T4E BUCKING APP

FIRST ACCURACY TEST OF A NOVEL MOBILE DEVICE BASED APPLICATION FOR VALUE-OPTIMIZED BUCKING IN MOTOR-MANUAL OPERATIONS

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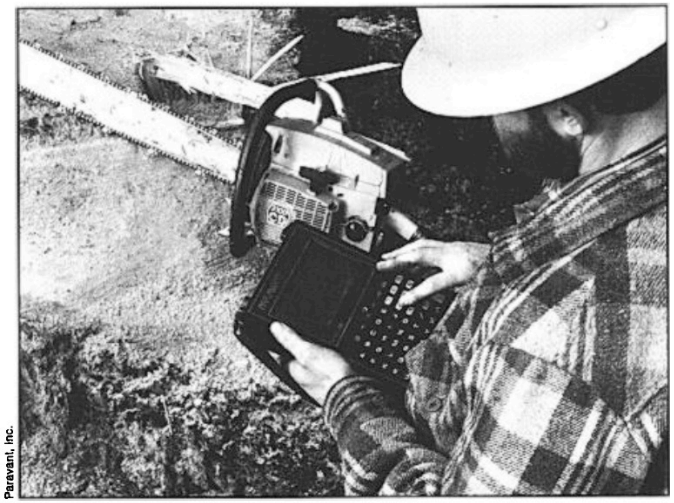
Introduction: The bucking problem

- **Bucking** is the process of **converting** a **stem** into **assortments** of **different length**, **diameter class** and **quality** during motor-manual felling and processing operations
- The **chainsaw operator** takes this **value-defining decision** by linking his **contractual requirements** and his **assessment** of a given stem.
- The **most important penalties** of **poor execution** of this task are 1) **loss of volume** and 2) **loss of value** due to inefficient bucking
- Contrary to fully-mechanized harvesting, **chainsaw operators** are **currently not supported by IT** in this process

Introduction:
Mobile bucking optimization



Logger with hand-held computer in field bucking situation.

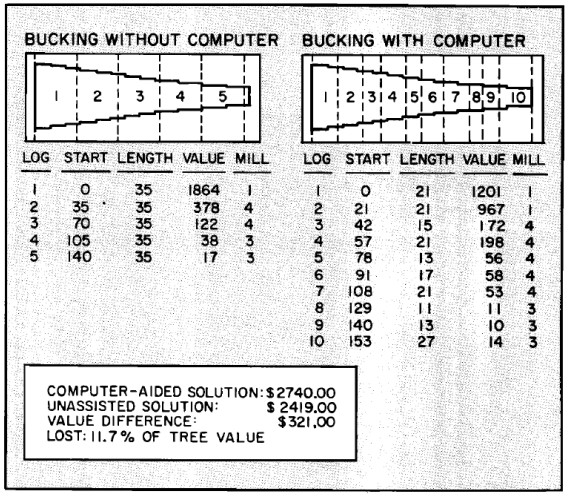
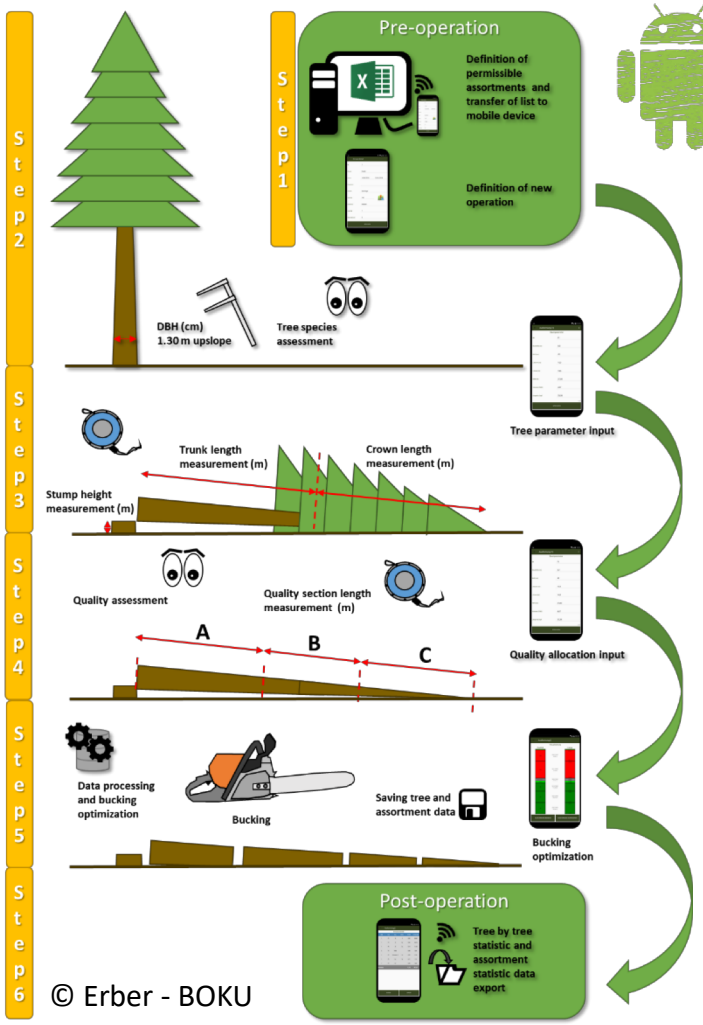


