Recommendations for fuel-break design and fuel management at the Wildland Urban Interface: an empirical approach in South Eastern France

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Abstract

In the regions of France submitted to a high wildland fire hazard, fuel build-up control around buildings is enforced by law at least on a 50 m wide perimeter in order to reduce fire's impact on buildings and inhabitants. Local regulation may be taken in order to specify fuel-break design and fuel management rules. The South Corsica region has produced recently the first local regulation including such rules. This regulation is presented here as an example. In order to assess the effectiveness of these fuel management rules, a wildfire concerning wildland urban interface (WUI) in this region was analyzed on last spring. A field form was designed in order to describe fire's behavior in the immediate vicinity of each building. The form was filled up on a set of sixty buildings concerned by this event. The early results of this inquiry are presented in this paper. Finally general recommendations are formulated in order to enlarge the application domain of fuel management rules around buildings for the whole French Mediterranean region.

Introduction

Since 1991, a network has been growing, in southern France, with forest managers, fire fighters, and range extension officers, territorial authorities technicians and researchers working on management plans for forest fire prevention. This network is an open forum for exchanging data, experiences and ideas on how to manage fuel-breaks. Its first objective is to assess technical combinations for fuel control for creating and maintaining fuel-breaks (Etienne & Rigolot, 2001). An important goal is also to organize fuel-break effectiveness assessments by both post-fire analysis when a wildfire affects a fuel-break (Lambert *et al*., 1999) and by an expert appraisement approach (Rigolot, E., 2002a). These analyses help to compare costs and benefits of the fuel-break construction policy. The final objective of this working group is to give operational guidelines for safe and effective fuel-break design (Rigolot & Costa, 2000).

In the frame of this network, a typology of fuel-breaks has been set-up distinguishing three main objectives that a fuel-break could achieve (Duché & Rigolot, 2000): (i) to decrease fire ignition events, (ii) to decrease total area burnt and (iii) to decrease fire effects on people and human resources. Fuel-breaks at the wildland urban interface (WUI) can be classified in the first category because human activities at the WUI can cause fire ignition, as well as in the third category in order to reduce fire impact on buildings and inhabitants. The French fuel-break-working group is currently implementing specific fuel management rules for each specific fuel-break type (Rigolot, 2002). These rules are taking into account the technical and scientific state of the art on the topic, but also empirical rules in order to give immediate operational responses for forest managers.

Fuel management at the WUI is complex because it concerns man-modified vegetation, mixing inert areas with others covered by vegetation including natural and ornamental species. The technical objective of fuel reduction around buildings is often opposed to the owners' points of view, which wish to live as close as possible to nature, under tree canopy shading.

In the regions of France submitted to a high wildland fire risk, fuel build-up control around buildings is enforced by law at least on a 50 m wide perimeter. Local regulation has to be taken in order to specify fuel-break design and fuel management rules. The first local regulation with these objectives has been taken recently in South Corsica. This study presents the fuel management rules defined in this context. These rules are then assessed on a real case wildfire which occurred in this region on last spring and threatened several buildings at the WUI. In order to assess the effectiveness of these fuel management rules, a wildfire at a wildland urban interface (WUI) in this region was analyzed on last spring.

This paper aims finally to summarize the general recommendations formulated by the French fuel-break-working group in order to enlarge the application domain of fuel management rules around buildings for the whole French Mediterranean region. These prescriptions are not only focused on shrub control, but also on tree clearing which is classically neglected in the current practice.

The new French forestry law

The new French forestry law from 9th July 2001, gives a general definition of fuel reduction operations (Art. L. 321-5-3). The objective is to reduce fire intensity and to limit fire spreading by reducing fuel amount and fuel continuity. It is also necessary to prune trees when maintained and to eliminate fuel residues. This general definition must be specified by the local represent of the French State in each "département" taking into account, when necessary, the particularities of each forest.

The law introduces the possibility of different modalities of fuel reduction considering the different possible objectives of a given fuel break. Thus vegetation shouldn't be treated the same way on a fuel break designed to reduce fire extension (strategical fuel break) and on fuel break designed to limit fire effects on a target (Wildland Urban Interface).

