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PHYSICAL MODELLING OF WIND EROSION ON WILDFIRE ASH LOADS

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Motivation & Goal

- **Forest fires** produce an extensive impact on **soil, water, air and vegetation**.
- In **South Europe**, wildfires are a **frequent phenomenon**, due to **climate regimes** propitious to **fire ignition and spreading**.
- Furthermore, the **frequency of forest fires** in Europe is expected to **increase** substantially in the next decades, part due to an **increase in weather conditions favorable to fire**.

- It is known that **wind erosion** can play a **major role** in **burned landscapes**, however **wind erosion and wind transport** processes are still largely **unstudied** in the **post-fire environment**.
- This work aims to contribute to fulfil this scientific gap, by **evaluating the relationship between wind speed and ash layer depth in the release of ash from the ground after fire.**

Case Study | forest types more prone to fire

2 Maritime pine stands and Eucalyptus plantation

To collect the material needed for this work, **two types of forest** that are predominant and more prone to fire in the **Center of Portugal** were studied :

plantations of **Maritime Pine** and of **Eucalyptus** were sampled in the **"summer-autumn" 2018** burnt areas of **Loriga** and **Palmaz.**

Loriga burnt area

Two stands of Maritime Pine were selected for their **contrast in height/age** and because they comprise two sub-areas with **contrasting degrees of fire severity**, the four pine sites being designated as **Young Maritime Pine (YP) vs. Mature Maritime Pine (MP)** with **low canopy consumption (LCC) vs. high crown consumption (HCC).**

Palmaz burnt area

An **early-stage third-rotation eucalyptus plantation (E3)** was selected for comprising two sub-areas with contrasting degrees of **crown consumption** as well.


LORIGA


raio2

Case Study | forest types more prone to fire

2 Maritime pine stands and Eucalyptus plantation

- Summarizing, **six study sites**, with **YP** and **MP**, and two degrees of **crown consumption**:

YP-LCC (Young Pine-Low Crown Consumption)

YP-HCC (Young Pine-High Crown Consumption)

MP-LCC (Mature Pine-Low Crown Consumption)

MP-HCC (Mature Pine-High Crown Consumption)

E3-LCC (Eucalyptus-Low Crown Consumption)

E3-HCC (Eucalyptus-High Crown Consumption)

Complete crown consumption HCC

young pine

Partial crown consumption LCC

mature pine

Spontaneous leave cast from scorched eucalyptus crowns LCC

eucalyptus

Experimental set-up | wind erosion experiments

For wind erosion experiments it was used the University of Aveiro/DAO **Open circuit, suction type wind tunnel**:

- **13** meters long
- test section of **6.5** meters in length, **1.5** meters in width and **1** meter in height.

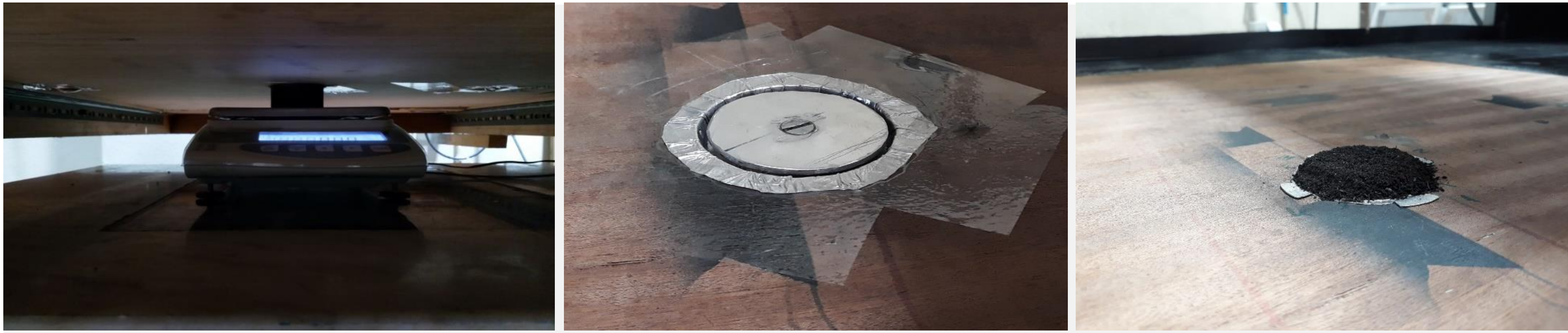
Laboratory of Atmospheric Aerodynamics at the Department of Environment and Planning of the University of Aveiro

Experimental set-up | soil aggregates and roughness

- For the preparation of tests, the **mean weight diameter of soil aggregates** for a typical soil was identified as **1.716 mm**.
- Considering that **50% of the soil aggregate is below the average soil level**, thus not exposed to the wind or the ashes, an average height of **0.858 mm** was considered, measured between the **average soil level** and the **top of the soil aggregate**.

