



**European standard for  
round and sawn timber  
(method of measurement of  
dimensions) – influence on  
volume losses**



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# Introduction

- European standards relating to dimensions of round timber date from **27 February 1997** (date of ratification) and were superseded by several others.
- Today's valid standard for round wood measurement is the **EN 1309-2:2006 standard** (Round and sawn timber – Method of measurement of dimensions – Part 2: Round timber – Requirements for measurement and volume calculation rules).
- This standard gives basic principles, which are to be followed when drawing up round wood measurement and volume calculation rules.
- This standard applies to the **rules for measuring hardwood and softwood felled round timber**. It does not apply to tropical timber.



# Introduction

- In Croatia, depending on the method of timber processing usually, tree length or cut-to-length scaling of timber is performed either in the stand (cut-to-length method, chainsaw + forwarder) or on the roadside landing site (tree length, half-tree length, chainsaw + skidder).
- Timber scaling is also regulated by several regulations (by-laws) and standards that prescribe exact information of each produced log: tree species, length, middle diameter, log volume, place (origin) of scaling and person responsible for timber scaling which is in accordance with the EU Timber Regulation i.e. Forest Law Enforcement, Governance and Trade (FLEGT) Action Plan.

Road-side landing  
– tree length timber processing method –



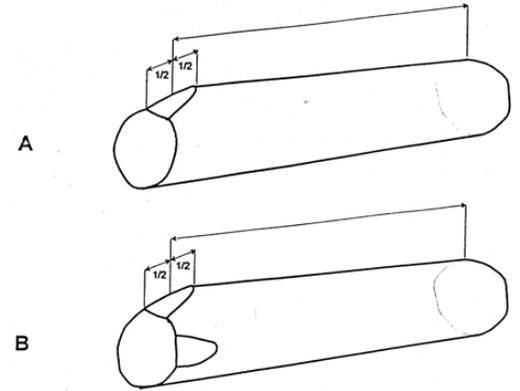
Forest stand  
– cut-to-length timber processing method –



## Materials and Methods

European standard EN 1309-2:2006 (E) defines measurements of:

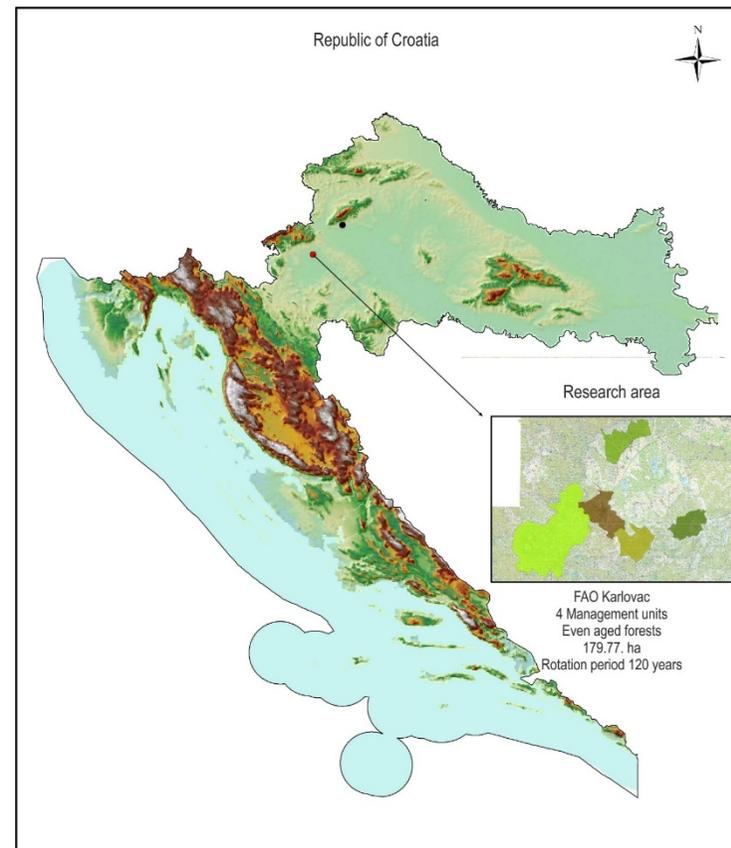
- Length → **shortest length** (accuracy of at least one centimetre). Timber with an undercut or butt trimming should be measured from **the middle of the undercut** or the butt trimming surface. The length is expressed in meters to one place of decimal **rounded down**.
- Diameter (over bark) → measured **under bark** at **mid-length** to an accuracy of at least one centimetre are **rounded down** (in case of over bark measure, conversion to a diameter under bark is necessary). The arithmetic mean of two measurements is rounded to the nearest centimetre according to the arithmetical rounding rule.
- Calculation of volume (round wood and stacks) → calculated by **Huber's equation** and expressed in cubic meters to two or three places of decimal. Ludolf's number ( $\pi$ ) is rounded to four places of decimal (3.1416).
- Weight (round wood and stacks).



