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Management of Mediterranean forests — A compromise programming approach considering different stakeholders and different objectives

António Manuel de Sousa Xavier [a], Maria de Belém Costa Freitas [a,*], Rui Manuel de Sousa Fragoso [b]

[a] Sciences and Technology Faculty, Universidade do Algarve, Gambelas Campus, Edf. 8, 8005-139 Faro, MEDITBIO, Center for Mediterranean Bioresources and Food, Portugal

[b] Management Department, Universidade de Évora, Largos dos Colegiais, N°2 Apt. 95, 7002-554 Évora, CEFAGE-UE, Center For Advanced Studies in Management and Economics, Portugal

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ABSTRACT

Forest management is a complex issue due to the different type of activities considered in the forest territory and to the criteria involved in the manager's decision: in the last centuries, Mediterranean forests have come under human influence and recently, probably as a consequence of rural depopulation in many of these areas, a decline in the potential of these forests to produce economic and environmental services has been observed. Risk of fire and the resulting economic loss is a common problem in Mediterranean areas, mainly in years when climatic conditions are more unfavorable. Specific strategies for dealing with that risk imply costs, have an impact on biodiversity, and are always implemented following different stakeholders' (landowners/farmers and managers) preferences. Furthermore, this kind of decision always implies a conflict of objectives. Compromise programming represents a very satisfactory way to combine different stakeholders' preferences regarding the criteria considered. The objective of this work is to present a methodology based on the MCDM approach that facilitates the collaborative planning process in the scope of Mediterranean forests, dealing with multiple criteria and multiple stakeholders in a risky situation. This approach was implemented in a Forest Intervention Zone (FIZ) in the Algarve, Southern Portugal.

1. Introduction

Decision-making is often difficult due to conflicting objectives (Freimer and You, 1976). In this context, the case of Mediterranean forests is paradigmatic. These forests are ecosystems with high biodiversity that ensures a balanced ecological environment, being recognized as an area of fundamental importance. However, in the last centuries they have been influenced by human activities, leading to degradation of these ecosystems (Scarascia-Mugnozza et al., 2000).

One of the major threats is forest fires, which are the result of tensions in the use and management of the territory (European Commission, 2001). The risk of forest fires is, therefore, a relevant criterion for management. Forest fires are one of the most important agents of land use change in Portugal, being a threat to the forests (Ricardo, 2010) and one of the most important natural risks affecting the country, especially in the summer, with economic impacts and consequences (Bugalho and Pessanha, 2009).

With regard to the risk of fire and its inclusion in management models, the first approaches emerged in the USA in the early 80s (Ferreira, 2011), and this is just one of many factors that managers should consider in managing forests (Martell, 2007). According to Ferreira (2011), existing studies that incorporate fire risk are divided in two groups: those considering forest management at the stand scale and those considering it at the landscape scale. Some of the first approaches are now presented. Martell (1980) developed a discrete stochastic model, considering age-dependent risk to analyze the impacts of fire risk in settlement management (Ferreira, 2011). Van Wagner (1983) introduced fire risk in forest management, analyzing the consequences of forest fires for wood production (Ferreira, 2011). More recently, in Portugal, Ferreira (2011) uses risk models and damages, based on the results of a logistic regression model. These are then inserted in optimization and simulation models that consider fire risk at the stand and the landscape scale. However, a fully-integrated approach that considers all the territory's land uses has still not been developed.

Forest production planning is also a complex problem, since every decision affects different criteria: economic, environmental or social (Diaz-Balteiro and Romero, 2008). Furthermore, forest management has not kept pace with the recent diversification of forest functions or resolution of conflicting interests of the various stakeholders involved. A good stakeholder analysis is relevant in a participatory process and if stakeholders are left out of the process, central questions might be ignored (Nordström et al., 2010). Regarding group decision methods (GDM), several studies have been carried out. Bantayan and Bishop (1998) used the analytical hierarchical process and studied the

* Corresponding author at: Faculdade de Ciências e Tecnologia, Universidade do Algarve Campus de Gambelas, Edf. 8 8005-139 Faro.

E-mail addresses: amxav@sapo.pt (A.M. de Sousa Xavier), mbmartins@ualg.pt (M.B. Costa Freitas), rfragoso@uevora.pt (R.M. de Sousa Fragoso).

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allocation of land uses in a group decision process in the Philippines. Ananda and Herath (2003) showed the value of a role-based approach in modeling the sums allocated by the various stakeholders involved in the management process. Ananda (2007) presented an approach that incorporates the preferences of various stakeholders using the analytical hierarchical process in a region of Australia. Tecle et al. (1998) formulated a problem with five goals in a group decision situation, using programming commitment and cooperative games. More recently, a promising approach using extended goal programming (EGP) was implemented in forest management by Diaz-Balteiro et al. (2009) in a case study in Spain, and developed by Nordström et al. (2009), who also implemented an EGP approach with multiple stakeholders and consensus matrices. In this case, four different social groups were established from stakeholder preferences in the form of pairwise comparisons of different sets of criteria, presenting a very promising method for modeling the majority and minority consensus, but also to define intermediate situations. Martins and Borges (2007) reviewed different group decision-making approaches and their potential use in forest management problems in Portugal.

