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Research

The social value of biodiversity and ecosystem services from the perspectives of different social actors

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ABSTRACT. A vast literature is now available on ecosystem services (ES), their potential as a tool for analyzing intertwined processes of ecological and social change, and their monetary valuation. Much less is known about the social value of different ES for different social actors (SA), and their links with specific components of biodiversity. We unpack the social aspects of an interdisciplinary and multi-SA methodology that allows us to assess how different SA perceive and value different ES, and how they associate them with different components of biodiversity, ecological attributes, and ecosystem types. We apply the methodology to a study area in the Gran Chaco region of South America, presenting original social-ecological information from the field. Being affected by the rapid and widespread expansion of agribusiness over the woody ecosystems of southern South America, this location provides a policy-relevant context in which to test our approach. We identified six major ecosystem types and five relevant SA. We carried out 163 individual in-depth interviews and ran seven single-actor focus groups. We identified 116 ES, which were then aggregated into 22 more general categories. Although all SA perceived all ecosystem types as multifunctional, they showed markedly different perceptions of and interests in the ES provided by them. Subsistence farmers and extension officers valued a large number of ES primarily provided by the most pristine ecosystems. Members of conservation agencies and policymakers also identified a wide range of ES, spanning all ecosystem types. However, large farmers and cattle ranchers recognized a dependency on only a small number of ES. Therefore, the rapid expansion of agribusiness occurring in this region is a threat to a large number of ES considered valuable by a wide range of SA. Without necessarily having to resort to monetary valuation, our methodology provides a rigorous quantitative-qualitative way to compare the perspective of different SA, including scientists, and is thus useful for social-ecological assessment and action.

Key Words: *Argentina; Chaco region; ecosystem services; interdisciplinary research; land use change; multifunctional landscapes; nature's benefits to people; social value of biodiversity*

INTRODUCTION

Large areas of land in Africa, Asia, and Latin America are being taken over by corporate capital, a process that, in some circumstances, is described as land grabbing (Zoomers 2010, Borras et al. 2012). This involves the expansion of industrial agriculture over native ecosystems and common resources (Vellema et al. 2011, Silvetti et al. 2013, Feintrenie 2014). These rapid land-use and land-cover changes, and concomitant changes in rural social structure, are generating a series of environmental and social costs and conflicts (Horrigan et al. 2002, Weis 2010, Woodhouse 2010), which have been interpreted as conflicts over the appropriation of ecosystem services (MEA 2005, Cáceres et al. 2010).

The joint consideration of these intertwined social and ecological processes, although essential, presents considerable methodological difficulties (Folke et al. 2005, Carpenter and Folke 2006, Chapin et al. 2010, Turner 2010). The concept of ecosystem services (ES), defined broadly as the benefits that people obtain from ecosystems (MEA 2005) has been proposed as a cornerstone element for the integrative analysis of coupled social-ecological systems, and a profuse literature has been produced on them (see e.g. recent reviews by Balvanera et al. 2012, Abson et al. 2014). Many authors have highlighted the potential of the ES concept to become a useful link in the integration of natural and social sciences (Perrings et al. 1992, de Chazal et al. 2008, Carpenter et al. 2009, Turner 2010, Díaz et al. 2011, Chan et al. 2012*a*, Martín-López et al. 2012, Liu et al. 2013, Nagendra et al. 2013, Reyers et al. 2013). They stress the need to (1) see the concept of ES as a twofold concept, i.e., environmental and social; (2) highlight the importance of studying cultural and social aspects of the ES, even when they might be difficult to assess and measure; and (3) integrate natural and social perspectives of ES as a strategy to better understand and tackle key problems related to sustainable development. Nonetheless, how ES should be measured remains unclear (Reyers et al. 2013, Martín-López et al. 2014).

Beyond those overarching frameworks and perspectives on ES, considerable uncertainty remains regarding the potential of the concept for integrating information acquired and analyzed from different disciplinary perspectives. Thus, researchers face a series of obstacles ranging from the lack of common vocabulary or research and communication rules, to the supposedly lower status of interdisciplinary publications (Chubin 1976, MacMynowski 2007). Despite honest attempts for more integrated approaches to science, tensions between disciplines arise (Garforth and Kerr 2011, Lele and Kurien 2011, Trompf 2011), which often discourage researchers from committing to interdisciplinary work. Formulating interdisciplinary research questions requires that the disciplines involved do more than simply "talk" to each other, but also deal with a series of concepts and methods that may be deeply unfamiliar to each other. As Radovich (1981) suggested, the discipline from which the research problem is defined permeates how the problem is actually conceived and also influences research methods, data analysis, and the kind of solutions proposed (Miller et al. 2008). To avoid this outcome, an

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ex-ante approach is needed, in which a common framework is constructed in the early stages of interdisciplinary collaboration (Díaz et al. 2011, Brandt et al. 2013), which complies with the nature of the research problems and with the disciplines involved.

Díaz et al. (2011) proposed an interdisciplinary framework for the analysis of the relationships between functional diversity, ES, and societies, which is applicable to specific social-environmental systems at local scales. Such a framework allows connections between functional diversity components of ecosystems and priorities of SA, using land-use decisions and ES as the main links between these ecological and social components. One of the novel contributions of this conceptual framework has been to unpack biodiversity and social heterogeneity and link the two explicitly. Drawing upon that framework, and presenting the results of a concrete case study in central Argentina, we further unpack the social system and its links with land use and land-use change. We thus describe a multistakeholder methodology aimed at finding out how different social actor groups (SA) in a highly heterogeneous society perceive and value different ES, and how they associate them to different ecosystem types.

Recent studies suggest that cultural perceptions and preferences toward ecosystem types and ES can be used to identify and assess how ES are valued by different SA (Quétier et al. 2010, Chan et al. 2012*b*, Martín-López et al. 2012, Milcu et al. 2013, Plieninger et al. 2014, von Heland and Folke 2014) and highlight the importance of considering the perspectives and interests of different SA (Barthel et al. 2005, Colding et al. 2006, Schultz et al. 2007, Tuvendal and Elmqvist 2011). Most studies to date have focused either on biophysical assessments of the capacity of ecosystems to deliver services, or on estimating their monetary value. Monetary valuation has proven useful for certain ES, particularly those with a well-established market value. But it is less useful to value cultural and regulating ES (Trainor 2006, Viglizzo et al. 2012, Deb 2014). Studies that follow a social-cultural approach to the problem (Quétier et al. 2010, Chan et al. 2012*b*, Daniel et al. 2012, Martín-Lopez et al. 2012, 2014, Milcu et al. 2013) are much more rare. Our study intends to move forward in this direction, by focusing on the social valuation of ES by different SA. It builds on the interdisciplinary framework of Díaz et al. (2011), providing a much more detailed description of the social aspects of the methodology. By presenting original results from an in-depth case study, we illustrate its potential, as well as contribute to the knowledge of the Chaco social-ecological systems.

