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Payment for Targeted Grazing: Integrating Local Shepherds into Wildfire Prevention

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Abstract: Wildfires are one of the most prominent risks for Mediterranean forests, reducing the flow of ecosystem services and representing a hazard for infrastructure and human lives. Several wildfire prevention programs in southern Europe are currently incorporating extensive livestock grazers in fire prevention activities to reduce the high costs of mechanical clearance. Among these the Andalusian network of grazed fuel breaks, the so-called RAPCA program, stands out for its dimension and stability over time. RAPCA currently works with 220 local shepherds who, with their guided flocks maintain low biomass levels in almost 6000 ha of fuel breaks in public forests to meet fire prevention standards. This work analyses the institutional design and performance of the RAPCA payment scheme under a payment for environmental services (PES) framework. Results show effectiveness of the payment scheme while efficiency is achieved through savings relative to the mainstream mechanized biomass removal, as well as through reduced information asymmetry. High-level and stable political commitment has been crucial for the emergence and consolidation of RAPCA. Moreover, key intermediaries and sound monitoring practices increased levels of trust amongst involved actors. Beneficial side-effects include social recognition of shepherds' activities and reduction of their friction with forest managers.

Keywords: Mediterranean; results-based payments; PES scheme; fuel break; public forests; environmental conflict; economic incentives; positive externalities

1. Introduction

Wildfires are one of the most important threats to European Mediterranean forest ecosystems and are expected to become larger and more severe due to fuel accumulation and drier climatic conditions [1]. Land-use changes associated with rural exodus and abandonment of traditional rural activities produced a reduction on the traditional rural mosaic that provided sufficient fuel fragmentation [2,3]. The so-called fire paradox (increase in biomass due to low levels of forest management and successful fire suppression) and lengthier dry periods are leading to increasingly severe wildfires that threaten not only forest ecosystems but also infrastructure and human lives [4–7]. Forest fire prevention arises as an essential way to make wildfires easier to suppress, reducing their severity [8]. However, the increased needs demanded by fire prevention activities contrasts with the high costs of mechanical clearance of biomass and the limited budgets of public administrations [9].

It is in this context where several wildfire prevention programs in southern Europe have begun incorporating extensive grazing for the purposes of biomass reduction and fire prevention [10,11]. Different studies conducted in the Mediterranean region have shown that, when adequately managed, targeted grazing can constitute a suitable and effective tool for reducing biomass [10,12–14]. It may also produce significant savings for fire prevention services in comparison to the costs of mechanical biomass reduction, and support many other environmental services [15–17]. The use of grazing to reduce understory biomass does also attempt to reconcile the use of products and services from the natural environment and pursues efficient land use through the production of meat and milk [14].

In this framework the network of grazed fuel breaks of Andalucia (the southernmost region of Spain) known as RAPCA (*Red de Áreas Pasto-Cortafuegos de Andalucia*), stands out as one of the most relevant and successful examples of the integration of extensive grazing into wildfire prevention practices due to its dimensions and stability over time. The program rewards extensive breeders for their biomass control services in fuel breaks located in public forests; the amount received as compensation depends on the size and difficulty of the area allocated to each shepherd, as well as the degree of accomplishment of the task [18].

The RAPCA scheme has been the subject of a number of studies assessing its ecological performance [13,19–21] or the typology of extensive farms involved in the program [22]. However, the institutional fitting of this initiative has been scarcely addressed, despite the fact that its continuity over time may be highly dependent on the interactions between the agents and institutions involved in the program.

In this study, we aim to analyze the conditions that allowed RAPCA to emerge as a new institution and its performance in achieving the desired objectives of biomass reduction. The novelty of our study resides in the assessment of RAPCA features within the framework of payments for environmental services (PES). To our knowledge, targeted grazing initiatives have not been analyzed under this framework so far. Lessons learned from this analysis may be useful for similar initiatives sprouting in Mediterranean regions.

PES schemes are novel institutional arrangements that compensate producers for positive externalities [23], channeling financial resources from ecosystem service beneficiaries (i.e., society as a whole in the case of wildfire protection) to service providers (i.e., the shepherds). PES have become popular as an add-on to regulatory approaches [24] that stimulate changes to the behavior of resource managers through the provision of economic incentives [25].

2. Theoretical Framework

2.1. PES Definition

PES schemes aim to connect people who function as environmental service (ES) providers (ES sellers), such as ecosystem managers, to people who are the direct or indirect beneficiaries of these ES (ES buyers) in contract-like arrangements [26]. The mainstreaming of the concept of ES in environmental policies has run in parallel with the increased attention towards PES.

First PES were developed under this label in Costa Rica. Since then, many more have followed, often in less industrialized countries where institutions are weaker [27], namely Central and South America [24], and have been pushed forward not only as environmental protection methods but importantly as pro-poor measures [28]. However, the idea has also been adopted to solve environmental externalities in more industrialized countries (e.g., [29]).

Wunder [30] defines PES as voluntary transactions between service users and service providers that are conditional on agreed-upon rules of natural resource management for generating offsite services. The offsite services term that is included in this definition emphasizes links to the concept of externality. The implication is that the spatial divide between ES provision and use calls for PES contracts [30]. Ferraro [31] considers that PES generally have two common features, voluntariness and participation involving a contract between the ES beneficiary (or its representative) and the

land manager. The widespread definition of PES provided by Wunder in 2005 [32] has been largely contested in ecological economic spheres for being too restrictive and normative [33,34]. However, it aptly captures the theoretical foundations that distinguish PES from other environmental schemes. First, the voluntary nature of the transaction presupposes that ES providers can choose to either respond or not to the monetary incentives offered by the potential user, unlike in command-and-control approaches [32]. Second, PES requires a transfer of (monetary or in-kind) resources from beneficiaries to provider, possibly via an intermediary, which is directly tied to the environmental goals [35].

