FIRE PARADOX: An innovative Approach of Integrated Wildland Fire Management – A joint European initiative

Rego F. [1], Alexandrian D. [2], Fernandes P. [3], Rigolot E. [4]

Abstract

FIRE PARADOX is a European integrated project on fire management, coordinated by Instituto Superior de Agronomia, Universidade Técnica de Lisboa, Portugal with a duration of 48 months (March 2006 - February 2010). The FIRE PARADOX consortium and its extension in the frame of specific measures in support of International Cooperation (INCO) includes 35 partners from 11 European countries plus 6 non-European countries

The main goal of FIRE PARADOX is to set the basis for new fire management policies and practices in Europe in order to prevent the current disastrous social, economic and environmental consequences of wildfires in the Mediterranean Basin. The ambition of the project participants is to contribute through their research to develop tangible, operational contributions to reduce the impacts of large-scale or high-severity forest fires such as those that occurred in Portugal, Spain and France in 2003 and 2005.

FIRE PARADOX uses a sequential and comprehensive approach and is structured around 4 integrative axes: ignition, prescribed burning, propagation and suppression fire. The domains of research, development and dissemination are integrated through the above four aspects of fire.

Fire is a highly destructive disturbance but can also be a powerful management tool. The FIRE PARADOX approach is innovative: the regulation of the wildfire problem is based on the wise use of fire, which should be a key component of fire management. Wildfire hazard reduction and the sustainable development of natural and managed ecosystems in Europe require the use of fire (prescribed burning and suppression fire), as well as a strong effort put in the transfer of knowledge and technology.

FIRE PARADOX expected benefits include the increased cooperation between European researchers, enhanced exchanges and increased integration for the forest and fire professionals using fire wisely, and a better awareness and preparation and safer behaviour of citizens. Finally, the FIRE PARADOX project will have an impact on policy making and initiative in regards to integrated wildland fire management

[1] Instituto Superior de Agronomia, Centro de Ecologia Aplicada Prof. Baeta Neves (ISA-CEABN), Tapada da Ajuda, P-1349-017 Lisboa, Portugal. +351.213.61.60.85. frego@isa.utl.pt

[2] MTDA, 298 avenue du Club hippique, F-13090 Aix-en-Provence, France, +33.442.20.12.57 daniel.alexandrian@mtda.fr

[3] Universidade de Tras-os-Montes e Alto Douro, CEGE / Departamento Florestal, Quinta de Prados, Apartado 1013, P-5001-801 Vila Real, Portugal. +351.259.35.08.85, pfern@utad.pt

[4] Institut National de la Recherche Agronomique (INRA), UR629, Site Agroparc, Domaine Saint Paul, F-84914 Avignon cedex 9. +33.432.72.29.21, rigolot@avignon.inra.fr

Introduction

It is well established in Europe that humans have been using fire for many thousands of years to regulate natural ecosystems and land-use systems, but it is also well known that its misuse or its complete exclusion may result in catastrophic wildfires. Forest fires are the most important damaging factor in the Mediterranean countries where between 300 000 to 500 000 ha of forests and other wooded land are burnt per year. Forest fires were particularly virulent during summer 2003 when the forests were exposed to very hot and dry climatic conditions. For instance, in Portugal, about 400 000 ha were destroyed by fire.

During the worst events of this severe fire season, regular fire fighting means were unable to control the situation. Very well equipped European Regions like in South Eastern France were facing extraordinary difficult situations even if thousands of fire fighters and extensive use of ground and aerial up to date equipments were involved. During the 2003 fire season, citizens and fire fighters died (5 in France, 15 in Portugal) and hundred of buildings, cars and other resources were destroyed. The limits of the current strategies have been encountered.

Therefore, the reduction of wildfire hazard and the sustainable development of natural and managed ecosystems in Europe require new practices in wildland fire management, such as prescribed burning and suppression fire, in conjunction with increasing public and political awareness through knowledge and technology transfers.

This fire paradox can be observed in all continents, but in Europe (some years later than in North America), it also becomes apparent that land use change, together with efficient fire exclusion, can have the paradoxical effect of an increase of large wildfires risk with an increase of the non-utilized plant biomass. In addition, "let burn" policies cannot take place in Europe, because in the more fire-prone areas, wildlands are in general too much inhabited.

In this context, a new international and interdisciplinary forest fire research programme FIRE PARADOX granted by the European Commission has been launched in March 2006 for four years. This pan-European research programme is untitled “FIRE PARADOX - An Innovative Approach of Integrated Wildland Fire Management Regulating the Wildfire Problem by the Wise Use of Fire: Solving the Fire Paradox”. FIRE PARADOX partners have the ambition to actively contribute to set the bases for fire management policies that would prevent wildfires of catastrophic sizes and having social, economical and ecological consequences, like those that occurred in Portugal, Spain and France in 2003 and 2005.