The new French forestry law indicates that in the regions submitted to a high wildland fire risk, fuel build-up control around buildings is enforced for buildings closer than 200 meters from forest, garrigue or maquis (Art. L. 322-3). Fuel clearing has to be done and regularly maintained on a perimeter of 50 m from the building which can be extend to

100 meters by local regulation. If the land property is a lot in an housing estate, fuel has to be controlled on the whole area of the property, even if there is no building on it. The owner of the land is in charge of this duty.
The local regulation should specify the fuel-break design at the WUI and the most effective fuel management rules. There is a lack of knowledge to help local stakeholders establish these rules, and so far, only South Corsica has introduced such a rules in its local regulation.

Local regulation of South Corsica: an example

The decision n°02-1270 from 22nd July 2002 is introduced by the following statements:

1. Fuel treatment depends on the distance to the settlement (Figure 1). In a first 30 m around the building, fuel treatment is supposed to be more intense than in the twenty remaining meters. The main difference between these two zones is that in the close perimeter around the house, trees must be cleared, but not in the distant perimeter. The other rules concerning tree pruning and shrub control are the same in the two zones.

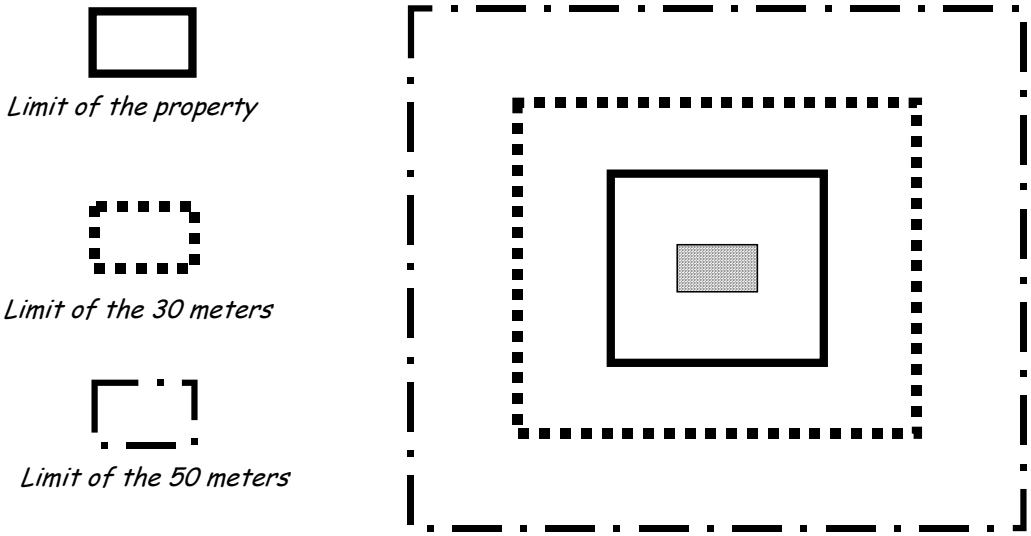


Figure 1: Fuel treatments depend on the distance from the settlement (perimeter is drawn as a square but should be a circle)

2. Fuel treatment depends on vegetation height: all the vegetation (natural or ornamental) less than 3 meters high is considered as shrubs. All the vegetation higher than 3 meters is considered as trees.

