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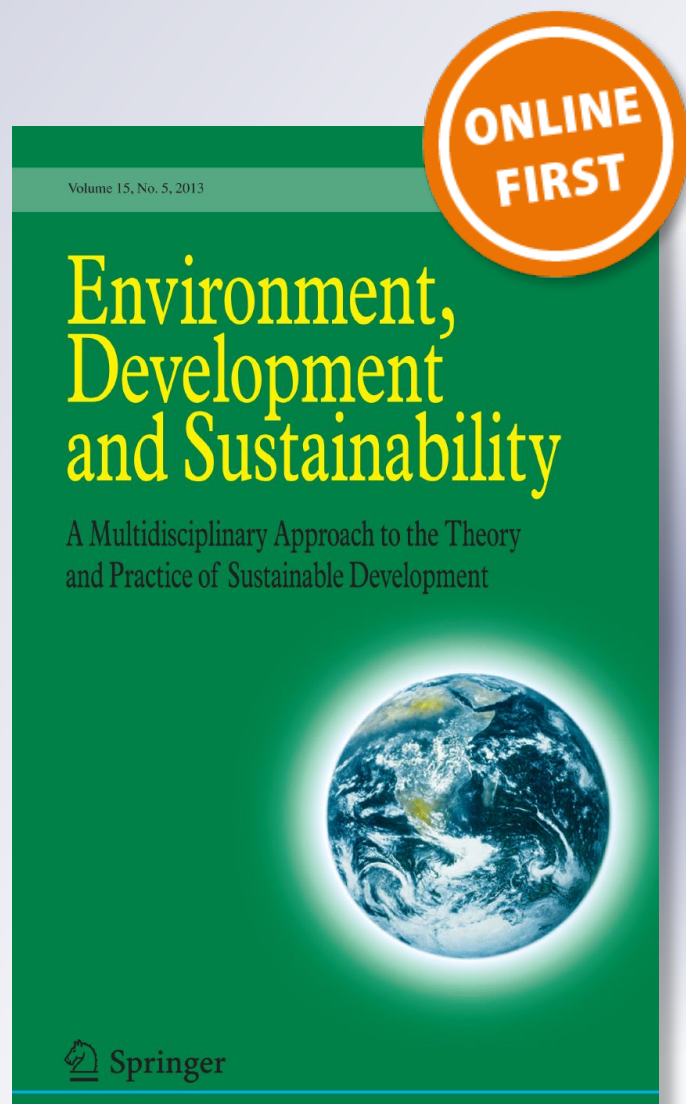
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# Mammals and birds as ethno-indicators of change: their importance to livestock farmers in Arid Patagonia (Argentina)

Lucía Castillo<sup>1</sup> · Ana Ladio<sup>2</sup> 

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**Abstract** This work focuses on the study of signs given to humans by domestic and wild vertebrates. These signs are interpreted culturally by settlers who live on the Central Patagonian Plateau and are taken into account in making decisions relating to their lives as subsistence livestock farmers. Open and in-depth interviews were carried out with 20 livestock farmers from 20 rural establishments of Sierra Rosada, Sierra Ventana and El Escorial. We found that locals' body of knowledge is pervaded by dynamic events in a dialectical, bidirectional process that sustains their traditional way of life. In local discourses, we have distinguished two types of signs: biophysical (e.g. variations in vegetation and climate) and sociocultural (changes in family conformation or in the community, announcement of visit, etc.). We describe 30 signs given by 18 animal ethno-indicators (15 wild and 3 domestic animals, 9 belonging to the class Mammalia and 9 to the class Aves). These signs are used to interpret the natural surroundings and predict both short- and long-term environmental and social processes of change. Amongst the main results, it was found that domestic animals are important principally as ethno-indicators of long-term biophysical changes, whereas wild animals are mainly important in marking short-term biophysical changes and as sociocultural indicators. Finally, the importance of traditional ecological knowledge is discussed with regard to perception, through signs given by domestic animals, of desertification processes such as drought and lack of food on the land.