Project partnerships

FIRE PARADOX is a European integrated project on fire management, coordinated by Instituto Superior de Agronomia, Universidade Técnica de Lisboa, Portugal. The FIRE PARADOX consortium and its extension in the frame of specific measures in support of International Cooperation (INCO) include 35 partners from 11 European countries plus 6 non-European countries. The FIRE PARADOX extension, FIRE PARADOX TTC started in March 2007 with a duration of 3 years. Partnership includes various types of entities necessary to ensure integration like universities and forestry schools, research institutes, fire management agencies, international networks, associations or SMEs. Partners listed by countries are the following:

- Finland: VTT, Technical Research Centre of Finland, Espoo

- France: Agence MTDA, Aix-en-Provence; EM, Espaces Méditerranéens, Fox-Amphoux; CEMAGREF, Centre National du Machinisme Agricole, du Génie Rural des Eaux et des Forêts, Aix-en-Provence; UAM2, Université de la Méditerranée, Aix-Marseille II; INRA-URFM-PIF, Institut National de la Recherche Agronomique, Avignon
- Germany: GFMC, Fire Ecology Research Group / Global Fire Monitoring Center, Max Planck Institute for Chemistry, Freiburg University, Freiburg
- Greece: AUTH, University of Thessaloniki, Thessaloniki; MAICh, Mediterranean Agronomic Institute of Chania, Chania, OMIKRON – Environmental Engineering and Technical works design, study, management Ltd, Thessaloniki
- Italy: CFVA, Corpo Forestale e di Vigilanza Ambientale delle Regione Autonoma della Sardegna, Cagliari; ARBOPAVE-UNINA, Dipartimento di Arboricoltura, Botanica e Patologia Vegetale – Università degli Studi di Napoli Federico II, Portici
- Morocco: ENFI, Ecole Nationale Forestière d'Ingénieurs, Salé
- Poland: FRI-FFPL, Forest Research Institute, Warsaw
- Portugal: UTAD-DF, Universidade de Trás-os-Montes e Alto Douro, Vila Real; IST-DEM, Instituto Superior Técnico, Lisboa; ISA-CEABN, Instituto Superior de Agronomia, Lisboa
- Slovenia: SFI, Slovenian Forestry Institute, Ljubljana
- Spain: DGESC-GRAF, Generalitat de Catalunya – Departament d´Interior – Departament General d´Émergencies i Seguretat Civil – Grup de Recolzament d´Actuacions Forestals, Tivissa; INIACIFOR, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Madrid; UC3M, Universidad Carlos III de Madrid, Madrid; UL-UFF, Universidad de Lleida, Lleida; UCM-GIPSF, Universidad Complutense de Madrid – Grupo de Investigación Politica y Socioeconomia Forestal, Madrid; CTFC, Centre Tecnologic Forestal de Catalunya, Solsona; XG-CIFAL, Centro de Investigaciones Forestales y Ambientales de Lourizán – Centro de Desenvolvemento Sostenible, Consellería de Medio Ambiente, Xunta de Galicia –, Pontevedra
- Switzerland: UZH, University of Zurich Univers, Zurich;WSL, Swiss Federal Institute for Forest, Snow and Landscape Research, Bellinzona
- Tunisia: INRGREF, National Institute of Research in Rural Engineering, Water and Forest, Ariana
- United-Kingdom: UBRIS, University of Bristol, Bristol; UEDIN, The University of Edinburgh,
- International: EFI, European Forest Institute, Joensuu, Finland.

Members of the FIRE PARADOX - TTC Consortium include:

- Portugal: ISA/CEABN, Instituto Superior de Agronomia, Lisboa

- Argentina: CIEFAP, Centro de Investigación y Extensión Forestal Andino Patagónico, Esquel; INTA, Instituto Nacional de Tecnología Agropecuaria, Buenos Aires
- South-Africa: SFS, Silva Forest Services, Sedgefield
- Russia and Mongolia: PFF, Pacific Forest Forum, Khabarovsk

Project structure for integration

The overall objective of this project, the creation of the Scientific and Technological bases for new practices and policies under Integrated Wildland Fire Management in Europe recommends an approach where the various complementary aspects of fire management are considered.

In fact integrated fire management has been defined as "technical and also a socio-cultural and political challenge that requires an effective network of willing partners, and appropriate fire management functions and processes to effectively find the appropriate balance between developing and conserving natural resources and managing unwanted fires".

Solving the Fire Paradox thus means improved knowledge of fire behaviour and effects in order to counter balance its negative impacts by promoting the sound use of fire itself. Our approach based on integration of the various aspects of fire will enable to change the way fire is considered at the different levels of the European societies and to shift the way it is managed by the relevant services and organisations.

This need for this type of integrated approach for wildland fire management has been recognized by many agencies around the world, such as the USA National Parks and Wildlife Service, that includes in the "full spectrum of fire related activities" the use of "prescribed fire and other mitigation activities" and the preparedness measures to ensure "an appropriate response" to unplanned fire, as in suppression fires. This is also the concept used in this Work-programme where integrated wildland fire management also aims at preventing and mitigating the negative impacts of wildfires by developing strategies for pre-disaster planning and mitigation of effects with a long term perspective.

