Wildland-Urban Interface Virtual Essays Workbench

WUIVIEW

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Technical Note TN 2.4.
Fuel sampling, tree ignition and burning tests in ADAI facilities

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Abstract	In this document, the followed methodology to characterize several natural fuels (trees of *Cupressus arizonica*, *Cupressocyparis leylandii*, *Prunus laurocerasus* and *Thuja occidentalis*) is presented. Also, the ignition method and the equipment used to monitor the burning of these fuels in two different configurations are described. These activities were performed in ADAI facilities (Lousa, Portugal).

(1) Draft / Final

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1. Introduction

A first set of burning experiments with natural fuels was performed in ADAI facilities at LEIF (Laboratório de Estudos sobre Incêndios Florestais) in Lousã (Portugal) between September 23th and 26th, 2019. During these fire tests, two configurations of four different ornamental species were burned and several data were recorded.

These four species (*Cupressus arizonica*, *Cupressocyparis leylandii*, *Prunus laurocerasus* and *Thuja occidentalis*) are typically used in different regions of the EU as green hedges.

In this Technical Note the methodologies used for fuel sampling and for the burning tests are described.

2. Methods

2.1. Fuel sampling

Destructive samplings of whole trees were performed for each one of the four tested species. The aim of these destructive samplings was to know the fuel load and its distribution all along the tree canopy of the different species. Besides, it was possible to know the moisture content of the different living and dead tissue. The trees were obtained from a garden center. Trees of the same species were coeval and similar in geometry and height.

To estimate the most important geometrical features of the sampled trees, pictures from two perpendicular directions were taken (front and lateral view). To allow the post-processing of the images, a chessboard pattern was positioned behind the specimen to be used as reference. Vertical and horizontal rules were also used to allow image-based distance measurements (Figure 1).

The canopy was divided (cut) in three sections of the same length along its longitudinal axis. These cuts were performed following parallel layers with the ground. If a branch belonged to more than one section, it was cut and separated among its subsequent sections. If the canopy base was not in contact with the ground of the pot, the bare stem between the ground and the canopy was removed and measured separately. The bottom section was named as the first section, the middle section as the second section and the upper one as the third section. The fuel in each section was classified into several subgroups regarding the criteria set in Table 1.

Table 1. Criteria and subsequent subgroups used to classify fuels. For example, the code used to identify fuels with a diameter between 3 and 6 mm of woody dead tissues belonging to the first section of the Cupressocyparis leylandii specimen was CL_1DW<6.

CRITERIA	LABEL	SUBGROUPS
SPECIES	CL	*Cupressocyparis leylandii*
	CA	*Cupressus arizonica*
	PL	*Prunus laurocerasus*
	TO	*Thuja occidentalis*
SECTION	1	1st section
	2	2nd section
	3	3rd section
STATE	A	Live fuels
	D	Dead fuels
PHYSIOLOGY	F	Foliage
	G	Green tissues
	W	Woody tissues
DIAMETER	<3	Ø ≤ 3 mm
	<6	3 mm < Ø ≤ 6 mm
	<10	6 mm < Ø ≤ 10 mm
	>10	Ø > 10 mm

Figure 1. Front view of a Cupressocyparis leylandii specimen. The horizontal rule is 0.6 m long; the vertical rule is 1 m long. The side of the chessboard reference square is 0.25 m long. There is no gap between the canopy base and the ground (tree height = crown height).

Note that not all the subgroups existed in each specimen (e.g. a tree could not have a dead woody stem with a diameter larger than 10 mm in its upper part). An example of this

classification system is shown in the header of Table 1. The fuels were classified following the previous criteria, weighted (wet weight), dried and weighted again (dry weight). The weight was measured in a balance Mettler PM600 (0.01 g precision) for the lighter samples (<600 g) (Figure 2a) and in a scale AND HW-100KGL (10 g precision) for the heavier samples (Figure 2b). Samples were dried during 24 hours in two ovens (MEMMERL 600-D06064 and TCT DHG-9203A; Figure 2, c-d) at temperatures ranging between 90°C and 100°C. If there was a lack of space inside the ovens, an aliquot part greater than 10% of the wet weight of the more bulky samples was used to estimate the moisture of the whole sample.

