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Flammability characteristics of typical garden species

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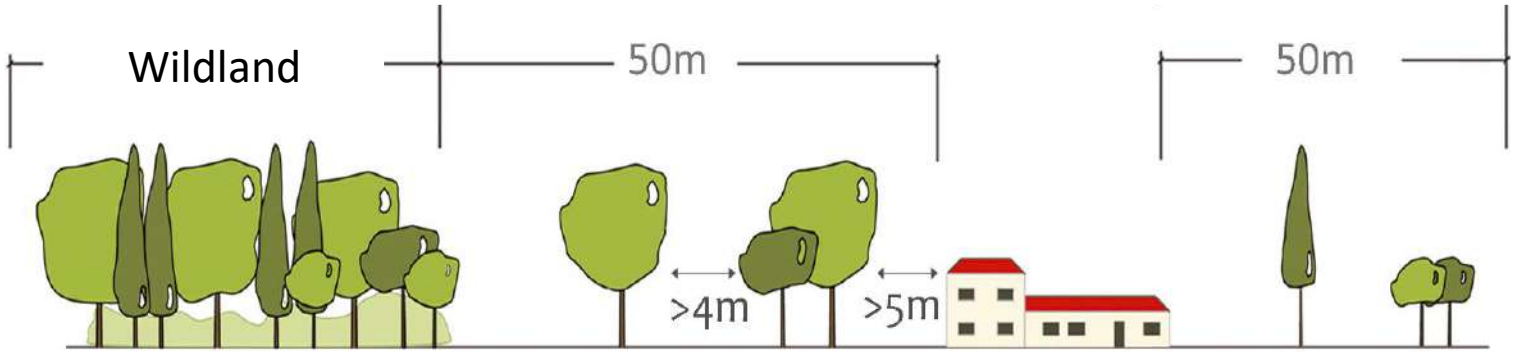
Scope and objectives of the study

Defensible space – Portuguese regulation



- DS of 50m regardless of the characteristics of the site area.
- No distances or required for garden or maintained areas.

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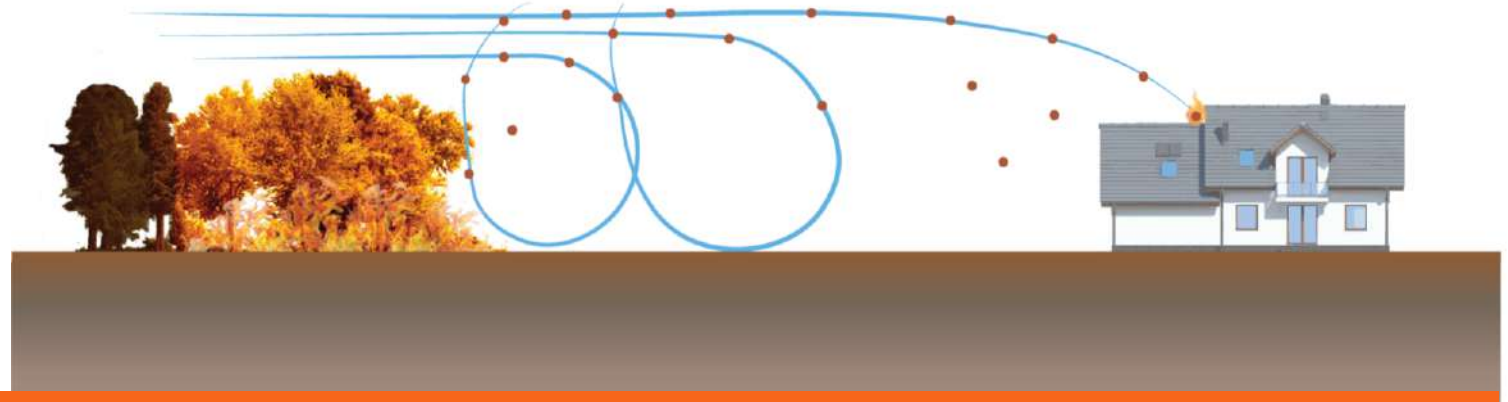
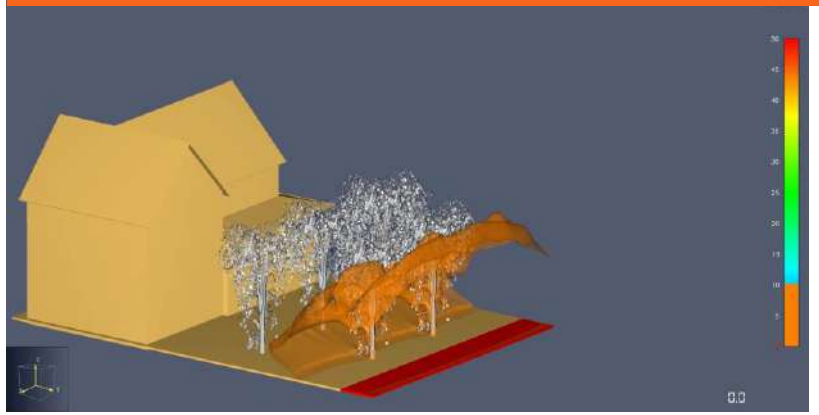
Scope and objectives of the study

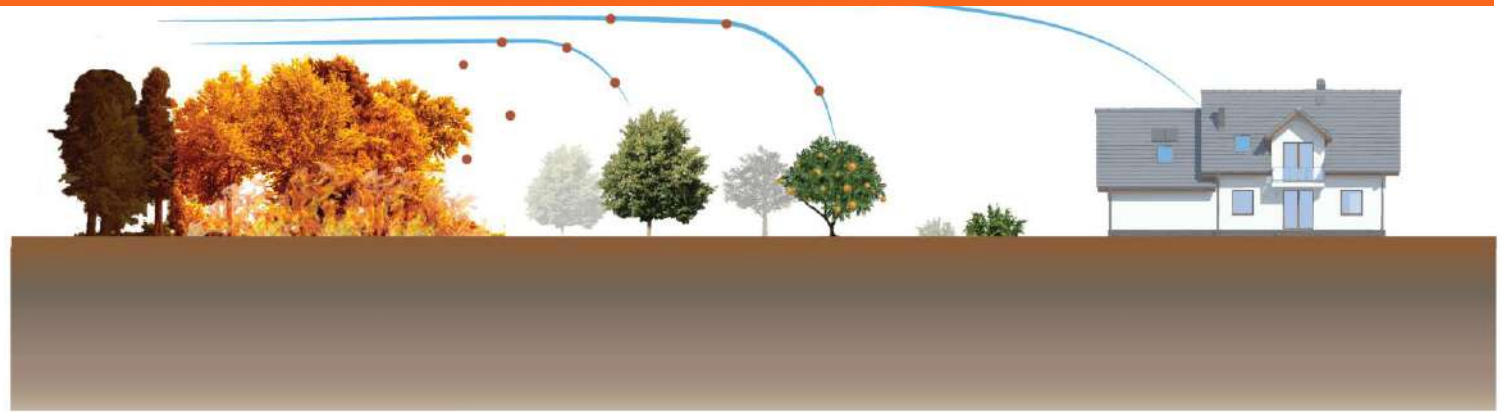
Relevance of vegetation in the DS

DS with no vegetation



Which vegetation is most beneficial for DS?