Ultimately FAO have formulated and reviewed through a multi-stakeholder process a Fire Management Voluntary Guidelines which set out a framework of priority principles that will aid in the formulation of policy, legal, regulatory and other enabling conditions and strategic actions for more holistic approaches to fire management (FAO 2007). Their scope includes the positive and negative social, cultural, environmental and economic impacts of natural and planned fires in forests, woodlands, rangelands, grasslands, agricultural and rural-urban landscapes.

Therefore, in order to achieve such objectives, integrated fire management has to consider simultaneously four aspects of fire such as:

a. the use of (i) prescribed burning to mitigate potential wildfire impacts,

b. the assessment of risk, vulnerability and hazard of wildfires, from (ii) initiation to (iii) propagation, and

c. the preparation for the use of (iv) suppression fires in fire-fighting.

The benefits of using the concept of Integrated Wildland Fire Management are clear in setting the management limits for wildfire. The spatial extent and intensity of

wildfires can thus be limited by prescribed burning (that reduces fuels in strategically located situations before wildfire) or by suppression fires (that are used as a tool during fire-fighting). t is concluded that the concept of Integrated Wildland Fire Management, based on the scientific and technical understanding of the underlying processes and mechanisms, allows for a significant influence on forest and fire related policies at the European scale.

Therefore, in order to enhance the potential impacts and the optimal use of the results of this project on fire and forest policies at the European scale, a special approach was adopted in the Work-Programme of the Project, by considering the integration of major domains, as research, technological development and innovation, demonstration, training and management activities. These domains are basically linked to the overall structure of the project, organised by modules and work packages.

As already mentioned the concept of "integrated wildland fire management" has to address a wide variety of fire aspects and with the proposed approach it also includes a complementary set of scientific, technical and organisational skills and capacities. Thus, this multi-disciplinary approach requires a strong effort for integrating the work done by the various teams involved.

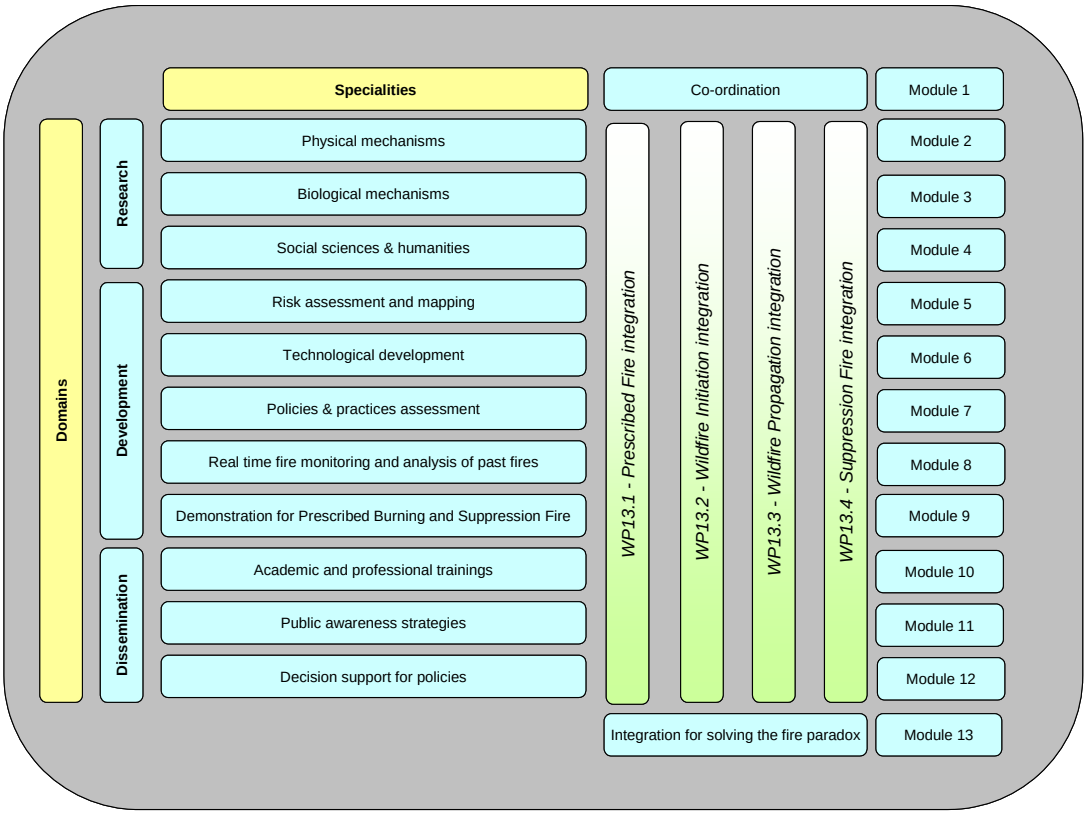

Figure 1— Fire Paradox matrix presenting the project structure

In order to ensure that the integration is fully achieved, we propose two dimensions of integration: one that ensures the coherence of the work done at the three domains (Research, Development, Dissemination), that we will refer to as the horizontal integration, and the other that ensures the achievement of the objectives for each aspect of fire (prescribed fire, fire initiation, wildfire, suppression fire), that we will refer to as the vertical integration (Figure1). On the whole, the FIRE

PARADOX project is structured into thirteen interrelated modules. Twelve modules deal with the horizontal or disciplinary integration and Module 13 ensures the vertical integration.

