Appraisal framework for actor interest and power analysis in forest management - Insights from Northern Portugal

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ABSTRACT

Forest management is currently challenged by the need to address an increasing demand for a wide range of ecosystem services. Addressing this challenge requires landscape-level supply approaches that may bring together multiple interests and goals of forest actors. Characterizing these interests and the corresponding forest management context is thus a prerequisite for an effective landscape-level approach. In this manuscript we develop actor analysis to characterize a forest management context. We implement and test the analysis in Vale do Sousa, in North-Western Portugal. The analysis encompassed the identification of key actors and 40 interviews. Results show that the analysis provides a thorough diagnosis of the current forest management context in Vale do Sousa. The findings give a snapshot of the actors and factors – interests, influential actors, conflicts, problems and power resources – that frame forest decisions. Specifically, results show the keen interest of all groups on wood provisioning and on regulating wildfires. However, actors have also revealed a strong interest in water quality, soil erosion prevention, biodiversity, landscape aesthetics and environmental education. Thus, there is a significant interest in the diversification of the provision of ecosystem services. Almost half of the actors have identified the multifunctional forest as being the ideal forest management framework for Vale do Sousa. Findings thus evince the potential of a participatory approach to negotiate a consensual landscape-level solution that may integrate the different actors' interests and provide a wide range of ecosystem services. This may be facilitated by another finding from actor analysis. A regional Forest Owners Association was recognized as the most influential actor and may support the development and negotiation of multiple objective landscape-level forest ecosystem management plans. In summary, these results may contribute to a better understanding of the forest management context in Vale do Sousa and to supporting the effectiveness of forest management planning. They may contribute further to anticipate problems and conflicts and to develop with actors from Vale do Sousa participatory processes to address them.

1. Introduction

Pressures on forest ecosystems are very likely to increase as a consequence of socioeconomic and demographic trends. A growing population will demand more products (e.g., wood) to be extracted from forest ecosystems. At the same time, forest managers must cope with the impacts of these harvesting activities on the sustainability of the supply of a wider range of ecosystems services (e.g., wildfire protection, water, and biodiversity). Addressing this challenge requires a joint landscape-level approach to forest management planning. It requires further cooperation across ownerships with various interests and goals.

A key success factor to joint collaborative landscape-level forest management is the forest actors' involvement in the decision-making process (Martins and Borges 2007). Such involvement increases the

social acceptance of measures and actions of forest management (Bruña-García and Marey-Pérez 2014). A participatory approach is an important tool to address different actor interests in ecosystem services and thus help develop effective forest management strategies (Borges et al. 2017; Martins and Borges 2007; Paletto et al. 2016). Actor analysis is a qualitative approach, which can be used to improve the understanding of issues related to forest management and thus contribute to the effectiveness of forest management planning at landscape-level and policy-making (Martins and Borges 2007). Actor analysis is the first step in a participatory process, as it includes the initial contact with the actors, and it sets up the process for organizing the actors' network for the following participatory stages.

Specifically, actor analysis provides insight into the main actors' concerns related to the forest management, from local to national level;
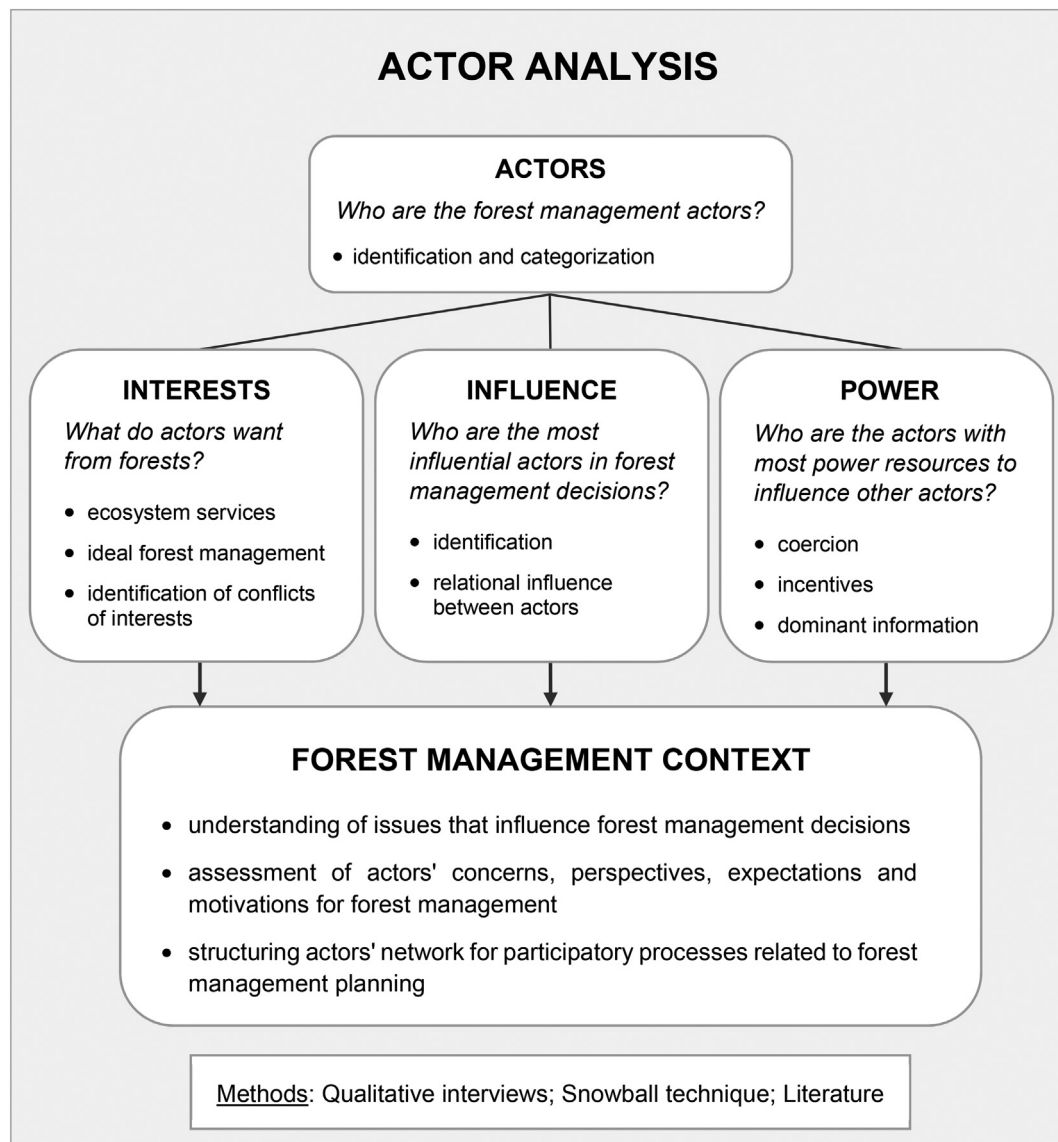

Fig. 1. Actor analysis framework for forest management context assessment.

assesses the influence and the power resources that different actors can have on forest management decisions; and identifies actors' relational influence. This kind of analysis contributes to the understanding of actors' perspectives and helps identify their motivations for forest management decisions (e.g., what forest owners want or need to diversify the provision of ecosystem services from their forest land). The actor analysis findings also provide forest managers, decision-makers or policy-makers with recommendations for the development of future actions, such as strategies for forest management, new policies or policy instruments (Raum 2018).

There are some examples of actor analysis associated with forest management in Portugal, e.g., Valente et al. (2015b) studied the main issues affecting forests and forest management in a municipality located in central Portugal, and Marta-Costa et al. (2016) analyzed stakeholder perceptions of forests and forest management in a conservation area in Northern Portugal. However, the research of actors' concepts of forest management is scarce (Feliciano et al. 2017), and no thorough analysis of actors' influence and power resources in forest management decisions has been developed in Northern Portugal. Generally, forest policy studies assume that all actors have the same interests or goals for forest management (Purnomo et al. 2012). Furthermore, in Portugal, there is a poor implementation of forest policies and management practices,

and this is mostly due to the insufficiency of the participation of relevant actors in the decision-making process (Valente et al. 2015a). This context suggests the need for a thorough characterization of the forest management in order to increase the effectiveness of planning processes.

The main objective of this research was thus to develop and implement actor analysis to characterize thoroughly a forest management context. For that purpose, actor analysis entailed the identification of the forest management actors, the characterization of their influence and power resources, the highlight of their interests in ecosystem services, of main conflicts, and of problems that may impact forest management decisions. We start by presenting a short summary of actor analysis. We use a case study – Vale do Sousa – in North-Western Portugal to illustrate the development and application of actor analysis. It is a forested landscape extending over 14,840 ha, with a forest ownership structure characterized by small forest holdings, mostly privately owned. Vale do Sousa might be considered representative of actors' interests, forest management practices and forest ownership structure (Juerges et al. 2017). Nevertheless, its forest management context has not been characterized yet. This research addresses this knowledge gap. Specifically, it develops the analysis of the actors and factors (interests, conflicts, problems, and power resources) that

influence forest management decisions in Vale do Sousa. In summary, the motivation for this research and its added value is to provide decision-makers with information and recommendations for enhancing policy instruments as well as forest management planning in joint management areas. By helping anticipate problems and conflicts this research may contribute to the effectiveness of participatory processes to develop joint collaborative management plans in Vale do Sousa. This research approach may also contribute to address joint forest management planning in other areas.

