FIRE TORCH: AN EUROPEAN PROJECT TO IMPROVE PRESCRIBED BURNING KNOWLEDGE AND USE

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ABSTRACT

The FIRE TORCH project is the logical step in European prescribed burning research, essential to expand and consolidate its use. FIRE TORCH associates very tightly experimental and management burns, profiting from past experience and integrating the available scientific and technical knowledge on prescribed burning. The activities comprise experimental, modeling, and validation tasks. The project is multidisciplinary and regroups teams from Portugal, France, Spain, Italy and Greece. The research component of the project is focused on two types of knowledge gaps, the replacement of qualitative by quantitative knowledge on the issues of planning and evaluation, and the study of prescribed burning effects at the management scale. The objectives of the project will be attained through different approaches, according to the degree of prescribed burning development in each country of Southern Europe.

Keywords: fuel treatments, prescribed burning, Europe

INTRODUCTION

European research on prescribed burning (PB) showed that this technique is acceptable both economically and ecologically. However, there is a resistance in assuming the role of fire in ecosystems, which can be explained by cultural and historical factors (Hetier, J. 1993). Because fire has been over-used in the Mediterranean region since historical times, foresters are not receptive to see it as a management tool. As a consequence, and with the sole exception of France, where the technique is being increasingly expanded (Rigolot, E. et al. 1996), PB in Europe is not allowed (Greece, Italy), or remains a local or sporadic practice (Portugal and Spain).

A partnership involving researchers and managers from the Mediterranean Basin (Portugal, Spain, France, Italy and Greece) has resulted in FIRE TORCH, a multidisciplinary project which, after previous cooperative efforts, is the logical step in prescribed burning R&D.

The general objectives of the project are i) to identify and analyze constraints to the use of PB in Southern Europe; ii) to address current knowledge gaps concerning environmental and operational issues of PB; iii) to develop decision-support tools for PB management; and iv) to help diffusion of the technique and training of the practitioners.

This paper describes the objectives of the project, and gives an overview of the activities and results achieved during its first year.

NEW OPPORTUNITIES FOR PB DEVELOPMENT

Task 1 of the project has the goal of identifying and analyzing the reasons responsible for the lack of use of PB in some countries or regions, and to address the factors that will make possible its development in the future.

A standard survey form was developed and sent to selected institutions and people in Italy, Greece and Portugal. The current response rate is 53% in Greece, 39% in Portugal, and 17% in Italy. Most of the addressees know prescribed burning, and in all three

countries fuel hazard reduction is referred as the firstreason to use the technique. Management of competing vegetation (Italy) and pastures improvement (Portugal and Greece) follows as second choices. Privilege is given to the most obvious and practical motives to use fire, especially in Italy and Greece, which suggests that the role of fire in ecosystems is poorly perceived.

The problems more commonly identified as obstacles to the development of PB are of technical nature, thus stressing the importance of technology transfer actions and training.

IDENTIFICATION AND APPRAISAL OF RELEVANT INFORMATION

Task 2 intends to define the parameters which are important for the practice of prescribed burning, to design the methods to collect these elements from previous and future research and management actions, that is, to develop PB field forms, and to collect and organize the data.

Since the level of PB development at the management level varies among the countries taking part in the project, we took an approach that distinguishes France from the rest of the countries.

The expansion of PB in France gave birth to a rapidly growing body of experience and knowledge which needed to be capitalized, organized and made available to the users. A close collaboration between researchers and managers within a PB network enabled the design of an operational PB form which is being constantly improved and it is structured in three parts: plot description, operational considerations and evaluation.

In the frame of FIRE TORCH, PB teams were trained to use the field form, with the objectives of i) improve data quality and homogeneity, ii) increase the volume of collected data, iii) increase the diversity of PB forms provenance, and iv) get feedback from managers to improve the form itself.