- To represent this **soil roughness**, a **Sandpaper** with Grit 24 was used, since the particle diameter of the sandpaper (minimum of 0.686 and maximum of 0.940 mm) fits with the 50% mean weight diameter of the soil.

Experimental set-up | wind erosion experiments

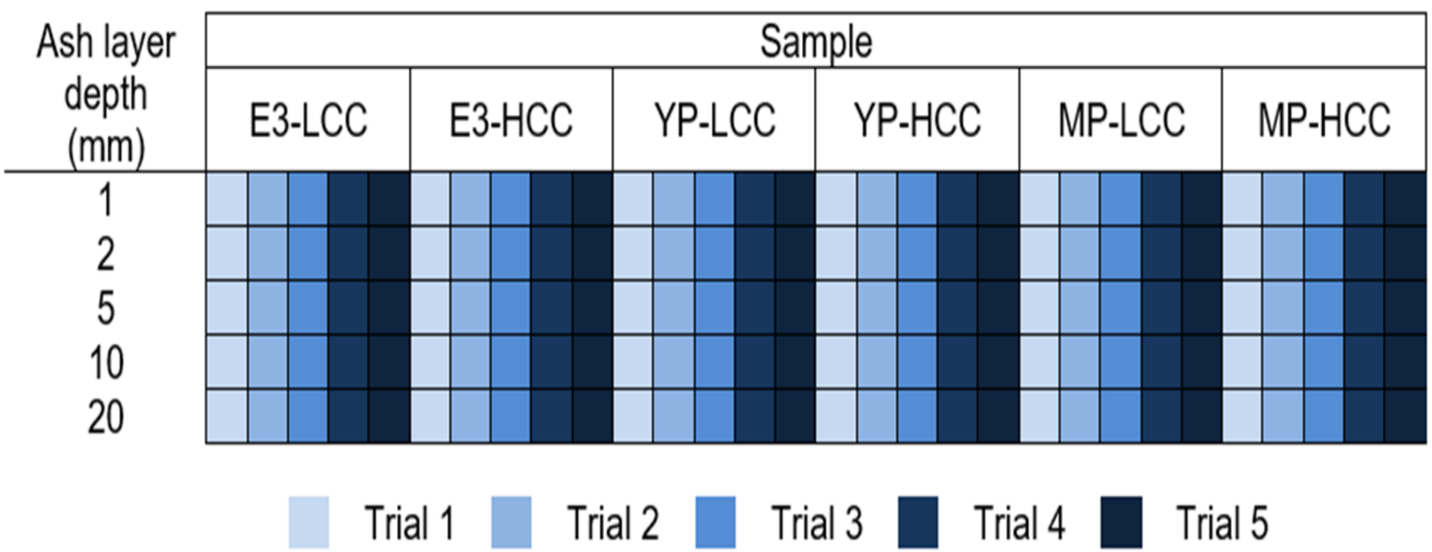


a) b) c)

- During experiments in the wind tunnel, to constantly weigh the ash mass along the tests, a **circular plate with a diameter of 60 mm** was built and positioned in line with the bottom of the wind tunnel (b).
- Sandpaper was added to the top of the circular plate (b) to correctly simulate the **interaction between the ashes and the soil**.
- The **ashes were placed on top** of this plate (c), connected to a **balance** (a) with a readability of 0.01 grams and a linearity of 0.01 grams.
- The balance was connected to a computer through a RS-232 connection, transmitting the mass measurement twice every second.

