Journal of Arid Environments 121 (2015) 84–99

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Cultural patterns of firewood use as a tool for conservation: A study of multiple perceptions in a semiarid region of Cordoba, Central Argentina

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ARTICLE INFO

Article history:
Received 23 June 2014
Received in revised form
15 May 2015
Accepted 20 May 2015
Available online xxx

Keywords:
Native categories
Preferences
Fuelwood
Social actors

ABSTRACT

The paper analyzes local perceptions and practices related to the quality, extraction, and use of fuels firewood by the inhabitants of two protected areas. Our working model assumes the existence of patterns of preference, use and acquisition of firewood, depending on the social actors involved, and their perceptions. Our research developed through: the making of a reference collection and the applicationand of in-depth interviews and semi-structured surveys. We identified the most frequently used species and those with the greatest number of uses. The presence of patterns in the provisioning of energy source, and of firewood gathering and use, were identified in different actors. Through the application of a PCA analysis, and the study of native categories, patterning in the grouping of species was established, according to the local firewood classification. The latter relate to differences in the ease of ignition, in the durability and temperature of the flame and/or embers and the amount and type of smoke or ash produced. On the basis of ecological and perceptual information, a ranking of local priorities for the conservation of woody species is proposed. Finally, we discuss the relevance of sociocultural patterns of local perceptions of firewood use for conservation.

1. Introduction

Firewood resources involve one of the major sources of energy in rural populations with varied forest ecosystems, due to their relative accessibility, low cost and ease of use, among other cultural and socio-economic reasons (Fox, 1984; Abbot et al., 1997; Tabuti et al., 2003; Ghilardi et al., 2007). Heavy use of firewood by local communities exerts increased pressure on native forests, leading to a significant loss of biomass and tree and shrub diversity (Chettri et al., 2002; Kataki and Konwer, 2002; Ramos et al., 2008a,b; Thomas et al., 2011; Cardoso et al., 2012, 2013). In Argentina, the severe reduction of forest areas, particularly the Chaco Serrano forest's, in conjunction with their related ecosystems, is a major concern since has reached an unprecedented scale in the last two decades, with an annual loss rate of 9.4 (Gavier and Bucher, 2004; Barchuk et al., 2010). This is proved by the fact that, at present, less than 5% of the original forest area is found in the province of Cordoba, central Argentina (Zak et al., 2008), leading to a process of increasing aridity and desertification.

In particular, firewood extraction and use are practices that, because of their impact on the ecosystem, require comprehensive knowledge and analysis of the culture in which they exist. The state, abundance and availability of timber resources notably influence the local perception of the quality of nearby forests and ecosystems, as people turn to them in order to meet basic needs such as food, shelter and energy supply for the development of household activities (FAO, 2008). Research into fuel resources includes patterns of firewood collection and use from an ecological perspective (Tabuti et al., 2003; Cardoso et al., 2013); their relation with socio-cultural and eco-environmental variables (Thomas et al., 2011; Cardoso et al., 2012, 2013); the impact of firewood extraction on the structure, distribution and biomass of forest species (Chettri et al., 2002); the influence of seasonal variations on firewood collection patterns (Ramos and Albuquerque, 2012); cultural preferences and/or frequency of firewood use and their relationship with its intrinsic properties (Abbot et al., 1997; Kataki and Konwer, 2002; Tabuti et al., 2003; Ramos et al., 2008a,b); and firewood consumption patterns and rates in relation to its end use (Kituyi et al., 2001; San et al., 2012).

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http://dx.doi.org/10.1016/j.jaridenv.2015.05.004
0140-1963/

In Argentina, with a vast tradition and literature relating to the study of firewood resources, research has mostly relied on dasonomic approaches coming from forestry; ethno-ecological research into firewood is thus rarely found. In some cases, knowledge of these resources is built as a side topic within ethno-botanical studies on the subsistence of aboriginal or rural communities from the Gran Chaco (Arenas, 2003; Scarpa, 2012), and within archaeo-botanical studies on prehispanic societies (Capparelli and Raffino, 1997; Marconetto, 2008). Specific studies on the subject relate to the use of about twenty firewood species by rural populations in the Patagonian steppe, southern Argentina (Cardoso et al., 2012, 2013), and about thirty fuelwood species in Valle de Ambato, Catamarca, northern Argentina (Gadban, 1999; Marconetto, 2008). Despite this, information about the local perception of firewood in Argentina is scarce and often not treated, particularly that related to protected areas.

There is general consensus about the significance of local perceptions of environmental problems and natural resources for conservation in arid and semi-arid regions (Orlove, 1980; Agnew and Warren, 1996). Local residents' perceptions, beliefs and attitudes toward the management of protected areas have been studied only over the last decades (Vodouhê et al., 2010). According to Slegers (2008), to understand them, it is important to link human behaviour to the environment. In effect, human beings observe the world around them, and act in terms of what they see. Considering that timber species are one of the most visible, useful and vulnerable resources in protected areas, the study of perceptions regarding their use should be a compulsory topic in planning the management and conservation of firewood by the community. In ethnoecological studies, categorization and local classification are one of the topics that best reveal the perception of local people (Berkes, 1999). Regarding this issue, and in contrast to other studies linked to ethno-categories, lack of information about folk taxonomies of firewood is noticeable. The importance of this issue lies in the fact that classification systems, resulting from the analysis of vernacular terminologies, usually gain particular significance when viewed from the perspective of mental processes that encode the cultural knowledge of a given group, while contributing to a deeper understanding of local perceptions (Berlin, 1992; Arenas and Martínez, 2012). In view of this, such taxonomies prove a valuable tool for the management of protected areas (Berkes, 1999).

In arid and semi-arid regions, human populations are subject to environmental limitations which bring about adjustments and restrictions in daily life, in addition to possible structural changes in plant communities near their settlements (Cardoso et al., 2012). Current populations inhabiting these regions depend substantially on woody species for fuel. Due to the frequent use that communities make of these resources, people commonly develop a traditional ethnobotanical knowledge of the species, their characteristics, properties and ecology. The limitations and changes described above would also cause ecological instability and restrictions on firewood supply, and thus would activate cultural mechanisms of adaptation and environmental resilience. It was noted however, that selection and procurement of firewood are governed not only by environmental supply, but also by the needs and preferences of the group. The particular selection of firewood is determined by cultural norms as well as by other social, symbolic and technological factors of culture and not always by the "principle of least effort" (Marconetto, 2008). For studies in protected areas, we should acknowledge, the policy and regulatory aspects, usually not treated. Likewise, many studies consider differences between gender and age, ignoring variability within the population studied, visible in the coexistence of different social actors with their own way of perception.

In relation to the study area, the Sierras de Cordoba, a semi-arid region in Central Argentina, has had a considerable impact associated with deforestation and retraction of woodlands. In this sense, the province has protected areas where the extraction of species is regulated. However peasants from rural places, especially "Creole" people, regularly use these resources for household needs, although it is unknown to what extent this practice has strained sustainability. In the province of Cordoba in central Argentina, Rodríguez López (2006)'s unprecedented research is, so far, the only work known, aside from our preliminary findings (Martínez and Fernández, 2011). Furthermore, there are no documented references about the different local perceptions of the species used, as well as the particularities of use in an environment with changeable characteristics, let alone what happens in protected areas.

Linked to these questions and topics, Cardoso et al. (2012) claim that the use of multiple fuel resources and recycling of biological products to supplement firewood with forestation practices should indicate ecological-social resilience processes (Ladio and Lozada, 2009). As Chettri and Sharma (2009) also point out, to help develop management strategies and to ensure the long term sustainability of forest resources, it is important to understand the basis of local people's preference for particular species. However, the criteria adopted by local people for selection of preferred woody species are often obscure and generally not understood in scientific terms. As an example, Ramos et al. (2008b) consider that physical qualities of the different fuelwood account for local preferences.

We base our hypothesis on the fact that, by considering the community's traditional ecological knowledge and way of perception, the preference and composition (native or exotic) of the species chosen as firewood differ according to the profile of the social actors. We also believe that cultural and socio-economic factors (preferences) shape the composition and characteristics of the extracted species. Moreover, we hypothesize that folk peasants' perceptual information constitutes a homogenous and consistent corpus to visualize firewood selection patterns based on the population's requirements, to guide studies of the intrinsic properties of firewood, and to locally define conservation criteria.

In order to develop and contrast these hypotheses, we consider it appropriate to undertake this research from an ethno-ecological point of view. Thus, this paper aims at analyzing local perceptions and practices related to the quality, collection process and use of fuelwood resources by the different social actors from two protected areas of Sierras Chicas in the district of Chaco Serrano from Cordoba, Central Argentina. It also intends to provide data on the conservation, management and sustainable use of these resources. Specific objectives include:

a) To document and analyse selection criteria of energy sources, the use and preference of firewood species, and the gathering strategies employed by the local actors in the regions under study.
b) To describe ways of extracting firewood species in the region in response to the perception of distance-effort, shape, volume and frequency of collection by the different social actors.
c) To identify local firewood categories and related preference criteria in connection with quality indicators, according to use requirements.
d) To suggest a ranking of local priorities for the conservation of firewood species in protected areas, on the basis of perceptual and ecological information.