2. Theoretical background

2.1. Actor analysis

An actor is defined as "a social entity, a person or an organization, able to act on or exert influence on a decision. In other words: actors are those parties that have a certain interest in the system and/or that have some ability to influence that system, either directly or indirectly" (Enserink et al. 2010, p. 80). On the other hand, the term stakeholder refers to individuals, groups or organizations that have an interest or a stake in decision-making processes and can affect or are affected by an evaluation process or its findings (Bryson and Patton 2015; Enserink et al. 2010). In practice, both terms are often used as synonyms (Enserink et al. 2010). However, in our research, we use the term actor.

The actor analysis is rooted in the method more commonly known as stakeholder analysis (Enserink et al. 2010). An actor (or stakeholder) analysis can be described as "a holistic approach or procedure for gaining an understanding of a system, and assessing the impact of changes to that system, by means of identifying the key actors or stakeholders and assessing their respective interests in the system" (Grimble and Wellard 1997, p. 175). In addition, actor analysis produces knowledge that can be brought to the decision-making processes about the relevant actors involved in forest management (Fig. 1), i.e. their interests, influence, conflicts, problems, values, power resources, etc. (Brugha and Varvasovszky 2000), providing an overview of who is relevant in forest management and who is affected by a decision (Marttunen et al. 2017). This kind of findings and knowledge helps link forest actors to policy-making processes and forest management planning (Hermans and Thissen 2009).

The actor (or stakeholder) analysis has become increasingly popular in natural resources' management (Bryson 2004; Prell et al. 2009; Reed et al. 2009), reflecting a growing recognition of the importance of actors involved in environmental decision-making (Prell et al. 2009). However, a general evaluation of the scientific publications' frequency in the last three decades, included in the Expanded Web of Science database (2019), reveals that only 13 publications focus on actor (or stakeholder) analysis and forest management while 45 publications address actor analysis in a broader forestry context. There is a wide variety of tools and approaches for actor analysis in different contexts and disciplines (Bryson 2004; Hermans and Thissen 2009; Reed 2008; Reed et al. 2009). Methodologically, the actors' opinions, values and perceptions can be collected using different techniques from: a) primary sources, such as face-to-face interviews (using checklists or semi-structured interviews), structured questionnaires, focus groups (Enserink et al. 2010; Reed et al. 2009; Varvasovszky and Brugha 2000); and b) secondary sources, like published and unpublished documents, reports, policy statements, websites (Varvasovszky and Brugha 2000).

The actor analysis findings provide valuable information that can be used to propose or develop future policy-making actions such as new policies or strategies, policy instruments and recommendations (Raum 2018). They may be used further for the preparation of participatory processes (Hermans 2008; Nordström et al. 2010) or for forest planning, involving different forest owners in joint collaborative management areas (ZIF). In recent scientific publications, there are examples of actor (or stakeholder) analysis associated with forests and forest management

(e.g., Kane et al., 2018; Pastorella et al. 2016; Sténs et al. 2016).

In the case of Portugal, we emphasize two studies associated with forest management. Valente et al. (2015b) analyzed the main issues affecting forests and forest management in a municipality located in central Portugal. According to the findings, the most important forest function for stakeholders was timber production. The main problems affecting forest management were forest fires, aging, depopulation and the abandonment of rural activities. Further, Marta-Costa et al. (2016) investigated the stakeholder perceptions about forests and forest management in a conservation area in the North of the country. According to the stakeholders' opinions, forest management is very affected by forest fires and agrarian abandonment, along with degradation of forest areas due to depopulation, old age, and absenteeism.

The findings from these two studies have revealed that the issues that have more influence on forest management in Portugal are forest fires, aging and abandonment of forest and related activities. Wildfires have been widespread in continental Portugal, burning extensive forest areas. In the years of 2003, 2005 and 2017 wildfires burned more than 200,000 ha of forest and shrubs area (ICNF 2018). In general, over the period 2001–2017 the total burnt area in continental Portugal amounted to more than 2 million hectares, which represents 36.5% of forest and shrubland (ICNF 2013, 2018). According to the last National Forest Inventory (ICNF 2013), the forest area decreased about 4.6%, from 1995 to 2010, which corresponds to a net loss rate of -0.3%/year ($-10,000$ ha/year). The decrease of forest areas is related to the occurrence of frequent and intense wildfires and pest and diseases, particularly in maritime pine stands (*Pinus pinaster*). Forest statistics (ICNF 2013, 2018) also report other trends such as the abandonment of agriculture (-12% of area) and the increase of shrubland ($+4.7\%$ of area).

2.2. Interests

Interests are understood as being "based on action orientation, adhered to by individuals or groups, and they designate the benefits the individual or group can receive from a certain object, such as a forest" (Krott 2005, p. 8). Actors' interests are associated with their goals, cultural values, and financial incentives. Asking an actor directly about their interests is a way of determining them. However, the actors may hide their real interests (Schusser 2013). Therefore, responses may not be enough, and interests should also be assessed through observations of actor behavior (Schusser et al. 2015). Thus, interviews are a useful technique for assessing actors' behavior and their responses regarding forest interests. A realistic estimation of actors' interests for ecosystem services or forest management can be incorporated into political decision-making or forest planning and help promote the development of win-win-strategies between forest actors and policy-makers or forest managers (Böcher and Krott 2016).

2.3. Influence

Actor influence is understood as the ability to alter other actors' behavior or perception of a situation, through information and communication, from what would have occurred without that information (Betsill and Corell 2001; Paletto et al. 2016). Usually, actors apply their influence according to their interests (Frooman 1999). Besides the identification of the most influential actors, it is also essential to understand the relational influence between actors, pinpointing with whom are they linked, how are the connections and its strength. Social network analysis (SNA) can help in the identification of relational influence, mapping the relations through a social network diagram, where the nodes are actors, and the ties are the connections between them (Kosorukoff 2011). The reader is referred to Aurenhammer et al. (2018) for details about an analysis of core values and beliefs of influential forest management actors, in five European countries (Germany, Slovenia, Spain, Portugal, and Latvia).

2.4. Power resources

Many authors (Arts and Van Tatenhove 2004; Betsill and Corell 2001; Krott et al. 2014; Sova et al. 2013) debate the complexity of the concepts "power" and "influence". For instance, Sova et al. (2013, p.12) refers that "power is often used interchangeably with the concept of influence (i.e., power produces influence and influence produces power)", and Krott et al. (2014, p. 35) argue that "forest policy authors use the terms 'influence' and 'capacity' to address processes similar to power". In contrast to influence, which derives from the relationship between actors, power can be based on resources or relations (Betsill and Corell 2001; Krott et al. 2014). In this study, power is defined as "the capability of an actor to influence other actors" (Krott et al. 2014, p. 35).

The power comes from the control of relevant resources, the asymmetrical distribution of resources or/and the ability of actors to mobilize resources to obtain the desired outcome (Arts and Van Tatenhove 2004; Brass 1984). Resources enable actors to influence the environment around them, including other actors, relationships, and rules in a network, increasing their capability to control or influence other actors with few alternative sources for acquiring the resource (Brass 1984; Enserink et al. 2010). The analysis of actors' power resources is useful to support decision-making of forest policy and forest management situations, where actors have different interests, the resources are limited and controlled by some of them (Mayers 2005).

3. Materials and methods

3.1. Case study area

The case study area of Vale do Sousa is located approximately 50 km East of Porto city, in North-Western Portugal region (Fig. 2). Vale do Sousa extends over an area of 14,840 ha and corresponds to two ZIF areas (joint collaborative management area), separated by Douro River: Entre-Douro-e-Sousa (North of the Douro River) and Paiva (South of the Douro River). In Vale do Sousa forests are the primary land use. The predominant species are eucalypt (*Eucalyptus globulus* Labill), for pulpwood, and maritime pine (*Pinus pinaster* Aiton), for sawlogs, in both pure and mixed stands. The forest holdings are privately owned, small scale and fragmented in multiple blocks (e.g., a forest owner with 36.4 ha of forest land held 50 blocks).

3.2. Actor analysis

The process of actor analysis encompassed three main stages: 1) the identification of actors, their characterization and classification into groups of interests; 2) qualitative interviews, conducted in a face-to-face meeting and call conference; 3) data analysis, coding the qualitative data, for frequency statistics, for mapping the actor's relations into a social network analysis (SNA), and for conducting a power resources analysis. For this study, we used qualitative interviews as the primary source of information and complemented it with information in the literature, e.g., previous studies and reports in Vale do Sousa (e.g., Integral Future-Oriented Integrated Management of European Forest Landscapes, 2015) and Portuguese forestry legislation.