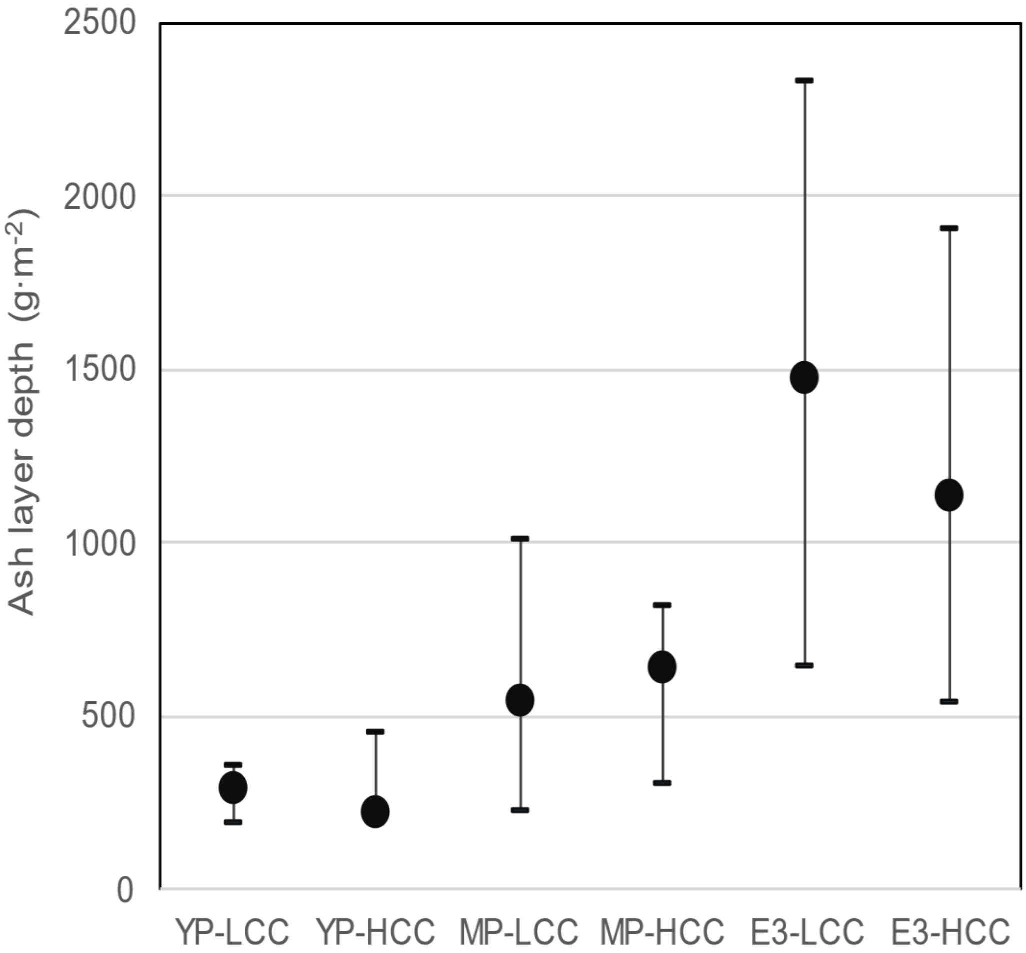
Experimental set-up | wind erosion tests

- 5 different ash layer depth were tested with **1, 2, 5, 10, 20 mm** for each **species** and **crown consumption** samples.
- For each **ash layer depth**, the free wind stream velocity ranged **from 1 to 10 m·s^{-1}**, with an average velocity-step of **1 m·s^{-1}**, keeping the wind velocity constant for 3 minutes at each time step.
- Five replicates were performed for each arrangement in a total of **150 experiments**, to increase the robustness of results.