Study system

In Argentina, agrarian capital, based on intensive crop cultivation and cattle raising, is currently expanding into areas occupied by forests that were historically used for extensive livestock raising, timber harvesting, fuel-wood, and nontimber forest products (Zak et al. 2008). This expansion is generating social conflicts between newcomers and the subsistence farmers traditionally settled in these areas (Cáceres et al. 2010, Tapella 2012, Cáceres 2014). Between 1998 and 2006 almost 2.3 million hectares were deforested in the country, a process largely driven by the rapid expansion of highly profitable soy cultivation in the past decade (SADSN 2008), which itself results from a combination of technological, ecological, and economic factors (Zak et al. 2008).

The interdisciplinary approach we present was tested in the southern extreme of the Gran Chaco biome, in Pocho Department, Córdoba Province, Argentina (31° 15′ 01″-31° 55′ 26″ S and 65° 16′ 16″-65° 40′ 51″ W). The climate is subtropical with a mean annual precipitation of 500 mm distributed in spring-summer (October-March), a mean annual temperature of 18°C and a water deficit of 500-800 mm (Cabido et al. 1994, Carranza and Ledesma 2005). Soils are mainly sandy-loam aridisols of alluvial origin (Gorgas and Tassile 2003). The vegetation that once covered most of the region is an open xerophytic forest dominated by the trees *Aspidosperma quebracho-blanco* and *Prosopis* spp. (Cabrera 1976, Cabido et al. 1994). At present, however, the predominant land cover is a mosaic of different ecosystems ranging from forest to open shrublands or cultivated patches, with a very small proportion of primary forest (Conti and Díaz 2013, Hoyos et al. 2013).

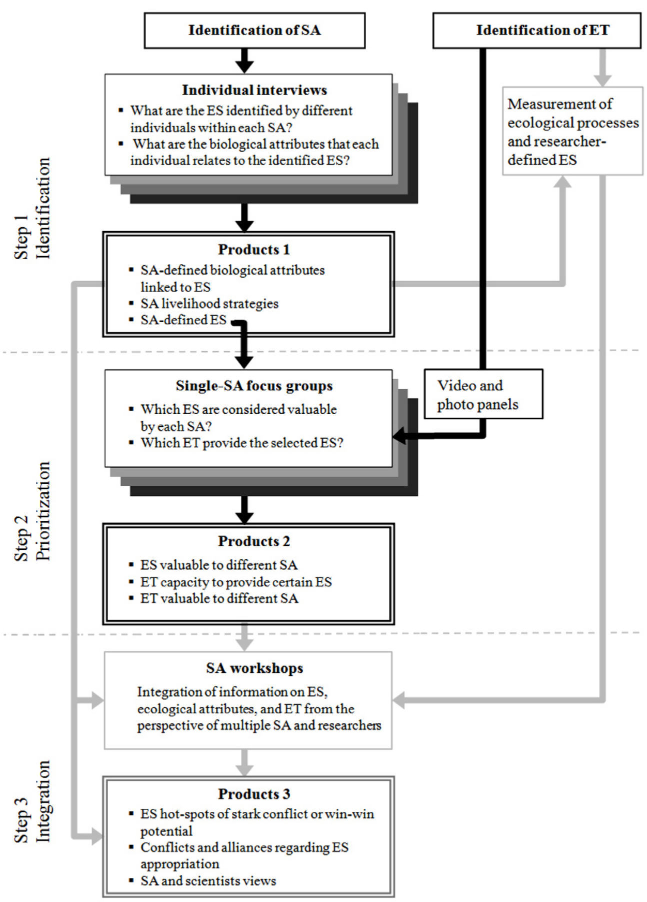
Expansion of agriculture over native ecosystems is occurring in the study area and neighboring regions. Considering an area of almost 2.5 million hectares including our study site, Hoyos et al. (2013) found that, between 1979 and 2010, the area covered with forests, both primary and secondary, decreased from 39.3% to 18.2%. The main changes occurred from 1999, with an average annual rate of conversion of forest into other ecosystem types of around 2%. The area devoted to agriculture increased over the same period, with an annual rate of expansion over other ecosystem types of 2.12% between 1999 and 2004 and 0.83% between 2004 and 2010. There is no published study showing the main land-cover changes specifically in the study area.

Overall, Pocho is a markedly rural department; population density is low (1.6 inhabitants/km²) and distributed in sparse settlements (DGEyC 2008). It is an economically depressed area, with 25.4% of its population having at least one unmet basic need, in contrast with a provincial average of 6.6% (DGEyC 2008). The main productive activity is animal husbandry, with over 33,000 cattle and 18,500 goats (Silvetti 2010). According to the latest rural census, at the beginning of the 2000s there were 436 farms in the department, but only 32 of them were larger than 1000 ha (7%), together representing 55% of the land area (INDEC 2002). Subsistence farmers, whose main productive activity is goat raising, are by far the most numerous farmer type; commercial farmers focus on cattle raising, i.e., cattle ranchers, or on growing annual crops, i.e., large farmers (Silvetti 2010, Tapella 2012). The average carrying capacity of rangelands in the area is approximately 10 ha per animal unit (Bocco et al. 2007). Intensive irrigated agriculture is an expanding emergent activity (Tapella 2012).

METHODOLOGY

Our methodology, summarized in Figure 1, can be described as a consensus methodology because it was designed to suit the frameworks, methods, and interests of both natural and social scientists, while also tailored for work with different SA. Drawing upon Díaz et al. (2011), it further develops what they described as Steps 1 and 2 of their interdisciplinary framework. A key aspect of our methodology is to highlight the importance of considering social heterogeneity during the process of analyzing biodiversity and ES. Taking into account the interests and priorities of different sectors of society as research inputs is of key importance in the production of policy-relevant scientific knowledge (Reyers et al. 2009). The proposed methodology allows the social valuation of ES, by focusing on the interests and strategies of different SA and their reliance on different ES provided by different ecosystem types. This provides insight into the connections between specific components of biodiversity, ecosystems, and groups within societies, and into possible conflicts emerging among SA pursuing totally or partially incompatible strategies for the appropriation of ES.

Fig. 1. Summary of the methodology presented (in black) within the framework of the broader methodology proposed by Díaz et al. (2011). The grey arrows and boxes are part of the methodology proposed by Díaz et al. (2011) but are not developed in the present article. Double-line boxes represent salient products of each step (for a more complete list of potential products see Table 1). Overlapping boxes in different shades of grey symbolize activities carried out in parallel with different social actors (SA). Step 1 focuses on the interdisciplinary identification of both SA and ecosystem types (ET), and on interviewing a wide range of individuals within each SA. Its main products (Products 1) are a list of ecosystem services (ES) identified by all interviewees, and detailed narratives of their perceived links with biodiversity and ecosystem properties. This list of ES and interdisciplinarily produced video and photo panels of the six ecosystem types are essential inputs to the next step. Step 2 consists of parallel, single SA focus groups. Its main products (Products 2) are SA priorities in terms of ES and the ecosystem types that can provide them. For steps not covered in this article, see Díaz et al. (2011), in which matrices and nonvectorial information represented by E and F of their Figure 3 are included in the Products 2 box, and matrix G is included in Products 3 box.