3.2.1. Identification of actors

We started the research by the identification and characterization of the relevant actors who: a) had interest in forest management and ecosystem services; b) influence, directly or indirectly, forest management; c) were related to forestry and forest management; and d) were able and willing to talk about their viewpoints and expectations about forest management issues. The actors were identified by an interactive process (Reed et al. 2009) that involved three sources of information: a) list of stakeholders from a previous research project (Integral Future-Oriented Integrated Management of European Forest Landscapes, 2015)

in Vale do Sousa (16 actors); b) research team contacts and regional Forest Owners' Association (AFVS) recommendations (17 actors); and c) results from the use of a snowballing technique, the interviewees were asked to identify other relevant actors who have influence or interests in forest management and could be involved in the actor analysis (seven actors). Not only individual persons (e.g., forest owners) were considered as actors but also organizations, institutions, and other relevant entities. Through this procedure, at the end of actor analysis, we identified, interviewed and characterized a total of 40 suitable actors (Table 1).

This approach allows flexibility in actors' identification and selection. Nevertheless, in order to avoid introducing bias in the analysis we included a) heterogeneous actors with a variety of interests; b) actors with potential influence and power over forest management decisions; c) actors with potential conflicts of interest with other actors; and d) forest owners with different forest size properties. The time frame and the financial resources constraints determined the number limit of actors interviewed. The actors were categorized into four groups according to their interests in forest management, based on interviews and literature: civil society, forest owners, market agents and public administration (Table 1). Interest groups can be defined as "organized groups with the aim to influence public policy without seeking to attain political office themselves" (Juerges and Newig 2015b).

3.2.2. Qualitative interviews

The first task of this stage was to develop the interview guide. It was first created in English and then translated and adapted to Portuguese (Juerges et al. 2017). Before the interviews, three researchers evaluated the guide for suggestions and improvements. Then two researchers pre-tested the interview guide. Also, the interviewer had training on how to conduct the interviews following the interview guide. To elicit actors' opinions with a qualitative-quantitative approach the interview guide encompassed both open-ended and closed-ended questions. It consisted of 27 questions divided into four thematic parts. In this manuscript we only present results from the Parts I and II. Part I focused on interviewed personal information, current position, role and years of work in the organization, forest-related work in Vale do Sousa within the last ten years, issues and concerns about silvicultural topics.

Next, Part II targeted the identification of the main actors' interests for ecosystem services, the current situation of forest management (decisions influence relations, conflicts and problems), and the ideal target forest according to the interviewee point of view. It elicited further a recommendation of other relevant actors to be interviewed (snowball technique). To evaluate the importance and interest for ecosystem services we provided a list of ecosystem services available in Vale do Sousa, according to the TEEB classification (TEEB 2010) and asked the interviewees the questions: "From your point of view, what are the most important forest ecosystem services in Vale do Sousa? And which is the level of importance for each forest ecosystem services, considering three levels: 0 = neutral; 1 = low importance; 2 = medium importance; 3 = strong importance?" The actors assigned high importance to the ecosystem services that they have more interest in or can get benefits from.

In order to perceive the influence on forest management decisions we asked the interviewees the following open-ended question: "Which actors or organizations are most influential when it comes to forest management decisions in Vale do Sousa?". To complement this information and analyze the relational influence of actors on forest management decisions, using the SNA technique, we asked the interviewees the following open-ended question: "With which individuals or organizations do you exchange information about silvicultural topics?". With the purpose of analyzing potential actors' coalitions, we also asked the interviewees: "Which individuals or groups do support your positions and interests?" and "Which do oppose your positions and interests?". To assess the main local conflicts and problems that may influence forest management, we asked the interviewees two open-ended
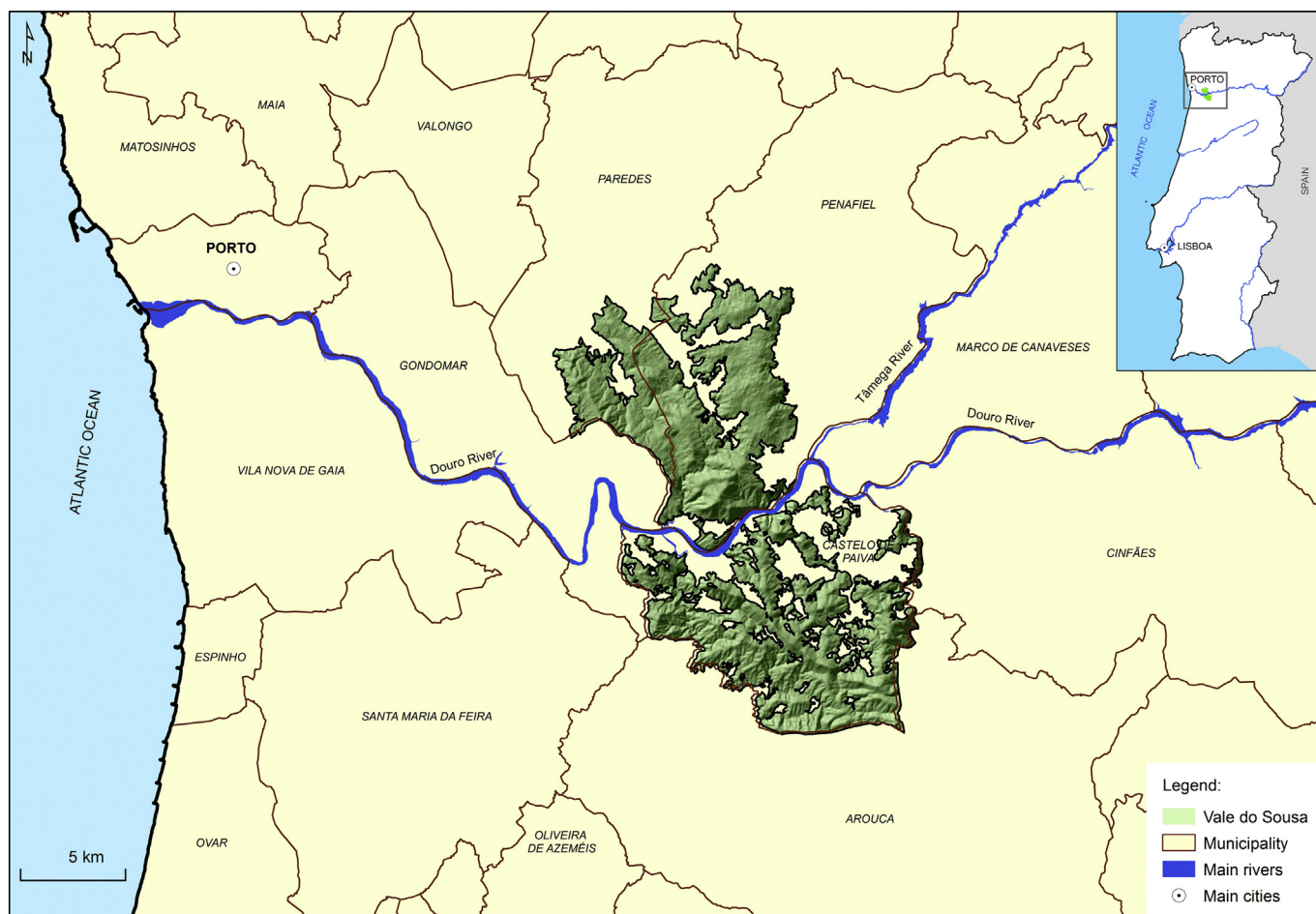
Fig. 2. Location of Vale do Sousa case study area in North-Western Portugal.

Table 1
Identification of actors, their categorization in interest groups, number of interviews and actors interviewed.

Interest group	Type of actor	Total of interviews	Actors interviewed
Civil society	Environmental NGO	3	3
	Forest certification	2	2
Forest owners	Forest owners' association	3	3
	Forest owner (non-industrial)	8	9
	Parish council with community properties	2	2
Market agents	Biomass industry	1	1
	Forest services provider	2	2
	Forest services provider and wood buyer	4	4
	Forest investment fund	1	2
	Wood industry	3	4
	Wood industry association	3	3
Public administration	Forest authority	5	6
	Municipality	3	3
	Total	40	44

questions: "What are the most important conflicts and problems in the forests of the Vale do Sousa that can influence forest management?" and "Which individuals or groups are involved in those conflicts or problems?"