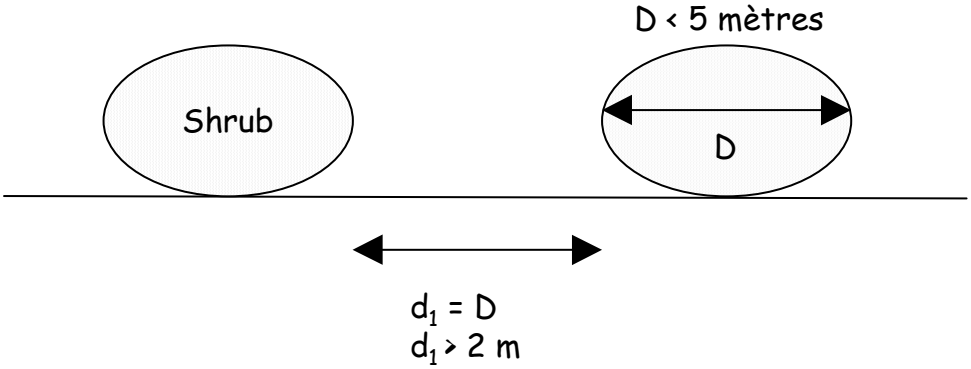


Figure 2: Fuel reduction in the shrub layer

3. All the individuals or groups of individuals are separated in order to break the fuel continuity. Shrubs are separated from a distance d_1 equal to the diameter D of the biggest shrubs or group of shrubs with a minimum of 2 meters (Figure 2). Individual trees are separated with a minimum distance d_4 of 2 meters (Figure 4). Individual trees and group of trees are also separated with a minimum distance d_4 of 2 meters (Figure 4). But groups of trees are separated with a minimum distance d_5 equal to the diameter of the biggest group of trees crowns D' (Figure 4). Distance d_2 between individual shrub or group of shrubs and a tree is equal to three times the tree height and cannot be less than 2 meters (Figure 3).

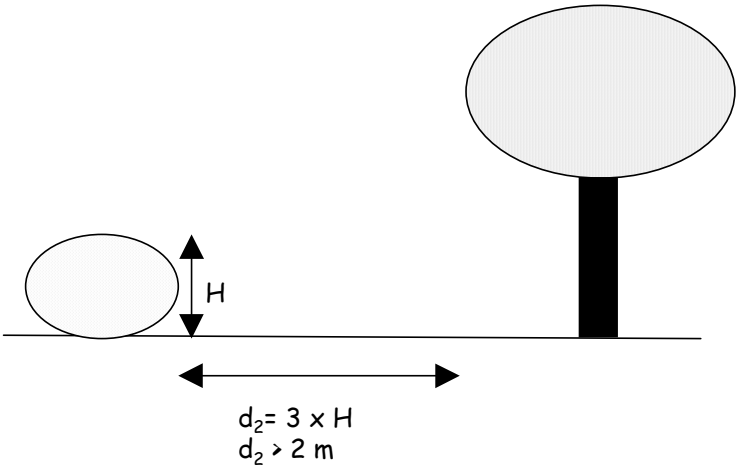


Figure 3: Distance between shrubs and trees

4. All the individuals or groups of individuals have a limited horizontal extension of 5 meters for the shrubs (Figure 2) and 15 meters for the trees (Figure 4).

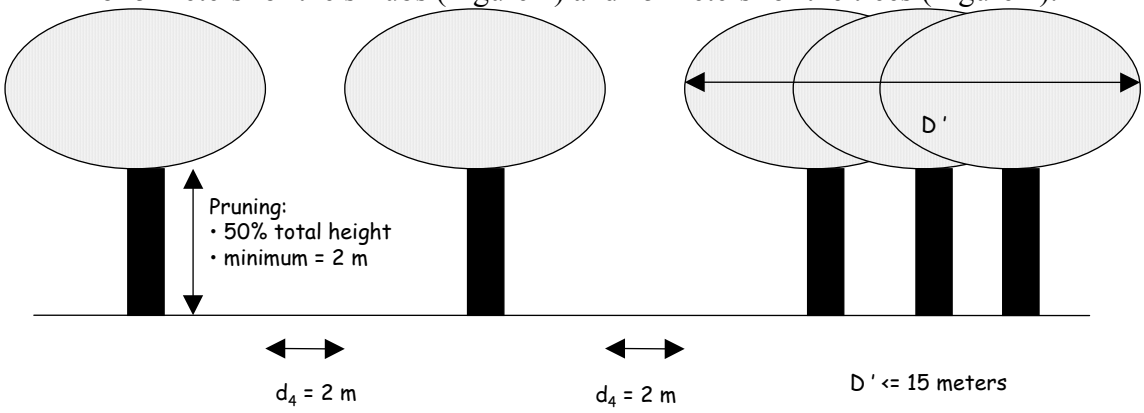


Figure 4: Tree layer thinning and pruning principals

5. The distance d_3 between a shrub or a group of shrubs and an opening of the building (door or windows) is equal to three times the height H of the shrub with a minimum distance of 3 meters (Figure 5). The distance d_3 between an isolated tree and an opening of the building (door, windows) is more than 3 meters. The distance d_5 between a group of trees and an opening of the building is higher than the diameter of the group of crowns.