Conditionality and additionality are also important features in differentiating PES from other types of incentives. Conditionality is most often based on land management proxies rather than a more complex measurement of the actual services delivered, since these may be mediated by natural processes and third-party effects [36]. Additionality in PES takes place when outcomes are measurable and it is verified that these have gone beyond what would have happened in the absence of the scheme [37]. Hence, the PES program produces a change in the behavior of the service provider.

2.2. Agents Participating in a PES Scheme

At a minimum, PES schemes require two broad groups of agents: ES beneficiaries and ES providers who affect the supply of ES. Often, a third group termed intermediaries is needed. Huber-Stearns et al. [38] define intermediaries as those agents who take on roles that connect and facilitate transactions between users and providers. Intermediaries may include all sorts of organizations (from private, public, academic or civil sectors), and may connect PES stakeholders across different scales (from local to international) [39,40].

The agents participating in a PES scheme determine the program structuring, the distribution of economic and institutional benefits and costs, and the conflicts that may arise [25,41,42]. Agents' interactions are shaped by socio-cultural relationships, historical contexts, and the nature of power and authority relationships. These interactions and their dynamics develop into formal and informal norms [43]. Furthermore, agents may take on different roles at different stages of PES development from initial feasibility assessment to program design, implementation, and adaptation [38]. These actor-related considerations (along with ecological, economic, and political contexts) are integral in understanding the set up and functioning of PES schemes as well as in determining if a PES scheme achieves its intended outcomes [44,45].

2.3. Institutional Arrangements

The concept of institutions is generally understood as "the rules of the game", consisting of both the formal and informal human-devised constraints that govern individual behavior and structure social interactions [46]. In an environmental context, institutions regulate human interactions with natural resources, therefore affecting environmental change processes [47]. Corbera et al. [25] conceptualize PES as new institutions designed to enhance or change natural resource managers' behavior in relation to ecosystem management through the provision of economic incentives.

The development of PES schemes takes place within already-existing institutional structures, amongst which they must conform in order to become effective and efficient within their working environment [26].

Corbera et al. [25] analyze the institutional aspects of PES considering three main institutional dimensions: design, performance and interplay. Design aspects encompass the reasons why the PES is proposed as a new instrument and the main features of the ES; performance alludes to the achievements of the project, and interplay considers the interactions of PES schemes with other institutions. The interplay of the PES scheme with other institutions can be both horizontal and vertical, depending on whether interactions occur between institutions operating at the same or at different decision-making levels, and is thus crucial for an understanding of the nature of these interactions and the role they play in the success of the PES scheme [26].

2.4. Performance Indicators

Impact evaluation of PES schemes has mostly focused on assessing how well PES has delivered environmental outcomes, which is typically measured by the identification of a counterfactual (i.e., what would have happened in the absence of the program).

Efficiency and effectiveness are the most commonly employed indicators to evaluate the success of PES schemes. Efficiency considers the costs at which these achievements were made while effectiveness relates to the extent of the achievement of the identified objectives [37]. Effectiveness is usually measured over the counterfactual scenario without PES, where effectiveness assessment encompasses evaluating direct environmental changes compared to the baseline situation.

In relation to efficiency, program costs are usually divided into implementation and transaction costs. Implementation costs namely relate to the design of the payment mechanism. Theoretically, PES schemes should compensate providers for forgone income due to the alternative land uses towards ES provision or preservation. However, adjusting payments to precisely cover the forgone income is challenging, particularly when a high number of providers are considered. If payments are too low, providers may not be interested in participating if their costs are not covered, or, participation may be limited to only those that have lower implementation costs. On the other hand, payments may generate information rents when ES providers are paid more than necessary to cover their ES provision costs, since the latter are unknown to program implementers [48]. Overcoming information rents requires differentiating payments to better match ES providers' opportunity costs [49] via, for example, calculating amounts based on proxies for opportunity costs [31]. When the gains in effectiveness from payment differentiation are higher, there will be more heterogeneity in opportunity costs among potential PES participants [49,50]. Still, the potential gains have to be weighed against the potential effectiveness due to the increased transaction costs associated with differentiating payments, as well as associated welfare implications [48]. Transaction costs concerns both the setting up of the system and the running of it [42], while implementation costs relate to the actual costs of implementing measures that will generate the ES [33]. Transaction costs may arise from monitoring and controlling that the ES are delivered, administering the payments and controlling for contract fulfilments. Payments can be output-based (result-based) or input-based (action-based) or a combination of the two. While the former is given only for ES that have been provided (either quantity or quality-related), input-based payments are given for certain management measures that are assumed to provide ES, without actually verifying their provision.

Finally, other criteria are also sometimes analyzed, based on acceptance and uptake of a scheme (e.g., [51]). Sometimes, also democracy-related criteria such as legitimacy, transparency, or equity issues are included [52].

2.5. Phases in Scheme Development

Understanding the phases that a PES scheme goes through until its full deployment, deems essential an understanding of the conditions that made its emergence possible. This will allow considering its transferability to other places. Different authors have classified these phases of PES scheme development. Sattler and Matzdorf [26] consider four different phases: (i) exploration phase, (ii) development phase, (iii) PES pilot testing and build-out phase and (iv) full PES operationality. The main factors influencing the development of PES schemes relate to the people and organizations involved into the design process, the environmental aspects, the policy implications and the program protocols that need to be developed (cf. [26]).

The exploration phase usually starts with an overall situation analysis [26] considering the basic goals with respect to the ES at stake, and mapping out of the main agents (i.e., providers and beneficiaries), but also considering whether intermediaries may be needed and which stakeholders need to be involved in the process.

