Inferences on Wood Density Variability in European Ash Growing in Two Different Floodplain Forest Sites

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Abstract. Wood density variations in 110-year-old European ash (*Fraxinus excelsior* L.) wood was examined in relation with different water regime treatments in two floodplain forest sites of similar elevation (Lednice 161 m a.s.l. and Tvrdonice 154 m a.s.l.) in South Moravia - Czech Republic, in order to infer on the oven-dry wood variability. Sample logs were obtained from breast height 1.3 m of the ground (log length 1 m) from 10 tree stems, i.e. 5 from each site. The oven-dry density was calculated along the radius of the stem cross section per tree and was compared between sites. The average oven-dry wood density of European ash was found significantly different for Lednice and Tvrdonice (689.8 kgm^{-3} and 665.1 kgm^{-3} respectively).

Keywords: floodplain forests; *Fraxinus excelsior* L.; oven-dry density; variability.

1 Introduction

European ash (*Fraxinus excelsior* L.) usually grows in mixed broadleaved forests as well as a groupwise admixture into oak, beech and alder stands (Dobrowolska et al. 2008). It also appears as a dominant species in floodplain forests and in moist clay-loam lowlands or even in relatively dry calcareous sites. This wide range of site types where European ash thrives, is attributed to a generally high tolerance in relation to water and nutrients (Střeštík and Šamonil 2006; Dobrowolska et al. 2011). Furthermore, it tolerates short-term flooding, although stagnant water is unfavorable for the species due to the limited oxygen supply. Vreugdenhil et al. (2006) reported intense negative effects of flooding on European ash growth.

European ash trees cover approximately 1.4 % of forest land areas in the Czech Republic (Ministry report 2014). The species commonly grows within the lowland belt which includes areas adjacent to large lowland rivers (below 210 m a.s.l.) covered mostly by floodplain forests, wetlands, inundated meadows, but also by sandy grasslands and saline habitats (Chytrý 2012).

European ash belongs to ring-porous hardwoods with a whitish to light brown sapwood and a dark brown heartwood, which is formed in older trees (Zeidler 2012). Aesthetically superior with outstanding wood properties (Dobrowolska et al. 2008), it

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produces a valuable raw material for wagons, boats and ships, furniture, parquet flooring, ladders, beams etc. (Tsoumis 1991).

Density is considered to be one of the most determinant wood characteristics, directly related with physical and mechanical properties (Tsoumis 1991). Wood density (or specific gravity) depends on the size of the cells, the cell-wall thickness, and moreover on the interrelationship between the number and the different types of cells (Panshin and de Zeeuw 1980). Wood density depends on the tree-ring structure i.e. earlywood and latewood. Considering that latewood consists of cells with thicker walls and smaller lumina in comparison to earlywood, the larger the latewood is, the higher the density becomes (Panshin and de Zeeuw 1980; Tsoumis 1991). According to the reported negative relation between the tree-ring width and the age, it is obvious that higher density is expected to appear in the central part of a tree stem of ring-porous species (Kollman 1951; Tsoumis 1991).

The average oven-dry wood density ranges from 650 to 687 kgm^{-3} for European ash (Kollman 1951; Matovič 1984). Kollman (1951) presented that European ash tree-ring width was narrow (less than 5 mm) by the first 10–15 years, becoming proportionally wider up to 40 years of age, whereupon it decreased continuously. Physical and mechanical properties of European ash also vary with the age, reaching the highest values by 30–40 years old. The difference between the wood density values measured in the center and the outer part of European ash stem was 22 % (Matovič 1984).

Variations in wood density are very important for wood industry (Taylor and Wooten 1973). These inferences can become a useful tool for estimating intra-species and inter-species wood variability in order to indicate representative density values for future tree selection projects. Finally, delineating the wood density profile is likely to improve the accuracy of stem biomass estimation.

The current study aimed to infer oven-dry wood variability in European ash (*Fraxinus excelsior* L.) growing in floodplain forest sites with different water regime treatments.

2 Materials and Methods

Two sites along the middle and lower course of the Morava river and lower courses of other rivers (Dyje) in southern Moravia in the Czech Republic were chosen for obtaining the sampling material. The first site (A) was a floodplain forest mixed stand of English oak and European ash (60 % of oak and 40 % of ash) in Lednice (161 m a. s. l.) and the second (B) was another floodplain forest mixed stand of similar mixture (70 % of oak and 30 % of ash) in Tvrdonice (154 m a.s.l.) (Fig. 1).

