3.4 The Importance of Economics in Fire Management Programmes Analysis

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3.4.1 Introduction

Wildfires are a societal problem that threatens many ecosystems, affects millions of people worldwide, and causes major ecosystem and economic impacts at local regional, national and global scales. In Europe, and especially in the Mediterranean countries (France, Greece, Italy, Portugal and Spain), wildfires continue to be a major environmental threat (Requardt et al. 2007) where, an average 500 000 ha of forests are burned annually (San-Miguel and Camia 2009). Wildfires affect the forests and other wooded land, and neighbouring systems such as urban areas, infrastructure networks (i.e. power-lines and transportation corridors), agriculture lands, and the civil society. These impacts can be reflected in many ways – for example, loss of human life or health, decreased well-being of the population (local and wider), and temporary or permanent loss of employment possibilities and economic activities. For a worldwide perspective on the effects of fire on the earth systems see Bowman et al. 2009.

The last decades have seen increased social awareness and growing concerns for wildfires' negative environmental and economic consequences, and, particularly, the loss of human lives (McCaffrey 2008). The growing importance of wildfire issues at EU level is also reflected in the increasing number of research projects funded to better understand and address this problem (e.g. Eufirelab, Fire Paradox).

In Europe, this change was galvanized by the large-scale wildfires and their consequences in the Mediterranean region during the 2000s. For example, during 2003 in Portugal about 400 000 ha of forests lands were burned; during 2005 in Spain some 190 000 ha of forests lands were damaged; and during 2007 in Greece around 270 000 ha of forests and other wooded lands were destroyed (JRC 2007). Events in other parts of the world also helped to increase the concern on this topic in Europe. These included, Indonesia 1997/1998, where 8 million ha burned; Australia 2007, more than 1 million ha; and California, USA 2007, 120 000 ha affected. These major wildfire events clearly showed that they are not only an environmental problem, but have also a significant social dimension, affecting millions of people, having major economic impacts, and causing significant human casualties (González-Cabán 2007). For example, the wildfires affecting vast forest areas of Portugal in 2005 caused economic damage worth almost €800 million and caused 13 fatalities. Even worse, the large fires affecting Greece during the summer of 2007 caused 64 casualties, and according to the Greek authorities the economic damage was estimated at €2–5 billion (Papachristou 2007; Petsini Arlapanou and Petsini Arlapanou 2007).

These events increase the public interest and concern about the wildfires and prompted the development and implementation of improved policies and management measures at different levels. The main objective of these improved policies and management measures is to minimize the negative environmental, economic and social impacts of wildfires (EU 2005). However, the implementation of such measures requires substantial investment of financial, human and organizational resources, which must be justifiable and efficient.

Decision support systems based on economic models can help to decide what would be the optimal use of the resources. For example, economic models can help to estimate whether investments in wildfire related measures (e.g. prevention, suppression, fuel management) are financially justified, or to choose the most efficient amongst several alternatives (i.e. the combination of investments in fire prevention, fire fighting and amount of wildfire acceptable). For the implementation of these decision support systems reliable knowledge and data are needed on the physical and economic impacts (negative and positive) of wildfires and the economic efficiency of fire management measures. The understanding and assessment of socio-economic impacts of wildfires should be considered an essential part of the fire risk assessment, development of wildfire related policies, as well as planning and implementation of management practices (Morton et al. 2003).

This chapter will first introduce the basic model used for the estimation of the economic efficiency of fire management programmes and revise some of the problems related with its application. In the subsequent section we discuss why the social preferences should be considered when planning fire management programmes and present a study dealing with this topic that was conducted in Spain. In section three of this chapter, we look in detail at the problems and a possible solution for the adequate estimation of costs related to wildfires. The last part of the chapter presents the main conclusions.

3.4.2 Estimating the economic efficiency of and social preferences for fire management programmes

3.4.2.1 Economic efficiency of fire management programmes

To combat the wildfires problem forest managers can apply different management measures. These include prevention (e.g. education, publicity campaigns), fuel treatment (e.g. prescribed burning, thinning, mechanical fuel removal), pre-suppression and suppression, and restoration measures. One of the thorniest questions in fire management is to determine how the limited financial, equipment, and human resources should be most efficiently spent and distributed among alternative fire management options.

