Land Use Change and Commodity Frontiers: Perceptions, Values, and Conflicts Over the Appropriation of Nature

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ABSTRACT Argentina is experiencing an expansion of soya and maize cultivation that is pushing the agricultural frontier over areas formerly occupied by native Chaco forest. Subsistance farmers use this dry forest to raise goats and cattle and to obtain a broad range of goods and services. Thus, two very different and non-compatible land uses are in dispute. On the one hand subsistance farmers fostering an extensive and diversified forest use, on the other hand, large-scale producers who need to clear out the forest to sow annual crops in order to appropriate soil fertility. First, the paper looks at how these social actors perceive Chaco forest, what their interests are, and what kind of values they attach to it. Second, we analyze the social-environmental conflicts that arise among actors in order to appropriate forest's benefits. Special attention is paid to the role played by the government in relation to: (a) how does it respond to the demands of the different sectors; and (b) how it deals with the management recommendations produced by scientists carrying out social and ecological research. To put these ideas at test we focus on a case study located in Western Córdoba (Argentina), where industrial agriculture is expanding at a fast pace, and where social actors' interests are generating a series of disputes and conflicts. Drawing upon field work, the paper shows how power alliances between economic and political powers, use the institutional framework of the State in their own benefit, disregarding wider environmental and social costs. KEYWORDS socioenvironmental conflicts, land-use change, nature's contributions to people, plural valuation, appropriation of nature, power relations

INTRODUCTION

The growing global demand for raw materials and the pressing need of most of the countries of the Global South for hard currency have increased the pace at which ecosystems are exploited and triggered socioenvironmental conflicts worldwide [1–3]. Power relations affect how value is constructed by societies and influence what types of nature's benefits are produced in each territory and how these benefits are appropriated and distributed among different social groups [4].

Ecosystems are called upon to meet multiple demands that respond to multiple needs and multiple strategies for producing and delivering Nature's Contributions to People (NCP)[1] to societies [6]. Diverse views exist (i.e., perceptions, interests, and values) on what and how NCPs should be produced and/or appropriated. Hence, in any

1. Nature's Contributions to People (NCP) are "all the contributions, both positive and negative, of living nature (diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to people's quality of life" [5].

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given territory, a series of social and environmental trade-off are usually at play and need to be managed. Different stakeholders are involved in NCPs production and appropriation, reflecting diverse perceptions, values, and interests in terms of what ecosystems can (or should) offer and the best strategies to produce them. To make those decisions requires defining priorities and assuming a series of environmental and social trade-offs [7–9]. Thus, ecosystems cannot simultaneously optimise the production of all NCPs. The production of some NCPs counteracts the production of others, since they depend on complex biophysical interactions, and human interventions may enhance the output of certain NCPs, while negatively affecting the production of other ones [8, 10, 11]. For instance, in agricultural frontiers, expanding annual-crops cultivation implies cutting down native forests which leads to ceasing the production of a broad range of forest-derived NCPs. From a social-economic perspective, this process of land-use change may undermine the livelihoods of forest users and transfers economic resources to agricultural farmers.[2] Although win-win situations might be identified [12], in most cases, neither the production of NCPs nor their benefits to human well-being can be simultaneously maximised to benefit all social actors.

Two main approaches are used to assess nature's benefits to societies. The approaches differ in the kind of metrics employed to assign values to nature and in how the relations between nature and societies are considered. Monistic perspectives (i.e., valuation based on a single metric or a single worldview about human-nature relations) [13] focus on unidimensional views for valuing biodiversity and NCPs that emphasise ecological/biophysical, social, cultural, or economic approaches. For instance, stakeholders drawing upon market-based approaches may reduce value to a single economic metric such as monetary value. Likewise, natural scientists may reduce nature's value to quantifiable biological metrics such as energy or net primary productivity [13–16]. Thus, value monism seeks to produce an "universal" vocabulary [17] that elicits values that are quantifiable, commensurable, and potentially exchangeable through markets and across stakeholders [6]. Monetary value tends to be the dominant valuation metric used for ecosystems valuation and is widely acknowledged as a pragmatic way to communicate, particularly with decision makers and the private sector [15, 18, 19]. However, for some authors, this approach fails to address the diversity of ways in which people value nature and responds to a form of value reductionism unable of capturing the noneconomic value dimensions of nature [20, 21]. Besides, in addition to drawing upon a single metric, monistic perspectives rely on a single worldview about human-nature relations [13] that tend to stress the dichotomy between instrumental and intrinsic[3] dimensions of nature that rests either upon a utilitarian view or an environmental ethics perspective [15]. Therefore, this approach fails to consider the multiplicity of values that people attach to nature and often assesses nature's importance only in an instrumental or monetary way [19].

In contrast, plural (or integrated) approaches to valuation are able to better capture the multiple values of nature and to more accurately express the points of view of different stakeholders by considering metrics arising from the kind of NCPs or ecosystems being assessed and the characteristics of the social actors involved in the process. Plural valuation seeks to bridge the dichotomy between instrumental and intrinsic values, giving great importance to relational values. Therefore, it aims at a more integrated understanding of nature that better responds to peoples' perceptions, interests, and needs [15]. Unlike value monism that seeks generalization, value pluralism is context specific since it responds to the socio-environmental conditions of every particular context [6]. From this approach, the concept of value refers to what is *important* to people and not just reducing the valuation problem to a single dimension [18]. Therefore, it acknowledges that people attribute multiple importances to nature, which can be described and measured in multiple ways. Plural valuation is a holistic perspective that integrates the diversity of values attributed to nature, as perceived and valued by different social actors with the aim of making this plurality explicit and bringing it into decision making [13, 19]. Thus, this approach puts forward natural and social heterogeneities as a way to better

2. This could be the case of agribusiness farmers expanding over territories formerly controlled by subsistence farmers relying on a diversified use of native forests.