2. Methods and materials

2.1. Study area

The project was carried out in two protected areas of the province of Cordoba, located west and southwest of the provincial capital, in central Argentina (Fig. 1). The mountainous terrain of this province is composed of three mountain ranges, Sierras Chicas being the easternmost location. From the phyto-geographical angle, the two protected areas belong to the Chaco Serrano District, province of Chaco, following Cabrera (1994), which in turn belong to the Chaco Seco eco-region, following Torrela and Adámoli (2005). In Argentina covers an area between 29° and 33° 30′(S), ranging in elevation from 400 to 1300 m above sea level. The annual rainfall varies from 400 to 750 mm, according to the place, and is concentrated mostly in the warm season (October–April), with mean maximum and minimum temperatures of 26 °C and 10 °C respectively (Giorgis et al., 2011). Its vegetation is characterized by xerophilous forests, mostly by *Schinopsis marginata* (horco-quebracho) and *Lithrea molleoides* (molle de beber), *Zanthoxylum coco* (coco) particularly found in the southern forests, and lots of cacti and thorny leguminous species in the north. In ecotonal regions, due to their proximity to the Argentine Espinal, we can frequently find *Aspidosperma quebracho-blanco* (quebracho blanco), *Celtis* spp. (talas), *Acacia* spp. (aromos y tuscas) and *Prosopis* spp. (algarrobos). The floristic composition of these forests varies according to latitude and altitude on a regional scale, and according to edaphic features and disturbance history on a local scale. This makes these areas as an heterogeneous system showing significant variations in the composition of species over short distances (Giorgis et al., 2011).

Historically, the vegetation of Sierras de Cordoba has been divided into three altitudinal levels (Luti et al., 1979). One of them, referred to as Bosque Serrano, is located between 500 and 1300 masl. It develops discontinuously and with diverging physiognomy due to differences in exposure to the heterogeneity of these environments and to the changes caused by human activity. Another, referred to as Romerillar or Matorral Serrano, is found above the forest, between 1300 and 1700 masl. The third one, Pastizales and Bosquecillos de Altura, is found in the upper area. The vegetation of both areas studied mostly forms part of Bosque Serrano.

2.2. Population studied

The sample consisted of two protected areas with a floristic composition mostly characterized by the Bosque Chaqueño Serrano landscape, where we also conducted active research and environmental conservation and education programs with local actors. The populations under study comprised:

a) Bamba: Nature Water and Recreational Reserve. Located in the district of Colón, covering about 20,000 ha in the west of the provincial capital. It has been recently declared a national place of interest for conservation purposes [in Spanish “ENIC”]. Its territory and adjacent Reserva Natural Militar Campo La Calera [La Calera Fields, a Military Nature Reserve] are being considered with regard to the creation of a Memorial National Park

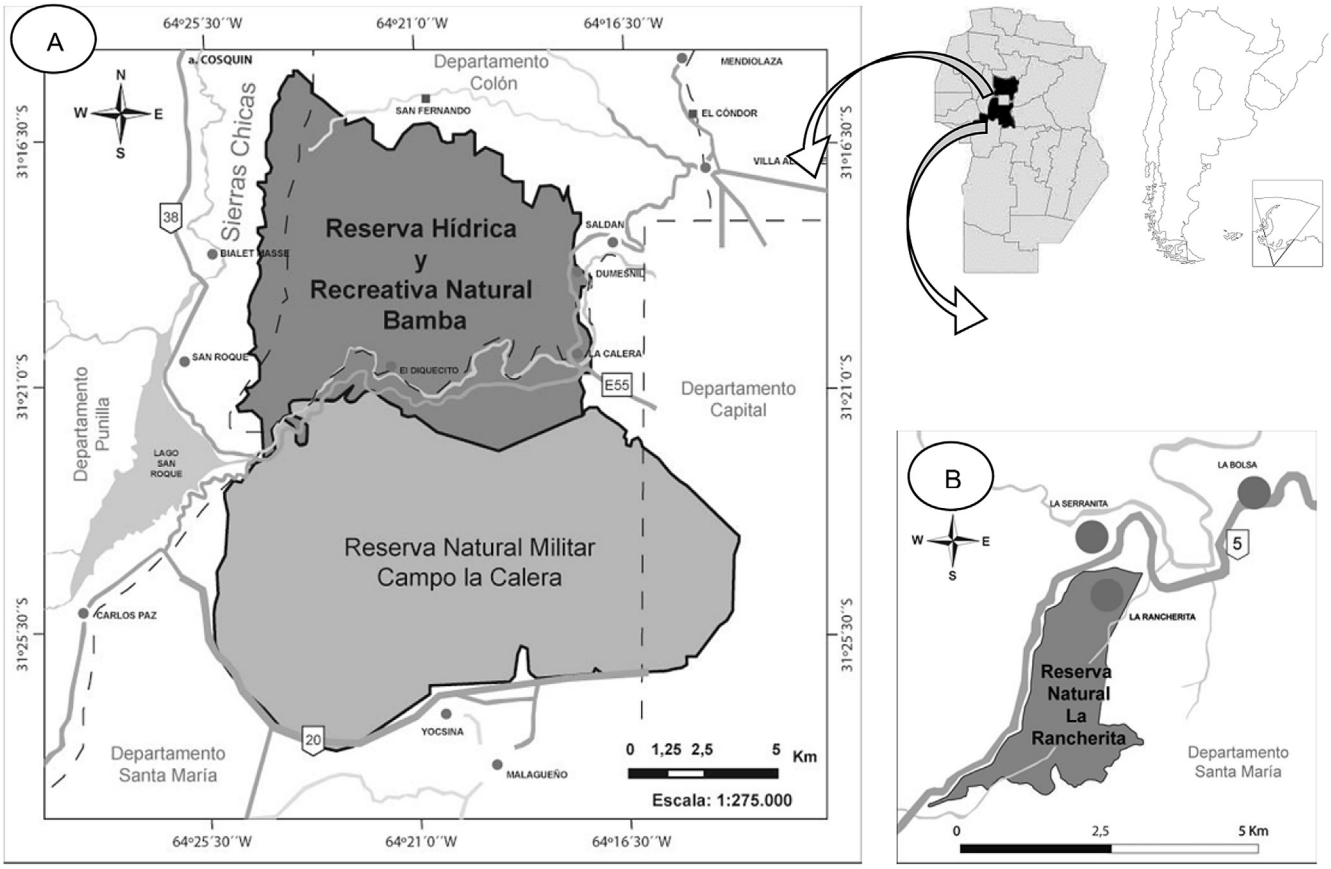

Fig. 1. Location of the study area and population. A) Nature Water and Recreational Reserve Bamba (District Colon, Cordoba Province) and adjacent Military Nature Reserve La Calera; B) Municipal Reserve La Rancherita (District Santa Maria, Cordoba Province).

(Palacios et al., 2010). In addition, within this regional context, that includes species typical of mountain forests, we can find the last relicts from the Province of the Espinal, characterized by xerophitic vegetation. The human population is composed of small livestock producers or peasants, natives in a depeasantization process, and a recently settled urban population with different cultural roots.

b) La Rancherita: It was officially declared a municipal reserve in 2004. Located in the region of Paravachasca, district of Santa María (south-west), it is a protected area having an strict zone of mountain forest, in which the implementation of a 300 ha Multi- Purpose Provincial Reserve is being planned. Today, its population comprises a rural peasant or depeasantized minority and foreign residents from the cities very much interested in conservation practices and in the development of the region recreational and (eco)tourism purposes (Fernández et al., 2013).

Both protected areas have regulations that restrict the extraction of wood, in particular, the felling of tree species. Yet, regulatory mechanisms have so far not been very effective; therefore, in practice, regulations have been rarely enforced, especially in Bamba.

In order to specify the characteristic traits of the rural population of both areas, we categorized and defined the following local social actors:

- Ps (Peasant): people native of a rural setting, having lived in the area for more than 15 years and whose economy is based on domestic livestock and/or agriculture practices.
- Dp (Depeasantized): native people or people having lived in the area for more than 15 years, whose past economy relates to domestic livestock and/or agriculture practices and are currently undergoing a depeasantization process, being engaged in other activities.
- Np (Non-peasant): people native of a rural setting, having lived in the area for more than 15 years and whose economy has never been associated with domestic livestock and/or agriculture practices.
- For (Foreign): non-natives or people foreign to a rural setting, having lived in the area for less than 15 years; and whose economy has never been related to livestock and/or agriculture practices.

We also defined two socio-economic profiles by means of the following categories:

- S (Subsistence): socio-economic and cultural profile showing some traits associated with a subsistence economy, and less dependent on capital.
- C (Capitalized): socio-economic and cultural profile, displaying no traits related to a subsistence economy, and more dependent on capital.

2.3. Field work and data collection

Fieldwork was performed with local actors from both areas of study, by combining methodologies from the social and natural sciences, on the basis of the interdisciplinary perspective of ethnoecology (Berkes, 1999; Cunningham, 2001; Arenas and Martínez, 2012). Accordingly, we have considered:

- Ethno-botanical documentation: with the help of informants, we identified and collected fuelwood resources, which make up a reference ethno-botanical collection and database for the hills of Cordoba, with records dating from 2001 to the present. Sample specimens (and its corresponding voucher) are deposited in the IMBIV Herbarium with the acronym CORD (CONICET – UNC).
- Open and in-depth interviews with 12 qualified informants carried out in household units. Open interviews were conducted first with qualified informants so as to gather background information on firewood use. Such data allowed adapting the design of semi-structured interviews carried out to different actors. Qualified informants were considered those who, at the time of the interview –and also traditionally–, collect and use firewood as the sole or major source of energy for cooking and heating their households. Generally, in the context of the interview, these informants supplied, spontaneously, a list or information related to the types of firewood and their properties for domestic use. Interviews were conducted on the basis of flexible, non-structured and guided questionnaires (Arenas, 1995), specifically designed for native people (peasants or depeasantized), according to the socio-economic variables and indicators from the community (Brokensha and Castro, 1983). They considered the following:
  - Species known and used; their application and frequency of use.
  - Firewood quality and properties.
  - Local classification patterns; vernacular terminology of firewood properties.
- Semi-structured and structured interviews (with pre-categorized data) designed for resident people (classified according to the 4 categories) living in each of the protected areas (n = 28 households), taking into account the following perceptual elements on the basis of research into the subject area (FAO, 1983; Cardoso et al., 2012, 2013) (See Supplementary Information 1):
  - Extraction/harvesting method
  - Extraction/harvesting distances
  - Extraction/harvesting frequency and volumes
  - Reminder of use related to a time-lapse (Re-call 24 h/1 month/1 year)
- Ethno-graphical, photographic (especially in winter) records, and those resulting from participant observation.