To answer this question, the economic analysis of the efficiency of fire management is generally evaluated by the cost plus net value change concept (C+NVC) (Althaus and Mills 1982; Donovan and Rideout 2003; González-Cabán

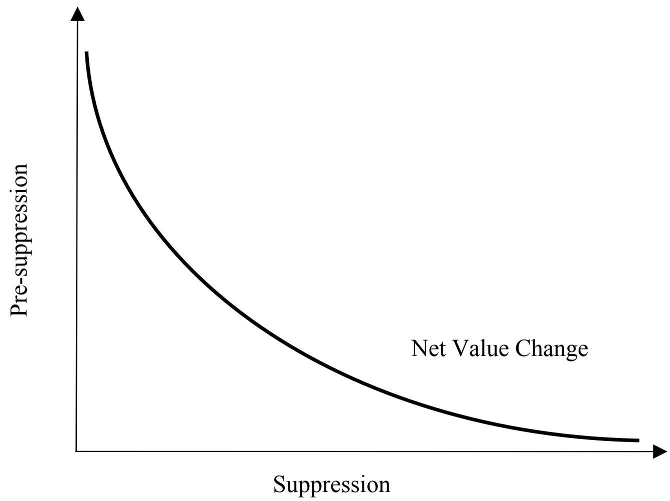

Figure 1. NVC level curve.

2007). This approach estimates all costs and benefits related to fire management measures. The model is derived by adding pre-suppression costs to the costs of fire suppression and the net value of the change in resources outputs that result from the fires (difference between benefits and damage to the resource). The pre-suppression costs represent the expenditure on fire management prior to the wildfire season (e.g. purchase of fire fighting resources such as fire engines, equipment for fire fighting crews). Suppression costs are fire fighting expenditures during a fire season (e.g. wages for fire fighting crews, fuel for aerial resources).

In the C+NVC model pre-suppression and suppression expenditures are considered as independent inputs, related through the Net Value Change (NVC) function (Donovan and Rideout 2003). The independence of pre-suppression and suppression expenditures means that one input does not determine the level of the other. For example, the purchase of some fire fighting equipment before the fire season, does not determine how frequently this equipment will be used during the fire season. Nevertheless, the pre-suppression may affect the optimal level of suppression through the NVC function (Figure 1). In Figure 1 the slope of the level curve is equal to the negative of the ratio of the marginal contributions of suppression and pre-suppression in reducing damage. It should be noted, that pre-suppression can be substituted by suppression, but only in the case that NVC is held constant (Donovan and Rideout 2003). Thus, both inputs are allowed to vary independently, but remain related through the NVC function (Donovan and Rideout 2003).

As mentioned at the beginning of this chapter, the objective of the C+NVC model is to find the most efficient management levels (González-Cabán et al. 1986; Lankoande 2005). Selecting the most efficient management level is an optimization problem, where we intend either to minimize the costs and the net value change, or to maximize the social benefits (Donovan and Rideout 2003; Mercer et al. 2007).

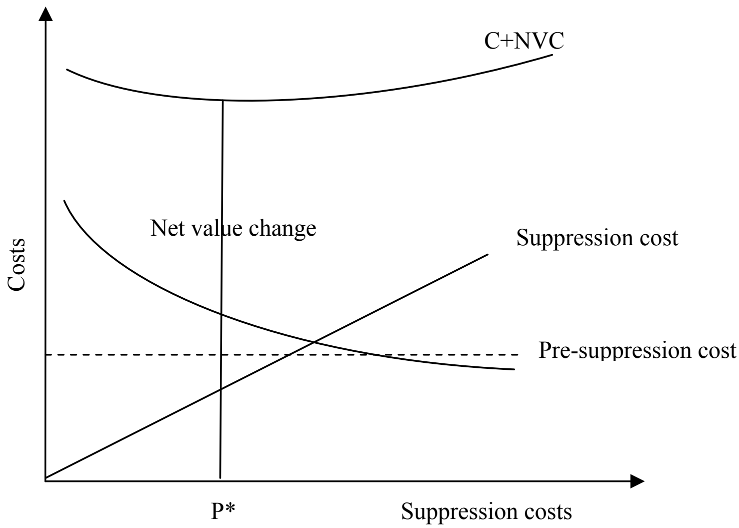

Figure 2. Illustration of the C+NVC model (Donovan and Rideout 2003).

