Accurate estimation of wood chip volume to increase efficiency in allocating chipper and transport capacities

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BAYERISCHE FORSTVERWALTUNG

ZENTRUM WALD FORST HOLZ
WEIHENSTEPHAN

Optimisation of wood chip production chains

- Joint research project
  - Technology and Support Centre
  - Bavarian State Institute of Forestry

Technologie- und Förderzentrum
im Kompetenzzentrum für Nachwachsende Rohstoffe

LWF Bayerische Landesanstalt für Wald und Forstwirtschaft

- Funding
  - Bavarian State Ministry of Food, Agriculture and Forestry

Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten

- Cooperation
  - Bavarian State Forest Enterprise

BAYERISCHE STAATSFORSTEN
Nachhaltig Wirtschaften.

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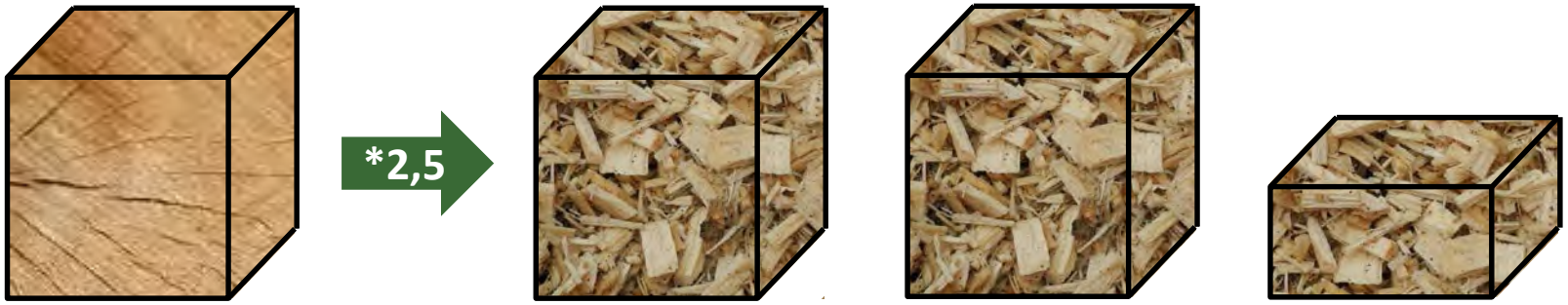
The challenge

- Chipping operations at forest roadside as a standard procedure in Bavarian forestry
- Expected wood chip volume is an important parameter when planning wood chipping operations and logistics

- Factor for the conversion of solid timber into wood chips:
  - 1 m^3 solid wood → 2.5 bulk cubic metres of wood chips



The challenge

- In forest wood chipping operations, we do not chip solid timber but…

Different approaches

- Estimations may be based on three types of data:
  - Total amount of wood harvested during the operation
  - Number and dimension of tree parts for chipping
  - **Dimensions of wood piles for chipping**
    - Two-step approach:
      Measurement of wood pile volume
      Calculation of chip volume using conversion factors
    - Different factors in use

Our research – Measurements in the field

- Measurements on energy wood piles:
  - Base length
  - Upper length
  - Maximum height
  - Mean height
  - Depth on both sides

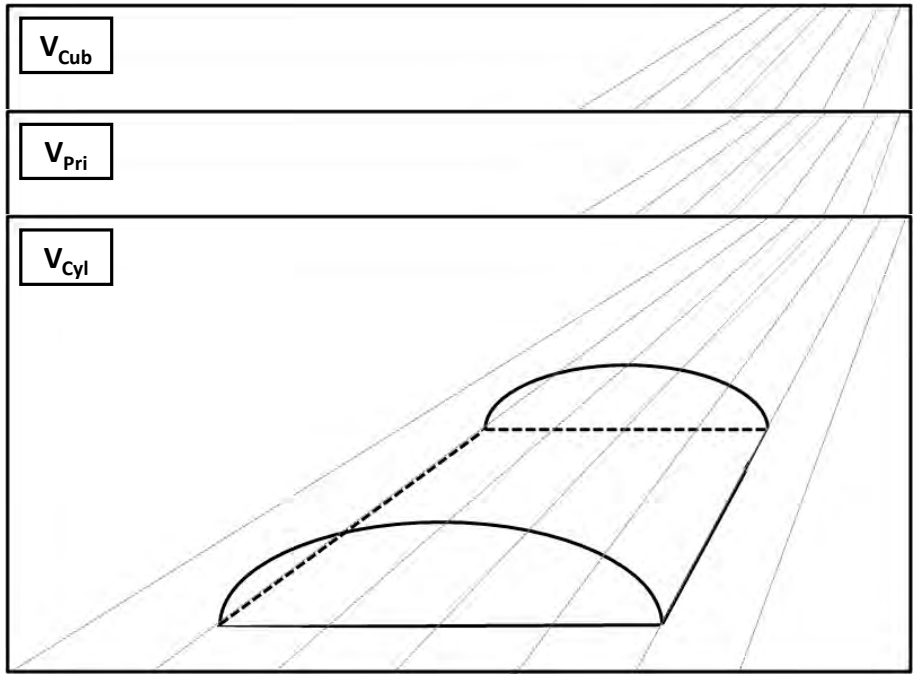
Our research – Measurements in the field