Contributions to the four aspects of fire

In order to address this objective in a coherent way, this project is completely focused on the fire paradoxes, from its negative impacts to its positive effects, from wildfires to management fires (Prescribed and Suppression Fires).

This approach, based on the development of the Integrated Wildland Fire Management concept, is thus considering fire in its more relevant aspects, corresponding to four sequential phases from its use in prevention to its use in fire fighting. The consideration of all these aspects of fire ensures integration, coherence, and a comprehensive view of the problem, and is the basis for quality and usefulness of the expected results.

The four different aspects of fire considered in the proposal are Prescribed Burning, Wildfire Initiation, Wildfire Propagation and Suppression Fire:

Prescribed burning

This technique represents a “controlled application of fire to vegetation in either their natural or modified states, under specified environmental conditions, which allow the fire to be confined to a predetermined area and, at the same time, to provide the intensity of heat and rate of spread, which are required to attain planned resource management objectives” (FAO 1986)

Prescribed burning has been already studied and developed in some European countries, but still requires additional research in some scientific areas, as in sociology, and adequate cooperation for professional training with demonstration facilities adapted to each country/region.

Additional research is also being implemented to provide scientific and technical backgrounds for prescribed burning, based on experiments and modelling efforts to simulate prescribed fire behaviour and effects.

Effectiveness of prescribed burning for limiting the intensity and spatial extent of wildfires depends extremely on its periodicity. Therefore, a special emphasis is placed in understanding the biological mechanisms of fuel dynamics. This will enable to determine fire behaviour and severity as a function of fuel accumulation with time and, consequently, adequate fire regimes.

Long-term effects of prescribed burning on fire risk under present and future climate conditions at the European level is being investigated by integrating the knowledge gained for particular case studies into the Dynamic Global Vegetation Model and related modelling exercises.

Wildland fire initiation

Wildfire is here defined as “any unplanned and uncontrolled wildland fire, which regardless of ignition source may require suppression response, or other action according to agency policy” (FAO 1986). And this first phase of wildfire, from ignition to first attack, is of extreme importance in preparedness and response policies based on early detection and suppression.

Because, in the Mediterranean regions, lightning fires are rare, the classical wildfires prediction models developed in Canada, United States, South Africa,

Australia and Russia and based on climatologic parameters are not efficient. These models predict, in fact, the forest fuel flammability and not the wildfire ignition.

FIRE PARADOX is currently analysing the effectiveness of diverse ignition procedures, which are all related to human activities: accidents, agriculture or forest works, equipments (power lines or train brakes), arsonists, pyromania, local conflicts.

Existing standard tests for flammability of materials have been adapted to forest fuel samples to study the basic mechanisms of their ignition and to determine the products and the energy released by their combustion. The most representative wildland fuels of both Mediterranean and Boreal ecosystems have been selected and tested using these adapted methods, to create a reference database of flammability and combustion properties of forest fuels. Such a database was not available so far. Fuel bed ignition by flaming firebrands, sparkles, cigarettes, open flames, are also being studied experimentally in particular to account for the random aspect of the process of ignition by contact.

Fuel moisture content is a key-parameter of all these studies, according to its important role in the ignition mechanism. From a scientific point of view, all these experimental data are used to improve the physics in the modelling of fire behaviour and effects, which in turn helps the study of wildfire initiation among other aspects of fire (prescribed burning feasibility). From an applied point of view, these reference data on fuel flammability is an important input of dynamic maps of ignition risk.

The same approach for understanding the mechanisms of ignition is being used to assess the settlements and structures vulnerability to firebrands, including the characteristics of the firebrands and of the materials exposed in the houses. This is an important and innovative contribution of this IP for reducing fire problems at the wildland-urban interfaces.

The spatial distribution of ignition points can be predicted by understanding the human (and natural) causes associated with them. An historical insight is being addressed to assess the temporal component as a result of land use changes and associated changes in fire use, detection and fighting practices. This feature of wildfire initiation is being considered, and methodological developments are being made on how to consider available local information in the generation of risk assessment and mapping.

Wildland fire propagation

In this aspect of fire a special emphasis is being given to large wildfires and in areas that only recently started to be studied in Europe, namely the spread by firebrands or the threat to structures and other values at risk.

A key-task of research is to develop and improve a 3D physically based fire model and to make its computer simulation more efficient in order to prepare a new generation of operational tools based on sound physics. Indeed the fast development of computer resources makes possible in a near future the objective of running such models of fires at a landscape scale (a few kilometres).