Following an ex-ante approach to the construction of interdisciplinary knowledge, one of the first joint tasks between natural and social scientists was to identify six distinct ecosystem types on which to focus the work with stakeholders. These ecosystem types, also called land-cover types in Díaz et al. (2011) and described in detail by Conti and Díaz (2013), include primary forest, secondary forest, closed species-rich shrubland, open *Larrea* shrubland, logged pastureland, and intensive annual cropland (Fig. 2). Each ecosystem type is the result of a different land-use history and as such relates to both ecological and socioeconomic issues that are considered relevant for natural and social scientists, respectively. Often more than one ecosystem type was present in an individual farm and all SA participating in the research were aware of the main characteristics of each ecosystem type (Appendix 1). Another initial joint task was to define who were the most relevant SA operating in the region and having stakes in these ecosystem types. These included local stakeholders who directly manipulate the ecosystems, i.e., different types of farmers, and remote stakeholders who via policies and regulations influence the way in which these ecosystems are being used, i.e., policy makers, conservation bodies, and extension officers.

Fig. 2. Main characteristics of six major ecosystem types observed in Western Córdoba, Argentina. For more detailed ecological description see Conti and Díaz (2013).

Ecosystem Type		Description
Primary forest		Old-growth forest, dominated by hardwood trees such as *Aspidosperma quebracho-blanco* and *Prosopis* spp. No significant logging or livestock foraging in the past seven and five decades, respectively. Currently, this ecosystem type is present only in small patches, most of them within protected areas.
Secondary forest		Forest with a more open canopy dominated by younger individuals of *Aspidosperma quebracho-blanco* and *Prosopis* spp (< 7 m tall). Current light selective logging and low livestock stocking rate.
Closed species-rich shrubland		Closed shrubland dominated by smaller trees (< 4 m tall) and shrubs such as *Mimozynganthus carinatus*, *Celtis ehrenbergiana*, *Acacia gilliesii*, *Larrea divaricata*, and *Capparis atamisquea*. Current moderate to heavy logging and moderate to high livestock stocking rate.
Larrea shrubland		Open shrubland dominated by *Larrea divaricata*, with high proportion of bare soil. Heavy logging and high livestock stocking rates during past decades, now decreasing due to declining productivity.
Logged pastureland		Open savanna-like vegetation where most woody plants have been cut down to stimulate grass production, often involving the introduction of the exotic *Cenchrus ciliaris.* When the latter fails to establish, resprouting shrubs form a dense lower vegetation layer.
Intensive annual cropland		Native vegetation entirely replaced by irrigated annual crops (potatoes, maize, wheat, and soy). Main current use grain and tuber production.

Table 1. Nonexhaustive list of potential results that can be produced using the methodology summarized in Figure 1.

Individual in-depth interviews
Number and type of ES identified as important for interviewees' livelihoods or professional interests.
Details about why these ES are important.
Narratives describing how ES are harvested, processed, consumed, and sometimes marketed.
Information about the biological attributes (equivalent of functional traits) that are associated to the provision of specific ES.
Information about the links between ES and ecosystem properties, as perceived by the interviewees.
Detailed information about the strategies followed by different types of farmers in order to appropriate ES.
Detailed information about the perspectives of policy makers, extension officers, and conservation bodies in relation to the appropriation of ES by end users.
Focus groups
Number and type of ES identified as important by each SA.
A ranking of the most important ES as perceived by each SA, and of the five most important ES as perceived by each attendee of the meetings.
Direct links between the ES marked as important by each SA and the ecosystem types that can supply them.
A ranking of the capacity of ecosystem types to provide the ES prioritized by each SA.
A list of ecological and social reasons why some ecosystem types are more important than others in providing certain ES.
Information about what is at stake for each SA and each ecosystem type in relation to processes of land-use change.
Areas of potential social-ecological conflict, agreement, and/or joint action among SA in relation to the use and appropriation of ES and ecosystem types.

To gather information on SAs perceptions of ES and ecosystem types, we used a combination of individual in-depth interviews and focus groups. Although individual interviews provide deeper insight into personal perspectives, group methods provide social context within which people discuss, negotiate, prioritize, reflect on, and mutually reshape their points of view, attitudes, and behavior (Ritchie 2003). It should be noted that even though individual in-depth interviews and focus groups are very different methodological tools, in our methodological approach they are inextricably linked, and need to be used in sequential order. The information generated during the individual interviews provides crucial input for the focus groups.

Individual in-depth interviews

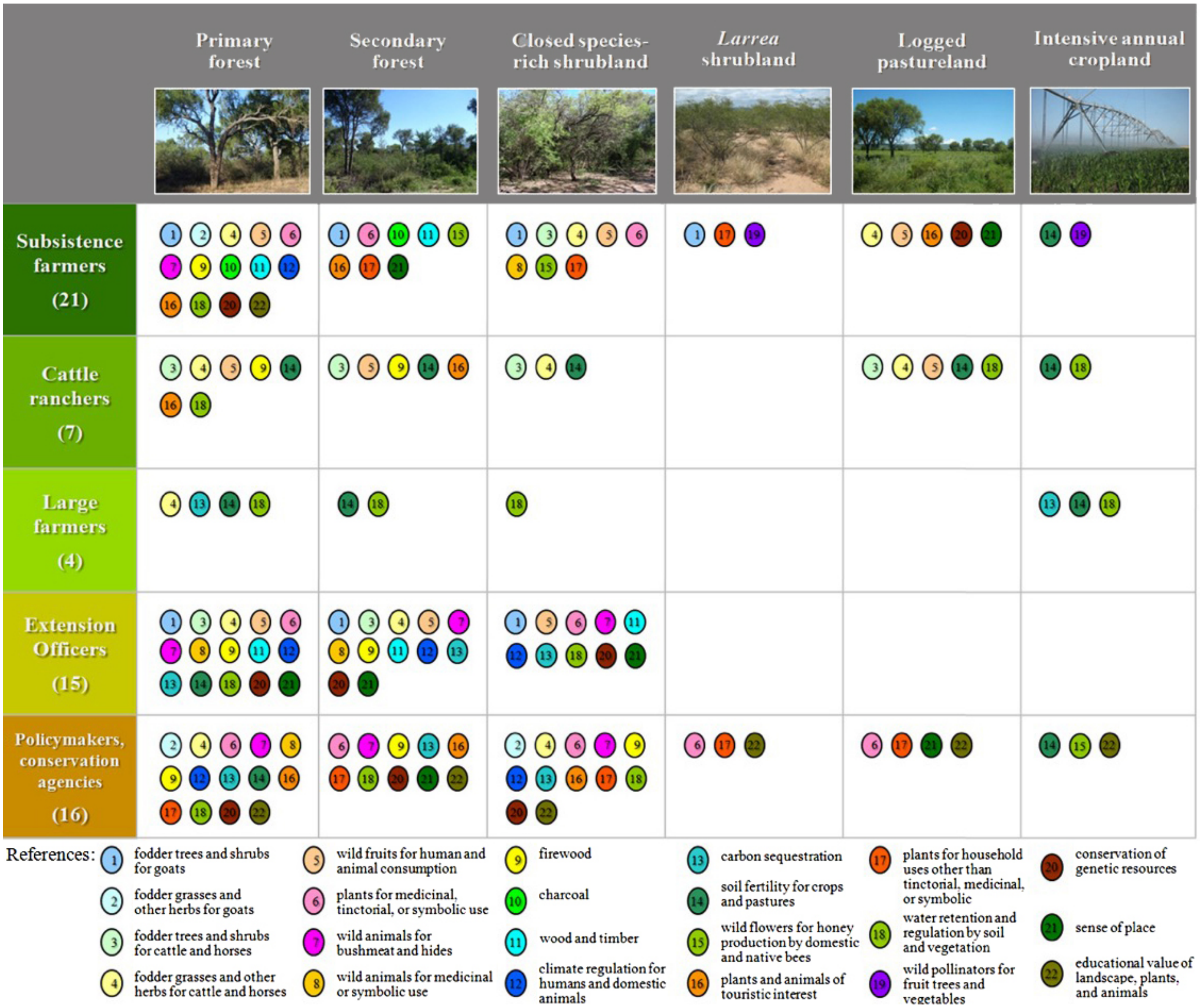
The method includes in-depth interviews with individuals belonging to the different SA categories defined in advance. These are semistructured situations based on a predefined set of questions but, at the same time, they are flexible enough to explore any promising insights offered by the interviewee (Legard et al. 2005).