The development phase is focused on setting up the components of the deal and the governance structures [26]. This includes assessing the baseline situation against which the ES provision will be

measured. In addition, the definition of the related property rights is essential, since it will define who is eligible for the payment. Contract lengths, rights, obligations and conclusion of contracts should be clarified at this stage, which ends with the promotion of the PES to motivate participation [26].

Pilot testing entails careful monitoring of the PES scheme to ensure that all parties act according to their assigned roles. Finally, once the program is operating, monitoring is essential to ensure that the scheme runs according to the defined goals over time, even when frame conditions change [26].

3. Background

PES schemes interact with socio-ecological realities shaped by cultural, institutional and political realities [23,53]. This section introduces some features related to wildfires, pastoralism and the relationship between pastoralism and forest ecosystems in the Mediterranean that are relevant to an understanding of the case study analysis in the broader socio-institutional context.

Evolutionary and paleoecological studies suggest that wildfires are natural in the Mediterranean basin [54] wherein many species have acquired adaptive mechanisms to persist and regenerate after recurrent fires [55]. Nevertheless, large wildfires are relatively recent in the recent history of the Mediterranean [54], and are responsible for a significant percentage of the annual burnt area [56]. The severity and recurrence of these large fires frequently surpasses the capacity of these ecosystems to recover after the fire [57], resulting in abrupt changes to the plant community [54,58] or important soil losses [59]. Losses due to forest fires are not only related to ecosystems, but also to human lives and infrastructures, especially in the so-called wildland–urban interface. A wide array of ecosystem services flowing to society will be interrupted or diminished due to the existence of wildfires [6].

The countries of southern Europe responded by creating fire fighting agencies in the early 1980s when wildfires started to be a problem [60]. However, despite the resources invested in fire prevention and suppression, the number of fires in recent decades has continued to increase remarkably [56]. In fact, the large funds invested in fire suppression policies observed in Mediterranean countries (especially after disastrous fire seasons) have demonstrated their limited ability to remove the risk of major disasters if not coupled with appropriate fuel management strategies [4,56,61,62], as fire control technologies can tackle only a small fraction of the potential intensity of a fire [63]. The prevalence of extreme fires is, however, partly a consequence of effective fire suppression in the past century, now a well-known paradox [64] resulting from fire policies that focus on fire suppression and ignore or assign a minor role to fuel management. In the absence of active landscape management, it is likely that suppression capacity will be the main driver of landscape configuration [5].

Fire prevention through biomass management is therefore increasingly acknowledged as essential to make wildfire more acceptable (i.e., less severe) and easier to suppress [65]. In the Mediterranean, fuel treatments have traditionally been based on forest compartmentalization by fuel break networks [56,66]. The construction and maintenance of fuel breaks typically involves complete removal of vegetation, which may result in a range of ecological impacts [9] and high financial costs for the administration. This perpetual burden is likely to divert efforts from fuels and vegetation management on the remaining majority of the landscape [67]. In this framework, targeted grazing is increasingly acknowledged as an inexpensive and synergistic strategy in the management of forest and shrubland biomass, complementing mechanical tools in decreasing the biomass content both at the fuel break and landscape scales [10,12,13,68].

However, the relationship between extensive grazing and forest ecosystems in the Mediterranean is complex and multifaceted. By the beginning of the 20th century, landscapes of the Iberian Peninsula were significantly deforested due to human disturbance, which included extensive grazing practices [69]. Large-scale reforestations and afforestations were needed to mitigate the impact of flooding on people's livelihoods and to meet the demand of the national market in terms of wood supply [69,70]. The Spanish forest service undertook significant reforestation campaigns from the 1940s to the early 1980s, reforesting roughly 3 million hectares [69]. The reforestation policy encountered social resistance, especially in rural areas and villages with communal land or where the land was

mainly used as pastureland, since traditional uses were consequently limited in those areas [70,71]. In some cases, it led to intentional fires set by livestock farmers who had previously used the land to breed their animals [72]. Similar conflicts are still ongoing on the Southern rim of the Mediterranean basin, where forests and rangelands still constitute a critical element of farming [73]. Social-ecological conflicts relate to different visions regarding economic development and competing priorities for different land uses [74], in this case between rural dwellers and forest administration. Nowadays, pastoral burnings are one of the main causes of wildfires in Spain (around 40% of wildfires with known cause), and may be considered another reason for the reluctance of forest administrations to accept extensive grazing practices in forests as it poses a potential threat to the forest cover. These burnings usually take place in regions where the grazing pressure is not enough to halt shrub colonization through secondary succession processes [75].

Some of the scenarios faced by forest ecosystems in southern Europe and particularly in Spain include reduced biodiversity [76], decay due to poorer regeneration [77] and increased vulnerability to wildfires [78] of monospecific afforested stands due to the lack of post-plantation silvicultural treatments. Mosaic landscape has been reduced due to colonization of marginal agricultural plots by shrub and tree pioneer species with high eventual densities, leading to increased risk of wildfires and even reduced availability of water discharge at the watershed level [79,80]. Effective and economically viable preventative measures should be implemented to improve the resilience of these forest stands against biotic and abiotic hazards within a climate change scenario [69,81,82]. In this framework, targeted grazing is a promising strategy for the improvement of ecosystem resilience in the face of climate change and related changes in wildfire regimes [83].

4. Materials and Methods

4.1. Data Collection

To undertake the analysis of the RAPCA program under the light of the PES scheme framework, different data collection methodologies were adopted. Participant observation in RAPCA-related meetings (both for its set up and periodic monitoring) took place as part of the CSIC research team (see Section 5.2 for more info). Face-to-face, phone and email interviews took place with relevant agents participating in the scheme (i.e., shepherds, RAPCA staff, members of the shepherds in Mediterranean forests association). Literature review of both peer-reviewed papers and grey literature was conducted. Finally, the celebrated seminar on the RAPCA scheme in Granada (Andalusia, Spain) in April 2018 allowed for an intensive exchange of information concerning the functioning of RAPCA and the challenges for its future. A world café was organized in the frame of this two-day seminar, wherein 50 participants attended the session, comprising a balanced representation between policy makers, civil servants, forestry engineers working for the regional wildfire protection plan (INFOCA), RAPCA staff, shepherds, environmental NGO representatives, and researchers. During a two-hour session with three thematic tables, participants discussed the benefits and services of the RAPCA, the wish list for the RAPCA in the future, and the means and resources needed to fulfil the wish list.