Table 1 lists information on the characteristics of the population interviewed in relation to the data collection methods adopted for both areas studied. In the present study we attempted to reach theoretical saturation rather than representativeness in the number of case, so no statistical inferences were made. We used multivariate analysis in order to provide a broad and exploratory overview of the research topic. In addition, the results derived from this study allow assisting subsequent ecological studies of quantitative nature into those species with higher extraction pressure.

2.4. Data analysis

Depending on the type of specific objective, we adopted qualitative and quantitative methods (descriptive and multivariate statistics), or a combination of both, i.e.:

- To analyse the selection criteria of energy sources and describe ways of extracting firewood species (Objectives a and b), we analyzed data from recordings and field notes, and from vernacular terminology and local classification patterns of firewood, taking as a reference, terms and set phrases uttered spontaneously during interviews. In order to identify patterns of energy source supply, and of firewood gathering and use by the

Table 1
Socio-economic aspects of the population interviewed and data collection methods for both areas protected.

	Bamba	La Rancherita
Characterizing features of the population		
Inhabitants	N = 93 in the core (Casa Bamba); N = 850 in the buffer area (Diquecito and surroundings).	N = 120
Socio-economical features	Mainly small livestock producers or peasants, natives in a depeasantization process, and a recently settled urban population, especially in the surroundings.	Mainly foreign residents; rural peasant or depeasantized minority more dependent on capital (tourism; state employees; entrepreneurs)
Educational level	Dp and Ps: Low or elementary For and Np: Medium or high	
Data collection methods		
Open and in-depth interviews	10 peasant native people (from 10 households) Applied throughout the year	2 peasant/depeasantized native people (from the only two households) Applied throughout the year
Semi-structured and structured interviews. Number of households (number of inhabitants.)	19 households (106 inh.) Dp: 3 (14 inh.) For: 2 (6 inh.) Np: 8 (41 inh.) Ps: 6 (45 inh.) Applied in winter	9 households (29 inh.) Dp: 1 (2 inh.) For: 3 (8 inh.) Np: 4 (10 inh.) Ps: 1 (9 inh.) Applied in winter

different social actors, we performed Multiple Correspondence Analysis (MCA) by combining socio-cultural and ecological variables according to local perceptions.

- To identify local firewood categories (Objective c) we designed a framework for firewood species, considering the following elements: characteristics or properties explicitly stated by informants (ease of ignition, ember duration, production of flame, heat production, production of smoke and odor, ash production) by giving: a positive value (+1) to each of the desirable qualities; a negative value (−1) to those undesirable; and (0) to those not explicitly informed by the respondents. We also show the native categories (in vernacular terms) that informants more frequently assigned to species in view of their properties (e.g. 'strong', weak'). By means of Principal Component Analysis, we sought to establish groupings for firewood species according to their properties and native categories, thus highlighting local criteria for classification of firewood.
- To suggest a ranking of local priorities for the conservation of firewood (Objective d), we took into account the perceptual information gathered from semi- and structured interviews. We also adopted rapid-assessment procedures for the evaluation of biodiversity based on local perceptions (Oliver and Beattie, 1993). Responses/references were considered for the development of categories whose combination of algorithms helped to define priorities for species conservation at local level (Martínez et al., 2006).

To evaluate the impact of extracting firewood on the region, we developed, on a percentage scale, the following Index of Extraction (IE):

1. IE = (HD * HM * VEF) * 100/Σ (HD * HM * VEF), where:
HD = harvesting distance
HM = harvesting method
VEF = (EV * EF) * 100/Σ EV * EF
- EV = extraction volumen
- EF = extraction frequency (based on recall records)

HD, HM and EV values were calculated from the total number of references made by interviewees (n = 28) to each type of firewood, multiplied by a factor that weighs impact (with values increasing from 1 to 5), according to Table 2. VEF represents a ranking system based on a percentage scale arising from the numerical combination of references that informants made in relation to the extraction volumes. This system is weighed against the extraction frequencies indicated in the recall records for the particular species.

For each species, we also considered firewood use in terms of Diversity (DIV) and Abundance (AB).

1. DIV = Usp * 100/Σ Usp, where:

Usp means total number of references made to the use of a particular species for the production of fire.

2 AB = Ab*100/Σ Ab, where

Ab refers to the estimated quantity of the species, according to the floristic inventory conducted by Giorgis et al. (2011) for Chaco Serrano, province of Cordoba, on the basis of 437 surveys of vascular plants in 20 × 20 m squares.

We finally developed a ranking of local conservation priorities of firewood species on the basis of ecological and perceptual information provided by the Extraction Index, Diversity and Abundance. Thus, an Index of Local Conservation Priority (ILCP) was calculated on a percentage scale, as follows:

ILCP = (Cat. EXTR * Cat. DIV * Cat. AB) * 100/Σ (Cat. EXTR * Cat. DIV * Cat. AB), where:

Table 2
Criteria for assigning scores and factors to variables in the Index of Extraction (IE).

Variable	Factor * number of answers	Criteria for assigning score
Where do you collect firewood?	1	Near home
	2	In the radius of one block
HD	3	In the radius of 1 km
	4	In specific places, (where?)
How do you collect it?	1	By hand
HM	2	With axe
	3	With chainsaw
How much firewood do you usually collect?	1	Less than 5 kg
	2	5–10 kg
EV	3	10–50 kg
	4	50–100 kg
	5	More than 100 kg
Extraction frequency (Recall)	1	Over a year ago
EF	2	Last year
	3	Last month
	4	Last week
	5	Last 24 h

Table 3
Species used as firewood in the study area: applications and classification categories. *Codes of more frequent uses in*: a) wood-fired ovens (including bread and Chilean ovens); b) roasting (ember); c) cooking and boiling food (pots, kettles); d) braziers; e) salamander stoves; f) fireplaces; g) water heaters; h) forges; i) starting fire and keeping it burning; j) coals and embers; k) brooms for ovens; l) non-relevant uses. *Local code categories*[a] *used*: We (weak); St (strong), Lo (loose), Bl (black), Wh (white), Ha (hard), Fa (false), So (soft); Bu (burner); Un (uncategorized).

Vernacular name Genus and species (Family)	More frequent uses (Destination and specific applications)												Vernacular categories
	Food baking			Home heating and technologies					Starting and production of flame		Tools	No details	
	a	b	c	d	e	f	g	h	i	j	k	l	
Abedul *Betula pendula* Roth (BETULACEAE)	*						*						We
Acacia blanca, acacio *Robinia pseudo-acacia* L. (FABACEAE)	*												We, Lo
Acacia negra *Gleditsia triacanthos* L. (FABACEAE)	*		*										Un
Aguaribay *Schinus areira* L. (ANACARDIACEAE)							*						Un
Algarrobo blanco *Prosopis* spp.: *Prosopis alba* Griseb. var. *alba* *Prosopis chilensis* (Molina) Stuntz emend. Burkart var. *chilensis* (FABACEAE)	*	*		*		*							St, Bl
Café del campo *Manihot grahamii* Hook. (EUPHORBIACEAE)							*		*				Wh, Fa, Lo
Chañar *Geoffroea decorticans* (Gillies ex Hook. & Arn.) Burkart var. *decorticans* (FABACEAE)	*	*											Ha, St, Bu
Chilca *Flourensia campestris* Griseb. (ASTERACEAE)		*		*	*			*		*			Ha, St
Ciprés *Cupressus lusitanica* Mill. (CUPRESACEAE)												*	Un
Ciruelo *Prunus domestica* L. (ROSACEAE)						*							Bu
Coco *Zanthoxylum coco* Gillies ex Hook. f. & Arn (RUTACEAE)	*	*	*		*								We, Fa, So
Crataegus, crateu, grateu *Pyracantha angustifolia* (Franch.) C.K. Schneid. (ROSACEAE)									*				We, Fa
Damasco *Prunus armeniaca* L. (ROSACEAE)						*							Bu
Durazno del campo *Kageneckia lanceolata* Ruiz & Pav (ROSACEAE)	*		*	*					*				Ha, St, Bl
Duraznillo *Cestrum parqui* L'Hér. (SOLANACEAE)											*		——
Espinillo, Aromito *Acacia caven* (Molina) Molina var. *caven* (FABACEAE)	*	*		*	*					*			Ha, St
Eucaliptus *Eucalyptus* spp.: *E. viminalis* Labill.; *E. camaldulensis* Dehnh. (MYRTACEAE)												*	We
Garabato *Acacia praecox* Griseb. (FABACEAE)	*	*			*	*		*					Ha, St
Guayacan *Porlieria microphylla* (Baill.) Descole, ÓDonell & Lourteig (ZYGOPHYLLACEAE)		*											St
Guindillo, manzanita *Sebastiania commersoniana* (Baill.) L.B. Sm. & Downs (EUPHORBIACEAE)												*	Fa

