From Theory to Practice: Challenges for Forest Engineering
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Damage to residual stands caused by cable yarding operations in steep terrain

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Background

- Large number of ecosystem services (ES) in **European mountain forests**
- **Harvesting is complex** because of considering various ES but also to account for the difficult terrain characteristics
- **Benchmark** (quality assessment) is needed to evaluate harvesting operations
- **Damage on the remaining trees** has been selected as an evaluation criteria to represent **vitality** and **stability** of forest stands

Photos: M. Kühmaier

Objectives

- Development of a **benchmark model** for the quality assessment of timber harvesting
- Identification of **parameters**, which are influencing the number and size of damages on remaining trees
- Developing models for **predicting** the share of damages on **plot** and on **tree** level
- Providing **recommendations** how to perform cable yarding operations in order to minimize damages

Photos: K. Stampfer

Study area

- Watershed protection forests of the City of Vienna
  - Provides high quality drinking water
  - 437 million liters per day to 1.7 million inhabitants
  - Conservation and restoration of forest soils and creation of a stable continuous forest cover
  - Volume of harvested timber is limited to 15% to 25% of the stand basal area

Photo: K. Stampfer

https://www.wikipedia.org

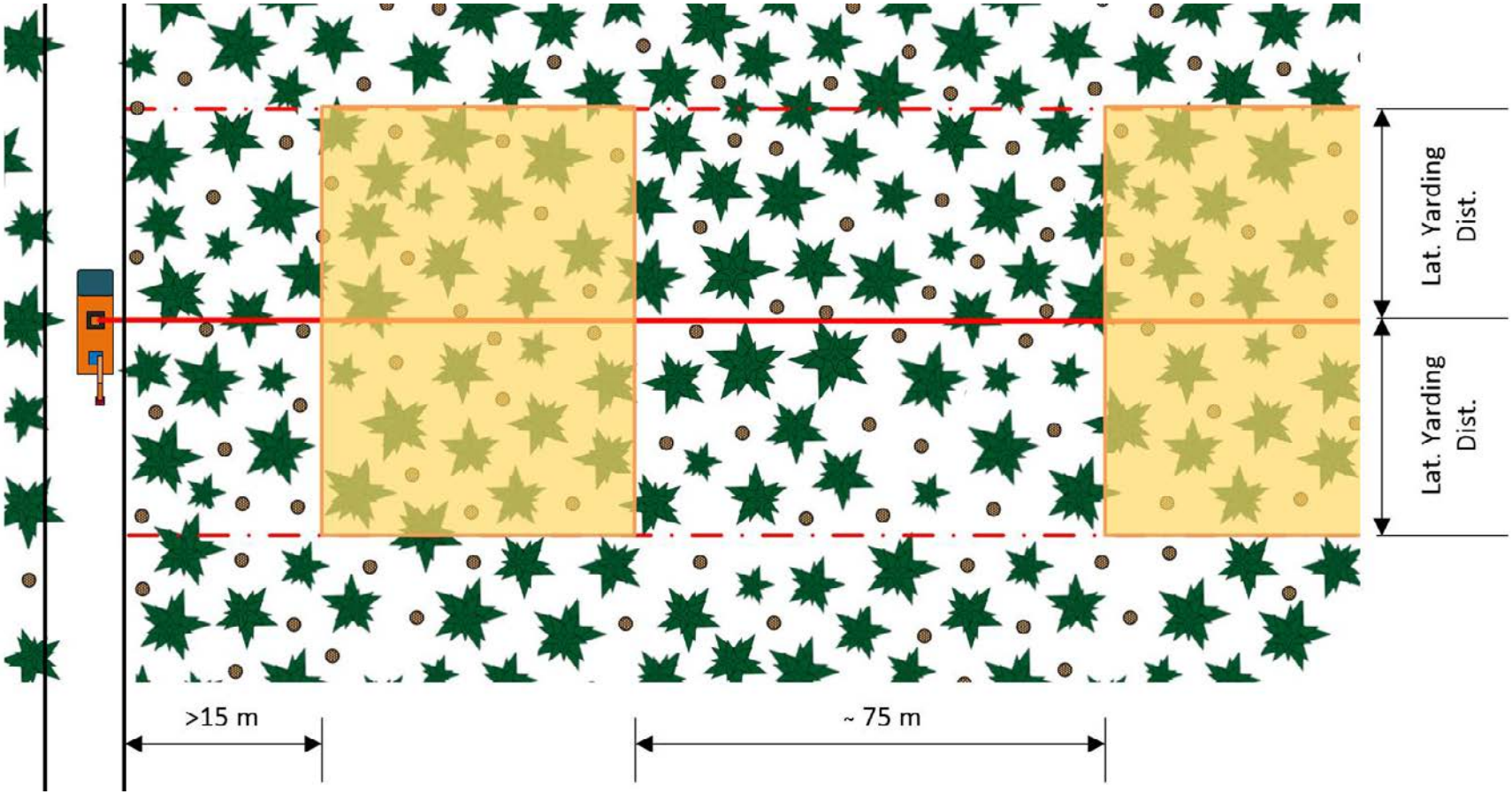
https://www.wien.gv.at/umwelt/wald/quellenschutzwaelder/images/karte-gr.jpg