For example, given that the pre-suppression expenses are at an optimal level (Figure 2), the most efficient level of fire programme is the point where the summation of costs and the net value change is minimized (i.e. P* in Figure 2). In the model, the cost part (C) is obtained by the estimation of the programme costs (pre-suppression and suppression activities); while the net value change (NVC) sums all the changes in the quantity/quality of resources outputs (goods and services) that result from the fire multiplied by the unit value of the output.

The objective of the evaluation of economic efficiency of fire management measures is not only to help identify the most efficient programme level, but also to decide how to distribute the resources (spatial component). Namely, once agencies have decided how many resources to use (e.g. fire detection facilities, suppression resources, fuel treatments), their most efficient and cost-effective allocation must be determined (Wei et al. 2008).

To be able to apply the C+NVC model and to include it into a decision support system (DSS) for planning and evaluation of the economic efficiency of management programmes it requires adequate information. For example, for each evaluated fire management program alternative it would at least need information on: monetary estimates of economic efficiency, quantitative estimates of effects on resource outputs, and assessments of the risk associated with these values. However, there are still considerable shortcomings in the knowledge and data availability.

One of the difficulties related to the application of the C+NVC model is the estimation of the NVC component. It requires information about the direct and indirect effects of fire on spatial and temporal provision of goods and services, and information about how fire-induced marginal changes in the quality and quantity of goods and services will affect social welfare. It is apparent that information is lacking in one or both of these areas for many of the types of goods and services that can be affected by wildfire (Venn and Calkin 2007). More on this issue will be presented in section 3.4.3 of this chapter.

The estimation of the costs and the NVC is further complicated by the possible temporal interrelation of fire events or management measures; meaning that present actions can influence decisions on applications of fire management measures in future fire seasons. For example, Mercer et al. (2007) showed that fuel management treatments applied in the current season can produce benefits (e.g. reduced fire risk) also in subsequent seasons. These, ‘extended’, benefits should also be taken into account when estimating the costs and benefits of fire management measures. Lagged benefits are not only a characteristic of management measures, but also of wildfires. Namely, wildfires significantly reduce the amount of fuels (similar to the effect of fuel management); thus, they notably affect the fire risk and intensity in the following seasons. According to Mercer et al. (2007) this reduced risk of wildfires can last up to 11 years.

Another important issue to consider when estimating costs and benefits of fire management is that multiple objectives can be accomplished by these measures. For example, prescribed burning can reduce fuels, dispose of logging debris, prepare sites for seeding and planting, improve wildlife habitat, manage invasive species, control insects and diseases, improve accessibility, enhance aesthetics and recreation activities, improve forage and grazing, and manage endangered species (Wade and Lunsford 1988).

At the European level, another important problem, and maybe the most fundamental, is the general lack of reliable data not only on the effects of fires on the quantity/quality of goods and services produced by the natural resources (in our case, forest lands), but the social value of different goods and services, as well as the costs and expenses of fire management and suppression activities. In many cases, there is no common methodology to collect and report such data, and therefore the available data is most often incomplete, unreliable, and available only for some countries or regions within countries. (Mavsar et al. 2007).

3.4.2.2 Social preferences for fire management programmes

Economic efficiency is an important criterion in deciding which fire management programme would be the most efficient. However, it should not be the only attribute considered when deciding about fire policies or management measures. In addition, it is important to consider other factors, for example social values and preferences for a certain programme or management measure (Daniel et al. 2007; Martin et al. 2008). Knowing the social preferences for different management actions and identifying when they might differ from the manager’s viewpoint can help agencies to understand and predict how different audiences may react to these decisions. For instance, this knowledge may (i) help the administration recognize when policies or actions may be supported or opposed by the public[1], and (ii) help to develop

1 For an interesting discussion on how public perceptions affect the implmentation of fire management programmes see Laband et al. (2006) and Laband et al. (2008).

information or education campaigns, which might help to get public support for a certain policy or action. Thus, learning about the social preferences could be useful in different ways. It can serve as a support tool in the design of policies and/or specific fire management programmes; or, if faced with a fixed budget for wildfire mitigation, land managers may want to design a fire prevention measure that mirrors society's preferences – for example, for fire behaviour with a lower impact on forest resources. Therefore, social preferences may allow policy makers to better identify priority-attention areas in fire management. This is seldom the case in Europe and there are only a couple of case studies where social preferences for fire management measures have been elicited (see Box 1).