Floodplains of these rivers have been strongly modified by floods and associated accumulation of loamy sediments. The emergence of floods increased after the deforestation of sub-montane and montane areas occurred in the medieval period (Ložek 2011). Typically the rivers flood after snowmelt in March–April and occasionally after heavy rainfall, mostly during summer but also randomly during the year. The incidence of floods has declined during the last decades as a result of regulating the course of the rivers by diverting and deepening the riverbed, as well as by constructing protective dikes (Prax et al. 2005). The site A was successfully regulated during ‘70s in order to lower the level of the water during floods. On the contrary, in the site B the water regime treatments were not successful enough to decrease the level. The mean annual temperature in the research area is 9.0–9.5°C and the annual precipitation amount is 500 mm (Chytrý 2012).

Five 110-year-old healthy European ash trees were selected randomly per site i.e. 10 trunks. Sample logs were obtained from breast height 1.3 m of the ground (log length 1 m). The mean diameter of the trunks ranged from 39.5 to 53.5 cm (site A) and from 44.0 to 56.5 cm (site B). Specimens 20 × 20 × 30 mm for oven-dry density testing were obtained radially from bark to pith (A – J) and prepared as shown on Fig. 1. The specimens were dried up to 0 % of moisture content in a program oven (at 103 ± 2˚C). Each oven-dried specimen was measured in three anatomical directions and specimens were weighed. Oven-dry wood density of specimens was calculated as:

$$\rho o = \frac{\mathrm{mo}}{\mathrm{Vo}}, \quad (1)$$

where: m_0 – the oven-dry weight (kg)

V_0 – oven-dry volume (m^3)

R-program was used for statistical analysis (Students t-test, Tuckey’s range test).

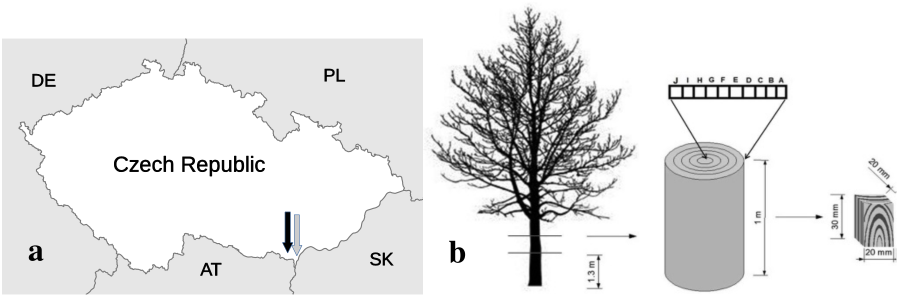

Fig. 1a. Sampling sites (Lednice-black arrow and Tvrdonice-grey arrow) in the Czech Republic, **b**. Sampling method.

3 Results and Discussion

The average oven-dry density of the specimens obtained from both sites (A and B) was found to be 677.3 kgm^{-3} (CV = 8.7 %), which is in line with the literature for European ash oven-dry density (Kollman 1951; Matovič 1984). Lexa et al. (1952) resulted to 680 kgm^{-3}, which was the closest to our finding.

The successful water regime treatment regulations in the site A resulted to a higher average oven-dry density in European ash, which was found to be in average 689.8 kgm^{-3} (CV = 8.9 %) and ranged from 495.4 to 814.2 kgm^{-3}. The average oven-dry density of the specimens obtained from the site B was found lower (665.1 kgm^{-3}, CV = 8.2 %) ranging from 508.8 to 773.3 kgm^{-3} (Fig. 2a,c).