**Keywords** Traditional ecological knowledge · Ethno-zoology · Social and environmental changes · Biophysical signs · Sociocultural signs · Weather prediction

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## 1 Introduction

Variations in global climate, economic and social dynamics affect productive systems throughout the world, particularly small rural production systems located in hostile zones with highly variable climates, such as the arid and semi-arid regions of the world.

Many authors have argued that the small farmer's knowledge of livestock management must be considered in order to understand how they interpret changes in their landscapes and make decisions to deal with uncertainty (Mortimore and Adams 2001). These management practices consist of multiple dimensions and actions that are fundamental for maintenance of both the herd and the environment (Andrade 2002; Bendini et al. 2005). This know-how constitutes part of the people's traditional ecological knowledge (TEK), which has been defined as a cumulative body of knowledge, beliefs and practices developed through adaptive processes, and involves cultural transmission over generations (Berkes et al. 2000). TEK has a dynamic nature (Toledo and Barrera-Bassols 2008) and forms part of a network where dialectical relationships at several different levels—natural, social and supernatural—are specifically interwoven in each biocultural setting (Van Kessel and Enríquez Salas 2002).

In livestock farming, TEK about both wild and domestic animals is based on their strong relationship of dependence and codependence with human beings (Alves et al. 2007; Lema 2013). This ethno-zoological knowledge enables settlers to provide themselves with food, medicines, materials, etc., and also play a major symbolic and cultural role in their everyday lives (Barbarán 2004; Alves et al. 2009, 2012; Martínez 2013; Hernandez et al. 2015). The dialogue that takes place between the people and their land, the climate, animals and plants is fundamental, helping dwellers in decision-making and therefore in sustaining their way of life. This was found amongst small farmers of the Peruvian Altiplano, where plants and animals seem to act as messengers, signallers or tellers, communicating a qualitative but precise forecast of future weather (Van Kessel and Enríquez Salas 2002). This dialogue makes adaptive management possible in the face of unpredictable climatic inclemency, minimises emotions such as fear and uncertainty and at the same time promotes conservation of ecosystems and their biodiversity (Coetzee et al. 2014; Rivero-Romero et al. 2016).

The use of animals as signs has been described in many cultures. It has been suggested that animals possess atmospheric sensitivity and therefore react to environmental change, which could be the basis of folk weather forecasts (Ulicsni et al. 2016). Variations in their morphological and behavioural characteristics are also used metaphorically through symbolic interpretation (Costa Neto 2006). In South America (Costa Neto 2006; Rivero-Romero et al. 2016), Asia (Bagde and Shampa 2015) and Europe (Ulicsni et al. 2016), the use of insects and reptiles has been cited as an indication of changing weather or bad omens. Birds also seem to play an important role, since interpretation of specific behaviours (reproductive, migratory), their song or even their presence is considered an announcement of some kind (Pereira de Araujo et al. 2005). For example, in Asia, Bagde and Shampa (2015) highlight the *fish owl* (*Ketupa* spp.) whose laughing sound heralds somebody's death. The role of owls as messengers for humans is shared by different cultures, showing the strong bonds that are established with these birds (Enríquez and Mikkola 1998; Enríquez and Rangel-Salazar 2004; Silva-Rodríguez et al. 2006; Restrepo and Enríquez 2014).

In Patagonia, wild vertebrates have been of great value to criancero populations on the Patagonian plateau, as in the case of the guanaco (*Lama guanicoe*), avestruz (*Rhea*

*pennata*) and other animals which are hunted and used in diverse ways: their skins, hides, feathers, bones and tendons, meat and other edible products, amongst others (Prates 2009; Vilela et al. 2009). Interestingly, conceptions of animism have been described in these communities; every living or non-living being is regarded as a person, endowed with intentionality, emotions and thoughts, with which humans create links (Silla 2004; Aigo and Ladio 2016). The role of vertebrates as signs, however, has not been analysed.