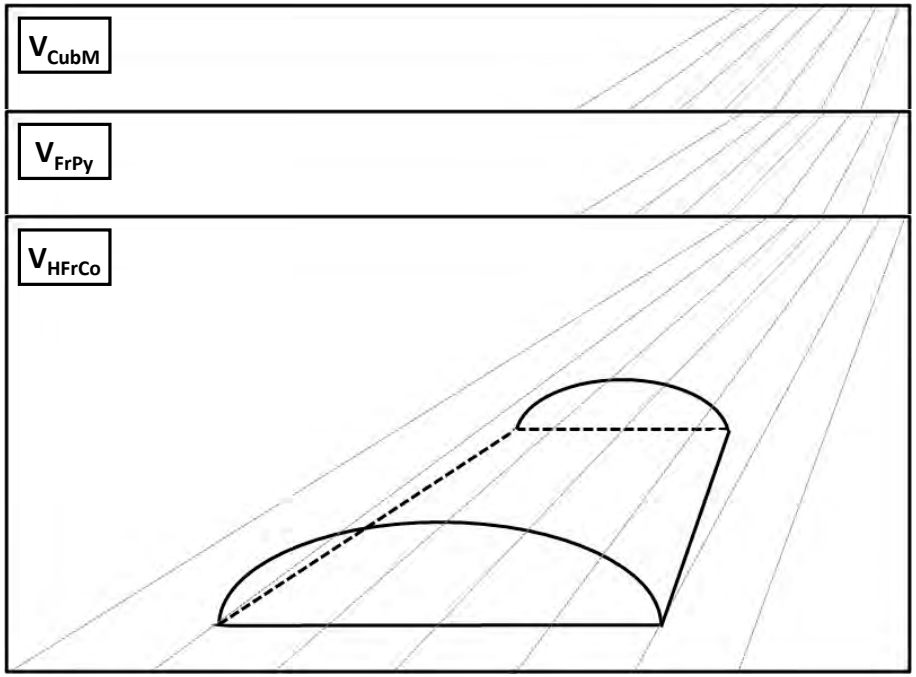
- Measurements on energy wood piles:
  - Percentage of cut surfaces on front side
  - Diameter of tree parts