$$V = \frac{\pi}{4} \cdot d^2 \cdot l \cdot 10^{-4}$$

# Materials and Methods

- Forest Administration Office (FAO) Karlovac in the central part of Croatia.
- 225 butt-logs of sessile oak (*Quercus petraea* (Matt.) Liebl.) from 27.5 cm to 67.5 cm diameter classes.
- The research was conducted in even-aged forests on the area of 179.77 ha with a rotation period of 120 years in eight different sub-compartments.
- The most common tree species in this FAO is European beech (*Fagus sylvatica* L.) at 50%, follow sessile oak at 13% and pedunculate oak (*Quercus robur* (Matt.) Liebl.) at 12%, the share of conifers is at 7%.



# Materials and Methods

## Measurements:

- Log length (L), expressed in metres and two places of decimal.
- Two diameters over bark at small end ( $d_1, d_2$ ), large end ( $D_1, D_2$ ), mid-length ( $d_{s1}, d_{s2}$ ), at the centre of volume (centroid) and on mid-length of each log section ( $d_{25-1}, d_{25-2}\dots$ ), expressed in centimetres and one place of decimal.
- For estimating log volume, four equations were used: Huber's, Smalian's, Riecke-Newton's and Centroid sampling.
- Control group was defined with a sectioning method, where each butt-log was divided into sections of 50 cm length where two diameters were measured at mid-length. Volume was then calculated by Huber's equation.