The second task was interviews scheduling. An introductory email was sent to the actors explaining the importance of the study and asking if they were available for an interview. This contact was followed by phone calls to schedule the interviews. Some actors asked for the list of questions before accepting to be interviewed. The following task was the actors' interviews. The goal was to collect different opinions, perceptions and information about values, interests, influence and power resources related to forest management decisions. The interviews were

semi-structured; it means that they were relatively open but followed a common interview guide (Juerges and Newig 2015a). The semi-structured interviews allow the collection of specific data in a structured way, with significant depth or "richness", while keeping the focus sufficiently broad to accommodate other subjects and topics not considered initially (Reed et al. 2009; Varvasovszky and Brugha 2000). In the study, we carried out 36 individual interviews and four interviews with two interviewees from the same organization, totaling 40 interviews and 44 actors interviewed (Table 1). The interviews were conducted in a face-to-face meeting (35 interviews) or call conference (five interviews), between October and November 2016. We held face-to-face interviews at the actors' office, at home or another convenient

location for them.

At the beginning of the interviews, the interviewer explained: a) the goal and the methodology of the actor analysis; and b) the location and land use of Vale do Sousa with the help of thematic maps. The interviewer ensured to the interviewees that their responses would remain anonymous to allow an open dialogue (Juerges and Newig 2015a). We recorded the interviews with the verbal consent of the interviewees. Only one actor did not allow recording, so the interview was written during the meeting. We structured the interviews for one hour but lasted from 32 min to one hour and 55 min, resulting in a total of 42 h, with an average of one hour and three minutes. The same interviewer conducted all the interviews working with the support of a supervisor. Collecting qualitative data by single analysts can ensure a uniform approach and higher reliability of data (Varvasovszky and Brugha 2000). The interviewer clarified with the interviewees some issues related to their answers and asked additional questions for more details when they approached new subjects or topics. The interviewer tried proactively no to bias the interviewees' responses, letting them speak freely and not encourage them to answer in a certain way (Bhattacherjee 2012).

3.2.3. Data analysis

We used a grounded theory approach (Charmaz 2006; Glaser and Strauss 1967; Reed 2008) to analyze the data. All material from the interviews, audio and written document, was transcribed and coded using MAXQDA Analytics Pro 2018, release 18.1.1 (Verbi GmbH, Berlin, Germany) software. For statistical analysis, we used the software IBM SPSS Statistics (Armonk, NY: IBM Corp.). The data analysis encompassed the following tasks:

a) First results and draft of the code's structure: during the interviews, the interviewer wrote down notes of the key issues, observations, comments, and behaviors, which may help interpret the interviewees' answers. With these notes, we organized in an excel file the first draft of codes structure, according to the main topics and keywords identified by the interviewees. This information encompassed the results of this primary data analysis.

b) Audio processing: we structured, in MAXQDA, the codes using the excel file from the previous task. All audio interviews were transcribed and coded in MAXQDA. We decided not to transcribe the audio *ipsis verbis* due to time consumption, but a summary with the most relevant issues and topics identified by the interviewees. During the audio coding, we refined the structure of the codes due to the identification of further codes. We grouped the codes into the thematic questions totalizing 27 groups of codes and 366 sub-codes. Coding the interviews aimed at creating quantitative data for statistical analysis and qualitative information for a report, a social network analysis (SNA) and power resources analysis.

c) Data processing: codes frequency statistics analysis, counting how often the interviewees mentioned each code (influential actors, supporters and opponents, conflicts and problems); median scores of the importance level of ecosystem services; interpretation of specific topics using the transcriptions (text analysis) and presentation of the results; development of SNA for assessing the actors relational influence.

The SNA is influential for quantifying, analyzing and visualizing the role and position of actors in the network and the relational influence among them (Paletto et al. 2016). We developed the SNA using the open source GEPHI 0.9.2 software (Bastian et al. 2009). For relational influence we applied a network centrality measure – the degree centrality. This measure refers to the number of nodes (individual actors) to whom an actor was directly tied or connected to (relationship) and represents the level of communication activity - the ability to communicate directly with others (Korhonen et al. 2018; Kosorukoff 2011; Freeman 1978; Mizruchi and Potts 1998). The actors mentioned more

often have a high degree centrality. These actors have more relation and communication connections with other actors, and so they have a greater influence. The node position was determined firstly by using the "Force Atlas" algorithm layout, where the linked nodes are attracted to each other and the non-linked nodes are pushed apart, and secondly by clustering by interest group.

For analyzing actors power resources we assessed their power based on the actor-centered power approach (Krott et al. 2014), considering three criteria: a) coercion, altering behavior by force, including the threat of force and even bluffing about force that does not really exist; b) incentives, altering behavior by material and immaterial (dis-) advantage; and c) dominant information, altering behavior by unverified information trusted by the subordinate, ideology or expert knowledge. We evaluated the power resources of actors related to forest management in Vale do Sousa, on three levels: strong impact (+ + +), medium impact (+ +) or low impact (+). For this analysis, we used qualitative information from: a) actors' interviews; b) literature; and c) forestry legislation. Having strong power resources means that the actor can have a strong impact on forest management, often against the interests of others. In contrast, having low power resources indicates that the actor can apply the power strategy to some extent, but is not able to achieve his own interests against the will of others. Having medium power resources means that the actor can hold interests against the interests of some actors with few power resources but is not able to impact forest management substantially against the interests of actors who have stronger power resources. Furthermore, the categorization of actors according to their interests (Table 1) is also important to a clear identification of the powerful actors (Maryudi and Sahide 2017).

4. Results

From the 44 interviewed actors, 32 were male and 12 were female. Fifteen interviewed actors managed 2890 ha of forestland in Vale do Sousa, which represents 19.5% of the total area. Of the interviewees, the wood industry managed most of the area (15.2%), followed by parish council with community properties (2.2%) and non-industrial forest owners (2.1%). Of the nine non-industrial forest owners, six have inherited their properties and three purchase and have managed their properties for more than 20 years. The remaining actors have, on average, 15 years of experience in the forestry sector.

For 53% of the interviewed actors, the most critical issue related to their forest work is the wildfire, followed by forest management (50% of the actors) and forest certification (30% of the actors). About 65% of actors are very concerned with wildfires in Vale do Sousa and pointed out the size of the burned area, the improper use of fire and the high number of wildfires occurrences. They are also worried with the lack of forest management as a consequence of: a) abandonment or disinterest of forest owners (35% of actors); b) low investment in forest management (28% of actors); c) loss of forest value (28% of actors); and d) the complexity of the planning processes, namely the access to financial forest funds and the need for compliance with forest policy and laws (20% of the actors).

Over the last ten years the activities prominent in Vale do Sousa were fuel treatments for wildfire prevention (48% of actors), reforestation (40% of actors), thinning and eucalypt shoot selection (35% of actors), forest certification (30% of actors), environmental education and information (25% of actors) and harvesting (25% of actors). About 48% of actors considered multifunctional forestry to provide a wide range of ecosystem services, as the ideal forest management paradigm. Besides, the interviewees also indicated the need to promote joint forest management at the landscape scale (40%) as well as the forest profitability (25%).

4.1. Interests in ecosystem services

The results show some consensual ecosystem services interests by

Table 2
Interests of actors in ecosystem services according to the level of importance, by interest group.

Ecosystem service	Interest group				Total (n = 40)
	Civil society (n = 5)	Forest owners (n = 13)	Market agents (n = 14)	Public administration (n = 8)	
	Median				
Provisioning	1.0	1.0	2.0	1.0	1.0
Wood provision	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**
Game provision	1.0	1.0	1.0	1.5	1.0
Fish provision	0.0	1.0	1.0	1.0	1.0
Mushrooms	2.0	1.0	2.0	0.5	1.0
Medicinal plants	1.0	1.0	1.5	0.0	1.0
Honey	2.0	2.0	2.0	2.0	2.0
Supporting	**3.0**	2.5	**3.0**	2.0	**3.0**
Biodiversity	**3.0**	**3.0**	**3.0**	2.0	**3.0**
Habitats	**3.0**	2.0	**3.0**	2.0	2.0
Regulating	3.0	3.0	3.0	2.0	3.0
Wildfires reduction	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**
Pest and diseases control	1.0	**3.0**	**3.0**	2.5	**3.0**
Carbon sequestration	**3.0**	**3.0**	2.5	1.5	**3.0**
Climate regulation	**3.0**	**3.0**	**3.0**	1.0	2.0
Water quality	**3.0**	**3.0**	**3.0**	2.5	**3.0**
Soil erosion prevention	**3.0**	**3.0**	**3.0**	2.0	**3.0**
Cultural	**3.0**	**3.0**	**3.0**	2.0	**3.0**
Outdoor recreation	**3.0**	2.0	2.0	2.0	2.0
Landscape aesthetics	**3.0**	**3.0**	**3.0**	2.0	2.0
Tourism	1.0	2.0	2.5	2.0	2.0
Environmental education	**3.0**	**3.0**	**3.0**	2.0	**3.0**
Research & Development	2.0	**3.0**	**3.0**	2.0	**3.0**

n = number of interviews; 0.0 to 0.4 = neutral; 0.5 to 1.4 = low importance; 1.5 to 2.4 = medium importance; 2.5 to 3.0 = strong importance.

the different groups, e.g., provisioning of wood and regulation of wildfires. Actors have also a strong interest in water quality, soil erosion prevention, biodiversity, landscape aesthetics and environmental education. Nevertheless, they evince different opinions for other ecosystem services (Table 2). All groups have a keen interest in wood supply (timber, fuelwood and other biomass for energy). However, actors such as "forest owners" and "market agents" (e.g., wood industries) depend economically, directly or indirectly, on the forest. Thus, their forest management interests are for high harvesting intensities, because they are concerned with profitability, and for low amounts of shrubs in the forest because of wildfire risk. Most forest owners and forest managers support the selection of forest species and ecosystem services to address the market demand (from wood industries). Actors from "civil society" and "public administration" groups mentioned their interest in low harvesting intensities, long-term species, and different ecosystem services. The interests of nature conservation actors, from the "civil society" group, are related to the protection of forest resources. Their central ecosystem service interests are on nature conservation, with native broadleaves forests (e.g., chestnut) and a more biodiverse forest.