Forest characteristics

- 49 harvesting operations in 21 different stands, ranging from first thinnings to regeneration fellings
- DBH 16-48 cm
- Average stand density 1200 trees/ha
- Uphill yarding was performed on 23 of the 49 analyzed cable lines
- Slope 17-78%
- Corridor length 100-450 m
- Average lateral yarding distance 30 m

Photo: K. Stampfer

Sampling design 1



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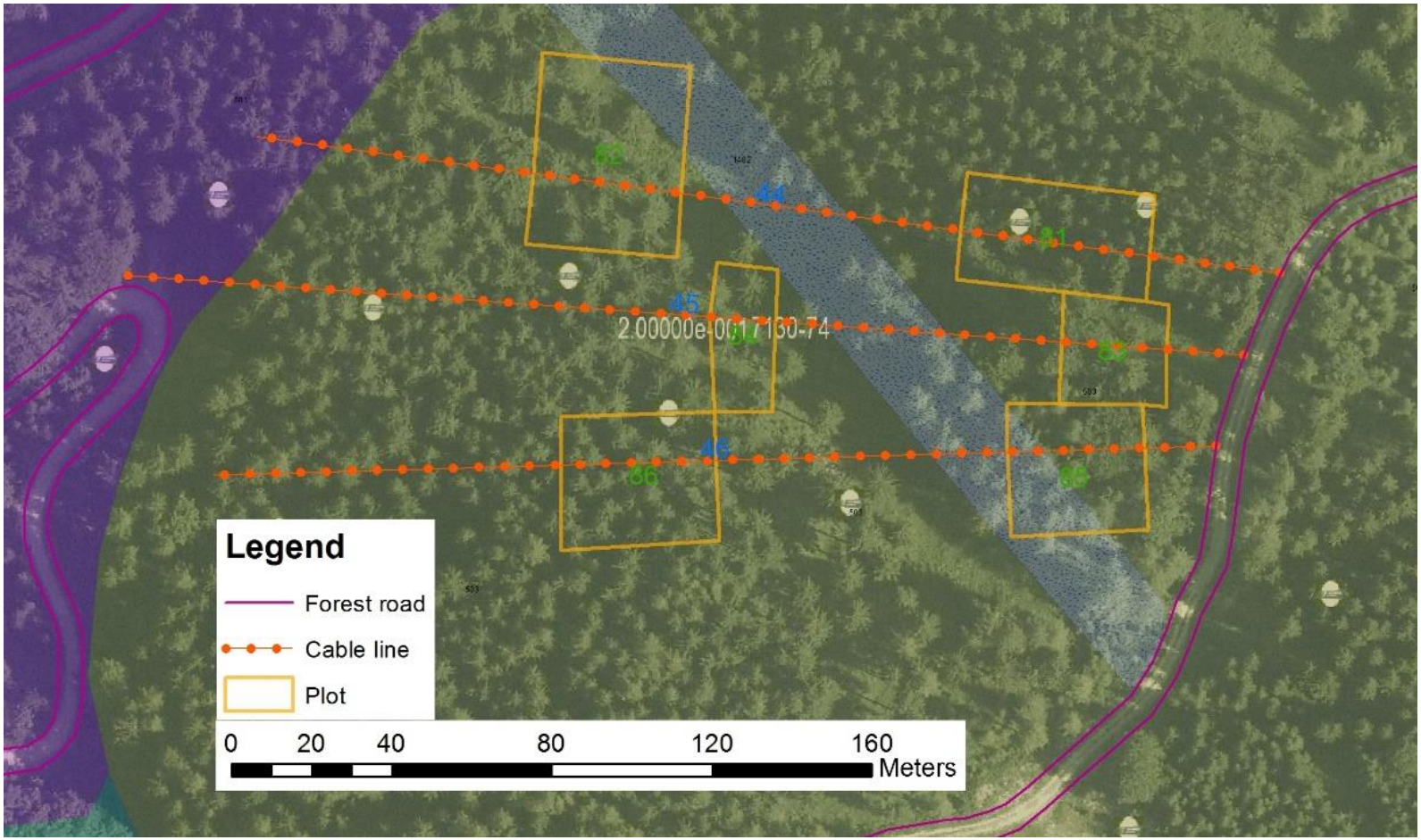
Sampling design 2