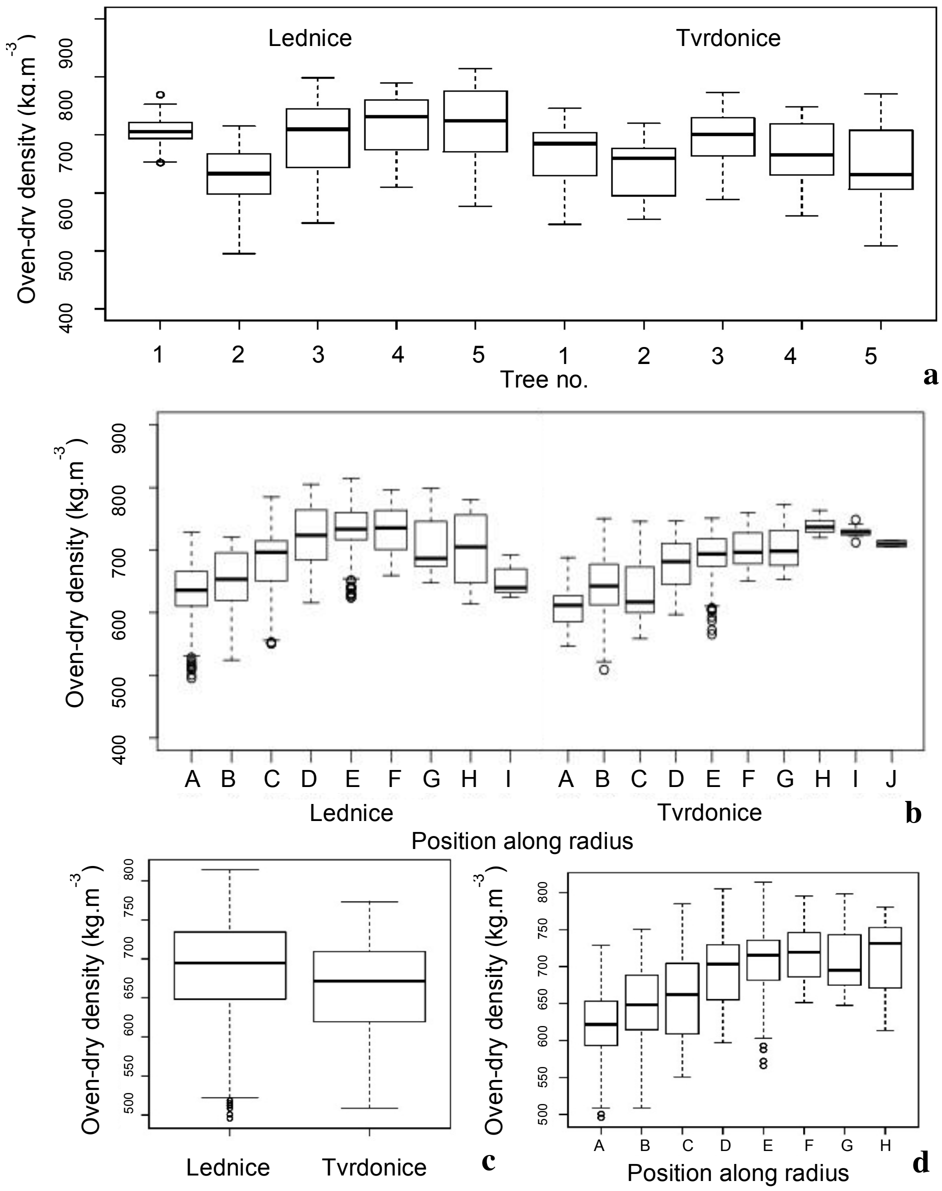

Fig. 2. a. Average oven-dry density per tree, **b.** Horizontal oven-dry wood density distribution, along radius from bark to pith (Lednice: A–I, Tvrdonice: A–J) per tree, **c.** Average oven-dry density per site, **d.** Horizontal oven-dry wood density distribution (both sites together).

The difference between the two sites was significant ($F = 1.3$, $p < 0.001$). The result of this study is in line with Matovič (1984) describing the negative relation between the oven-dry density of European ash wood and the level of the water during flooding.

The horizontal wood density variation analysis along radius (from bark to pith) differed significantly among the trees within the same or between two sites (Fig. 2b, d). In the site A, the highest average oven-dry density was found 732.6 kgm^{-3} (CV = 5 %) approximately 80 mm away from the pith (A–I), while in the site B, the highest average oven-dry density (739.3 kgm^{-3}, CV = 1.7 %) was located approximately 20 mm closer to the pith (A–I). Finally, in both sites (A + B) together, the highest average oven-dry density reached 718.0 kgm^{-3} (CV = 5 %), measured approximately 80 mm away from the pith. In all cases (A, B, A + B sites), the outer margins of the radial sections (close to bark and pith) presented significantly lower average oven-dry density than the central parts, which is in accordance with Matovič (1984). Furthermore, lower oven-dry density was observed to the specimens obtained closer to the bark in comparison with the samples that came from the parts closer to the pith, probably due to the sapwood area.

