





Acknowledgements and funding

This research was funded through the 2018-2019 BiodiversA joint call for research proposals, under the BiodiversA3 ERA-Net COFUND programme, and with the funding organisations



MEDIZINISCHE
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IFE
Institute of
Forest Ecology

Integrating Tree Species Identity and Diversity in Particulate Matter Adsorption

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The forest as a natural filter

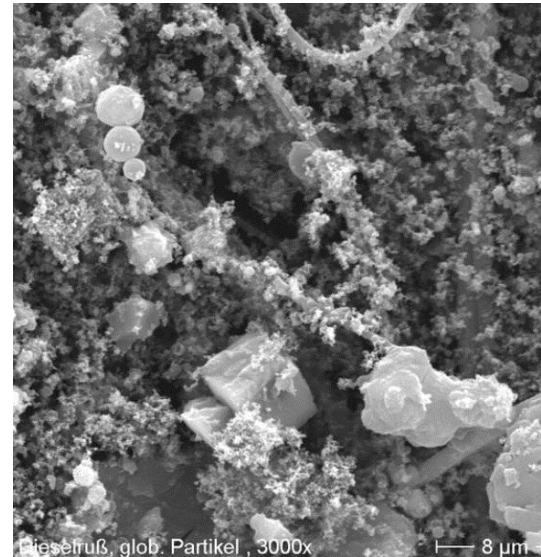


Particulate matter (PM)

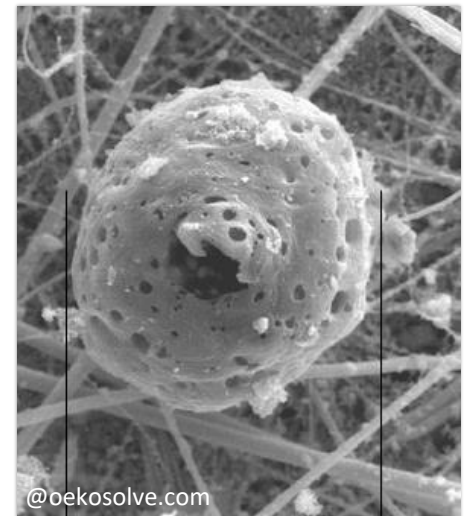
PM₁₀₀ particle size 100-10 μm

PM₁₀ particle size 10-2.5 μm

PM_{2.5} particle size 2.5-0.2 μm



Dieselfuß, glob. Partikel, 3000x
@Umweltbundesamt/C. Trimbacher

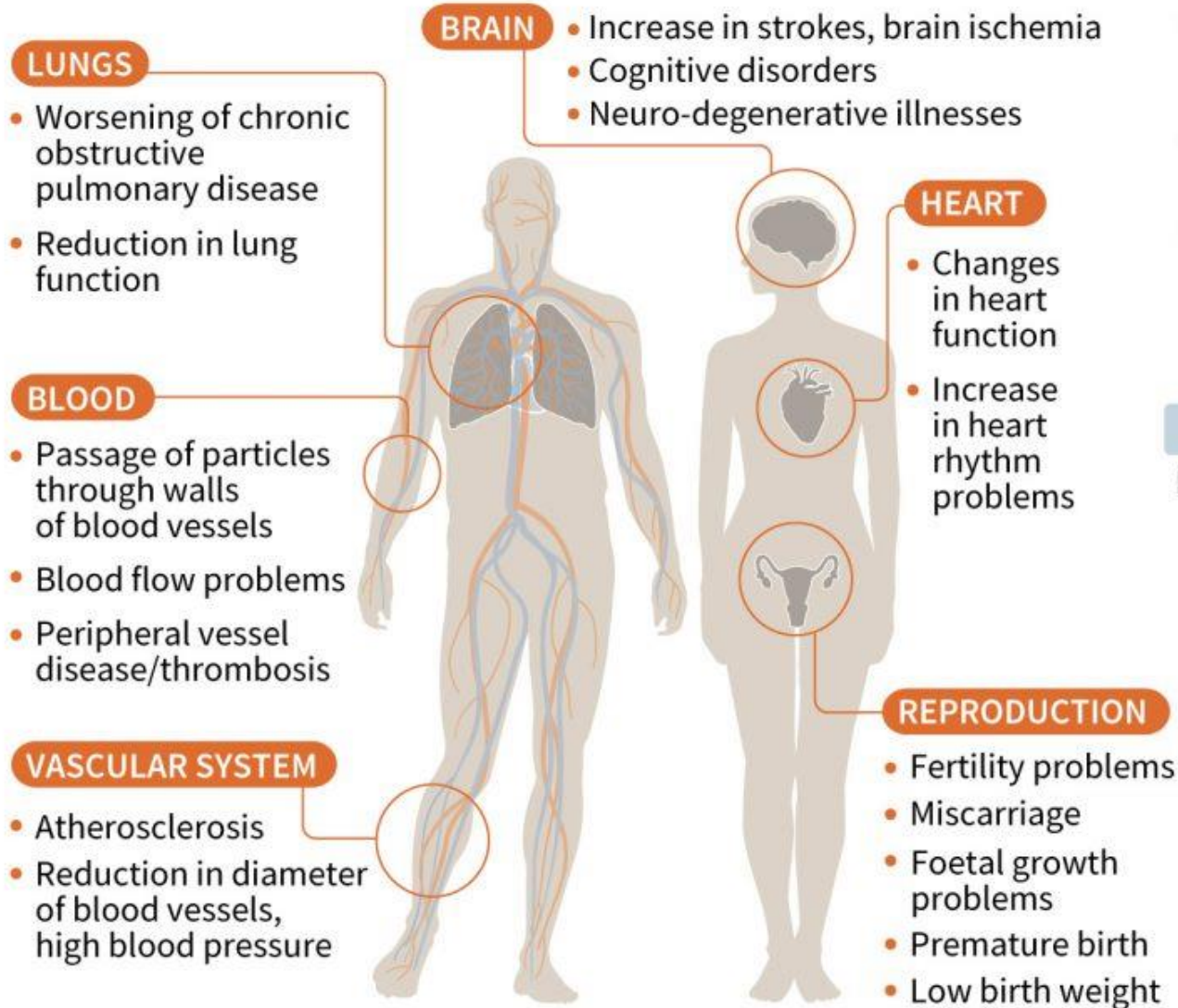


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PM 2.5 = 0.0025 mm

Deadly impact of air pollution

How fine particles affect the body



Effects of exercise

- 5 times more pollutants inhaled during moderate exercise than at rest
- Deeper penetration of pollutants into the lungs
- Blood levels of toxins in city runners along busy roads can double after 30 minutes to those of regular smokers