Models are being validated with fire experiments conducted in various natural conditions and by intensively using observations during wildfires monitoring.

Well-documented fires enabling accurate comparisons with model predictions are quite rare. Therefore, we are carrying out specific efforts to collect a complete

characterization of fire spread over the terrain through the use of both video and IR imaging systems from ground observations but also aerial means.

This information will enable an improvement of the SALTUS spotting probabilistic model, by analysing all the cases where spot fires will occur (fuel, wind, topography…) in order to better estimate the possible spotting distances.

A technological platform developed in the project is assembling the different models here above described to run simulations that are of extreme importance for the dissemination of the project.

The physically based fire model predicts the radiative heat flux and the thermal conditions at any point of the simulated domain and at any time. This output will be used in the second part of FIRE PARADOX as input of other existing software (Fire Dynamic Simulator from the NIST) and simplified models to assess the threats to houses structures and people at the wildland-urban interface.

Suppression Fire

This is an “intentional application of fire to speed up or strengthen fire suppression action on wildfires; types of suppression firing include burning out, backfiring, line firing, counter firing, and strip burning” (FAO 1986).

This technique to stop wildfire propagation is not sufficiently used in Europe, requiring research and cooperation and using practical know-how scattered throughout southern Europe. Also, cooperation with regions where this technique is widely used is being promoted and included in the planning of the proposed professional training.

The knowledge about the mechanisms associated with the behaviour of suppression fires is still at a very initial stage. Therefore, we are following two independent but complementary approaches in the framework of FIRE PARADOX:

The first approach, based on the development of the 3D physically based fire model, will provide a theoretical frame and a computational tool to understand the physical mechanisms associated with the process of two interacting fire fronts, the running wildfire and the suppression fire. Numerical studies of such interacting fires using the 3D-model will be conducted in the coming months.

The second approach, based on collecting and complementing existing observations, images, experiments and databases related to the practical use of suppression fires.

These two approaches will enable analysis of existing examples by understanding the effects of topography, wind, and fuels using the developed technological platform.

The collection, organisation and interpretation of existing information on the practical use of suppression fires will enable to evaluate the costs of this technique and the physical, biological and human factors involved.

The understanding of the reduction of damages by the use of suppression fire will allow a cost-benefit analysis for assessing and mapping potential and limits of the use of suppression fires.

Also the use of suppression fires based on areas treated by prescribed fire or other fuel reduction techniques are being analysed within the concept of "integrated forest fire management".

Human factors involved in the use of suppression fire call for the comprehension of the perceptions of the public in general, professionals and policy-makers on the use of this technique (similarly with prescribed fire). Therefore, an important component of this analysis is to evaluate the current practices and limitations of fire use in the different regions (see Montiel *et al.* 2007 in this conference).

In the objective of convincing stake holders of the strategic interest of promoting the use of fire as a tool, the FIRE PARADOX project is undertaking the ambitious task of setting a network of prescribed fire demonstration sites covering ecosystems from subtropical Canary Islands to Northern boreal Europe (see Molina and others 2007 in this conference).

A balanced contribution to the 3 domains: Research, development and dissemination

Under the main objectives of the project, specific modules are defined within the various domains of activity: Scientific/Research, Technological/Development and Implementation/Dissemination items. These domains organize disciplines and competencies in the overall structure of the project.

Scientific / Research domain

Physical mechanisms

The overall objective of Module 2 is to provide the project, (i) with a clear understanding of physical mechanisms of both fire behaviour and effects, and (ii) with methods and tools allowing the prediction of these phenomena in various conditions (Pimont and others 2006). A main goal is to develop a 3D fire behaviour and effects model based on a sound representation of the physics of fires. Both computational and experimental approaches are being used to achieve this objective. Experiments serves the improvement of physics (laboratory studies) or the validation of the model (mainly field fires). The new model will then contribute to solve the FIRE PARADOX through its predictions of the interaction between fire lines, the interaction between a fire and targets, as in the wildland-urban interface, or the immediate impacts of fire on the components of the ecosystems.

Biological mechanisms

The overall objective of Module 3 is to provide the project with a deep knowledge of the biological mechanisms involved in the various aspects of fire, covering different spatial scales (from research on ignition and flammability of fuel particles to the use of remote sensing at the landscape level) and diverse temporal scales (from hourly and daily variation of fuel moisture to yearly accumulation of fuels after prescribed burning) (Brewer and others 2007). Main innovative objectives of FIRE PARADOX in the frame of biological mechanisms of fire are being in the development of: (i) a prediction of ignition and fuel flammability and temporal variation of fuel moisture (Curt and others 2007 and Jappiot and others 2007 in this conference), (ii) models simulating the limits of resistance of individual trees to assess the vulnerability of forest stands to different fire regimes, (iii) a physically and biologically based model to understand the mechanisms of temporal variation of fuel accumulations and of living and dead fuel moistures based on experimental evidence for establishing the relationships under climatic change conditions, (iv) a fuel typology, characterization and modelling using namely remote sensing (Koetz and others 2007).