4.2. Analysis

Qualitative content analysis has been undertaken adopting the institutional analysis and development framework adapted to PES schemes [84], taking into account PES features and design, its agents and interactions, PES development and finally, PES performance.

5. Results

5.1. Main Features of the RAPCA Scheme Considering the PES Framework

RAPCA is a scheme where local shepherds that provide wildfire prevention services through targeted grazing are remunerated by the regional administration on behalf of the Andalusian society

according to the biomass reduction accomplished, thus acting as a proxy for wildfire risk reduction. To reduce information rents and increase program efficiency, payments are modulated in a two-fold process. Maximum payments are established, consisting of a fixed initial bonus of 300 € for participating in the scheme and a variable share ranging from 42 €/ha to 90 €/ha considering the grazing difficulty. This depends on the type and amount of vegetation, slope and proximity to animal shelter (for further information on the payment formula see the work by Ruiz-Mirazo et al. [85] and Varela et al. [16]). Levels of compliance with the target consumption modulate the maximum payment: 100%, 75% or 50% compliance. Compliance levels below 50% do not receive remuneration. According to the contracts signed by the shepherds and the Department of Environment (DoE), the farmers are requested to achieve a consumption of 90% of the annual herbaceous growth and 75% of the annual shrub growth. Mena et al. [22] surveyed 54 small ruminant farms in the RAPCA network finding that on average, these shepherds were each assigned 38 ha of fuel breaks, at a mean distance of 3 km from their farms. Wildfire protection (prevention and suppression) can be considered a public good (showing features of non-excludability and non-rivalry) [86] and is often provided by the public administration as part of the general welfare system. The public good character of many ecosystem services provided by forests and the public bad character of wildfires affecting these, justifies the governmental intervention on behalf of the population. Wildfire damages can be regarded as a negative externalities reducing or interrupting the flow of final services (i.e., these directly related to benefits for the society [87]) that forest ecosystems provide both on- and off-site. Targeted grazing produces positive effects not only on-site, but importantly off-site as well, by maintaining prevention structures that may stop wildfires and that enable access to fire breaks for fire fighters which will support efficient fire suppression efforts.

5.2. Agents in the RAPCA

Shepherds participating in the scheme as ES providers use rangeland neighboring the forests and can easily access the fuel breaks to be grazed [85]. They are invited to participate in the program, since it does not operate through open calls. Most of the invited shepherds (94% in 2015) have small-ruminant herds of traditional sheep and goat breeds adapted to local conditions. In 2016, a total of 223 shepherds and their herds were participating in the RAPCA scheme [88].

The DoE and the Andalusian Public Agency of Environment and Water (AMAYA) act on behalf of society as the service beneficiary. The RAPCA staff hired by AMAYA prepares the contracts and align the different agents (namely local councils, forest managers and shepherds) involved in the program. They identify the fuel breaks suitable to be maintained by grazing and verify task fulfilment via periodic monitoring. Finally, they also assess the results leading to final payments, conducting pre-assessments during the spring and keeping in contact with the shepherds year-round [18].

The research team on silvopastoral systems at the National Research Council (CSIC) played the intermediary role in the initial phase of the RAPCA. Some members of the team had participated in similar targeted grazing programs in France [11] and had proposed their application in Spain [89]. They carried out scientific surveys to evaluate the capacity for biomass consumption by livestock in fuel breaks in Andalusia, developed the monitoring protocol and provided technical support and training to the RAPCA staff [85,90], who were then entrusted with the evaluation of biomass consumption. Furthermore, the outcome-based payment scheme was developed together with RAPCA staff, forest guards and forestry engineers at the DoE [18]. Researchers also acted as a trusted or authoritative source [40], assuming a bridging role between shepherds and public administration to reduce mutual distrust in the initial stages and to facilitate program implementation.

5.3. Phases in the Development of the RAPCA Scheme

We have identified three main implementation phases of the RAPCA scheme since its early days in 2003 up to its current status.

5.3.1. Exploration Phase

The seed of RAPCA lies in the political will to initially fund a research project carried out by the National Research Council for the DoE during 2003–2005 to test the effect of targeted grazing for fire prevention purposes in experimental plots in a public forest state and in collaboration with a local shepherd in the province of Granada. The exploration phase sets up the goals in terms of biomass reduction, adapting the methodology applied in the French program of wildfire prevention (DFCI, *Défense de la Forêt Contre les Incendies*) to the Andalusian conditions [11].

5.3.2. Development and Pilot Phase

This phase was focused on setting up the components of the PES agreements and the basic governance structures. The analysis of the suitability of targeted grazing expanded to public forestland in three natural parks in the region in 2006. AMAYA hired one person, the first RAPCA staff member, to monitor the activity of the five shepherds initially involved in the scheme. This was the origin of the RAPCA staff that currently work in monitoring the network.

The political will allowed that the annual payment scheme was launched in 2007 through a grazing service contract. Coupled with the remuneration, the methodology for characterizing fuel breaks and monitoring the effectiveness of grazing was developed and refined between 2005 and 2007 [85].