3. There are three main types of value that people attach to nature. "Instrumental value: The value of an entity as merely a means to an end. Intrinsic value: The value of nature, ecosystems, or life as ends in themselves, irrespective of their utility to humans. Relational values: The importance attributed to meaningful relations and responsibilities between humans and between humans and nature" [22].

understand the complexities and dynamism of social-ecological systems.

Plural valuation does not only help to produce more integrated and socially comprehensive views of nature to inform decision making, it also improves clarity on the trade-offs and conflicts. Conflicts arise when there are irreconcilable differences or incompatibilities between social actors in terms of their interests, values, power, perceptions, and/or objectives [23]. Noteworthy, environmental conflicts are always *social* conflicts [2, 24] because they necessarily involve the participation of social actors with incompatible views about how they perceive, value, use, or appropriate NCPs. Environmental conflicts are also *distributional* conflicts because they arise from (perceived or real) inequalities of income and power between social actors. Thus, they respond to contrasting strategies for appropriating nature's benefits and on how to dispose pollutants and other negative effects of production [25]. Environmental conflicts are—by their nature—socioenvironmental conflicts that can be understood as having to do with access and control of natural resources and territories, which—in turn—are motivated by divergent interests and values between parties usually in the context of power asymmetries [2].

There is a wide spectrum of socioenvironmental conflicts stemming from numerous economic activities such as mining, hydropower projects, tourism, agribusiness, urban sprawl, road infrastructure, nature conservation, and deforestation [26], which has prompted the development of comprehensive typologies of socioenvironmental conflicts [24]. In Latin America, in the name of economic development, ecosystems have been degraded and peoples' livelihoods have been compromised. But, at the same time, numerous resistance movements calling for environmental justice have emerged committed to the development of new critical environmental and development thought [2, 24, 25, 27]. In several Latin American countries, the expansion of the agricultural frontier is modifying territories differentially, impacting social actors, and drastically shifting the balance of NCP provided by ecosystems.

In this case study, we demonstrate how carrying out plural valuation assessment can produce more accurate valuation of ecosystems and of the NCPs they provide to the different stakeholders. Nevertheless, we also warn about the social-ecological conflicts that could arise during the process and discuss the challenges observed when trying to mainstream the main findings of the assessment into socioenvironmental policies.

THE SOCIOECOLOGICAL SYSTEM

With an annual production of 125.8 million tons, Argentina is the fifth largest global grain producer after United States, Brazil, China, and India. It is also the third exporter of soy and maize, the fifth of wheat, and the first exporter of soy meal and soy oil [28]. Historically, the production of grain crops was concentrated in the Pampas, but after the introduction of transgenic crops in 1996, it rapidly expanded to the less fertile non-Pampean areas. A technological package based on transgenic seeds, zero tillage, pesticides, and synthetic fertilizers made possible such an expansion, but it produced a series of ecological and social problems (e.g., deforestation, soil-nutrients depletion, weeds resistance, agrochemicals pollution, and peasant emigration). From a social-economic point of view, this process fostered both economic concentration and social exclusion, as well as new strategies for capital accumulation based on capital intensification and the fast appropriation of nature's richness [29].

The case study is situated in central Argentina, more precisely in the Pocho Department,[4] West of the Province of Córdoba (31° 15′ 01"–31° 55′ 26" S and 65° 16′ 16"–65° 40′ 51" W). From a phytogeographic point of view, the region is located in the southern part of the Gran Chaco biome (figure 1). The natural vegetation is an open xerophytic forest dominated by *Aspidosperma quebracho-blanco* and *Prosopis flexuosa* mixed with patches of thorny shrublands [31–33]. Currently, the vegetation reflects different land-use histories that range from relatively well-preserved forest to intensive agriculture.[5] The climate is subtropical with a mean annual precipitation of 500 mm occurring mostly in the summer season (December–March), a mean annual temperature of 18°C, and a water deficit of 500–800 mm [36, 37]. Soils are from alluvial origin, mainly sandy-loam Aridisols [38].

Since the beginning of the last century, Western Córdoba was occupied by subsistence farmers and

4. In Argentina, "Department" is an administrative and political division of provinces. It refers to what in other countries is known as "County" or "District."

5. Although native forests are being exploited since the beginning of the twentieth century, the most important transformations occurred during the last decades [34, 35].

