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EUFIRELAB:

Euro-Mediterranean Wildland Fire Laboratory, a “wall-less” Laboratory for Wildland Fire Sciences and Technologies in the Euro-Mediterranean Region

Deliverable D-02-03

Methods for wildland fuel description and modelling: European standards (intermediate)

Paulo FERNANDES, Britta ALGÖWER, Mercedes GUIJARRO, Pedro CUIÑAS, Carmen HERNANDO, José MENDES-LOPES, Felix MORSDORF, Luís RIBEIRO

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SUMMARY

The subject of Deliverable D-02-03 is the general procedures used by EUFIRELAB partners to measure, describe, inventory and map wildland fuels.

This is the first step in the process of defining methodological European standards.

A survey form was prepared in order to gather each partner's information.

This document summarises the responses to the questionnaire and draws trends concerning the current methods.

The degree of standardisation seems already high.

Most of the differences between partners are likely to be an outcome of the available equipment and specific research objectives.

1 INTRODUCTION

Deliverable D-02-03 has been preceded by a comprehensive state of the art concerning the methods used worldwide to describe vegetation as a fire fuel (D-02-01), and by a deliverable inventorying the fuel characteristics and plant species studied by the EUFIRELAB partners (D-02-02).

Following the previous efforts, Deliverable D-02-03 is a preliminary exploratory attempt at defining standards for the methodologies that European researchers adopt in order to characterize wildland fuel properties, and classify, appraise and map fuel assemblages.

Deliverable D-02-03 was established according to the following sequence of procedures:

1. A preliminary questionnaire was prepared by P025 and uploaded to the EUFIRELAB web site, and participants were requested to assist in refining the final version of the survey. The questionnaire inquired about the methods used (and why are they used) to obtain information on fuels.
2. After receiving and integrating the suggestions for improvement, the final questionnaire version was uploaded to the EUFIRELAB web site to be filled in.
3. The concerned partners downloaded the questionnaire, filled in the relevant information and uploaded their contributions to the same folder in the web site.
4. Based on the contributions received, a draft was prepared and uploaded again for comments and suggestions.
5. A final version was written, taking into account the feedback received from the interested partners.

Following this introduction, the questionnaire used is presented, a summary of the responses is given, and the information collected is discussed.

2 THE QUESTIONNAIRE

2.1 INTRODUCTION

The questionnaire was divided in five tables, respectively Fuel Particles, Fuel Moisture, Fuel Classification, Fuel Sampling and Field Inventory, and Fuel Mapping from Remote Sensing and Modelling. Each table occupied a worksheet of an Excel file.

General instructions to fill the tables were as follows:

- Each partner should only fill issues within its current or past domain of study;
- have deliverable D-02-01 at hand in order to clarify doubts that might occur in respect to terminology or items selection;
- the information should be written in the orange cells;
- response to "used", "not used" and "preferred" is simply a cross (X), for the remaining topics it consists of free text;
- methods not listed should always be indicated in "other";
- whenever references absent from deliverable D-02-01 are provided please give their complete bibliographic information.

Furthermore, specific instructions were provided in commentaries associated with the cells to be filled.

Each table is reproduced below.

2.2 TABLES

2.2.1 Table 1: Fuel particles

	Used	Not used	Prefered	Why ?
SPECIFIC GRAVITY, DENSITY or MASS TO VOLUME RATIO				
Weighing and volume measurement by water displacement				
Weighing and volume measurement by mercury displacement				
Weighing and volume estimated from physical measurements				
Other method:				
SURFACE AREA TO VOLUME RATIO				
Image analysis and measurements on cross-sections				
Determined from physical measurements assuming simple geometrical shapes				
Surface projection, volume measured by water displacement				
Surface estimated from geometry, volume by water displacement				
Surface estimated from correlation with other variables, volume by water displacement				
Water immersion				
Other method:				
ASH CONTENT				
Weighing after heating in a muffle furnace				
Chemical analysis				
Thermogravimetric analysis				
Other method:				
EXTRACTIVES CONTENT				
Extraction with solvents				
Other method:				
HEAT CONTENT or CALORIC VALUE				
Bomb calorimetry				
Near-infrared reflectance spectroscopy				
Other method:				