The objective of this stage was to gather the widest possible variety of perceptions of ES, as well as perceptions of the biological attributes behind them. We focused on two main questions: (1) what are the ES identified by each interviewee?; and (2) what are the main biological attributes that each interviewee relates to the identified ES?

To prevent interviewees from being influenced by categories defined by the researchers in answering question (1) above, we did not provide a premade list of ES. Importantly, during the interviews, we did not use the concept of "ecosystem services" as such. Rather, we asked the interviewees what they used, liked, and/or valued from ecosystems in general, without explicit reference to different ecosystem types. This included key biological attributes that interviewees mentioned and valued in relation to a certain ES. For example, if someone said that "forests provided poles for fencing" (an ES), the interviewer would then ask "what makes a good pole for fencing?" Answers such as "trees with straight branches, and dark brown or dark red core" provided insight into the biological traits of the kinds (species, groups of species, life-stages) of trees that best provide the ES. This information is essential to understand how ES depend on ecosystem properties and biodiversity, including the presence or abundance of different species, and/or their functional traits (biological attributes) and interactions. These biological attributes, in turn, provide a direct link with data on ecosystem processes and functional diversity gathered independently by ecologists (Díaz et al. 2011). Some SA showed an accurate, and often very detailed, knowledge about the mechanistic links between ES and different components of ecosystems and biodiversity. For instance, subsistence farmers were able to describe in great detail the biological attributes or ecosystem- or biological community-level processes underpinning the provision of the ES in which they were interested. For example, good fodder for cattle was related to the presence of perennial grasses that resprout early and have broad and dark green leaves; the provision of key wild fruits depend on the presence of pollinators and certain weather conditions that have to be met during the flowering period; rains or dry winds do not favor the process.

In total, we carried out 163 interviews (137 interviewees), and they identified a total of 116 ES. We interviewed 36 subsistence farmers, 15 cattle ranchers, 17 large farmers, 35 extension officers, 24 policy makers and members of conservation agencies, and 10 people who had stakes in the study area but did not easily fit in any of the above categories (Appendix 2). The number of people interviewed within each category of SA was related to its relative abundance, heterogeneity, and relevance according to the study objectives. To guarantee accuracy and reliability, a wide variety of people belonging to the five categories of SA were interviewed during fieldwork. The concept of theoretical saturation (Bowen 2008) allowed us to identify redundancy and to decide when to

Fig. 3. Ecosystem services (ES) perceived as important by social actors (SA) and their link with the ecosystem types that are able to supply them, based on the results of the focus groups (see Selection of ES). The number between brackets in the first column represents the total number of ES perceived by each SA. For a detailed ranking of each ecosystem service by each social actor see Table 2.



stop interviewing people within a certain SA category. Members of all SA were interviewed in parallel to cross-check information and to adjust and sharpen the research questions used during interviews. This also ensured that potential biases associated with the introduction of adjustments during the process affected all SA in a similar way. All the interviews were recorded with the consent of the interviewees and complemented with written notes and photographs.

To use the information gathered during the first stage in the focus groups, we aggregated the 116 ES identified during the individual interviews into 22 more general categories to make the process more manageable and to avoid repetition. For example, if the interviewees had identified four different species of wild animals useful for their meat or hides as different ES, we grouped all four species into a wider category called "wild animals for bushmeat and hides." At the same time, we avoided the creation of categories whose broadness would have failed to capture the diversity of interests in ES by different SA. For example, merging the use of wild animals, wild fruits, and honey from the forest into a single "nontimber forest products" would have been too broad. For the sake of ecological accuracy and to respect the importance that ES have to the interviewees, these wider categories (listed in Fig. 3 and Table 2) were jointly constructed by ecologists and social scientists.

Focus groups

The next step in our methodology involved focus groups (sensu Morgan 1996). This technique collects data through group interactions among typically 4 and 12 people, on a well-defined

Table 2. Relative importance of the ecosystem services (ES) offered by six ecosystem types according to the priorities and interests of different social actors (the lower the number the more important is the ES). The importance of the ecosystem services was calculated using the priorities made by attendants of the focus group. The numbers in brackets correspond to those of colored circles in Figure 3.