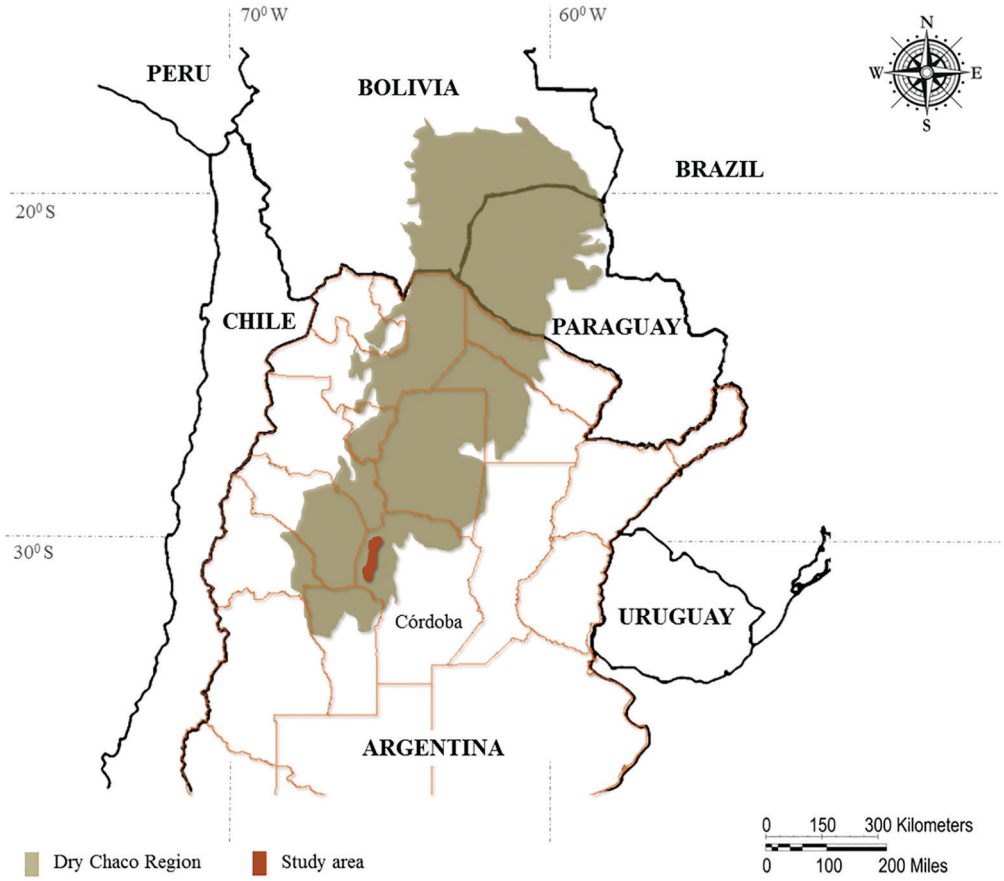

FIGURE 1. The study area is located in the southern part of the Gran Chaco biome in Western Córdoba (Argentina). Source: Elaborated from Olson et al. [30].

aboriginal peoples who focused on extensive livestock keeping (mostly goats), as well as several extractive activities (both timber and nontimber products)[6] [35, 39]. From the 1990s, a series of technological, economic, politic, financial, and market changes, together with an increase of rainfalls, favoured the expansion of a more intensive and capitalised agriculture and fostered the replacement of native forest and low-impact agriculture for more capital-intensive farming practices [29, 41–45], highly dependent on external industrial inputs such as high-yielding seeds, pesticides, and fertilizers [46].

This process triggered profound social, environmental, and productive transformations in the region. The forests, from which subsistence farmers make their livelihoods, have been and continue to be progressively replaced by semi-intensive cattle ranching and annual-crops cultivation (e.g., potato, corn, wheat, and soy) which (due to climate restrictions) can be only cultivated under irrigation [39, 47, 48]. In the province of Córdoba, as well as in other areas of Argentina where the agricultural frontier is active, such transformations gained momentum after the approval of transgenic crops in 1996. Between 2000 and 2012, 150,000 hectares of native forests were logged in Córdoba with the fastest deforestation pace occurring between 2003 and 2007 (90,000 ha). Hoyos et al. [43] analysed 2.5 million hectares in Northern and Western Córdoba between 1970 and 2010 and observed that the areas covered by native forest moved from 39% to 18%, with the highest deforestation rates taking place between 1999 and 2010. This forest retraction correlated with a sharp expansion of annual crops, which had its highest growth rate between 1999 and 2004 (table 1).

As a consequence of land-use change, a series of socio-environmental conflicts emerged between subsistence

6. The most important timber products obtained from the Chaco forests of Western Cordoba are firewood, charcoal, and posts. Wild fruits for human and animal consumption, medicinal and tinctorial plants, bushmeat, and wild honey are among the nontimber ones [39, 40].

TABLE 1. Area Covered by Forests (Closed Forest + Open Forest) and Annual Crops in the Years 1979, 1999, 2004, and 2010, in an Area of 2.5 Million Hectares of Northern and Western Córdoba (Argentina). Annual variation rates are also presented.

	Year			
	1979	1999	2004	2010
Closed forests + open forests (% of the total area)	39.3	40.5	29.9	18.2
Annual variation (%)	—	0.06	-2.12	-1.95
Croplands (% of the total area)	27.4	33.2	42.8	47.8
Annual variation (%)	—	0.29	1.92	0.83

Source: Elaborated from Hoyos et al. [43], and Estimaciones Agrícolas (http://datosestimaciones.magyp.gob.ar/).

farmers, large farmers[7] following the logic of agribusiness [49], and the government. The main topics being disputed were how the territory should be managed, which NCPs should be prioritised, and whose rights should prevail. Land-use transformations are prompting more intensive use of the territory, shifting from extensive and diversified use of ecosystems that aims at appropriating a broad variety of NCPs (i.e., subsistence farmers' approach), toward a strategy that focuses mostly on the appropriation of a single NCP, which commercial farmers value the most: soil fertility (i.e., agribusiness' approach). Thus, by using new technologies, agribusiness is cashing in on a key NCP that forests built and accumulated over centuries, which is compromising not only nature's richness but also the livelihoods of the most vulnerable social actors, since the forests they rely on are being replaced by annual crops and exotic pastures [1, 29].[8]

7. Large farmers hold high sums of capital, control large tracts of land, use wage workers, and produce for the market. Conversely, subsistence farmers hold very little capital and land, use family labour, and produce mostly to self-consumption.