2.2.2 Table 2: Fuel moisture content

	Used	Not used	Prefered
Direct and semi-direct methods			
Oven-drying			
Microwave-drying			
Chemical methods			
Electrical methods			
Indirect methods:			

2.2.3 Table 3: Fuel classification

	Used	Not used	Prefered	Why ?
1. FUEL STRATIFICATION				
Classical U.S. Forest Service classification				
Fuel Classification System				
Other:				

2. DESCRIPTION TYPE	Used	Not used	Prefered	Why ?	Spatial scale of application
QUALITATIVE DESCRIPTIONS					
Vegetation type					
Canadian FBP system Fuel Type					
Photo-series					
Other:					
QUANTITATIVE DESCRIPTIONS					
Standard (NFFL) fuel models (U.S. Forest Service)					
Modified (NFFL) fuel models (U.S. Forest Service)					
Custom fuel models (U.S. Forest Service)					
Other types of fuel models:					
QUANTITATIVE-QUALITATIVE DESCRIPTIONS					
Photo series of fuel models					

2.2.4 Table 4: Fuel sampling and field inventory

	Used	Fuel beds/layers	Not used	Prefered	Why ?	References
DESTRUCTIVE SAMPLING						
NON-DESTRUCTIVE SAMPLING						
Measurements of physical descriptors						
Points						
Quadrats						
Line intercepts/transects						
Belt transects						
Other:						
Calibrated visual estimation						
Double sampling and estimation with equations						
Other:						

2.2.5 Table 5: Fuel mapping from remote sensing and modelling

	Used	Fuel beds/layers	Not used	Prefered	Why ?	References	Resolution and Scale	Accuracy
REMOTE SENSING TECHNIQUES								
Direct methods								
Indirect methods								
BIOPHYSICAL MODELLING								

3 RESPONSE TO THE QUESTIONNAIRE

3.1 INTRODUCTION

Six partners from the EUFIRELAB consortium answered the call to fill the questionnaire: P010, P012, P013, P018, P025, and P033.

The information provided was generally poor.

Unfortunately, most partners just indicate what methods (or family of methods) they use without addressing the remaining topics contained in the tables.

The results below (aggregated in three tables concerning fuel properties, classification and inventory, and mapping) summarize the responses, and are presented in terms of the methods used by each partner, and the overall representativity of the method within the surveyed teams' universe.

Additional data, whenever available, will be detailed in section 4.

Only one partner (P033) develops work in the field of Fuel Mapping.

The respective information is more comprehensive and merits a separate treatment.

3.2 RESULTS

3.2.1 Fuel properties table

Fuel property	Used by	%
Specific gravity, density or mass to volume ratio		
Weighing and volume measurement by water displacement	P018, P025	100
Weighing and volume measurement by mercury displacement	P018	50
Weighing and volume estimated from physical measurements	P025	50
Surface area to volume ratio		
Image analysis and measurements on cross-sections	P010, P013	40
Physical measurements assuming simple geometrical shapes	P010, P013, P018, P025, P033	100
Surface estimated from geometry, volume by water displacement	P018, P025	40
Water immersion	P025	20
Ash content		
Weighing after heating in a muffle furnace	P018, P025	100
Extractives content	-	-
Heat content or caloric value		
Bomb calorimetry	P010, P018	100
Moisture		
Direct and semi-direct methods		
Oven-drying	P010, P012, P013, P018, P025, P033	100
Electrical methods	P025	17

3.2.2 Fuel classification and inventory table

	Used by	%
Fuel stratification		
Classical U.S. Forest Service classification	P010, P013, P018, P025, P033	100
Other	P025 (adaptations)	20
Description type		
Qualitative descriptions		100
Vegetation type	P010, P013, P018, P025, P033	100
Photo-series	P013, P025, P033	60
Quantitative descriptions		100
Standard (NFFL) fuel models (U.S. Forest Service)	P010, P018, P025, P033	80
Modified (NFFL) fuel models (U.S. Forest Service)	P010, P018, P025, P033	80
Custom fuel models (U.S. Forest Service)	P013, P018, P025, P033	80
Quantitative-qualitative descriptions		80
Photo series of fuel models	P013, P018, P025, P033	80
Destructive sampling	P010, P013, P018, P025, P033	100
Non-destructive sampling		100
Measurements of physical descriptors		
Points	P018, P025	40
Quadrats	P013, P018, P025, P033	80
Line intercepts/transects	P013, P018, P025, P033	80
Belt transects	P025	20
Calibrated visual estimation	P013, P033	40
Double sampling and estimation with equations	P010, P013, P018, P025	80

3.2.3 Fuel mapping

Partner P033 uses both direct and indirect remote sensing methods to map wildland fuels.