Scope and objectives of the study

Objectives of the study

Analysis of burning characteristics for typical garden species

- Mass characterization of the plant
  - ✓ Live plant
  - ✓ After burn
- Determination of flammability parameters
  - ✓ Mass loss decay
  - ✓ Heat flux
  - ✓ Temperature
  - ✓ Up-flow velocity
  - ✓ Flame dimensions
- Analysis of the potential for the release of firebrands capable of short distance spotting

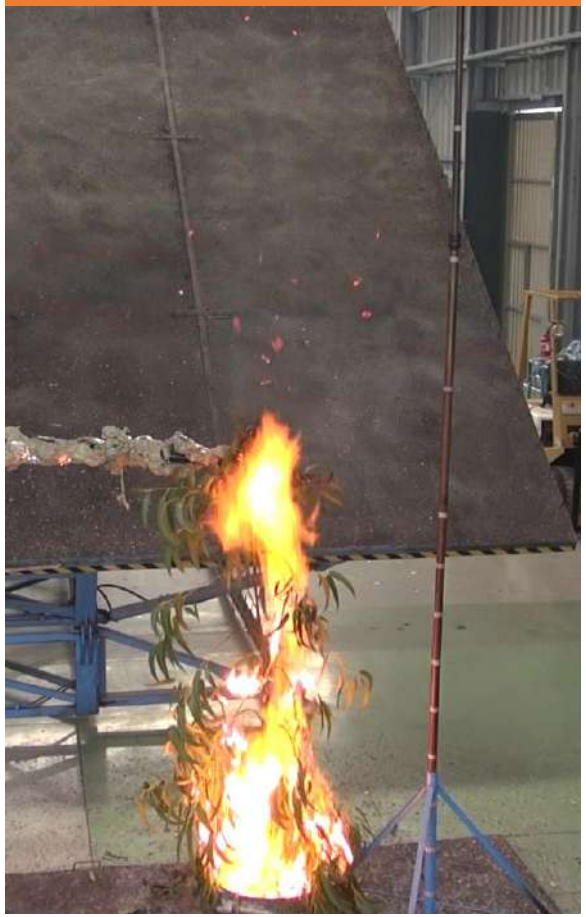
Scope and objectives of the study

Previous Work

Tests with forest trees

https://doi.org/10.3389/fmech.2021.651135

Eucaliptus globulus



Pinus pinaster

Quercus robur

Quercus suber

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Scope and objectives of the study

Previous Work

Tests with vegetation hedges (Project WUIView) www.wuiview.org

Cupressus arizonica

Prunus laurocerasus

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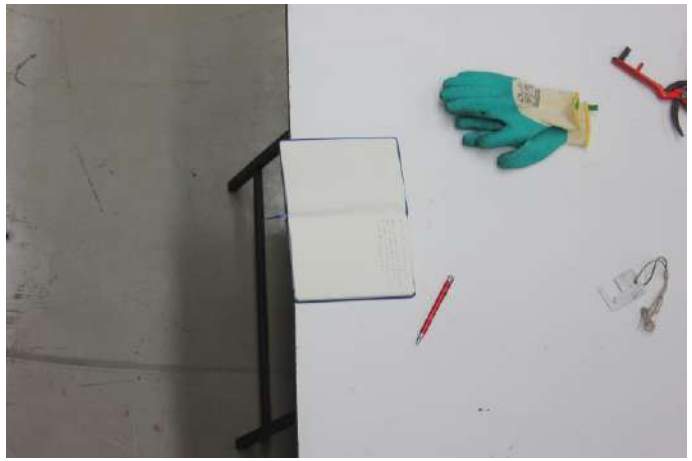
Methodology