8. Subsistence farmers do not only lose access to forests, often they are also evicted from their lands by large-commercial farmers aiming at sowing annual crops and/or high-yielding pastures for cattle [42]. In Northern and Western Córdoba (as well as in many other non-Pampean areas of Argentina), land prices rocketed after the 1990s, since low productivity lands became suitable to produce commodities [45]. Land tenure is open to dispute in these regions, and resource-poor farmers do not always hold legal land titles. Although the Argentinean law grants legal ownership to those who can prove a continuous possession of the land over a period of at least 20 years (Civil Code, articles 4015 and 4016), this law is often disregarded. Thus, resource-poor farmers who have lived and produced in the land for generations are often dispossessed by agribusiness farmers, sometimes using fraudulent or violent dispossession methods [1, 50, 51].

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METHODOLOGY

Díaz et al. [52] proposed an interdisciplinary framework to link biodiversity and society that included an innovative multistakeholder participatory methodology which is able to capture both ecosystem and societal heterogeneities. Drawing upon that framework, Cáceres et al. [47] developed a quantitative-qualitative methodology that complies with the requirements of both natural and social sciences to study how different social actors from Western Córdoba perceived and valued NCPs and how they associated them to the different types of ecosystems present in the region. This is a participatory methodology that aims to capture those ecosystem aspects that stakeholders value most. Largely based on those two papers, we carried out a five-step methodology. Starting with a biophysical valuation and followed by a series of sociocultural valuations, these five steps summarise the actions carried out to put into practice the plural valuation approach in our case study.

a. *Ecosystems and stakeholders.* Two initial interdisciplinary tasks were jointly carried out by natural and social scientists. Firstly, we identified the main ecosystem types that are present in the study area, which are socially and environmentally relevant, according to the points of view of both social actors and scientists. Conti and Díaz [53] offer a detailed description of the six main types, but a synthesis of their main characteristics is presented in table 2. Notably,

TABLE 2. Main characteristics of six major ecosystem types observed in Western Córdoba (Argentina).

	Primary forest	Secondary forest	Closed species-rich shrubland	*Larrea* shrubland	Logged pastureland	Intensive annual cropland
Ecosystem type						
Description	Old-growth forest, dominated by hardwood trees such as *Aspidosperma quebracho blanco* and *Prosopis* spp. Currently, this ecosystem type is present only in small patches, most of them within protected areas.	Forest with a more open canopy dominated by younger individuals of *Aspidosperma quebracho blanco* and *Prosopis* spp (< 7 m tall). Mostly devoted to livestock raising with relatively low stocking rates.	Closed shrubland dominated by smaller trees (< 4 m tall) and shrubs such as *Mimozynganthus carinatus*, *Celtis eehrenbergiana*, *Acacia gilliesii*, *Larrea divaricata*, and *Capparis atamisquea*. Former heavy logging and current moderate to high livestock stocking rate.	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.	Open savanna-like vegetation where most woody plants have been cut down to foster grass production, often involving the introduction of the exotic *Cenchrus ciliaris*.	Native vegetation entirely replaced by irrigated annual crops (potatoes, maize, wheat and soy). Main current use grain and tuber production.

Source: Modified from Cáceres et al. [47]

each ecosystem type responds to the specific extractive or productive activities carried out by different social actors during the last century in the territory. And secondly, a map of the most important social actors with stakes in those ecosystems was also interdisciplinary produced and included not only those actors who directly use or transform the ecosystems (e.g., different types of farmers) but also those who have indirect impact on them through legislation, rural extension, or actions carried out by associations belonging to the civil society.

b. *Individual interviews.* In a first stage of the fieldwork, individual interviews were carried out with representatives of all the relevant stakeholders with stakes in the region. Due to the nature of the research questions, the heterogeneities observed in the territory, and the experience of the research team in the study area, a nonprobability sampling method was used [54], which prioritised the comprehension of key socioecological processes and relationships rather than aiming at statistical representativeness. The concept of theoretical saturation [55] helped to decide when to stop interviewing people, since new interviews did not yield any relevant information. A total of 163 semistructured interviews were completed (137 interviewees). We interviewed 36 subsistence farmers (by far the most numerous and heterogeneous stakeholder in the region), 15 cattle ranchers, 17 large farmers, 35 extension officers, 24 policy makers and members of conservation agencies, and 10 people whose insights were relevant but did not easily match any of the above categories (e.g., teachers of rural schools, local catholic priest, and local healer). The number of interviewees within each stakeholder category depended on its relative abundance and heterogeneity in the study area. Interviewees were asked to identify those NCPs that they considered important from the point of view of their livelihoods, productive strategies, or professional activities.