Smalian's 
$$v = \frac{(G+g)}{2} * L$$

Riecke-Newton's 
$$v = \frac{L}{6} * (G + 4 * g_s + g)$$

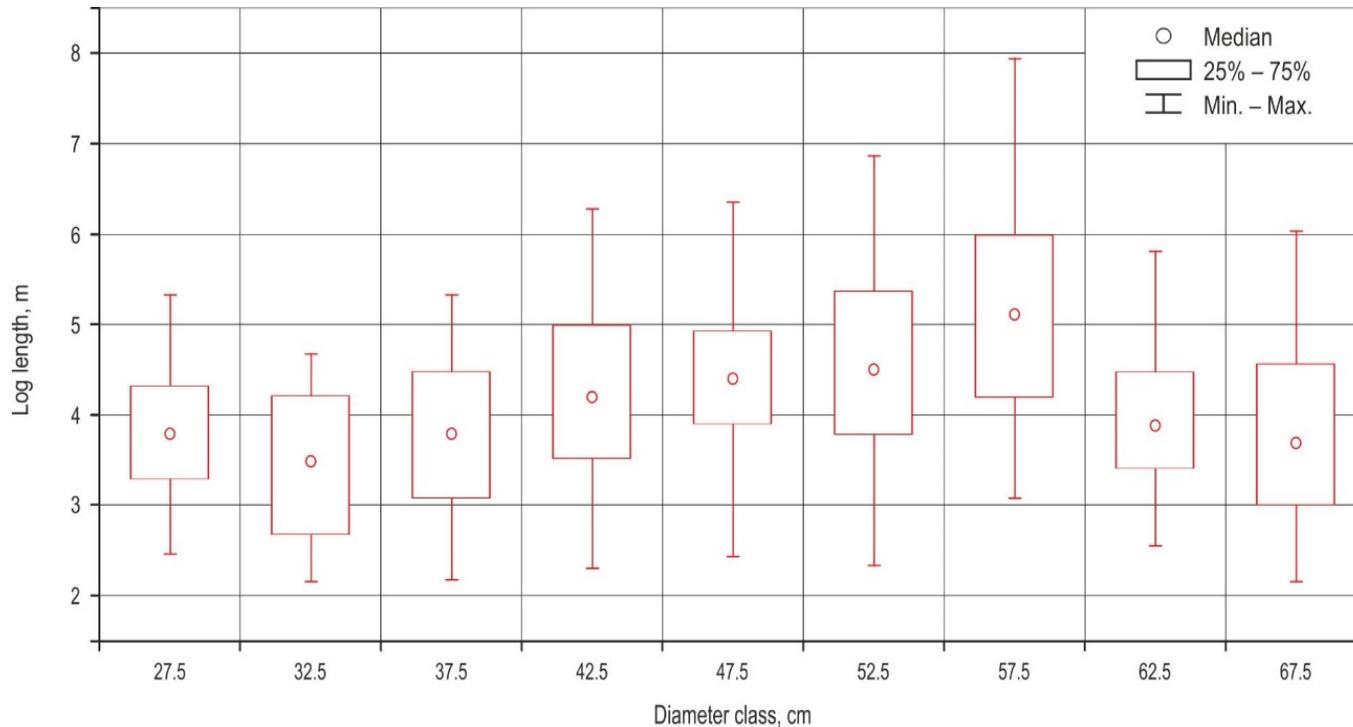
Centroid sampling 
$$v = g * L + \frac{b_1}{2} * L^2 + \frac{b_2}{3} * L^3$$

$$b_1 = \frac{G-g-b_2*L^2}{L} \quad b_2 = \frac{G-g_c*\frac{L}{e}-g*\left(1-\frac{L}{e}\right)}{L^2-L*e}$$

$$e = L - \left[ \frac{\left[ \sqrt{\left(\frac{D}{d}\right)^4 + 1 - \sqrt{2}} \right]}{\sqrt{2} * \left[ \left(\frac{D}{d}\right)^2 - 1 \right]} \right] * L$$