Fine particles

PM = particulate matter

PM₁₀
Ø <10 microns
(0.01 mm)

PM_{2.5}
(the smallest and most dangerous)
Ø <2.5 microns

Human hair
Ø 50-70 microns

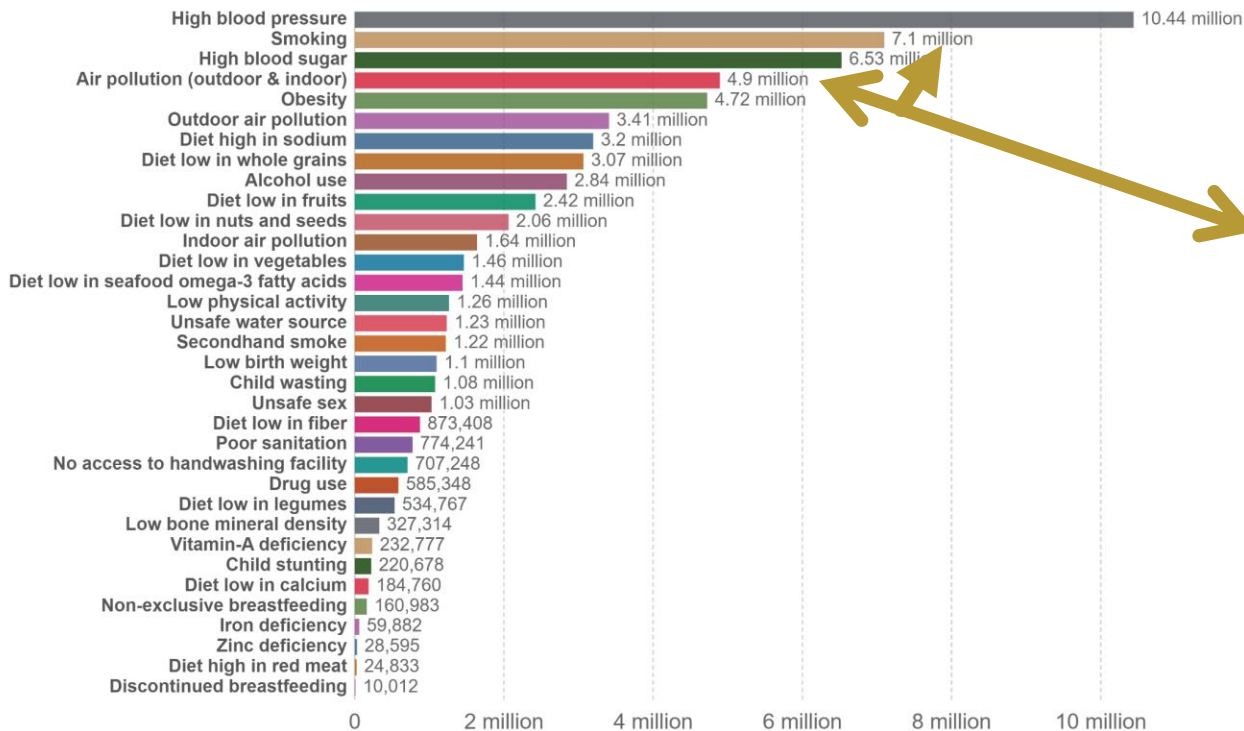
Particulate matter (PM)

- ◇ leads to over 8.8 million deaths every year, globally (Burnett et al., 2018; Lelieveld et al., 2020).

Number of deaths by risk factor, World, 2017

Total annual number of deaths by risk factor, measured across all age groups and both sexes.

Our World
in Data



The background image is a dark, atmospheric landscape. It features a dense forest of evergreen trees in the foreground and middle ground. In the background, there are rolling hills and mountains under a dark, cloudy sky. The overall tone is somber and naturalistic.

Best solution: Zero air pollution

Phytoremediation

Trees...

- ⑧ act as a **natural filter**
- ⑧ a form of **phytoremediation**
- ⑧ well-suited for **air purification**
- ⑧ big **absorptive area** e.g. Leaf Area Index (LAI)



Hypothesis



- (1) Small, rough leaves $>$ large, smooth leaves
- (2) LAI is a great modifier
- (3) Monocultures $<$ Polycultures

B-Tree

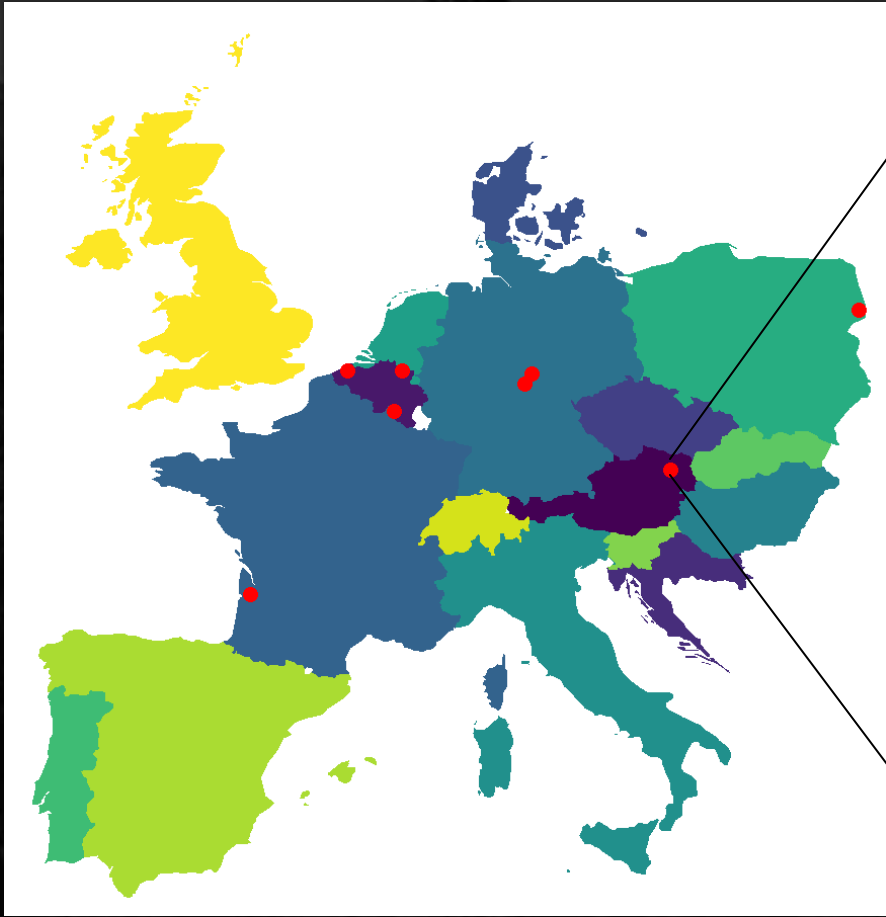


Fig. 2. Dr.FOREST sites locations marked with red dots.