Plants characterization

Mass characterization

Live plant
Burned plant

Mass %:
Foliage
Fruit
∅<3mm
3<∅<6mm
6<∅<10mm
∅>10mm



Determination of moisture and mass distribution

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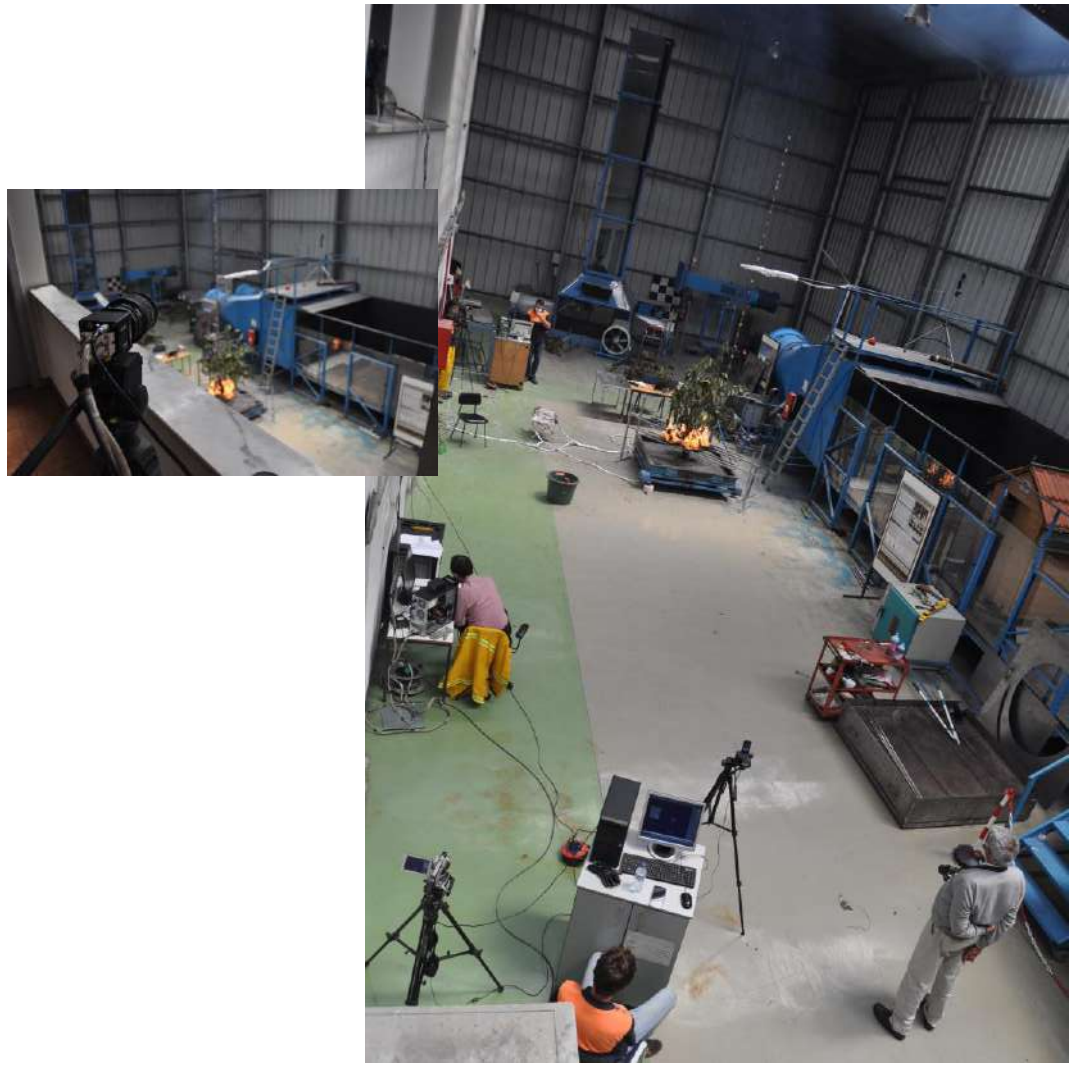
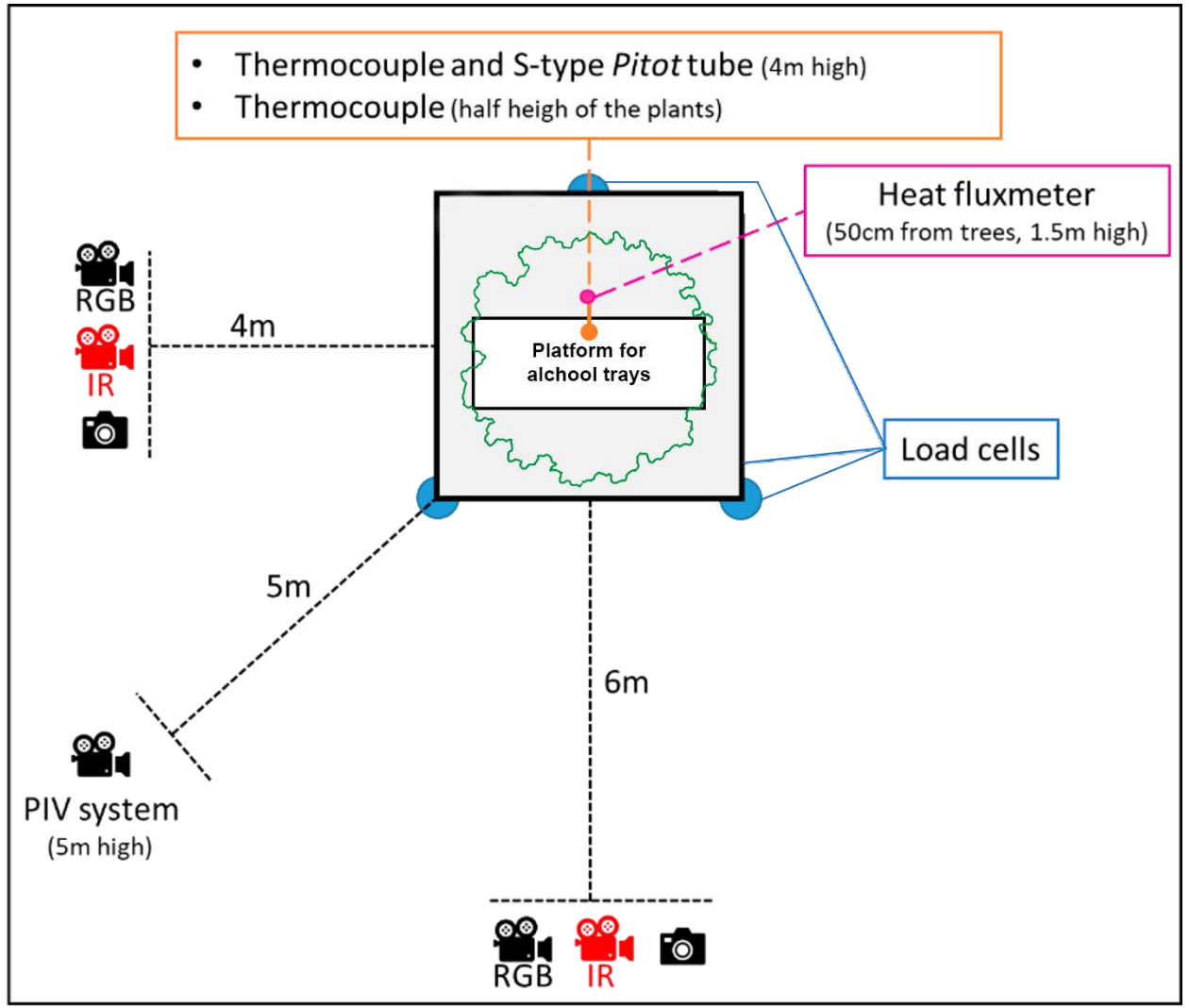
Methodology

Burning tests





Methodology

Current work – 1st group of plants studied

Wild species in the vicinity of a house

Acacia (*Acacia dealbata*)

Sylva (*Rubus ulmifolius*)

Stevia (*Cistus ladanifer*)

Methodology

Current work – 2nd group of plants studied

Plants attached to buildings

Ivy (*Hedera helix*)

Vine plant (*Vitis vinifera*)

Kiwi plant (*Actinidia deliciosa*)

Methodology

Current work – 3rd group of plants studied

Ornamental shrubs

Oleander (*Nerium*

Hydrangea (*Hydrangea macrophylla*)

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Methodology

Current work – 4th group of plants studied

Fruit trees in the vicinity

Fig tree (*Ficus carica*)

Apple tree (Malus sylvestris)

Medlar tree (*Eriobotrya japonica*)

Blackthorn (*Prunus spinosa*)

Medlar tree (*Eriobotrya japonica*)

Cherry tree (*Prunus avium*)

Methodology

Current work – 5th group of plants studied

Other trees in the vicinity

Laurel tree (*Laurus nobilis*)

Red Candle tree (*Rhus typhina*)

- Linden tree (*Tilia tomentosa*)
- Holly tree (*Ilex aquifolium*)
- Olive tree (*Olea europaea*)

Strawberry tree (*Arbutus unedo*)

Methodology

20 Species tested

6 Fruit trees
Lemmon tree (*Citrus limon*)
Cherry tree (*Prunus avium*)
Fig tree (*Ficus carica*)
Apple tree (*Malus sylvestris*)
Medlar tree (*Eriobotrya japonica*)
Blackthorn (*Prunus spinosa*)

6 Other trees
Linden tree (*Tilia tomentosa*)
Strawberry tree (*Arbutus unedo*)
Olive tree (*Olea europaea*)
Holly tree (*Ilex aquifolium*)
Red Candle tree (*Rhus typhina*)
Laurel tree (*Laurus nobilis*)