All groups are interested in high resistance to wildfires and pests and diseases, soil erosion prevention and water quality. The wildfires reduction has a keen interest for all actors within Vale do Sousa because of the substantial number of fires and the resulting burned area.

Wildfires are a negative incentive to forest investment and management, affecting the multifunctionality of forests. The interest of cultural services actors' is for ecosystem services and forests that produce landscape enhancement and recreational opportunities.

4.2. Influence on forest management decisions

The majority of the forest actors interviewed (27 interviewees; 68%) have indicated the Forest Owners Association as the one with more influence in forest decisions (Fig. 3). The regional Forest Owners Association (AFVS – Forest Owners Association of Vale do Sousa) has been effective in influencing forest owners and their management practices when they ask for its technical advice. However, in general, forest owners apply traditional forest management practices without the benefit of a forest management plan or technical advice. Typically, the forest owners decide according to the example provided by neighbors ("forest management by imitation"). They also point out the Wood industry (20 interviews; 50%), due to the profitable forest management they practice and the market demand. Furthermore, they mentioned the National Forest Authority (14 interviews; 35%) and the Municipalities (13 interviews; 33%) because they define regulatory framework for forest management practices and they also provide technical advice when this is requested.

During the interviews, the actors frequently argued that proper forest management example is one of the most important tools to influence decision-making, because *"forest owners want to see good examples of forest management, only in this way they can be influenced, doing through the "imitation" of what is profitable"* (PA5 - Regional forest authority). Moreover, *"focus on forest management demonstrating with examples that producing wood in a well-done manner, observing the good forestry practices and forest certification systems, with the least impact of forest operations is profitable. It is needed to scale the forest, and the ZIF can be a solution. It will be important to know how to integrate the different actors in forest management"* (MA3 - Pulpwood industry). However, *"forest owners would like to do forest management following good examples, but they did not even have money to manage forest fuels"* (FO11 – Parish council with community properties).

The SNA diagram of relational influence according to the degree of centrality (Fig. 4), shows that there are three distinct clusters of actors:

a) The actors who related with a large number of actors and can be considered as those who can influence or be influenced more significantly: regional forest owners association (FO1; FO2); national forest owners association (FO13); national forest authority (PA1); forest services providers association (MA14); municipalities (PA4, PA3; PA2); regional forest services providers and wood buyer (MA8; MA7, MA11; MA6); pulpwood industries (MA3; MA2).

b) The actors who related with a medium number of actors: non-industrial forest owners (FO4; FO3; FO6; FO5; FO7; FO8; FO9; FO10); regional forest authority (PA6; PA5); forest certification (CS5); wood industry associations (MA12; MA5).

c) The actors who have few relations and therefore can be considered as the ones with the weakest influence: regional forest services provider and wood buyer (MA9); wood industry association (MA10); environmental NGO (CS4, CS1, CS3); parish council with community properties (FO11; FO12); regional forest authority (PA8; PA7); forest certification (CS2); pine wood industry (MA4); biomass industry (MA13); forest investment fund (MA1).

We evaluated the coalitions between actors analyzing the supporters and opponents of the interviewees. Most interviewees (25 interviews; 63%) identified the regional Forest Owners Association (AFVS) as their main supporter, followed by forest owners (8 interviews; 20%) and associates of the interviewee entity (7 interviews; 18%). About 60% of the actors did not identify opponents, which does not necessarily mean that there aren't opponents. From these results and actors' interests,
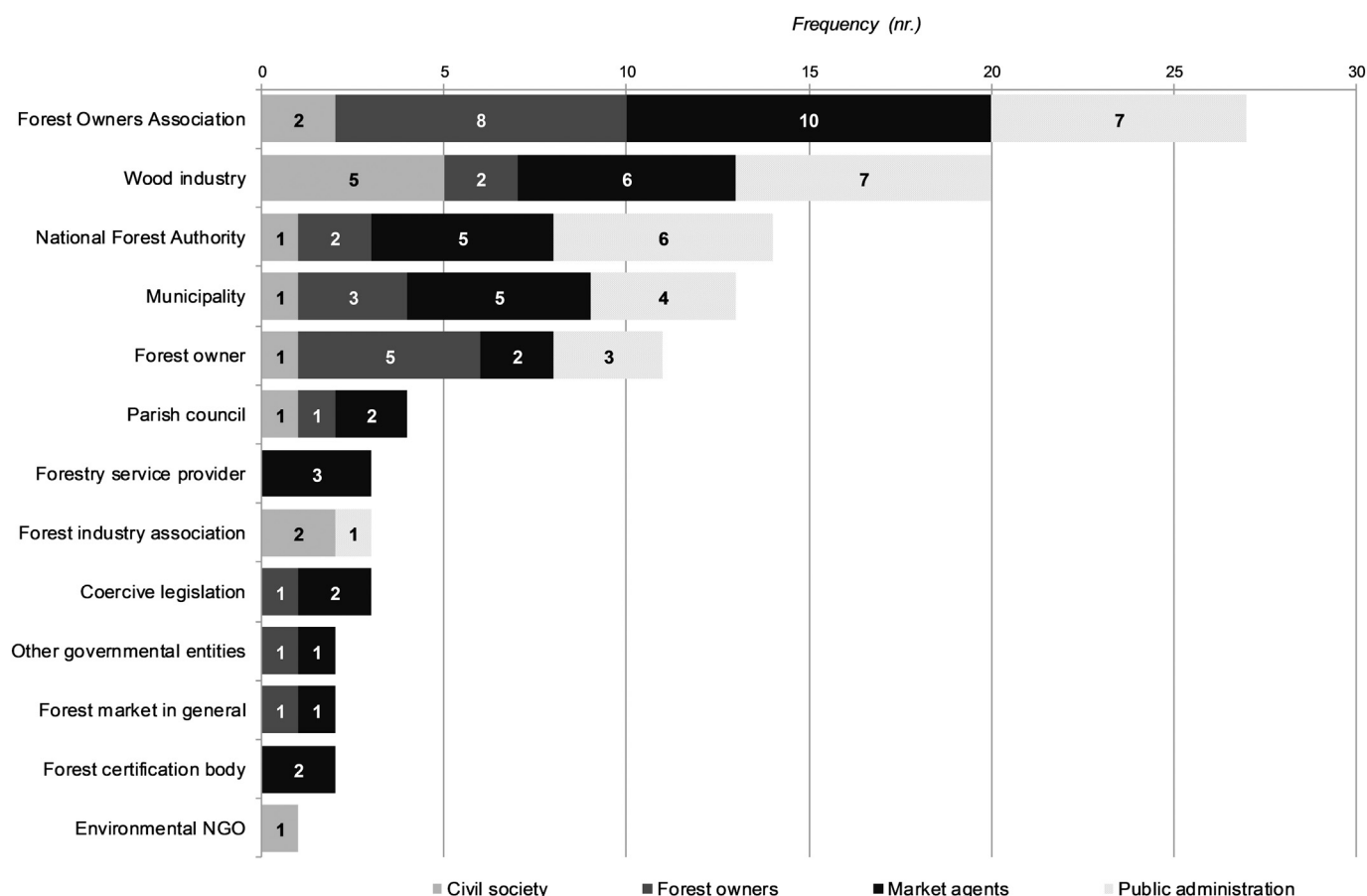
Fig. 3. Actors with influence when it comes to forest management decisions in Vale do Sousa, by interest group.

influence and actions targeting forest management it was possible to identify three main coalitions:

- Economic coalition, consisting of market agents (wood industry, wood buyers), forest owners (industrial and non-industrial) and forest managers. These actors have a strong interest in the economic profitability of the forest. The dominant model associated to forest management is focused primarily on wood provision. For example, this coalition opposes policy constraints to the use of eucalyptus plantations.
- Nature protection coalition, encompassing the national forest authority, municipalities, environmental NGO, forest certification bodies, forest owners with no economic interest in the forest (e.g. parish councils with communal properties). Their forest management focus is on the protection of forest resources, e.g. soil erosion and water quality, as well as the promotion of biodiversity and forest species diversification. This coalition is mostly interested in supporting and regulating forest ecosystem services.
- Social and recreational coalition, encompassing recreational and leisure organizations, motorized enthusiasts, population in general that develop recreational activities in the forest. Their interests have little reflection in national forest policies. However, in Vale do Sousa their interests and actions have an impact on forests and can be influential at the local level since they have free access to the forest even if it is private. Their forest management model stresses the recreational point of view.