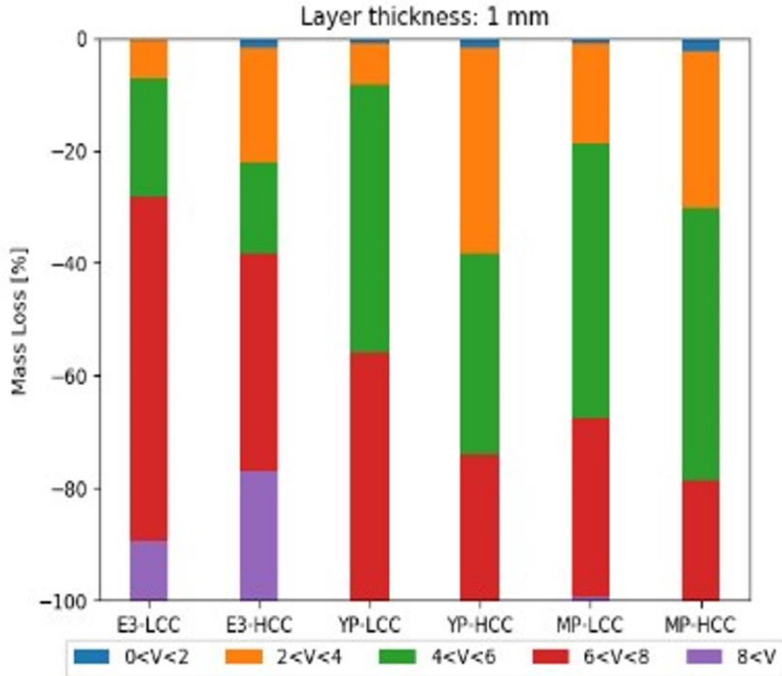
Results | ash layer depth

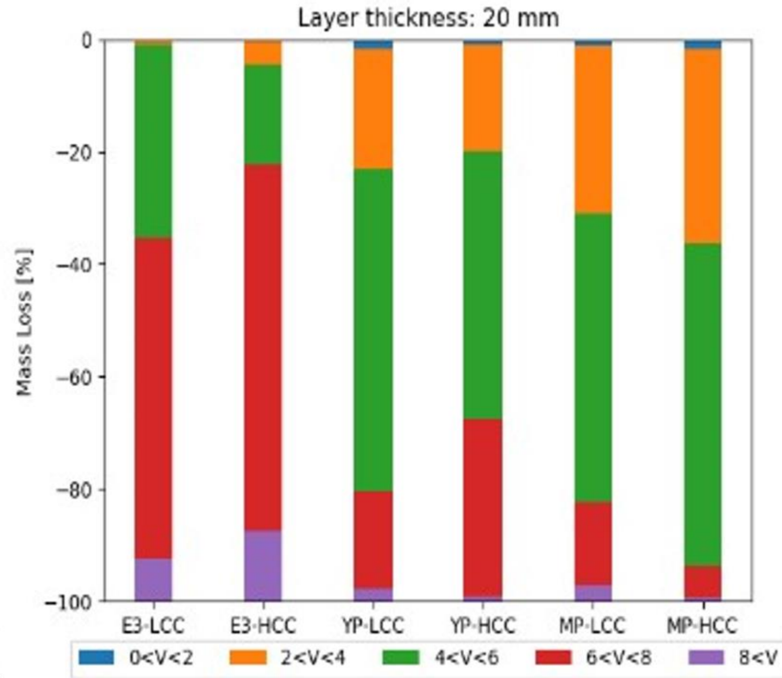
The tests were based on the characterization of the **ash collected at the sampling sites** and on the **patterns of wind erosion** associated with **each species and canopy consumption**.



1. The **ash layer depth** at the patches revealed a tendency to be **lower at the young pine** stand, **intermediate at the mature pine** stand and **higher at the eucalyptus** plantation.
2. This was not only the case for the **median loads** but also for the **minimum and maximum loads**.
3. The two types of **crown consumption** did not play a consistent role in patch ash layer depth across the three forest stands.