3 Wild plant
Acacia (*Acacia dealbata*)
Stevia (*Cistus ladanifer*)
Sylva (*Rubus ulmifolius*)

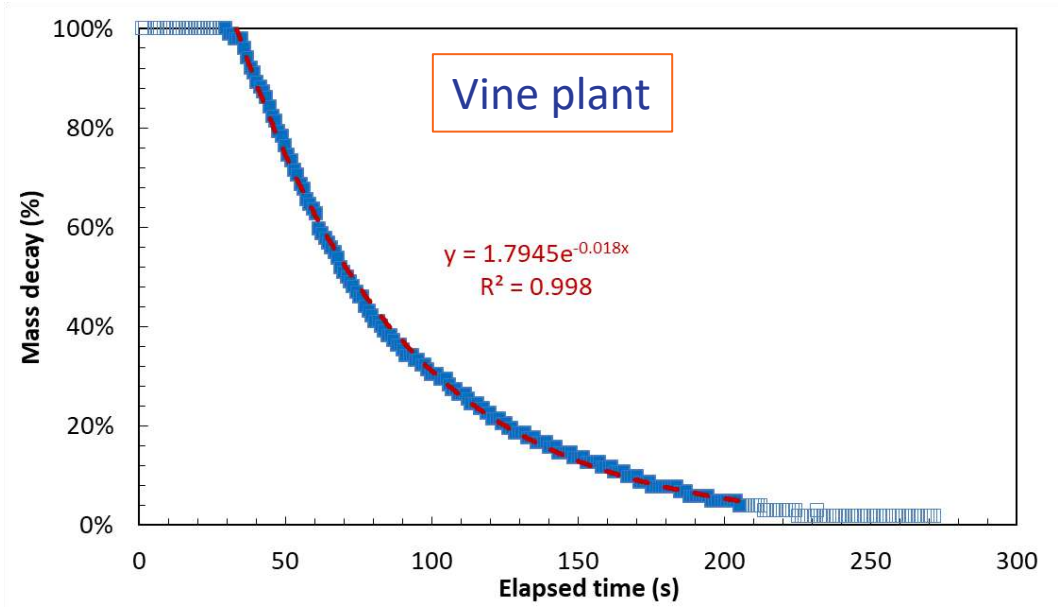
3 "Structure" plant
Ivy (*Hedera helix*)
Kiwi plant (*Actinidia deliciosa*)
Vine plant (*Vitis vinifera*)

2 Ornamental plant
Hidrangea (*Hydrangea macrophylla*)
Oleander (*Nerium oleander*)

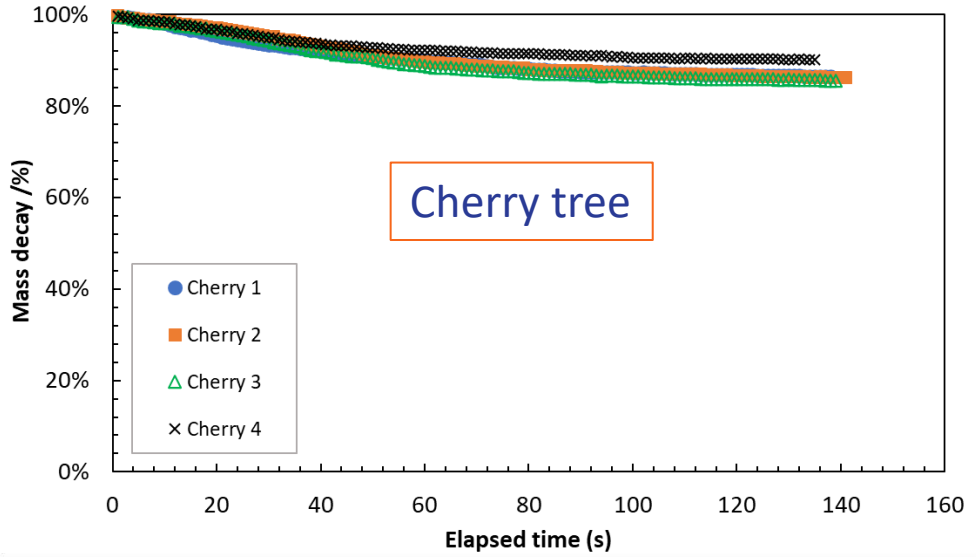
- Specimens collected on the day of the test or the day before
- Specimens kept in laboratory
- Tests carried out during the Summer season
- Plants taken from their normal environment with common watering
- 4 to 6 tests for each specie

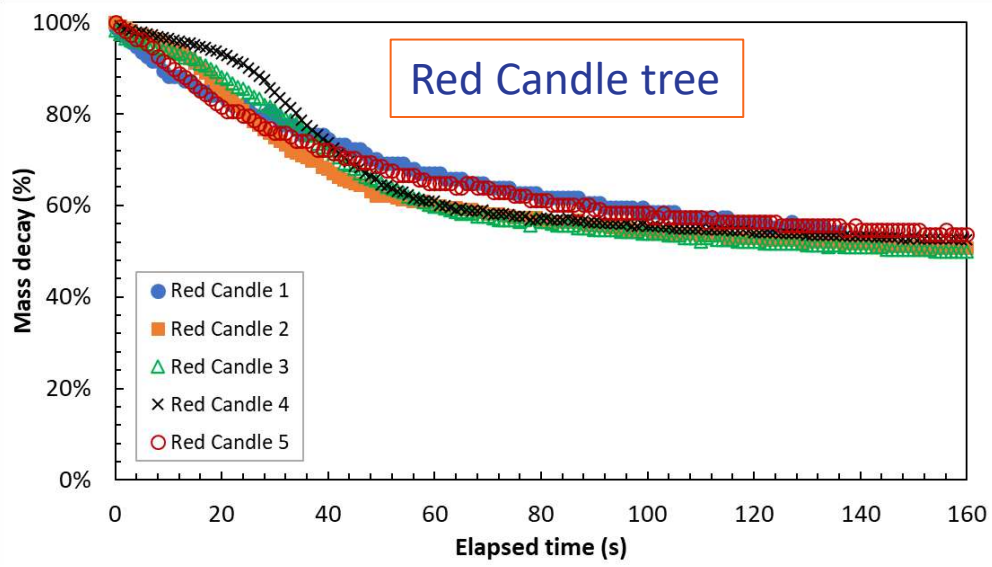
Main results

Mass loss



$$m/m_i = \sim 1 \times e^{-k \times t}$$





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Main results

Mass loss

Fruit trees	k (s^{-1})
Lemmon tree (*Citrus limon*)	0.000831
Cherry tree (*Prunus avium*)	0.000898
Fig tree (*Ficus carica*)	0.000863
Apple tree (*Malus sylvestris*)	0.001124
Medlar tree (*Eriobotrya japonica*)	0.003130
Blackthorn (*Prunus spinosa*)	0.000995

Other trees	k (s^{-1})
Linden tree (*Tilia tomentosa*)	0.001146
Strawberry tree (*Arbutus unedo*)	0.002612
Olive tree (*Olea europaea*)	0.001725
Holly tree (*Ilex aquifolium*)	0.001817
Red Candle tree (*Rhus typhina*)	0.003458
Laurel tree (*Laurus nobilis*)	0.006180