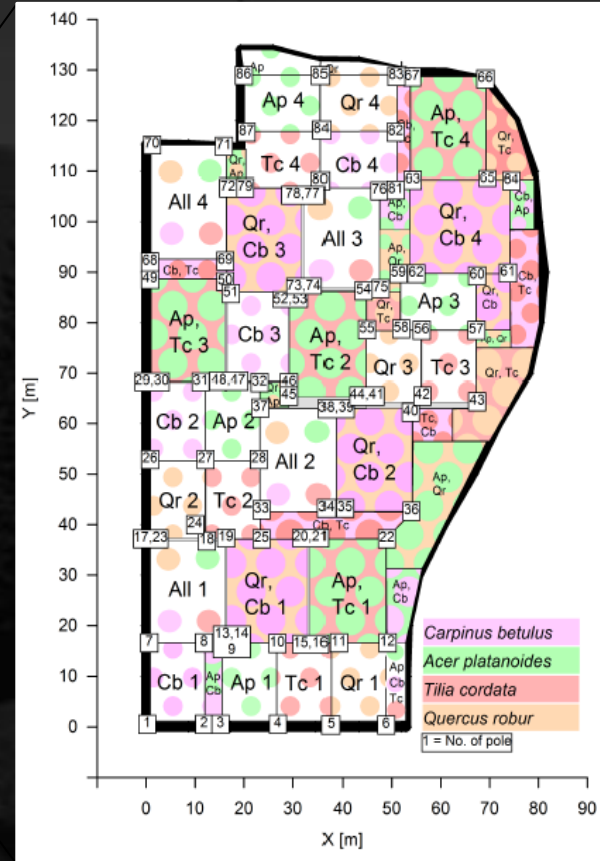


Fig. 3. B-Tree plot arrangement.

Tab. 1. B-Tree details.

Location	Tulln, Lower Austria
Planting date	April 2013
Area	1.2 ha
No. of plots	44
Diversity gradient	1, 2, 4 species
Species pool	Acer platanoides, Carpinus betulus, Quercus robur, Tilia cordata

Methods: LAI

➔ direct LAI estimation

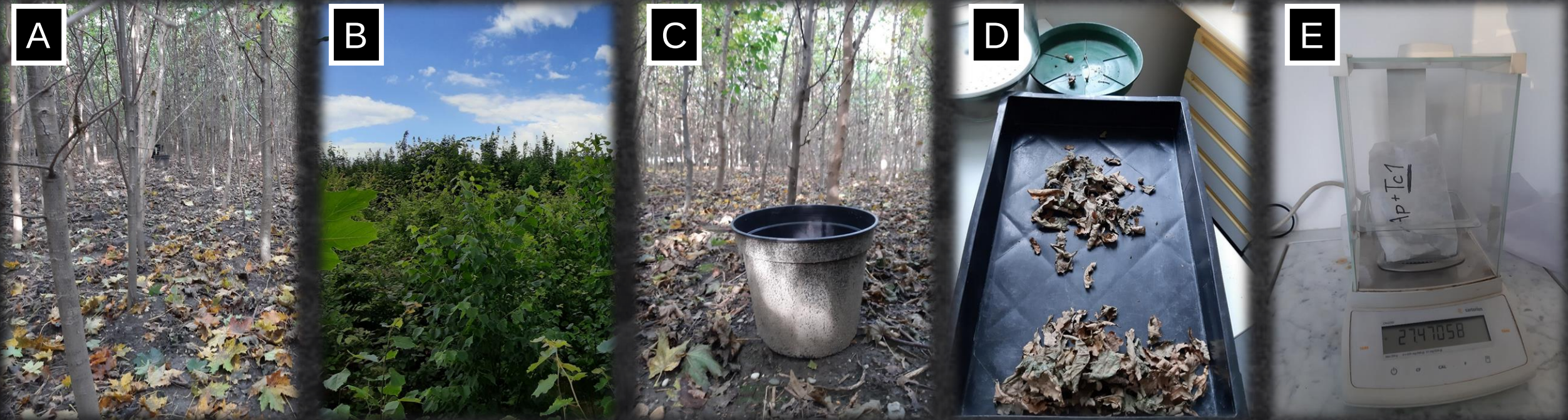


Fig. 4. [A, B] Experimental site B-Tree in Tulln, Lower Austria; [C] leaf litter bucket in the field; [D] sorting of litter material; [E] leaf-litter dry weight determination.