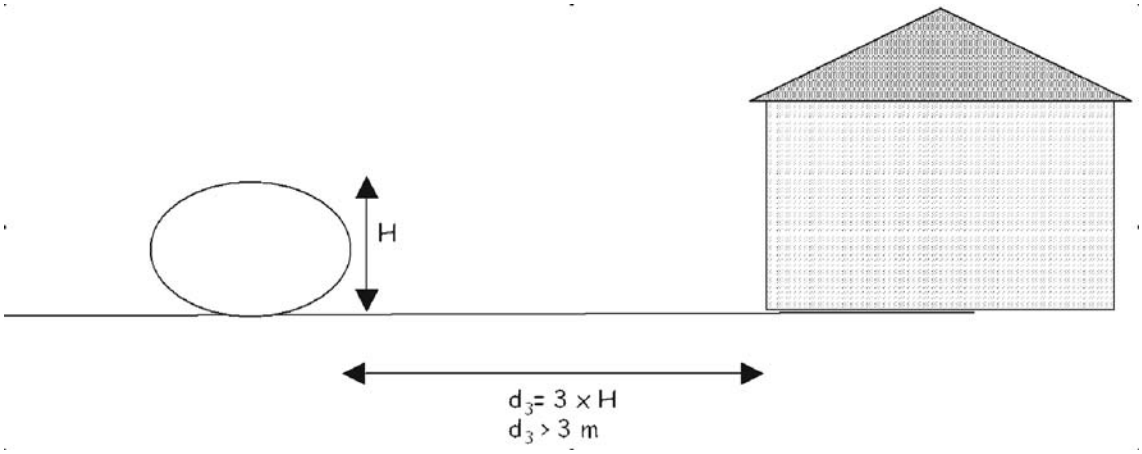


Figure 5: Distance between a shrub and an opening of the building.

6. In order to ensure a break in the vertical distribution of the fuel, trees must be thinned on 30% of their total height for broadleaf and on 50% of their total height for resinous, with a minimum of 2 meters (Figure 4).

Others recommendations concern specific vegetation structures of the WUI like hedges and are not detailed in this paper.

Figures 7 and 8 illustrate the combination of these different rules in two contrasted situations with respectively high and low initial tree cover. Figure 7 shows that when tree cover is high, and if tree presence is important for the owner, shrub must not be maintained. In this context, shrub clearing must be regularly done on the whole area. Figure 8 shows that when tree cover is naturally low, even if the priority is to maintain all the trees, some ornamental shrubs can be maintained.

These rules have been defined on empirical basis using current knowledge and expertise. They need to be assessed in order to verify their effectiveness in protecting building and people against fire. On last spring a fire event close to Ajaccio gave the opportunity to make an analysis on a real case.

Analysis of the Coti Chiavari wildfire (6th - 7th May 2003)

The Coti Chiavari fire was an early spring wildfire spreading over a WUI close to Ajaccio city (South Corsica). Almost 200 ha were burnt during this fire. More than sixty buildings were threatened by this fire.

An analysis was organized in collaboration between local authorities of South Corsica (Forest administration, Fire fighters) and a research team (INRA-URFM, Avignon) in order to realize a post fire inquiry based on two field forms.

Field form in Annex 1 was filled up for more than sixty houses including a great variety of situations. The objectives were to appraise the fire impact on buildings in relation with the pre-fire fuel management of the immediate surroundings. When fuel management had been done, the treatments were compared with the recommendations of the local regulations. This first form includes questions in order to describe fire behavior before the zone with fuel treatment. If there was a zone with fuel treatments, it had to be described and also the behavior of the fire spreading through it. Finally the possible impacts on the house were assessed.

Figure 6a: General view of the WUI on the Coti Chiavari wildfire

(Photos: DDAF Corse du Sud)

Figure 6b: Building partly destroyed by the Coti Chiavari wildfire

A second form was set up in order to collect information from residents and fire fighters to know whether or not buildings were actively protected (Annex 2).

Fire was quite intense: fire risk estimated with the Forest and Meteorology Index (IFM) given by Météo France was 49. Fire spread over a lot of properties and two houses were burnt as well as numerous garden buildings made of woody materials.