4.3. Conflicts and problems that influence forest management decisions

Conflicts and problems influence forest management decisions. The interviewees point out distinct conflicts of interest in Vale do Sousa.

Nevertheless, many agreed in listing two major conflicts. First, half of the interviewees stated that the outdoor motorized recreation activities, particularly the unorganized activities that take place in the forest without the authorization of forest owners, is the major forest management conflict in Vale do Sousa. These activities cause three types of impacts: a) on the forest, by the opening of rails in the forest stands, causing the destruction of the vegetation cover (forest and riparian galleries) and consequent soil erosion; b) financial, the forest owner has to pay for the recovery of the forest and the infrastructures (e.g., forest roads); and c) social, because of the stress to the forest owners (forest properties invaded and destroyed) as to the local population due to the noise it causes. This conflict is between the economic and nature protection coalitions and the social and recreational coalition. The interviewees mentioned that this type of activities in forests should be regulated and controlled because of its negative impact on forests and the pressure on forest owners and the local population. *"There is an added advantage of organized activities as serve as surveillance regarding wildfires. However, the conflicts that occur are related to the unorganized motorized activities in the forest, i.e., the ones that happen without authorization request to cross private properties"* (MA2 – Pulpwood industry).

The second conflict, identified by 40% of the interviewees, was between the monoculture of eucalypt for wood supply and biodiversity. This conflict is between forest owners and managers (economic coalition) and the National Forest Authority and environmental NGO (nature protection coalition). *"The lack of forestry planning, on the landscape scale, leads to the difficulty of the owner to understand that on his property he cannot plant eucalyptus in ecological corridor area without being compensated for this (trade-off of not having a productive forest to provide a non-market ecosystem service). Is important to find payment mechanisms for non-market ecosystem services so low productive areas can be a conservation*
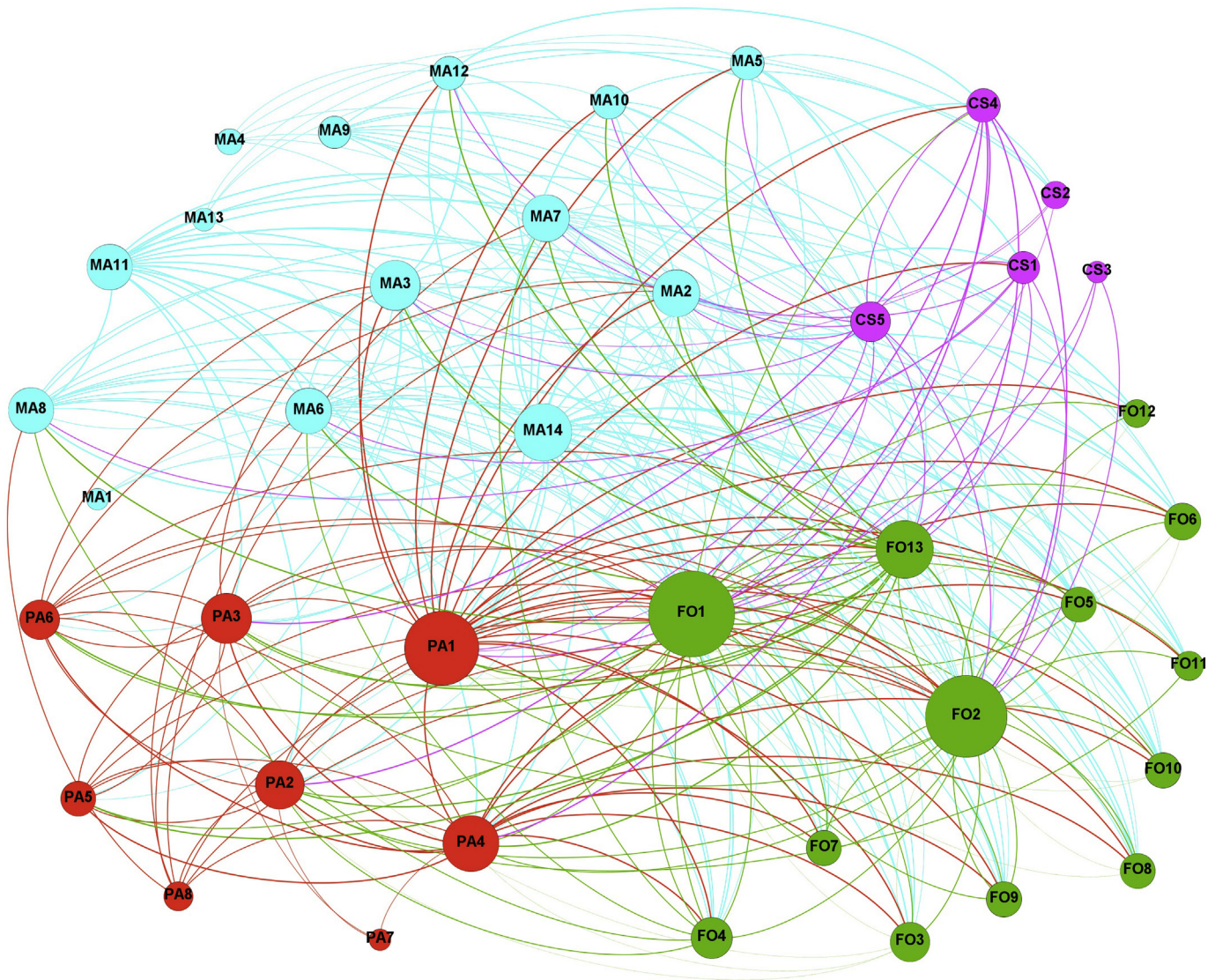
Fig. 4. Social relational influence network (n = 40). Nodes are sized according to the degree of centrality, the larger the node, the more information is exchanged by the actor with other actors (CS = civil society; FO = forest owners; MA = market agents; PA = public administration).

area. These conflicts should be managed through dialogue between forest owners and public administration" (CS1 – National environmental NGO).

The interviewees identified a range of problems in Vale do Sousa that influence the decisions (Fig. 5). For most of them (37 interviewees, 93%) the problem that can influence most forest management decisions is wildfire risk. Over the period, 2001–2017, a total of 16,756 ha were burnt in Vale do Sousa. In 2005 about 5383 ha (36.3% of total area) and in 2017 circa 4006 ha (27.0% of total area) were burned, respectively. These events greatly influence forest management decisions of forest owners and forest managers. They prefer short rotation eucalypt stands (10 to 12 years coppice) because, overall, the income loss is smaller in the case of a wildfire occurrence (big fires cycle is about ten years). Therefore, forest species with longer rotations, such as maritime pine or chestnut *(Castanea sativa* Mill), are less preferred by forest owners.

"In Vale do Sousa there is a serious problem of wildfires, with a high number of fires occurrences. It will be important to solve the problem of wildfires as well as the value of the forest. The application of good forestry practices will address many of the problems of wildfires, and its consequences, like soil erosion" (MA3 – Pulpwood industry) and *"wildfires are so problematic that it leads forest owners to give up the forest management"* (FO7 – Forest owner). Furthermore, *"climatic conditions favor the rapid development of shrubs, increasing the fuel load and making the task of fuel*

management more difficult and costlier for forest owners. They only invest in forest management if the forest has value or is mandatory by law. Is also important to change the use of fire in the forest; it can be achieved through information, forest awareness, and forest management" (PA5 – Regional forest authority).

The invasive alien species are also a problem (31 interviewees, 78%) because of the difficulty in its control, which is scattered throughout Vale do Sousa. In the managed forest areas, it is not a problem because invasive alien species are controlled. However, the interviewees stated that *"the wildfires promote the appearance of invasive alien species"* (CS4 – National environmental NGO) and *"if there is no forest management will be complicated to control invasive alien species. Where there is acacia, the other forest species have serious difficulties to survive. Moreover, the wood industry does not want acacia wood"* (MA6 - Regional forest services provider and wood buyer).