Methods: PM



Selection



Sampling



Washing



Shaking + Sonication



Solution



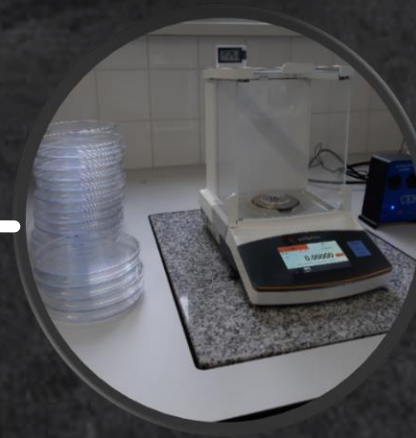
Filtration



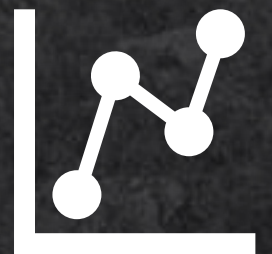
Loaded filters



Balancing



Weighing



Data

Results

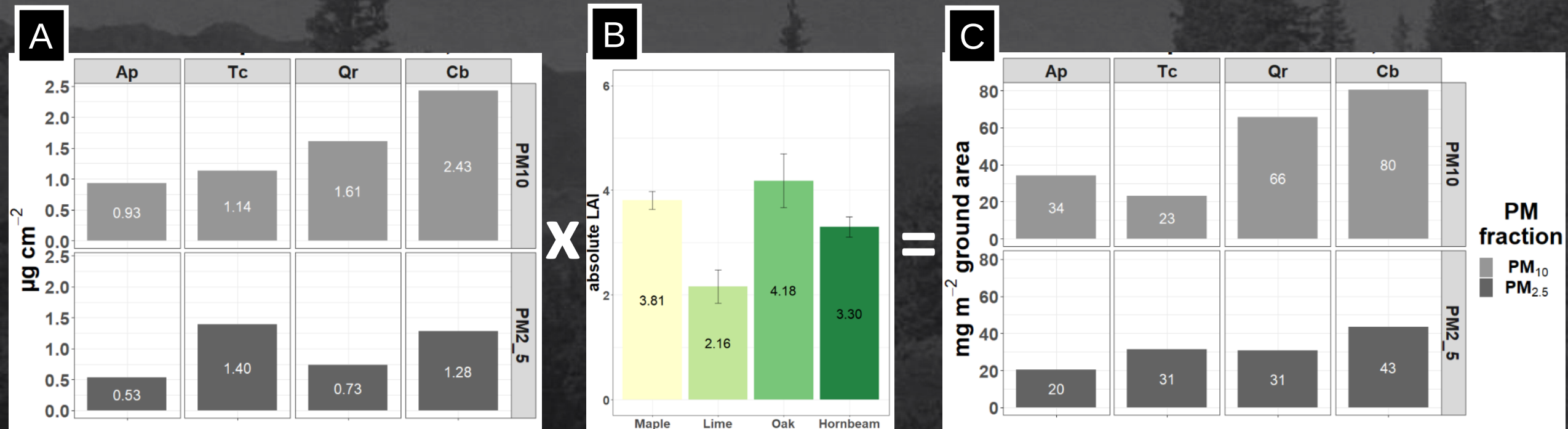
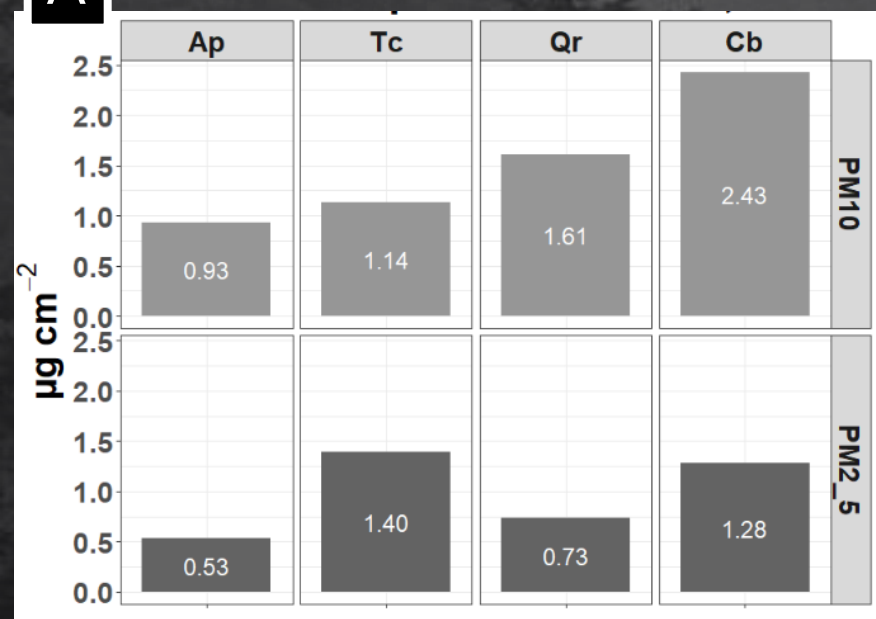
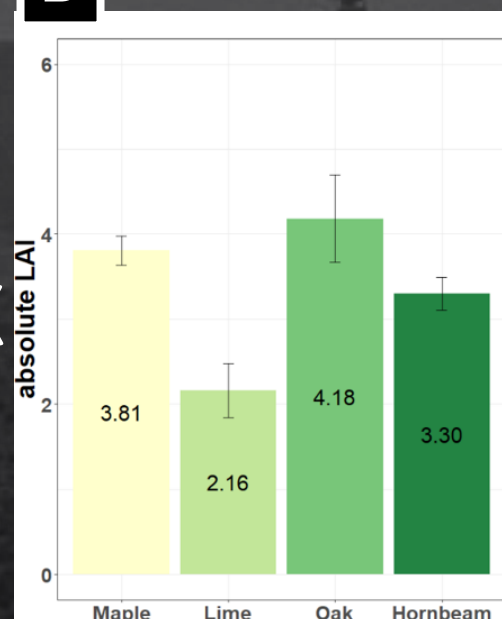
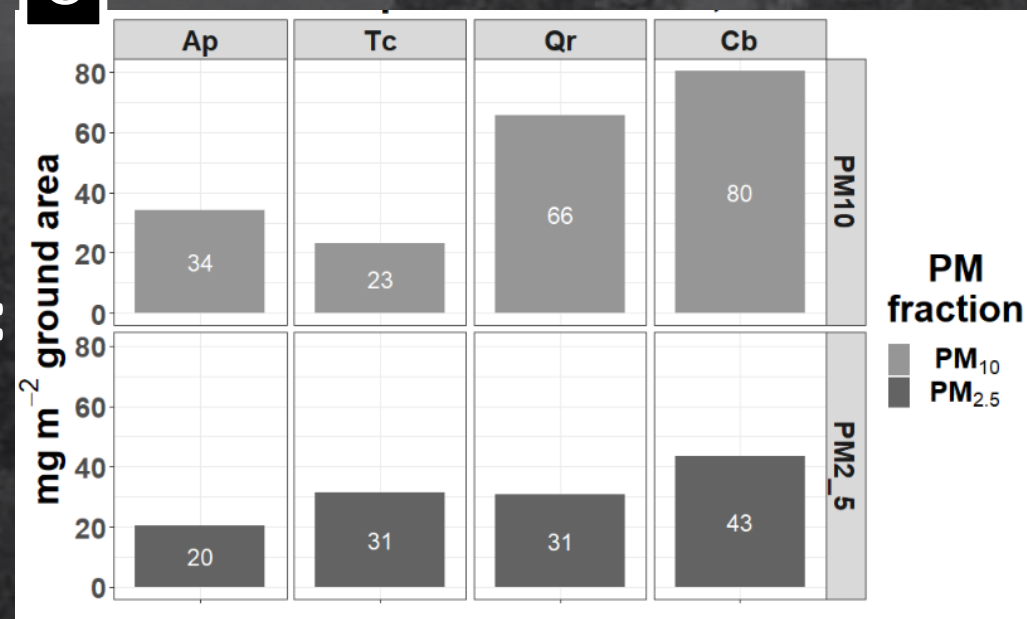


Fig. 13. Dataflow for PM₁₀ and PM_{2.5} for monocultures from left to right.

