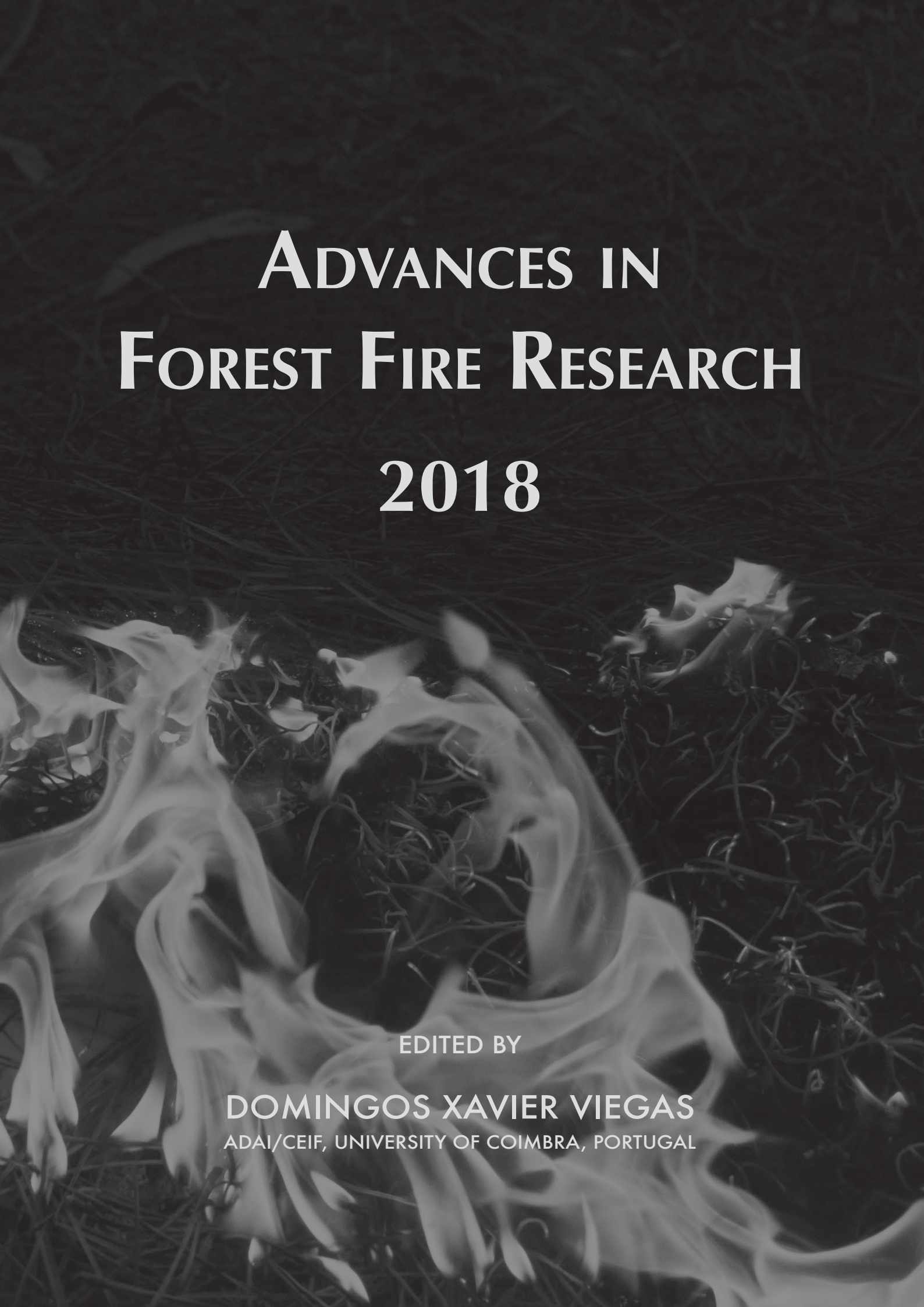
Advances in Forest Fire Research 2018



EDITED BY

DOMINGOS XAVIER VIEGAS

ADAI/CEIF, UNIVERSITY OF COIMBRA, PORTUGAL

https://doi.org/10.14195/978-989-26-16-506_136

Short contribution – Fire Risk Management

Cohesive forest fire management within an imperfect information environment: a review of risk handling and Decision Support Systems actually in use

Abílio P. Pacheco[1*], João Claro[1], Paulo M. Fernandes[2], Richard de Neufville[3], Tiago M. Oliveira[4], José G. Borges[4], José Coelho Rodrigues[5]

[1] INESC TEC and Faculdade de Engenharia, Universidade do Porto, {app@fe.up.pt*, jclaro@fe.up.pt}.*

[2] CITAB, UTAD. Quinta de Prados, 5000-801 Vila Real, Portugal, {pfern@utad.pt}.