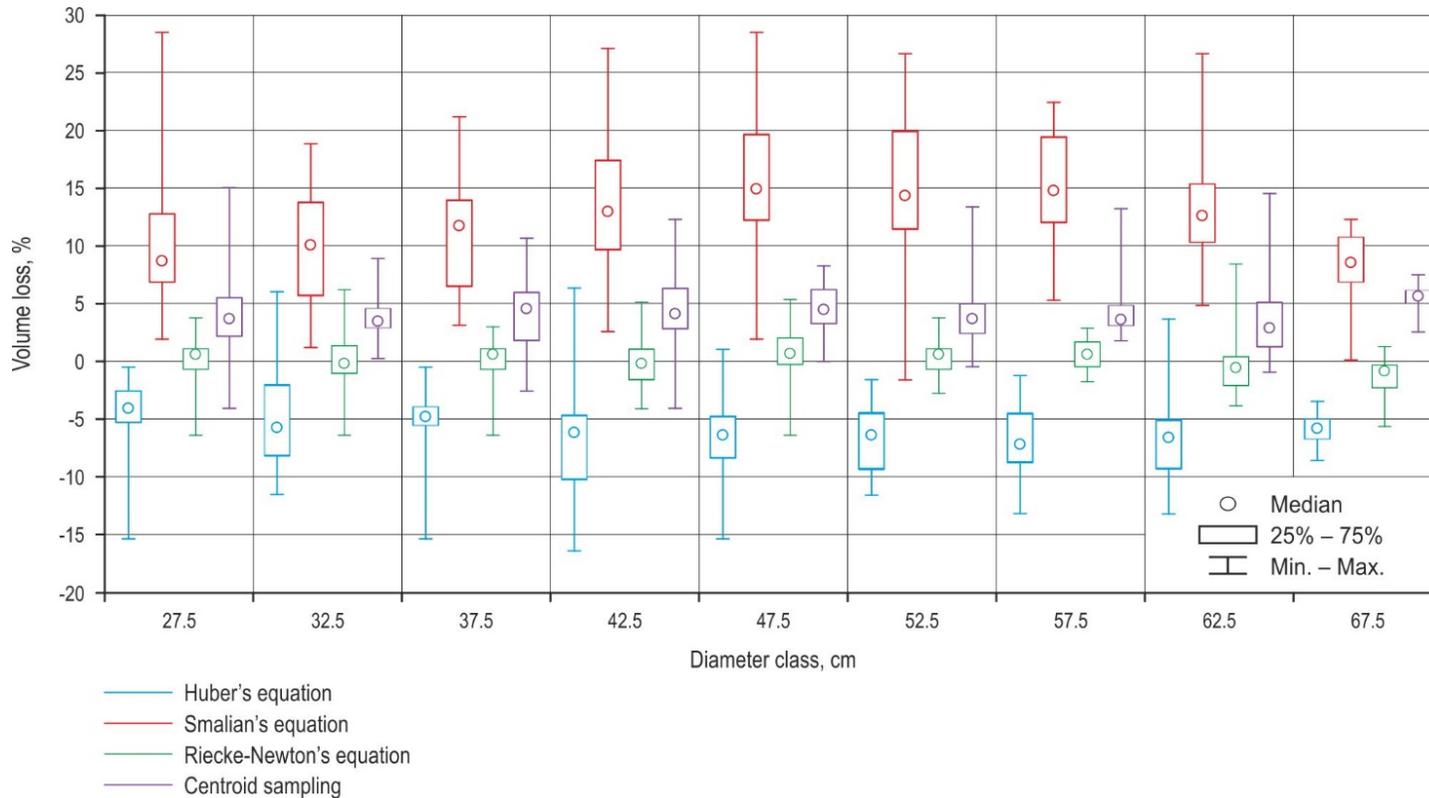
# Results



## Butt-log length measurements:

- Minimal length of butt-logs was at **2.11 m** and maximal at **7.98 m**.
- With the growth of mid diameter, butt-log length increased → the exceptions are diameter classes **62.5 cm** and **67.5 cm**, which were from older forest stands with many wood defects (ring shake, heart shake, rot) and butt-logs were bucked and cut to shorter lengths so that second logs could be classified in higher assortment classes.
- Taper of processed butt-logs ranged from 0.0 to 2.5 cm/m (median value for all 225 logs at **0.9 cm/m**).

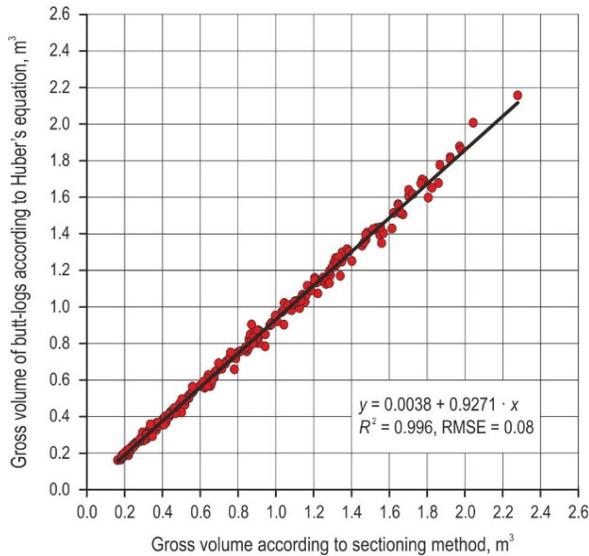
# Results – losses in volume due to different equations