Results

A**B****C**

Results: PM

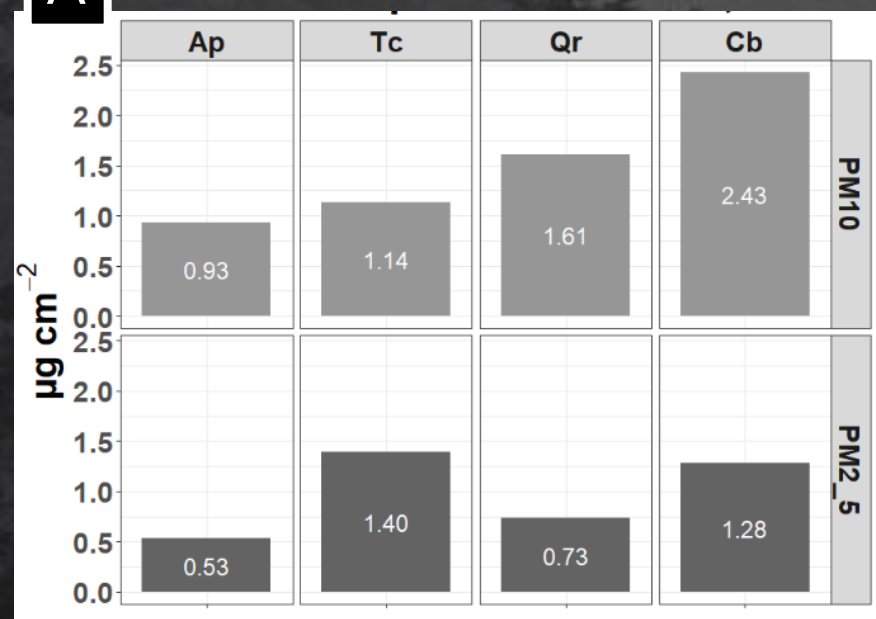
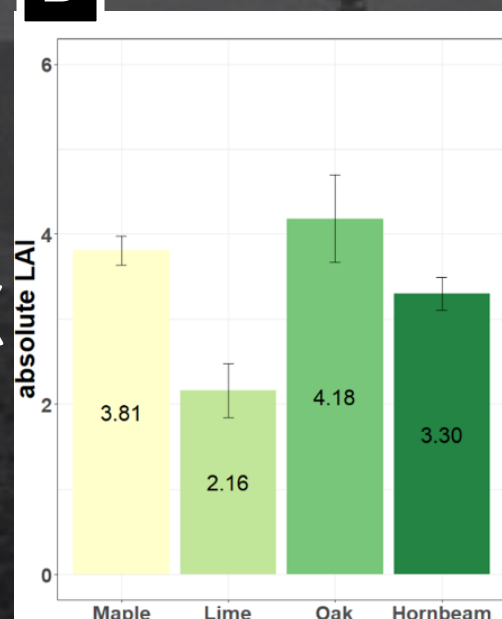
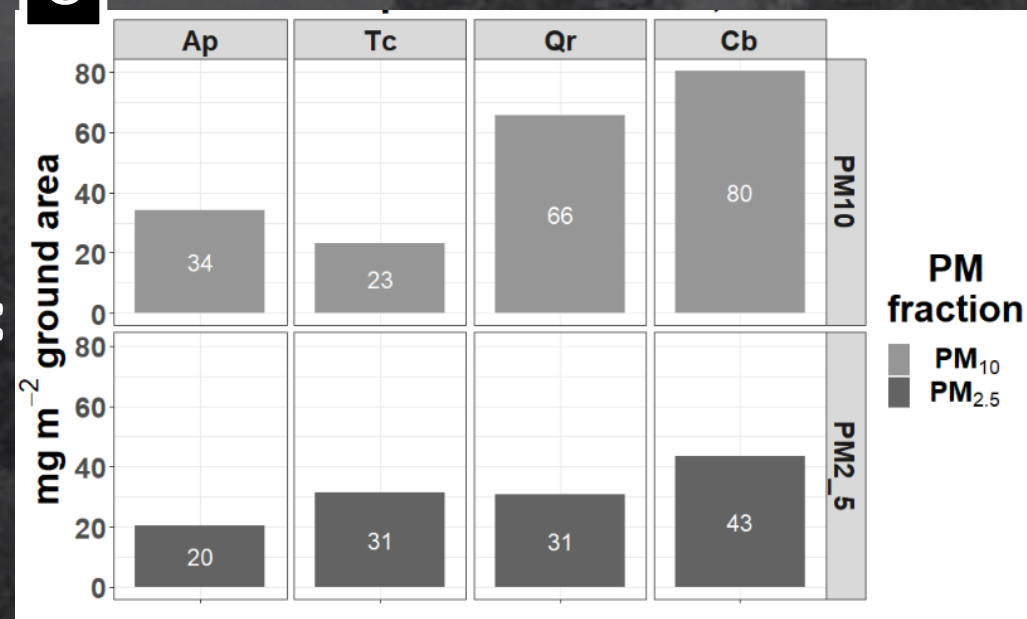


Tab. 2. Particulate matter (PM) fractions removed from leaves of *A. platanoides* (*Ap*), *T. cordata* (*Tc*), *Q. robur* (*Qr*), *C. betulus* (*Cb*) for the PM classes PM_{100} , PM_{10} , $PM_{2.5}$. Data shown in $mg\ PM \cdot m^{-2}$ leaf area $\pm$ standard error (SE).