Figure 1. Comparison of logs actually bucked with logs of the computer-aided solution.

Source: Sessions J, Garland J & Olsen E. 1989: Testing computer-aided bucking at the stump. Journal of Forestry 82(4): 43-46.

- **Bucking optimization** bases on the ground-breaking considerations of **Bellmann** (1954) on "**The theory of dynamic programming**" and was for the first addressed by **Pnevmaticos** and **Mann** (1972) in "**Dynamic programming in tree bucking**"
- At the end of the 1980ties, a team at **OSU** around **John Sessions** and **John Garland** developed a **bucking software** (**OSU © Buck**), which could be operated on a **handheld computer**

Introduction: “T4E Bucking App”



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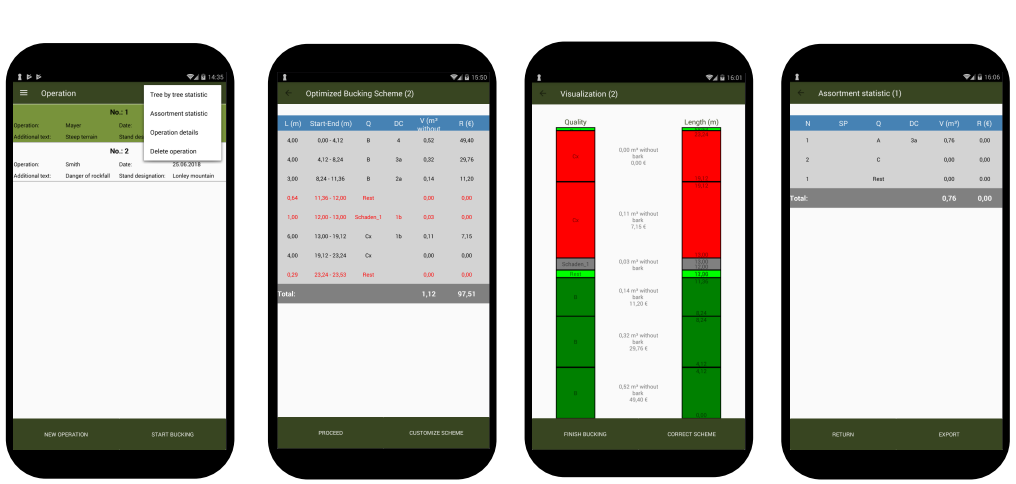