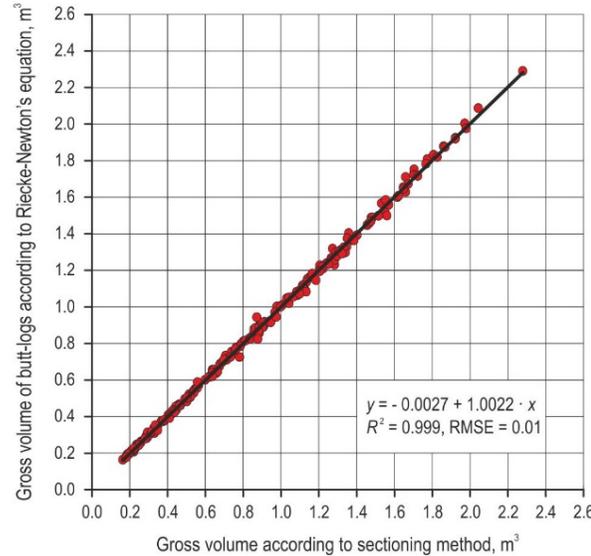
- Huber's equation gives **the lowest negative values** (average  $-6.0\% \pm 3.6$  standard deviation, median at  $-6.0\%$ ),
- Smalian's equation gives **the highest positive values** (average  $13.2\% \pm 5.9$  standard deviation, median at  $11.8\%$ ),
- Centroid sampling equation gives **slightly higher values** (average  $3.8\% \pm 3.1$  standard deviation, median at  $3.3\%$ )
- Riecke-Newton's equation is **the most accurate** (average  $0.0\% \pm 2.1$  standard deviation, median at  $-0.0\%$ ) in comparison to the sectioning method.

# Results – losses in volume due to different equations

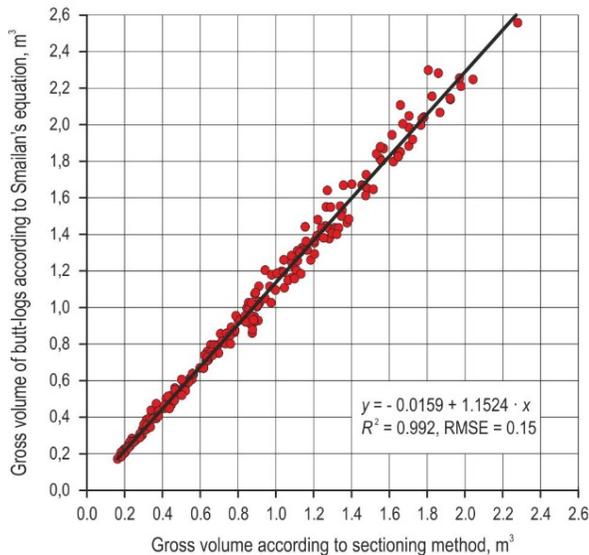
A) Discrepancy of Huber's equation



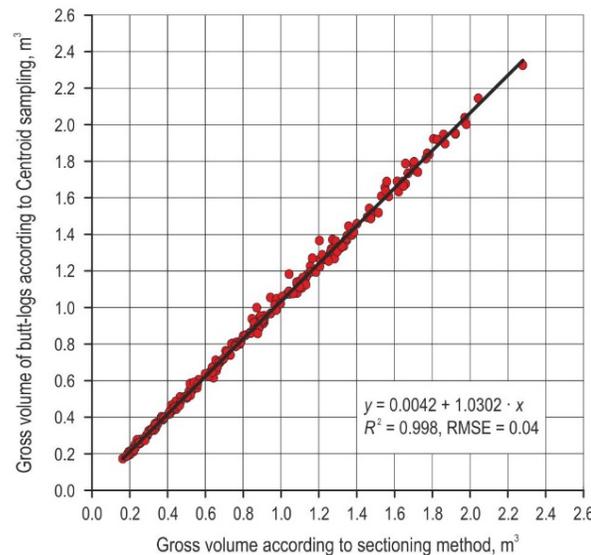
B) Discrepancy of Riecke-Newton's equation



C) Discrepancy of Smailan's equation



D) Discrepancy of Centroid sampling equation



- A strong relationship between dependent and independent variable ( $R^2 > 0.99$ ).
- Root mean square error (RMSE) varied from **0.01 to 0.15**, being the most favourable in Riecke-Newton's equation.
- Repeated variance analysis showed statistically significant difference ( $F = 339.86, df = 4, p < 0.001$ ) between several volume equations.
- Tukey post-hoc test showed that there was **no difference** between Riecke-Newton's equation and sectioning method in volume of 225 oak butt-logs, while all other volume equations were significantly different.