Our research – Measurements in the field

- Measurement of produced wood chip volume

Our research – Maths in the office

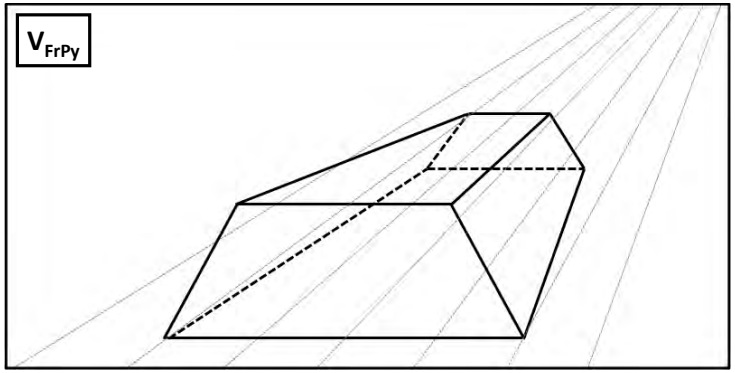




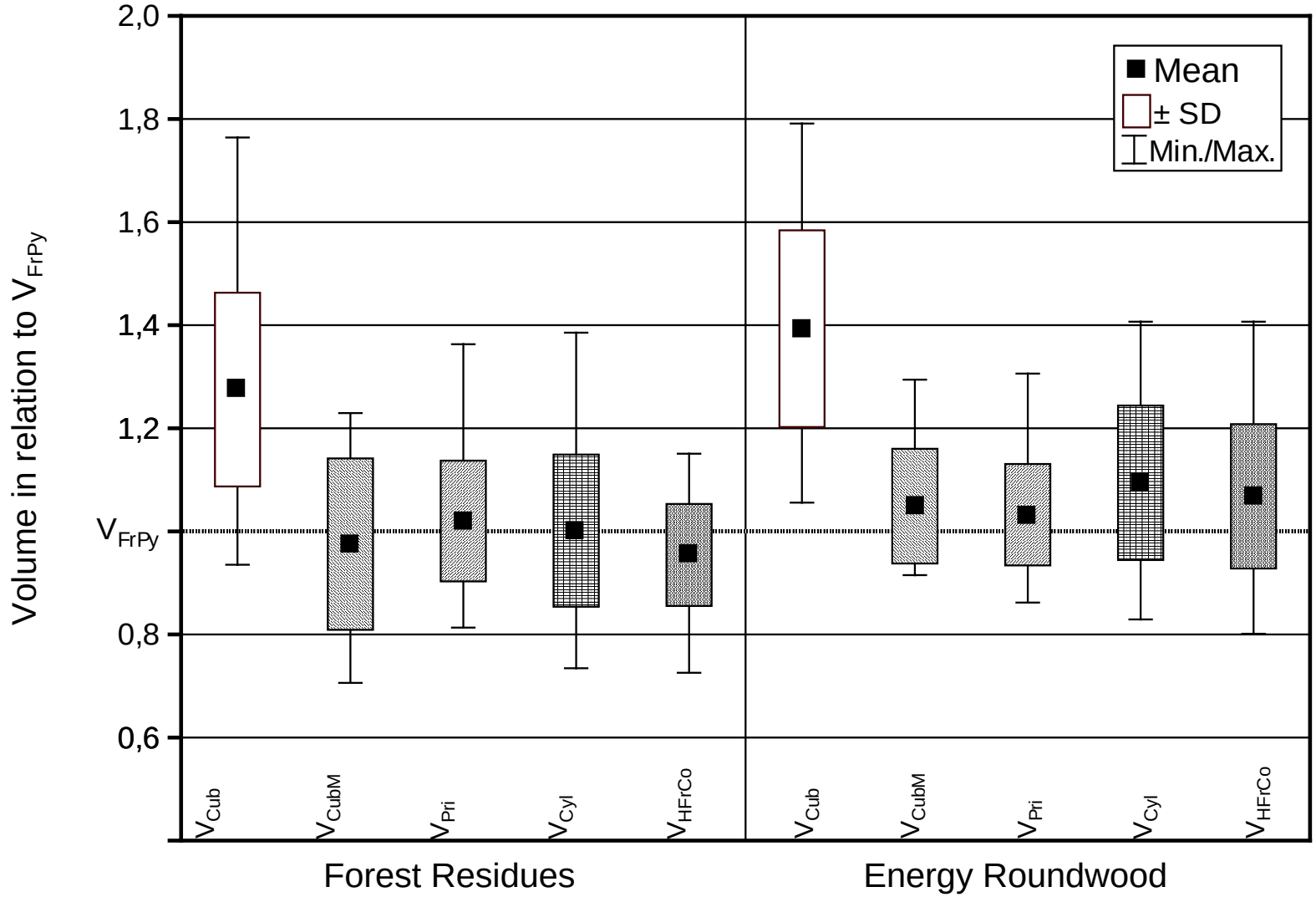
V_{cub}	Cuboid
V_{Pri}	Prism
V_{cyl}	Cylinder
V_{cubM}	Cuboid (mean height)
V_{FrPy}	Frustum of pyramid
V_{HFrCo}	Halved frustum of cone

