

Introduction

The aim of this study, conducted in the hemiboreal forest zone of the Eastern Baltic region, was to compare the wind-loading resistance of Eurasian aspen, silver birch, Scots pine, Norway spruce, European beech, and pedunculate oak.

Materials and methods

Static tree pulling-test for detopped trees was applied to quantify mechanical stability and thus resistance against wind damages as the strength of the soil–root anchorage and stem (Fig. 1, 2, 3).

Results

Species	Tree (n)	DBH (cm)	H (m)	H DBH ⁻¹ (m cm ⁻¹)	V _{stem} (m ³)	WD _{roots} (m)	DP _{roots} (m)	BBM _{PF} (kNm)	BBM _{SF} (kNm)
Aspen	28	36.0±2.2	33.5±0.9	0.94±0.10	1.70±0.20	1.5±0.6	0.8±0.3	90±28	123±34
Beech	18	34.0±2.8	29.1±1.2	0.89±0.10	1.43±0.20	1.5±0.7	0.9±0.4	135±36	184±43
Birch	88	26.0±1.5	26.9±1.0	1.06±0.00	0.74±0.10	1.9±0.4	0.8±0.2	49±9	67±13
Oak	31	34.0±2.5	27.0±0.5	0.82±0.10	1.26±0.20	1.0±0.4	1.0±0.4	109±21	141±27
Pine	27	33.0±3.0	27.4±1.0	0.87±0.10	1.17±0.20	1.4±0.5	1.1±0.4	89±17	130±29
Spruce	50	29.0±1.7	26.2±0.9	0.93±0.00	0.88±0.10	2.4±0.7	0.7±0.2	59±9	75±12

Table 1. The total number, mean (± 95% confidence interval) stem diameter at breast height (DBH), height (H) of the sampled trees.

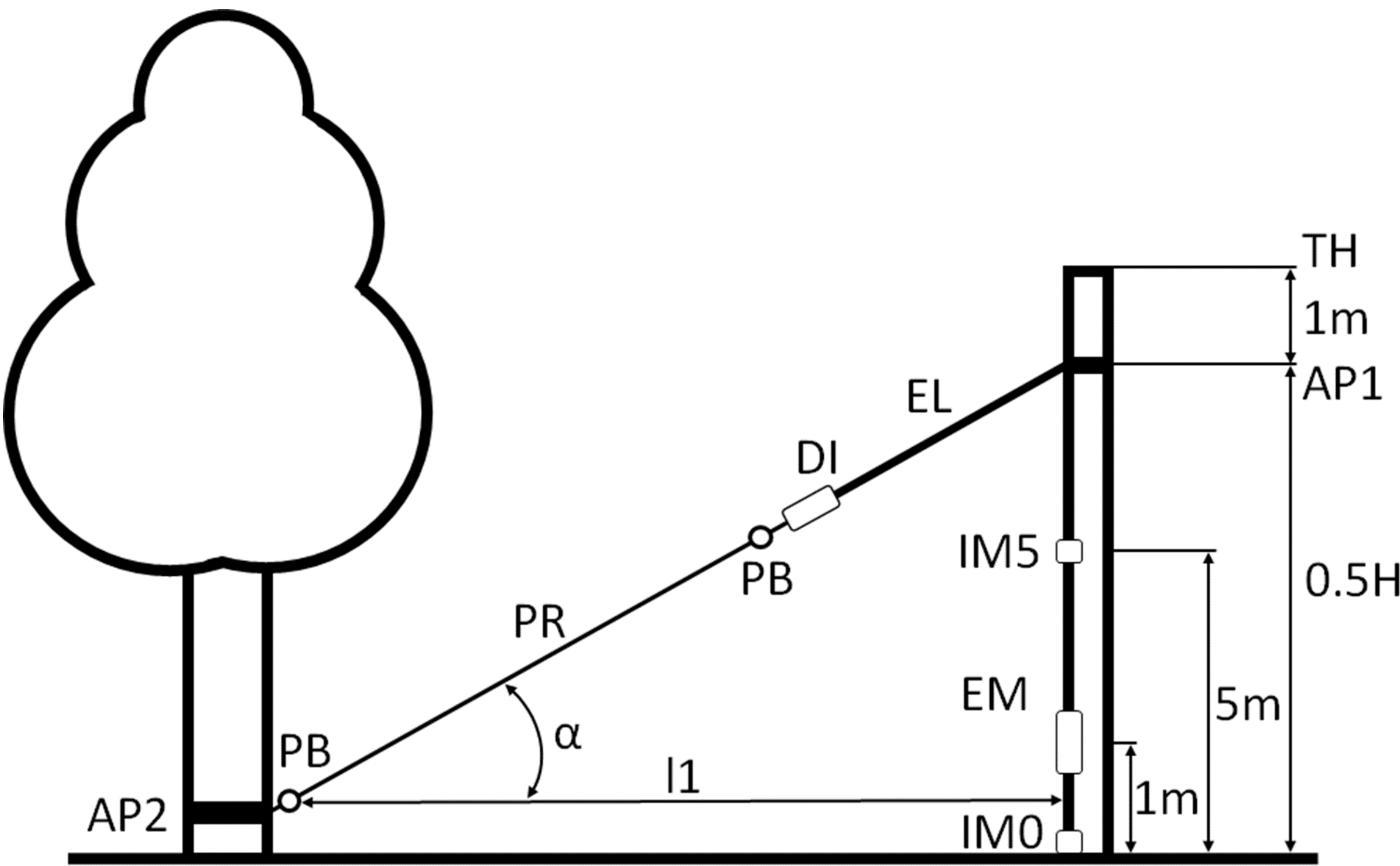


Figure 1. A scheme of the destructive pulling test.