Five French PB teams, which are responsible for 80% of the PB activity in France received training according to the following steps: i) filling the description sheet on future PB plots, ii) validation of specific field forms developed by some teams to replace the second part of the official French PB form, and iii) filling the evaluation sheet on old PB plots. Contact with the managers was also important to establish a list of possible improvements for inclusion in the next version of the form, and to list elements to include in the guide to help filling the forms that will be made during the second year of the project.

PB forms other than the French form have been developed in Europe before the FIRE TORCH project. The available data on the operational use of PB in Portugal, Spain and France is being compiled. However, to build compatible regional data bases on PB and enable both analyses of common variables at the European scale and of local data at the regional scale, the following objectives have to be accomplished by task 2: i) identify a common and relevant set of parameters for PB management at the European level, ii) ensure that they can be collected by PB managers, iii) design regional PB field forms to collect the data for each European region involved in the project (SE France, Portugal, Galicia, Catalonia, Sardinia), and iv) start the data collection process through these PB regional forms.

The common parameters have been pre-selected. Headlines in the French PB form were sub-divided in 4 classes:

1. Prescribed burning description.
2. Weather conditions.
3. Vegetation before the fire.
4. Vegetation after the fire.

In each class, data was also grouped according to small thematic headlines, corresponding to the different tables of the French database BDSYSTEM. Three types of analysis were subsequently defined: i) analysis of current use of prescribed burning: balance sheet of areas burnt, burning objectives, costs, periods of burning, vegetation types, ii) analysis of the technique used by the different management teams, and iii) analysis with research targets.

Data considered important for each type of request was selected by each research partner, who in addition listed interesting elements not included in the BDSYSTEM. Two types of selected data were identified at the end of the process: common data between partners, which needs to be compatible, and regional data.

As a general rule a large set of data has been selected by each partner, and very few compatibility problems have to be mentioned. Nevertheless, some differences are apparent in what concerns fuel description, burn prescription and fuel moisture content.

A new PB form - essentially based on the French form - has been designed for Portugal; it will be tested and validated by the Forest Service during the 1999-2000 PB campaign. A guide to help managers to fill the form has also been written.

Two Regional and one National PB form are also being developed for Spain.

Besides being validated by local managers, the Regional PB forms have to be validated to check their inter-regional compatibility.

NEW EXPERIMENTAL BURNS

Objectives of task 3 were to plan new experimental burns to fulfill knowledge gaps both on the operational and fire ecology issues, to design/define the corresponding methodologies and to carry the experiments.

A wide variety of vegetation types, potential burn objectives and fire characteristics is being covered by the experiments, reflecting the diversified and specific roles that prescribed fire can accomplish in the management of natural resources. The spatial scale of the experimentation varies with the objective(s):

i) Small plots of 100 m^2 are used to address subjects related with fire ignition and fire behavior which are not scale-dependent, in order to achieve acceptable levels of uniformity within a burn and derive data sets large enough to be of use for modeling purposes;

ii) Larger plots (up to 0.5 ha) are used to study PB effects on soil and trees;

iii) finally, studies of the effects of PB on fauna are being conducted at the same scale of management burns, at the stand level (>1 ha), but reaching the landscape level in one experiment that examines a mosaic of fire regimes, while operational issues of slash burning are also studied at the management-scale.

Common approaches to the methodologies used during the experimental burns have been discussed between the project partners. A general framework, the experimental form, was conceived to synthetically describe (who, what, how...) the PB field experiments (Table 1).

COUNTRY: Portugal ***TEAM:*** EFN
OBJECTIVE(S) OF THE EXPERIMENTS: Evaluation of prescribed burning effects on i) avifauna, ii) insects and iii) stand health
REGION - SITE - VEGETATION TYPE: Minho - Perímetro Florestal de Entre-Vez e Coura - *Pinus pinaster* stands with an understory dominated by *Ulex minor* or *Chamaespartium tridentatum* Estremadura - Tapada de Mafra - shrubland dominated by *Erica scoparia*, *E. lusitanica* and *Brachypodium phoenicoides*
EXPERIMENTAL BURNS *Number:* 21 *Plot size:* 1 ha on average *Burning period:* November 1998 - April 1999 *Firing technique:* Back fires *Fire intensity:* Very low to high
MEASUREMENTS / MONITORIZATION General assessment of preburn fuels, weather, fire behavior and fuel consumption. Postburn dynamics of the understory vegetation Bird communities sampling Carabid beetles sampling Tree condition assessment, and presence of scolitidae and fungi
REMARKS: The majority of the burns were simultaneously management burns for fuel hazard reduction.