Results of this inquiry are currently analyzed and no conclusion can be given so far. However, three preliminary findings can be listed:

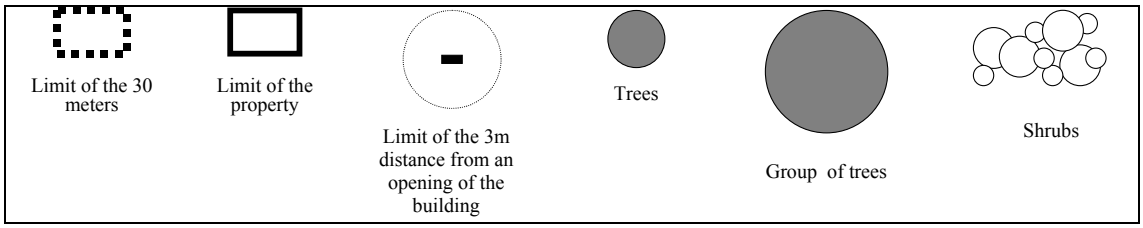
1. As a general rule the perimeter with fuel treatments was lower than recommended in the Forestry Law and in the local regulation. The fuel treatments were not realized on the land of the neighbors and were generally limited to the land property.
2. When some fuel treatments were done, they were less intense than recommended. Namely tree thinning was almost never realized.
3. Some well-prepared houses offered an effective protection by screen effect toward neighboring buildings, when directly in the spreading direction of the fire.

General recommendations of the French working group

In order to get fuel management rules that could be applied in any geographical context, the French working group made a first attempt to define general technical recommendations at the WUI (Rigolot, 2002b):
A perimeter close to the building has to be fixed within the 50 meters wide area defined by the Forestry Law. The extension of this perimeter must take into account factors conditioning the fire risk like fuel build up and local topography. Within this perimeter:

- Tree crowns shouldn't be closer than 5 meters from the building, and in all the cases they should never dominate the roof.
- Trees when maintained should be pruned between 30% and 50% of their total height and at least 2 meters.
- Tree crowns should be clearly separated with a distance which should increase close to the building.
- Fuel distribution should be organized in order to limit crowning by creating horizontal and vertical breaks between the crowns of the trees and the shrubs. Ornamental vegetation is included in these recommendations.
- Hedges composition should avoid very flammable species like cypress and mimosa. Hedges shouldn't be orientated in the same direction than the dominant wind.
- Shrub and grass control should be more intense when more trees are maintained. Two thresholds of shrub phytovolume are defined:
    1. 2000 m^3/ha when trees are intensively cleared: good distance between tree crowns and no tree closer than 5 meters from the building.
    2. 500 m^3/ha when tree cover is higher than 50%.

Beyond the close perimeter, and up to the legal perimeter, shrub control is recommended in order to maintain fuel phytovolume under 2000 m^3/ha. In this area tree pruning is recommended, but no tree clearing is necessary.