In a considerable number of situations, forest management models need to be formulated according to the multiple criteria decision-making (MCDM) paradigm (Diaz-Balteiro and Romero, 2007) and finding an acceptable balance between forest uses has become a challenge today (Barreiro and Tomé, 2011).

MCDM is very satisfactory for solving several problems in forest management and there has been an increase in the use of approaches such as Data Envelopment Analysis, Goal programming or the Analytical hierarchal process (Diaz-Balteiro and Romero, 2008). These authors reviewed the use of multi-criteria methods in forest management and found more than 255 examples. The compromise programming approach is a very promising method since it allows simulation of the manager's decision with the assumption that it will search for the "most suitable" point, which is defined as the efficient solution closest to the ideal point. However, compromise programming is still one of the least used. In their review, Diaz-Balteiro and Romero (2008) concluded that only 10 of the 255 articles analyzed used compromise programming. For example, Tecle et al. (1998) and Kazana et al. (2003) formulated different compromise programming models for harvest scheduling problems that incorporated timber and non-timber criteria; Diaz-Balteiro et al. (2014) used compromise programming and multi-objective optimization to model fire risk. Martins and Borges (2007) reviewed different group decision-making approaches with an MCDM orientation and their potential use in forest management problems in Portugal, concluding that the forest collaborative planning problem suggests the need for an integrated approach. Additionally, this MCDM problem should consider the risk of economic losses due to forest fires using MCDM, which is not fully developed. Diaz-Balteiro et al. (2014) state that the use of the MCDM technique to integrate fire risk is neither common nor well developed. Martins et al. (2013) developed an integrated MCDM management model in which fire hazard is considered, but did not fully develop an MCDM approach in a risky situation.

Therefore, the objective of this paper is to present a methodology based on the MCDM approach that facilitates the collaborative planning process in the scope of Mediterranean forests. As is well known, different stakeholders intervene in the management of Mediterranean forests, with different goals and perspectives. Thus, an intriguing question is: how are they able to work together? In this paper, the proposed framework is applied to a Forest Intervention Zone in the Algarve, southern Portugal, where the main stakeholders are farmers and institutional managers who represent the Portuguese State and therefore social interests. Thereby, the aim is to determine how the farmers' set of compromise solutions is different from that of FIZ managers.

The paper is organized as follows. Section 2 provides a brief description of the case study where the approach was applied. Section 3 is devoted to the methodological approach, where the model is presented and its specific contributions, such as fire risk and compromise approach, are described. Results are presented and discussed in Section 4. Finally, Section 5 provides the concluding remarks.

2. Case study

The proposed methodological approach was implemented in a Forest Intervention Zone (FIZ) in the Algarve, southern Portugal. An FIZ is a continuous and delimitated area with common management, composed mainly of forest spaces, subject to a forest management plan and a specific forest intervention plan (Martins et al., 2013). This FIZ represents a typical situation of forest management in the Algarve region: management problems associated with the integration of agricultural, forestry and livestock-rearing activities, which usually coexist on the farms, different stakeholders make decisions (FIZ managers and farmers/landowners) and the FIZ has been hugely affected by fires in the last decade. It has a total area of 1783 ha and is located in inland Algarve (Fig. 1).

For this study, the FIZ was divided in farm-types — group of farms with similar characteristics — considering economic, social and environmental factors, so that we could understand the importance of management decisions taken by each farm type for the whole FIZ and, on the other hand, the importance of management decisions taken by the FIZ for each farm

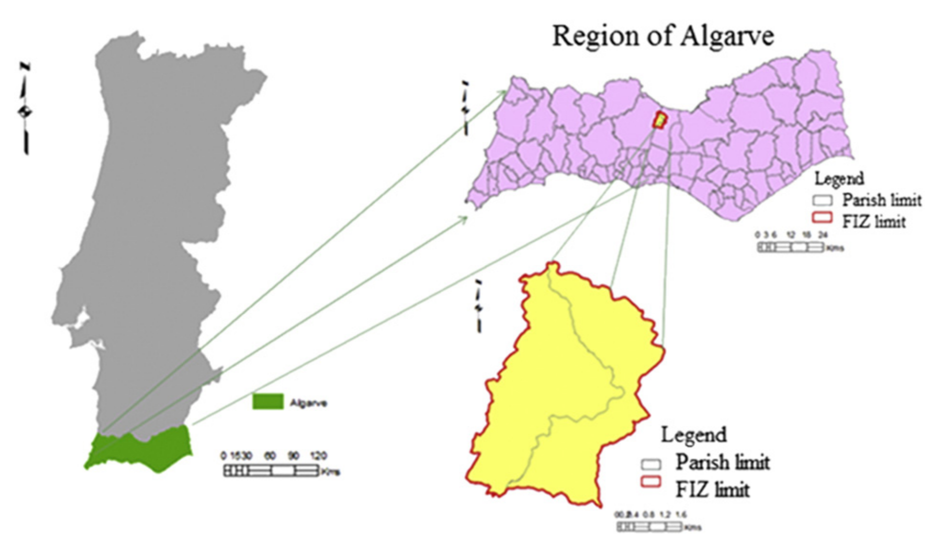

Fig. 1. Location of the selected FIZ.