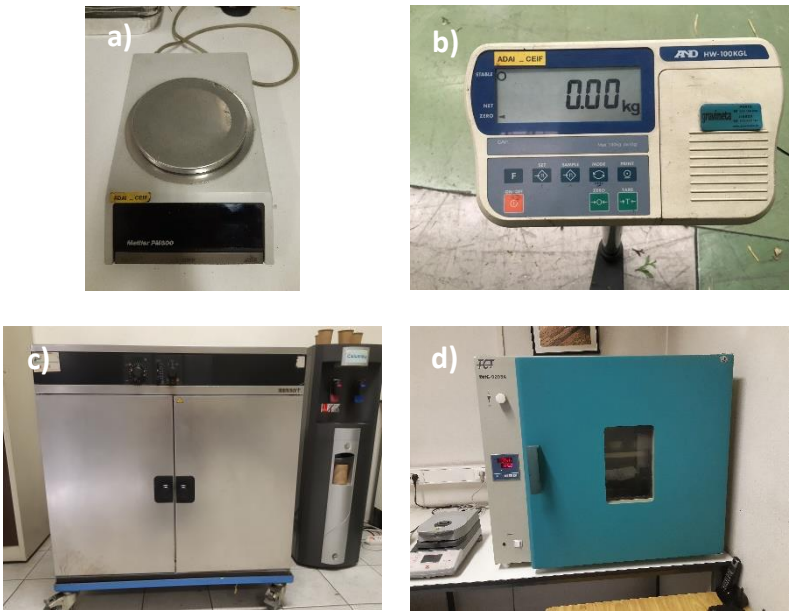

Figure 2. a) Mettler PM600 balance (precision: 0.01 g); b) AND HW-100KGL scale (precision: 10 g); c) MEMMERL 600-D06064 oven; d) TCT DHG-9203A oven.

2.2. Fuel configuration and ignition

Two kinds of fuel configurations were tested: (i) single-tree (Figure 3a) or (ii) a set of three-trees (Figure 3b). In configuration (ii) the tree stems had a separation between them of about 30 cm and the crowns were imbricated.

The ignition of these fuel configurations was achieved using trays filled with alcohol. Four trays (31.5 × 18 cm^2 each one) with 300 ml of alcohol were used to ignite the single-tree setups, and 9 trays with 250 ml of alcohol were used in the three-trees setups (4 trays of 31.5 × 18 cm^2 on the back plus 5 trays of 31.5 × 23.5 cm^2 each one on the front). The ignition trays were evenly positioned under the canopy base, mounted over a structure that was directly resting on the floor (Figure 3c). The vertical distance between the ground of the load cell module and the trays was of 0.42 m.

Figure 3. (a) Single-tree configuration (4 ignition trays distributed under the canopy base); (b) Three-trees configuration (9 ignition trays distributed under the canopy base); c) Load cell module and structures to hold ignition trays.

2.3. Monitoring equipment

The experiments were monitored by recording data from a load cell module (AEP C3S), two IR cameras (FLIR SC660 & OPTRIS PI 640), two visible cameras (Sony HXR-NX30E & Sony FDR-AX53), three thermocouples (type K; model BT.MiK.1.2.1,5.10000.MFATW0), a pitot tube (type S; Gems 5266-50L transducer) and one radiometer (Vatell TG9000-9). The spatial distribution of these devices can be seen in Figure 4. Further descriptions of these devices are available in the Technical Note[1] *WUIVIEW_TN2.1_Facilities&Equipment_ADAI_CEIF*.

[1] Technical specifications of the IR camera OPTRIS PI 640 are not included in the cited Technical Note as it is out of its scope. These technical specifications are available in: https://www.optris.com/thermal-imager-optris-pi-640?file=tl_files/pdf/Downloads/Infrared%20cameras%20US/datasheet-optris-pi-640.pdf (accessed 19/11/2019).

