XUNTA DE GALICIA
CONSELLERÍA DE MEDIO RURAL
Dirección Xeral de Montes

CENTRO DE INVESTIGACIÓN
FORESTAL - LOURIZÁN

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PROTECTION DEPARTMENT REPORT, OF LOURIZAN FOREST INVESTIGATION CENTER, ON THE BURNING DEMONSTRATION SUBJECT TO THE EFFECTIVENESS OF THE FIRE EXTINGUISHING AGENT (LONG TERM RETARDANT) "FS-01" THAT BELONGS TO THE COMPANY "GREEN CANYON".

INTRODUCTION

The Test took place the burning demonstration of the forest fire extinguishing agent FS-01, performed by the product manufacturers (Green Canyon), with the cooperation of The Defense Service against Forest Fires of the General Mounts Direction, The Fire Provincial Service of Pontevedra and the Forest District of Deza-Tabeirós. Lourizan Protection Department has been involved in the documentation tasks about the characteristics of the burning site, the fuels, the environmental conditions, the fire behaviour, and the answer of the aforementioned extinguishing agent.

Due to the limited quantity of product available by the company, as a consequence of the restrictive EU importation policies, only a demonstration test over a reduced surface area was performed.

The data obtained by this activity is presented below:

SITE AND FUEL CHARACTERISTICS

The Fire Provincial Service and the Forest District chose and installed three demonstration parcels on the West hillside of Mount Carrío, Lugar de Asorei, Vila de Cruces Town Hall. The plots of land, with a rectangular shape and an approximate size of 40x10 m, were delimited on the previous day to the test, with different orientations, in order to use the one best aligned with the existing wind at the time of burning. The plots were isolated from the rest of the vegetation by firewalls made with tractor and brush cutter.

The parcel finally used had the following features:

Shape: Rectangular
Size: 40x11m
Parcel direction axis with respect to the forward direction of fire: 37 degrees from the North.
Parcel Orientation: 217 degrees North
Parcel axis slope: 15%
Hillside orientation: South-West (236 degrees)
Hillside slope: 18.5%
Elevation: 609 m
Coordinates: 42º 44' 49.5''North
8º 10' 11.4'' West (Datum ETRS89. UTM 29)

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The forest fuel was composed by a continuous bush formation of considerable height, integrated by *Erica australis* and *Ulex europaeus*. A Linear longitudinal transect was made in order to obtain height information, vegetation cover and litter fall present on the plot. Data obtained is shown in Table 1.

Figure 1. Scheme of plot location in relation to the hillside.

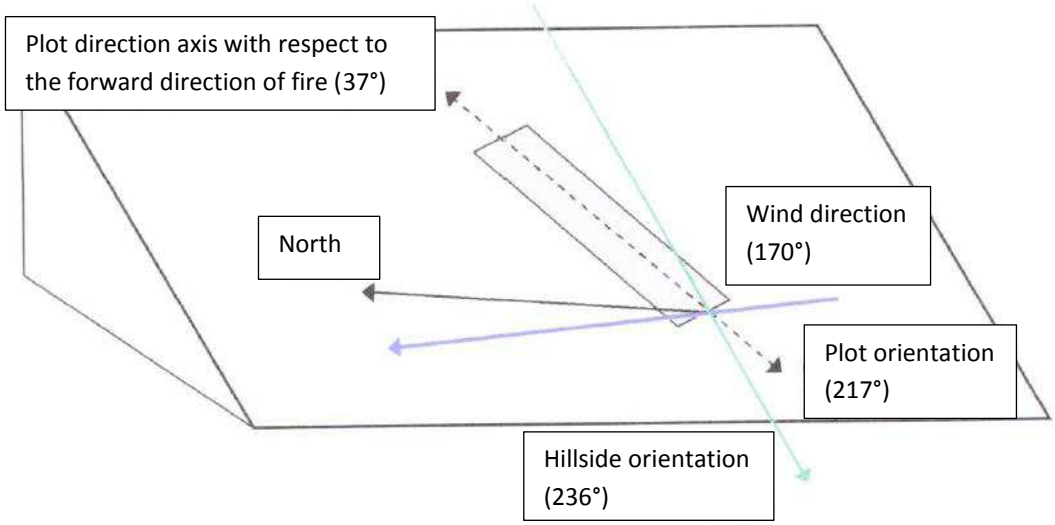


Table 1. Average value of the observed fuel parameters before the fire.

Leaf litter depth + mulch (cm)	6.2
Coverage (%)	100
Bush species coverage (%)	
Ulex europaeus	42.3
Erica australis	57.7
Total bush coverage (%)	100
Bush species height (cm)	
Ulex europaeus	260.9
Erica australis	298.3
Total bush height (cm)	282.5
Height of beginning of dry bush crown (cm)	33
Height of beginning of green bush crown (cm)	136

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The total amount of bush layer, estimated by the equations made at Lourizán Center in base of the type of community, height and depth of leaf litter + mulch, was equal to 65t/ha of which 25t/ha correspond to fuel with a diameter below 6 mm. This last amount is the one estimated to be consumed at the flame phase of the fire. Apart from that, a thick layer of leaf litter and mulch of about 20 t/ha was found under the bush, this weight has been also calculated by equations developed by the above mentioned center.

METEOROLOGICAL CONDITIONS AND HUMIDITY OF THE FUEL.

The analysis of meteorological variables during the test was made by a portable meteorological station that had been set up in the surroundings of the test plot.