[3] MIT Institute for Data, Systems, and Society, Massachusetts Institute of Technology. 77 Massachusetts Avenue, Cambridge, MA 02139, USA, {ardent@mit.edu}.

[4] Forest Research Centre, School of Agriculture (ISA), University of Lisbon. Tapada da Ajuda, 1349-017 Lisboa, Portugal, {toliveira@isa.ulisboa.pt, joseborges@isa.utl.pt}.

[6 5] INESC TEC and FEUP. Porto, Portugal, {jpcr@fe.up.pt}.

Keywords: Forest Fire Management, Decision Support Systems, Risk, Economic Efficiency, Natural Resources, Implementation Management, Fire Simulation

1. Introduction

Wildfire management has been struggling in recent years with escalating devastation, expenditures, and complexity. Uncertain and highly unpredictable factors, such as weather forecasts, performance of suppression resources, and fire behavior, spread and effects are the basis of fire management and policy decisions, across multiple levels and scales. Given these copious factors and the complexity of their interactions, uncertainty in the outcomes is a prominent feature of wildfire management strategies, at both policy and operational levels. Theoretical and computational progress in the last four decades has enabled the development of risk-based Decision Support Systems (DSS) that contribute to improve those decisions, namely by facilitating a structured assessment of the outcomes and costs associated with alternative policies, budgets, and suppression resource mixes. Improvements in risk handling and in risk-based decision support tools have therefore a key role in addressing these challenges. In this context, we review key systems created to support wildfire management decision-making at different levels and scales, and describe their evolution from an initial focus on landscape-level fire growth simulation and burn probability assessment, to the incorporation of exposure and economic loss potential (allowing the translation of ignition likelihood, fire environment – terrain, fuels, and weather – and suppression efficacy into potential fire effects), the integration with forest management and planning, and more recently, to developments in the assessment of values at risk, including real-time assessment. This evolution is linked to a progressive widening of the scope of usage of these systems, from an initial more limited application to risk assessment, to the subsequent inclusion of functionality enabling their utilization in the context of risk management, and more recently, to their explicit casting in the broader societal context of risks and decisions, from a risk governance perspective. This joint evolution can be seen as the result of a simultaneous pull from methodological progresses in risk handling, and push from technological progress in wildfire management decision support tools, as well as more broadly in computational power. Seeking to characterize this movement, in a recent paper (Pacheco *et a*l 2015) we identify the key benefits and challenges in the development and adoption of these systems, as well as future plausible research trends.

level fire growth simulation and burn probability assessment, to the incorporation of exposure and economic loss potential (allowing the translation of ignition likelihood, fire environment – terrain, fuels, and weather – and suppression efficacy into potential fire effects), the integration with forest management and planning, and more recently, to developments in the assessment of values at risk, including real-time assessment. This evolution is linked to a progressive widening of the scope of usage of these systems, from an initial more limited application to risk assessment, to the subsequent inclusion of functionality enabling their utilization in the context of risk management, and more recently, to their explicit casting in the broader societal context of risks and decisions, from a risk governance perspective. This joint evolution can be seen as the result of a simultaneous pull from methodological progresses in risk handling, and push from technological progress in wildfire management decision support tools, as well as more broadly in computational power. Seeking to characterize this movement, in a recent paper (Pacheco *et a*l 2015) we identify the key benefits and challenges in the development and adoption of these systems, as well as future plausible research trends.

2. Materials and Methods

In recent years, several authors have updated the state of the art on the way these challenges have been addressed, organizing and aligning the sources of uncertainty with decision support tools and methodologies, in order to facilitate cost-effective, risk-based wildfire management and planning efforts. Reviewed developments include operations research methods applicable to wildfire management, and the economic efficiency analysis theory behind the fire management measures of fire management DSSs in use in America, Australia and Europe. Some of these DSSs allow the integration of wildfires into forest planning, sometimes also addressing risk and uncertainty, but broadly they include (real-time or not) wildfire simulators (autonomous or not) which in turn, were built over some surface fire spread simulation model.

