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Governing a pioneer program on payment for watershed services: Stakeholder involvement, legal frameworks and early lessons from the Atlantic forest of Brazil

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ABSTRACT

Increasing acceptance of payments for ecosystem services (PES) programs as environmental policy alternatives suggests a clear need for research on PES implementation, both to validate theoretical frameworks and improve approaches for existing and future programs. We provide a history of the 10-year old *Conservador das Águas* program in Extrema, a city in Minas Gerais located within the Atlantic Forest of Brazil. To date, the program has coordinated restoration activities that have increased native forest cover in 60% in targeted sub-watershed through contracts with 53 landowners, and has established long-term collaborations among government agencies, civil society, and landowners. Evaluation of the institutional elements of the program using an institutional framework reveals lessons that are relevant for future projects. We find that national legislation and local government organizations have played key roles in enabling and maintaining program activities. Further, strategic decisions by program staff, including targeting important regions and actors within the municipality, the use of Forest Code mandates as an incentive for participation, and use of municipal legislation to secure funding, were critical to the program's success. We use an institutional framework to provide a review of the program, including its legal context, actors, and financial instruments, for those engaged in establishing and sustaining similar programs.

1. Introduction

The conceptual development of payments for ecosystem services (PES) is now over a decade old (Ferraro and Kiss, 2002; Scherr et al., 2004; Wunder, 2005). The discussion of these programs extends from the assessment of ecosystem services and suitable proxies to appropriate structures and performance metrics for programs in practice. The much-cited early framework proposed by Wunder (2005) has become a foundation for a larger discussion of the socioeconomic factors that enhance the likelihood of viable PES schemes (Wunder, 2013; Muradian et al., 2010; Wunder et al., 2008). A focus on institutional structures and interactions has also emerged in an attempt to better analyze conditions that affect the performance of PES-type programs in greater detail (Muradian et al., 2010; Corbera et al., 2009).

This shift in focus for PES research is influenced in part by discussion in the academic literature, but also by the growing number of active PES programs in a wide range of geographical and sociopolitical contexts. The list of existing programs now includes over 400 active or pilot programs that focus solely on water-related ecosystem services, with a reported growth rate of 14% since 2008 (Bennett and Carroll, 2014). This rapid expansion has created new challenges for the field, as broad policy support for PES programs to provide services for public water supplies has moved rapidly ahead of local capacity to implement program activities at scale (Bennett and Carroll, 2014; Guedes and Seehusen,

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2011). In their review of ecosystem services research in Latin America, Balvanera et al. (2012), note challenges in implementation of payments programs among the highest-cited needs in the field, including a broader knowledge base on strategies to secure funding, develop legal support, and build relationships and effective participation criteria for program participants. Pioneer PES programs, including some that have been in implementation for over a decade, have provided important experiences and lessons for the development and scaling up of future PES schemes. While the literature on existing projects is growing (Wendland et al., 2010; Fisher et al., 2010; Pagiola, 2008), there is still a limited set of critical analyses of established projects to serve as a reference for implementers.

In this paper, we provide perspective on strategies to address these challenges, through discussion of a Brazilian PES program developed to encourage legally required forest restoration and soil conservation to improve the provisioning of water-related ecosystem services. The *Conservador das Águas* program, in the municipality of Extrema, Minas Gerais, has been actively negotiating and implementing contracts with farmers since 2007, and was one of ten recipients of the 2010 Dubai International Award for Best Practices, offered by the UN-Habitat initiative to recognize leading global conservation projects (UN-HABITAT, 2012). In addition to providing a history of the program as an example of an effective governance framework for PES programs, we explore the importance of the institutional context of Extrema, the changing scale of the program, and the strategic use of partnerships by government officials on participation in *Conservador das Águas*, and reflect on the relevance of the project to the development of PES projects generally.

We use the institutional approach proposed by Corbera et al. (2009) to shed light on how *Conservador das Águas* was planned and implemented to promote forest restoration and soil conservation within a watershed in the Atlantic Forest biome of Brazil. This entails consideration of the components and dimensions of PES programs in the context of their institutional and organizational environment. These components and dimensions include institutional design and performance, the interplay between institutions (e.g., property rights, jurisdiction, and cooperation between organizations), the capacity of organizations, and the scale of the program (Corbera et al., 2009, see Table 1). This range of factors is useful for consideration of the *Conservador das Águas* program, as it permits analysis of the various components of PES in the context of the institutions that shape the space in which such a program operates, as we describe in the subsequent section.

1.1. Brazil's institutional history with water

Concern over ecosystem service provision is not a recent development in Brazil; one of the earliest known cases of forest restoration for watershed management occurred here, in the 1860s. At that time, ongoing deforestation around Rio de Janeiro – then the capital of the country – compromised the provision of drinking water for the city. In response, Emperor Dom Pedro II established a forest restoration project in the headwaters of the watershed that provided water for the city (Dean, 1996). Between 1861 and 1873, over 68,000 tree seedlings were planted on a 180 ha site that eventually became part of Tijuca National Park (Castro Maya, 1967; Drummond, 1988). Remarkably, most of the trees planted were native species, in sharp contrast to most afforestation activities undertaken until quite recently, and a precedent that is of great relevance today to restoration ecology.