Pest and diseases have affected the forest and are nowadays a severe problem in Vale do Sousa (30 interviewees, 75%). Earlier, the pine nematode *(Bursaphelenchus xylophilus)*, and more recently the *Gonipterus platensis* in the eucalyptus stands. According to the interviewees, this problem is also related to the wildfires because *"pest and diseases are one of the collateral damages of the wildfires caused by the imbalance in the forest ecosystem"* (MA14 - Forest services providers
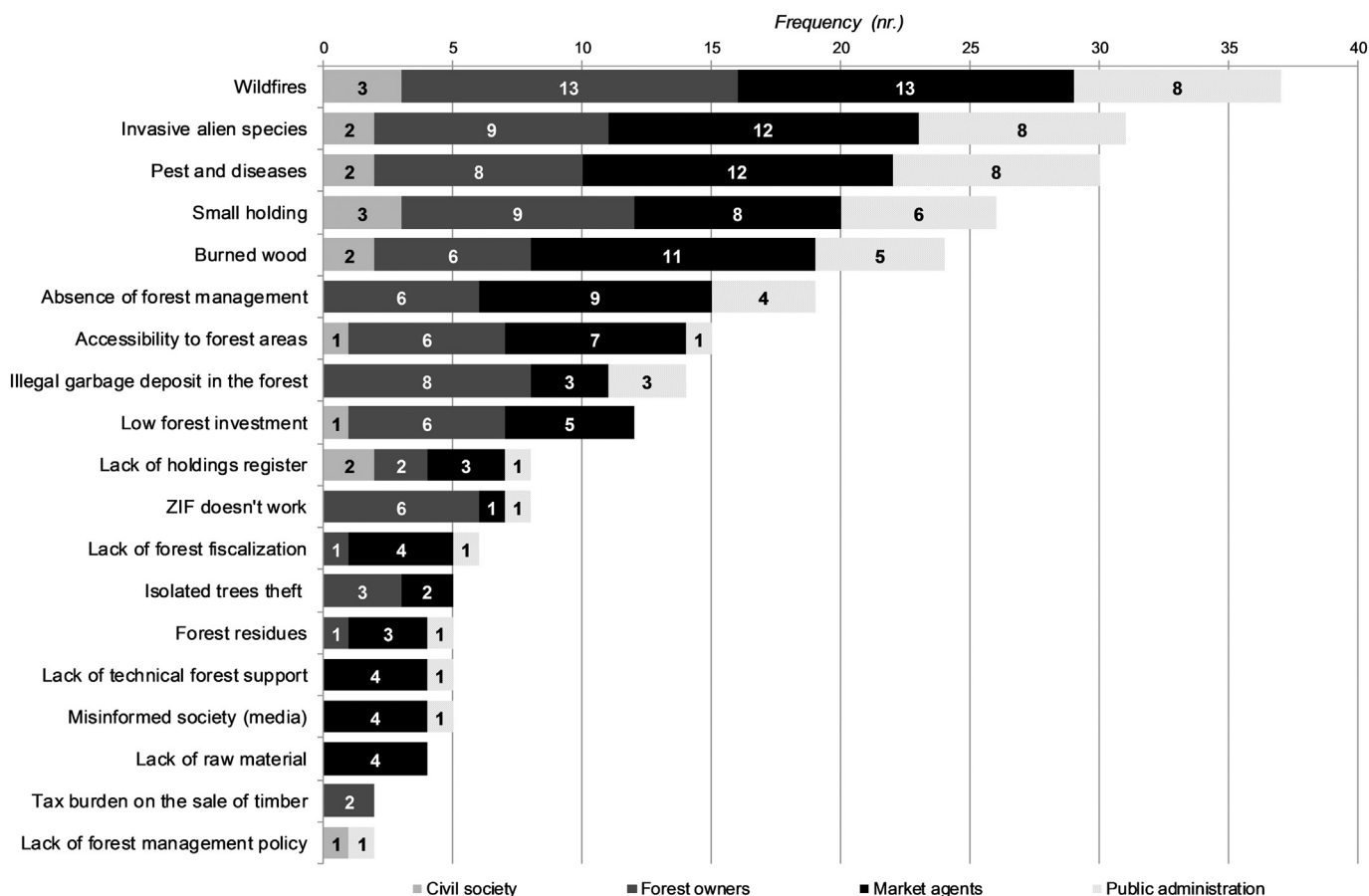
Fig. 5. Problems that can influence forest management decisions in Vale do Sousa, by interest group

association) and *"extensive areas with the same species provide the spread of pests and diseases"* (CS4 - National environmental NGO).

4.4. Power resources to influence the forest actors' decisions

The results indicate that "market agents" and "public administration" groups have the strongest power resources to impact forest management in Vale do Sousa, while "forest owners" and "civil society"

groups have a medium power (Table 3).

The "market agents" group controls the wood market prices and therefore employ indirect coercion in the choice of species by the forest owner. The direct coercion is related to the demand and control of wood or biomass which the industry wants to receive. The demand for wood and the prices offered are incentives for forest owners to follow the preferences of the timber industries in the choice of forest species as well as of the intensity of cutting. Further, some actors within the

Table 3
Overview of power resources of different interest group in Vale do Sousa.

Interest group	Means of coercion	Incentives	Dominant information	Overall power resources
Civil society	+ +	+ +	+ +	Medium
Environmental NGO	+	+	+ +	Low
Forest certification	+ +	+ +	+ +	Medium
Forest owners	+ + +	+ +	+ +	Medium
Forest owners' association	+ +	+ + +	+ + +	Strong
Forest owner (non-industrial)	+ + +	+	+	Medium
Parish council with community properties	+ + +	+	+	Medium
Market agents	+ + +	+ + +	+ + +	Strong
Biomass industry	+ + +	+ +	+ + +	Strong
Forest services provider	+ + +	+ + +	+ + +	Strong
Forest services provider and wood buyer	+ + +	+ + +	+ + +	Strong
Forest investment fund	+ +	+ +	+ + +	Medium
Wood industry	+ + +	+ + +	+ + +	Strong
Wood industry association	+ +	+ +	+ + +	Medium
Public administration	+ + +	+ +	+ + +	Strong
Forest authority	+ + +	+ + +	+ + +	Strong
Municipality	+ + +	+	+ +	Medium

+ + + = strong impact; + + = medium impact; + = low impact.

"market agents" group do training actions for forest owners and other actors, advising them about the species to select and how to manage the forest. Unverified information on forest management is disseminated in direct contact with forest owners, providing advise. Some industries play a role in the enhancing of forest management practices by developing research, owning nurseries and publishing technical forestry information.

The "public administration" group has a coercive authority through forestry policy, legislation, and authorizations related to forest management. The power resources are mainly *"through legislation and regulations that determine how forest management should be done. Besides, the approval of the forest management plans by the public administration constraint the individual options for the forest property"* (PA1 - National forest authority). The group establishes material incentives through the financing of forest management measures and immaterial incentives over the national forest management strategy, legislation and other obligatory regulations. *"The financial incentives are a way of motivating forest management"* (PA5 - Regional forest authority). The group has its own information (forest inventory and several technical studies). They hold technical sessions and training actions and develop research in partnership with Research Centers. They publish technical forestry information.

The coercion of "forest owners" group is based on the direct access to forests and decision-making power over properties based on their private property rights. In Vale do Sousa forests are mainly privately owned. Therefore, private forest owners have the ultimate forest management decisions (e.g., species, harvesting). The Forest Owners Association incentives morally forest owners to manage their forest and not to abandon it. They also provide to its members and other forest owners' technical advice and information about public policy instruments related to forests.

The Forest Certification body, from "civil society" group, exerts coercion through the grant or withdraw of the forest management certification. This actor establishes immaterial incentives by appealing to moral standards, giving a label for more sustainable forest management and providing, indirectly, market incentives due to increased prices for certified timber. The environmental NGO defends biodiverse forests and develops diverse projects to persuade the plantation of an autochthonous forest. This actor has a limited impact in Vale do Sousa but establishes immaterial incentives by appealing to moral and norms as environment and nature advocates. The group has several studies and publications related to forest management. The groups "civil society", "market agents" and "public administration" disseminate unverified information on forest management in lobbying, public relations, contribution to research projects, reports, technical documents and general participation in public discourse (workshops, seminars, meetings, working groups, media).

Results show that the strongest actors, i.e. the actors with the same overall power resources classification (strong in the three levels of power analysis) are: "Forest services provider", "Forest services provider and wood buyer", "Wood industry" and "Forest authority". The three actors from the "market agents" group are directly involved in forest management either by working with forest owners or else by managing their own forest areas. The "Forest authority" is indirectly involved in forest management by both a) coercion, e.g., authorizing (or not) specific management options (e.g. species use), and b) providing subsidies. Forest management is strongly influenced by these four actors because they have relevant power resources to influence the others actors' actions and decisions.