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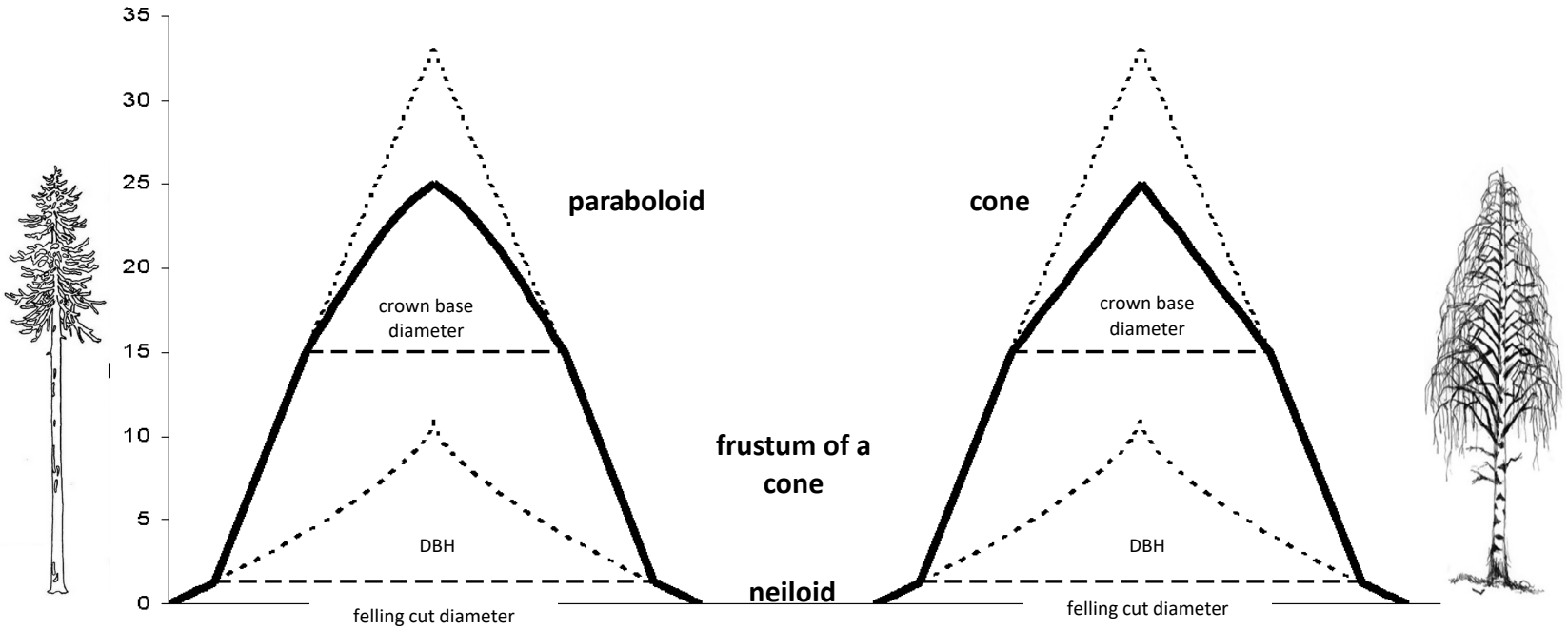
„**T4E Bucking App**“ is a **mobile device based application** for **value-optimized bucking** of a given tree based on **tree parameters** and **contract data**, operating on Android OS and developed in the TECH4EFFECT project

Introduction: Study goal

- The goal of the presented study was to:
  - investigate **how accurately** the app **estimates** the **tree shape**
  - determine **if** the app **provides** a **value-optimized solution**
  - evaluate the **effect of deviations** from the observation

Material and methods: ”T4E Bucking App“ taper curve estimation



Source: Eckmüller O, Schedl P, Sterba H. 2007: Neue Schaftkurven für die Hauptbaumarten Österreichs und deren Ausformung in marktkonforme Sortimente. Austrian Journal of Forest Science 124(3): 215-236.

