# SHORT TERM SCIENTIFIC MISSION (STSM) ACADEMIC REPORT

**Action number:** *CA18135 - Fire in the Earth System: Science & Society*
**STSM title:** *WUI flammability experiments at whole-plant scale*
**STSM start and end date:** 01/07/2021 to 15/08/2021
**Grantee name:** Juan Antonio Muñoz Navarro

**Abstract:**
*During this STSM we have collaborated with the Association for the Development of Industrial Aerodynamics of the University of Coimbra to carry out burning experiments on wild and ornamental plants from species typically present in the surroundings and the gardens of the wildland-urban interface settlements. We have sampled trees from these species before and after the burning tests to know their fuel and moisture distribution, and the changes in moisture content and the degree of fuel consumption of each fuel type after a fire. We have developed burning tests at both, full-scale and bench scale, recording data on mass depletion over time, flame temperature and geometry.*

## INTRODUCTION

*One of the emergent fire-scenarios that are causing a huge impact over society is the Wildland-Urban Interface (referred hereafter as WUI), which is the area where human settlements are in contact with (WUI-Interface) or immersed within (WUI-Intermix) the wildlands. Fire management in these areas, neither fully urban nor fully wildland, is complicate as long as bring together two very different fire scenarios: neighbourhoods and forests. Traditional models to forecast and evaluate fire risk do not apply in the WUI because they have been developed for natural fuels with spatial continuity, while in the WUI continuity is broken due to urban development. Traditional models to evaluate fire risk in urban areas neither directly apply to the WUI, as it is mandatory to take into account the vegetation into the fire dynamic analysis. In this sense, the vegetation allocated closer to the dwellings is the one used for gardening and landscaping, known as ornamental vegetation.*

*Many works have tried to characterize fire risk from this ornamental vegetation evaluating its flammability, but most of them used small samples at bench scale (e.g. Curt et al., 2007; Ganteaume et al., 2013; Della Rocca et al., 2015). However, later works showed that this scale of experimentation was poorly correlated with the real burning behaviour of the vegetation (Madrigal et al., 2012; Fernandes & Cruz, 2012) because it missed many characteristics that influence flammability (bulk density, mixture of fuels, geometry of the canopy, etc.). At a larger scale, some research has been performed on flammability using whole individuals instead of portions of them (e.g. Etlinger & Beall, 2004; Morandini et al., 2019). Unfortunately, this methodology requires from expensive devices, hindering the measure of flammability for most research groups.*

*During the WUIVIEW project (www.wuiview.org, already finished), researchers from the Centre for Technological Risk Studies (CERTEC) of the Universitat Politècnica de Catalunya (UPC) and from the Association for the Development of Industrial Aerodynamics (ADAI) of the University of Coimbra (PT) performed burning tests with different spatial configurations, levels of water stress and physiological status. These trees belonged to four different species frequently found in the WUI and presented different levels of drought. During the tests, we measure—among other variables—the mass loss rate curve, which can be used to define the burning behaviour of the vegetation and, therefore, its flammability. This measurement presents the advantage of being easy to perform and do not require expensive devices, making affordable to most research groups to measure flammability at this level. However, in order to develop a methodology based on the mass loss rate of the vegetation while burning, we must enlarge the number of tested species to provide a sound basis of experimentation for the statistical analysis.*

*The aim of this STSM was to collaborate with ADAI in a new set of full-scale burning tests performed in their Forest Fire Research Laboratory (LEIF), in the framework of the House Refuge project (https://adai.pt/houserefuge/en/home/), testing wild and ornamental plants from species typically present in the surroundings and the gardens of the wildland-urban interface settlements.*

## MATERIALS & METHODS

*The flammability experiments followed three workflows:*

1. *Fuel samplings: we sampled two trees from each one of the tested species, classifying the different types of fuel as a function of their diameter and physiological status. We sampled the first tree right after collecting it, to have realistic measurement of its moisture content, and the second tree after the burning experiments. The difference between both fuel samplings will allow us to estimate the changes in moisture content and the degree of fuel consumption of each fuel type. We followed the methodology described in WUIVIEW Deliverable 2.1 (available online in www.wuiview.org) to perform these fuel samplings.*

