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A novel management-based system of payments for ecosystem services for targeted agri-environmental policy

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ABSTRACT

Agricultural policy should recognize the farmers' role in delivering ecosystem services (ES) to society, for which both farmers and policy makers need improved tools to set objective environmental targets and fair distribution of subsidies. We aimed to quantify the effect of beneficial agricultural practices on ES delivery, and to develop and apply a generic framework of management-based payments for ES (PES). We carried out a Delphi expert consultation (researchers and technicians/managers) on the interface agriculture-environment by which we measured the contribution of current agricultural practices at farm level to relevant ES in Mediterranean agroecosystems. Next, we designed a novel framework of PES that used these contributions to rank the practices that satisfied three agri-environmental policy objectives (equal importance of ES, focus on biodiversity and climate, and focus on social demands). We found that the relative contribution of practices to individual ES delivery was rather similar, especially for those ES influenced by many agricultural practices. However, when considering different objectives in the PES framework, differences in practice prioritization were apparent. The framework was able to reward farmers according to their objective contribution to conservation priorities. The PES system also showed that grazing management practices were multifunctional and delivered ES in bundles.

1. Introduction

Agriculture is a multifunctional activity since it does not only provide commodity outputs (food and fiber production), but also additional functions such as socio-economic viability of rural areas, food security, animal welfare and environmental outcomes (OECD, 2001; Renting et al., 2009). Among the positive environmental outcomes, ecosystem services (ES) focuses on the linkages between ecosystems, including agroecosystems, and human well-being (MEA, 2005). The ES framework invites to assess and explore further the multifunctionality of agroecosystems and stimulates debate about the need to introduce deep changes in the way agricultural policies are designed (EC, 2011), as well as has the potential to integrate provisioning and non-provisioning services at the same level of priority (Rodríguez-Ortega et al., 2014).

Currently, a wide range of farming systems with different degrees of specialization, integration and intensification of production coexist across the world (Bouwman et al., 2005). Depending on management practices, these systems can be a source of numerous disservices or, conversely, of multiple ES (Power, 2010); in turn, both ES and disservices affect agricultural productivity (Dale and Polasky, 2007), especially at large temporal scales. In general, low-input farming systems, such as pasture-based livestock systems or integrated mixed farming systems, are associated with a larger number of beneficial agricultural practices providing a great range of ES, compared to intensive farming systems (Cooper et al., 2009). Examples of these ES provided by low intensity farming across Europe are the preservation of agricultural landscapes, farmland biodiversity, water quality and availability, soil functionality, climate stability (related to carbon storage and greenhouse gas emissions), resilience to flooding and fire, or air quality. However, most of these ES exhibit the characteristics of public goods, so conventional markets are often not the best institutional frameworks to manage them (Costanza et al., 2014) and thus farmers have little incentives to provide them. One way to solve this is to economically recognize the ES delivery by farmers' activity and compensate them accordingly to the provision of ES, for example by shifting the emphasis of agricultural policies and public money towards the supply of ES demanded by society.

Farmers and farming communities may be seen as modulators of ecosystem functioning that build a humanized (agro)ecosystem, where

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they have a significant role to play in the preservation and conservation of resources and in providing ES (or ecosystem disservices) in multiple ways depending on their farm management. To ensure the engagement of farmers in conservation through the sustainable use of resources and the delivery of ES, farmers and policy makers need a way to connect agricultural management with the provision of ES. Despite the incomplete scientific understanding of the complex causal relationships between management actions, biophysical processes and ES delivery (Rodríguez-Ortega et al., 2014), there is information and knowledge to better design agri-environmental policies, and we cannot wait for certainty and precision of methods to act (Farley and Costanza, 2010). Payments for ecosystem services (PES) applied to farming can offer an alternative way to achieve conservation objectives (Engel et al., 2008).

The ES framework has gained increasing attention from the research community and recently reached the political agenda. However, some authors conclude that in terms of policy design the ES framework is currently a "buzz approach", which nobody really knows how to use (Matzdorf and Meyer, 2014). PES can be defined as "a *voluntary* transaction where a *well-defined ES* (or a land use likely to secure that service) is being 'bought' by a (minimum one) *ES buyer* from a (minimum one) *ES provider* if and only if the ES provider secures ES provision (*conditionality*)" (Wunder, 2005). However, only few existing PES fit the narrow Wunder's definition, as reviewed by Sattler and Matzdorf (2013), while the majority of approaches rather fit the broader PES concept (definition of Muradian et al., 2010), which also includes incentives or public subsidies defined by regulatory means. Wunder (2015) also defends PES as a functional tool, rather than normative prescriptions of desirable outcomes, such as poverty or justice. He also recognizes that a sophisticated design (payment differentiation and spatial targeting) and adequate implementation (compliance monitoring and sanctioning) are desirable but too costly (transaction cost), so that they are only partially applied in practice (Wunder et al., 2018).