In addition, FIRE PARADOX extension will study the relationships between fire and grazing in regions of South Africa and Argentina where savanna is forming a significant natural vegetation cover. Understanding these relationships will contribute to streamlining prescribed burning fire regimes in these areas, such as the rotation and season of burn.

Social sciences and humanities

In FIRE PARADOX a significant effort is being made to assess the socio-economic impacts of forest fires, including the direct economical effects and the overall social value. These objectives are being achieved by using a range of different techniques by market values, non-market valuation models and choice modelling approaches. All the outputs of the economical and social impacts are also being integrated in the risk, vulnerability and hazard assessment and mapping.

Another effort is being developed for integrating the effects of land use changes induced all over Europe but mainly in the Northern Europe new member states, and potentially related to the new agriculture policy. Less valuable areas may be abandoned, progressively invaded by flammable shrub species, which will create new high risk zones next to forested areas.

Studies in fire anthropology are identifying and characterizing traditional use and knowledge of fire to avoid losing them, and identifying the conditions for a technical and social remediation of fire (especially prescribed burning and suppression fire). The objective is to break resisting behaviors and conceptions and to identify the potentialities of European cultures as to their use of fire in natural areas.

The main objectives of FIRE PARADOX in the social sciences domain can be defined as exploring and modelling the different socio-economic factors influencing the occurrence and spreading of forest fires and applied fire management measures.

Technological / Development domain

Risk assessment and mapping

The overall objective of this module is to improve the special accuracy of risk maps in its two components that are hazard and vulnerability, considering at the same time all the aspects of the fires; wildfire initiation, wildfire propagation, as well as prescribed burning and suppression fire.

The aspects of fire risk in the specific wildland urban interface are also considered (Galiana and others 2006, 2007 ; Lampin and others 2007a, 2007b in this conference). Impact of fire management on risk level is assessed in order to consider the benefits of prescribed burning in prevention (Loureiro and others 2006).

To assist end-users, such as land managers, in understanding the possible use of management fires, a GIS is being produced to help them in mapping areas where prescribed burning and suppression fires could be extensively considered.

Technological development

In FIRE PARADOX a European fuel and fire effects visualization system is being developed to facilitate fuel complex representation and use as entry of the physical based fire model. A new technological platform is also being developed using a complete spatial fire growth tool based on the full physical model created within the project to be used instead of the semi-empirical models available. The technological platform developed will then allow for integrating all spatial and

temporal mechanisms, scales and models resulting from research and experiments including the assessment of hazard, vulnerability and risk. We will use this platform as a dissemination tool in academic and professional training, and as a decision-support system for land managers (in particular at the wildland-urban interface) and policy-makers.

The objectives of this module is also to improve existing models and systems: (i) SALTUS, a probabilistic model on fire spotting, (ii) GAMMA-EC, a MultiMedia courseware on real cases analysis, (iii) WasP, a grid based model for predicting the distribution of wind speed and direction over a landscape, (iv) FIRE COST, a computer software programs estimating economic losses from wildfires. Moreover a technological tool for supporting prevention and fire-fighting activities is being developed.

Policies and practices assessment

In this project a complete evaluation of regulation, policies and practices on the use of fire as a management tool is being extended both thematically and geographically with the ambition, when necessary, of formulating proposals for new policies and for enhancing best practices (see Aguilar and others 2007, Lazaro and others 2007 and Montiel and others 2007 in this conference). The overall objective is to set the bases for new legislation and long-term policy measures for an integrated wildland fire management adapted to the European context.

Moreover, the existing detection systems effectiveness is being analysed (Lafarge, 2006 ; see Catry and others 2007 in this conference).

In order to analyse the potential of prescribed burning and suppression fires in the context of the Kyoto Protocol the amount of emissions in CO2 equivalents by wildfires, by prescribed burning and suppression fires has been reviewed, as well as the amount of emission in CO2 equivalents.

Real time fire monitoring and analysis of past fires

Real time fire monitoring and analysis of past fires in FIRE PARADOX is a forum that shares the full resources of the consortium. There is a search, collection and organisation of the information and of the experiences on the 4 components of fire: prescribed burning, wildfire initiation, propagation and suppression. The overall objectives of this module are in the creation of the human and logistic conditions required for the collection of field data on wildfires and to analyse and organise that information on the fires monitored during the project and on past fires.

The specific objectives of this module are (i) to create a joint summer research base for the FIRE PARADOX consortium being also a welcoming and exchange European pole on forest wildfires, (ii) to monitor wildfire with a transdisciplinary approach, by assessing aircrafts and aerial observation and imagery devices, including the infrared imagery analysis method.

Demonstration

FIRE PARADOX is setting up a net of demonstration sites, showing both positive effects and negative impacts of prescribed burning, producing a set of didactic materials for interpretation. A very innovative approach taken in this project is the active aerial observation of wildfires, suppression fires and prescribed fires in order to feed the documentation and demonstration platform that will collect all available documentation on practices and experiences related with the various aspects

of integrated wildland fire management (see Molina and others 2007 in this conference).