	<i>Ap</i>	<i>Tc</i>	<i>Qr</i>	<i>Cb</i>
PM_{100}	38.0 ± 6.5	130.9 ± 40.0	60.4 ± 8.8	91.4 ± 20.7
PM_{10}	9.7 ± 3.3	11.7 ± 5.1	15.9 ± 2.9	22.0 ± 3.9
$PM_{2.5}$	4.1 ± 1.3^a	14.2 ± 2.4^b	$6.7 \pm 1.5^{a,c}$	$12.9 \pm 1.6^{b,c}$

Species identity effect

Results

A**B****C**

Results: LAI

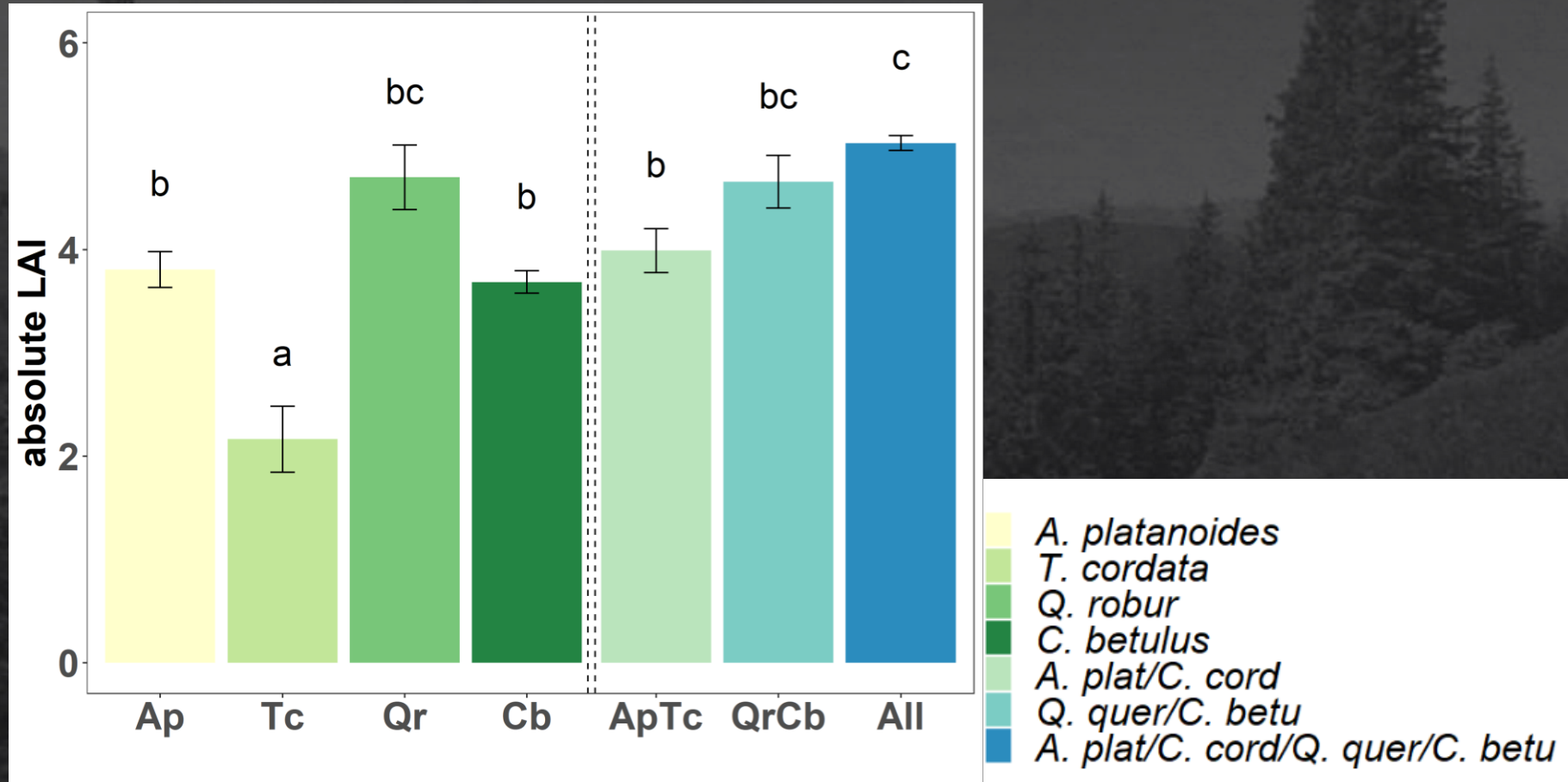


Fig. 14. Differences in mean leaf area index (LAI) measurements of all species combinations.