The shepherds that initially agreed to participate in the scheme played an essential role engaging their peers to increase mutual trust with RAPCA staff and the forest service. The research team played a vital role as mediator by providing scientific evidence and balancing the interests of all agents to build trust in the scheme. Refinement in the selection process of suitable fuel breaks in public forests also took place at this stage. Basic pastoral infrastructures (such as suitable access paths, water points or shelters) were shown to have a significant impact on the accomplishment of the activity, as they facilitate the extra efforts required for targeted grazing. Similarly, coordination with fire prevention services had to be devised, so that the grazing activities were well coordinated with the periodic mechanical clearance of fuel breaks.

5.3.3. Fully Operational Phase

As of 2010 the scheme was fully deployed and already consisted of 67 shepherds. The RAPCA staff increased from two to five people who are nowadays distributed across the region. In 2011 the funds allocated to RAPCA increased, and the number of shepherds was increased to 210 in 2011, tripling the total grazed area.

By 2016, the RAPCA network reached a total surface area of 6000 ha, grazed by the collaboration of 223 shepherds.

The monitoring protocol and payment scheme are fully deployed and stable while the paid quantities have remained unchanged since they were established in 2007.

The main change that has taken place in the last years relates to the linkage of the RAPCA scheme to the lease contracts between the Andalusian DoE and the shepherds for access to pastures in public forests. Where the lease area granted to a shepherd encompasses fire breaks, maintenance of fire breaks may be entrusted to that shepherd within RAPCA. However, the shepherd does not receive a direct payment for the fire prevention service provided, but rather experiences a reduction in the annual lease price for the equivalent amount. Nowadays, both options, either a RAPCA contract or a contract linked to the lease are in place, with the latter being preferred by the managing administration [91]. The merging of lease contracts with the PES scheme may distort the philosophy of the payment mechanism. Shepherds' role changes from being providers of a risk reduction service to the administration (highly valued, positive behavioural reinforcement) to becoming the potentially bad agent, e.g., considering reduced biomass reduction targets as a punishment ("I have to pay more for the lease if I do not perform well") [92].

New institutions have emerged from the RAPCA. Some of the stakeholders participating in the payment scheme created the association Shepherds in Mediterranean Forests in 2009. This as an NGO that advocates for extensive grazers in the region, bringing together shepherds, technicians, forestry engineers and researchers. The Andalusian school of shepherds was launched in 2010, which also has a close connection with RAPCA. Shepherds participating in the RAPCA scheme, RAPCA staff and CSIC researchers collaborate with the school every year.

5.4. Institutional Arrangements

The RAPCA scheme has been linked since its beginning to the regional plan for fire protection (INFOCA) that guides wildfire management activities. This plan is managed by the DoE and counts on its own budget for fire prevention and suppression activities. AMAYA works for the DoE implementing INFOCA. Regional and provincial offices for fire suppression and prevention (COR and COP, respectively) depend on the DoE and supervise the implementation of the INFOCA. The RAPCA scheme and its corresponding expenses are included in the budget of the INFOCA plan while the RAPCA staff are hired by AMAYA.

RAPCA as a new governance mechanism is related namely to belonging to the environmental protection and forestry spheres, therefore increasing the interaction of these agents with the shepherds, which was one of the expected side-effects of the scheme (J. Guirado, personal communication, 26 April 2018).

The RAPCA fuel breaks are located in public forests of Andalusia, with a management plan supervised by a forestry engineer belonging to the Forest Service, and are surveilled by forest guards. Hence, the involvement and support of the Forest Service is essential for the inclusion of a given forest in the scheme. Often these forests are located in regional Natural Parks that have their own regulations and management plan. Fire prevention activities in these forests are undertaken by INFOCA staff and include for example mechanical clearance of biomass in fuel breaks or tree pruning. These actions are decided by COP and COR offices in agreement with the forest service or the head of the Natural Park.

Coordination between all these agents is needed for granting shepherds access to the forest areas that were not previously grazed and wherein improvement of pastoral infrastructures may be needed. The RAPCA staff deploys horizontal and vertical coordination efforts to fit the RAPCA scheme into the existing institutional framework and hence they are experienced in "the PES scheme meeting the messiness of the real world" [93]. For example, challenges are found in coordinating mechanical clearance of fuel breaks by INFOCA staff with the targeted grazing activity.

The payments that RAPCA offers to the shepherds are compatible with CAP payments that these shepherds can receive, linked both to Pillar 1 and Pillar 2, and therefore a horizontal interaction exists with these public subsidies. Shepherds have to declare the grazed area, which is then checked against the CAP Land Parcel Information System, where forest and agricultural land is classified according to a number of categories that determine the eligibility of land parcels for CAP payments.

5.5. Performance of the RAPCA Scheme

Environmental effectiveness assessment entails considering biomass consumption targets of the RAPCA scheme. The monitoring procedure of the RAPCA scheme allows analyzing the degree of accomplishment achieved by the shepherds participating in the scheme. In the 2008—9 campaigns, high or very high achievement of grazing objectives was found in 68% of contracts, medium in 23% and low in 9%. In 2011, the year of the great expansion of the network, around 14% of grazers lost their payments as a result of not meeting the required results. Targeted grazing does not completely substitute for the need for mechanical clearance of biomass in fuel breaks, but it does reduce the frequency of mechanical interventions. Some estimates from 2012–2014 show that the area covered by targeted grazing corresponded to 30% of the area manually cleared in fuel breaks of Andalusian public forests [94]. The public tariffs for mechanical and manual clearance of biomass (the most similar to animal browsing of vegetation) have a broad variation depending on three key variables that determine

the harshness of the task: plant coverage, stem diameter and slope. Accordingly, tariffs may vary between 364.70 €/ha and 2412.14 €/ha for manual clearing and between 209.67 €/ha and 2339.50 €/ha for light machinery, which are the alternatives that may produce the more similar effect to livestock grazing. The unit costs of RAPCA are distinctively lower. Additionality of RAPCA compared to the no intervention baseline is clear in terms of the area maintained by targeted grazing activities, since targeted grazing was not previously undertaken for fuel break maintenance and shepherds had no incentives to provide such service.