Implementation / Dissemination domain

Academic and professional training

FIRE PARADOX is developing strategies for implementing academic and professional training programs and tools on the innovative concepts and practices under "integrated wildland fire management". Production of educational and training materials is considered as an essential component of this project. An innovative aspect in the proposed training component is in the extensive use of the interacting capabilities of the technological platform using the dynamic 3D models developed. Resources organised in training modules is being integrated in accreditation or academic degrees making a full use of existing networks, experiences and facilities provided by participants as in MAICh (under the CIHEAM network) or UNIVEMED-AVICENNE (under the auspices of UNESCO).

FIRE PARADOX is currently working towards the unification of the professional training system for fire managers and the recognition of levels of expertise. The objective is to introduce logical fire analysis to fire managers, and to improve knowledge transference between professionals by creating the opportunities of accumulating and transferring knowledge and experience, both in prescribed burning and in managing large fast intense fires (Graf 2007c in this conference).

Public awareness strategies

The general objective in this domain is an appraisal of the current strategies for communication and public awareness in the various aspects of integrated wildland fire management at the European scale. In that respect, the relevant sources of communication on forest fires and natural disasters in Europe have been reviewed.

The next step will be to define and propose communication strategies for recommendation in the field of forest fires and more specifically concerning prescribed burning and suppression fire.

Decision support for policy makers

The general objective of Module 12 is to serve as a catalyst for FIRE PARADOX with regards to the production of both task specific and strategic level information products. It will provide both the project and target groups' access to data/information through its information management platform and various other means of information dissemination i.e. guidelines and publications.

The central output of Module 12 will be a comprehensive synthesis report, of the FIRE PARADOX activities. The FIRE PARADOX "white book" is intended to serve as input for high level policy discussions on the integrated fire management. The information management platform will support the white book by allowing users easy access to the manifold results and outputs of the FIRE PARADOX project.

Integration for solving the Fire Paradox

FIRE PARADOX is a quite ambitious IP, which covers the three types of activities Research, Development and Dissemination.

In particular, dissemination activities occupy a much larger part of human and financial resources than previous R&D projects dedicated to wildland fire domain.

FIRE PARADOX consortium has a real will to integrate the scientific and technological achievements in the following domains: (i) professional practices and courses delivered at specialised universities and forestry schools, (ii) technical guidelines for wildland areas managers and operational practices for fire-fighters, (iii) stakeholders' decisions and, (iv) regulations produced at regional, national and European levels.

Therefore, FIRE PARADOX internal organisation has been elaborated for fostering the exchanges and linkages among modules and work packages.

In order to rationalise these exchanges, four aspects of fire have been selected to organise the transfers of knowledge, know-how and information within well identified sectors: Prescribed Burning, Wildfire Initiation, Wildfire Propagation and Suppression Fire (see Graf 2007a, 2007d, Molina and others 2007a and 2007b in this conference).

The overall objectives of the integration activities are to provide added values to each specific sectors: by promoting the continuous dialogue between scientists, technicians, developers and end-users, by including the end-users demands in the scientific and technical approaches, and by organising the assessment of the scientific and technical achievements and the demonstration of the designed prototypes.

Conclusions

Several benefits can be expected from the FIRE PARADOX project.

The project consortium is willing to be opened to all the scientific community at the European and International level in the perspective of increased cooperation.

FIRE PARADOX is promoting enhanced exchanges between the research community and the forest and fire professionals and other agencies involved in fire management, in the perspective of an increased integration for a wise use of fire.

FIRE PARADOX outcomes will help citizens to learn to live with fire with a better awareness and preparation before the fire season, including home protection by mitigation actions at the WUI, and a safer behaviour in case of emergency situation to preserve lives and assets.

Stakeholders are also a target group for FIRE PARADOX. It should lead them to a new view on the issue. One measure of success in the project results will be the evolution of regulations and policies at the Regional, National and European levels towards an integrated fire management.

More information on http://www.fireparadox.org

References

Aguilar, S.; Galiana, Luis; Lázaro, A. 2007. **Analysis of wildland fire risk management from the territorial policies perspective: strenghts and weaknesses in the European regulatory framework.** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2.

Brewer, S.; Borgniet, Laurent; Alleaume, Samuel; Curt, Thomas. 2007. **Temporal and spatial structure of Fuel Moisture Content values in garrigue vegetation, South of France.** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2.

Catry, Filipe X.; Rego, Francisco C. ; Santos Teresa ; Almeida Joel ; Relvas Paulo. 2007. **Forest fires prevention in Portugal – using GIS to help improving early fire**

detection effectiveness. In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°7.

Curt, Thomas ; Ganteaume, Anne ; Alleaume, Samuel ; Borgniet, Laurent ; Jappiot, Marielle ; Lampin, Corinne ; Chandioux, Olivier. 2007. **Vegetation flammability and ignition potential at road-forest interfaces (southern France).** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2.