After independence, concern over drinking water continued to influence public policy. The National Water Law (Decree #24,643/1934) and the Forest Code (Decree #23,793/1934) were enacted in the mid-20th century to foster, in part, protection and sustainable use of water sources. In its current version, the Forest Code (Law #12,651/2012) requires private landowners to protect or restore land features, such as riparian buffers, natural springs, steep slopes, and mountaintops, as Areas of Permanent Protection (APP), in part to provide erosion control and reliable water supplies. In addition, 20% of each property in the country's southeast region must be maintained as a Legal Reserve (LR), where the exploitation of timber and forest products is limited. Although the Forest Code has undergone recent revisions that limit its power (Soares-Filho et al., 2014), it still serves as the major legal instrument combatting land degradation and promoting ecosystem conservation and restoration in Brazil (for details on Forest Code requirements, see Garcia et al., 2013).

The Forest Code has not been adequately enforced throughout its history, for both political and practical reasons. However, as remote sensing and other technologies have become more accessible, land use monitoring has become more accessible to both government agencies and civil society, leading to louder calls for enforcement and increasing pressure on many farmers and agricultural companies to restore APP and Legal Reserves to comply

Table 1
Analytical domains and dimensions, and research questions for examining elements of *Conservador das Águas*. Adapted from Corbera et al. (2009).

Analytical domain and dimensions	Guiding research questions	Analytical variables
Institutional design Are rules conducive to achieve goals?	Why was PES selected as a policy tool in Brazil? Which actors shaped the design of PES? How and why have rules changed over time in Extrema?	Brazilian water and land use policies (national, state, municipal) Actors involved in PES design Priorities of different actors involved in PES in Brazil
Institutional performance Is an institution achieving its goals?	How has *Conservador das Águas* affected forest cover and water quality in Extrema? Why do farmers decide to participate in *Conservador das Águas*? How is the provision of ES measured and monitored in Extrema?	Number of participants and land area under contract Processes for recruitment and enrollment of participants Incentives for participation by landowners Monitoring of ES and proxies
Institutional interplay How do institutions affect each other?	How does *CdA* account for existing institutions in Extrema? Where have synergies and conflicts occurred as a result of interactions between institutions?	Types of institutional interactions and their effects on design and implementation of *CdA*
Organizational capacity How does capacity affect performance?	Has *CdA* benefitted or been hampered by organizational capacities of its primary actors?	PES actors' levels of organizational capacity over time Use of partnerships at different program stages
Scale How does scale affect PES design and performance?	What institutions have been created to address problems or capitalize on opportunities across different institutional levels (e.g., municipal, federal)?	Development of institutions to address challenges or enable synergies Interactions among PES actors over different stages of *CdA*

with the law (Rodrigues et al., 2011). Despite the potential impact of these developments on improved law enforcement, restoration costs remain a major obstacle to compliance for landowners. In this context, PES schemes have been suggested as a means to foster legal compliance by owners of small and medium-sized landholdings (Brancalion et al., 2012; Banks-Leite et al., 2014). The new Forest Code acknowledges this, and a chapter is dedicated to financial incentives for legal compliance, with an emphasis on PES (Garcia et al., 2013).

Watershed management in Brazil is decentralized. At the federal level, the National Water Agency (*Agência Nacional de Águas* – ANA) oversees water policy and administers water use licenses, but most management decisions occur in conjunction with state government bodies. In 1997, an institutional framework was established to facilitate the creation of watershed committees and local water agencies to manage water resources (Veiga and Magrini, 2013). Each watershed committee is comprised of government representatives (either state or federal, depending on the jurisdiction for a given river), civil society representatives, and stakeholders, such as landowners and water users. These committees collectively decide how to (i) allocate water; (ii) implement new development projects; (iii) arbitrate conflicts among stakeholders; and (iv) impose pollution control restrictions (Porto and Kelman, 2000). National level actors still exert heavy influence on water management, but these committees provide a voice for local-level actors in project management and implementation.

The ANA has also created its own payment for watershed services, the Water Producer program (*Produtor de Água*), of which *Conservador das Águas* is part. In 2004, a method for estimating the environmental benefits and setting financial awards for landowners was developed for the *Produtor de Água* project (Heilbuth Jardim, 2010) and was used to design more than 30 Brazilian PES programs (Guedes and Seehusen, 2011). Funds for financing these operations have been procured through fees for water use in each basin, and are used provide technical and financial support to local governments and institutions to promote PES programs in important watersheds for the provision of drinking water.

2. Methods

2.1. Study region and context

Extrema is a city of 32,000 inhabitants located in southern Minas Gerais, near the border with the state of São Paulo, in southeastern Brazil. Its proximity to São Paulo has encouraged industrial development in the city, and, as of 2008, it held the highest gross domestic product (GDP) per capita of any municipality in Minas Gerais (R$47,000 or US$21,400) (Pereira et al., 2010). In contrast, land use in its rural areas remains primarily agricultural, with beef and dairy production serving as the primary revenue generating endeavors for farmers. Productivity is relatively low, as most farms are small, grazing potential is limited, and the labor force is aging (average age = 60 years) (Gavaldão, 2009). Despite their small size, these family farms have a collective impact on water quality extending beyond Extrema to the São Paulo metropolitan region, by far the most populated region of Brazil. These farms often include riparian corridors, and pasture management influences erosion and pollution. Water from these farms drains into two rivers, the Camanducaia and Jaguari, which flow into the Cantareira System (Fig. 1).

Extrema is located in the Atlantic Forest biome (*Mata Atlântica*) of eastern Brazil, which was once one of the largest and most biodiverse biomes in the world, covering approximately 130 million hectares (Dean, 1996). Centuries of agricultural expansion have registered the Atlantic Forest as a top five Global Biodiversity Hotspot for conservation (Laurance, 2009) that occupies less than 12% of its pre-European range, mainly as small (< 50 ha) fragments (Calmon et al., 2011; Ribeiro et al., 2009). The Atlantic Forest region continues to be the economic and demographic heart of Brazil – states in the biome produce over 70% of national GDP and harbor over 60% of Brazilian population (Melo et al., 2013). In addition, watersheds within its boundaries supply three-quarters of the Brazilian population with drinking water and generate 62% of Brazil's electricity (Joly et al., 2014).