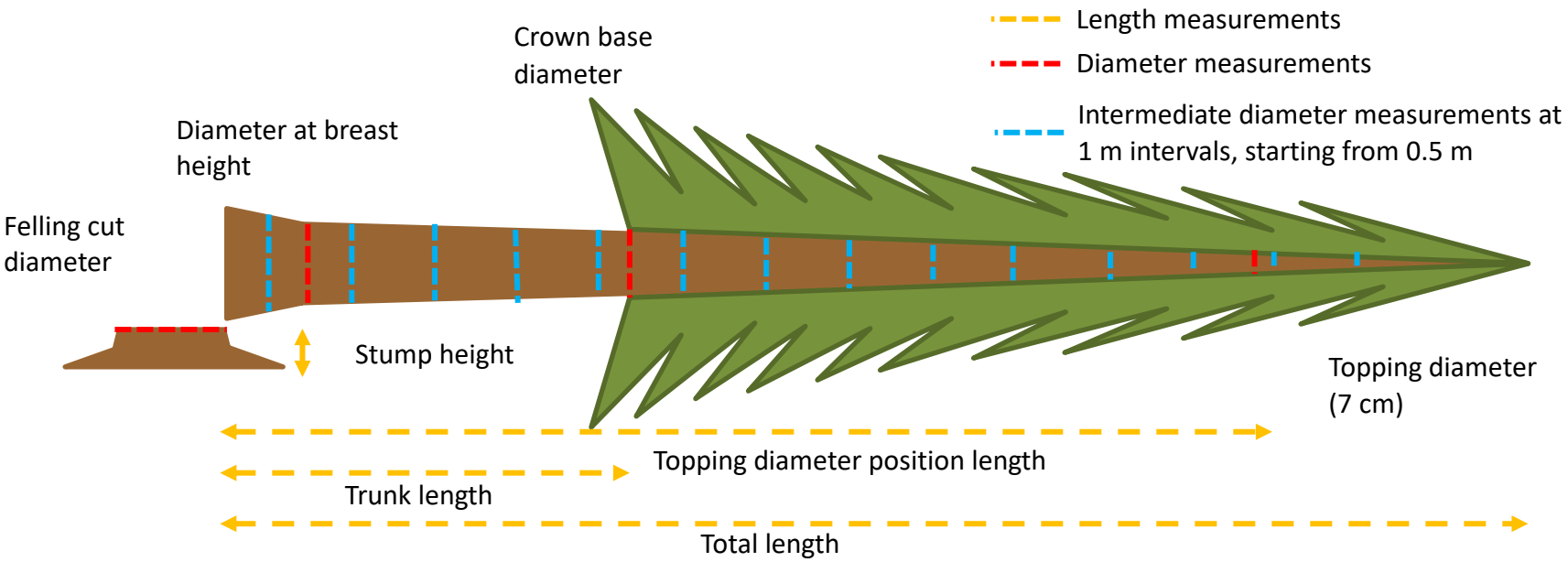
- Functions for **estimating diameter at crown base** and **at the felling cut** by Eckmüllner et al. (2007) based on 17.003 function trees from Austrian Forest Inventory
- **Species**, **DBH**, **stump height**, **trunk length** and **total tree height**, **height above sea level** required for estimation

Material and methods: Study trees

Parameter		Unit	Mean ± Standard deviation	Minimum	Maximum	Median
Stump height		m	0.14 ± 0.07	0.05	0.31	0.12
Felled	Trunk length	m	13.45 ± 2.61	7.80	21.50	13.08
	Crown length	m	10.50 ± 3.21	5.15	18.50	10.73
	Tree length	m	23.95 ± 3.79	16.20	34.60	23.85
	Crown share	%	43.35 ± 9.31	27.03	63.57	43.92
	Topping length	m	21.12 ± 3.95	11.42	31.35	21.42
Diameter at felling cut		cm	47.4 ± 19.0	19.6	89.0	48.6
Diameter at breast height		cm	30.9 ± 11.6	14.2	60.2	29.3
Diameter at crown base		cm	20.1 ± 8.7	7.1	46.1	21.1
Volume in bark		m^3	1.03 ± 0.88	0.14	3.38	0.81

20 (bark beetle trap) **Norway spruce** (L.) **trees** at Leiben (Lower Austria), trees felled but no further processing