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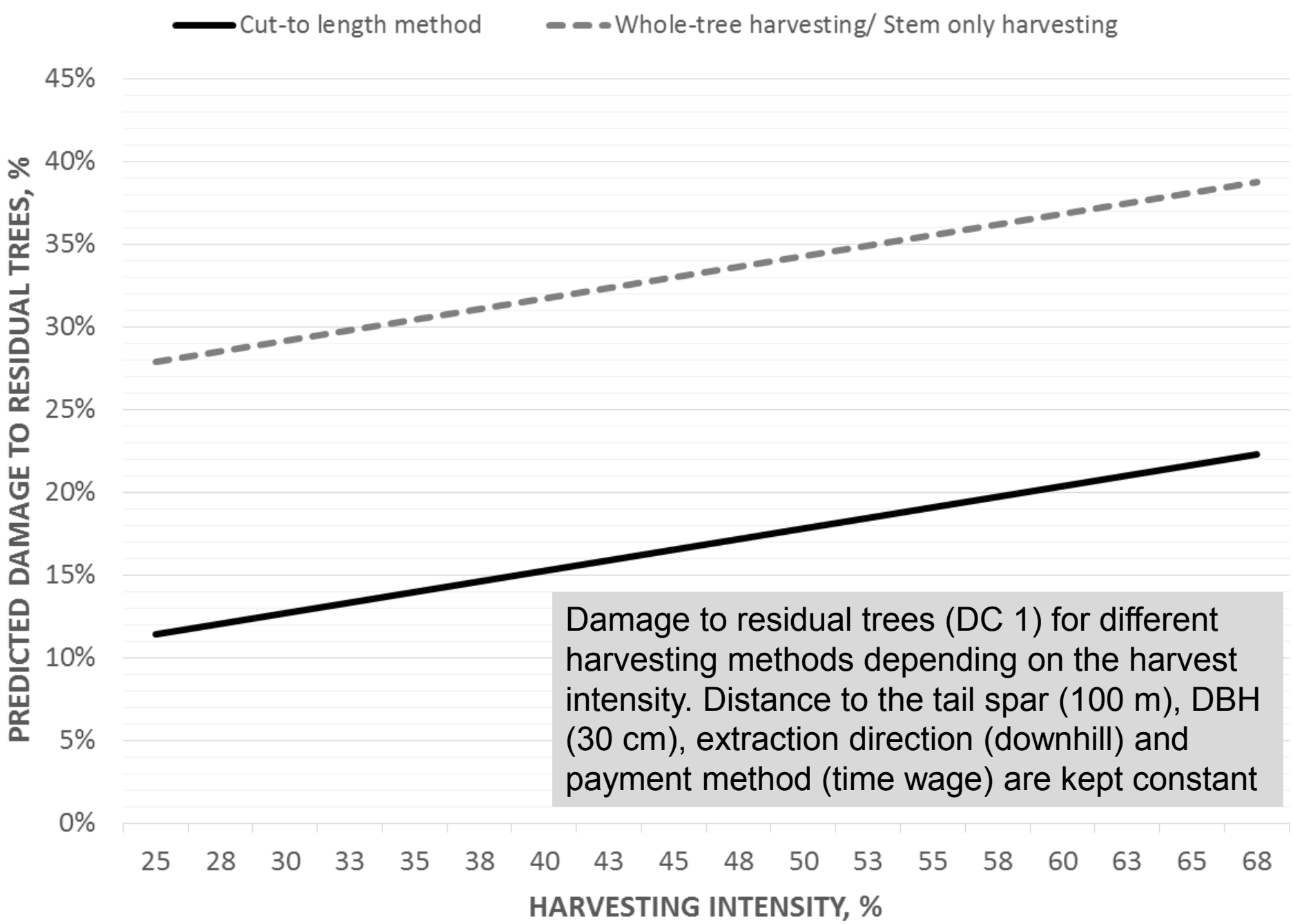
Methodology for the plot level model