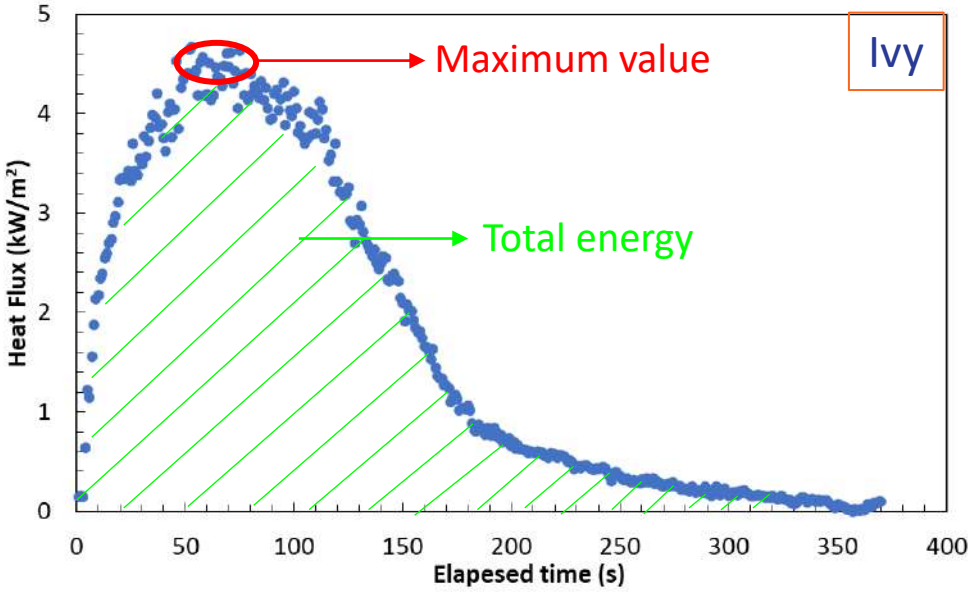
"Structure" plant	k (s^{-1})
Ivy (*Hedera helix*)	0.000895
Kiwi plant (*Actinidia deliciosa*)	0.009211
Vine plant (*Vitis vinifera*)	0.015576

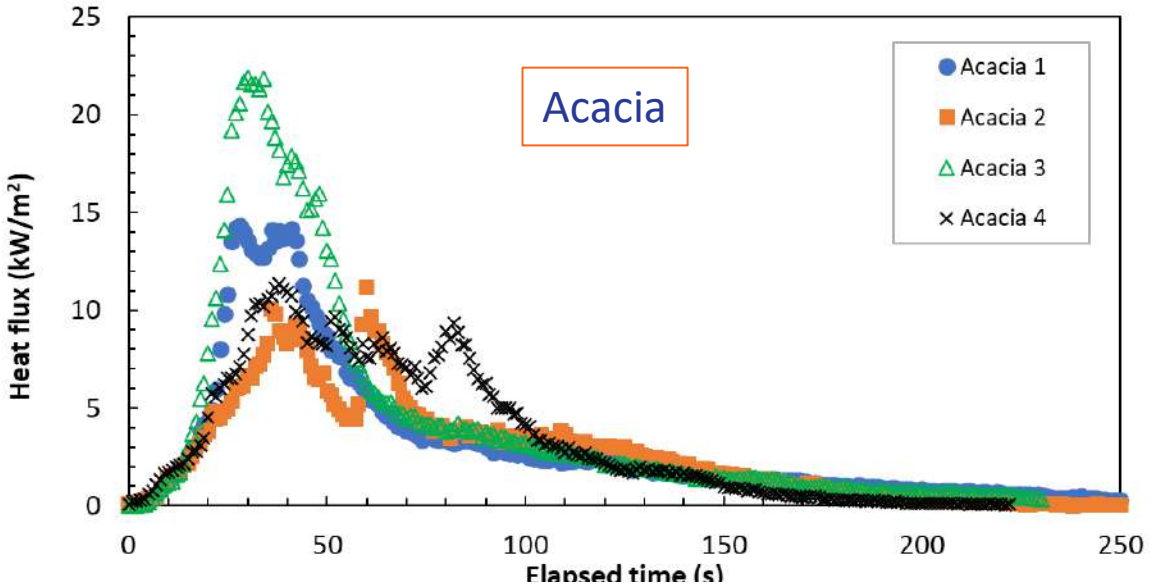
Wild plant	k (s^{-1})
Acacia (*Acacia dealbata*)	0.003647
Stevia (*Cistus ladanifer*)	0.003862
Sylva (*Rubus ulmifolius*)	0.010584

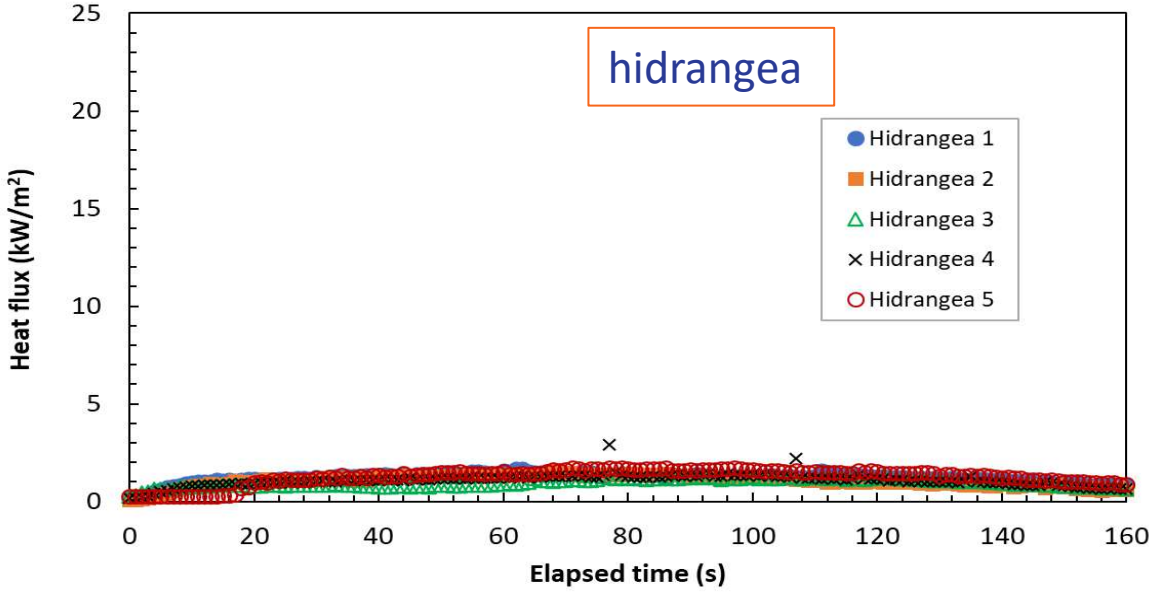
Ornamental plant	k (s^{-1})
Hidrangea (*Hydrangea macrophylla*)	0.004053
Oleander (*Nerium oleander*)	0.002214