Material and methods: Field measurements and quality assignment



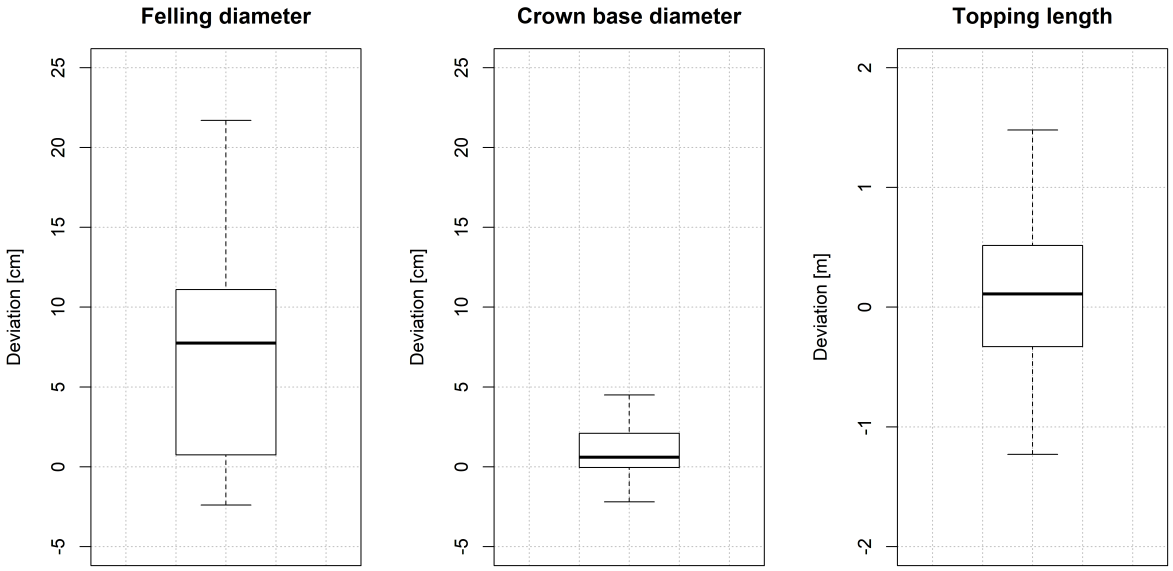
Nominal length [m]	Quality	Diameter class	Price [€ m^{-3} without bark]
3, 4, 6	AC	2a, 2b, 3a, 3b, 4, 5, 6	91.50
	AC	1b	73.00
	AC	1a	47.00
	Cx	1a, 1b, 2a, 2b, 3a, 3b, 4, 5, 6	58.00

- Species: **Norway spruce** (L.)
- Height above sea level: **300 m**
- Quality assignment: **quality AC below** and **Cx above crown base**, pricing according to regular price table

Material and methods: Analysis

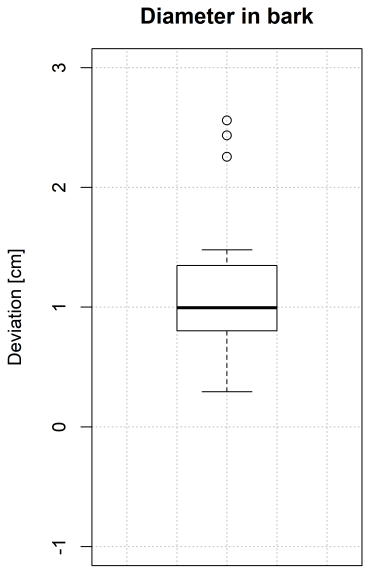
- **Tree parameter estimation** accuracy**:**
  - Estimations were compared with observation of:
    - **felling cut** and **crown base diameter**
    - **topping diameter position**
    - **diameter between DBH** and **topping diameter position**
  - Share of **diameter class deviation**
- **Bucking scheme estimation** accuracy**:**
  - Comparison of **volume** and **value** of app‘s value optimized solution to all maximum value schemes
- **Effect of deviations:**
  - Value-optimized schemes were **recalculated** with **observed diameters** and **topping lengths** and the estimated **volume** and **value** were compared to observation