Legend

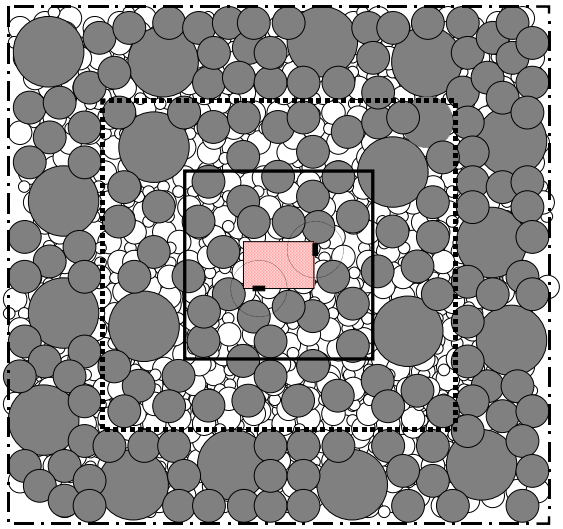


Figure 7a : High tree cover situation before treatment

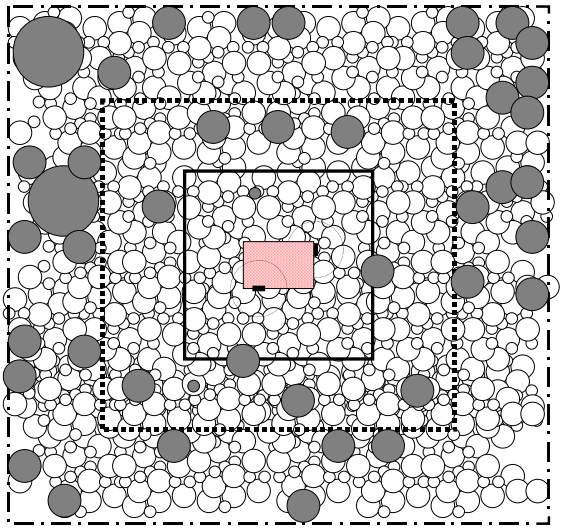


Figure 8a : Low tree cover situation before treatment

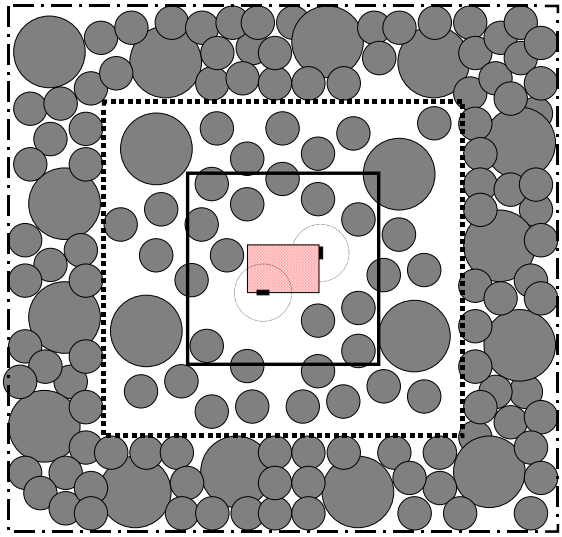


Figure 7b : High tree cover situation after treatment

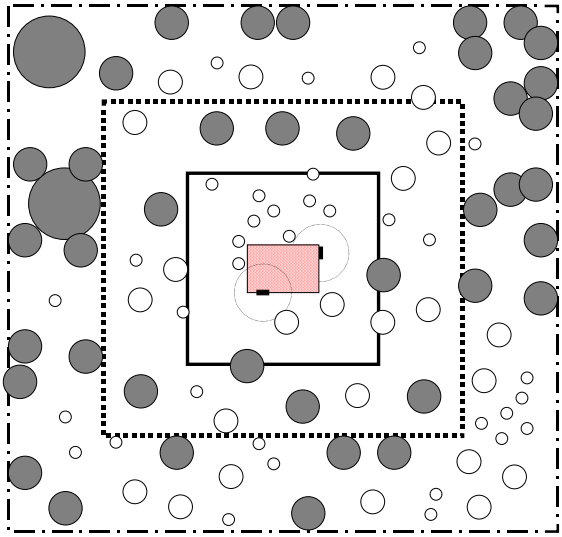


Figure 8b : Low tree cover situation after treatment

Conclusion

This work is a first attempt to specify fuel management rules at the WUI in the French Mediterranean region. This approach follows the obligations of the Forestry Law which are quite strong in term of area to be treated, but needs also to be completed by technical recommendations in order to ensure the effectiveness of the operation. A lot of social and economical constraints have to be taken into account to verify the feasibility of the prescriptions.
This work proposes also a methodological frame for assessing the effectiveness of such fuel treatments around buildings when submitted to a real wildfire. The inquiry forms have to be used in a wide range of fire events in order to get a good sample of experience to be analyzed together. This will be the way to obtain practical and effective rules for fuel reduction at the WUI able to give an answer to the great variety of situations.
This approach is completed by the modeling approach developed in the frame of the Fire Star European project. The study cases to be simulated with the Fire Star fire model were built using the outcomes of such an empirical approach in order to select the most realistic and most promising scenarios.

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Close this chapter

ANNEX 1: EFFECTS OF THE FIRE ON BUILDINGS

Investigator name:……House number (written on the map):……
Name of the residents:…… Phone number :……..……

TOPOGRAPHICAL POSITION OF THE HOUSE :

☐ flat ☐ brow or crest ☐ hillside ☐ lower part of hillside ☐ col ☐ thalweg ☐ bottom of valley ☐ other:

Exposure : ☐ N ☐ NE ☐ E ☐ SE ☐ S ☐ SW ☐ W ☐ NW ☐ all

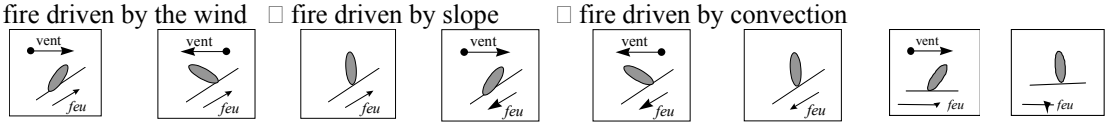
Length of the private road: ……Was the undergrowth vegetation cleared on both sides? ❒ Yes ❒ No