Table 1. An example of a prescribed fire experimental form.

ANALYSIS OF OPERATIONAL RESULTS IN THE NEW EXPERIMENTAL BURNS

Task 4 concerns the quantitative assessment of the PB operational issues related with fuels and fire ignition and behavior, and evaluation of the effectiveness (fuel consumption and wildfire hazard reduction) and costs of the burns.

Two types of new experimental burns that deal with operational issues of PB are being carried by the project partners: i) litter ignition tests, which are only concerned with the likelihood of sustained fire spread, and ii) experimental burns, which take into account fire behavior and its effects on fuels and trees. Data from both types of experiments will be used to model (task 6) the links between environmental conditions, fire behavior and effects important for operational purposes, and in the development of a field guide for PB based on the predictive relationships.

The modeling work should be preceded by the examination of existing models/systems related with PB management, namely those developed by the U.S. Forest Service, in order to assess their capabilities to develop sound burning prescriptions.

The effectiveness of prescribed burning in fire hazard reduction

Different but complementary approaches are being taken to evaluate the efficiency of PB to reduce fuel hazard:

1. Based on fire behavior
   a) Observed during experimental burns
   b) Predicted from fire behavior simulators:
   b1) at the plot / stand level, using the BEHAVE system:
   b11) in the new experimental burns
   b12) in experimental treatments where PB was compared with other fuel management techniques
   b13) in management burns
   b2) at the landscape level using the FARSITE software

2. Based on percolation theory and examined at the landscape level with the FRAGSTATS software. Scenarios for specific areas have to be prepared, containing the following elements as inputs: stand limits and age, time since last wildfire or harvesting, time since last PB or cutting, fuel accumulation model.

3. Based on case studies of wildfires that encountered areas which were previously treated with PB.

Preliminary and final results are available, respectively for the approaches a), and b12) and b13).

a) Fire behavior observation in two differently aged fuel-complexes. Some of the new experimental burns were carried in a stand with both untreated areas (fuel age=25 years) and areas that were prescribed burnt 10 years ago. Preliminary data analysis shows that fuel age did not influence rate of fire spread, but had a statistically significant (and positive) effect on flame length and trunk char height. The results show that the beneficial effects of PB in reducing fuel hazard are still visible 10 years after the operation. Further and more in-depth conclusions will be drawn after finishing the fuel sampling and burning program.

b12) Comparison of PB with other fuel management techniques. Three different fuel treatments at three locations of Serra do Marão (Northern Portugal) were applied to *Pinus pinaster* and *Pinus nigra* stands with low but dense shrub understory: PB, mechanical cutting without residues removal, and herbicide spraying. Because the former two treatments modify fuels instead of removing them, they could be economically interesting alternatives to PB.

Wildfire potential under typical summer weather exceeded the initial scenario after the mechanical and chemical treatments were applied, as a consequence of residues curing. In contrast, fireline intensity was reduced in 89-98% by PB, making wildfire suppression possible by means of direct attack with hand tools.

b13) Simulation of fire behavior after PB in maritime pine stands. The data base of management burns conducted by the Portuguese Forest Service in maritime pine stands provided a good opportunity to simulate the immediate effect of the technique in the reduction of wildfire hazard.