Geographically, Extrema is also part of the Cantareira system, an interconnected set of reservoirs that provide water to more than 10 million people living in the metropolitan region of São Paulo (Pereira et al., 2010). In 2014, the state of São Paulo experienced one of the driest and hottest years in its recorded

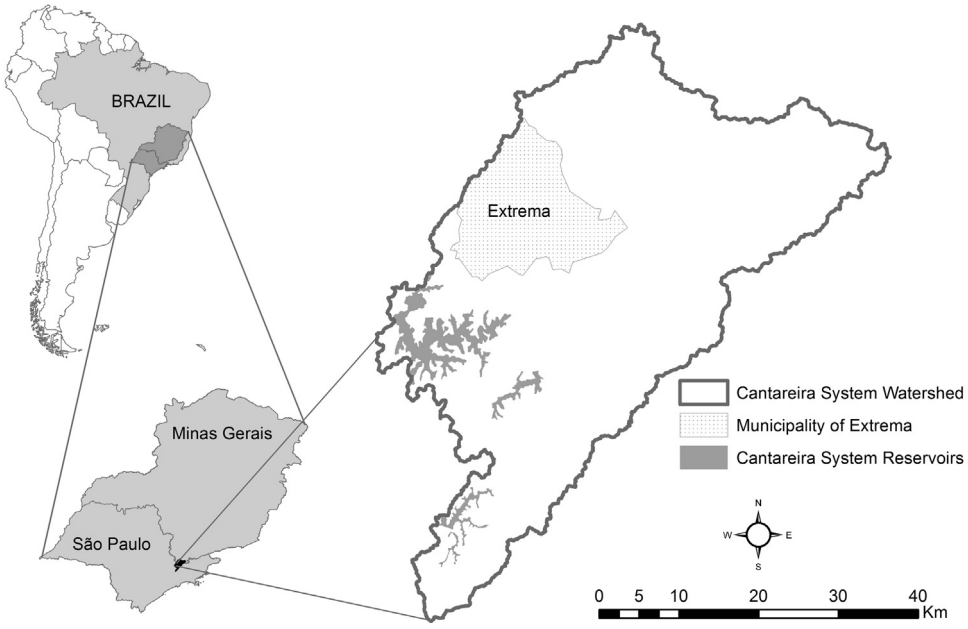

Fig. 1. The study area in the Cantareira reservoir system, and the municipality of Extrema, Minas Gerais, SE Brazil.

history, and the Cantareira system retained less than 10% of its water storage capacity for several consecutive months. This water crisis has continued into 2015, and has stirred an intense political debate in Brazil. Given the importance of these reservoirs, there is increasing concern over the impact of environmental degradation in the watershed on water quality and quantity (Cassola, 2010; Heilbuth Jardim, 2010; González et al., 2011).

Some of the concern during this water crisis has been directed at the greatly reduced native vegetation cover and poor soil management in agricultural areas of the watershed. In these conditions, much of the rainfall does not infiltrate the soil, instead immediately generating runoff, thus preventing groundwater recharge and causing siltation of watercourses (Salemi et al., 2013). Consequently, water supply is compromised in the dry season, and the lack of a riparian buffer enables pesticide, fertilizer, and sediment accumulation in waterways, reducing water quality year-round. To avoid this scenario, improved watershed management, through soil conservation practices and restoration of native vegetation, especially in riparian buffers, has become the main strategy to improve future water security (Agência Nacional de Águas, 2011).

2.2. Literature review and interviews

We conducted an extensive review of the literature on PES programs in Brazil – and in Extrema, in the state of Minas Gerais, specifically. This review included peer-reviewed journal articles as well as government documents and reports of project partners to develop an understanding of the institutional design and interplay that affected *Conservador das Águas*. The second phase of the study consisted of interviews with experts and project stakeholders to understand the strategies and interactions that led to the establishment of the program. Interview subjects included representatives from government agencies, NGOs, and academia (see Supplementary Table S1 for a list of literature and interview subjects). Information on landowner attitudes toward the project are drawn from interviews conducted by H. Gonçalves as part of an MSc thesis.

These interviews were used to map the roles and motivations of these stakeholders at each stage in the project's development, and their interactions with each other. The resulting history is presented in the subsequent section. A set of research questions were developed from the analytical variables proposed by Corbera et al. (2009), which guided the identification of important lessons from *Conservador das Águas*, including how the national and local legal framework, the organizational capacity of the Extrema municipal government, and interactions among stakeholders affected the implementation and expansion of the program over time (see Table 1 and Section 4).

3. Results: 10 years of "Conservador das Águas"

3.1. Legal framework

Although the aforementioned national programs have influenced restoration projects in Extrema, *Conservador das Águas* was also heavily affected by the local legal context. Following the launch of the *Produtor de Água* program, the Extrema municipal government saw an opportunity to develop its own PES program to invest in local watershed improvements. Forest restoration was central to this effort, as a large portion of the municipality's forest buffer areas along riparian areas and springs – mandated for conservation under the Forest Code – had been converted for use as rangeland for cattle. During early phases of the program, the delivery of payments to landowners under *Produtor de Água* was complicated and sometimes slow due to bureaucratic processes regulating public expenditures. In an attempt to remedy this situation, Law n° 2100/2005 was promulgated to authorize the use of municipal funds from Extrema to support rural landowners who would voluntarily commit to conservation or restoration activities. This was the first time a Brazilian municipality assumed the authority to conduct such transfers for a PES program, and the legal framework is now a template for other programs throughout the country.