Our research – Maths in the office

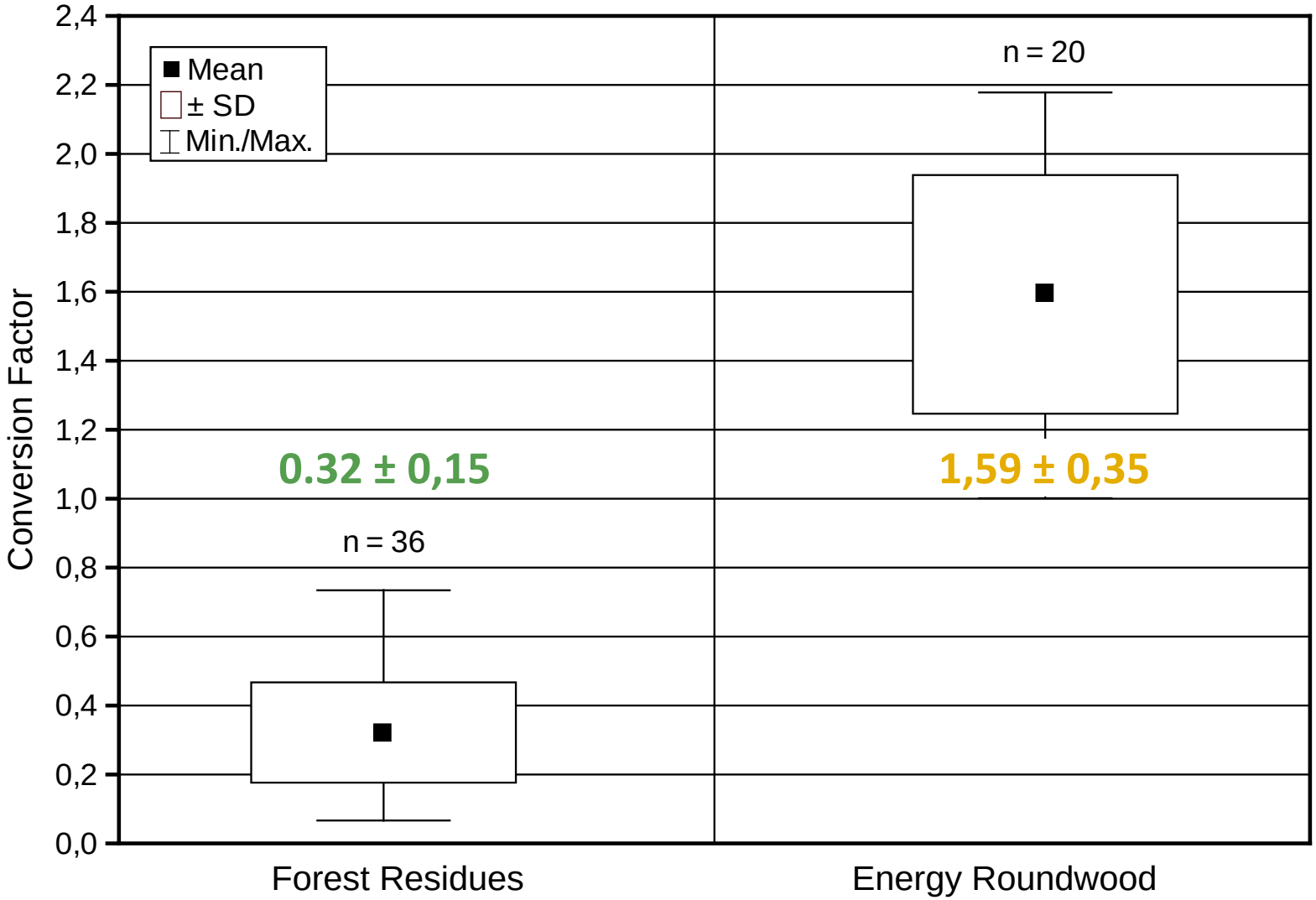
- Frustum of pyramid
  - Most input parameters
  - Back side dimensions
  - Visually best fitting for majority of piles