The livestock farmers living on the plateau in the province of Chubut, Argentina, who call themselves *crianceros*, are made up of families of Mapuche/Tehuelche and/or Creole ancestry (*Criollos*). These people base their lifestyles on a subsistence economy; they live on small-scale, fenced-off farms, approximately 2500 hectares in size. Small herds of sheep and goats constitute an important social and cultural capital and are therefore distinctive elements of their way of life, which is characterised by a particular way of interacting with the environment, based on values, beliefs and traditional knowledge (Richeri et al. 2013a, b). The prevailing environmental conditions, like low temperatures, strong, dry, constant western winds, periodic snowfalls and low levels of precipitation determine low productivity of the natural grasslands (Bertiller et al. 1995; León et al. 1998; Elissalde et al. 2001). The foraging produced by these pastures is the principal source of food for both wild and domestic animals and sustains the rural model of livestock farming.

Livestock husbandry began in the Patagonian territory at the end of the nineteenth century. After the Desert Campaign (from 1878), the Mapuche and Tehuelche native populations were subjected to genocide practices, and the remaining populations were forced to adopt this economic model (Bandieri 2005; Delrio 2010; Coronato 2011; Pérez 2012). The families, together with foreign settlers (mainly from Europe, Chile and the north of the country), inhabited the most marginal and less productive areas, adopting livestock raising as a way of life, assimilating new elements and meanings through intercultural contact (Coronato 2011; Richeri et al. 2013a, b).

Similar to other arid zones of Patagonia and the rest of the world, this territory has suffered drastic processes of desertification due to the imposed economic model of development, as well as policies related to the extensive livestock system (Ares et al. 1990; Bisigato and Bertiller 1997; Andrade 2002; Paruelo et al. 2005; Coronato 2011; Rostagno and Degorgue 2011; Cheli 2016). These pasturelands are affected by desertification processes caused by the interaction of several factors, including climatic variations and anthropic activities (Villagra 2005), and mainly involve soil erosion, modification of the structure of the vegetation and a decrease or extinction of edible plant species of importance to animals (Paruelo et al. 2005). In addition to these biophysical changes, the decrease in the value of wool in recent years has given rise to a major social crisis which in turn has forced young people to migrate to the cities, and as a consequence, fields have been abandoned. Various authors (Ladio and Lozada 2009; Bendini and Steimbregger 2010; Pérez 2010) have drawn attention to the pronounced processes of change affecting lives of livestock farmers in different areas of Patagonia.

Due to this situation of high vulnerability, the United Nations Convention to Combat Desertification (UNO) has proposed the creation of indicators to facilitate the measurement, monitoring and integrated evaluation of this process. Various authors have put forward suggestions for diverse environmental indicators in different regions of South America, compiled by Abraham and Beekman (2006), as well as indicators of social aspects within the framework of degradation processes (Torres et al. 2005). The construction of these indices generally involves different components of the natural environment (soils, vegetation, animals) (Beeskow et al. 1987; Ares et al. 1990); however, TEK



and particularly local management practices are not included in this kind of index or examination (Ochoa and Ladio 2014).