c. *Focus group discussions.* In the second stage of the fieldwork, a series of single stakeholder focus groups [56] were implemented to discuss which were the most important NCPs for each social

group and which were the ecosystem types that best provided the selected NCPs. Also, a ranking of the capacity of the ecosystem types to provide the NCPs prioritised by each social group was produced in each focus group. We carried out seven focus groups: three of subsistence farmers (one of them, women only), one of cattle ranchers, one of large farmers, one of extension officers, and one of policy makers and conservation agencies.[9] To hold single-actor meetings not only permitted knowing what NCPs and ecosystem types were the most important for each of them, it also lessened the power differences among groups, since discussions occurred among peers. Most of the participants who attended the focus groups had been previously interviewed by the researchers.[10]

d. *Conflicts.* The identification of socioecological conflicts was conducted by combining and contrasting the information obtained from different sources. The individual interviews were highly relevant for identifying the main issues at stake and the essence of the conflict. The focus groups allowed us to identify the activities carried out by other social actors who, according to each actor, had negative impacts on their own activities (i.e., what activities and whose activities). Finally, a review of the printed media (e.g., local and provincial newspapers informing about productive, social, and environmental problems) helped to identify the most important aspects of conflict, according to stakeholders' perspectives, and their position in relation to the conflict (e.g., which were the most valuable assets in dispute and who they were confronting with). These three sources were complemented with a literature review of the historical trajectories of the main stakeholders in the Province of Córdoba.

e. *Plural valuation and the science-policy interphase.* The plural valuation of the ecosystems of Western Córdoba (i.e., Steps a–d) produced scientific knowledge that was relevant, since it provided key information about why native forest were both socially and environmentally important and needed to be conserved (e.g., [39], [40], [53], [57–59]). This knowledge was used to inform the discussion of a provincial law aiming at protecting native forests that arose when the research was nearly finished. Researchers held a series of meetings with key political representatives to show the outcomes of the plural-valuation assessment and to raise awareness about the environmental and social importance of native forests. Representatives were informed of the perspectives of each stakeholder on each ecosystem type, why they were considered important, and the main issues at stake for each of them. Also, the socioecological value of each ecosystem type was summarised and shared with them. Thus, the degree of impact of the knowledge generated by the research was assessed by analysing the extent to which it was reflected in the new law.[11]

It is worth noting that when the field work was carried out (in 2010 and 2011), the NCP concept had not yet been proposed, and the term "ecosystem services" was widely used in academic and institutional spaces. We did not use this term neither in the individual interviews nor in the focus groups because, in Spanish, it can be misleading for some stakeholders. Instead, throughout the field work, we used the concept of "benefits obtained from nature" to refer to ecosystem services by broadly asking what the interviewees used, liked, and/or valued about ecosystems. In this article, we prefer to use the NCP concept because it is more comprehensive and includes the idea of ecosystem services [5], and it better represents the approach we developed during the fieldwork.[12]

PLURAL VALUATION IN WESTERN CÓRDOBA

In this section, we report the main findings obtained during the fieldwork followed by a description of the main socioenvironmental conflicts arising among the

9. Many people in Argentina are from aboriginal ancestry. However, since in the study area local inhabitants do not acknowledge themselves as belonging to any indigenous group, we did not hold any focus group targeting specifically the interests and knowledges of aboriginal peoples.

10. Three of the seven focus groups held during the field work were with subsistence farmers, which is by far the most numerous and heterogeneous social actor in the region (one of them was composed only by women). And the other four were held with large farmers, cattle ranchers, extension officers, and policy makers plus conservation agencies.

11. This was done by analysing the text of the approved law and checking whether the information provided by scientists to policy makers was reflected in the text of the new law.