5. Discussion

The purpose of this study was the development of actor analysis to characterize the forest management context in Vale do Sousa. This entailed the identification of the main actors and of issues that influence the forest management decisions (interests, influential actors,

conflicts, problems, and power resources). This knowledge is needed to increase the effectiveness of forest management planning. These results may help ZIF managers develop a collaborative landscape-level management planning process to target the provision of a wide range of ecosystem services. The development of this process will benefit from the actor analysis results as it calls for the coordination of decisions made by the actors involved. The actor analysis highlighted a strong interest for wood provision and wildfires reduction, and also revealed a keen interest in water quality, soil erosion prevention, biodiversity, landscape aesthetics and environmental education. This may help managers set priorities to engage ownerships and actors in a multiple objective forest management planning process.

Moreover, the identification of the main conflicts and problems that impact and influence forest management is also very useful to ZIF managers. The findings highlight the need to balance the interests between the economic and nature protection coalitions and the social and recreational coalition. The unorganized outdoor motorized recreation activities are one of the conflicts of interest that can most negatively influence forest management in Vale do Sousa. Actors considered this conflict as a disincentive to forest management. The proximity of Vale do Sousa to the second largest city in Portugal leads to an intensive use of the forest for a range of cultural activities. This pressure and the resulting conflict reinforce the importance of integrating cultural services into forest management planning by ZIF managers. Furthermore, these findings highlight the need of regulation and supervision of outdoor motorized recreation activities, safeguarding the interests of forest owners. The effectiveness of this regulation may build from the promotion of awareness among sports enthusiasts and the population in general about the impacts of these activities. ZIF managers may promote further the dialogue between forest owners and sports enthusiasts to develop a negotiated balance between interests in provisioning and cultural services.

ZIF managers also need to balance conflicting interests between wood production and biodiversity. Actors concerned with the profitable use of forests (economic coalition) are not opposed to nature conservation and increased biodiversity as long as they receive payments for the ecosystem services they provide. Thus, this conflict might be addressed by adequate policy instruments to internalize forest externalities. Nevertheless, the Forest Owners Association as one of the most influential actors in forest management may support the development and negotiation of multiple objective landscape-level forest ecosystem management plans and the estimation of opportunity costs associated with conservation strategies. This may be influential to the design of adequate policy tools to promote the supply of biodiversity.

The results also underline the importance of forest management to address the main problems in Vale do Sousa acknowledged by the interviewees - wildfires, invasive alien species, and pest and diseases. According to the interviewees' experience, forest management plans may be designed to prevent and control invasive alien species as well as to consider a wider range of ecosystem services. The impacts of wildfires can be reduced with landscape-level planning targeting wildfire resistance levels. ZIF managers may use this information to help forest owners understand the spatial and temporal interactions of forest management decisions and their impact on the provision of regulatory ecosystem services. According to the interviewees the abandonment, the disinvestment, the disinterest in forest management and the decrease in forest value result from the lack of strategies for addressing the conflicts and the problems to forest management. This research has provided information that may be useful to develop these strategies by ZIF managers, namely, to motivate forest owners to develop landscape-level forest management to contribute to a forest more resilient to wildfires and to pest and diseases.

This research showed further that almost half of the interviewees target a multifunctional and profitable forest providing a wide range of ecosystem services. However, it highlighted further that different interests for ecosystem services can lead to different ideas regarding the

ideal forest management for Vale do Sousa. This diversity of interests suggests the use by ZIF managers of participatory techniques to help actors discuss and negotiate their interests. This research also showed that payments for non-market ecosystem services would be influential to develop a multifunctional approach to forest management that can be economically sustainable for forest owners.

Powerful actors, from "market agents" and "public administration" groups, can have a relevant role in promoting a landscape-level multifunctional forest manaagememt approach, mostly through material incentives and information. Namely, it will be important to develop business models to attract payments for non-market ecosystem services. The "public administration" group manage financial incentives programs and may promote this kind of mechanisms. The "market agents" group can support the non-market payment mechanisms as a social responsibility for the use of natural resources. These actors have dominant information and can work together to disseminate forest management alternatives that integrate different ecosystem services. This information should be clearly explained, with reference and demonstration of current examples: a) the basket of ecosystem services available in Vale do Sousa (what); b) the forest management practices (how to do); and c) all the costs and expenses, i.e., the net present value (how much).

The results of this actor analysis can be compared with other studies reported in scientific publications. Our findings reinforce that wildfires are the most influential problem in forest management decisions in Portugal (Marta-Costa et al. 2016; Valente et al. 2015b). They also confirm the actors' interests for cultural and regulating services (Clemente et al. 2015). The findings can be different according to the region and socioeconomic context. For example, in the Aurenhammer et al. (2018) research, market and state were considered the most influential actors. Conversely, in this study, the Forest Owners' Association was acknowledged as the actor with more influence. The present research analyzed the actors involved in forest management and presents information not yet documented in scientific studies, namely the relational influence and power resources in a Portuguese region. This research is influential to promote adequate forest management strategies.

Actors' opinions and perceptions can be collected using different techniques such as interviews, focus groups, questionnaires (Brescancin et al. 2018; Varvasovszky and Brugha 2000). Interviews are the most personalized form of data gathering (Bhattacherjee 2012). The main advantages are: a) building trust and relationships with actors (Reed et al. 2009); b) collecting qualitative and quantitate information asking the actors for more details about their opinions; c) understanding their behavior and emotions; d) explaining the questions and avoid misunderstandings; and e) all actors have the same opportunity to express themselves on the same issues.

Nevertheless, interviews are time and financial consuming technique and need personal involvement and interviewer training. The interviewees identified 19 more actors they considered relevant for the study. However, due to the time and budget limitation, it was not possible to interview them. Although, they were invited to take part in other participatory events in the frame of the study (workshops, questionnaires). Interviews and processing were time intensive; the actors' interviews were long (over one hour), resulting in 42 h of recording to process and analyze. Nevertheless, we got a rich understanding of the different points of view related to actors' forest management decisions. Another limitation of the study is related to the period of the interviews, since the responses of the actors may be associated with recent events that are more present in their minds. In this study, we conducted the interviews in the autumn, at the end of the fire season. Although the fires were recurrent in Vale do Sousa, two months before the interviews one fire burned 1763 ha (11.9% of Vale do Sousa). All actors mentioned the wildfires of that year and the problems associated with it, and half of them talked about that specific fire in Vale do Sousa.

Only a complete understanding of the different actors' opinions of

forest management can support decision-makers in the development of strategies for improving synergies (Brescancin et al. 2018) between forest management and market and social demands. The actor analysis, as a consultation and collaboration tool, helps increase trust in decision-makers and the transparency of the decision-making process (Brescancin et al. 2018). The results from this research are useful to support policy-making as well as ZIF forest management planning.

6. Conclusions

The findings of this study emphasize the importance of the actor analysis as an analytic tool to provide an understanding of actors' perspectives, expectations and concerns. This analysis provides a snapshot of the forest management context for Vale do Sousa. It highlights the need to integrate different interests in forest management and to address conflicts and problems. These results have several implications for forest owners, forest managers, ZIF managers and decision-makers. It provides information useful to develop more effective forest management planning processes and forest policy programs. This is influential to promote a joint landscape-level forest management.

First, it gives a big picture about the ecosystem services that are of strong importance for actors and need thus to be addressed by forest management. Wood provision and wildfires reduction ranked very high and are consensual for all interest groups. Also, with high importance are the biodiversity, water quality, soil erosion prevention, landscape aesthetics and environmental education. This leads us to conclude that the multifunctional forest management approach is the one that best reflects the diversity of interests and ideals of actors in Vale do Sousa. Second, this study identifies the conflicts of interests that can be a disincentive for forest management, particularly between the provisioning services (economic and nature protection coalitions) and cultural services (social and recreational coalition), as well as between biodiversity (nature protection coalition) and provisioning services (economic coalition). This research highlights that these conflicts may be addressed through participatory forest management and the negotiation of a consensual forest management plan that can integrate different interests and objectives.

Third, the findings show that the major problems are, in addition to wildfires, the invasive alien species and pests and diseases. According to the experience of the interviewees, these problems can be minimized by landscape-level forest management. Fourth, the results reveal that the most influential actors are the Forest Owners Association, Wood Industry, National Forest Authority and municipalities. However, according to actors, good examples of forest management have also a great influence in forest managers decisions, since often they practice a "forest management by imitation". Thus, it will be relevant to develop forest management examples in Vale do Sousa by the influential actors to forest owners, forest managers and decision-makers that may be sued to demonstrate the type of forest management to follow. The groups with strongest power resources to impact forest management in Vale do Sousa, the "market agents" and the "public administration", can have also an important role to accomplish this task.

The actors involved in this research revealed a great interest in communicating their preferences and objectives as well as participating in the search of forest management solutions to Vale do Sousa. Future research will build from these findings to focus on the development of participatory multi-criteria decision analysis to integrate further the actors' priorities and expectations in the Vale do Sousa joint landscape-level management planning process. The diversity of interests in ecosystem services enhances the use of this technique that can enable actors to combine alternative forest management programs according to the diversity of ecosystem services in a trade-off analysis.

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Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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