Main results

Heat flux





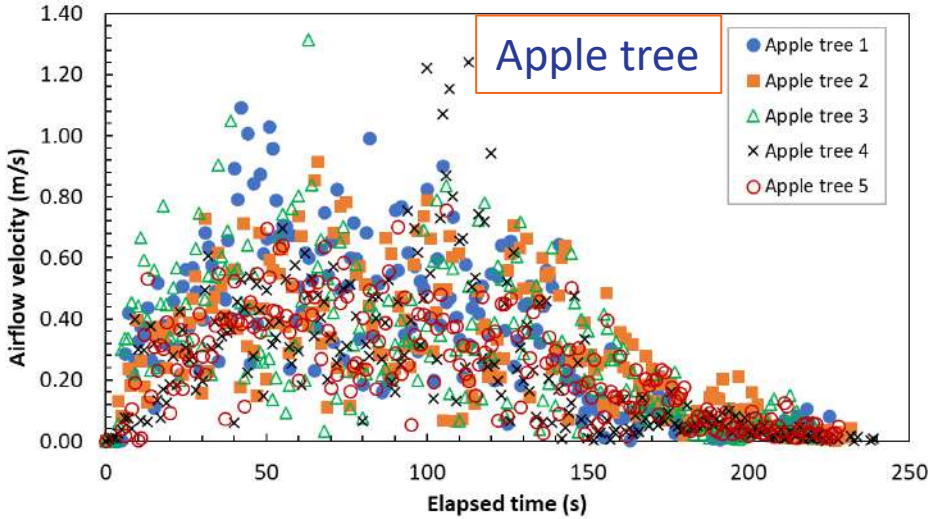


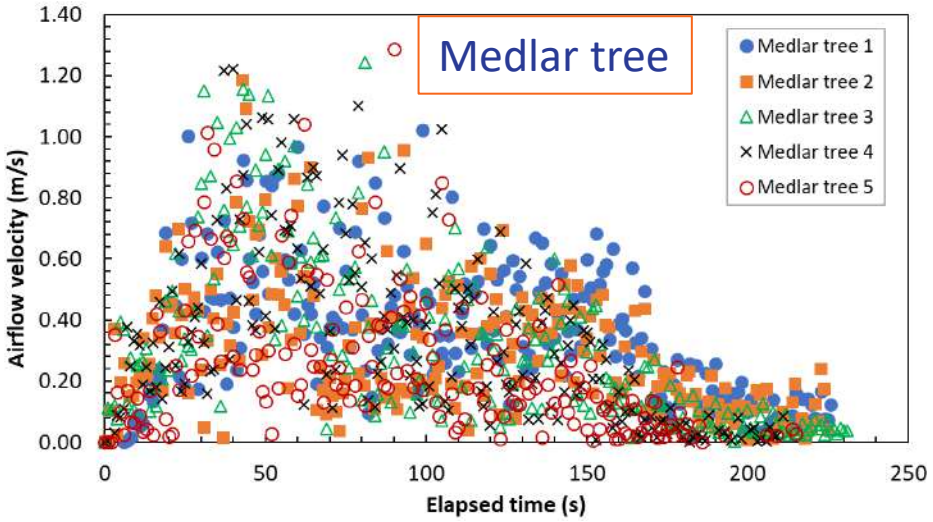
Main results

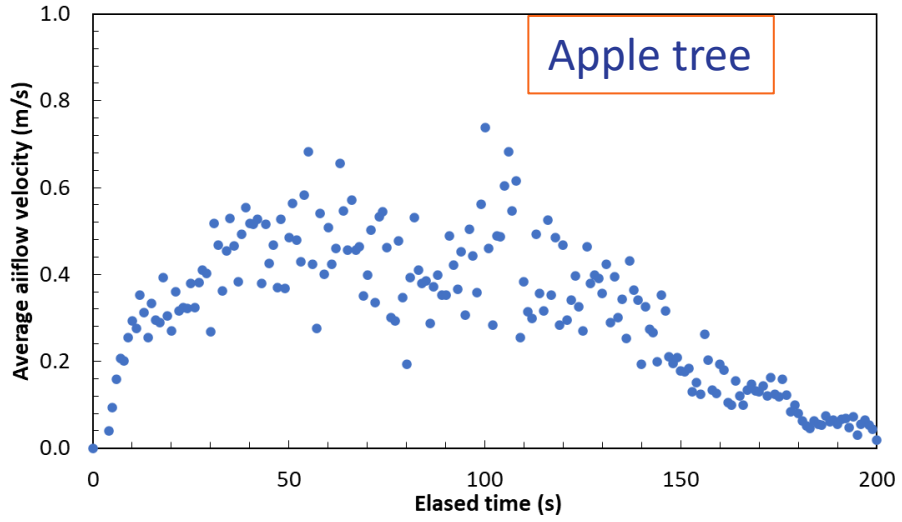
Heat flux – reference test

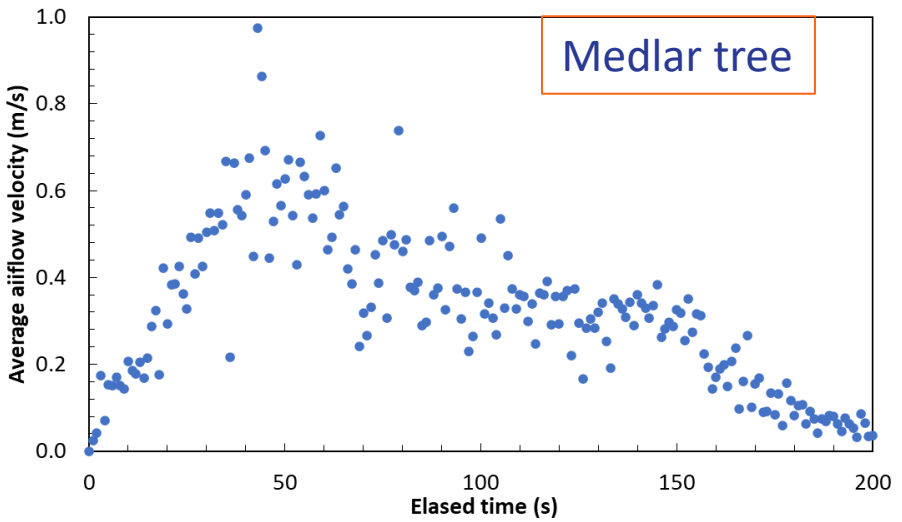
Main results

Airflow velocity









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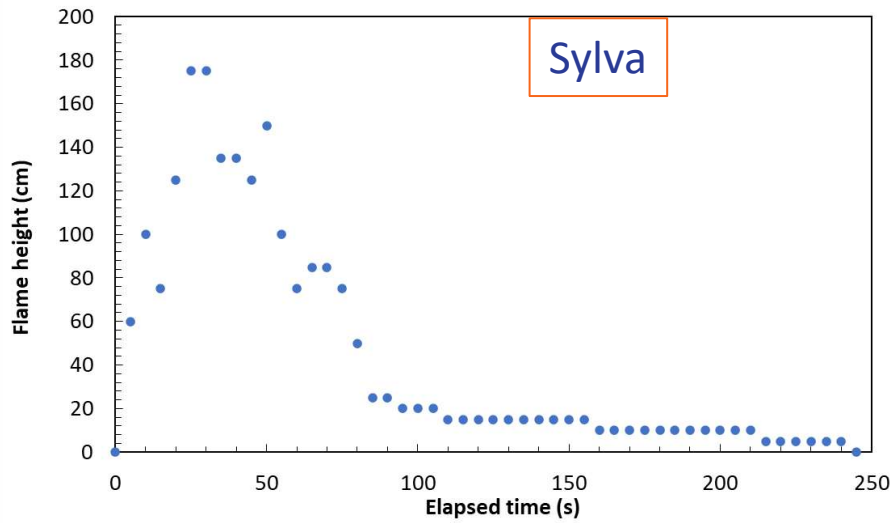
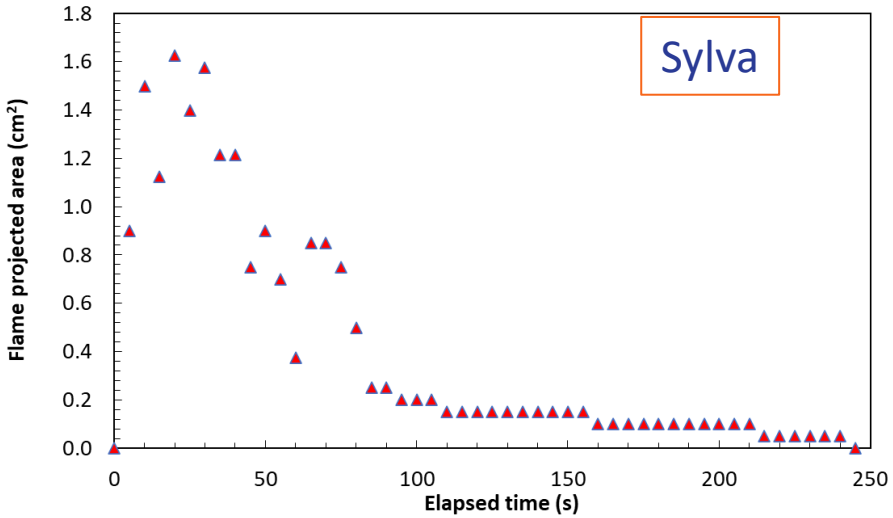