## Results – losses in volume due to the prescribed diameter measurements

- In Huber's equation loss in volume ranges from **-5.1% to -2.0%** i.e.  $-2.9\% \pm 1.3\%$  and with median value at **-2.6%** for the entire measuring sample.
- In Smailan's equation loss in volume ranges from **-4.2% to -1.7%** i.e.  $-2.6\% \pm 1.3\%$  and with median value at **-2.3%** for the entire measuring sample.
- In Riecke-Newton's equation loss in volume ranges from **-4.6% to -1.8%** i.e.  $-2.8\% \pm 1.4\%$  and with median value at **-2.7%** for the entire measuring sample.
- In Centroid sampling loss in volume ranges from **-3.8% to -1.9%** i.e.  $-2.9\% \pm 1.2\%$  and with median value at **-2.9%** for the entire measuring sample.
- Repeated ANOVA analysis showed a significant difference between volume losses due to the prescribed diameter measurements ( $F = 6.2, df = 3, p < 0.001$ ).



## Results – losses in volume due to the prescribed length measurements

- Length loss due to the measurement **from the middle of the undercut** or the butt trimming surface for the entire sampling group was  **$4.8 \pm 2.9$  cm**, with median value at 4.0 cm and mod value at 3.0 cm.
- Length loss due to **decimal round down** for the entire sampling group was  **$4.6 \pm 2.9$  cm**, with median value at 5.0 cm and mod value at 6.0 cm.
- Length loss due to **prescribed length measurement** of butt-logs for the entire sampling group was  **$9.4 \pm 3.9$  cm**, with median value at 9.0 cm and mod value at 9.0 cm.

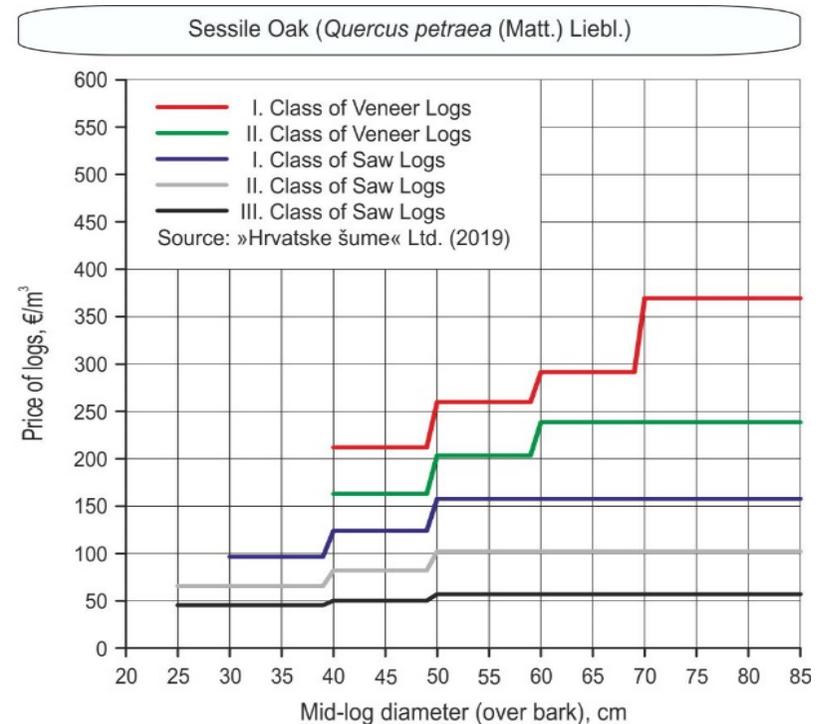
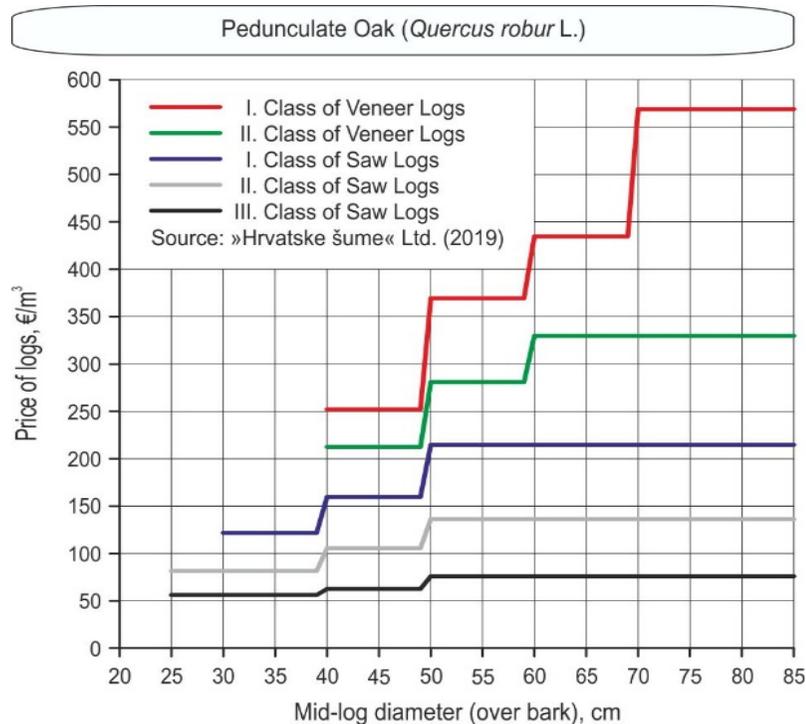