Results: LAI

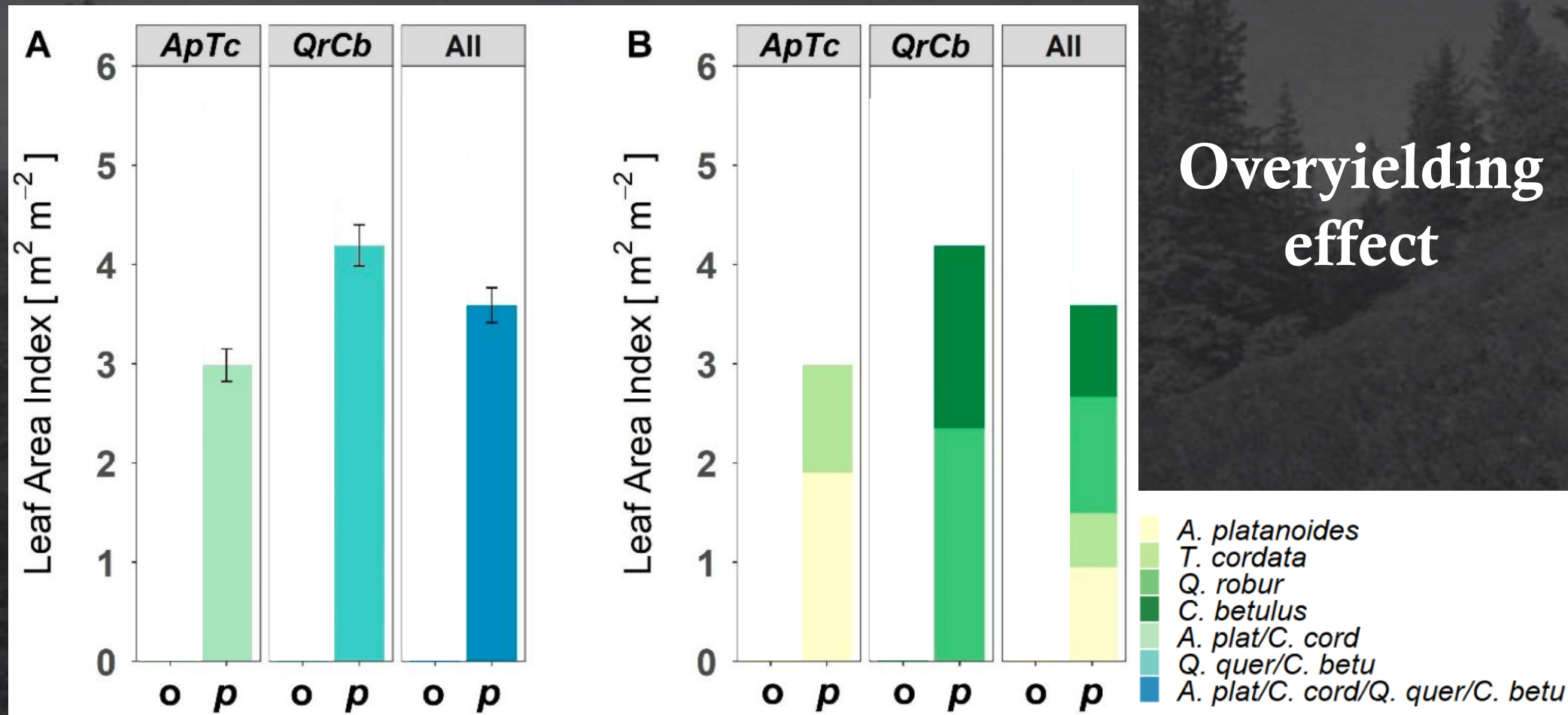
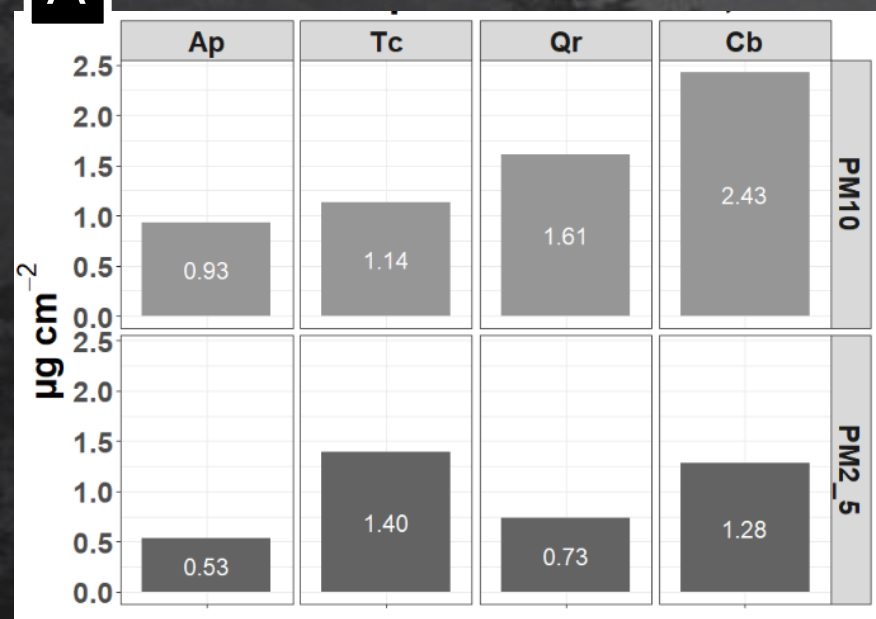
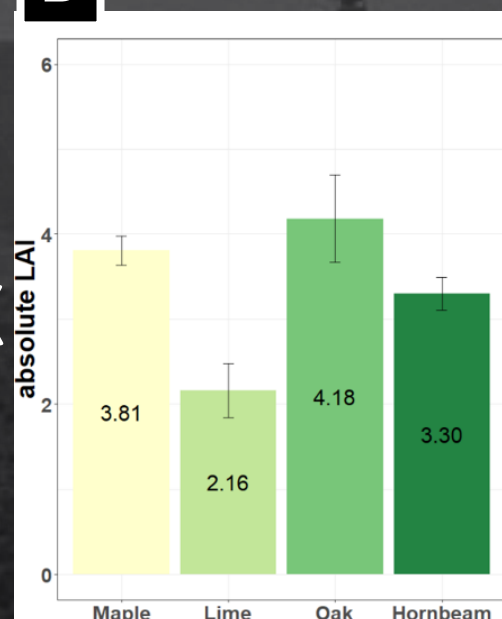
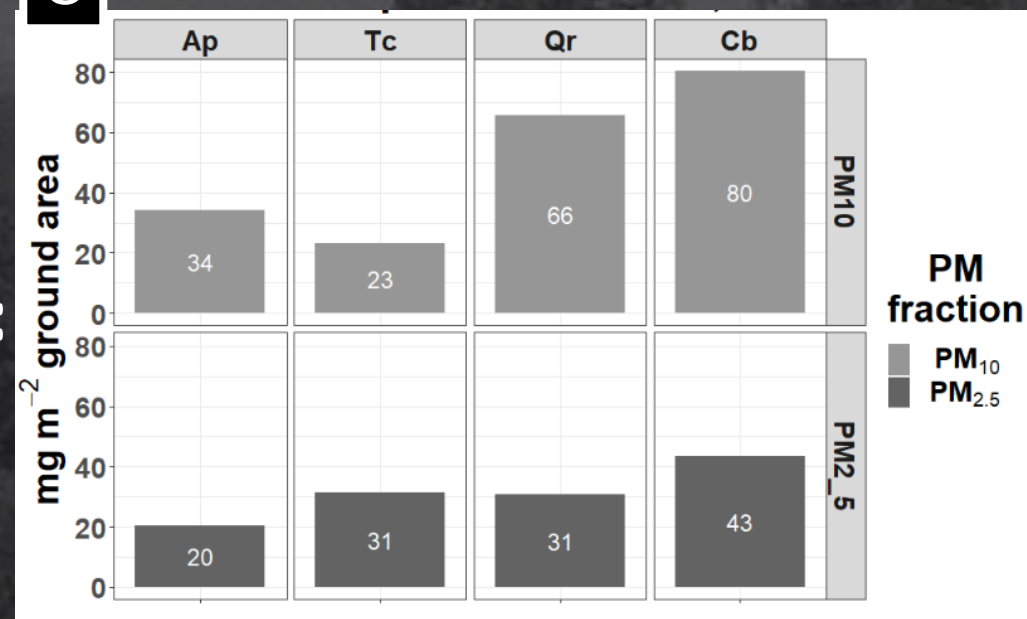


Fig. 15. (A) Observed (o) and predicted (p) leaf area index (LAI) and (B) the contribution of each species to the LAI in two species polycultures (ApTc, QrCb), and the four species polyculture (All) of the four species *A. platanoides* (Ap), *T. cordata* (Tc), *Q. robur* (Qr), *C. betulus* (Cb).

Results

A**B****C**

Results: PM canopy storage

Tab. 3. Mean PM₁₀ and PM_{2.5} removed from leaves per square meter stand area (mg·m⁻²) and standard error (SE) of the monocultures and polycultures.