(*continued on next page*)

Table 3 (*continued*)

Vernacular name Genus and species (Family)	More frequent uses (Destination and specific applications)												Vernacular categories
	Food baking			Home heating and technologies					Starting and production of flame		Tools	No details	
	a	b	c	d	e	f	g	h	i	j	k	l	
Higuerilla *Broussonetia papyrifera* (L.) Vent. (MORACEAE)									*				Fa, We
Horco molle undocumented												*	Fa
Horco sauce *Sapium haematospermum* Müll. Arg. (EUPHORBIACEAE)												*	Un
Macluro *Maclura* sp. (MORACEAE)												*	Un
Manzano del campo *Ruprechtia apetala* Wedd. (POLYGONACEAE)	*		*										So, Lo
Molle *Lithrea molleoides* (Vell.) Engl. (ANACARDIACEAE)	*	*	*	*	*	*			*	*			St, Ha
Mora blanca / Mora negra *Morus* spp.: *M. alba* L. / *M. nigra* L. (MORACEAE)							*		*				Fa, Wh, Lo
Moradillo *Schinus* spp.: *Schinus longifolia* (Lindl.) Speg.var. *longifolia* / *Schinus fasciculatus* (Griseb.) I.M. Johnst. var. *fasciculatus* (ANACARDIACEAE)	*		*						*				We, Lo, Bu
Olmo *Ulmus* sp. (ULMACEAE)									*				Fa
Palo amarillo *Aloysia gratissima* (Gillies & Hook. ex Hook.) Tronc. var. *gratissima* (VERBENACEAE)									*				–
Paraíso *Melia azedarach* L. (MELIACEAE)	*	*	*				*						We, Fa, St
Pino *Pinus* spp.: *Pinus halepensis* Mill., P. e*lliottii* Engelm. and other (PINACEAE)									*				We, Bu
Piquillín *Condalia buxifolia* Reissek *Condalia microphylla* Cav. (RHAMNACEAE)	*			*	*				*				Ha, St, Bl
Quebracho blanco *Aspidosperma quebracho-blanco* Schltdl. (APOCYNACEAE)	*	*		*				*					Bl, St
Quebracho colorado de las sierras – Horco quebracho *Schinopsis marginata* Engl. (APOCYNACEAE)	*			*	*			*					Bl
Quina *Chenopodium* spp.: *Ch. album* L. Bosc ex Moq. and other (CHENOPODIACEAE)									*				–
Romerillo dulce; Pichana *Heterothalamus alienus* (Spreng.) Kuntze (ASTERACEAE)	*			*					*				We
Sauces: *Salix* spp. (SALICACEAE) Sauce alamo *Salix alba* L. Sacue guaso, Sauce amargo, Sauce criollo *Salix humboldtiana* Willd. var. *humboldtiana* Sauce mimbre *Salix fragilis* L. Sauce llorón *Salix babylonica* L.	*								*			*	Fa, We
Siempreverde, Ligustro *Ligustrum lucidum* W.T. Aiton (OLEACEAE)		*							*				Fa, We

Table 3 (*continued*)

Vernacular name Genus and species (Family)	More frequent uses (Destination and specific applications)												Vernacular categories
	Food baking			Home heating and technologies					Starting and production of flame		Tools	No details	
	a	b	c	d	e	f	g	h	i	j	k	l	
Sombra de toro *Jodina rhombifolia* (Hook. & Arn.) Reissek (CERVANTESIACEAE)										*		*	We, Fa, Wh
Suncho *Baccharis salicifolia* (Ruiz & Pav.) Pers. (ASTERACEAE)											*		—————
Tabaquillo *Polylepis australis* Bitter (ROSACEAE)		*											Wh
Tala, tala churqui *Celtis ehrenbergiana* (Klotzsch) Liebm. (CELTIDACEAE)	*	*		*					*				St, We, So, Wh
Tala falso *Bougainvillea stipitata* Griseb. (NYCTAGINACEAE)												*	Fa, Wh
Tintitaco *Prosopis torquata* (Cav. ex Lag.) DC. (FABACEAE)		*											St
Tuna *Opuntia ficus-indica* (L.) Mill. (CACTACEAE)									*				—————
Tusca *Acacia aroma* Gillies ex Hook. & Arn. (FABACEAE)	*	*						*					Ha, Ft
——— (s/d) *Abutilon pauciflorum* A. St.-Hil. (MALVACEAE)											*		—————
———— (s/d) *Croton lachnostachyus* Baill. (EUPHORBIACEAE)											*		—————

[a] Local native categories and their relation to the properties of firewood. They are presented below according to the properties assigned to them by interviewees and grouped according to the following criteria:

- ➢ Differences in the ease of ignition, production and duration of flame: firewood is specified 'for fire-starting' ("para fuego"), 'for flames' ("para llamas") or as a 'burner' ("ardedoras") (those that produce a lot of flame but are not suitable for producing ember), as 'loose' ("flojas") or 'soft' ("blandas") (whose flame is quickly extinguished). Other properties mentioned concern the firewood 'extinguishy' nature ("apagadizas") (not easily ignited) or 'sparkling' ("chispeadoras") (sending out lots of sparks when ignited).
- ➢ Calorific value and duration of ember: 'false' ("falsas") and/or 'weak' ("débiles") categories refer to low calorific value, i.e., firewood whose embers are usually quickly consumed and which shows different types of flames (generally profuse but short-lived), depending on the species. By contrast, we also found 'strong' ("fuertes") or 'hard' ("duras") firewood, viewed as 'tough' ("aguantadoras"), resistant and long-lasting.
- ➢ Amount and type of smoke or ash originated: 'white' ("blancas") firewood species, comparable to 'false' species, are quickly consumed; they generally produce a lot of ashes and flames, thus, they are usually more suitable for water heaters and furnaces. By contrast, 'black' ("negras") firewood, comparable to 'strong' or 'hard' species, are firmer and slower to burn out. They produce good embers, leave little ash, and are particularly suitable for roasting. This type of firewood is occasionally referred to as 'clean' ("limpio"), 'smoky' ("humeante") or 'smelly' ("oloroso").

(1) EXTR Cat. = value from the Extraction category (1–6), on the basis of EI values
(2) DIV Cat. = value from the Diversity category (1–6), on the basis of DIV values
(3) AB Cat. = value from the Abundance category (1–6), on the basis of AB values, (Higher AB values correspond to lower values of AB Cat.)

Values from the different categories were assigned according to percentile values of 95, 90, 75, 50 and 25 in each category.

In all cases, Infostat package as developed by Di Rienzo et al. (2014) was used to run the statistical tests and figures.

3. Results

3.1. Criteria for the selection of energy sources and for the use and preference of firewood species by the different social actors

3.1.1. General firewood use and harvesting pattern

Of all the semi-structured interviews conducted (n = 28), 89% of households confirmed having harvested some type of firewood near home or near the protected area; in addition, 14% stated getting firewood via commercial means. A total of 54% of interviewees reported using firewood frequently, very frequently or permanently; 38% rarely used firewood, and only 8% reported not using firewood. This shows the relative importance of firewood in terms of subsistence and local economy.

Supplementary Information 2 and 3 show more details about the general firewood use pattern, indicating, for example, that 67% of interviewees, in winter, used and harvested firewood over the last 7 days, whereas only 18% surpassed the rate of a month elapsed since the last collection and use, showing how common this practice is in the region under study. This is so even when several households buy bottled gas, which does not meet all energy requirements. In terms of number of uses, food cooking is the main application of fuelwood resources (38%). The second largest use involves heating and domestic technologies (27%), and plant material used in the ignition and production of fire. In open interviews, particularly, spontaneous reference is made to the properties of some poor-quality firewood available, without indicating specific

use (11%). Finally, species specifically used in the manufacture of species specifically used in the production of fire (3%) represent the least common application.

In terms of use and production of domestic fire, local people identified 102 applications of 56 different species in the mountain forest of these areas. Table 3 lists common names, species and botanical families, in addition to an overview of species use and categories explicitly stated by the informants. Of all the species, 75% are native plants, whereas 25% are exotic tree species, either cultivated or adventitious.

Fig. 2 depicts the use and preference of energy sources and the gathering features of firewood related to the profile of the local actors in the regions under study. This is seen on the first axis of the bi-plot (48% inertia), which clearly opposes the profile of foreign (For) and not peasant (Np) population, regarding depeasantized (Dp) and peasant (Ps) actors. On the right are the groups For and Np, which usually prefer using liquid gas (Lg) and acquiring firewood (Buy); they also recall having gathered firewood last within a period ranging from 1 month to over a year. In contrast, Ps and Dp commonly cook with firewood (Fw) or in combination with liquid gas (Fw/Lg). They buy practically no firewood, which is collected with a variable frequency (Alw/Freq/Rare). Likewise, they remember the last collection episode taking place 24 h or 1 week ago. In relation to the protected area, we find differences associated with the social actors involved. The influence exerted by the kind of subsistence economy is shown to be more closely linked to the peasant (Ps) labor in Bamba (B), and contrasts with a capitalized economic system, observed in foreign (For) and not peasant (Np) populations in La Rancherita (LR). In addition, when analyzing the characteristics of the population and frequency of firewood use we can note that the extractive activity and its impact on firewood use is greater in Bamba (B) than in La Rancherita (LR), the latter being an area with more restrictions on the extractive practice, greater use of other fuel sources, and preference for the purchase of non-local firewood rather than its harvesting. We can also see how the four categories of social actors are located in different quadrants, with the foreign (For) group differing mostly due to its pattern of use and reminder of last collection.