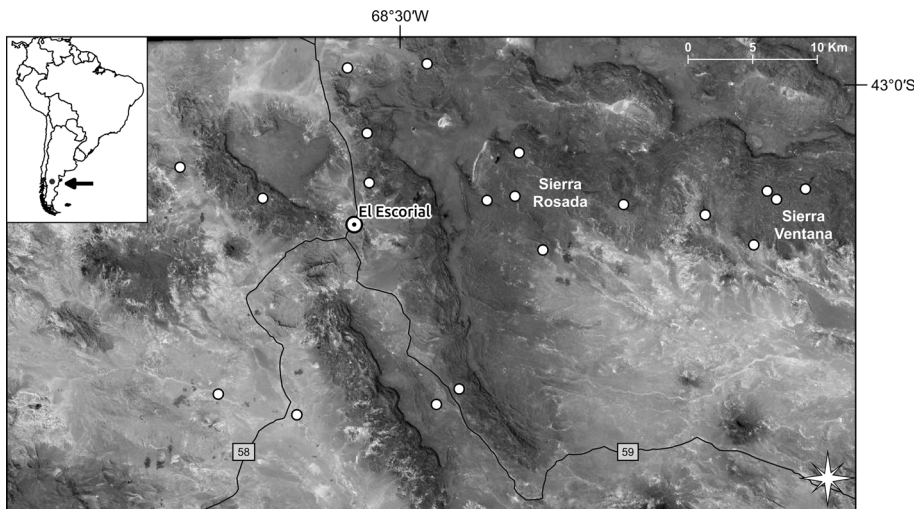
In our case study on the Chubut plateau, we hypothesise that over the passage of years and throughout the history of livestock breeding in the region, locals have been able to identify and interpret signs given by animals, which from our ethno-ecological perspective, we call ethno-indicators. We defined ethno-indicators as the animal species whose behaviour is interpreted by livestock farmers, and whose dynamics are interconnected with them in both space and time. A dialogue is thus established which enables the prediction of future events. It is important to note that we define ethno-indicators in a broad sense, referring to the animals which act as messengers of information whose accuracy is particularly sensitive and valuable for small-scale farm life. This information, however, cannot be extrapolated in quantitative terms.

The principal questions in this work are: What is the local vision with regard to dynamic processes affecting the livestock farmer living on the Chubut plateau? What animals serve as ethno-indicators for farmers and in what way?

## 2 Methods

### 2.1 The study area and human populations

This study was carried out with the rural small-scale farmers who live in the zones of Sierra Rosada, Sierra Ventana and El Escorial. These remote spots are found in the northern central region of Chubut Province, Argentina, in the dry sector of the Patagonian region (Fig. 1). The landscape consists of rolling hills and steep-sided rocky basalt protrusions (Beeskow et al. 1987). In the study area, the climate is dry and cold for much of the year (average annual temperature 11.3 °C and average annual precipitation 174 mm), exposing inhabitants to severe conditions at certain times of the year (98 days of frost is the annual



**Fig. 1** Area of study of the rural communities of Sierra Ventana, Sierra Rosada and El Escorial (Chubut, Patagonia, Argentina). White dots represent sampling rural establishments

average). The predominant vegetation is shrubby steppe. Amongst the most conspicuous native species in this area are: *Berberis microphylla*, *Senecio* spp. *Mulinum spinosum*, *Chuquiraga avellanedae*, *Nardophyllum bryoides*, *Schinus* spp., *Grindelia chilensis*, *Acantholippia seriphioides*, *Nassauvia axillaris*, *N. glomerulosa*, *Acaena* spp., *Sisyrinchium* spp., *Pappostipa* spp., *Poa* spp. and *Erodium cicutarium*.

Access to this zone, by means of dirt roads, tends to be difficult and sometimes even impossible due to snow or the consequences of heavy rain. Public transport runs weekly from coastal urban centres along the closest main road and goes as far as the village of El Escorial, a small settlement in the area where locals from the surrounding establishments can buy supplies. Messages can also be sent from here by AM radio, the main method of communication, using the “rural messenger” service. There is also a healthcare centre where basic medical assistance is available from a nurse and basic medicines can be obtained. The families, of Mapuche, Tehuelche and/or Creole ancestry, live in small establishments which are widely spread out, as shown in Fig. 1. Their subsistence economy, which depends very much on the work of the whole family, is based on sheep and goat management combined with hunting, family horticulture and the gathering of edible and medicinal plants, and firewood for heating (Richeri et al. 2013a, b).

The production method used is extensive livestock farming with a fixed stock load. Due to the small size of farms, they are generally not subdivided in sections, so animals are kept together. Due to the low market price of wool, profits from livestock breeding are very low, and this situation is aggravated by a high level of animal mortality as a result of predators, and the drought suffered over the last 10 years (Andrade 2002; Ejarque 2006). These factors have led to abandonment of farms, a decrease in the number of young people in the area and a high level of dependence on public policies, which generates considerable change in social structure, organisational models and traditional activities (Franco 2005). This phenomenon of abandonment in arid rural areas shares common socio-economic determining factors with other dry areas throughout the world (Valipour et al. 2014).