4 Conclusions

In this study, the highest average oven-dry density was found approximately 80 mm away from the pith. The margins of the radial sections (bark and pith) presented significantly lower average oven-dry density than the central parts in accordance also with Kollman 1951. Furthermore, in line with Matovič (1984), it was concluded during this research that the successful water regime treatment regulations in the site A resulted to a higher average oven-dry density in European ash.

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References

1. Chytrý, M. (2012) Vegetation of the Czech Republic: diversity, ecology, history and dynamics. Preslia 84: 427–504.
2. Dobrowolska, D., Hein, S., Oosterbaan, A., Skovsgaard, JP and Wagner, S.P. (2008) Ecology and growth of European ash (*Fraxinus excelsior* L.). 35 pp. http://www.valbro.uni-freiburg.de/

3. Dobrowolska, D., Hein, S., Oosterbaan, A., Wagner, S., Clark, J. and Skovsgaard, J.P. (2011) A review of European ash (*Fraxinus excelsior* L.): implications for silviculture. Forestry, 84(2): 133–148. doi:10.1093/forestry/cpr001.
4. Kollmann, F. (1951) Technologie des Holzes und der Holzwerkstoffe. 2nd ed. Berlin: Springer-Verlag, p. 1050.
5. Lexa J., Nečesany V., Paclt J., Tesařova M. and Štofko J. (1952) Mechanické a fyzikálne vlastnosti dreva. Mechanical and physical properties of wood [in Slovak]. Bratislava, Práca – vydavateľstvo ROH. p.432.
6. Ložek, V. (2001) Molluscan fauna from the loess series of Bohemia and Moravia. Quatern. Int. 76–77: 141–156.
7. Matovič, A. (1984) Makroskopická stavba, fysikální a mechanické vlastnosti dřeva jasanu úzkolistého (*Fraxinus excelsior* L.). Macroscopic structure, physical and mechanical properties of wood of European ash (*Fraxinus excelsior* L.) [in Czech]. Drevársky výskum 29(4): 1–24.
8. Ministry report (2014) Report on Forest and Forestry in the Czech Republic by 2013 (In Czech). eAGRI. http://eagri.cz/public/web/mze/lesy/lesnictvi/zprava-o-stavu-lesa-a-lesniho/zprava-o-stavu-lesa-2013.html. Accessed 16 February 2015.
9. Panshin, A.J. and de Zeeuw, C. (1980) Textbook of wood technology: Structure, identification, properties, and uses of the commercial woods of the United States and Canada. New York: McGraw-Hill, p. 722.
10. Prax, P., Prax, A., Kloupar, M., Heteša, J., Sukop, I. (2005) Optimization of hydrological system of floodplain forest ecosystem after anthropogenic influence and its utilization in forest management of Tvrdonice forestland. Grant Agency of Czech State Forest, Teplice, Czech Republic. Final report, p. 64.
11. Střeštík, S. and Šamonil, P. (2006) Ecological valence of expanding European ash (*Fraxinus excelsior* L.) in the Bohemian Karst (Czech Republic). Journal of forest science, *52*(7): 293–305.
12. Taylor, F.W. and Wooten, T.E. (1973) Wood property variation of Mississippi delta hardwoods. Wood and Fiber Sci. 5(1): 2–13.
13. Tsoumis, G.T. (1991) Science and technology of wood: Structure, properties, utilization. New York: Chapman & Hall, p. 494.
14. Vreugdenhil, S. J., Kramer, K. and Pelsma, T. (2006) Effects of flooding duration, -frequency and -depth on the presence of saplings of six woody species in north-west Europe. For. Ecol. Manage. 236(1): 47–55.
15. Zeidler, A. (2012) Wood Lexicon. Czech University of Life Sciences, Faculty of Forestry and wood Sciences. p.7–8.