Law n°2,100/2005 defines the objectives of the project in Extrema as well as the financial framework for its implementation. Under the law, the city is permitted to enter partnerships with civil society organizations and other government agencies to provide technical and financial support for ecological restoration. In addition, the scope of financial agreements between landowners and the city are defined, such that contracts are transparent and mismanagement is discouraged. Several municipal decrees followed, which refined the framework for contracts. Decree n°1,703/2006 defined four activities that must be accomplished by landowners to guarantee payment from the municipality:

i. adoption of soil conservation practices in order to reduce erosion and siltation of water courses,
ii. installation of a water sanitation system for on-farm wastewater treatment,
iii. planting and maintenance of native vegetation to comply with APP coverage under the Forest Code, and
iv. registration of the Legal Reserve on the property.

The decree also defines the necessary conditions for program eligibility, including the location of properties within a sub-basin covered by the program, minimum property size (2 ha), active agricultural management of the property (recreational farms, called *chácaras*, were not eligible), and the range of water uses on the property. These restrictions were included for logistical reasons, given the limited benefits and high transaction costs of restoration on very small farms. Restoration of larger areas was considered more effective and relevant to ecological goals. Properties that were used only for recreation were excluded because payments were deemed unlikely to alter land use or management.

Another decree (Decree n°1,801/2006) established geographic priorities within Extrema. The municipality extends across several sub-basins, with varying levels of forest cover and population density. The Posses basin (1201 ha), which possessed the lowest native vegetation cover of all sub-basins in Extrema, was selected as the first priority for project investments. Cost-effectiveness was a major consideration in priority setting, as environmental gains from project activities were expected to be highest here. As the program matured, the Salto sub-basin (4200 ha) was included in the program as well. The development of the legal framework was guided primarily by the municipality's Environment Department. Meetings were organized with landowners to update them in the design of the laws, although the general structure of the program had already been conceptualized prior to these discussions (Fig. 2).

3.2. Management structure

At the start of the *Conservador das Águas* project in 2005, no formal partnership among different stakeholders had been developed. The Environment Department of Extrema (DSUMA) had designed the project and, following the passage of municipal legislation, its representatives approached potential partners to request support for project implementation. Approval of legal decrees was granted by the Extrema Municipal Council of Environmental Development (CODEMA), which was composed of

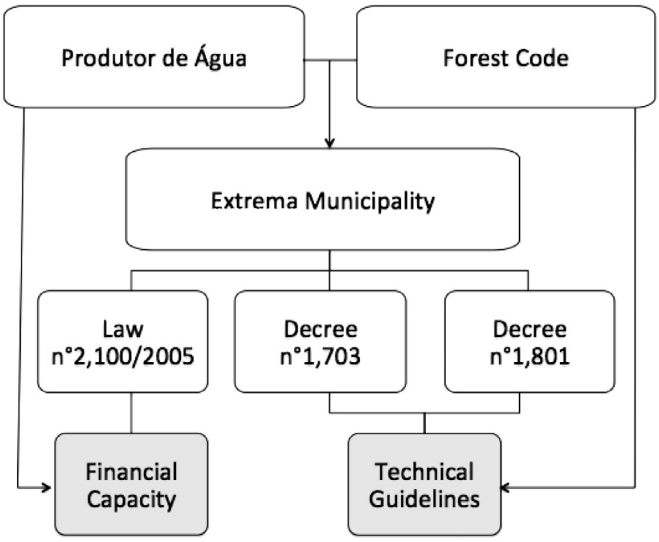

Fig. 2. Legal framework enabling the financial and technical guidelines for the *Conservador das Águas* program in the municipality of Extrema, Minas Gerais, SE Brazil.

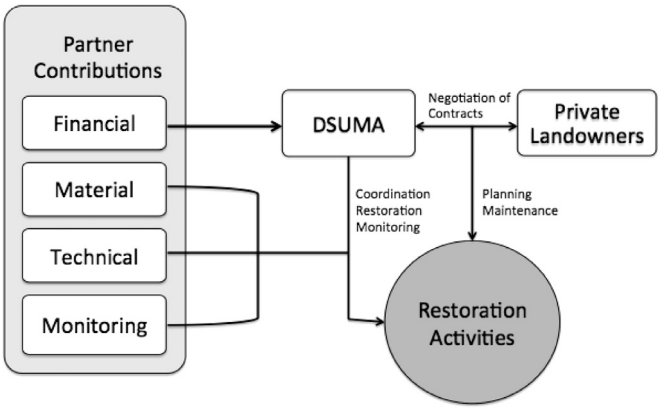

Fig. 3. Interactions and Partnerships in the *Conservador das Águas* program, in the municipality of Extrema, Minas Gerais, SE Brazil. Details on partners and contributions are listed in Table 1.

representatives from private and public sectors and NGOs (Pereira et al., 2010). There was already an existing relationship between DSUMA and The Nature Conservancy (TNC), the National Water Agency (ANA), and the Minas Gerais Institute of Forests (IEF), on other projects within the municipality, and this served as the basis for securing additional support for the project. Contracts with landowners were arranged through the municipal government. Contract duration was set at 4 years, with DSUMA negotiating each contract with individual landowners to establish reforestation commitments, management of remnant forest patches, and soil conservation measures. DSUMA and other partners were also engaged in restoration activities, including fencing off riparian areas and restoration plantings. Payments for compliance were initially procured via the municipal budget, with the first compensation distributed in 2007. The municipality was also responsible for compliance, as the primary legal authority for the project. Under the terms of the contracts, landowners receive payments for carrying out designated activities. Program staff monitor compliance with these obligations during site visits to each farm several times per year.