3.1.2. Species with most applications and frequency of use

Fig. 3 reveals the first fifteen species with most uses among the rural people of the area under study. The first species on the list, "molle" (*L. molleoides*), offers seven different uses and is considered by some informants as the "best firewood". "Espinillo" (*Acacia caven* var. *caven*), "garabato" (*Acacia praecox*) and "chilca" (*Flourensia campestris*), with five different uses, are also highly valued. They are all native species, except "paraíso" (*Melia azedarach*), which, in spite of being exotic, is highly regarded and cited by rural people given the diversity of its uses, specifically, due to the suitability of its flame properties for bread ovens.

Fig. 4 also shows how species with the highest number of uses show remarkable similarities with those most frequently used, especially if we look at the first 10 firewood species on the list, headed, once more, by "molle" (*L. molleoides*). This suggests a relation between the frequency of uses reported and versatility of use, which, in turn, confirms the value of positive correlation between the two variables (R Spearman = 0.81, $p < 0.0001$).

3.1.3. Firewood most frequently collected and ways of extracting firewood according to the social actors' profile

By means of MCA, Fig. 5 shows the species of firewood most frequently collected and their origin, in relation to the socioeconomic and cultural profile of the local actors, in both regions under study. On its first axis (inertia of 50%), the bi -plot clearly opposes the profile of the foreign (For) and not peasant (Np) population, with respect to depeasantized (Dp) and peasant (Ps) actors. On the right we can find that Np, and particularly For, more frequently incorporates alien species as fuel, and even some invasive species such as "acacia negra" (*Gleditsia triacanthos*) and "siempreverde" (*Ligustrum lucidum*), accounts for sustainable and conservationist selection criteria. Conversely, Dp and Ps, make use of native woody species with a great variety of applications, long-lasting and with high calorific value.

In particular, Ps most frequently exploit large trees ("quebrachos", "algarrobo", "tusca"), while Dp tend to use shrubs or low-growing trees. Consequently, we assume that they mostly fulfill utilitarian criteria, rather than ecological ones. Moreover, although they do not underestimate some valuable exotic species (for example, "mora"), their use is unrelated to ecological aspects, but related to their value as firewood. Concerning protected areas and socio economic profile, we identified the same differences as those found in Fig. 2.

The relationship between the profile of social actors and mode of firewood collection (places, sites and quantity) can be displayed in the Multiple Correspondence Analysis, Fig. 6. This analysis corresponds to the first two dimensions of the contingency table from the intersection of the following variables: social actors, socioeconomic profile, protected areas and firewood extraction (method, distances and volumes perceived). An opposition of two different types of firewood extraction can be found on the first axis (inertia of 36%). On one hand, Np and For are associated with chainsaw, with greater distances (radii greater than 1 km) and volumes (50–100 kg), and more frequent use of exotic species. Conversely, Dp and Ps extract firewood with hand or ax, at lower volumes (except + 100 kg that only occurred in one Ps respondent) and at places nearby (near home and within 1 block radius).

By examining further the information provided by the previous MCAs, we can note that, while Ps and Dp collect firewood following utilitarian criteria and on the basis of the desirable qualities of timber species, Np and For do so with volumes and methods having higher impact (Chainsaw, within 1 km radius), although less frequently.

3.2. Local native categories and their relation to the properties of firewood

From the in-depth interviews, 12 vernacular terms were compiled, all of them belonging to native categories which classify firewood in relation to its properties (See description at the bottom of Table 3). Table 3 shows the details of species and the categories they have been grouped into. An overview of these categories can be seen in the Bi-Plot of Fig. 7 generated by the PCA which groups fuelwood species in terms of the properties attributed to them and in terms of native classifications. Some 62% of variability found in the classification and grouping of species on the basis of their intrinsic properties is accounted for by the first two components. In the first axis, the major source of variation (41%) can be found in the contributions of the variables "duration of ember" and "heat production", and in the opposite direction, "ease of ignition" and "production of ash". Overall, CP1 can clearly distinguish the clustering of firewood into "strong" (St), "hard" (Ha) (molle, piquillín, garabato, tusca) and "black" (Bl) (algarrobo, quebracho colorado) as opposed to "white" (Wh) (tala, tala falso, café del campo, sombra de toro, tabaquillo), "loose" (Lo) (moradillo), "false" (Fa) and/or "weak" (We) (several species). Depending on the particular case, "weak" and "soft" (So) categories would also prove more ambiguous; sometimes associated with the duration and force of the flame, sometimes with the poor firmness of its ember.

Variability in CP2 (21%) is mainly explained by the "production

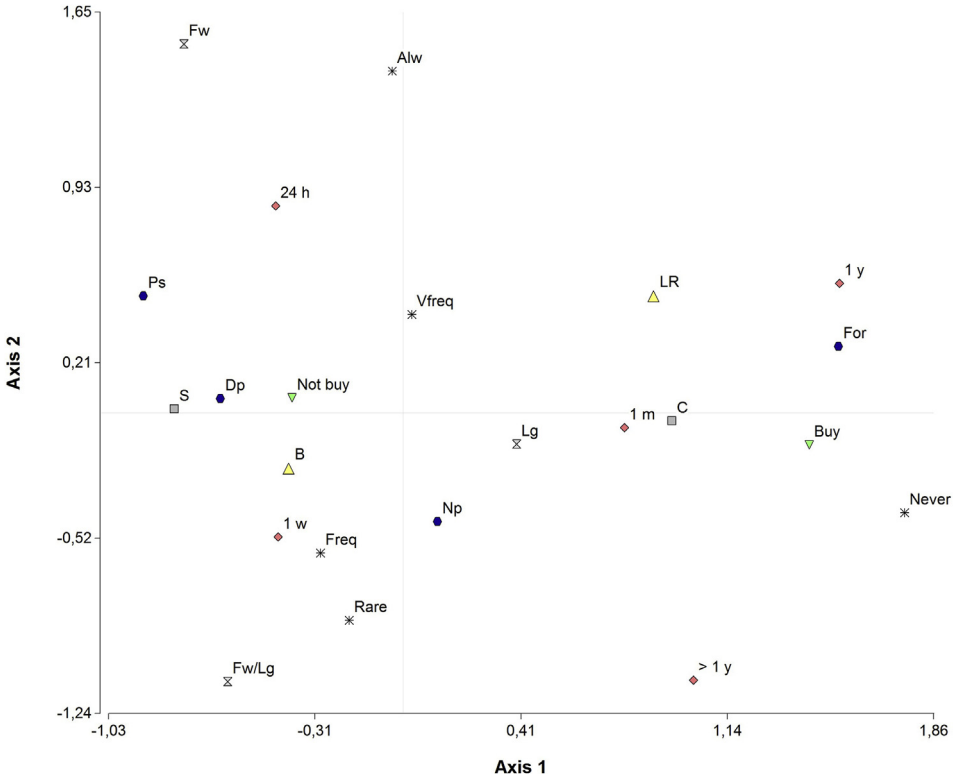

Fig. 2. Bi-Plot corresponding to Multiple Correspondence Analysis between social actors (modalities in blue hexagons), profile of socioeconomic categories (grey squares), fuel most commonly used (grey hourglass), frequency of firewood use (black crosses), acquisition of firewood (green inverted triangles), reminder of last firewood collection (red diamonds), and protected area (yellow triangles). References: Social actors (Ps = peasant; Dp = depeasantized; Np = non peasant; For = foreign); Profile of socioeconomic categories (C = capitalization; S = subsistence); Fuel most commonly used (Lg = liquid gas; Fw = firewood; Fw/Lg = both); Frequency of firewood use (Nev = never; Rar = rare; Freq = frequent; Vfreq = very frequent; Alw = always); Acquisition of firewood (Buy; Not buy); Reminder of last firewood collection (24 h = One day; 1 w = One week; 1 m = One month; 1 y = One year; >1 y = More than one year); Protected area (B = Bamba; LR = La Rancherita).

of flame" variable. Only two categories are closely related to this variable: species considered "burners" (Bu) (chañar, damasco and other fruit) and those regarded as "soft" (So) (coco, tala). Such a classification would allude more to the production of profuse (although not always long-lasting) flame than to ease of ignition. Finally, some species showing ambiguous classifications as perceived by interviewees (paraíso, chañar) are anomalously located in terms of the variability accounted for by the axes.