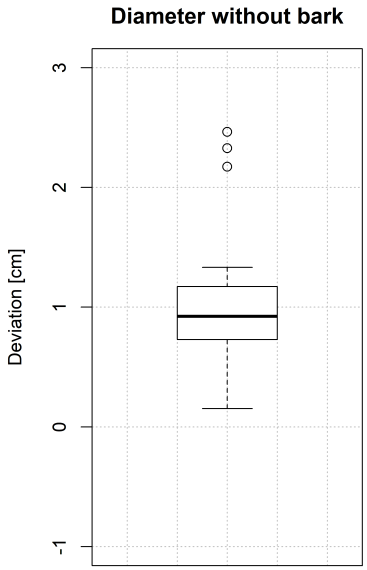
Results: Felling and crown base diameter and topping length estimation accuracy

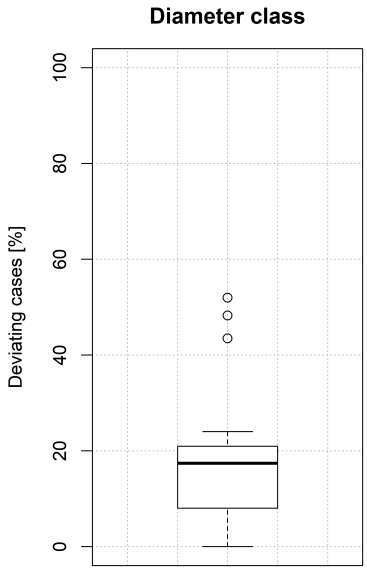


- **Felling diameter** regularly **underestimated** (7.1 ± 6.5 cm)
- **Crown base diameter** only **slightly underestimated** (0.90 ± 1.80 cm)
- **Topping length** only **slightly underestimated** (0.05 ± 0.70 cm; 60 % of the cases)
- **Felling diameter deviation increased significantly** (p=0.006) **with increasing DBH**