3.4.3 Estimating the costs of wildfires

A precondition for the estimation of the socio-economic damages caused by wildfires is to understand what the important factors are and how they influence the quantity and quality of goods and services provided by a natural resource (e.g. forest). This knowledge is vital for the identification of goods and services that can be or are damaged by a fire. Only a complete picture of the damages enables a reliable estimation of the socio-economic impacts of wildfires. Further, it should be acknowledged that wildfires can have positive effects (González-Cabán 2007). For example, improving the wildlife habitat, improving understory forage and grazing, managing endangered species and fire dependent species (Wade and Lunsford 1988). These positive effects (benefits), when existing, must also be included into the estimation methodology.

A wide range of costs can be related to a wildfire, and there are different ways to categorize them (Ashe et al. 2008; Dale 2009; Zybach et al. 2009). In general, we can divide costs into direct and indirect. Direct costs are those which are directly related to a wildfire event, and incurred as a result of the fire and/or exposure to the fire, such as losses or damages of environmental (forest) goods and services, property, and direct suppression costs. In contrast, indirect costs are related to the risk of wildfire occurrence or as a response to the occurrence of a wildfire, like prevention, monitoring and pre-suppression costs, restoration costs, and other costs associated to the individuals who suffer a loss of benefits as a consequence of a wildfire.

An important concern in evaluation of fire management efficiency and estimation of wildfire costs is the proper consideration of environmental (forest) goods and services that might have been damaged (or enhanced) as a consequence of a wildfire. In estimating the economic impacts of wildfires, only a few of them have traditionally been considered, mainly the decreased quantity/quality of timber. However, in the last decades it has become obvious that forests are also important as providers of environmental and social goods and services (Farrell et al. 2000). Thus, nowadays estimating the costs of wildfires must also include these goods and services (Butry et al. 2001; Dunn et al. 2003). However, it is important to understand that in contrast to forest goods and services that have a market price (e.g. timber, fruits, and mushrooms) that reflects their value, there are goods and services (e.g. biodiversity, recreation activities, erosion prevention, water purification) that are not

Box 1: Case study on social preferences regarding fire management measures[2]

Burned forest area or dead trees? A choice for Catalan citizens

The objective of the study, conducted in Catalonia (NE Spain), was to elicit the social preferences regarding fire prevention measures in terms of their impact on fire behaviour – fire propagation and intensity – and to estimate the value of these measures for the society. We applied the choice experiment methodology. The label 'choice experiment' refers to a survey-based valuation method that simulates actual market behaviour (Hanemann and Kanninen 1999; Bennett and Blamey 2001). This technique is based on the idea that any alternative, or good, can be described in terms of its attributes, or characteristics. In a choice experiment, respondents are presented with a series of choice sets comprising at least two alternatives and are asked to choose which alternative they prefer (Hanley et al. 2001; Bateman 2002).

In our empirical application, 207 interviews were conducted in three Catalan provinces – Barcelona, Gerona and Lérida – in June 2007. The first part of the interview presented the attributes to be valued, as well as the payment mechanism and the consequences of each choice. The second part contained the choice experiment exercise and a number of debriefing questions. The final part was designed to collect some socio-economic data about the respondents.

The study results suggest that additional fire prevention measures increase the welfare of the Catalan population (similar results were reported in Riera and Mogas (2004). Further, results show that the attribute of highest concern is fire propagation (area burned). A plausible explanation for this may be the publics' familiarity with information on the quantity of area burned, as this is often used by the media in Spain to quantify the consequences and the severity of a wildfire. The result implies that from a social perspective reducing the forest area burned is one of the most relevant elements when designing fire prevention and protection programmes. However, the design of fire prevention and protection programmes also depends on other factors such as vegetation type and characteristics, complexity of the fire problem, available funds, available experience and expertise. Thus, social preferences should be considered in the decision making process, but are not the only factor influencing the design of fire management programmes.

traded in traditional markets (hereafter non-market goods and services) and thus, we have no information about their value (González-Cabán 1998; Mavsar et al. 2008).