Efficiency assessment of the RAPCA scheme entails evaluation of the different types of costs in the program. Transaction costs in the RAPCA scheme correspond to hiring the RAPCA staff and setting up infrastructures in the forest areas so that shepherds can develop their activities. Implementation costs encompass the payments allocated to the shepherds for the provision of the service of biomass control. Average unit (transaction and running costs) of the RAPCA program according to 2017 data are 137 €/ha while average running costs (i.e., payments to the shepherds) are 80 €/ha [91]. Transaction costs therefore represent 42% of total costs. Total running costs of the program amounted to 450,000 € in 2017 [91] for 6000 ha of fuel breaks under targeted grazing activities (i.e., 75 €/ha on average). According to this, total cost estimates for the RAPCA program are 822,000 € (2017 data), representing approximately 1% of the total budget allocated by INFOCA to fire prevention activities in the region [95]. Since payments depend on delivery of results before summer (wildfire campaign) season, livestock farmers decide when and how to graze to achieve the required biomass reduction. This approach reduces transaction costs since it would be costlier to monitor grazing.

The periodicity of interventions in standard fire prevention planning greatly depends on the type of vegetation and its growth rate, usually taking place every third or fourth year to guarantee that preventive infrastructures fulfill its purpose. In contrast, RAPCA shepherds undertake their activity every year, allowing a reduction in standard mechanical interventions. It is estimated that the scheme saves up to 75% (average 63%) of the costs of managing fuel breaks by mechanical clearance with handheld brush cutters [16]. Considering a rough estimate of the cost of fuel break mechanical clearance and comparing it with the maximum payments that shepherds could earn, these are always below 50% of the avoided costs represented by targeted grazing [96].

Figure 1 shows how the RAPCA scheme works in reducing the costs of mechanical clearing and compensating the shepherds, theoretically for the costs incurred in providing the service (although these costs have thus far not been calculated). The total costs of the scheme are below the costs of mechanical clearance, producing social benefits via cost savings.

Previous studies have estimated the social demand for biomass removal through targeted grazing and light machinery at 1254 €/ha and in 1284 €/ha, respectively [15]. Figure 2 shows how, despite the fact that social demand is slightly higher for light machinery clearance, the costs of mechanical clearance are distinctively higher compared to those of a targeted grazing and PES scenario.

The approach adopted in the RAPCA scheme did not estimate the costs that targeted grazing may entail for the farmers in terms of time and extra food supplementation to their flocks. According to the shepherds, the payments may not fully cover the costs incurred, there being other motivations apart from payments that are key drivers for their participation, such as being part of the RAPCA community, improvement of their relationship with forest administrators, and recognition of their work (A. Río, personal communication, 26 April 2018). This may explain their involvement despite that the amounts paid have remained constant since 2007.

Furthermore, some of the forestry engineers of the regional Natural Parks have expressed additional benefits of targeted grazing. While periodic mechanical clearance of fuel breaks may not take place at the optimal moment, due to other areas being prioritized in budget allocation, counting on local shepherds guarantees that biomass reduction activities will take place every year (José Quintanilla, personal communication, 27 April 2018).

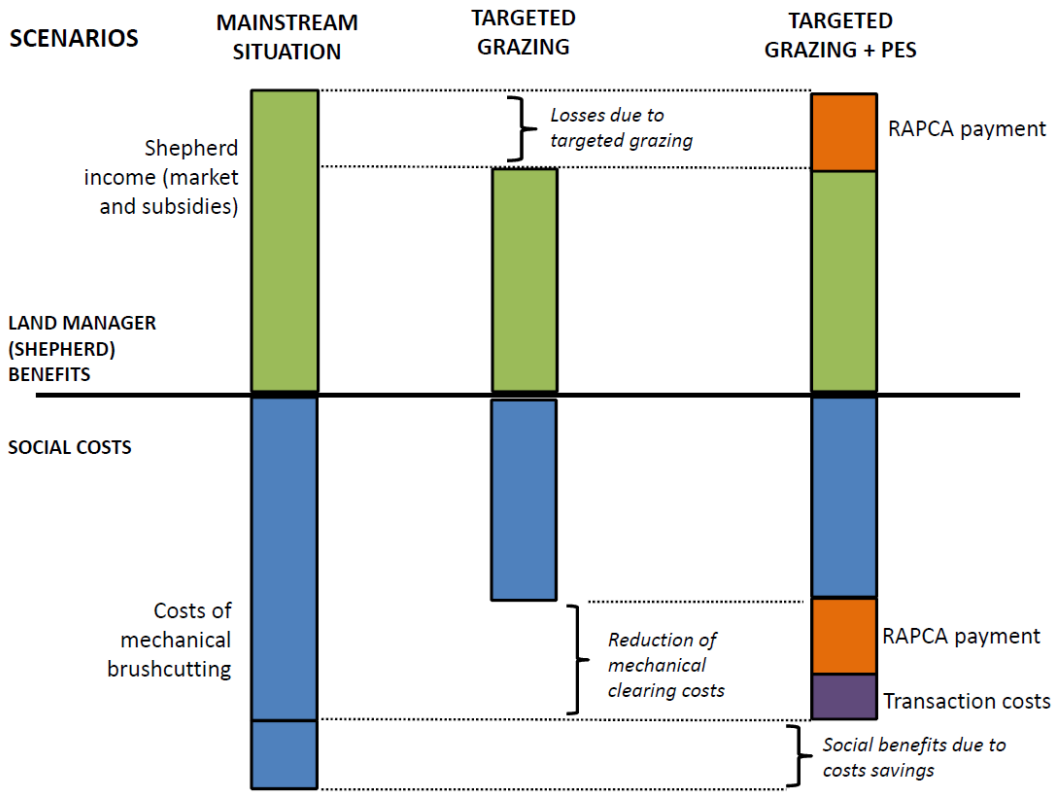

Figure 1. Land manager benefits and social costs in three scenarios: with no fire prevention, fire prevention with targeted grazing, and targeted grazing remunerated service. Source: own elaboration based on Engel et al. [93].