Results: Diameter with and without bark, diameter class estimation accuracy

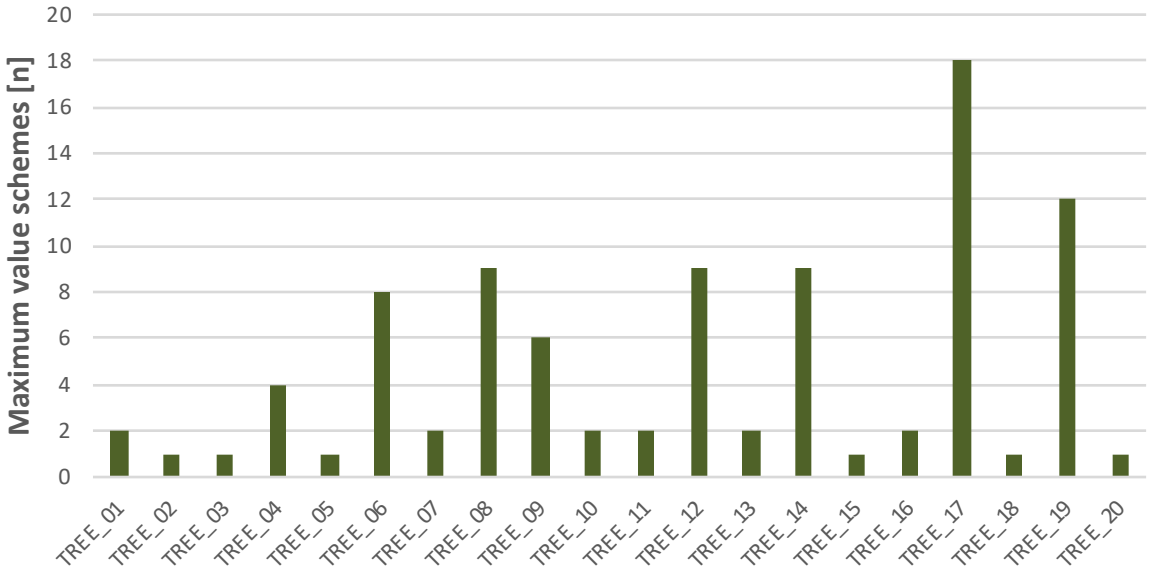






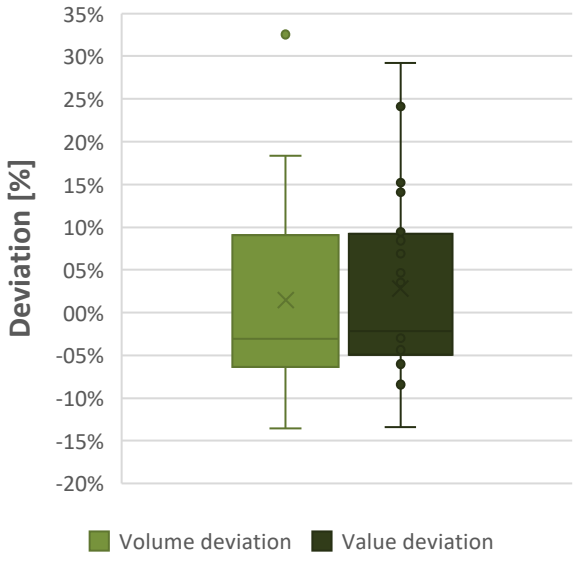
- **Absolute deviation** of **diameter with bark** (1.1 ± 0.6 cm) **slighty larger** than **without bark** (1.0 ± 0.6 cm) and **mean deviation** of **diameter with bark** (0.8 ± 0.9 cm) **slighty larger** than **without bark** (1.0 ± 0.8 cm) showed that Bucking App tends to **slightly overestimate diameters** and **deviations increased significantly with DBH** (p=0.003 and p=0.002)
- **Diameter class deviation share** was 18.5 ± 14.4 % and **increased significantly with DBH** (p=0.006)

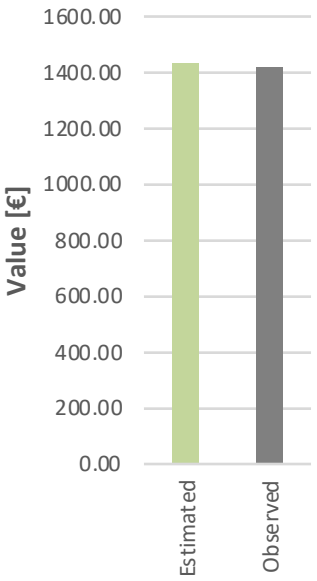
Results: Bucking scheme estimation accuracy

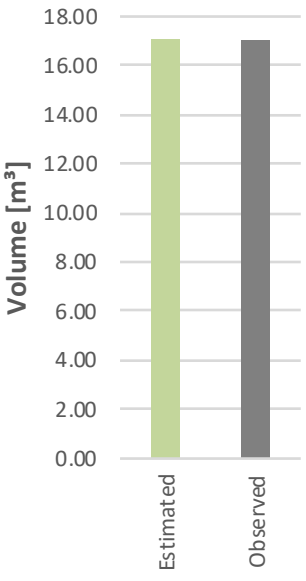


- **All Bucking App schemes** constituted an **optimized (maximum) value solution**
- For 20 trees in total **73 alternative** (0-17, 3.7 ± 4.6) **maximum value schemes** were **found**
- **Number of alternative solutions increased significantly** with **increasing DBH** (p=0.028), **topping length** (p=0.007) and **volume in bark** (p=0.028)

Results: Effect of deviation on volume and value recovery







- **Six top end logs lost** due to **topping length overestimation** (0.2 m³ in bark; 11.49 €)
- Further **six log's diameter class** was either **over-** (1) **or underestimated** (5), which led to a lower price per m³ in one case
- **Observed total volume** was **slightly smaller** (17.05 m³ vs. 17.10 m³, 0.29 %) than **estimated**
- **Observed total value** was **slightly smaller** (1,417.34 € vs. 1,433.66 €, 1.15%) than **estimated**