The roles of partners were developed as needs became known. Funding was secured primarily through municipal sources, but the PCJ watershed committee, IEF, and both ANA and Ministry of Environment (MMA) contributed funds to the project as well. Private firms were also engaged to fund components of the project. Given the interdisciplinary nature of the project, collaboration with universities and civil society organizations in the region was necessary to provide required expertise (Brancalion et al., 2013 – Fig. 3; Table 2). TNC and the University of São Paulo (USP/ESALQ) provided courses on the use of native species and maintenance of ecological restoration plantings to DSUMA staff. Native tree seedlings were supplied at no cost through an institutional partnership with SOS Mata Atlântica, a national NGO dedicated to conservation and restoration of the Atlantic Forest. Researchers from the Federal University of Lavras (UFLA) assisted in the mapping of soil types and prioritization of restoration sites.

3.3. Enrollment

Participation in the *Conservador das Águas* program was fostered through several years of consultation and discussion with landowners as the program was developed by DSUMA. As the legal framework for the program was developed, landowners and rural landowner associations were consulted and potential contracts and obligations were described to gauge interest. The rural landowner associations provided their support for the project in 2005, in spite of heterogeneous member opinions about the arrangement (Gonçalves, 2013). Relationships between neighbors were also considered when planning outreach and recruiting farmers for the program. Information would spread rapidly by word of mouth, and so municipal officials focused early efforts on key people who were active in the community and would share their views with those who were less familiar with the project. An analysis of landowner perceptions toward the program revealed that enrollment was influenced by both a concern over legal ramifications of non-compliance and whether neighbors had enrolled in the program (Gonçalves, 2013). As a result of this strategy, 53 contracts have been signed in the Posses sub-basin, representing 49% of the 108 landowners and 90% of the land area.

Encouraging enrollment was the most challenging phase of the project, and galvanizing participation has been achieved through the persistence of municipal officials. Initially, DSUMA staff focused on communicating the economic benefits of enrollment to landowners. In particular, they emphasized the benefits of receiving payments to comply with the Forest Code, and the utility of additional revenues for aging landowners on low-productivity farms. However, changing the income previously obtained by cattle ranching in riparian buffers by PES, in a context of weak legal compliance, would not increase farmers' income and would be risky due to uncertainties in the renewal of contracts. Thus, the economic argument was not initially sufficient to encourage enrollment in contracts. DSUMA officials shifted their messaging focus to the legal ramifications of non-compliance with the Forest Code in their interactions with landowners. Under federal legislation, restoration of areas designated as APPs is compulsory, and if a landowner chose not to enroll in the program they would be considered in violation of the Forest Code. Restoration would still be required at the landowner's expense if enforcement agents detected lack of compliance with legal requirements. State officials joined municipal staff to visit landowners, explain environmental laws, and suggest the PES program as a way for landowners to receive payment for restoration that was in any case legally required. However, restoration activities were negotiated with each farmer individually, and many concessions were made. In some cases, DSUMA officials did not require strict compliance with the Forest Code if the proportion of areas mandated for restoration was likely to compromise all on-farm economic activities.

Table 2
Partner engagement and contributions to the "*Conservador das Águas*" project, in the municipality of Extrema, Minas Gerais, SE Brazil. Project phase abbreviations – Conceptualization (C), pilot implementation (P), refinement/expansion (E).

Type	Institution	Project phase	Support	Details
Federal	Brazilian National Water Agency (ANA)	C, P, E	Material technical	Soil conservation measures
	Ministry of the Environment (MMA)	C, P	Financial	Project "*Água é Vida*" Environmental diagnostics
State	Minas Gerais State Forestry Institute (IEF-MG)	P, E	Material technical	Site planning Fence building Forest cover maps
Regional Committees	Piracicaba, Capivari and Jundiai Rivers Watershed Committee (PCJ Committee)	C, P, E	Financial	Funding for contracts
NGOs	The Nature Conservancy (TNC)	C, P, E	Financial Material Technical Monitoring	Preliminary studies Site and project planning Monitoring Communication and reporting
	SOS Mata Atlântica	P, E	Material technical	Natives plants and seeds
Universities	Lavras Federal University (UFLA)	P	Technical	Soil maps Environmental diagnostics
	University of Sao Paulo (ESALQ-USP)	P, E	Technical	Restoration training
Private firms	Badouccon (biscuit producer)	P, E	Financial	Funding for contracts
	Laticínio Serra Dourada (milk company)	P, E	Financial	Price increases for participants
	Aqualimp (water filtration firm)	P, E	Material	Bio-digestor installation

3.4. Negotiation of payments

Opportunity costs served as the basis for calculating payments for each contract. Given the prevalence of dairy and beef production in the municipality, the average value of grazing leases became the basis for estimating opportunity costs. Upon consultation with farmers, DSUMA set the per hectare contract price as the value of raising one head of cattle per year (the average stocking rate in this region), equivalent to US$95/year/ha (2013 values) (Kfouri and Favero, 2011). This price is linked to a Federal financial mechanism to protect it from inflation. The contract value was calculated using the number of hectares of each enrolled property, and payment was allocated on a monthly basis to provide regular income for farmers. At the start of the project, funding was only available through municipal sources. As the process continued, and enrollment increased, additional sources of funding became necessary. In order to enable private investment, the city council passed legislation in 2009 (Law no. 2482/2009) to create the Municipal Public and Private Fund for PES (*Fundo Municipal para Pagamentos por Serviços Ambientais* – FMPSA). FMPSA is dedicated solely to the purpose of supporting the *Conservador das Águas* program, and permits the receipt and allocation of funding from non-municipal sources. Tax revenue from the state of Minas Gerais, water use taxes from the PCJ basin, and funding from national and international institutions are now held by the fund. FMPSA remains primarily a tool for routing municipal funds to PES contracts; the goal is to guarantee sufficient funding to maintain payments to farmers through the year 2030.