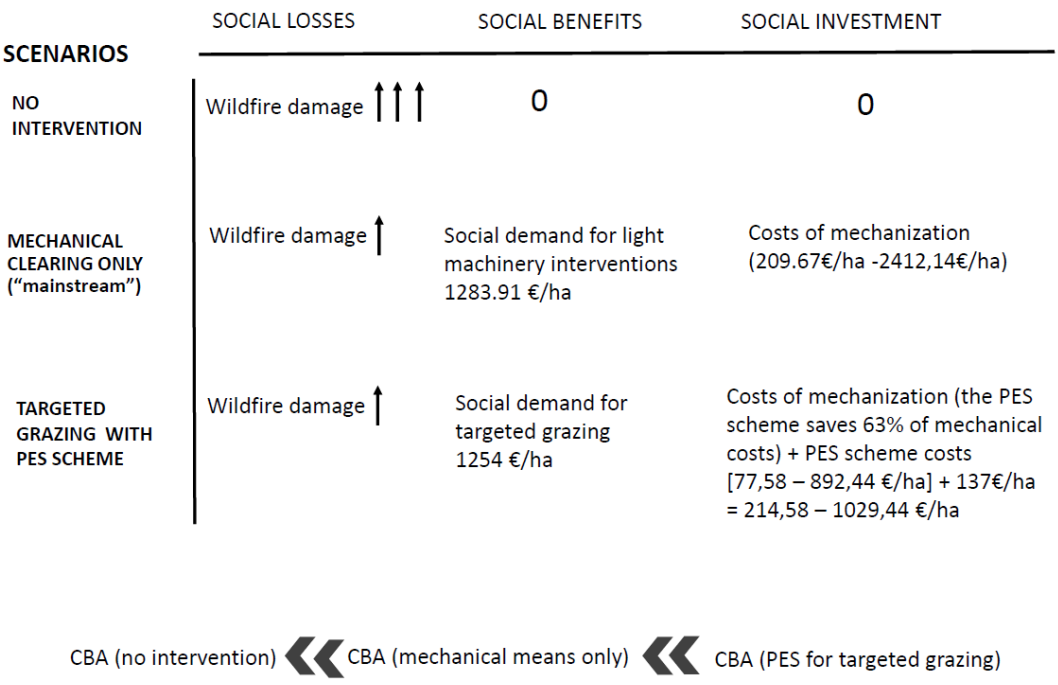

Figure 2. Rough estimate of Extended Costs and Benefit Analysis for three alternative scenarios of fire prevention: no fire prevention, fire prevention with mechanical clearing of biomass, remunerated targeted grazing service. Estimates of social benefits based on Varela et al. [15]. Estimates of social investment in the scenario with a targeted grazing scheme based on public tariffs and [16].

6. Discussion

The RAPCA scheme represents a new institution for fire prevention that provides incentives to local shepherds to implement targeted grazing for fuel biomass reduction. By opting for a traditional animal-based approach instead of the mainstream technological methods, the RAPCA program also highlights the interdependencies of institutions and human interactions with nature [23,97]. It also contributes to the creation of new governance grounds where local dwellers and public administrations work together to promote resilience to wildfires [98].

For the emergence of the RAPCA scheme and its durability over the years, it has been crucial to count on stable long-term commitment by public administrations, specifically by top-level politicians with a strategic vision of the socio-ecosystem.

The institutional framework embedding this PES scheme determines its design and performance [84]. The RAPCA scheme has always been linked to the wildfire prevention plan (INFOCA), and hence competent environmental and forestry agencies manage it. The high level of social concern existing towards wildfire prevention has resulted in the budget remaining stable even in times of economic crisis, allowing for the continuity of the RAPCA scheme.

Some of the roles for intermediaries distinguished by Huber-Stearns et al. [38] were played by the research team, such as serving as authoritative source of information [40], bridging information gaps between different stakeholders and facilitating the set up and functioning of PES, developing sound monitoring protocols and presenting information that is appropriate for the target audience [99]. Intermediaries also assumed mediation and networking duties, building mutual trust in initial stages of the RAPCA scheme and acting as agents for underrepresented populations [100,101], along with identifying potential project participants [102].

A PES scheme is fundamentally different from conventional environmental policy instruments since it operates through incentives rather than disincentives like legal regulations, sanction mechanisms, or taxes [48]. Differing from many PES schemes that fail to meet the conditionality criteria [103], or show payments made on good faith [33,104], wherein success is hard to measure [37], the RAPCA scheme implemented a comprehensive and complex monitoring structure that allows tracking of its performance. This entails incurring transaction costs representing around 42% of the total costs of the scheme, similar to other cases reported in the literature [42].

Effectiveness achievements increase with herd size and with pasture availability in the vicinity [22]; small herds that need to move to different locations for pasture availability show more difficulties to meet biomass control targets. Importantly, the RAPCA program is one of the few cases of outcome-based mechanisms, hence ensuring its conditionality [36]. Moreover, the differentiated design reduces the information asymmetries and thus improves its efficiency. In most PES programs, compliance is based on land-use or management action proxies since it is less costly than measuring provision, and in uncertain situations, outcome-based contracts increase the risk for the provider and hence, may crowd out participation [48,105,106]. This is not the case in the RAPCA results-based scheme since shepherds' willingness to participate is not a limiting factor for the scheme to expand. Whether action- or outcome-based payments are more cost effective is thus an empirical question. Payments for outcomes (or results) tend to be more cost-effective when outcomes are more inexpensive to monitor and the effort required for increasing ES is high.