Results | mass loss

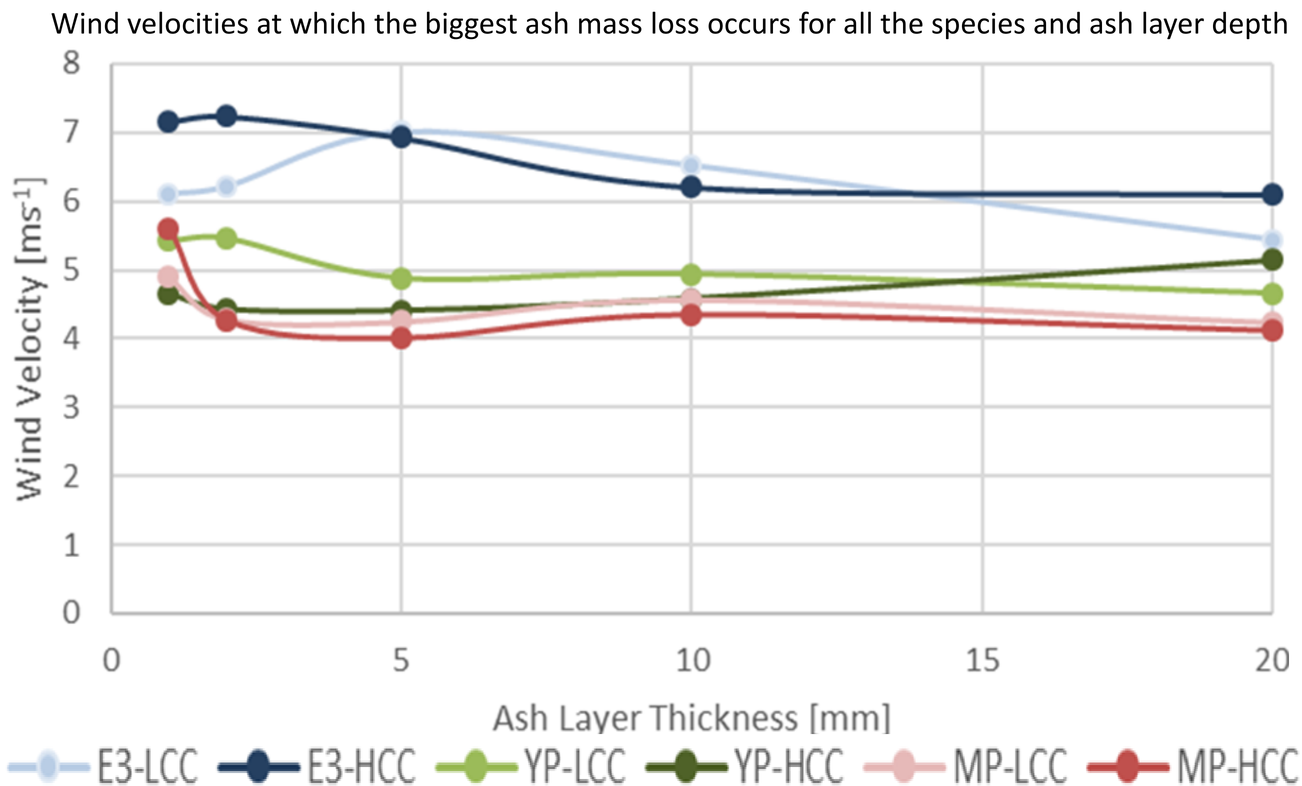




- ✓The figures show, in percentage, the **mass loss (in relation to the initial mass**) within the five different velocity groups, for all species. The **increasing ash layer thickness** results in **greater ash mass losses** at **lower wind velocities.**
- ✓The **Eucalyptus (E3)** results show **increased resistance** when compared to **Young Pine (YP)** or **Mature Pine (MP)** → most of the **mass loss** of **E3** ashes occurs at **higher wind velocities for all ash layer thicknesses**.
- ✓**Thinner ash layers** are **more resistant** to **wind erosion** than **thicker ash layers.**

Results | wind velocity

- The differences between **Eucalyptus (E3)** and **Maritime Pine (MP)** stands are visible, and the **wind speeds** at which the **greatest loss of ash mass** occurs are **greater for E3 than for YP and MP**.



- The expected behavior of **deeper ash layers** was not found to be **less resistant to wind erosion** for E3-LCC.
- The wind speeds at which the **greatest loss of mass** occurs **increases** for ash layers **below 5 mm depth** and **decreases** for ash layers with a depth of **10 and 20 mm**.

Outcomes

The experimental results highlight **trends** and **behaviours** that are crucial to the definition of **mitigation wind erosion measures**.

Four main results pop-out:

1) **Eucalyptus** exhibited **more resistance** to **erodibility** than **Maritime Pine** specie;
2) **Thinner ash layers** are more **resistant** to **wind erosion** than **thicker ash layers**;
3) **High wind velocities** promote **higher ash detachment** from the soil due to wind erosion;
4) **Smaller particles** are **less susceptible** to **detachment** due to **compaction level**.

Future work

- Test the **effectiveness** of selected measures for the **worst wind erosion scenarios**.
- Introduction of **barriers around and over the ash** to reduce the transport of ash by wind.
- Compare with **numerical simulation** results.

Thank you!