Did the next properties upstream in the direction of fire propagation had any fuel treatments?❒ Yes ❒ No

A – THE FIRE UPSTREAM THE AREA WITH FUEL TREATMENTS

☐ Directly observed ☐ Immediate investigation ☐ Delayed investigation ☐ Other

☐ fire driven by the wind ☐ fire driven by slope ☐ fire driven by convection



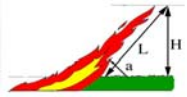
1 Uphill + wind ward | 2 Uphill + against the wind | 3 Uphill with no wind | 4 Down hill and against the wind | 5 Down hill and wind ward | 6 Down hill with no wind | 7 Flat and wind ward | 8 Flat and no wind

☐ Grass, matorral, maquis, garrigue | ☐ Grass, matorral, maquis, garrigue | ☐ Local crowning | ☐ Crowning | ☐ Total fire

Length of flames :L

Average value :…….m < L <……m

Maximal value :…….m < L <……m



B – DESCRIPTION OF THE VEGETATION

1-B. SURROUNDING VEGETATION	**Cover**		**Height**	**Species**	**Effect of fire***
TREES (height > 2m)	1 – 25 %	25 – 50 %			
	50 – 75 %	75 – 100 %			
SHRUBS	1 – 25 %	25 – 50 %			
	50 – 75 %	75 – 100 %			
OTHERS (slashes, dry grass…)	1 – 25 %	25 – 50 %			
	50 – 75 %	75 – 100 %			

* PS = partially scorched ; TS = totally scorched ; G = green.

2-B – AREA WITH FUEL TREATMENTS

General assessment of the fuel treatments (=, +, -)	
Width of the area with fuel treatments toward fire front:	m

	Cover		**Height**	**2 main species**		**Effect of fire**
TREES (height > 2m)	1 – 25%	25–50%				
	50 – 75%	75–100%				
SHRUBS	1 – 25%	25–50%				
	50 – 75%	75–100 %				
GRASS	1 – 30%		0,01–0,1m			
	30 – 60%		0,1–0,5m			
	> 60%		>0,5m			
LITTER	1 – 30%		<0,01	leaves	residues	
	30 – 60%		0,01–0,1m	needles	humus	
	> 60%		>0,1			
TREES AND SHRUBS (Total cover)	1 – 25%	25 – 50%				
	50 – 75%	75 – 100%				

HEDGES

Is there any hedge? ❒ Yes ❒ No ❒ its combustion has reached the house

Species	Minimal Distance to the house	Height	Width	Behaviour and effect of the fire**

**Foliage: S = scorched; PS = partially scorched; TS = Totally scorched; V = Vector for fire spreading

AREA WITH NO FUEL

Is there any area with no fuel at all around the house? ❒ No ❒ Yes. Length toward fire front: …… m

Type : ❒ pavement ❒ swimming-pool ❒ tracks ❒ other : ……..

Prescribed distances in the local regulation	***Application*** **= + -**	***Behaviour and effects of the fire****
Between shrubs or groups of shrubs, d_1 >= D_{shrubs} and d_1>= 2m		
Between shrub(s) and tree, d_2 >= 3 x H_{shrubs} and d_2 >= 2 m		
Between shrubs and doors, windows or part of basic structure, d_3>= 3 x H_{shrubs} and d_3 >= 3 m		
Between trees, d_4 >= 2 m		
Between trees and group of trees, d_4 >= 2 m		
Between trees and doors, windows or part of basic structure, d_4 >= 2 m		
Between group of trees, d_5 >= $D_{treegroup}$		
Between group of trees and doors, windows or part of basic structure, d_5 >= $D_{treegroup}$		
Between hedge < 2m and shrub(s), d_1 >= D_{shrubs} et d_1 >= 2 m		
Between hedge < 2m and tree, d_2>= 3 x H_{hedge} et d_2 >= 2 m		
Between hedge < 2m and doors, windows or part of basic structure, d_3 >= 3 x H_{hedge} et d_3 >= 3 m		
Between hedge >2m and shrub(s), d_2 >=3 x H_{shrub} or H_{hedge} and d_2 >= 2m		
Between hedge > 2m and tree, d_4 >= 2 m		
Between hedge > 2m and doors, windows or part of basic structure, d_3>= 3 x H_{hedge} and d_3 >= 3 m		
Pruning: 50% for conifers and 30% for hardwood and 2 m.		