Ecosystem Services	Social Actors				
	Subsistence Farmers	Cattle Ranchers	Large Farmers	Extension Officers	Policy Makers, Conservation Agencies
Fodder trees and shrubs for goats (1)	1	-	-	8	-
Fodder grasses and other herbs for goats (2)	12	-	-	-	10
Fodder trees and shrubs for cattle and horses (3)	15	4	-	12	-
Fodder grasses and other herbs for cattle and horses (4)	3	1	4	11	10
Wild fruits for human and animal consumption (5)	2	4	-	4	-
Plants for medicinal, tinctorial, or symbolic uses (6)	8	-	-	11	6
Wild animals for bushmeat and hides (7)	13	-	-	6	5
Wild animals for medicinal or symbolic use (8)	18	-	-	9	8
Firewood (9)	7	5	-	11	8
Charcoal (10)	10	-	-	-	-
Wood and timber (11)	4	-	-	5	-
Climate regulation for humans and domestic animals (12)	9	-	-	1	9
Carbon sequestration (13)	-	-	3	10	4
Soil fertility for crops and pastures (14)	16	2	1	9	8
Wild flowers for honey production by domestic bees (15)	6	-	-	-	-
Plants and animals of touristic interest (16)	19	6	-	-	4
Plants for household uses other than tinctorial, medicinal, and symbolic (17)	11	-	-	-	8
Water retention and regulation by soil and vegetation (18)	5	3	2	2	1
Wild pollinators for fruit trees and vegetables (19)	14	-	-	-	-
Conservation of genetic resources (20)	7	-	-	7	2
Sense of place (21)	17	-	-	3	3
Educational value of the landscape, plants, and animals (22)	16	-	-	-	7
Total number of ES prioritized by SA	21	7	4	15	15

topic established in advance. It is based on the assumption that group processes can help explore and clarify people's views in ways that would be less easily accessible in individual interviews (Kitzinger 1995). The recommended group size is based on the idea that with less than 4 people, discussions may not be rich enough; on the other hand, with more than 12, it may be difficult to complete all the planned activities within the proposed 3-hour time target, or to ensure the active involvement of all participants. This group size range proved adequate for our research aims.

We organized a series of single SA focus groups, in which participants met to discuss two main questions: (1) which are the most important ES for each SA; and (2) which are the ecosystem types that best provide the selected ES. In contrast to individual interviews, which provided personal perspectives, during the focus groups we intended to discuss, find consensus on, and rank ES and the ecosystem types that provide them. Because of their nature, the links between ES and different biological attributes were beyond the scope of these focus groups; they will be addressed elsewhere.

The main reason for our decision to hold single SA focus groups was to consider the power relations between SA. Had this not been considered, focus groups would have brought together SA with very different social, economic, and political trajectories and above all with very different shares of power. This would have hindered the participation of the less powerful SA and could have compromised the results of the research. Single SA focus groups do not totally eliminate the problem, because some intra-SA differences may still exist, but power asymmetries are much less marked. Most individuals who participated in the focus groups had previously been interviewed by the research team. This had a positive impact on the group situation because the participants were already familiar with the researchers and their aims.

Our focus group methodology was designed to meet a set of requirements. It had to: (1) be based on solid theoretical grounds from both the ecological and social perspectives; (2) be suitable for use with very different SA, from subsistence farmers with very little formal education to university-educated policy makers; and (3) be completed in less than three hours. A further challenge was to present the six ecosystem types to different audiences in a comparable and unbiased way. To this end, well in advance to the focus group series, ecologists and social scientists jointly developed a 15-minute video showing each of the 6 ecosystem types in great detail. Drawing upon in situ ecological field work, the video showed the vegetation structure, superficial soil characteristics, and most abundant and typical plants in each ecosystem types. To allow comparison, each ecosystem type was presented in the same way, using the same background music, and following the same communication protocol. There was no text accompanying the images, and the biotic configurations were presented following an identical order, chosen at random (http://www.youtube.com/watch?v=c1l1UjJVi6s). In addition to the video, six 1 x 1.5 m photo panels with representative pictures of the ecosystem types were placed on the meeting room walls before the start of each session. The main purposes of these panels were to help the participants remember the six ecosystem types once the video was finished, and to support the subsequent allocation of ES to, and valuation of different ecosystem types.

We ran a total of seven focus groups with the main SA having stakes in the region in general and in the six ecosystem types in particular. Three focus groups were carried out with subsistence farmers, which is by far the most numerous and heterogeneous SA group in the region. One of these consisted entirely of women, including the research team members coordinating the focus group. The remaining focus groups were held with cattle ranchers, large farmers, extension officers, and policy makers plus conservation agencies.

All focus groups were jointly coordinated by an ecologist and a social scientist. This methodological decision made sure that appropriate expertise was available during all meetings, as a way to obtain maximum benefit from the knowledge offered by SA. A trained nonparticipant observer was also present in the meeting room, with the roles of taking notes, providing logistic support, and giving feedback to the coordinators at the end of the meeting.

Importantly, in all seven focus groups, coordinators addressed the same research questions and used the same methodology. What follows is a brief description of the activities carried out in the meetings to address the two major research questions mentioned above.

Meeting opening
The meeting started with a general introduction, presentation of the objectives pursued by the research team, and a description of the subsequent activities.

Selection of ES
From a set of printed cards showing the 22 ES identified during individual interviews, each person was invited to pick the 5 ES that they judged most important for their livelihoods, i.e., in the case of different types of farmers, or for their professional activities, i.e., in the case of policy makers, extension officers, and members of conservation boards. Then each person ordered their selected ES from most important to least important.

Video and photo panels
After watching the video, the participants were invited to associate their selected ES to one or more ecosystem types. They were asked to pin their cards, containing the ES of their choice, to those photo panels showing the ecosystem types that, in their opinion, were able to provide these ES. Additional cards showing the same ES were available to allow participants to attach them to different photo panels if they thought that a certain ES was offered by more than one ecosystem type. Depending on the participants' interests and priorities, after this activity some photo panels ended up full of cards and others almost empty.

Summary, discussion, and rankings
The coordinators provided an oral summary of the ES linked to each ecosystem type. This was visually assisted by reordering the cards pinned to each panel, so that cards showing the same ES appeared together. By comparing the ES prioritized in each photo panel, it was possible to visualize (1) which were the most important ES for the group, i.e., total number of cards for each ES across all the panels; (2) which were the most valued ecosystem types, i.e., total number of cards pinned to each ecosystem type panel; and (3) which were the ES associated to each ecosystem type, i.e., number of cards for each ES on each ecosystem type panel. Then the coordinators asked the participants to explain why they made those links between ES and ecosystem types, and asked them to rank the ecosystem types according to their capacity to provide each ES. When there was a disagreement, they were encouraged to discuss the differences and to explain the reasons underlying their opinions. The ranking was made either by consensus of the whole group or through a majority of raised hands. Starting with the ES that appeared as the most important one, the same procedure was followed for all the other ES. To check the reliability of the rankings made by the group, before the end of the meeting the nonparticipant observer asked the group to produce again the ranking referred to a certain ES already discussed by the group. This allowed checking for internal consistency. In all cases, the participants were able to reproduce the original rankings.

It is important to mention that the ecosystem types identified by the interdisciplinary research team were cross-checked with the perspectives of all SA. When presenting the ecosystem types to the SA during the focus groups, the researchers did not provide any of the names used here. Rather, we named them with correlative numbers, which were randomly assigned. Therefore, neither in the video, nor in the photo panels did we identify the ecosystem types with a specific name. Following the concept of social representations (Durkeheim 1986), at the end of each meeting, the coordinators asked the participants to name the different ecosystem types and to describe their main characteristics. Their descriptions matched very well researchers' categories and allowed the validation of the six ecological categories we were working with.