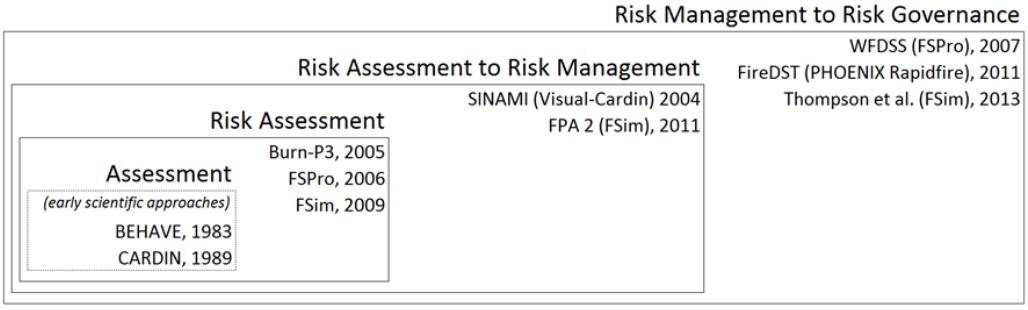


Figure 1 - Conceptual outline of the expanded focus, from risk assessment to management to governance, with examples (DSSs and methodologies).

Our review first assesses the characteristics of the fire modeling systems in operation (BehavePlus, Visual-Cardin used by SINAMI, FARSITE, SiroFire, Prometheus used by Burn-P3, FSPro used by WFDSS with RAVAR, FSim used by FPA, and PHOENIX Rapidfire used by FireDST) which include fire behavior, fire spread, and probabilistic fire spread simulators, and then adopts a higher-level perspective to provide a broader and more complete view of the evolution of the field. Indeed, we concisely present several important risk-based decision support models for fire management, on the one hand highlighting their usefulness within the scope and the purposes that guided their development, but on the other rendering explicit a number of limitations that they present. Some of these limitations have also been discussed recently, although in a fragmented way, in the literature on challenges in the development and deployment of risk-based decision support systems.

We bring together this set of observations, and highlight what seems to us to be an important trend of broadening of concerns from risk assessment, to risk management, to risk governance (Figure 1).

This trend frames an increasingly ambitious utilization of these systems, gradually and successively broadened to address each of those areas of concern. This overall evolution pattern is the result of simultaneous methodological progress in risk handling, as well as specific technological progress in wildfire management decision support tools, and generic technological progresses in computation.

3. Results

A myriad of interacting social and ecological factors influences the severity of forest fires. Thus, we need to understand the non-linear relationships between interconnected physical, biological, and cultural systems to be able to effectively reduce the vulnerability of ecosystems and human societies, through improved and proactive risk governance. Problem structuring methods, system dynamics, simulation, decision analysis, and optimization, together with qualitative methods such as expert elicitation, open interviews, questionnaires, and surveys, can help model the dynamics and advance the understanding of these complex systems, gaining insight into problem structures, and better enabling the exploration of alternative management options, in face of always present budgetary constraints.

The integration of forest fire risk concerns into forest planning processes is a significant step. However, more research is needed characterizing the impacts of alternative fire management options on market and nonmarket values at risk, and on the economic losses in goods and services triggered by the fire consequences that they try to mitigate. Risk-based analysis is required for the integration of risk handling and fire management, in order to improve the prioritization of future efforts to mitigate the risks associated with these natural and human caused disturbances. Risk assessment should also identify and characterize the importance and weight of uncertainties to improve the management of human and ecological resources at risk, in areas ranging from fuel mapping to how society values those resources.

Our review of DSSs in current use stresses the importance of the integration between risk handling and DSS development, to facilitate and improve the quality of decisions under uncertainty, and enable a cohesive fire management in an uncertain environment. It also points out the importance of understanding the institutional constraints of management programs within which forest fire mitigation programs develop, that along with ecological constraints, the need to engage multiple stakeholders, and the need for adaptation to local contexts, must be reflected in the usability and flexibility of these systems. In the case of Portugal, our work may also contribute to address the lack of a DSS in use.

2. Acknowledgements

This work is financed by the ERDF through the COMPETE and by National Funds through the FCT within project FIRE-ENGINE/MIT/FSE/0064/2009 and The Navigator Company; and by project UID/EEA/50014/2013. FCT also supported the research performed by Abílio Pereira Pacheco (Grant SFRH/BD/92602/2013). Our work greatly benefited from the many colleagues acknowledged in the cited paper.

3. References

Pacheco, Abílio Pereira, João Claro, Paulo M. Fernandes, Richard de Neufville, Tiago M. Oliveira, José G. Borges, and José Coelho Rodrigues. 2015. "Cohesive fire management within an uncertain environment: A review of risk handling and decision support systems." Forest Ecology and Management 347 (0):1-17. doi: 10.1016/j.foreco.2015.02.033.