## 2.2 Methodology

Fieldwork was carried out according to the rules established in the United Nations Conference on Sustainable Development Río+12 (2012) for the regulation of access to genetic resources and protection of traditional knowledge and rights to intellectual property. In addition, the guidelines of the Ethnobiological Society Code of Ethics (ISE 2006) were followed. During the years 2013 and 2014, four 10-day campaigns were undertaken in the study zone, and repeated visits were made to rural establishments. Staying overnight in establishments meant sharing complete days with *criancero* families, allowing interviews to be carried out in different contexts (walks, work/slaughter of the animals, barbecues, marking, breakfasts, lunches, dinners, etc.). This made it possible to obtain a wide ethnobiological range of data, which were recorded in audio form for later analysis. This exhaustive survey was conducted up to the point of data saturation, thus validating the information. We interviewed all the farming families, performing a census of those living in the zones of Sierra Rosada (seven rural establishments), Sierra Ventana (five rural establishments) and El Escorial (11 rural establishments). Open and semi-structured interviews were carried out, as well as walks in the countryside (Albuquerque et al. 2014) with 20 informants ranging from 45 to 77 in age; one individual who was responsible for the livestock in each establishment (75% men (15) of average age  $64.3 \pm 11$  years and 25% (5) women of average age  $67.2 \pm 9$  years). Questions centred on three points: (1) the daily dynamics of the way of life of a livestock farmer and the problems associated with

the animals and production over time, (2) the changes perceived over time, and (3) knowledge related to both domestic and wild animals, concentrating on the dialogue developed between them during management of livestock. This work includes just some aspects of the dynamics of this rural life and TEK.

Our methodology was based on inhabitants' cultural interpretation of the animal behaviours we consider which are used as socio-environmental and cultural signs to predict certain aspects of environmental and social dynamics. We focused on inhabitants' insights into the dynamic processes that affect farm life, such as changes perceived in the climate, environment, vegetation, wild and domestic animals and the relationships established between these components. In addition, social, natural and supernatural processes were interpreted. As proposed by Medrano (2012), these aspects are all included in order to obtain an "inside" perspective, "from the main actors" with regard to the phenomena affecting their own reality. Some testimonies have been described, and informants named using letters.

### 2.3 Data analysis

The information obtained from the interviews was first analysed and interpreted qualitatively, considering both emic and/or etic dimensions and then quantitatively, by means of statistical comparison of categories using the Chi-square test ( $p < 0.05$ ) and binomial ( $p < 0.05$ ) tests.

Animal species were identified and named from personal observations and with the help of informants during the fieldwork. In some cases photographic material was also used to facilitate recognition of animal species (Medrano 2012). We followed the classification and nomenclature of local bird and mammal guides (Narosky and Babarskas 2001; Chebez et al. 2014) and the IUCN (<http://www.iucn.org/>).