Main results

Flame dimensions

Acacia





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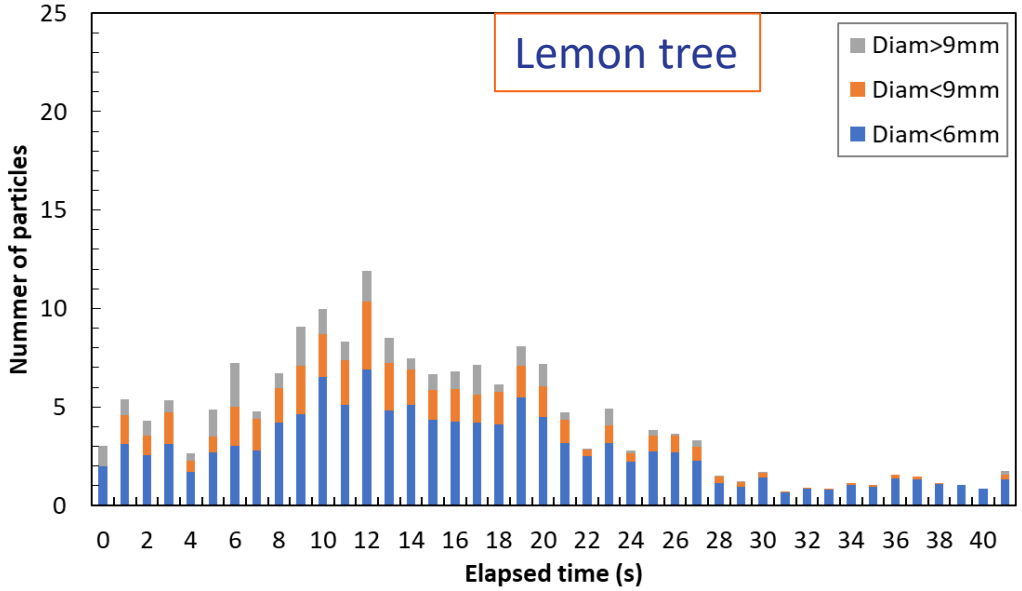
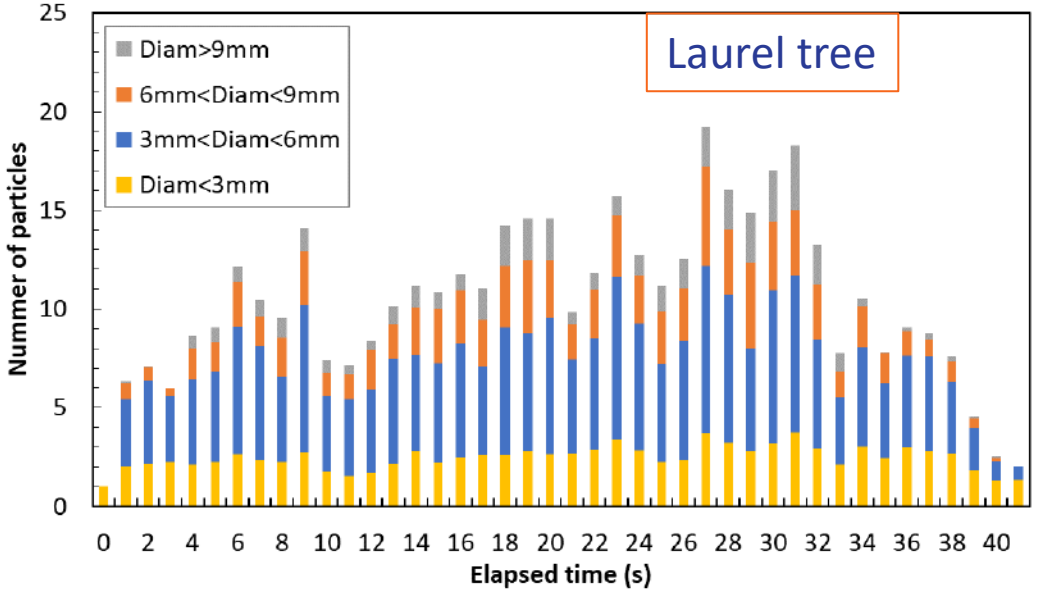
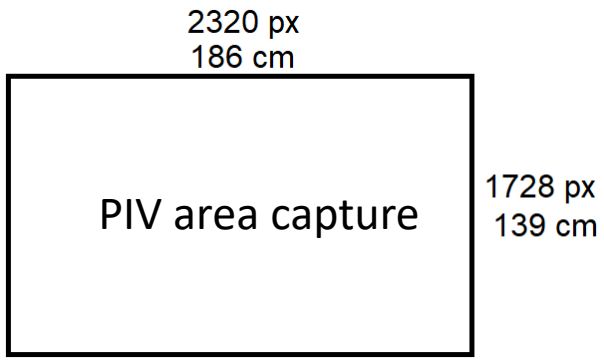
Main results

Firebrands release







Final results

Firebrands release

Low	Medium	High	Very High	Extreme
[0-125[P	[125-200[P	[200-300[P	[300-400[P	>400 P