3.3. Perceived impact of extraction and local conservation priorities

Table 4 lists the first fifteen firewood species with the highest

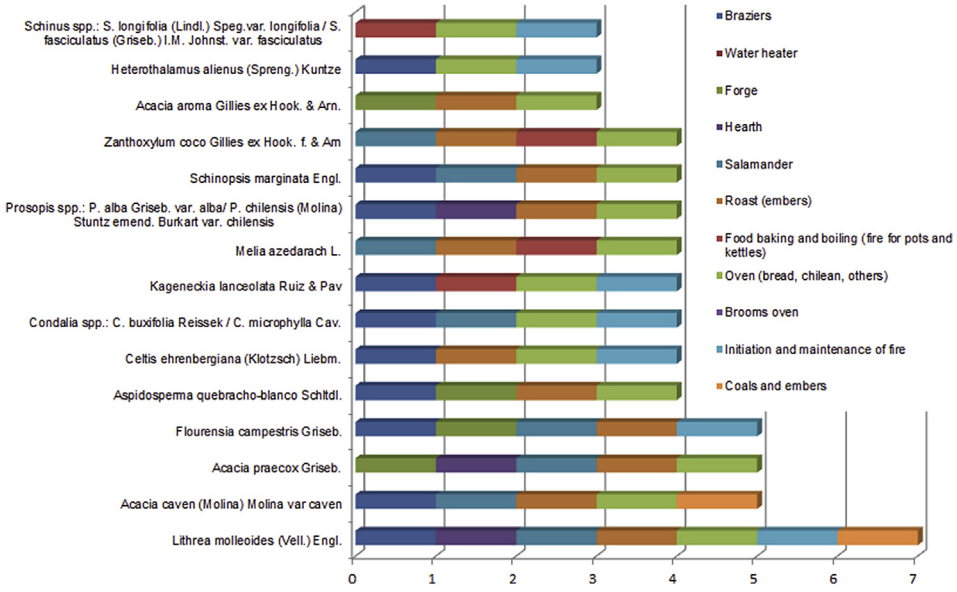

Fig. 3. List of fuelwood species with the highest number of uses in the management, production and use of fire.

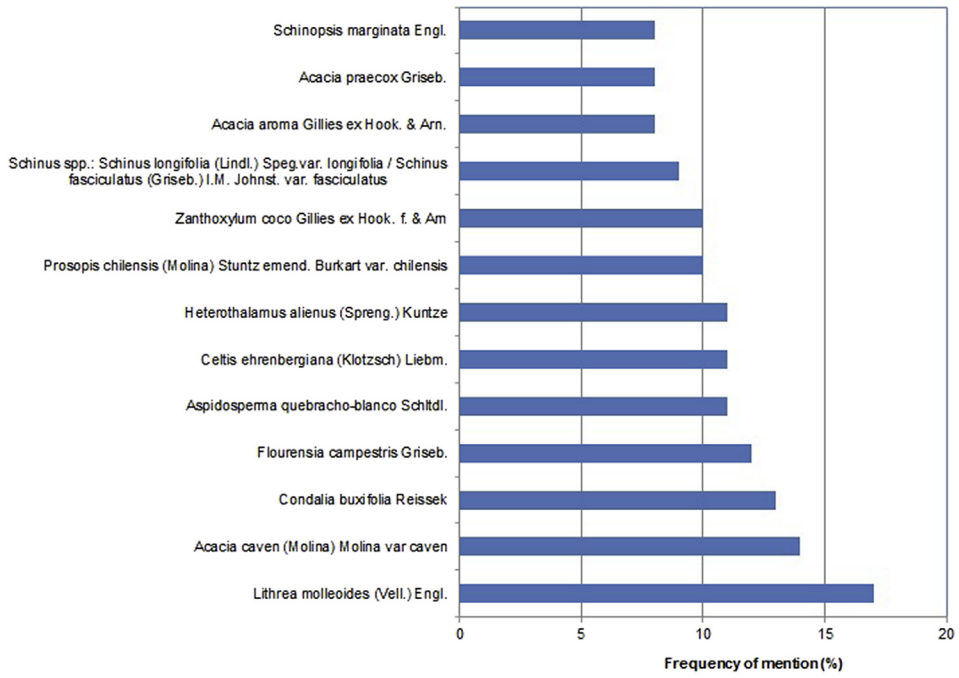

Fig. 4. Firewood species with highest frequency of mention of use (%) by the informants.

values of ILCP, in addition to details of weighted values from the Index of Extraction (IE), Abundance (AB) and Diversity (DIV), and their corresponding categories, on the basis of the information gathered in semi structured interviews. The combination of these variables in the IE allows identifying those species that, according to perceptual information, are more pressured for extraction, such as *Celtis ehrenbergiana*, *L. molleoides*, *Acacia aroma* (EXTR Cat. 6), followed in order by *Acacia caven* var. *caven* and *Prosopis* spp. (EXTR Cat. 5). This is the case of species having a wide range of uses (DIV Cat. 5 and 6), despite markedly varying in abundance. While *C. ehrenbergiana*, *A. caven* var. *caven* and *L. molleoides* are the species most widely found (AB Cat. 1 and 2), *A. aroma* and *Prosopis* spp. are

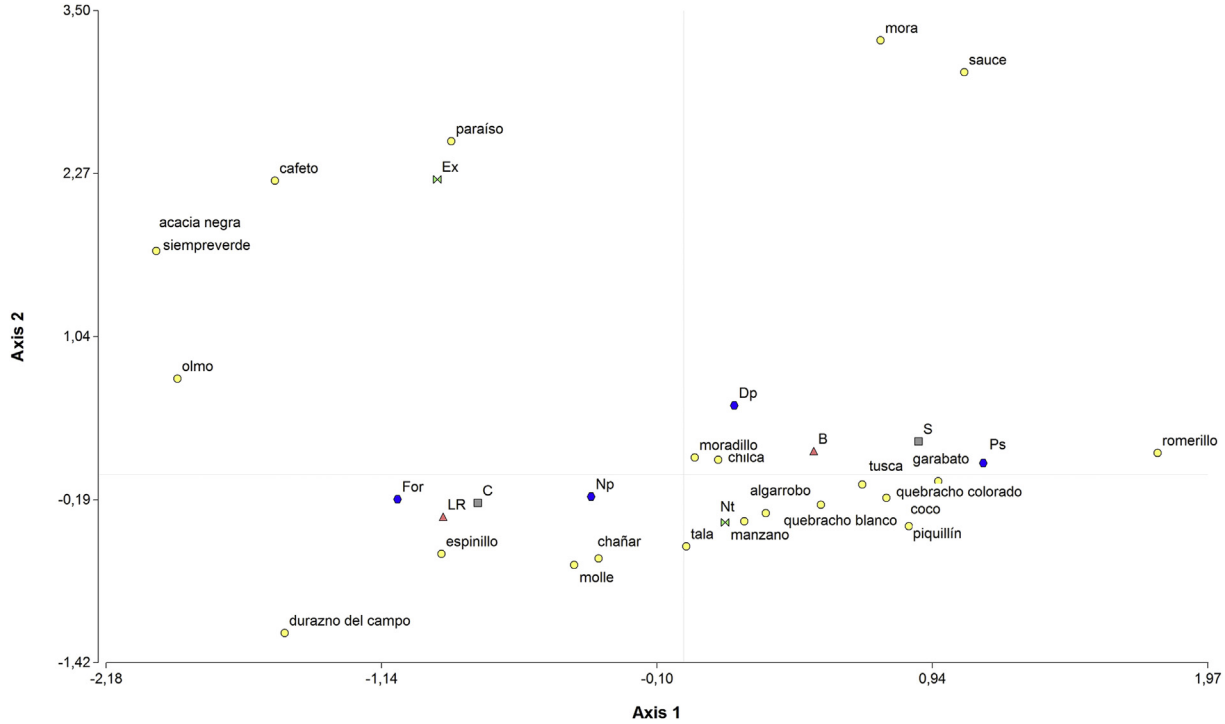

Fig. 5. Bi-Plot corresponding to Multiple Correspondence Analysis between social actors (modalities in blue hexagons), firewood most frequently collected (vernacular names in yellow diamonds), origin of species (green hourglass) and protected area (red triangles).

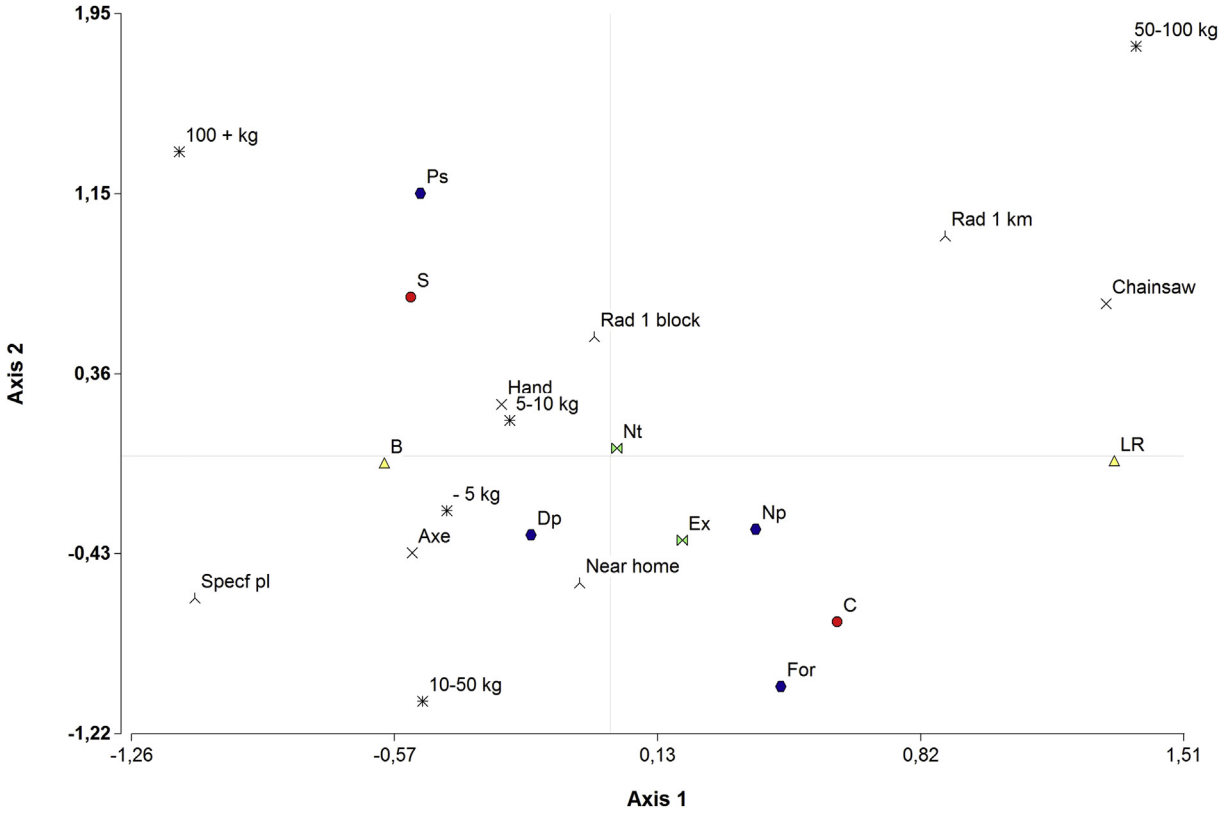

Fig. 6. Bi-Plot corresponding to Multiple Correspondence Analysis between social actors (modalities in blue hexagons), origin of species (green hourglass) protected area (yellow triangles) and ways of firewood extraction (black crosses).