Payment mode can be oriented twofold: by the outcome ES or by the land management that secure that ES. Both approaches have advantages and disadvantages. On the one hand, result-based PES are desirable because they theoretically reward environmental outcomes objectively; however, they implicate a higher risk for the provider (farmers, in our case) because the ES generation is complex and not all influencing factors (such as weather) are under the control of farmers (Reed et al., 2014). Additionally, while the payment should be for the farmer that provide the ES, ES may be delivered at different scales (Hein et al., 2006), some of them higher than the farm, and need to be measured at the appropriate resolution (Dale and Polasky, 2007), which place conflicts with other farmers' management. Also, ES measurement can add further to the transaction costs of the schemes (Farley and Costanza, 2010). On the other hand, management-based PES are seen as less effective, as the link between land management and ES can be rather weak and might be based on assumptions that are not always backed up by scientific evidence (Reed et al., 2014). Nevertheless, considering the multiple interrelations between ES flows, management payments may be the preferred solution, as they can deliver ES in bundles, avoiding the commodification of single ES (Kosoy and Corbera, 2010).

PES are historically much more frequent in developing countries, mostly in Latin America (Schomers and Matzdorf, 2013). Few authors have made the efforts of reviewing the different PES mechanisms. One of the most comprehensive assessment was done by Sattler et al. (2013), who collected from the literature 32 characteristics, grouped in 10 categories, with multiple specifications to explain the variety of PES approaches. They indicated that characteristics such as intermediaries, involvement of governmental actors, contract length, co-benefits, voluntariness in agreements and design of PES as output-based schemes are of particular importance for the success of PES. However, result-based PES should be restricted to cases where causal relationships are well established and can be represented by simple indicators (Uthes and Matzdorf, 2013), which is not the case in agriculture where interrelationships between practices and multiple ES are fairly complex, not well-studied yet and expressed with a wide range of indicators (Rodríguez-Ortega et al., 2014).

Thus, some authors have developed studies to assess effects of land management on ES (van Oudenhoven et al., 2012), to design indicator-based agri-environmental payments to cover landscape public goods (Hasund, 2013), to study key farm management practices of high conservation relevance (Ribeiro et al., 2016), etc. Although the importance of land management is acknowledged in the descriptions of all the existing PES, agricultural management is not explicitly included and linked to the objective provision of ES. In this sense, a better understanding of the processes by which management regimes influence trade-offs and synergies among ES is critical to choose the most beneficial agricultural practices that would allow the outputs of a range of ES to be envisioned (Dale and Polasky, 2007; Power, 2010). It would also address a greater integration between agri-environmental schemes to attain a wider and more efficient delivery of ES for society (Reed et al., 2014). However, to our knowledge, there are no generic frameworks that link agricultural practices with multiple ES delivery.

The aims of this study were: i) to quantify the effect of beneficial agricultural practices on ES delivery, ii) to develop and apply a generic framework of management-based payments for ES, and iii) to apply this PES framework to diverse policy settings that represent different combinations of ES.

2. Materials and methods

We valued the contribution of agricultural practices to relevant ES in Mediterranean agroecosystems through an expert-based assessment embedded in the PES framework. Below, we explain in three sections how we: i) selected the relevant agroecosystems, identified the ecosystem services linked to mixed sheep-crop farming systems and the agricultural practices carried out by these systems; ii) estimated the contribution of these practices to the relevant ES; and iii) designed and applied the PES framework.

2.1. Selection of agroecosystems, ecosystem services and agricultural practices

We set our study in north-east Spain (Aragón region), due to its heterogeneous environmental characteristics that gives rise to a wide variety of farming systems, in particular mixed sheep-crop systems (Barrantes et al., 2009; Olaizola et al., 2015). Overall, these farming systems are located in two dominant Mediterranean agroecosystems: i) mountain areas, with traditional self-sufficient systems characterized by extensive, low-input/low-output farming (Asensio and Casasús, 2004) and with little use of arable land and large dependency on natural pastures; and ii) semi-arid lowlands, with systems that followed a path of intensification, linking sheep to the most developed agriculture with irrigated lands and a higher use of off-farm feed inputs (Olaizola et al., 1995).

Due to the focus of our study, we only considered non-provisioning ES, which do not normally have market price (de Groot et al., 2012). The five ES under consideration were: maintenance of sustainable agricultural landscapes (cultural ES), biodiversity conservation (supporting ES), forest wildfires prevention (regulating ES), regulation of climate change through the carbon sequestration (regulating ES), and production of local quality products (quality regards more cultural ES than provisioning ES). These ES are among the most relevant non-market functions of European agriculture (Cooper et al., 2009) and have been identified from a biophysical point of view in pasture-based livestock systems by the scientific community (Rodríguez-Ortega et al., 2014). Additionally, they were confirmed in previous socio-cultural studies using focus groups with citizens and farmers (Bernués et al., 2016).

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