Fruit trees

- Lemmon tree (*Citrus limon*)
- Cherry tree (*Prunus avium*)
- Fig tree (*Ficus carica*)
- Apple tree (*Malus sylvestris*)
- Medlar tree (*Eriobotrya japonica*)
- Blackthorn (*Prunus spinosa*)

Other trees

- Linden tree (*Tilia tomentosa*)
- Strawberry tree (*Arbutus unedo*)
- Olive tree (*Olea europaea*)
- Holly tree (*Ilex aquifolium*)
- Red Candle tree (*Rhus typhina*)
- Laurel tree (*Laurus nobilis*)

"Structure" plant

- Ivy (*Hedera helix*)
- Kiwi plant (*Actinidia deliciosa*)
- Vine plant (*Vitis vinifera*)

Ornamental plant

- Hidrangea (*Hydrangea macrophylla*)
- Oleander (*Nerium oleander*)

Wild plant

- Acacia (*Acacia dealbata*)
- Stevia (*Cistus ladanifer*)
- Sylva (*Rubus ulmifolius*)

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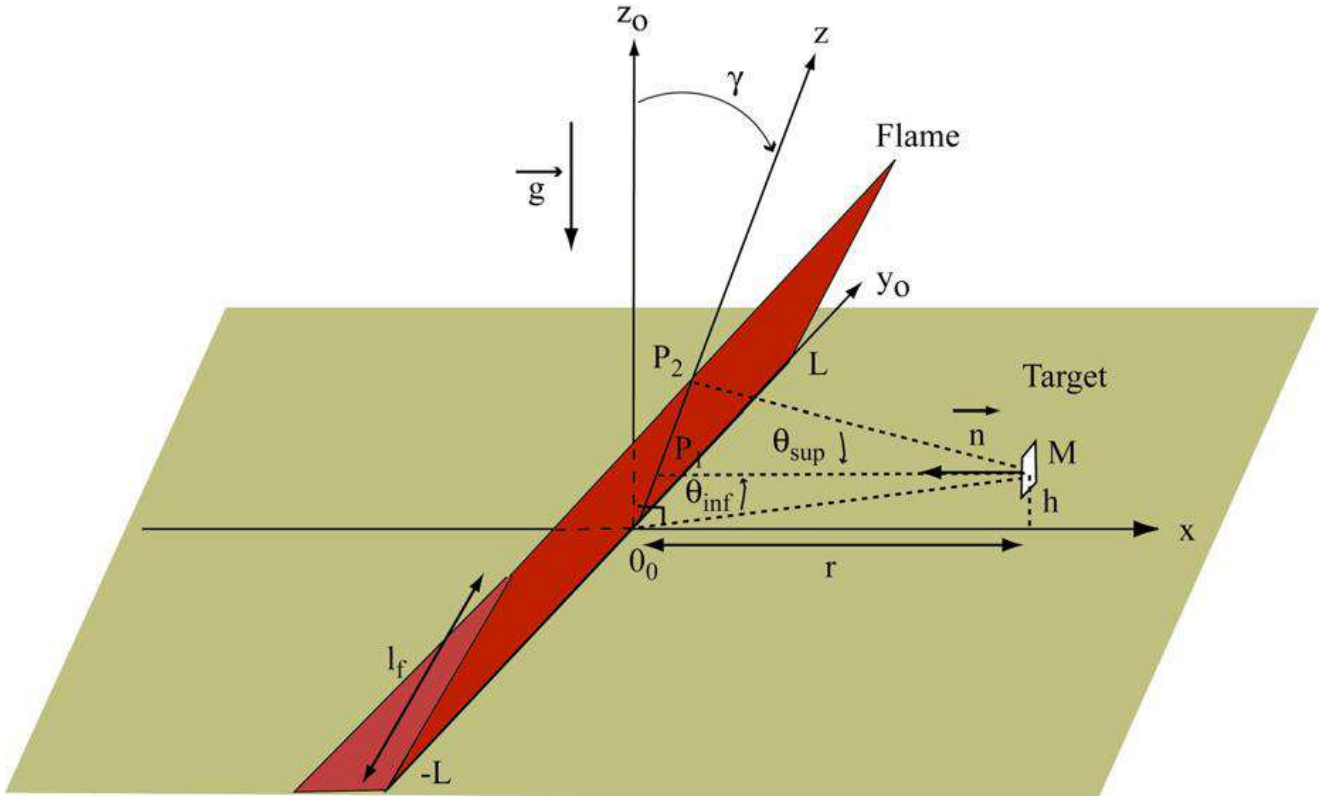
Final results

$$ASD = \left(\frac{L_f \Phi_{thres} \cos(\gamma) \sqrt{-4 L_f \Phi_{thres} + \left(B T_f^4 \varepsilon \tau \right)^2}}{2 \Phi_{thres}} + L_f \sin(\gamma) \right) \left(1 - exp\left(-\frac{2L}{L_f} k_{thres} \right) \right)$$



Rossi, J.L.; Simeoni, A.; Moretti, B.; Leroy, V. Analytical expression of the safety distance for wildland fires. In 6ICFFR, 2010, pp. 1-9.

Final results

Danger: Low | Medium | High | Very High | Extreme

Fruit trees	$Hflux_{max}$ (kW/m^2)	ASD (m)
Lemmon tree (*Citrus limon*)	250	5.0
Cherry tree (*Prunus avium*)	428	8.0
Fig tree (*Ficus carica*	250	5.0
Apple tree (*Malus sylvestris*)	323	6.0
Medlar tree (*Eriobotrya japonica*)	699	13.2
Blackthorn (*Prunus spinosa*)	281	5.3

Other trees	$Hflux_{max}$ (kW/m^2)	ASD (m)
Linden tree (*Tilia tomentosa*)	344	6.4
Strawberry tree (*Arbutus unedo*)	294	5.5
Olive tree (*Olea europaea*)	735	13.7
Holly tree (*Ilex aquifolium*)	2410	13.6
Red Candle tree (*Rhus typhina*)	873	16.3
Laurel tree (*Laurus nobilis*)	2273	42.5

Structure" plant	$Hflux_{max}$ (kW/m^2)	ASD (m)
Ivy (*Hedera helix*)	884	16.5
Kiwi plant (*Actinidia deliciosa*)	790	14.8
Vine plant (*Vitis vinifera*)	394	7.4

Structure" plant	$Hflux_{max}$ (kW/m^2)	ASD (m)
Acacia (*Acacia dealbata*)	448	8.4
Stevia (*Cistus ladanifer*)	6730	37.9
Sylva (*Rubus ulmifolius*)	1240	23.2

Structure" plant	$Hflux_{max}$ (kW/m^2)	ASD (m)
Hidrang. (*Hydrangea macrophylla*)	259	5.0
Oleander (*Nerium oleander*)	255	5.0

Final remarks

- When managed appropriately, the presence of trees in the DS is beneficial in reducing the likelihood of building ignition.
- Even when well maintained and watered, vegetation within the WUI should maintain a minimum distance to buildings.
- The selection of species to be planted in the WUI should take into consideration their flammability and potential for the release of firebrands.
- The results produced will facilitate fire spread simulation exercises in WUI.

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11/18 November 2022 - Coimbra, Portugal

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