S | 393.97 *(281; 41.98)* | 1.87 *(281; 0.46)* |
| | slope (stony) nutrient-medium *(lapidosa mesotrophica)* | F | 383.78 *(40; 43.23)* | 2.29 *(40; 0.30)* |
| | water-deficient *(subxerothermica)* | C | | |
| | nutrient-rich *(eutrophica)* | B | 403.69 *(141; 44.29)* | 2.14 *(141; 0.47)* |
| | limestone *(calcaria)* | W | | |
| | loamy (compacted, nutrient-rich) *(illimerosa trophica)* | H | 421.39 *(80;39.3)* | 2.06 *(80; 0.38)* |
| enriched with humus | enriched-collurial *(deluvia)* | D | 407.38 *(40; 45.76)* | 2.08 *(40; 0.40)* |
| | stony-colluvial *(lapidosa acerosa)* | A | 400.60 *(40; 26.23)* | 2.15 *(40; 0.36)* |
| | talus *(saxatilis acerosa)* | J | 449.97 *(20; 36.21)* | 1.57 *(20; 0.45)* |
| enriched with watwr | floodplain *(alluvialis)* | L | | |
| | valley *(vallidosa)* | U | | |
| | mast to wet *(humida hygrophila)* | V | 399.86 *(101; 37.40)* | 2.05 *(101; 0.37)* |
| gleyic | nutrient-medium *(variohumida trophica)* | O | 407.94 *(241; 40.7)* | 1.95 *(241; 0.49)* |
| | acidic *(variohumida acidophila)* | P | 427.07 *(162; 46.42)* | 1.78 *(162; 0.47)* |
| | nutrient-poor (varihumida oligotrophica) | Q | 417.21 *(180; 49.4)* | 1.45 *(180; 0.44)* |
| water-logged | nutrient-poor, wet *(paludosa oligotrophica)* | T | 400.31 *(60; 42.46)* | 1.46 *(60; 0.36)* |
| | nutrient-medium, wet *(paludosa mesotrophica)* | G | 373.34 *(120; 35.39)* | 2.04 *(120; 0.51)* |
| peaty | nutrient-medium *(turfosa)* | R | 379.35 *(98; 35.26)* | 1.92 *(98; 0.46)* |
| | nutrient-poor *(turfosa)* | | | |
| mean | | mean (n; std. dev) | 409.61 *(2495; 47.17)* | 1.75 *(2495; 0.55)* |

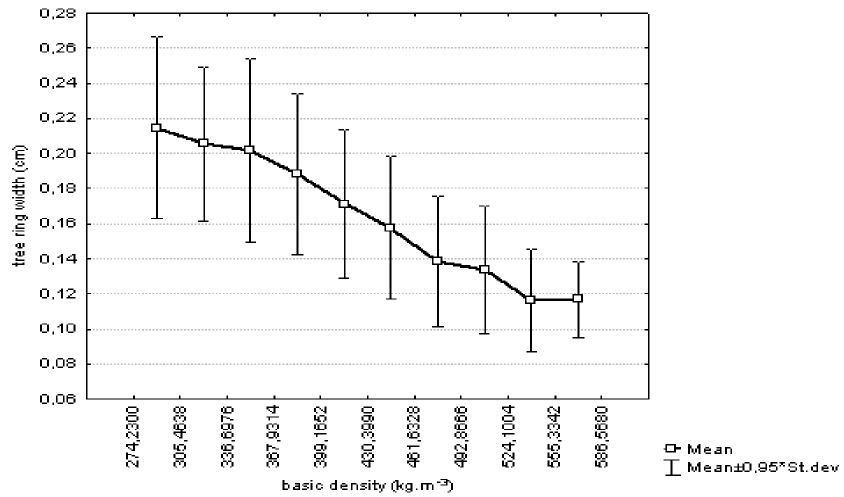


Fig. 1 Relation between basic density and tree ring width

## Conclusions

Significant influence of environment on wood properties have been proved. The highest value of basic density has been found for fourth (beech) vegetation zone and generally we can say that higher values of basic density are on stands with lower pH. The assumption of decrease of wood density with increasing tree ring width has been validated. To conclude, the research results of environment impact to properties of wood can improve forestry and wood industry management.

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