PM ₁₀	Monocultures				Polycultures		
	<i>Ap</i>	<i>Tc</i>	<i>Qr</i>	<i>Cb</i>	<i>ApTc</i>	<i>QrCb</i>	All
observed	36 ± 10 a	23 ± 10 a	74 ± 14 ab	81 ± 15 ab	52 ± 21 ab/A	114 ± 8 b/A	58 ± 20 ab/A
predicted nominal					31 ± 5 A	82 ± 4 B	66 ± 6 A
predicted actual					43 ± 13 A	88 ± 7 B	71 ± 8 A
PM _{2.5}	Monocultures				Polycultures		
	<i>Ap</i>	<i>Tc</i>	<i>Qr</i>	<i>Cb</i>	<i>ApTc</i>	<i>QrCb</i>	All
observed	16 ± 6 b	32 ± 9 ab	32 ± 9 ab	48 ± 7ab	35 ± 13 ab/A	61 ± 12 a/A	62 ± 3 a/A
predicted nominal					24 ± 5 A	41 ± 8 A	37 ± 4 B
predicted actual					24 ± 5 A	43 ± 9 A	40 ± 6 B

Key messages



Trees remove PM and ultimately aid to human health and wellbeing



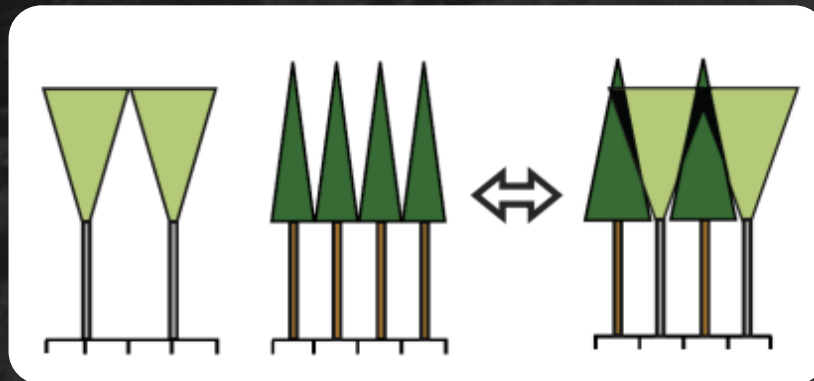
Leaf properties and LAI significantly influence PM retention

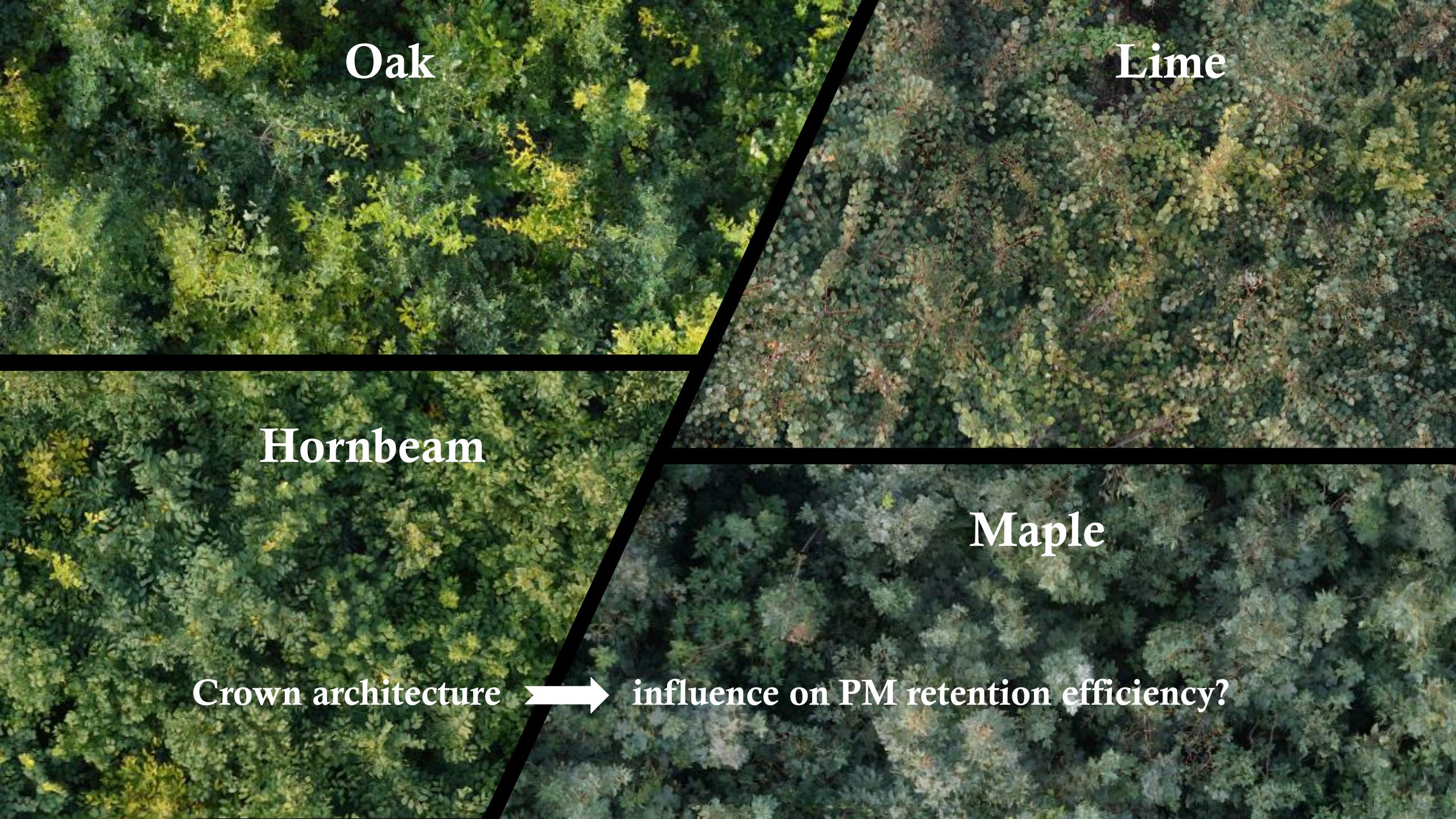


Tree species composition plays a role



Overyielding can result in greater PM removal





Oak

Lime

Hornbeam

Maple

Crown architecture → influence on PM retention efficiency?

A scenic mountain landscape. In the foreground, there's a hillside covered in low-lying vegetation with reddish-brown and green hues. Several tall, dark green evergreen trees are scattered across the slope. In the background, a range of blue-toned mountains stretches across the horizon under a clear, light blue sky with a few wispy clouds.

Thank you for your attention!