Non-market valuation methods can be applied to value these goods and services. Even though these methods have improved considerably in the last decades, they still have limitations, which should be considered when used. One of the most important limitations is that the estimated values cannot be easily extrapolated. For example, recreation values in different forests are probably different and this difference is not necessarily only the result of different site characteristics, but might also be influenced by other factors (e.g. population size, income in the region, accessibility). This limitation is especially important when developing a system for the assessment

2 For detailed information see Mavsar and Farreras (2008).

of socio-economic impacts of wildfires, because the fire may spread over areas where no values for non-market goods and services have been estimated. In this case, simply applying values from another site may generate significant estimation errors. Nevertheless, with the use of the right data, adequate techniques (e.g. benefit transfer method) or employing proxies (e.g. restoration costs) this problem could potentially be overcome (for example see Rideout et al. 2008).

Nevertheless, as mentioned earlier, in most cases only fire suppression costs and loss of timber production are considered, while damage to forest non-market goods and services are often omitted or very limited (Pettenella et al. 2009). The absence of non-market values is somehow expected, given the complexity and high cost in measuring them; in addition, the obtained values are site specific and transferable to other sites only under some specific conditions (e.g. similar forest site and population characteristics).

3.4.4 Conclusions

The extreme wildfire events of the past decade have shown that fires are not only an ecological, but even more a socio-economic problem. Economics has an important role in helping to quantify the magnitude of the problem (i.e. assessing the costs of wildfires) and to find adequate solutions (i.e. evaluate efficiency of fire management measures and provide information on public preferences). This also implies that the role of economics in the fire management process should change. Therefore, it is important for decision makers to start considering economic analysis as an integral part of a proactive fire management; a tool that provides information that can help managers make better informed decisions that can lead to selection of the most efficient alternatives in a given situation.

Although there has been considerable development of economic methods (e.g. non-market valuation methods) and models (e.g. C+NVC model), important problems still remain to be solved in the future. In this respect, the main issues are the inadequate understanding of:

- the impacts of wildfires on the spatial and temporal provision of goods and services (e.g. how the quality and quantity of a good or service is affected and for how long);
- the potential effect of the changes caused by wildfires on society's wellbeing (e.g. what is the value of the losses);
- the impact of fire management measures on risk, extent and severity of wildfires (e.g. quantify the effects of different management measures).

Thus, development of a decision support system (DSS) requires, first, answers to these three concerns. Once this is accomplished, the next step is to develop models that would adequately simulate the behaviour and impact of wildfires, the effects of fire management measures, and the potential economic impacts (positive and negative). Furthermore, development and implementation of a DSS necessitates that a significant amount of information be collected and processed (e.g. fuel models, historical fire data, weather parameters, geographic data, availability of fire management practices and resources, values of market and non-market goods and services). In addition, standardized procedures must be established on how to collect and process the needed data.

Finally, it is important to recognize that no decision support system or computer simulation model is a substitute for a decision maker. A decision maker must still weigh and assimilate a large number of relevant factors, many of which cannot be measured in common units or even be measured quantitatively at all, and must place fire programs within the context of other management programs and institutional constraints (Mills and Bratten 1982). A DSS simply quantifies some of the factors, which are relevant to fire management program planning and helps trace the interaction of relationships that are too complex and numerous for a person to easily follow. In the case of a fire economic efficiency DSS, this would provide the decision maker only with information on how to possibly design the most economically efficient fire management programme. However, the results depend on the model assumptions and restrictions (e.g. fire management policies). A DSS could show some of the costs of imposing institutional constraints on the programme; and while many of those constraints are valid, their costs must always be considered (Mills and Bratten 1982). After careful consideration of all the information provided by the DSS, and other sources, the final decision on what kind, and to what extent the fire programme will be implemented rest squarely on the decision maker's shoulders.

There are still many obstacles to overcome on the path to the development and application of a model for the evaluation of economic efficiency of fire management and protection programs at the European level. One of the main problems is the lack of reliable and comparable data on fire effects, the social value of affected goods and services, and the costs of fire management activities. Considering these limitations, there is a need not only to develop a relevant DSS, with the potential to deal with territorial differences, but furthermore to ensure that adequate data is collected in a standardized form. Hopefully, this will change for the best in the near future.

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