Discussion

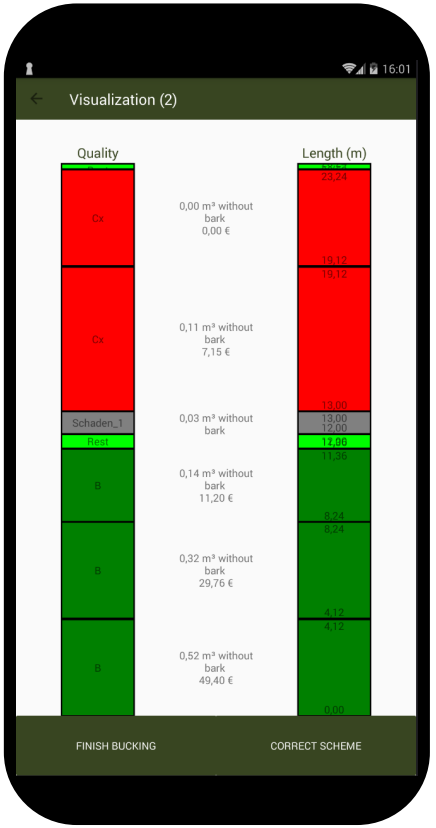
- **Accurate estimation** of **crown base diameter** is **crucial** for high value trunk section
- Eckmüllner et al.'s (2007) functions proved **very reliable** for **crown base diameter** estimation **but not** for **felling cut diameter**
- **Felling cut diameter underestimation** is **irrelevant** as no middle diameter is located below DBH and root collar is usually cut straight
- **Effect of diameter class deviation** might increase with a more graduated price scheme
- **Underestimation** of **topping length** resulted in **loss** of **low-volume** and **low-value** top end **logs**
- **Optimized (maximum) value solution** found out of a varying number of maximum value alternatives

Conclusion

- "Bucking App" provides a **reliable estimation** of **tree parameters** and **taper curve**
- "Bucking App" provides a **value optimized solution** out of a varying number of alternatives
- "Bucking App " tends to **overestimate topping length**, which leads to marginal volume and value losses at top end
- "Bucking App" **underestimates diameter class more often than it overestimates**, therefore remaining on the safe side
- At **operation level**, **deviations** in **volume** and **value** were **negligible**; however, a more graduated pricing scheme might lead to pronounced effects

Outlook

- Use of “T4E Bucking App” shall focus on:
  - **Decision support** (occasionally bucking user)
  - **Teaching and training** (forest workers education)
  - **Calibration and work documentation** (professionals)
- “T4E Bucking App” does not aim to replace, but to **assist** and **improve** the way the human brain is taking the bucking decision
- Larger **field tests** are **planned** for **2019**
- **Replacing manual measurements** and data input with **built–in sensors** of the mobile device (e.g. iPhone X 3D scanner) to obtain exact diameter profile and specify quality sections in a single operation



Outlook ?

21/05/2025 – 08:34
48°12'2" / 15°8'10"
Tree 21 / Log 1
4.06 m - 33 cm - 0.34 m³
2b - B - € 31.3
Tree 21 / Log 2
4.06 m - 26 cm - 0.21 m³
2b - B - € 19.4
Tree 21 / Log 3
4.06 m - 22 cm - 0.15 m³
2a - C - € 13.9
Tree 21 / Log 4
4.06 m - 16 cm - 0.08 m³
1b - Cx - € 4.7
FUEL
LUBRICANT
Tree 21 - Spruce
Species: Spruce
Total logs: 5
Total volume: 0.84 m³
Total value: 72.5 €
2.734.3 €
VALUE
42.3 m³
PRODUCTION
11.5 m³/h

Consortium

Research institutes and universities

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University of Natural Resources and Life Sciences, Vienna

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TECH4EFFECT

Acknowledgements

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