Meeting closure
By the end of the meeting, a summary of the main group conclusions was presented by the coordinators. Finally, a social event took place, providing an opportunity to discuss ES, ecosystem types, and livelihood strategies in a more relaxed atmosphere.

This methodology, i.e., individual interviews plus focus groups, produced detailed information about SA's perceptions of ES and the ecosystem types that provide them, as summarized in Table 1.

RESULTS

Perceptions of different social actors on ecosystem services and ecosystem types in central Argentina

A synthesis of the information gathered in the seven focus groups is presented in Figure 3, where each cell contains the ES that each SA associated to each of the six ecosystem types. In other words, the presence of a certain ES within a cell means that at least one of the participants linked that ES to that particular ecosystem type.

Subsistence farmers identified 21 ES, out of a total of 22, as important for their livelihoods and related them with all six ecosystem types. However, they did not consider all ecosystem types as equally important. The less modified ones, i.e., primary forest, secondary forest, and closed species-rich shrubland, were the most important in terms of the number of ES provided. At the other end, large farmers identified only four ES relevant to their livelihoods and related them to four ecosystem types. Cattle ranchers represented an intermediate situation both in terms of the number of ES identified (seven) and related ecosystem types (five). Large famers and cattle ranchers preferred both the most pristine and the most modified ecosystem types. Neither of them considered that open *Larrea* shrubland could supply them with ES of interest.

There was stark contrast between the ES prioritized by subsistence farmers on the one hand and large farmers on the other. Although subsistence farmers focused mostly on livestock raising, especially goats, and on a number of hunting and gathering activities carried out in forests and shrublands, large farmers relied much less on the ES provided by native Chaco vegetation because industrial agriculture allows them to focus on just a few ES. Cattle ranchers once again represented an intermediate situation, manipulating the ecosystems to maximize fodder production. Even when they frequently produce major changes on ecosystem structure, for instance, when they cut down the forest to sow exotic pastures, they still rely, at least partially, on the forage and wild fruits produced by native trees and shrubs.

The SA that do not directly manipulate ecosystems for their livelihoods, i.e., policy makers and conservation agencies along with extension officers, recognized a large number of ES (15), and they acknowledged the importance of native vegetation in providing rich bundles of them. The latter point was particularly highlighted by extension officers. This may be related to the fact that the extension officers who work in the study area mostly belong to governmental programs, peasant organizations, and NGOs with a focus on subsistence farmers. They may thus have resonated with the interests of the farmers with whom they work most directly.

Overall, all ecosystem types were associated with bundles of ES. This was particularly marked in the case of, but not exclusive to, native ecosystems. There was general agreement among SA on the large number of ES associated with the primary and secondary forests on the one hand, and the low number associated with the *Larrea* shrubland, on the other.

Although Figure 3 provides a general picture of SA preferences for ES and ecosystem types, Table 2 shows how different SA ranked the ES that they considered important. “Fodder trees and shrubs for goats” and “wild fruits for human and animal consumption” were the most important ES for subsistence farmers. “Water retention and regulation by soil and vegetation” and “soil fertility for crops and pastures” were prioritized by large farmers; whereas “fodder grasses and herbs for cattle and horses” and “soil fertility for crops and pastures” were the most important for cattle ranchers. Policy makers and conservation agencies focused on “water regulation by soil and vegetation” and on the “conservation of genetic resources.” Finally, “climate regulation for humans and domestic animals” was the most important ES for extension officers. “Soil fertility for crops and pastures;” “fodder grasses and other herbs for cattle and horses;” and “water retention and regulation by soil and vegetation” were the only ES prioritized by all five SA.

Focusing on those SA that directly manipulate the ecosystems, i. e., farmers, there are two salient aspects. First, the wider range of ES that subsistence farmers identified and used may be related to their more complex and diversified livelihood strategies and to their closer daily interactions with the ecosystems. Second, the ES that each SA highlighted as the most important was strongly linked with the core of their livelihood strategies. In central Argentina, goat raising has been the backbone of the livelihoods of subsistence farmers for generations (Silvetti and Cáceres 1998, Silvetti 2010). In the case of large farmers, soil fertility is a very important ES because it directly drives crop yield. However, if the soils do not supply the levels of fertility demanded by each crop, they can add chemical fertilizers bought from the market. Similarly, water retention and regulation by soil and vegetation is a crucial aspect of their strategy, but they can partially substitute it with irrigation.

As well as displaying some of the major results of this case study, Figure 3 illustrates the more general potential of the described methodology to summarize major trends of association between ES, ecosystem types, and SA because they assess the social value of different ES and ecosystem types, applicable to other studies. In addition, although not the only possible way of synthesizing information emerging from the application of this methodology, Figure 3 has proven to be an effective visualization tool in the communication with various SA.

The results within the wider framework of the Millennium Ecosystem Assessment categories of ecosystem services

To facilitate comparability with other works in the literature, the identified ES were also classified ex post by the research group following the Millennium Ecosystem Assessment categories, as defined in Carpenter et al. (2009; Appendix 3). However, these were not discussed with the SA at any stage. Having done so would have compromised our methodology because it would likely have conditioned SA’s perceptions and responses. Out of the 22 ES, 11 were provisioning, 5 regulating, 3 cultural, and 3 had a mixed cultural and provisioning nature. There were some commonalities across SA in two of the categories. Provisioning ES were favored by all SA, which is not surprising because of their essential role in making a living. Perhaps more unexpected is the fact that all SA also identified regulating services, which in general are more difficult to grasp. In the case of cultural ES, there were differences among SA, with subsistence farmers identifying the largest number and large farmers identifying none. Overall, however, the number of cultural and cultural-provisioning ES identified by all SA was low. This is unlikely the result of a bias introduced by the way the interviews were carried out, because these inquired broadly about what people used, liked, and/or valued. It is also not a consequence of an over-lumping of cultural ES compared to other ES types during the aggregation process described in the methodology section. The proportion of provisioning ES in the original disaggregated list of 116 ES (c. 59%) was even higher than in the final aggregated list of 22 ES (50%), because SA tended to identify a large number of them with great precision. In contrast, the regulating, cultural, and cultural-provisioning ES mentioned by the SA were both fewer in number and less specific, requiring less aggregation, and representing c. 22, 14, and 14%, respectively, of the aggregated list, as compared to c. 9, 9, and 23% of the original list. In sum, there is a marked predominance of provisioning over other types among the ES identified in our study, and this is unlikely to be the result of methodological biases. The reasons for this pattern, and whether this is specific to our case study or simply reflects a more universal trend, are beyond the scope of this artile.

DISCUSSION

Overall, our results show that SA with stakes in the land of the study region in central Argentina have very different perceptions of and interests placed on the benefits provided by local ecosystems. Subsistence farmers rely on the highest number of services for their livelihood, which are provided mainly by the less intensively managed ecosystem types. This probably relates to their strategies of ES appropriation, based on more diversified livelihood strategies (Landini 2011), which tend to rely nonintensively on a wide variety of resources, rather than concentrate in the full exploitation of a single option. Neither large farmers nor cattle ranchers show such a heavy dependence on the benefits provided by native ecosystems. In particular, the former group reported reliance on just a few ES and was able to substitute the most important ones with industrial inputs, such as fertilizers.