Figure 2,3. Sample trees results of the pulling test.

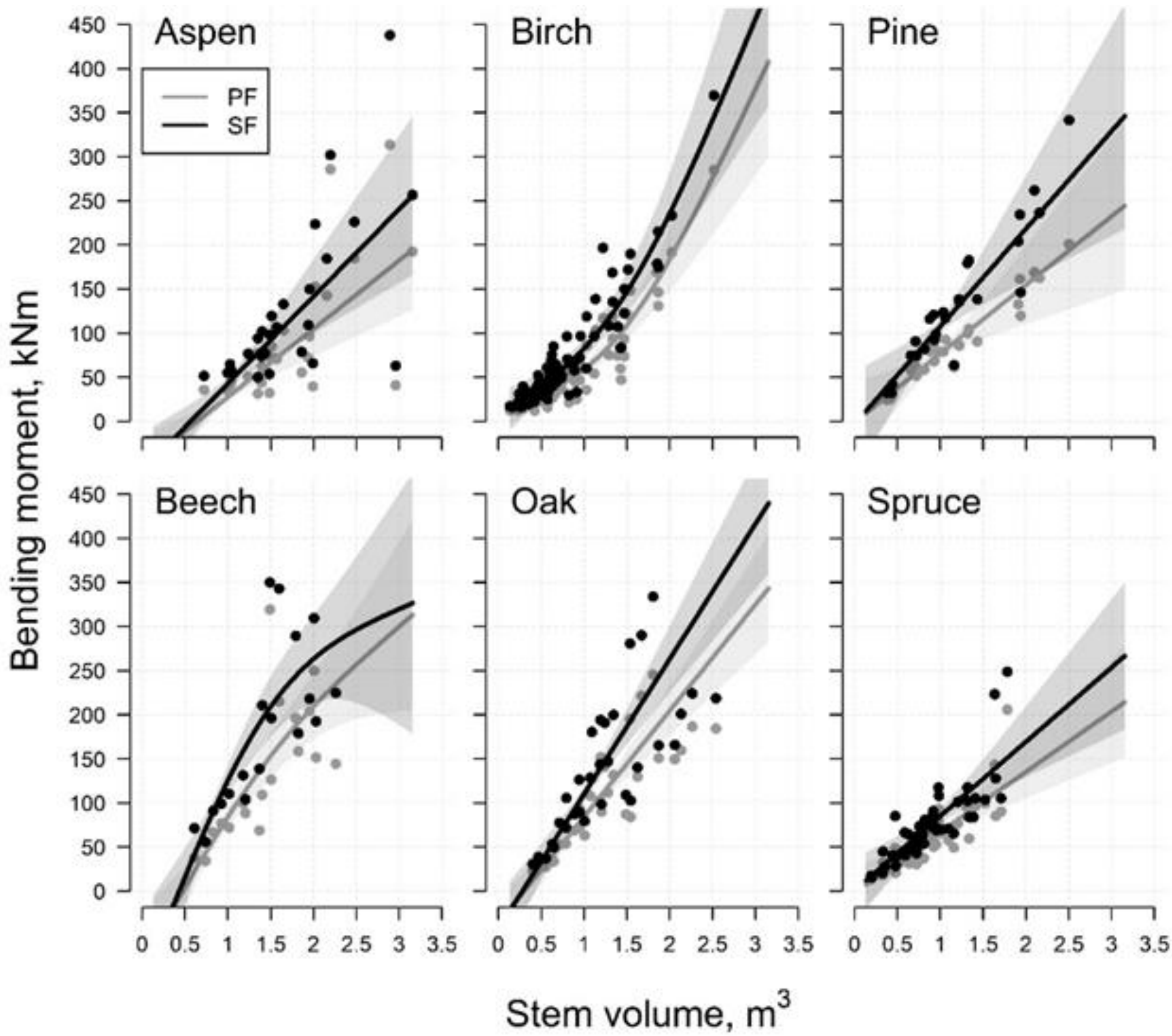


Figure 4. Generalized additive model (GAM) responses of the relationships between basal bending moments at both primary (BBMPF) and secondary (BBMSF) failures and stemwood volume (Vstem) of the sampled trees.

- Uprooting was the prevailing failure type of fatal failure for most of the studied species.
- Beech had reduced loading resistance for larger individuals.
- For birch the resistance increased as trees aged and became dominant.

Conclusions

As hemiboreal stands in the Eastern Baltic region face intensifying natural disturbances driven by climate change and a northward shift in species distribution, the expansion of more thermophilic species such as beech is expected. However, the rapid decline in mechanical stability among older and larger beech individuals may point to an incomplete adaptation to local conditions—potentially making mature beech stands more vulnerable to wind damage compared to birch.