- Three damage categories: DC1, DC2 (>11 cm²), DC3 (> 51 cm²)
- PASW 18 statistic package
- Kolmogorov-Smirnov test
- Levene test
- Scatter plots
- Pearson correlation coefficients
- ANCOVA
  - Forward stepping procedure (p=0,05)
- Variance Inflation Factor (VIF)

Results for the plot level model

- Cross slope, soil moisture, soil type, maximum lateral yarding distance and slope had no significant impact on damage level
- Harvesting intensity ↑
- DBH ↑
- Harvesting method: CTL ↓
- Payment method: Time wage ↓
- Direction: Uphill ↓

Photo: K. Stampfer



Damage to residual trees (DC 1) for different harvesting methods depending on the harvest intensity. Distance to the tail spar (100 m), DBH (30 cm), extraction direction (downhill) and payment method (time wage) are kept constant

Methodology for the tree level model

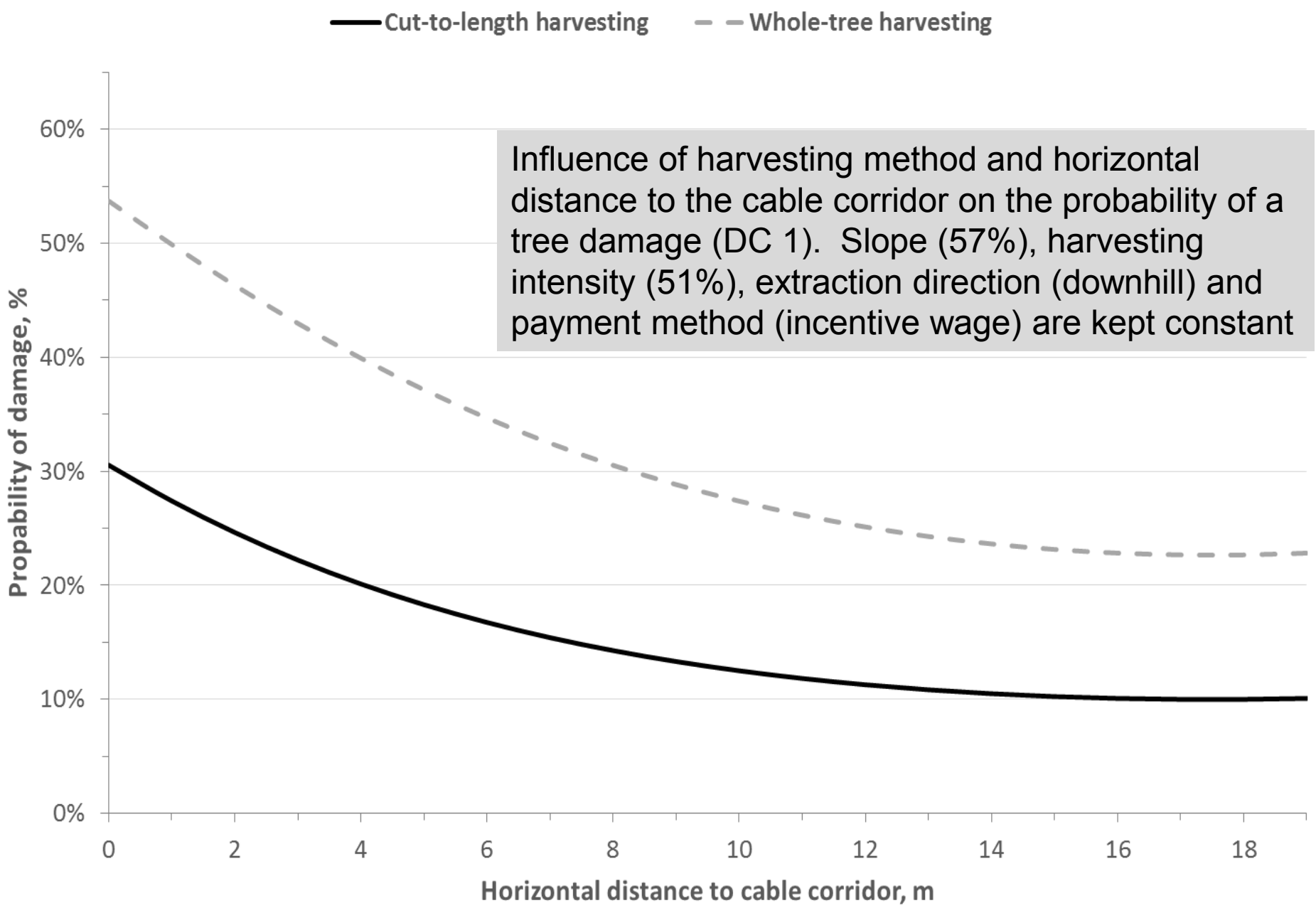
- Three damage categories: DC1, DC2 (>11 cm²), DC3 (> 51 cm²)
- PASW 18 statistic package
- Binary logistic regression models
  - Wald χ^2-statistic
  - Forward selection approach
- Hosmer-Lemeshow tests
  - χ^2-statistic
- Receiver operating characteristic curves (ROC)