In the particular case of the study region, logged pasturelands and intensive annual croplands occupy a small proportion of the land compared to other ecosystem types (Conti 2012). However, they are likely to expand in the near future, given the high international demand for the goods produced by agribusiness in Argentina and considering that government policies clearly foster grain and beef production (Gasparri et al. 2013, Silvetti et al. 2013, Cáceres 2014). The rapid appropriation of ES by agribusiness, together with the expulsion of subsistence farmers from the land, fall within the process of accumulation by dispossession described by Harvey (2003). Our findings show that this process will likely entail the loss of numerous ES considered important by the most vulnerable sectors and society in general in central Argentina. Specifically, further replacement of native forests by annual crops and exotic pastures will jeopardize several ES important to local subsistence farmers. As such, it may amplify current conflicts between agribusiness and subsistence farmers political movements (McMichael 2009). This process of fast land conversion is also likely to be detrimental to global public goods, such as the evolutionary heritage embodied in biodiversity (Faith et al. 2010, Mace et al. 2014) and the capacity to regulate climate through biological sequestration of carbon (IPCC 2014).

These social-ecological systems undergoing fast structural changes provide a policy- and practice-relevant setting for investigating how the social valuation of ES gives insight into trade-offs and synergies between ES, and into conflicts and alliances between SA in the process of appropriating them. The social valuation approach presented provides useful insight into what is actually at stake when land-use changes are accelerated, as occurs in the Chaco region of Argentina. Our social valuation approach does not necessarily preclude monetary valuation of some ES, but incorporates a wider range of perspectives and a more comprehensive idea of the value of different ES for the livelihood or professional life of different SA. This is particularly important in developing countries in which subsistence or informal economies are very common, large power asymmetries are widespread, and some SA may have little experience in dealing with money (Pascual et al. 2010, 2014, Martín-López et al. 2014).

In particular, we were able to show: (1) the environmental consequences of the land-use changes, measured in terms of loss/gain of various ES and ecosystem types; (2) how these transformations would affect different SA in terms of supply of, or access to, ES that are critical for their livelihoods; and finally (3) who would be the likely winners or losers of the overall process. Such information could feed into multicriteria decision support tools (as in de Chazal et al. 2008). It can inform public policies and the political strategies of the different SA engaged in the land-use change process, with relevant data about the importance of the ecosystems undergoing the process.

More generally, our ex ante interdisciplinary approach, initially proposed by Díaz et al. (2011), and presented here in further detail and operationalized through an original in-depth case study, is able to produce detailed information that could be used to describe and analyze: (1) foci of interest for each SA, both in terms of the ES they value most and the ecosystem types they consider as key sources for such services (Fig. 3); (2) likely conflicts between SA showing interest in the same ES or ecosystem types, or fostering incompatible uses for a given ecosystem type; (3) possible agreements or alliances among SA who have a shared interest in conserving or accessing some ecosystem types that they consider important; and possible areas of disagreement or conflict among SA, which can help expose demands, and discuss or negotiate future strategies and alliances.

Articulating the social and ecological dimensions of ES is a key challenge of social valuation studies, and our research did not follow a vectorial trajectory: different levels of articulation/integration between ecological and social fields were negotiated iteratively, as described by MacMynowski (2007). New, shared methods and new concepts emerged as a consequence of this process. Overall, the notion of ES and its SA specificity was central in articulating the different disciplines and in the construction and application of the methodology. Following Star and Griesemer (1989) and Abson et al. (2014), the concept of ES could be understood as a boundary object because it is both adaptable to different viewpoints and robust enough to maintain identity across disciplines. Our study shows how this was indeed the case.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/7297

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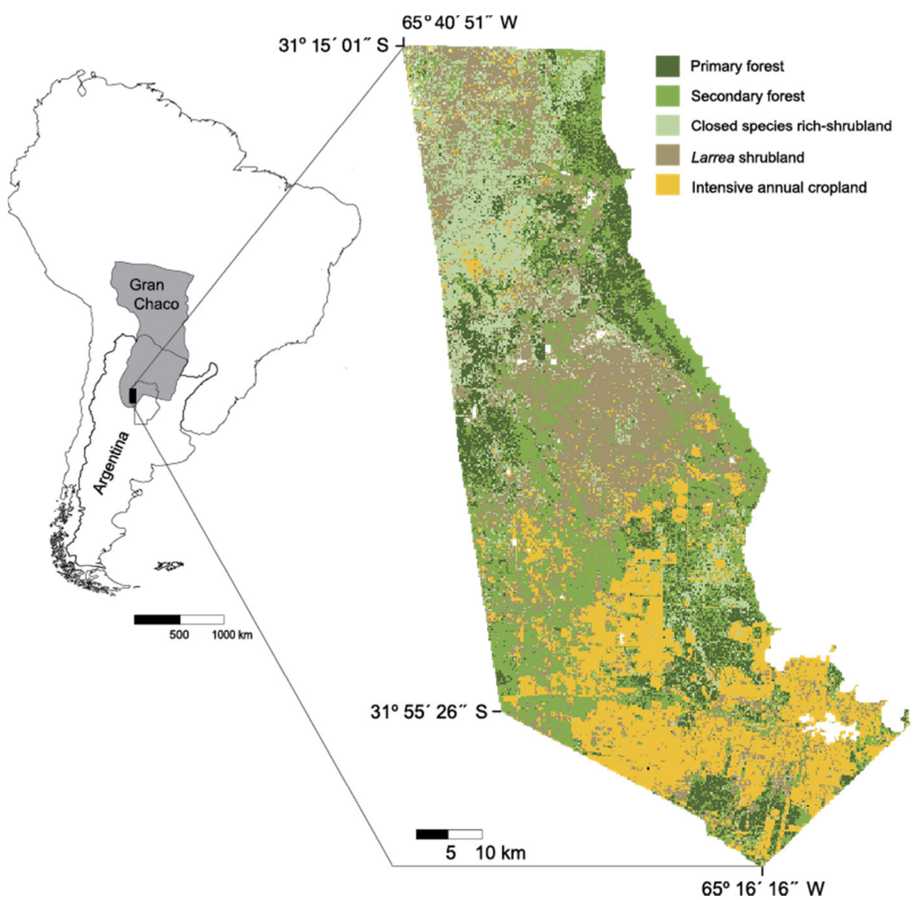
Appendix 1

The study area shows a heterogeneous ecological pattern where different ecosystem types coexist in the same territory (see Fig. A1.1 below).