2. *Burning tests: we burned vegetation in full-scale mockups to ensure a realistic fire behaviour, with a minimum of 5 repetitions per species. Wild plants were collected between 1 hour and 1 day before the tests, but some ornamental plants were collected in advance, to burn them with different levels of moisture content. We measured the weight, the volume and the moisture content of each mockup prior to burning and recorded data on flame geometry, air flow, temperature and mass loss during the tests. We followed the methodology described in WUIVIEW Deliverable 2.1 (available online in www.wuiview.org) to perform these burning tests.*

3. *Cone calorimeter: we burned in a cone calorimeter samples of these species and recorded their time to ignition, time to flame out, mass loss rate and variation of temperature over time to estimate its average effective heat of combustion. We followed the methodology described in Madrigal* et al. *(2011).*

## RESULTS & DISCUSSION

*We have obtained data on burning behaviour from several species typically present in the surroundings and the gardens of the wildland-urban interface settlements. These data regard fuel distribution and consumption, moisture contents and its evaporation due to fire, mass depletion over time, flame temperature and geometry at full-scale tests (i.e. realistic* *burning behaviour). The data from the cone calorimeter will allow us to compare flammability at large scales with flammability at bench scale. Between them, the data that we are more interested in are those one regarding mass depletion, that will let us to compare the mass loss rate curve with the observed behaviour from each test. As this tests were part of an ongoing project, the host research group will keep performing fuels samplings and burning tests.*

*The tests are being succesfully performed and are producing quality data. However, we scheduled burning tests of dry ornamental vegetation during this STSM, that could not being performed on time. Our aim was to burn them after naturally dry them out by water stress—instead of forcing them to dry out exposing the plants to high temperatures inside a furnace—but they presented a larger resistance against water stress than expected. A better prediction of the period of time needed to dry them out would have improved this point. These tests will be performed once these plants dry.*

## CONCLUSIONS

*With the support of this Fire links' STSM we have been able to collaborate with ADAI and participate in a set of experiments,* strengthen ties between both research groups, working together and accurately marking our work lines and potential future collaborations since we both hold similar works dealing with forest fires in the WUI. The data generated during this STSM will help us in our aim of characterizing flammability from ornamental plants based in their mass loss rate curves.

## BIBLIOGRAPHY


*Curt, T., Ganteaume, A., Alleaume, S., Borgniet, L., Chandioux, O., Jappiot, M., Lampin, C & Martin, W. (2007, May). Vegetation flammability and ignition potential at road-forest interfaces (southern France). In Proceedings of the 4th International Wildland Fire Conference (pp. 14-18).*

*Della Rocca, G., Hernando, C., Madrigal, J., Danti, R., Moya, J., Guijarro, M., Pecchioli, A. & Moya, B. (2015). Possible land management uses of common cypress to reduce wildfire initiation risk: a laboratory study. Journal of environmental management, 159, 68-77.*

*Etlinger, M. G., & Beall, F. C. (2005). Development of a laboratory protocol for fire performance of landscape plants. International Journal of Wildland Fire, 13(4), 479-488.*

*Fernandes, P. M., & Cruz, M. G. (2012). Plant flammability experiments offer limited insight into vegetation–fire dynamics interactions. New Phytologist, 194(3), 606-609.*

*Ganteaume, A., Jappiot, M., Lampin, C., Guijarro, M., & Hernando, C. (2013). Flammability of some ornamental species in wildland–urban interfaces in southeastern France: laboratory assessment at particle level. Environmental Management, 52(2), 467-480.*

*Madrigal, J., Guijarro, M., Hernando, C., Diez, C., & Marino, E. (2011). Effective heat of combustion for flaming combustion of Mediterranean forest fuels. Fire technology, 47(2), 461-474.*

*Madrigal, J., Marino, E., Guijarro, M., Hernando, C., & Díez, C. (2012). Evaluation of the flammability of gorse (Ulex europaeus L.) managed by prescribed burning. Annals of Forest Science, 69(3), 387-397.*

*Morandini, F., Santoni, P. A., Tramoni, J. B., & Mell, W. E. (2019). Experimental investigation of flammability and numerical study of combustion of shrub of rockrose under severe drought conditions. Fire Safety Journal, 108, 102836.*