12. For a more detailed description of the methodology, see Cáceres et al. [47].

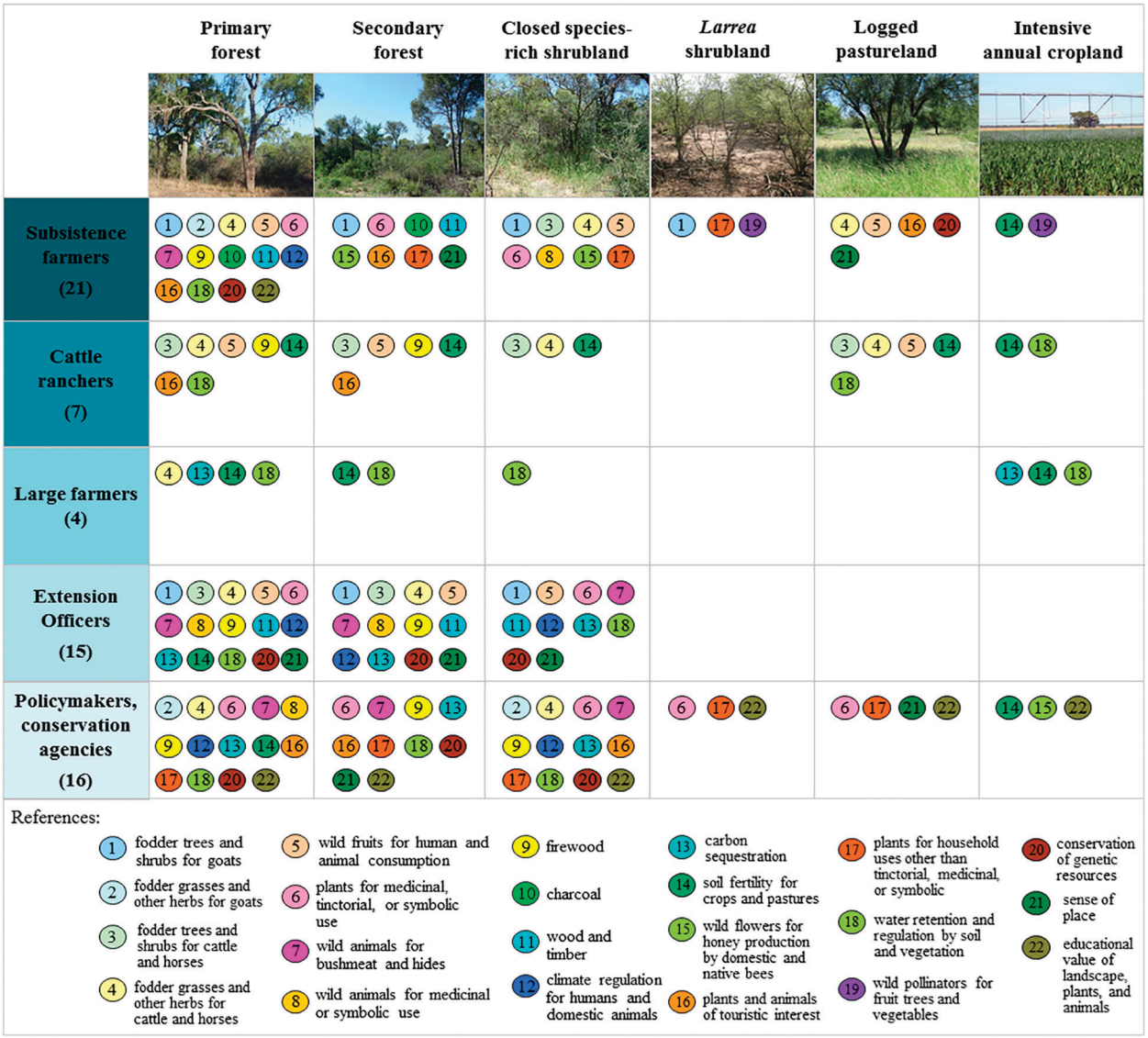

FIGURE 2. Nature's Contributions to People (NCPs) perceived as important by social actors and their link with the ecosystem types that supply them. The number between brackets represents the total number of NCPs perceived by each social actor. The coloured numbers within each cell indicate that at least one participant in the groups linked that NCP to that particular ecosystem type. Source: Modified from Tapella [39] and Cáceres et al. [47].

actors with stakes in the territory. Also, we analyse how the knowledge generated during the project was used to inform policy makers and the problems and conflicts that occurred when navigating the science-policy interface.

As we mentioned earlier, the research was conceived within an interdisciplinary framework and tried to elicit a wide range of values that the stakeholders attributed to the different ecosystem types, whether material or non-material. In other words, we aimed at identifying what was important to them in terms of the benefits they recognised from nature and how they linked these NCPs to the different ecosystem types present in the region.

All the social actors perceived ecosystem multifunctionality, but they showed marked differences in the kind of NCPs highlighted as well as in their connections with the relevant land-cover type. We present the most relevant research findings in figure 2, which summarises the information gathered during the focus groups. Each cell shows which were the NCPs identified by each social actor during the focus groups and how they connected them to the ecosystem types.

Subsistence farmers were the actors who perceived the most diverse set of nature's benefits: 21 of a total of 22 NCPs.[13] Unsurprisingly, most of the NCPs that they identified were linked to the less modified land-cover types (i.e., primary forest, secondary forest, and closed species-rich shrubland), which are the most suitable for providing the benefits they need for their livelihood. "Fodder trees and shrubs for goats" and "wild fruit for human and animal consumption" were the most important ones and were the most frequently mentioned. Conversely, large farmers identified only four NCPs which they consider important for annual crops. "Soil fertility for crops and pastures" and "water retention and regulation by soil and vegetation" were the most frequently mentioned NCPs. Apart from intensive annual cropland, large farmers also identified primary forest as another important ecosystem type because they recognised in the latter the presence of those NCPs that they value the most. In other words—and according to individual interviews—they anticipate the likelihood of future land-use change (i.e., the conversion of native forests into crop fields). Cattle ranchers were in an intermediate situation. They identified seven NCPs, where "fodder grasses and other herbs for cattle and horses" and "soil fertility for crops and pastures" were chosen as the most important. Primary and secondary forests and logged pastureland were their preferred land-cover types.

Although policy makers and conservation agencies and extension officers are not able to directly transform the territory in the same way as producers, they indirectly influence agricultural practices and biodiversity through the policies, environmental regulations, education campaigns, and/or technical advice to farmers that they espouse. They identified a large number of NCPs (16 and 15, respectively) and related them to the less modified ecosystem types. "Water retention and regulation by soil and vegetation" and "conservation of genetic resources" were the most important NCPs for policy makers and conservation agencies, while extension officers identified "climate regulation for humans and domestic animals" and "water retention and regulation by soil and vegetation" as the most relevant ones.