Table 2. Average values of meteorological variables.

Time of Burning (UTC)	12:03 to 12:09
Air Temperature (° C)	17.4
Relative Humidity (%)	32
Solar Radiation (w m-2)	453
Wind speed at a height of 2 m (m s-1)	0.88
Range speed of wind at a height of 2 m(m s-1)	0.95 to 1.94
Wind direction	SSE (170°)

Fuel humidity was calculated by sample collection of the different fuels found in the area, brought in sealed containers to the laboratory, and dried in heater at 105 °C. Table 3 shows the figures obtained.

The extinguishing agent was applied approximately two hours before the beginning of the fire, with a concentration of 1kg of product for every 6 litres of water, with a sprinkled dose over the fuel of 4 l/m². When the fire began, two hours after the product application, the sprinkled fuel presented a substantial amount of humidity when compared to the non treated zone, as it is reflected on Table 3.

Table 3. Average values of fuel humidity.

Specie	Group	Non Treated area	Area Treated with Extinguishing Agent
E. australis	*GI Dry	13.89	47.5
U. Europaeus	G.I. Dry	7.81	28.39
E. australis	G.I Green	85.06	110.51
U. Europaeus	G.I. Green	104.47	121.99
Leaf litter		92.7	143.3
Soil 0-5		35.66	42.62

*GI= Fuel portion with a diameter > 6 mm

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FIRE BEHAVIOUR

To characterize the behaviour of fire, 2.5 meter high milestones were set up every five meters, making two parallel lines at both ends of the plot that served as a visual field reference for both propagation speed of the fire front and the flame height, information completed with the images obtained by the video recorded during the burning test. (Table 4).

In order to identify the temperatures obtained at the bush layer and leaf litter, seven thermocouple stations were set up next to the axis of the plot, with a 5 meter separation from each other, comprising both the area treated by the extinguishing agent and the area not treated. Each station comprised a thermocouple (with a 1 mm cover made of Inconel) located half way along the bush layer and the other one placed on the surface of the leaf litter. The temperature values recorded by the sensors were registered over intervals of one second.

Table 4. Average values of fire behaviour parameters.

	Average	Range
Plot axis angle with the line of maximum slope in horizontal projection (°) (Figure 1)	19	------
Wind direction angle with the axis plot in horizontal projection (°)	47	42 - 49
Propagation speed of fire (m/m)	4.05	1.9 - 13.04
Length of flame (m)	6	2 - 8.5
Linear Intensity of fire front (kw/m)	3600	1700 - 11700

Over the last stretch journeyed by the fire over the area not treated with the product (6 m of length), the fire developed a speed of 11 m/min, generating a linear intensity (according to Bryam) of 9865 kw/m and a length of flame of 7.5 m that, according to Thomas formula, would equal to an intensity of about 10500 kw/m. The flame front reached the treated zone, under those conditions, producing an extinction of the fire without practically penetrating the area. This response is this way corroborated by the strong decrease of the average temperature values.

Table 5.Maximum Temperatures (°C) and time in seconds during which temperatures remained above 60, 350 and 700 degrees Celsius.

	Non Treated Area				Area with Extinguishing Agent			
	Bush		Leaf litter		Bush		Leaf litter	
	Average	Range	Average	Range	Average	Range	Average	Range
Maximun T (°C)	976	846 – 1102	457	17 – 923	62	29 – 96	18	17- 18
Time with T > 60°C (S)	286	236 – 341	322	0 – 553	8.5	0 – 17	0	--
Time with T > 350°C	49	21 – 69	65	0 – 114	0	--	0	--
Time with T > 700°C	18	6 – 35	0	--	0	--	0	--

As it is shown in Table 5, in the area treated with the extinguishing agent the maximum temperature decreased drastically at both bush and leaf litter zones.

Likely, the time in which temperatures stood above the indicated maximums absolutely dropped to values that correspond to the absence of flames.

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CONCLUSIONS

1) The burning test that took place can be considered as the usual fire of these bush formations that normally produce high intensities, due to the age, height, and amount of bush present in them. At some moments, the fire spread was diminished by low wind speed and deviated from the longitudinal axis of the plot. Despite the fact, in the path where the fire reached the treated zone, it developed great intensity, thanks to the wind that blew with higher speed (7 km/h) and was better aligned in respect to the axis of the parcel.
2) The estimations reached and the temperature data obtained indicate that, in the proportions used, the mixture presented a total effectiveness in the extinction of the flame front, because the fire was extinguished without its extension beyond the limit of the treated zone.
3) When undergoing this test, its comparison with the application of the same dose of water without the extinguishing agent was not considered.
4) This test can only be considered a demonstration experiment, being necessary to test the product on a wider experimental basis to obtain a more concluding and certified result.

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Photography 1. Plot view before the burning. Milestone number 5 located by the wooden stakes and the sign of the company "Green Canyon", marking the limit between the non treated
zone, to the left of the rod and the area treated with FS-01, to the right.



Photography 2. Beginning of fire with tailwind and slope.



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Photography 3. Fire progression in the area not treated with the fire extinguishing agent.



Photography 4. Moment in which the fire reaches the limit between the non treated area and the area treated with extinguishing agent. Liner Intensity (Bryam) of approximately 10.000 kw/m.



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Photography 5. Fire extinguishes when it enters the area treated with the extinguisher agent. It can be observed that the fire did not pass beyond milestone number 5 which marks the beginning of the area treated with the extinguishing agent (FS-01).