3.5. Program development

We identify three periods in the development of the program in Extrema: the conceptualization phase (2005–2006), pilot implementation of the program (2007–2009), and a joint refinement/expansion phase (2009-present) (Fig. 4). Program conceptualization began with the realization that existing policy measures were inadequate given the demands of the Forest Code and concerns over water quality presented in Section 3.1. Once legal support for a PES program was secured, rules for the program were set and development of contracts and payments were developed within the municipal government. Rural landowners were engaged once the legal framework had been established.

Implementation activities included identification of eligible farmers and negotiation of individual contracts, and engagement with project partners to secure adequate support – both financial and logistical – for contracts. Municipal teams, and their partners, carried out restoration activities during this phase, and payments began to be distributed. Forest restoration activities consisted of fencing forest remnants to protect against cattle intrusion, fencing areas with suitable biodiversity and regeneration potential for 'passive restoration', and high diversity plantings, following methodology proposed by Rodrigues et al. (2011), to kickstart restoration in highly degraded areas. In the Posses sub-basin, where the project began, these activities resulted in a potential increase of approximately 60% of forest cover, concentrated along riparian buffers (Fig. 5). Over 170,745 m of fencing was installed to reduce the detrimental impact of cattle on water quality and their contribution to soil erosion. In addition, 30 biodigestors to treat wastewater on farms and 50 water reservoirs were built to control soil erosion and improve water quality (Prefeitura de Extrema,

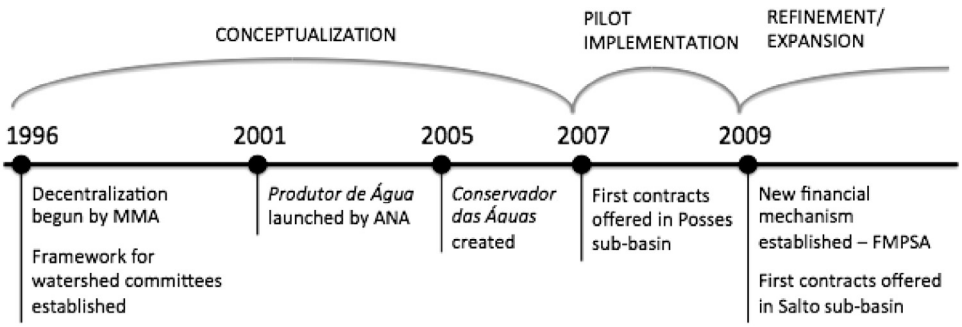

Fig. 4. Timeline of key events in the development of *Conservador das Águas* project, in the municipality of Extrema, Minas Gerais, SE Brazil.