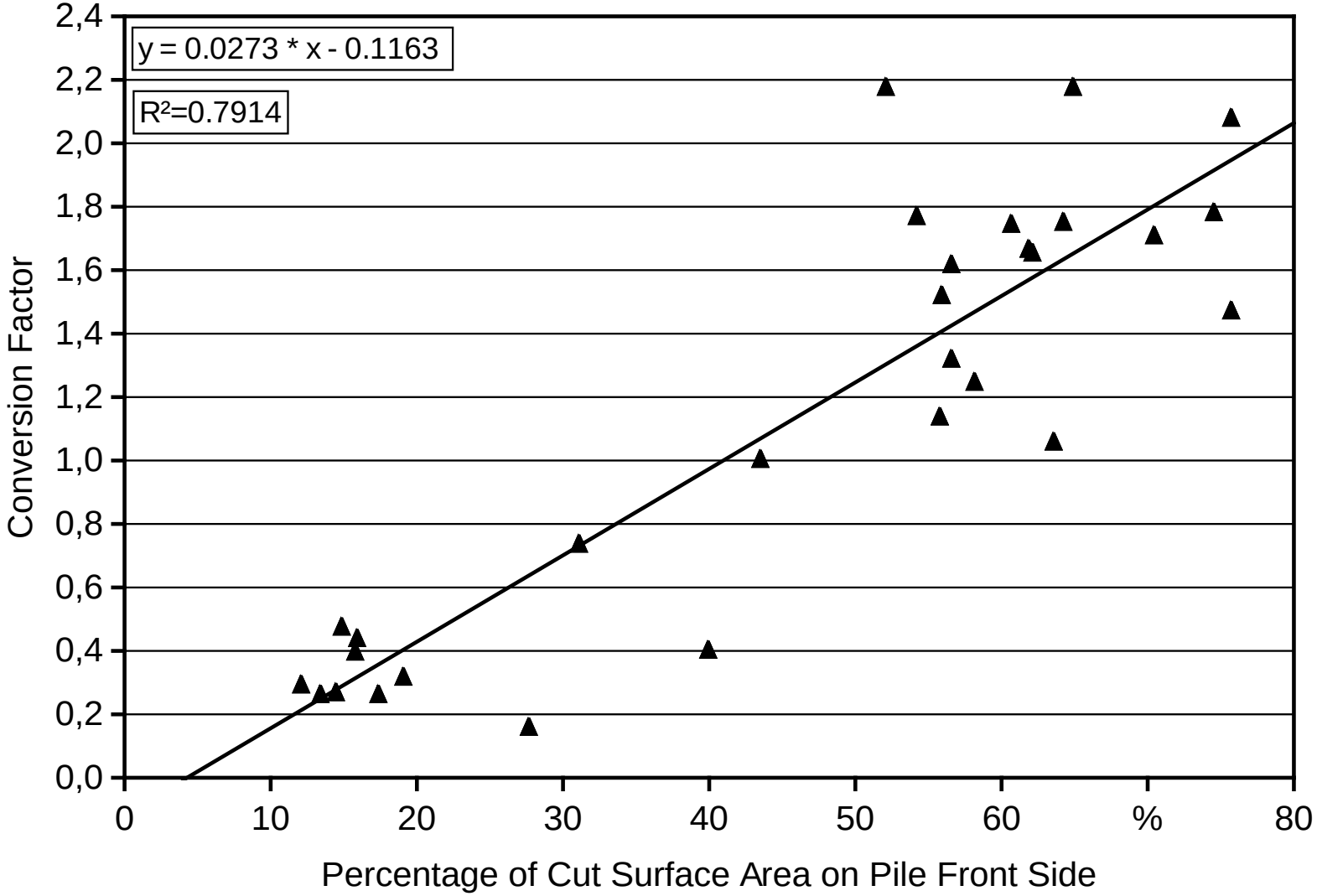
Volume calculations



Conversion factors



Cut surfaces on front side

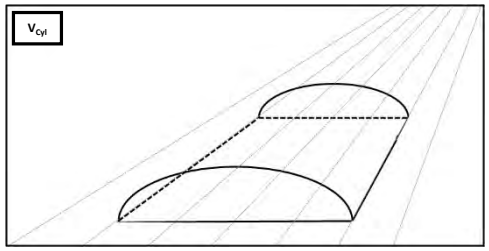


Recommendations for practitioners

- Estimation of pile volume
  - As accurate as possible with the least number of measured parameters
  - No measurements on back side

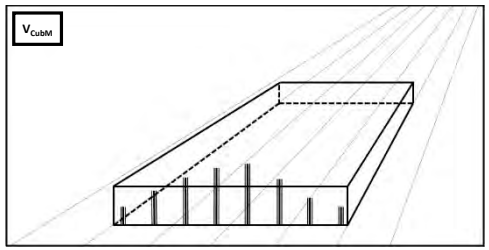
  - Forest residues:
    Volume of cylinder

$$V_{ForRes} \approx \frac{\pi}{4} \times l_{bf} \times h_{maxf} \times d_{mean} \pm 10\ \%$$



  - Energy roundwood:
    Volume of cuboid with mean height

$$V_{EneRou} \approx l_{bf} \times h_{meanf} \times d_{mean} \pm 10\ \%$$



Recommendations for practitioners

- Conversion factors:
  - Forest residues:
    Percentage of cut surface area: 20.2 %

Cut surface area [%]	15	20	25
Conversion factor	0.3	**0.4**	0.5

Recommendations for practitioners

- Conversion factors:
  - Energy roundwood:
    Percentage of cut surface area: 61.5 %

Cut surface area [%]	50	60	70
Conversion factor	1.2	**1.5**	1.8

Thank you for your attention!

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