❒ elimination of dead parts of remaining plants ❒ elimination of slashes

3.B <u>FUEL TREATMENT MAINTENANCE AND IRRIGATION</u>

Is the fuel treatment maintained? ❒ Yes ❒ No

Is there any irrigation system of the ground? ❒ No ❒ Yes: ❒ sprinkling ❒ drop by drop ❒other: ……

C - DESCRIPTION OF THE BUILDING

<u>1-C GENERAL DESCRIPTION:</u> Material: ❒ masonry ❒ wood ❒ PVC ❒ other : ……

External coating compound: ……

Flammable elements in contact with the house (pile of wood, …) : …….

<u>2-C DOORS & WINDOWS:</u> Are there any doors or windows on the frontage exposed to the fire?

❒ No❒ Yes:❒ door❒ window ❒ bay window❒ other: ……..

Joinery : ❒ wood ❒ PVC ❒ aluminium ❒ other : …… Shutters : ❒ No ❒ Yes, material :……

During the fire, doors and windows were: ❒ open ❒ closed Shutters were : ❒ open ❒ closed

<u>3-C ROOF AND BASIC STRUCTURE:</u>

Is the material at the junction between roof and walls combustible? : ❒ No ❒ Yes.

Description: …….

Roofing material: ……. Insulation material : ……..……..

Presence of a porch roof : ❒ No ❒ Yes Presence of gutters : ❒ No❒ Yes. Material: ……..…

<u>4-C EFFECT OF FIRE</u>

Description of the damages observed (walls, roof, windows, doors) / Diverse observations: ……..……

In case of fire entrance in the building: weak point

❒ door ❒ window ❒ roof ❒ external wood from the roof construction ❒ other: ……..

Reason why the fire entered in the house (for example: plants in contact with a part of the house, to be specified):……

Did any construction element have protected the house or the ground from fire propagation or radiation?

ANNEX 2 - INTERVIEW OF RESIDENTS AND FIRE-FIGHTERS

House n°: …….

Fuel treatments:

According to the resident, had there been some fuel treatments on the property ? ❒ Yes ❒ No

Date of the last treatment: ……

Irrigation :

How often is the area watered? ….. days a week.

Was the irrigation system running during the fire? ❒ Yes ❒ No

Was it running before the fire? ❒ No ❒ Yes: …..number of hours before the fire.

Active protection of the building:

During the crossing of the fire on your property :

Did you protect your house by yourself? ❒ No ❒ Yes: How?…….

……

Did fire-fighters protect your house? ❒ Yes ❒ No

FIRE FIGHTING AROUND THE HOUSE

□ Directly observed □ Immediate investigation □ Delayed investigation □ Other

PRESENCE OF FIRE FIGHTERS : □ Yes □ No

- If NOT: Other fighting objective: □ No □ Yes

Comments:……

…..……

Is the place difficult of access? □ No □ Yes

Security of the place for vehicles: □ everywhere □ nowhere □ here and there

Comments:……

……..

General assessment of the surroundings of the house:

Comments :……

……

- If YES: Fire fighting actions : □ Yes □ No: reason:……

Security in the surroundings of the house for a well equipped person: □ No □ Yes

Comments :……

……

Walking access in the surroundings of the house : □ No □ Yes

Comments:……

……

Access for a vehicle in the surroundings of the house: □ No □ Yes

Comments :……

……

Difficulties due to the fire: □ Radiation □ Smoke □ Rapidity of the fire □ Noise

Comments :……

……

Description of the fire fighting action (number and type of vehicles, control line preparation,…)

:…….

……

First propositions to improve the surroundings of the house: …….

……

SYNTHESIS DIAGRAM

Summarise on a diagram: orientation, scale, direction of the wind, direction of the fire front, localisation of the areas with no fuel and of the irrigated areas around the house, on which you will draw the windows and the doors. Draw also the foliage of trees, shrubs, clumps of trees and hedges.