Tree height, crown base height and canopy cover are important determinants of crown fire activity which are required by landscape fire growth simulators (namely FARSITE).

These three variables are directly assessed with LIDAR (MORSDORF et al., 2004) on a small scale of 14 km^2.

Tree height estimates have a 2-m resolution with accuracy below 1 m.

The accuracy of cover and crown base height remain to be validated; their resolution is respectively 2-m and 5-m.

The indirect methods are based on radiative transfer models (KÖTZ et al., 2004), have a 30-m resolution and operate on a scale of 24 km^2.

They are applied in the estimation of fuel moisture content and Leaf Area Index, which can be a valuable crown bulk density indicator.

4 ANALYSIS OF RESULTS AND CONCLUSIONS

The estimation of fuel particles' **mass to volume ratio** differs among partners on the technique used to determine the fuel element volume.

The use of water displacement seems to offer a good compromise between accuracy and simplicity/cost.

All five partners conducting **surface area to volume ratio** measurements use estimation procedures, which rely on physical measurements that assume basic geometrical shapes.

However, like P018 remarks, the combination of an estimation of surface area by geometry and volume by water displacement can be an adequate alternative when dealing with more complex-shaped fuels, such as leaves and spines.

Only two teams use the more expensive procedures of image analysis.

Finally, usage of the water immersion method has not expanded beyond its developer (P025).

The chemical properties of fuels, i.e. **ash content** and **heat content** are studied through well-established methods, respectively weighting after heating in a muffle furnace and bomb calorimetry.

Near-infrared reflectance spectroscopy is an alternative to bomb calorimetry proven in its reliability, but it is not used by the EUFIRELAB members.

None of the partners addresses **extractive content** measurement, possibly because fire behaviour models do not currently require knowledge on this variable.

Fuel moisture content is a critical variable in fire behaviour and fire danger rating.

Perhaps this explains why all partners exclude the many indirect methods that are available, and use, for research purposes, the most reliable and accurate method of oven-drying.

Additionally, P025 uses the T-H moisture meter, a device based on electrical methods, which has been calibrated and provides very good results for fine dead fuels.

Unit 2 partners generally share common methods to classify, describe and inventory fuels in the field. All of them use the **fuel stratification** of the U.S.

Forest Service, which is implicit in ROTHERMEL's fire spread model.

Modifications to such stratification scheme were mentioned by P025 only.

It is probable that the number and type of fuel strata will evolve in the future, as a response to fire modelling needs.

Concerning the **description type**, the adoption of qualitative descriptions, fuel models (ROTHERMEL's sense) and quantitative-qualitative descriptions is also universal.

Destructive sampling is a necessary step in the characterization of wildland fuel beds and complexes.

However, only P018 and P025 mention the application of such procedures to the canopy layer.

In the next deliverable an attempt should be made at describing various destructive sampling methods for different fuel types and objectives.

Non-destructive sampling of physical descriptors in quadrats and along line transects is universally used, but point sampling and belt transects do not have the same degree of importance.

The same is true for **calibrated visual estimation**, while **double sampling and estimation with equations** is a widespread procedure.

The results of the survey suggest a relatively high degree of standardization among partners.

It is probable that the majority of the differences between partners are an outcome of the available equipment and specific research objectives.

5 REFERENCES

KÖTZ K., M. SCHAEPMAN, F. MORSDORF, P. BOWYER, K. ITTEN, AND B. ALLGÖWER. 2004. Radiative transfer modelling within a heterogeneous canopy for estimation of forest fire fuel properties. Remote Sensing of Environment 92(3): 332-344.

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