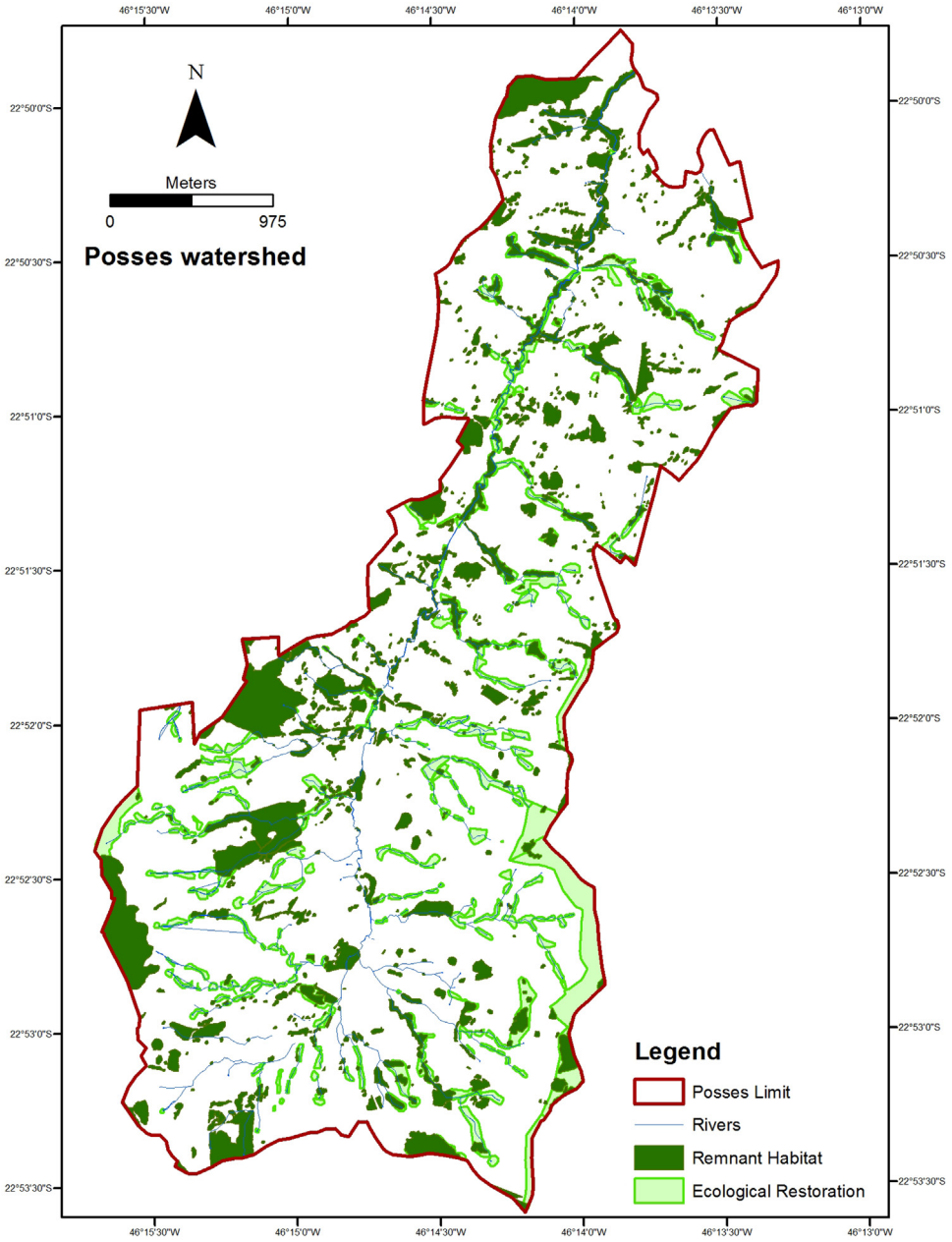

Fig. 5. Distribution of natural forest remnants and forest restoration sites in the Posses sub-basin, Extrema municipality, Minas Gerais, SE Brazil.

2012). While there is insufficient data as yet to quantify the impact of the various project activities on water quality and quantity, there are several organizations currently involved in tracking and monitoring these indicators throughout Extrema. The municipal government works with the Agronomy Institute of Campinas (IAC), the Agricultural Research Foundation (FUNDAG) and the Minerals Research Foundation (CPRM) to monitor water resources in the basin. Water flow and quality, as well as precipitation, are monitored through an agreement with ANA in third-order watersheds from both treated (i.e., undergoing restoration) and control basins in order to determine the impact of project activities. Spontaneous or assisted regeneration, and carbon storage, are also monitored in sub-basins where restoration is underway. The goal is to collect sufficient, accurate data for the project (Kfouri and Favero, 2011) to estimate the impact of PES investments in Extrema.

As early implementation activities were carried out and monitoring began, project managers used the information collected to refine the project and consider new goals, including expansion into additional sub-basins. In 2009, DSUMA began to negotiate contracts with farmers in Salto, another sub-basin within the municipality, with funds provided by the PCJ watershed committee. Program managers also expanded their teams to include technicians with skills that had been previously provided by partners. While the project still depends on external partners, the ultimate goal is to carry out field activities without requiring technical support from outside organizations.

In addition to increasing its own technical capacity, DSUMA has refined targeting strategies for new contracts. In 2011, it decided to implement new restoration contracts solely for APPs on private land, and began to acquire parcels for the municipality to improve forest cover. In particular, the department is targeting parcels that contain water sources and riparian zones, especially where agricultural land is being subdivided for housing. These acquisitions are supported, in part, by additional assistance from the Department of Protected Areas (DAP) of the Ministry of the Environment

(MMA), which develops strategies for the creation, public use, and financing of Protected Areas (PA) throughout the country. These areas are defined under Law n°9985/2000, which established the National Nature Preservation Units System (SNUC) to protect important natural heritage sites by limiting development (Ministry of Environment, 2010). This provides another opportunity for restoring forest cover as a proxy for improving watershed services provisioning in Extrema. The municipal government has also expanded its partnership with TNC to create a project that will complement *Conservador das Águas* by generating carbon credits for sale on the international voluntary carbon market. It is hoped that this additional source of revenue will help offset the operational costs of restoration and support the expansion of the project into other sub-basins. This partnership began in 2012, but as of 2015 participation in this program has been very difficult, with only two contracts. The much longer (30 year) landowner obligations normally required for carbon credits may have been a limitation. Whether this is due to opportunity costs or perceived risk inherent in a long-term contract is not evident.

4. Discussion

The development of the *Conservador das Águas* program highlights some practical lessons about local conditions and institutions that can be used to complement the general frameworks for PES presented in the body of literature on the subject. As an early example of a PES program that has matured beyond the pilot stage and adapted its operations to gain scale in the municipality, *Conservador das Águas* also provides lessons for practitioners at a time when water funds are experiencing rapid growth in popularity, especially in Latin America.

In the case of Extrema, PES was selected from a pool of policy options because of the relative importance of private property to the delivery of ecosystem services. The heterogeneous costs of delivery of these services (and compliance with the Forest Code) for individual landowners was a challenge to other policy and enforcement regimes, and a situation in which PES is considered to be advantageous (Jack et al., 2008). Relatively strong municipal organizations and socioeconomic pressures provided the necessary momentum to move the program into planning and implementation, but legal institutions – in particular the Forest Code – were also a tool for recruiting landowner enrollment in PES contracts. The scale of the program was carefully considered to maximize the impact of its investments given the capacity of municipal institutions, and as the project developed, managers considered feedback from various sources to adapt strategies and institutions and improve interactions with partners and the scale of program actions. Finally, there were sufficient connections between government and non-government organizations that gaps in knowledge and funding could be overcome and the program could be strengthened and expanded. Each of these factors were important to the development of *Conservador das Águas* and, in light of recent discussions on challenges to expanding PES in the region, important topics for further elaboration (see comments by Finney (2015) and Banks-Leite et al. (2015) regarding PES transaction costs).