less abundant (AB Cat. 3 and 5 respectively), thus the influence of extraction on the conservation of these species would be greater, as evidenced by their first positions in the ranking of ILCP values. The above data also show that people regularly use those species versatile in nature and with varied applications, concentrating mostly on those more widely found and readily available, and particularizing those less frequently found but with desirable properties. Actually, they are all grouped into the category of

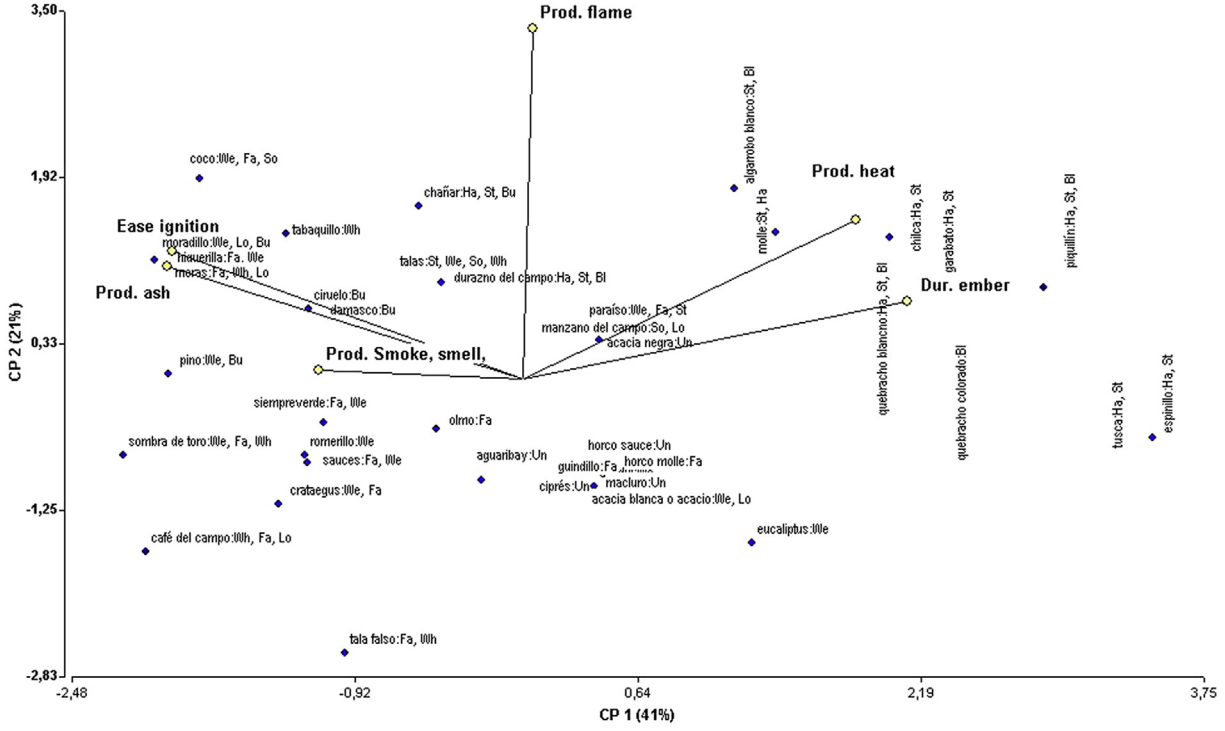

Fig. 7. Bi-Plot corresponding to PCA for the grouping of firewood species according to native classificatory categories and to properties attributed to them (r = 0.89).

"strong", "black" or "hard" firewood species, except *C. ehrenbergiana*, occasionally reported as "weak". This would indicate a higher pressure to extract trees, particularly, is associated with a specific use of firewood for ember. However, for the production of flame, people resort to a nonspecifically wide range of species, including some bushlike species. Among firewood used for the production of flame, greater impact was found on *Z. coco* and *M. azedarach*, two commonly used and highly versatile species. There are also species less widely available, such as *Schinposis marginata* and *Aspidosperma quebrachoblanco*, which, despite being frequently mentioned on account of the quality and versatility of their wood, their in-situ extraction level is virtually null due to regulatory and cultural constraints ("species not to touch") on their collection, or due to the fact that other species are readily available for sale.

If we look at the ILCP value, species which are given local priority for the purpose of conservation are mostly native species, relevant in the composition of Chaco Serrano's biodiversity, being *Prosopis alba* var. *alba*/*Prosopis chilensis* var. *chilensis*, *Acacia aroma* and *F. campestris* at the top of the list. Exceptions are *M. azedarach* and *Ulmus* sp., ranking fourth and fifth respectively, due to their exotic nature. Although both species in Chaco Serrano have been cited as being low in abundance (AB Cat. 5 and 6), the former is collected in larger quantities than the latter. In addition, the former is particularly appreciated among local people since *Ulmus* sp. species are frequently found to host phytopathogens, making them less acceptable.

Other native species ranked in the first 15 positions are important plants from an ethnobotanical point of view, due to the wide variety of uses attributed to them by local people (for food and/or as a medicine). This is especially evident in *Condalia* spp., *Z. coco*, *C. ehrenbergiana*, *Acacia caven* var. *caven*, *Schinus* spp., *A. quebracho-blanco*, to name but a few.

4. Discussion and conclusion

In this study we documented 56 species associated with the handling and use of fire in two protected areas of the hills of Cordoba, 75% being native species. As compared to other geographical areas in the world, the amount of species used in this area is similar to those used in northeast Brazil (Ramos et al., 2008) and in Cambodia (San et al., 2012). It is also significantly higher than other areas in Argentina; in some cases, about two and a half times more than those found in the Patagonian steppe (Cardoso et al., 2012, 2013), and almost double the amount in eastern Catamarca (Gadban, 1999). Such differences can be ascribed, in principle, to the rich ecosystem of the region and to the methodological approach we adopted, which sought to combine spontaneous quantitative references with in-depth interviews.

Of those interviewed in this research, 89% reported collecting some type of firewood near their homes; only 8% rule out its use completely, resorting to non-timber resources. These figures are similar to those found in other regions of Argentina (Cardoso et al., 2012) and Latin America (Ramos and Albuquerque, 2012); however, they are somewhat lower than those reported in Asia and Africa, where the population relies more on forest resources (San et al., 2012). In general, the different uses that people make of firewood agree with those reported in other studies and areas of the world, as well as their preference for cooking with embers. Yet, there are some particular uses that were not reported in these protected areas, such as the manufacture of coal, a typical practice in other regions of the province of Cordoba (Rodríguez López, 2006).

We also found that the use of firewood from mountain forests is still registered among population of these protected areas in Sierras Chicas; a large number of people also use firewood as a first choice in order to meet energy requirements at the household level. Firewood collection and consumption were also found to be a common, frequent, selective and nonhomogeneous practice. In fact, the extraction and level of consumption of firewood are influenced not only by its amount and availability, as suggested by Kituyi et al. (2001), but also by the end-use, the specificity of applications of a given species and the profile of the social actors collecting them. The result of this study strongly suggests that local knowledge, extraction and use of firewood depend on the perception of the multiple social actors which coexist in the protected area. Yet, this study also finds that traditions and profiles linked to peasant activity follow utilitarian criteria based on the desirable qualities of timber species. In this regard, peasants appreciate more particularly the hard, strong and long-lasting firewood, especially large native trees; their collection is frequent but with volumes and methods having a lower impact than that harvested by foreign or non-peasant people. With reference to these last actors, we could also postulate a preservation and sustainable criteria applied to the frequent use of exotic species, including some of the local invasives. The present results account for the fact that sustainable use of forest woody resources is a complex issue, not easily characterized in terms of monolithic practices without considering the multiple cultural constructions of nature among local actors. As claimed by Nygren (2000), the use of natural resources (firewood in this case)

Table 4
Ordering of the fuel species according to decreasing values of Index of Local Conservation Priority (ILCP), considering values and categories of the Index of Extraction (IE), Diversity of Uses (DIV) and Abundance (AB). (First fifteen species with higher values of IPCL are presented).