## 3 Results and discussion

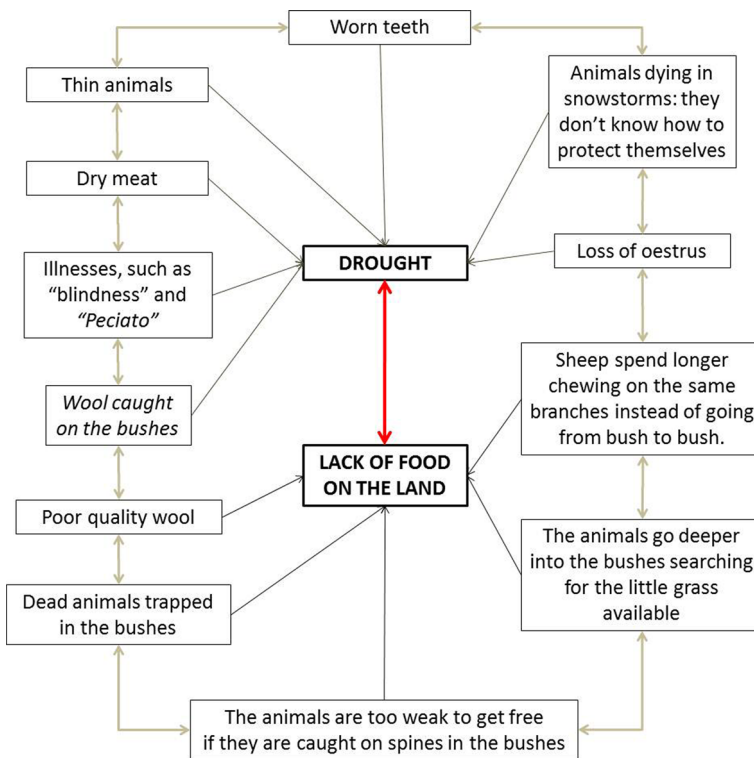
### 3.1 What is the local vision with regard to dynamic processes affecting the livestock farmer living on the Chubut plateau?

Local vision regarding the dynamic process is unique, and therefore, any attempt to simplify it through the particular rationalising eye of the scientific perspective should be discouraged, since we run the risk of altering and/or minimising biocultural significance accorded by local farmers. In agreement with Medrano (2012), we found that informants did not have the same vision of environmental dynamics or terminological meanings as the scientific world, particularly with respect to definitions that do not take an integrated point of view into account as the traditional worldview does. Inhabitants of the Chubut plateau, through dialogue with the environment and a multicausal, spiral and holistic approach that does not separate Nature and Humanity (Viveiros de Castro 1996a, b, 2002), keep a detailed record of how their livestock farming lifestyle experiences dynamic events. In local discourses, we have distinguished two types of change: biophysical (e.g. variations in vegetation and climate) and sociocultural (changes in family conformation or in the community, announcement of visit, etc.). Different signs, from animals, plants, sky, clouds, etc., are used as sources of information associated with different forecasts. These processes are always integrated as an interlocking network and are also charged with a strong



emotional component which generates permanent dialogue within a framework of mutual respect. Similarly to Van Kessel and Enríquez Salas (2002), we found that both short- and long-term changes were mentioned during interviews. The short-term changes are sporadic events such as a heavy snowfall, rain, wind and visitors. In contrast, the long-term processes are those which take place over a period of time, imply prolonged periods (a matter of years) and involve diverse sociocultural and biophysical factors. In addition, long-term sociocultural processes involve the transformation of ways of life or of family structure, for example, migrations.

According to inhabitants, long-term biophysical processes are mainly due to *drought* and *lack of forage* (food) on the land for the animals. Drought is a local term used frequently by informants and refers to a complex process involving changes detected in different components of the natural surroundings, particularly the animals (changes in physical and behavioural aspects, e.g. thin animals, changes in feeding behaviour) and plants (changes in attributes such as colour, abundance the presence of fruit and shoots, morphology and, specifically, a decrease in abundance of forage plants (see Fig. 2). We can therefore say that the emic vision of drought differs considerably from the technical definition of the United Nations Organisation. For example, the ONU in their Convention to Combat Desertification document (UNCCD 1994) defines drought as: “the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land



**Fig. 2** Conceptual map of the physical characteristics and behaviours interpreted by livestock farmers as signs of long-term change, such as the processes leading to drought and lack of food on the land

resource production systems". This result is a clear example that highlights the importance of understanding other ways of seeing things and of "naming" natural phenomena, so as to build bridges of communication and create opportunities for rural farmers and technicians to work together on the complex problem of desertification, where local wisdom is not considered inferior to technical knowledge.