4.1. Institutional capacity and political will

Improving environmental quality has been the focus of many new legal instruments around the world, but lack of political will and legal hurdles can limit the capacity of these institutions to develop beyond their promulgation. In Extrema, much of the necessary organizational structure for administering environmental programs was already in place prior to *Conservador das Águas*, and the staff in the municipal government has been relatively stable. In addition, the same political party has been consistently supported in municipal elections, which has likely made the modification of legal instruments and stability of budgets for environmental programs much easier to achieve. This resulted in lowered transaction costs for establishing PES, and supports the growing body of evidence that it is one of the key conditions for effective governance of natural resources (Waite et al., 2015; Wunder, 2013). Extrema also benefitted from geographic and political factors – the tax structure of Minas Gerais, and Extrema's proximity to the state of São Paulo (and its higher tax rates on industry), has supported industrial growth in the city, which has provided a tax base for municipal funds that can support a PES program.

4.2. Setting appropriate goals and targets

Although the legal and political context of Extrema favored PES, building a sustainable program required strategic planning. Limiting the availability of contracts to select sub-basins targeted areas where degradation was high and the potential return on investment was greatest reduced the risk of over-committing project resources, which is especially important given the high implementation and maintenance costs associated with forest restoration and retention ponds required in the terms of the contracts. These commitments create larger obstacles for gaining scale than other PES programs (e.g., Costa Rica's national PES program) and are likely to emerge in other tropical regions where restoration of complex plant communities is required. This strategy has also supported the development of municipal capacity over time to take on more contracts, use initial results to procure additional funding, and augment enrollment in PES contracts with land purchases to deliver additional services.

4.3. Minimizing transaction costs for producers

Encouraging pro-environmental behavior requires a consideration of all of the barriers to action faced by the target population. In the Atlantic Forest, for example, a desire to comply with the Forest Code can be overcome by the costs of reforestation, as native tree seedlings and the requisite labor costs are often substantial (Brancalion et al., 2012). Although PES programs account for these costs in their contracts, there is evidence that transaction costs play a role in participation decisions along with opportunity costs (Zanella et al., 2014; Falconer, 2000). It is therefore important for strategic planning to consider the mechanisms through which participation will be encouraged beyond immediate economic considerations. In Extrema, program managers sought to reduce these costs for farmers by securing the endorsement of rural associations, visiting individual farmers to negotiate customized restoration plans for enrolled parcels, and by supplying labor for restoration activities following enrollment.

4.4. Maximizing partnerships

Organizations not immediately involved in the procurement or sale of ecosystem services provide another option for reducing transaction costs, although their engagement in program activities will depend on the flexibility and capacity of organizations administering PES to identify needs and recruit assistance. In the case of Extrema, it is unlikely that the project would have been feasible if the municipality and individual landowners had been responsible for all aspects of project planning and execution from the outset. Partnerships with universities and civil society organizations provided key technical and monitoring capacity that supported planning and implementation of the project. It was evident during the research phase of this study that these

partnerships could be attributed to a very engaged city official who identified both community needs and potential partners. Their daily presence in the sub-basins where contracts were first implemented made the process more transparent for participating landowners. Their social networks also enhanced DSUMA capacity to identify opportunities to adapt the PES framework proposed by the ANA to the local conditions of Extrema. The presence of this type of leadership to coordinate organizations has also been noted in other recent reviews of governance (Waite et al., 2015). The partnerships created during the early phases of the project in Extrema have provided the municipality with additional tools for leveraging funding to secure additional environmental benefits, and access to skilled labor pools for project implementation. This helped solidify trust with landowners and encourage the compliance with contracts to support future administration of the program.

5. Conclusions

Since its inception in 2005, the *Conservador das Águas* program has contributed to the on-going ecological restoration of over 3000 ha of Atlantic Forest in the Extrema municipality. This achievement can be attributed to several factors. National water policy enabled the development of local watershed committees that unified stakeholders and established support for PES, and the municipal government capitalized on this opportunity. It identified gaps in legislation and adapted policies that addressed the financial and governance needs of a PES program. The program also benefitted from staff networks that were able to link different partners and find synergies for implementation of restoration projects, thereby increasing program capacity. Finally, program managers did not over-extend themselves during the initial implementation of the program, prioritizing participation and reforestation in highly degraded areas to test the program concept and organizational capacity.

Despite the initial success of the program, there is clearly room for improvement and need for additional research and project refinement in Extrema. Chief among the topics to be considered is a better understanding of the hydrological benefits gained through forest restoration. Although the use of proxies is generally accepted, monitoring of water quality and flow in intact, restored, and degraded watersheds would give greater confidence to the program's impact on watershed services and potentially attract new investments. Recent work by Naeem et al. (2015) suggests that this is not an issue unique to *Conservador das Águas*, and their proposed science guidelines for PES may be useful for extending existing collaborations with universities and NGOs in Extrema to develop future monitoring. It is also worth noting that, while the impact of municipal leadership is evident, the process of improving enrollment was time-consuming in Extrema and may present challenges in other locales. A better understanding of how landowners value land and consider incentives would improve targeting and strategic planning in future projects.

This case study provides lessons for practitioners engaging in similar efforts elsewhere, especially as increasing attention is being paid, nationally and globally, to the potential benefits and effectiveness of PES as a policy tool for securing environmental benefits on private land (Banks-Leite et al., 2014; Miteva et al., 2012). It is our hope that the work described here will serve as a complement to ongoing research on the benefits and effectiveness of PES, and inform program development in a manner that is effective and sustainable.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.ecoser.2015.09.002.

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