## Discussion

- In 2007 Poršinsky and Vujeva wrote about volume losses in European spruce and expressed their hope that the Croatian Standards Institute will **revise new European standards for Round and sawn timber** in their application in Croatian forestry. This has still not happened.
- Currently used national standards contain the **same principles regarding methods of measurements with one exception**. Diameter measurements are rounded down to the nearest centimetre, and their arithmetic mean of two measurements is also rounded down to the nearest centimetre.
- Even though some authors argue that Centroid sampling is a useful and more accurate alternative to other standard volume equations (Wood and Wiant 1990, Wood et al. 1990, Wiant et al. 1991, Wiant et al. 1992, Yavuz 1998), this research indicated that **Riecke-Newtons' equation is the most precise** in terms of oak butt-logs of approximately 4 m length (average  $0.0\% \pm 2.1$  standard deviation, median at  $-0.0\%$ ).



# Discussion



- In most cases, **butt-log is the most valuable log of a felled tree** (when minimal dimensions define assortment classes) which usually corresponds to “A” class of European standards or as it in Croatian case I or II class of veneer.
- On Croatian timber market, pedunculate oak and sessile oak I and II classes of veneer together account to **42.48% of all veneer assortments together**.
- I. class veneer logs of pedunculate and sessile oak are **3.15 times more costly** than European beech, 1.52 time more costly than narrow-leaved ash and other ash species (*Fraxinus angustifolia* L. and other) and 4.33 time more costly than hornbeam (*Carpinus betulus* L.).

## Conclusions and final remarks

Should these losses be ignored?

- $9.4 \pm 3.9$  cm of length losses in butt-log measurements,
- $-2.9 \pm 1.3\%$  volume losses due to diameter measurements

Next steps:

- The inclusion of bark i.e. double bark thickness in terms of prescribed bark deductions i.e. is bark waste, loss or by-product?
- Financial simulations due to volume losses and bark deductions and possible rationalisation in costs and eco-efficiency.



- The law of large numbers,
- The probability of butt-logs to be the most valuable logs of the tree,
- The most important commercial species,
- Significant losses?





**Thank you for your attention!**