Targeted grazing has proven to be a financially competitive method for reducing biomass in fire prevention structures, complementing mechanical clearing. Furthermore, social demand for this management alternative fully justifies the development of the RAPCA payment scheme.

Besides the original main objective to effectively and efficiently spur the provision of ES, PES schemes can also contribute to other secondary objectives [26]. An innovative side of PES is their ability to create positive side effects such as opening up new spaces for participation and creating unusual alliances [26,107]. A key objective of the promoters of the RAPCA scheme, beyond service provision, was to increase the social and institutional legitimacy of extensive grazing in forest ecosystems, reducing mutual distrust between the forest service and local shepherds. Despite not being an economic

or environmental objective, its achievement has been key in the continuity of the scheme which has already reached 15 years. A key success of the RAPCA has been jointly addressing the three dimensions of environmental conflicts [74]: technical (i.e., fuel break maintenance), policy (i.e., establishing financial incentives) and cultural (i.e., improving the ability of stakeholders to communicate with each other).

In addition, RAPCA also provides unforeseen benefits that should be considered when evaluating the feasibility of targeted grazing against its mechanical counterparts [15]. Recovery of ecological processes such as seed dispersal and improvement of soil fertility, discouragement of arson, and early wildfire warning due to the presence of the shepherds in these forests are some of these benefits [75].

Policies are negotiated and co-produced through complex interactions between a multitude of agents at different levels [108]. PES institutions are adapted and used for multiple purposes and they are attributed alternative meanings [23]. Insights into how a PES scheme is framed to align with specific interests by particular social groups requires a focus on how divergent interests and constructed narratives around conservation and development create 'hybrid regimes of truth' [109], since these shape the design, implementation and outcomes of such projects [110]. The INFOCA supervisors of the RAPCA program, emphasize the innovative character of the scheme, the area managed under the program, and the unit costs of the program (€/ha). Since the focus is on financial performance and cost reduction, they advocate for merging the RAPCA scheme with grazing lease contracts in public forests as much as possible to simplify administrative tasks. However, the merging of lease contracts with the PES scheme implies a reduction in the lease payment that may produce confusion and potentially discourage shepherds participation. This shows that despite that RAPCA enables linking forest conservation to livestock grazing, shepherds and their organizations have little influence in the scheme design and operationalization. Moreover, task reduction and therefore reduction of transaction costs can also be achieved by extending the length of RAPCA contracts from annual to plurennial, hence lessening the bureaucratic burden. Many of the participating extensive farms are not viable if depending exclusively on the market remuneration they get from their products and thus complement their income mainly with CAP subsidies and, to a much smaller extent, with the RAPCA payments. Hence, complementarity with economic incentives dealing with other income sources is needed to ensure the viability of service providers and hence of the RAPCA scheme. The discourse held by researchers at the National Research Agency (CSIC) and by the RAPCA staff highlights side effects such as cooperation between the forest service and the shepherds as one of the main achievements. In addition, they underline side-benefits in relation to ecological dynamics or discouragement of arsonists and advocate for a more inclusive participation by shepherds and/or their organizations in the management of the scheme. Some of the shepherds in the RAPCA scheme have expressed that the monetary gains provided by the scheme are important, but that other non-financial motives were vital in eliciting their participation. Since the skills needed to enter the program are high, it is unlikely that increasing the amounts paid would trigger crowding-out effects among the livestock farmers.

Positive environmental outcomes in PES schemes are associated with the involvement of trustworthy intermediaries, sufficiently long contracts, social co-benefits (well-being, public image), and voluntary participation [37]. The RAPCA scheme has already lasted for 15 years, fulfilling some of these key elements. Its emergence was possible thanks to top-level policy decision-making combined with key intermediaries that contributed to build mutual trust between providers and payers and to set up a monitoring protocol that has solid scientific knowledge behind it. There is still some room for improvement of the scheme in terms of involvement of service providers and acknowledgement of their needs. The future of the RAPCA seems guaranteed as long as livestock farmers find ways to make their activities economically viable, the RAPCA promoters maintain the monetary and non-monetary incentives for the shepherds, trust is maintained, and the political commitment persists. Conditionality verification through monitoring builds credibility on the RAPCA scheme and allows differentiating it from conventional subsidies, contributing to highlight the service provided by the shepherds towards society. Finally, RAPCA-like initiatives may also represent an opportunity to produce a change in the

typically reactive dynamics of the administrations, improving their capacity for diversifying strategies for fire risk management.

7. Conclusions

In the Mediterranean basin, a series of initiatives have arisen in the last decades that try to incorporate livestock grazing into wildfire prevention activities. Among these initiatives, the RAPCA program represents an outstanding example for its dimensions and long-term stability, showing that targeted grazing is an efficient and effective way of biomass reduction for wildfire prevention.

Some key findings may be extracted from the analysis of the RAPCA scheme under a PES framework. Political will and stable commitment from public administrations together with a well-designed and -performed monitoring system of biomass reduction by targeted grazing are key for establishing a successful results-based payment scheme. Despite that monitoring may represent a potentially high share of the transaction costs, its implementation is crucial to show that public investments are not made simply on good faith but are based on provable achievements. Long-term functioning seems more likely to be attained when PES schemes are linked to stable budgets with permanency over time, such as that allocated to wildfire prevention. Finally, the ability of the RAPCA scheme to open up new spaces for unusual alliances between beneficiaries and providers can be considered a significant contribution to the long-term performance of RAPCA. Thereby, mutual trust and involvement have allowed the emergence and continuity of the RAPCA scheme, where the intermediaries have played a key role for their attainment.

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