Figure 2 offers a synthesis of key social and environmental information that can be produced from plural valuation exercises in heterogeneous territories and provides useful insights into four main issues: (a) the NCPs that are perceived as important for each social actor, (b) the land-cover types that best provide those NCPs (according to stakeholders' perspectives), (c) who may win or lose when processes of land-use change are underway, and (d) the main socioenvironmental conflicts existing in the territory (or which conflicts could emerge in the future).

Regarding conflicts, two main types of rationale are confronted in the study area that respond to very different productive strategies and ways of understanding the relationship between nature and society. The most striking contrast is observed between subsistence farmers and large farmers. While the former pursues extensive and diversified productive and hunting and gathering strategy aiming at a broad range of NCPs, the latter follows an intensive and single-purpose productive strategy aiming at appropriating mostly one NCP: soil fertility. These approaches are not only different but also incompatible with each other since, to cultivate annual crops, large farmers have to remove native forests which are the most important livelihood source for subsistence farmers. This socioenvironmental dissonance is currently very active, since it is fuelled by a dynamic process of land-use change that fosters the expansion of the agricultural frontier to produce commodities for international markets [60]. But to better understand the conflicts occurring in the study area, another player should be considered: the government. We discuss this issue in the following section.

HOW PLURAL VALUATION IMPACTED ENVIRONMENTAL POLICIES?

In order to regulate land-use change processes that are affecting native forest in Argentina, in 2007, the National Parliament passed the Law 26.331 aimed at protecting remaining forests and the livelihoods of subsistence farmers and indigenous peoples. It proposed three conservation categories (red, yellow, and green) referring to areas with high, medium, or low conservation value and defined the main activities that could be carried out in each of them. The law ordered all provinces to produce their own laws which had to include a map showing the three conservation categories. Also, the provinces had to

13. During the individual interviews, 116 NCPs were identified which were then aggregated into 22 more general categories. These were the NCPs used later in the focus groups. For instance, if the interviewees had mentioned four different benefits related to climate regulation, we merged them into a single NCP category called "climate regulation for humans and domestic animals." To guarantee accuracy, these categories were jointly constructed by natural and social scientists [39, 47].

follow a very strict participatory protocol (e.g., open meetings and regional public hearings) where all relevant stakeholders should take part. To that end, in 2009, the government of the Province of Córdoba created an ad hoc Commission, coordinated by a provincial legislator, that included all major stakeholders. This Commission had to produce a bid that would later have to be discussed and approved by the Provincial Parliament.

The process was regarded by the research team as a golden opportunity to test whether the knowledge generated using a multistakeholder participatory methodology could be of interest in the discussion of the provincial law. According to Cáceres et al., soon after the Commission's sessions started, two interest groups advocating for very different positions were formed: the pro-agribusiness network (PAN) and the pro-environment network (PEN) [61]. PAN gathered organizations and actors related to the production and industrialisation of agricultural commodities and promoted policies that foster economic freedom and the relaxation of environmental regulations. On the other hand, PEN drew together environmental groups and grassroots organizations and advocated for policies that favour a more equitable access to NCPs and an ecologically sound and socially inclusive path to development. The differences between these two approaches were large and, after a few sessions, most of the representatives belonging to PAN decided to walk away from the Commission.

The research team did not formally take part in the Commission but had an active role during the process. Besides the research results presented in this article, substantial ecological and social knowledge was also produced by the research project. Thus, the representatives of the research team held a series of meetings with ministers, legislators, and the Commission to present the main research findings, informing about the multiple NCPs produced by native forests, their social importance, and the risks associated with removing them to cultivate annual crops, or to foster semi-intensive cattle ranching. The academic input was followed with interest by the different political bodies and, in every case, the researchers handed out tailored dossiers including key social and environmental information in a format that was accessible for nonacademic public.

At the end, two bills were submitted to the provincial Parliament: the one produced by the Commission which complied with all the methodological, participatory, and technical aspects required by the national law and another one presented by PAN that did not fulfil any such requirements. Nevertheless, only the PAN proposal reached parliamentary status. Using nonformal channels, it was presented to the Parliament just 24 h before its discussion and was approved in an express parliamentary session in August 2010 (Law 9814). The coordinator of the Commission did not explain why he did not submit the bill produced by the Commission, nor why he disregarded the multiactoral procedures ordered by the national law, which were embodied in the discussions and the bill written by the Commission. The new law mostly represents PAN's interests and disregards the points of views of the organizations gathered around the Commission [57, 61], as well as the findings and the socioecological recommendations of the research team.

This process allows to reflect about the complexities of the science-policy interface and the political struggles that arise when economic issues are at stake.[14] Even when scientists provided key socioecological information to policy makers, their input and that of PEN's had a minimal influence in the new law. Power asymmetries based in both historical trajectories and current political balances of power were too large to allow for the transformation of the participatory process carried out by the Commission into environmental policies [57, 61].[15] Thus, by aligning with PAN's economic interests, the provincial government took sides in the socio-environmental conflict and sealed the future of the native forest of the Province of Córdoba and of those who make a living out of them. As a result, agribusiness, with the connivance of the state, is carrying out the largest-ever transformation of natural capital into economic capital in the history of the region [1].[16]

14. It is worth noting that similar processes also happened in other provinces of Northern Argentina when discussing the provincial laws for the protection of native forests. Although each case shows its particularities, they follow the same pattern: Conflicts over the appropriation of forests' NCPs arise among stakeholders and the government is sided with those who foster the expansion of agribusiness' activities [62–64].