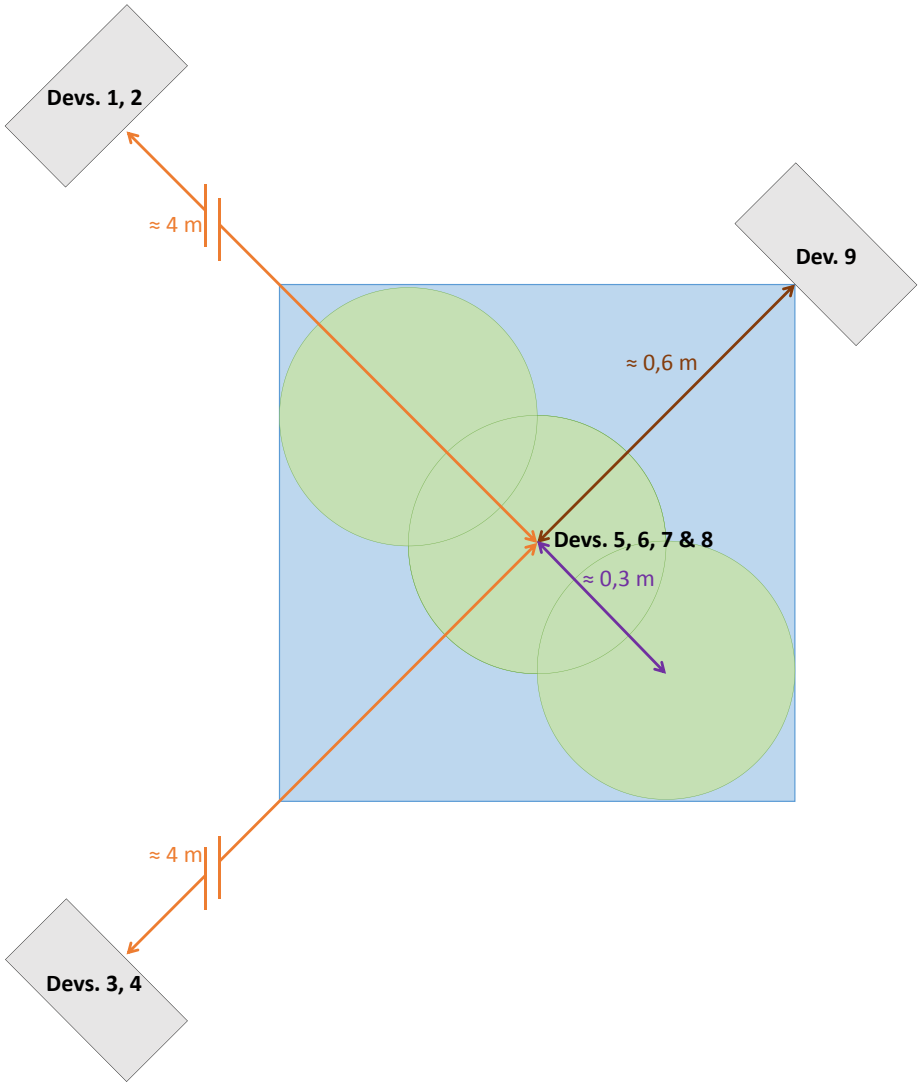

Figure 4. Top view scheme of the experimental setup. Load cell module coloured in blue, trees in green and devices in grey with black bold letters. Dev(s) = device(s). z = height above the ground of the load cell. Dev. 1: RGB camera Sony FDR-AX53 (z ≈ 1.5 m); Dev. 2: IR camera FLIR SC660 (z ≈ 1.5 m); Dev. 3: RGB camera Sony HXR-NX30E (z ≈ 1.5 m); Dev. 4: IR camera OPTRIS PI 640 (z ≈ 1.5 m); Dev. 5: pitot tube (z = 3.75 m); Dev. 6: thermocouple (z = 0.62 m); Dev. 7: thermocouple (z variable); Dev. 8: thermocouple (z = 3.75 m); Dev. 9: radiometer (z ≈ 1 m).

Trees were weighted in a scale (AND HW-100KGL, Figure 2d) before and after the burning and the mass loss was registered continuously during the experiments with the load cell module (Figure 3c). IR and RGB videos were recorded from two perpendicular views: front and lateral, at a distance of approximately 4 m from the central point of the burning trees setup. The convective air flow was measured using a pitot tube centered above the ground of the load cell module at 4.17 m high. Temperature was recorded with three K thermocouples positioned at three different heights above the centered ground of the load cell: the lowest thermocouple was positioned at 0.62 m (*i.e.* 0.2 m above the ignition trays), the middle thermocouple had a variable height, being positioned at the middle of the canopy height. The highest one was positioned next to the pitot tube at 4.17 m above the ground of the load cell (*i.e.* 3.75 m above the ignition trays). The radiative flux was recorded by a radiometer positioned at the back of the trees, close to the fuels (approx. 0.6 m far in perpendicular direction from the trees plane and 1 m above the ground of the load cell).