Species	IE	Cat. EXTR	DIV	Cat. DIV.	AB	Cat AB	ILCP
1. *Prosopis* spp.: *P. alba* Griseb. var. alba/*P. chilensis* (Molina) Stuntz emend. *Burkart* var. *chilensis*	**13.33**	**5**	**10.66**	**6**	**0.67**	**5**	14.73
2. *Acacia aroma* Gillies ex Hook. & Arn.	**17.83**	**6**	**10.15**	**6**	3.43	3	10.61
3. *Flourensia campestris* Griseb.	0.45	4	3.05	4	**1.19**	**5**	7.86
4. *Melia azedarach* L.	3.99	4	3.55	4	**0.71**	**5**	7.86
5. *Ulmus* sp.	0.27	4	1.52	3	**0.57**	**6**	7.07
6. *Acacia praecox* Griseb.	4.59	4	7.61	4	2.43	4	6.29
7. *Aspidosperma quebracho-blanco* Schltdl.	1.15	4	3.55	4	2.47	4	6.29
8. *Lithrea molleoides* (Vell.) Engl.	**18.30**	**6**	**8.63**	**5**	8.85	2	5.89
9. *Condalia* spp.: *C. buxifolia* Reissek/*C. microphylla* Cav.	0.37	4	1.52	3	5.42	3	3.54
10. *Kageneckia lanceolata* Ruiz & Pav	0.01	3	1.02	3	1.81	4	3.54
11. *Zanthoxylum coco* Gillies ex Hook. f. & Arn	0.36	4	1.52	3	7.13	3	3.54
12. *Celtis ehrenbergiana* (Klotzsch) Liebm.	**23.36**	**6**	**9.64**	**5**	12.42	1	2.95
13. *Acacia caven* (Molina) Molina var. *caven*	**15.77**	**5**	**8.63**	**5**	15.27	1	2.46
14. *Schinopsis marginata* Engl.	0.00	1	**13.71**	**6**	2.62	4	2.36
15. *Schinus* spp.: *Schinus longifolia* (Lindl.) Speg.var. longifolia/*Schinus fasciculatus* (Griseb.) I.M. Johnst. var. *fasciculatus*	0.00	1	0.51	3	8.71	2	1.77

Bold categories with the highest value (5 and 6).

is a social process in which different interest groups, pursuing diverging ends, confront each other. Moreover, the use of resources involves a practice historically and politically constructed, with the concepts of sustainability changing among different social and cultural actors. Hence, it proves interesting to gain greater understanding of such different perceptions and viewpoints. This would indicate that, according to the different actors living in a protected area, and according to their perceptions, we could find different ways of extracting and using firewood species. This should be considered in order to plan adequate strategies for managing and reforesting forests. As an example, we have to propose particular strategies in rural areas in which peasants are a majority, in order to decrease the pressure of use on native plants and improve the quality of life of these actors, while considering their needs.

The present work is in agreement with the findings of several authors like Fox (1984), Marconetto (2008), Thomas et al. (2011), and others. In this sense, we consider that, although the environmental supply of firewood or the distance to fuelwood resources would condition, to some extent, firewood use, there are other socio-cultural factors that determine specific and not random selection, as well as the amount of wood used. Ramos et al. (2008) point out that cultural, socio-economic and personal aspects, particularly those related to the informants' sex and age, exercise a significant influence on people's knowledge and firewood use. Although our comparisons have been drawn at household levels, involving the entire family, we agree with the authors on the importance of these socio-economic and cultural aspects, and of the collector's personal preference for plant species, which, in this study, is manifested in the wide range of native categories to classify firewood. Another aspect to consider in relation to sustainability and the different socio-economic characteristics of the population of Bamba and La Rancherita is the composition of household units and the per capita use of Ps and Dp. As suggested by San et al. (2012) average fuelwood consumption per capita in large-sized households is shown to be lower for cooking and boiling water than in small-sized households. In fact, local people subject to in-depth interviews, even today, develop a type of economy with traces of subsistence patterns. This explains the respondents' complex cognitive frameworks regarding the properties and qualities of firewood species, whose perceptual expression is valid for over a dozen native categories comprising a classifying system uniformly agreed upon as to the way of ascribing categories to the different species. Although further studies are required, these categories also seem to be supported by their intrinsic qualities, accounting for the traditional empiricism and plasticity of traditional ethno-ecological knowledge (Berkes, 1999).

Since cooking constitutes the major use of firewood, species offering high calorific value, durability, low production of ash, smoke and odors are preferred, which, according to local categories, are considered “hard”, “strong” and “black” species. These properties agree with those suggested as relevant by populations in South America (Ramos et al., 2008), Africa (Tabuti et al., 2003), Asia (Kataki and Konwer, 2002) and other regions in the world accounting for a general pattern in the preference and intended use of firewood on the basis of subsistence needs. Moreover, Chettri and Sharma (2009) found a positive correlation between the rankings provided by the community and firewood attributes, i.e., higher ranked firewood species were highly correlated with their intrinsic attributes.

Although we do not seek to analyze in this study the intrinsic physical properties of timber resources, bibliographical information on species available (Dimitri et al., 1997; http://www.ceitapsaexport.com.ar/maderas.html; http://www.maderasenargentina.com.ar/) and on those most frequently used would confirm the relation identified in other studies between high density and calorific durability; between moisture content and ease of combustion, amount of smoke and heat energy produced (Kataki et al., 2002; Tabuti et al., 2003). For example, species such as *Acacia caven* var. *caven*, *Prosopis* spp., and *A. quebracho-blanco*, whose woods are considered “hard” and/or “strong”, weigh over 0.90 kg/dm3; in contrast, firewood species considered “soft” and/or “loose”, such as *Salix* spp. *Morus alba* and *Z. coco*, weigh less than 0.65 (Dimitri et al., 1997). The detailed study of firewood mostly preferred and most frequently used according to the Firewood Value Index (FVI) and to an empirical evaluation of its physical–mechanical properties suggests a promising analytical perspective for this region in view of what was evaluated in other populations and areas of study (Goel and Behl, 1996; Kataki and Konwer, 2002; Tabuti et al., 2003; Ramos et al., 2008) due to limited information available in relation to the subject.

Despite the uniformity found in the patterns of preference for firewood species shown by this and other populations in the world, this research also reports thorough knowledge of the energetic properties of a remarkable number of species which are less popular and less used. In this sense, unlike what is reported by Ramos et al. (2008), species more likely to be extracted are not only those with desirable properties (“hard” or “strong” species), but also those with specific use (such as producing flame for bread-baking), such as “weak” or “soft” firewood like *Z. coco*, a species locally extracted.

Moreover, and unlike that reported by Abbot et al. (1997) and Kituyi et al. (2001), attributes including ease of splitting or breaking, quick drying and lighting were not explicitly stated or associated with any category identified by our population.

In relation to our goal of conservation, of the species registered in this research, most are found to be Not Evaluated (NE), due to lack of worldwide criteria for latent threat according to the UICN Red List of Threatened Species (2013). However, in the list of priority species, some conservation agencies refer to them as Almost Threatened (AT), as in the case of *Prosopis* spp. and *A. quebracho-blanco*. The list also includes species classified as Vulnerable (VU), such as *Schinopsis marginata* and *Kageneckia lanceolata*. In addition to species usually agreed on by other studies and by popular belief in terms of need for conservation (such *as Prosopis* spp., *Acacia aroma*, *C. ehrenbergiana* and *Acacia caven* var. *caven)*, we could highlight taxa barely explored in other studies. As an example, we could also see the relevance of *F. campestris*, *Acacia praecox*, *Condalia* spp., *K. lanceolata* and *Schinus* spp. from the perspective of local people. *M. azedarach*, commonly regarded by ecologists as an exotic invasive species, is also a species which is valued and prioritized for conservation purposes, due to the usefulness and quality of its wood, or to the shade it provides, among other uses. The species previously identified and prioritized in this rapid assessment biodiversity survey underlines the need to pursue ecological population-based studies, to further local and specific legal regulations and coordinate in and ex situ conservation actions.

Considering these results, we suggest that the understanding of vernacular knowledge, native categories and local preferences (differing according to social actors) could be the basis for the in situ conservation and cultivation of high value firewood species in the protected areas. In this article we point out in what ways the study of traditional ethno-ecological knowledge of firewood resources reveals some points of this intricate interweaving among different aspects. They include ecological (availability and/or chance of use), socio-economic and cultural (preference in relation to properties and uses and social actors) and environmental aspects associated with conservation practices. Finally, it should also be noted how environmental perception is reflected in categories that define not only the clustering of species according to desirable

properties, but also the precise knowledge of attributes gained from traditional knowledge and practices.

Acknowledgements

We are deeply grateful to rural settlers from Córdoba for granting the author their valuable time and information, as well as the kind hospitality of the families, inhabitants and institutions that facilitated this work. The author would like to thank Alejandro Fernández, Jessica Manzano and degree students of Anthropology, for technical assistance in the field and laboratory work. The assistance of Carolina Mosconi in English proofreading is also acknowledged. The present study was carried out as part of the ANPCyT/FONCyT Pict 1001 project. Conicet supported the work of the author.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jaridenv.2015.05.004.

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Glossary

AB: abundance
Alw: always
B: Bamba Reserve
Bl: black
Bu: burner
C: capitalized
DIV: diversity
Dp: depeasantized
EF: extraction frequency
EV: extraction volumen
Fa: false
For: foreign
Freq: requent;
Fw: firewood
Ha: hard
HD: harvesting distance
HM: harvesting method
ILCP: Index of Local Conservation Priority
Lg: liquid gas
Lo: loose
LR: La Rancherita Reserve
Nev: never
Np: non-peasant
Ps: peasant
Rar: rare
S: Subsistence
So: soft
St: strong
Un: uncategorized
Vfreq: very frequent;
We: weak
Wh: white