Quantifying the energy dissipation capacity of trees after a forest fire: the case of the Bitsch massif (CH)

Context

- Increase of forest fire in no fire-prone areas
- Forest protective effect against rockfalls depends on trees' capacity to dissipate energy ($E_{diss,cap}$)
- $E_{diss,cap}$ is computed from stem diameter (SD) and Facture energy (FE) ratio (Dorren and Berger 2005)
- Decrease of wood moisture content and mechanical resistance after thermal treatment

Questions and Objectives

- How are stem mechanical properties and $E_{diss,cap}$ altered after a forest fire?
- How do wood properties changes impact $E_{diss,cap}$?
- Implementation of the stem and wood properties into an integrative $E_{diss,cap}$ equation
- Creation of a routine protocol for laboratory testing and validation of the model

Experimental design

Picea abies

Mean diameter: 18 ± 4 cm

Stem length: 2.5 m

- Green (Gr) stems (n=15)
- Artificially burnt (AB) stems (n=15)

- Severely burnt stems from Bitsch forest (BF) 2 years after forest fire (n=5)

3-points bending test

→ Facture energy ratio $E_{diss,cap}$ measured

↓

\+ Wood properties → Bayesian modelling of $E_{diss,cap}$ Gr and AB stems

Wood properties and stem mechanics

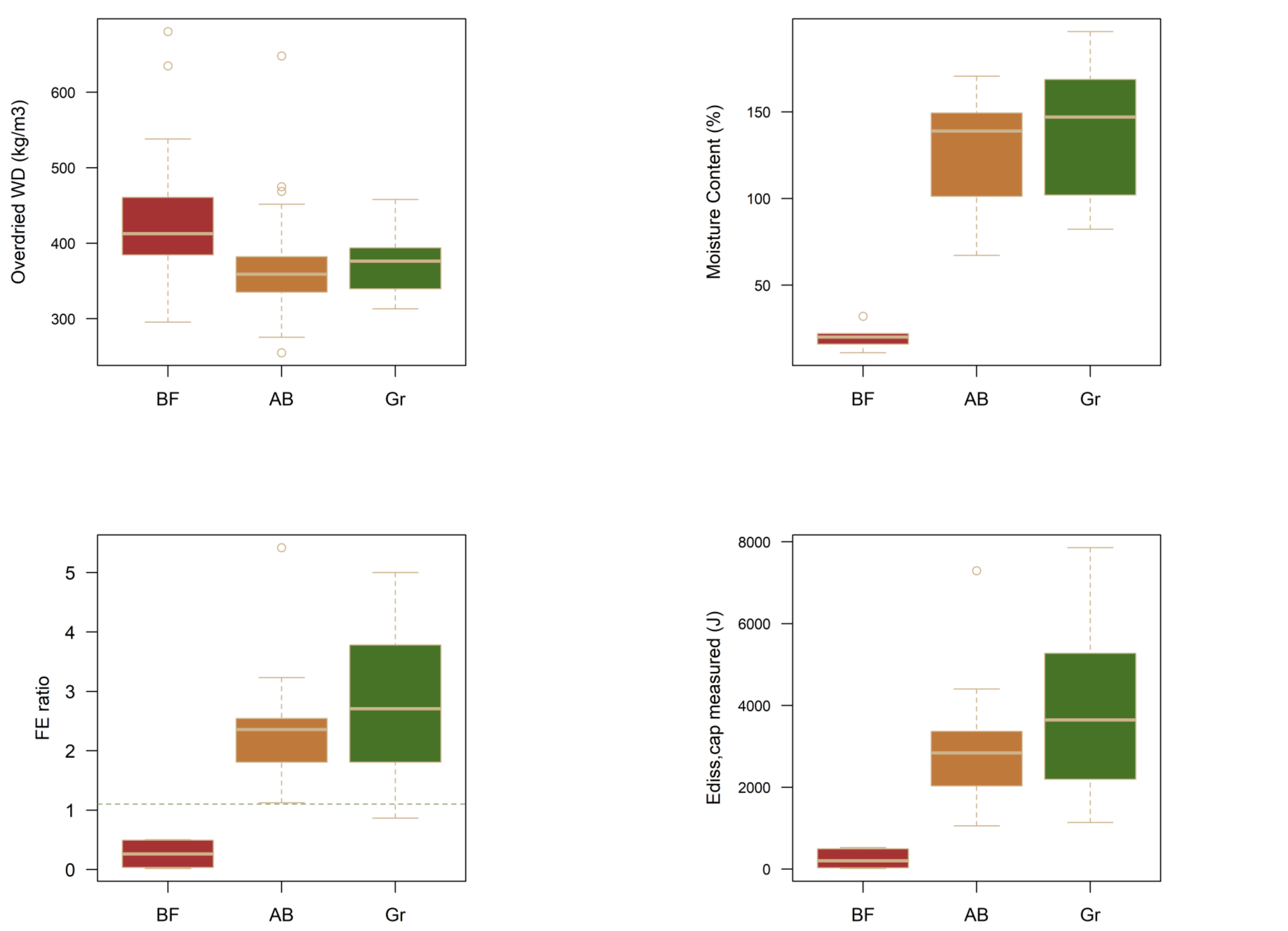