Photo: K. Stampfer

Results for the tree level model

- DBH and stoniness had no significant impact on damage level
- Harvesting intensity ↑
- Lateral yarding distance ↓
- Slope ↑
- Stand density ↓
- Harvesting method: CTL ↓
- Payment method: Time wage ↓
- Direction: Uphill ↓

Photo: K. Stampfer



Influence of harvesting method and horizontal distance to the cable corridor on the probability of a tree damage (DC 1). Slope (57%), harvesting intensity (51%), extraction direction (downhill) and payment method (incentive wage) are kept constant

Conclusion

- Less damage if harvesting intensity is lower, forest is younger, assortments are shorter, own staff is used, uphill yarding
- Damage levels are similar or lower compared with other studies
- Plot level model has been implemented and will be used as benchmark model
- Model will be improved by further data collection
- Results should be compared with economic and social data

Modell zur Abschätzung des Anteils der geschädigten Bäume des verbleibenden Bestandes

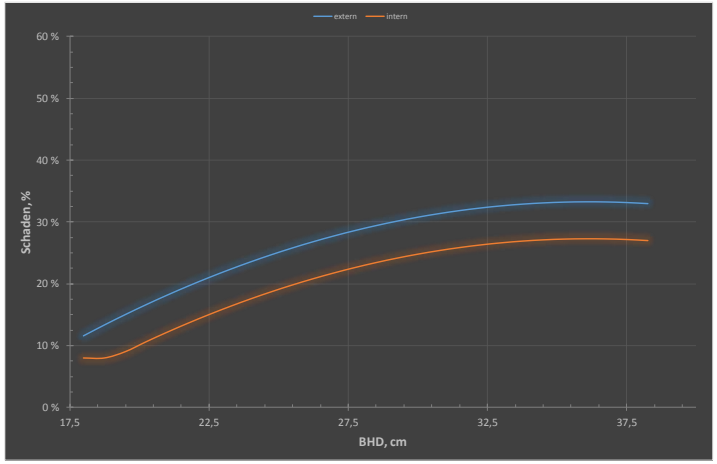
BHD	Schadensprozent extern	Schadensprozent intern
18	11,61	8,00
18,75	13,36	8,00
19,5	15,04	9,02
20,25	16,65	10,63
21	18,19	12,16
21,75	19,64	13,62
22,5	21,03	15,00
23,25	22,34	16,32
24	23,58	17,55
24,75	24,74	18,72
25,5	25,83	19,80
26,25	26,84	20,82
27	27,79	21,76
27,75	28,65	22,63
28,5	29,44	23,42
29,25	30,16	24,14
30	30,81	24,78
30,75	31,38	25,35
31,5	31,87	25,85
32,25	32,29	26,27
33	32,64	26,62
33,75	32,92	26,89
34,5	33,11	27,09
35,25	33,24	27,21
36	33,29	27,27
36,75	33,27	27,24
37,5	33,17	27,15
38,25	33,00	26,97

Neigung (%)	66
Eingriffsstärke	0,55
Rückerichtung	Bergab
Arbeitsverfahren	Sortimentsverfahren
BHD	27,95

Schadensprognose	
extern	28,87
intern	22,84

Gute Nutzugen	von	0,00
	bis	22,84
Mittlere Nutzungen	von	22,84
	bis	27,84
Schlechte Nutzungen	von	27,84
	bis	100,00

UW	MW	OW
29,90	56,76	74,10
0,28	0,51	0,70
-	-	-
-	-	-
17,36	28,44	43,77



Thank you for your attention!

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