FAO. 1986. **Wildland Fire Management Terminology.** Food and Agriculture Organization of the United Nations, FAO Forestry Paper 70, 257 p. which revised version is built and hosted by partner No 5 (GFMC) web site http://www.fire.uni-freiburg.de/literature/glossary.htm

FAO. 2007. **Fire management: voluntary guidelines. Principles and strategic actions.** Fire Management Working Paper 17. Rome (also available at www.fao.org/forestry/site/35853/en).

Loureiro, Carlos; Fernandes, Paulo ; Botelho, Herminio; Mateus, Paulo. 2006. **A simulation-based test of a landscape fuel management project in the Marão range of northern Portugal.** In: D.X. Viegas (Ed.) 2006. V International Conference on Forest Fire Research, 27-30 Nov. 2006, Figueira da Foz, Portugal.

Galiana, Luis; Herrero, Gema; Solana, Jesus. 2006. **Forest fire risk management. Understanding the wildland-urban interface: Landscape dynamics and patterns in a Mediterranean hinterland (Sierra Calderona. Region of Valencia, Spain)**. In: Permanent European Conference for the Study of the Rural Landscape 2006 meeting (Berlin and Brandenburg, 4-9 September 2006).

Galiana, Luis; Herrero, Gema; Solana, Jesus. 2007. **Caracterización y clasificación de Interfaces Urbano-Forestales mediante análisis paisajístico.** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°5.

Graf 2007a. **El modelo de extinción de incendios forestales catalan.** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2

Graf 2007b. **El papel del fuego en la gestión del paisaje**. In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2

Graf 2007c. **Experiencias de formación continuada en Cataluña durante las campañas 2003, 2004, 2005 y 2006.** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2

Graf 2007d. **Fire types: a tool to plan and manage emergencies.** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2

Jappiot, Marielle ; Curt, Thomas ; Lampin, Corinne ; Borgniet, Laurent ; Vinet, Olivier; Louis, S.; Chandioux, Olivier; Estève, Roland. 2007. **Characteristics and Flammability of French Mediterranean Dead Litter Fuels.** International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2.

Koetz, Benjamin; Morsdorf, Felix; Curt, Thomas; van der Lindenc, S.; Borgniet, Laurent; Odermatta, D.; Alleaume, Samuel; Lampin, Corinne; Jappiot, Marielle; Allgöwer, Britta. 2007. **Fusion of imaging spectrometer and Lidar data using support vector machines for land cover classification in the context of forest fire management.** In: ISPMSRS workshop, Davos, March 2007.

Lafarge, Emilie. 2006. **Évaluation des dispositifs de détection des feux de forêt en France.** Agence MTDA - ENGREF - Fire Paradox. 91p.

Lampin, Corinne; Jappiot, Marielle; Long, Marlène; Morge, D.; Bouillon, C.; Galiana, Luis; Herrero, Gema; Solana, Jesus; Mantzavelas, Antonis; Loddo, Giorgio; Delogu, Giusepe; Brigalia, Simonetta; Dettori, Gonaria. 2007a. **Characterization and mapping of wildland-urban- interfaces: a methodology applied in the case study area in**

Sardinia. International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°5.

Lampin, Corinne; Jappiot, Marielle; Long, Marlène; Morge, D.; Bouillon, C. 2007b. **Characterization and mapping of wildland urban interfaces. Assessing forest fire risk in South of France.** 10th AGILE International Conference on Geographic Information Science Aalborg University Aalborg – Denmark May 8-11 2007

Lazaro, Andrea; Herrero, Gema; Montiel, Cristina; Molina, Domingo. 2007. **Organización de la defensa contra incendios forestales en el Estado de las Autonomías: el caso español.** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2.

Montiel, Cristina; Kraus, Daniel; Goldammer, Johann; Schuck, Andreas; Van Brusselen, Jo. 2007. 2007. **Wildland fire management in European countries: legislation and policy instruments.** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2.

Molina, Domingo; et al. 2007a. **Prescribed fire use to establish shaded fuel breaks: case studies in Gran Canaria, Spain**. In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2

Molina, Domingo; et al. 2007b. **Prescribed fire use for cost effective fuel management in Spain**. In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2

Molina, Domingo M.; Goldammer, Johann G.; Loureiro, Carlos; Castellnou, Marc; Vega, José-Antonio; Delogu, Giusepe; Rigolot, Eric; Defossé, Guillermo; Kunst, Carlos; de Ronde, Neels C.; Abdelmoula, Kais; Sesbou, A. 2007. **A network of prescribed fire demonstration sites for Europe, Africa and Argentina.** In: International Wildfire Fire Conference 2007, Sevilla, Spain. Thematic session N°2.

Pimont, François; Dupuy, Jean-Luc; Scarella, Gilles; Caraglio, Yves; Morvan, Dominique. 2006. **Effects of small scale heterogeneity of vegetation on radiative transfer in forest fire.** In: D.X. Viegas (Ed.) 2006. V International Conference on Forest Fire Research, 27-30 Nov. 2006, Figueira da Foz, Portugal.