Fig. 1: Wood properties (ovendry wood density (WD) and, moisture content (MC)), and stem mechanical performances (FE ratio and $E_{diss,cap}$) of stems from Bitsch Forest (BF), artificially burnt (AB) and green (Gr) stems. The dotted horizontal line in the FE ratio plot represents the value for *Picea abies* published by Dorren and Berger (2005).

- Artificial burning treatment: not as intense as severely burnt BF stems
- BF stems: FE ratio and $E_{diss,cap}$ < AB and Gr stems
- FE ratio AB and Gr > FE ratio defined in literature: effect of moisture content?

$E_{diss,cap}$ modelling

Dorren and Berger (2005) $E_{diss,cap} = 38.7 \cdot SD^{2.31}$

Tested models

Pooled $E_{diss,cap} = a \cdot SD^{b}$

Pooled MC $E_{diss,cap} = a \cdot SD^{b} \cdot MC^{c}$

Unpooled $E_{diss,cap} = a(treat) \cdot SD^{b(treat)}$

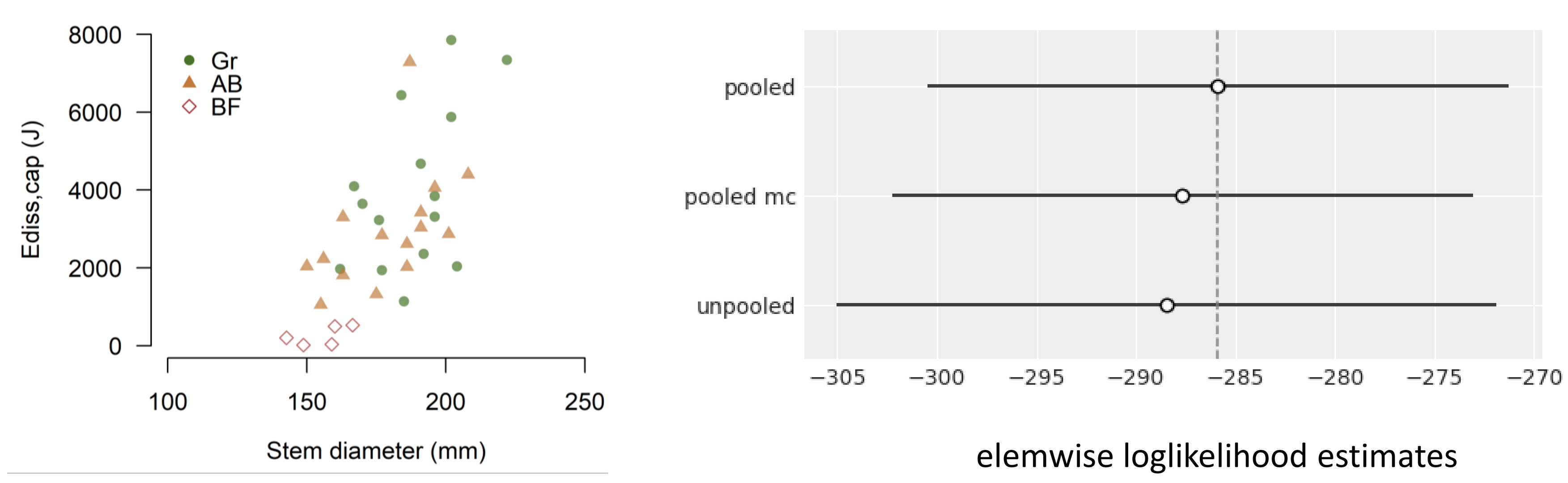

Fig. 2: Relationship between $E_{diss,cap}$ and stem diameter in Bitsch Forest (BF), artificially burnt (AB) and green (Gr) stems (left) and estimates of the elemwise loglikelihood of posterior samples of the tested models (right).

- Pooled model (without fire treatment) fits the most to the experimental data: $E_{diss,cap} = 7 \cdot SD^{2.5}$
  - Lightly burnt stems do not have significant lower $E_{diss,cap}$ than green stems
  - Low moisture content variability?

Reference: Luuk K. A. Dorren, Frédéric Berger, Stem breakage of trees and energy dissipation during rockfall impacts, *Tree Physiology*, Volume 26, Issue 1, January 2006, Pages 63–71, https://doi.org/10.1093/treephys/26.1.63

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