The number of PB forms which simultaneously contained data on pre-burn and post-burn fuels reached 215. The “typical” surface fuel reduction achieved by a PB results in almost total consumption of litter (L layer) and shrub foliage. Potential fire behavior that results from the average fuel reduction shows a fireline intensity reduction of 98% when compared to the pre-

burn situation, and would be easily controlled by minimally equipped suppression forces. Nevertheless, the estimates are considered optimistic, because they assume that the entire area was effectively treated and they do not account for needle fall after the burn.

Economical analysis of prescribed burning

Considering that economical questions cannot be properly addressed with experiments at the plot level, the teams are using management burns or experimental burns conducted at the management scale.

PB costs were retrieved from 413 PB Forest Service forms, concerning both forest stands and shrubland in Portugal. Average cost per burn (labor plus drip torch fuel) is approximately 229 Euro ha^{-1}. However, assuming that prescribed fires smaller than 0.5 ha are not meaningful from the management point of view, and excluding them from the analysis, the mean cost drops to 76 Euro ha^{-1}.

As treated areas become larger, PB unitary costs tend to decrease, and it was found that the cost of a management burn per unit of area can be related to the size of the burn through a power function with a negative exponent. Other variables had a significant effect, and PB costs increase with increasing flame height and rate of spread, when wind conditions are not steady, and at higher elevations. It is likely that more severe fire behavior requires more field personnel to complete a safe burn, but also that the willingness to take risks increases when more workers are available in a burn, thus allowing for higher fire behavior levels. The presence of elevation in the model is probably a consequence of its correlation with relative humidity and air temperature.

Calculated costs for slash burns in Catalonia are near 95 Euro ha^{-1} if 10 ha are burned in 8 hours. Like in the Portuguese case, higher burned acreage during the same amount of time will lead to lower unitary costs.

ANALYSIS OF ENVIRONMENTAL EFFECTS ASSOCIATED WITH EXTENSIVE MANAGEMENT USE

Task 5 intends to analyze environmental effects associated with the extensive use of PB, including the study of ecological effects poorly addressed, or not addressed at all, by previous research. This task comprises effects of repeated PB on soil, effects on tree mortality and regeneration, effects on fauna, and effects on landscape structure.

Given the nature of this task only a few preliminary results are available. In *Pinus pinaster* stands of NW Portugal, the effect of PB on bird densities seems to be closely related to the structure of understory vegetation. E.g., the passerine *Sylvia undata* disappears in the first two years after PB. Other species, such as *Parus ater*, depend of the tree canopy and are not affected by the burn.

In *Cytisus purgans* shrubland of France, it was found that postburn modifications in bird communities consist more in changes in the proportions of the dominant bird species than in drastic changes of the breeding avifauna composition.

A demographic analysis of the small mammal *Apodemus sylvaticus* populations in Mediterranean-type shrubland of France indicates that PB did not result in a significant increase of the mortality rate. A slight decrease seemed to occur six months after the fire, but was compensated four months later. Both variations did not exceed the variation interval of the "normal" mortality rate.

Burning seems to have a negative, and relatively long-lasting, impact on the Orthoptera insects.

INFORMATION STORAGE AND PRESCRIBED BURNING DECISION SUPPORT SYSTEM

The objectives of Task 7 are to design and build a prescribed burning Decision Support System, establish the approach that will enable its progressive validation, and deliver functional releases. It comprises two subtasks, 7.1 to improve the existing French database BDSYSTEM and propose the specification for a European network of data bases, and 7.2., dedicated to the development of decision support functions and their distribution to the users.

Data storage

The French database BDSYSTEM - developed before FIRE TORCH - has been designed according to the information included in the PB forms. The database is a management tool regularly distributed to managers and taught to future French PB bosses, but can also be used for scientific purposes. In the frame of the project, BDSYSTEM undergone a first set of improvements during this 1st year:

- Improvement of some headings of the input forms. Addition of some warning boxes to assist and homogenize data input.
- Improvement of the "cost" computing process.
- Improvement of the management of different units for weather data input and storage.
- Improvement of the management of burns occurring on several days.
- Improvement of the management of growing seasons: a new growing season begins on July 1st.
- A set of automatic requests was implemented to offer the "Summary of a burning season" which contains a complete multi-criteria annual evaluation of burning campaign, and presents economical statistics.
- The initial application implemented in Access" 2.0 was upgraded in 1998 to Access" 97.