15. The discussion of this law expressed the conflicts arising between social actors showing opposite views about environment and development (i.e., PEN and PAN). PAN's power is based on their economic importance derived from the production of agricultural commodities. Along history, this sector has developed deep roots into the economic, political, and institutional powers in the country. Thus, the approved law is the manifestation of the power alliances consolidated throughout history between the hegemonic agricultural sector and the political and economic powers, who use and build the institutional frameworks (e.g., the approved law) to meet their ends, and disregarding social or environmental costs [57].

16. For a detailed analysis of the science-policy interphase in relation to this case study, see Cáceres et al. [61].

THE POLITICAL ECOLOGY OF PLURAL VALUATION

NCP values and valuations are socially constructed [18]. They are also context dependent, since they respond to very specific spatial and temporal situations (including environmental, social, economic, cultural, and political factors). Therefore, the valuation of ecosystems and the NCPs derived from them is the result of historical processes of co-production that reflect the material or symbolic values that social actors attach to nature [65, 66]. By showing how different social actors perceive ecosystems and their benefits, plural valuation helps to illuminate the priorities of actors, the prospective uses they are fostering, possible incompatibilities of such uses, and how these incompatibilities may differentially impact each one. Monistic approaches based on a single metric for valuing nature (e.g., grain commodities that can be measured in monetary units) obscure the importance of a broad range of NCPs that may have little monetary value but which, nonetheless, are crucial for the livelihoods of the most vulnerable social groups.

Plural valuation approaches take into account different perspectives and world views and facilitate understanding potential or ongoing social-ecological conflicts, as well as recognizing the main contenders, the reasons for the dispute (i.e., what is at stake), and the prospective winners or losers in relation to the appropriation of NCPs. Power asymmetries are common currency both along plural-valuation processes and during stakeholders' disputes over the appropriation of nature's benefits [4, 67–69].

A growing number of scientists advocate for a shift towards plural valuation methods as a strategy for fostering more just and environmentally sustainable outcomes through the development of more transparent and participatory spaces that could incorporate such values into decision making [13, 15, 69–71]. But plural valuation *alone* cannot produce such desirable outcomes since it is just a tool that helps to identify more clearly a broader range of values. Therefore, to benefit the environment and the most disadvantaged social actors, it is also necessary to make the right political decisions, which is often beyond the competences of scientists.

Socioenvironmental conflicts are dynamic processes, where tensions, disputes, alliances, and strategic agreements are expressed. Conflicts are always historically rooted, but they are also influenced by conjunctural factors [61, 72]. Thus, the two most important aspects to look at in order to understand the dynamics of socioecological conflicts are (1) the economic (or strategic) importance of what is at stake and whose interests could be favoured or compromised and (2) the power balances among the stakeholders taking part in the dispute.

The participation of all parties is important since it allows to bridge differences and help to settle socioenvironmental conflicts. However, some controversies exist about the capacity of participatory processes to successfully resolve conflicts and to effectively produce fairer outcomes [73, 74]. It is also worth noting that not every conflict can (or should) be "solved" [75]. In some cases, they are the expression of opposing political positions that respond to singular worldviews, different approaches to socioproductive processes, confronting ideas about what a fair development path should be, and from a wider perspective, they ultimately have to do with how social actors understand the relationship between nature and society. Often, their interests (and the activities they foster) are not only different but also exclusionary and, therefore, it is not possible to reach a consensual agreement endorsed by all parties. In such cases, the dispute has to be settled drawing upon normative or political grounds (e.g., through the intervention of the State or judicial bodies), as happened in this case study.

To improve the livelihoods of the most disadvantaged social actors and to foster sustainable practices is a formidable challenge that in many cases transcends scientists' training and capacities. More knowledge is still needed to identify the best strategies to navigate the science-policy interface and adequately respond to each social, ecological, economic, political, and historical context. As everyone else, decision makers are not rational actors making unbiased decisions and producing policies following people's common good by drawing upon the information they gather in relation to a certain social-environmental issue [61, 68, 76]; they also have their own interests, prejudices, and political agendas. The translation of interdisciplinary research and plural-valuation exercises into policies is a complex and multifaceted process. It has a lot to do with the nature of the problems being addressed and with the prevailing power balances (e.g., consensus, disputes, alliances, and/or power asymmetries) among the stakeholders involved. Political, institutional, and historical contexts, as well as current sociopolitical power struggles, are also key factors to consider as they play a critical role throughout the decision-making process [68].

CASE STUDY QUESTIONS

1. What are the main strengths and weakness of monistic *versus* plural valuation approaches?
2. How do social actors (both local and remote) perceive, use, and/or value NCPs?
3. Why are socioenvironmental conflicts easier or possible to identify when using plural-valuation methods?
4. Which are the tensions or conflicts observed among social actors in relation to access, use, and appropriation of NCPs?
5. Which factors need to coincide in order to improve the uptake of scientific knowledge into environmental policies?
6. Why is it important to consider historical legacies and contexts when trying to understand socioenvironmental conflicts?
7. If the political process had fairly considered both the PAN and PEN bills, what would have been a sustainable and just outcome? Describe it.

AUTHOR CONTRIBUTIONS

Daniel M. Cáceres and Esteban Tapella provided project supervision and guidance. All authors contributed to the original draft preparation, review, and editing of this article.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

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