Fig. A1.1 Location of the study area in Argentina and South America, and distribution of different ecosystem types within it. The land cover map was made using Landsat images for 2004 (TM, 30 x 30 m resolution) over the study area (c. 240.000 ha) and is based on Hoyos et al. (2013). The names of the ecosystem types follow Conti & Díaz (2013). Percentage of the study area occupied by each ecosystem type are: 12.93% for primary forest, 27.22% for secondary forest, 14.62% for closed species-rich shrubland, 23,84% for *Larrea* shrubland, 21.14% for intensive annual cropland and less than 1% for logged pastureland. The latter is not shown because the size of the patches is below the resolution of the map. Detailed descriptions of each ecosystem type are provided in Conti & Díaz (2013) and summarized in Figure 2. The percentage of primary forest is unusually high for the wider region, and is associated to the existence to the Chancaní Provincial Nature Reserve.



It is common that several ecosystem types are found in the same farm. Due to this fine-grain heterogeneity, all SA are very familiar with the main ecological and productive features of each ecosystem type. For example, even when the main focus of some of these farmers is intensive agriculture, some portions of their farms still have areas occupied by other ecosystem types. On the other hand, it is a common practice for subsistence farmers to work part time in the farms of large farmers (e.g., during the harvest, to repair fences, or to help with a series of livestock-related tasks). Finally, extension officers and policy makers and conservation agencies are all knowledgeable about the study area, the different ecosystem types and the kind of ES they can provide.

Appendix 2

Table A2.1: Summary of the social actors (SA) interviewed in the study. The number between brackets represents the number of interviewees per institution. SA in the "Other" category were interviewed but did not participate as such in the focus groups.

Social Actor	No. of Interviewees	Description
Subsistence farmers	36	Small farmers focus on extensive livestock raising (mostly goats) and also using native vegetation for firewood, timber and non-timber products. Farms located in El Cadillo, Chancaní, Santa Rosa, El Quemado, La Patria, Quebrachitos, Los Médanos, Los Medanitos, Las Oscuras and Cortaderas.
Cattle ranchers	15	Large ranchers devoted to semi-intensive cattle ranching and in some cases the production of firewood and charcoal for non-local markets. Farms located in El Cadillo, Chancaní, Santa Rosa, El Quemado, La Patria, Quebrachitos, Los Médanos, Los Medanitos, Las Oscuras and Cortaderas.
Large farmers	17	Large agricultural farmers focusing on irrigated farming (potatoes, corn, wheat, and soy). Farms located in San Vicente, San Miguel, San José and Los Cerrillos.
Extension officers	12 from extension institutions	Subsecretaría de Agricultura Familiar y Desarrollo Rural (4)
		Facultad de Ciencias Agropecuarias – Universidad Nacional de Córdoba (3)
		Ministerio de Agricultura Ganadería y Alimentos – Delegación Zonal de Villa Dolores (1)
		Instituto Nacional de Tecnología Agropecuaria – Agencia de Extensión Rural de Villa Dolores (4)
	11 from research institutions	Instituto Nacional de Tecnología Agropecuaria – Estación Forestal de Villa Dolores (2)
		Secretaría de Ciencia y Técnica (2)
		Facultad de Ciencias Agropecuarias – Universidad Nacional de Córdoba (4)
		Instituto Multidisciplinario de Biología Vegetal (1)
		Instituto Nacional de Tecnología Agropecuaria – Estación de Experimentación Agropecuaria Manfredi (1)
		Instituto Nacional de Tecnología Agropecuaria – Centro Regional Córdoba (1)
	12 from civil society organizations and the private sector	Unión de Campesinos de Traslasierra (3)
		Tecno Riego Agro Servicios (2)
		Consorcio de Riego Río Los Sauces (2)
		Asociación de Productores del Norte de Córdoba (2)
		Veterinaria Belgrano (2)
		Agroquímicos Bio y Sam SRL (1)
Policy makers and conservation agencies	12 from national and provincial government agencies	Secretaría de Ciencia y Técnica (1)
		Instituto Nacional de Tecnología Agropecuaria (3)
		Servicio Nacional de Sanidad y Calidad Agroalimentaria (1)
		Dirección de Ganadería de la Provincia de Córdoba (3)
		Dirección de Agricultura de la Provincia de Córdoba (2)
		Ministerio de Agricultura Ganadería y Alimentos (2)
	8 from conservation bodies, and natural reserves	Administración de Parques Nacionales (3)
		Secretaría de Ambiente de la Provincia de Córdoba (2)
		Parque Provincial *y* Reserva Forestal Chancaní (2)
		Plan Provincial de Manejo del Fuego (1)

	4 from local authorities	Major from the Departments of Pocho, San Alberto and San Javier (3)
		Representative of the Comune of Chancaní (1)
Other	10 from rural schools, catholic church, and local institution	Teachers of rural primary schools (5)
		Teachers of rural secondary schools (3)
		Local catholic priest (1)
		Local healer – Fundación Niños del Mañana (1)

Appendix 3

Tables in this section show (1) how the ecosystem services identified by the social actors fit into the Millennium Ecosystem Assessment categories (Table 1), and (2) the number of different types of ecosystem services identified by each social actor (Table 2).

Table A3.1 Ecosystem services identified by stakeholders according to the Millennium Ecosystem Assessment categories (as defined in Carpenter et al. 2009). The numbers between brackets coincide with the order number in which they are listed in Figure 2.

Ecosystem Services	Type of Ecosystem Service
Fodder trees and shrubs for goats (1)	provisioning
Fodder grasses and other herbs for goats (2)	provisioning
Fodder trees and shrubs for cattle and horses (3)	provisioning
Fodder grasses and other herbs for cattle and horses (4)	provisioning
Wild fruits for human and animal consumption (5)	provisioning
Plants for medicinal, tinctorial, or symbolic uses (6)	cultural and provisioning
Wild animals for bushmeat and hides (7)	cultural and provisioning
Wild animals for medicinal, or symbolic use (8)	cultural and provisioning
Firewood (9)	provisioning
Charcoal (10)	provisioning
Wood and timber (11)	provisioning
Climate regulation for humans and domestic animals (12)	regulating
Carbon sequestration (13)	regulating
Soil fertility for crops and pastures (14)	regulating
Wild flowers for honey production by domestic and native bees (15)	provisioning
Plants and animals of touristic interest (16)	cultural
Plants for household uses other than tinctorial, medicinal, and symbolic (17)	provisioning
Water retention and regulation by soil and vegetation (18)	regulating
Wild pollinators for fruit trees and vegetables (19)	regulating
Conservation of genetic resources (20)	provisioning
Sense of place (21)	cultural
Educational value of the landscape, plants, and animals (22)	cultural

Table A3.2 Number of different types of ecosystem services (ES) as perceived by different social actors (SA). The number between brackets indicates the total number of ES in each category identified by all SA.

	Provisioning ES (11)	**Regulating ES (5)**	**Cultural ES (3)**	**Cultural & provisioning ES (3)**
Subsistence farmers	11	4	3	3
Cattle ranchers	4	2	2	0
Large farmers	1	3	0	0
Extension officers	7	4	1	3
Policy makers and conservation agencies	6	4	3	3