Other possible improvements of the French database have been identified as a result of visits to management teams, and will be taken into account for the 2nd year of the project.

An English demo of the French PB database BDSYSTEM has been developed and can be downloaded from the FIRE TORCH page at http://www.cindy.cma.fr/europe/firetorch/BDSys_gb.html.

In the frame of FIRE TORCH, a database containing management burns in maritime pine stands of NW Portugal has been established and analyzed. Different countries have separately analyzed the PB information collected with Regional PB forms but no common analysis has been attempted. During the 2nd year of the project the specifications of a European network of Regional databases will be defined, to enable compatibility across countries and regions, and thus, data analysis on PB at the European scale. The conceptual model of data of BDSYSTEM has been distributed to Spanish and Portuguese partners for them to better understand the way data are organized.

The Training and Decision Support System (TDSS)

Basic information for building the TDSS comes from the French database BDSYSTEM, scientific and technical literature on PB, the PB field guide, and expert interviews. The Unified Modeling Language (UML) has been chosen to formalize knowledge on PB.

UML is a language for specifying, visualizing, constructing, and documenting software systems. It unifies three popular modeling languages and makes use of many aspects of object-oriented programming. Fundamentally, the UML is concerned with capturing, communicating, and levering knowledge.

Two new modules that address sensitive issues, the "constraints" and "smoke" modules, were added to the four modules that initially were planned to be developed (traps, PB effects, ignition, technical and economical evaluation).

Six expert interviews directed towards the traps and constraints modules have been accomplished with PB specialists. Experience and knowledge were collected on these subjects and were completed with the data available in BDSYSTEM.

A prototype of the technical and economical evaluation of a PB campaign for a given team was developed and is now available as an additional functionality of BDSYSTEM. The second part of this module is about the global evaluation of a burning season for a whole European Region and has still to be developed.

CONCLUSION

Few conclusions can be drawn at this stage of the project, especially in what concerns the attainment of objectives pertaining to tasks that depend of experimental burns.

There is a general awareness of PB potentialities for forest management, mainly as a tool to reduce fuel hazard, and issues of technical nature dominate the motives that are viewed as obstacles to the technique development. However, the ecological role of fire is poorly perceived by the addressees.

The partners have selected similar sets of important parameters to appraise in the context of PB planning, execution and evaluation, with only minor compatibility problems. Nevertheless, significant improvements in the process of data standardization through the integration of user feedback are precluded by the current stage of prescribed fire development in Portugal and Spain.

The new experimental burns are being conducted at different spatial scales, and cover a wide variety of

vegetation types and potential burn objectives, thus reflecting the diversity of situations that are possible in PB management.

The efficiency of prescribed burning to reduce potential fire behavior was confirmed by both simulation and experimentation at the plot/stand level. However, it is likely that minimization of wildfire acreage and achievement of cost-effectiveness will strongly depend on the technique scale and pattern of application.

ACKNOWLEDGEMENT

The FIRE TORCH project ("Prescribed Burning as a Tool for the Mediterranean Region. a Management Approach") is being funded by the Environment and Climate program of the European Commission under contract ENV4-CT98-0715.

REFERENCES

Hetier, M. J. (1993). Les incendies de forêts en Europe du Sud: évolution du phénomène et enjeux environmentaux. In: *Forest Fires in Southern Europe: Overview of the EC Actions: Towards an International Cooperation?*. STOA - Environment Programme. The European Parliament. pp. 25-30.

Rigolot, E., Gaulier, A., Vauché, D., and Guarnieri, F. (1996). Toward a prescribed burning decision support system for the French Mediterranean region. To appear In: *Proc. 13th Conference on Fire and Forest Meteorology: International perspectives on landscape fire*, October 27-31, 1996, Lorne, Australia.