*Lack of forage* on the land is another inside term that refers to a sign of change perceived by the livestock farmers. This is related to a decrease in the percentage cover of vegetation of foraging importance, an aspect not directly evaluated in this work, but the livestock farmers' perception of a decrease in the availability of forage coincides with satellite studies carried out in the region (Nakamatsu et al. 2013). *Lack of forage* on the land is experienced by locals as a constant reason for worry, drastically reducing numbers of animals and directly affecting quality of life and ultimately, the future of these farming families. The scientific community has shown that this change in vegetation is part of the desertification phenomenon, and implies a process over time related to diverse factors such as humidity throughout the year, changes in the soil, in seed dispersion and livestock density (Abraham and Beekman 2006); i.e. it involves a long-term process. After explaining the ethno-indicators (see below), we will return to the livestock farmers' integrated vision of change and discuss actions they have carried out.

### 3.2 What animals serve as ethno-indicators for farmers, and in what way? How is the animal behaviour interpreted?

Animals are in permanent communication with the people, giving signs of diverse processes of biophysical and sociocultural change in rural life. A total of 18 species of vertebrates which act as ethno-indicators were registered (Table 1). Of these, 50% are birds (such as *Geranoaetus polyosoma*, *Bubo virginianus magellanicus*, *Rhea pennata*), and the remaining 50% are mammals (i.e. *Lama guanicoe*, *Ctenomys magellanicus*, *Ovis orientalis aries*, *Capra aegagrus hircus*); 3 of these species are domestic animals, and the remainder are wild.

The most important domestic ethno-indicators are dogs, sheep and goats (Table 1). The farm dog is an essential part of rural tradition; it collaborates in the work, rounding up herds or provides company and protection in the domestic area. *Sheep*, principally the Merino race, are kept for the production of fine wool, meat being a by-product of the wool industry. And finally, *goats*, principally the Angora race, produce Mohair fibre, milk and meat. Livestock farmers interact with them for many hours each day. The average size of a flock of sheep is  $316.11 + -206.74$  and of goats,  $154.16 + -107.31$  animals; 60% of interviewees own both types of livestock.

Of the wild species described, 60% are birds, while the remaining 40% are mammals. The significance to farmers of bird behaviour in terms of conveying messages has already been cited by several works (Marques 1999; Arenas 2009; Coetzee et al. 2014). It has been established that some birds are seen as timekeepers in relation to seasonal changes; that is, they announce the change from the dry season to the wet one, or vice versa (Coetzee et al. 2014). Pereira de Araujo et al. (2005) describe 30 species of birds in Brazilian communities, and Van Kessel and Enríquez Salas (2002) mention various species in Bolivia whose song or behaviour are bioindicators of rain. Bagde and Shampa (2015) cite the case of the *House sparrow* (*Passer domestica*): if it takes sandbaths, this is interpreted as a lack of rain in the near future. In addition, various authors highlight the importance of identification of these signs for decision-making, such as preparation of the land and the crops (Pereira de

**Table 1** List of animal species used as ethno-indicators by rural populations on the Chubut plateau (Patagonia, Argentina)

Scientific name	Common name	Phylum	Class	Order	Family
<b>Domestic</b>					
<i>Capra aegagrus hircus</i>	Goat (Chiva)	Chordata	Mammalia	Artiodactyla	Bovidae
<i>Ovis orientalis aries</i>	Sheep (Oveja)	Chordata	Mammalia	Artiodactyla	Bovidae
<i>Canis lupus familiaris</i>	Dog (Perro)	Chordata	Mammalia	Carnivora	Canidae
<b>Wild</b>					
<i>Leopardus geoffroyi</i>	Geoffroy's cat (Gato montés)	Chordata	Mammalia	Carnivora	Felidae
<i>Puma concolor</i>	Puma	Chordata	Mammalia	Carnivora	Felidae
<i>Pseudalopex griseus</i>	Grey fox (Zorro gris)	Chordata	Mammalia	Carnivora	Canidae
<i>Pseudalopex culpaeus</i>	Culpeo fox (Zorro Colorado)	Chordata	Mammalia	Carnivora	Canidae
<i>Lama guanicoe</i>	Guanaco	Chordata	Mammalia	Cetartiodactyla	Camelidae
<i>Ctenomys magellanicus</i>	Magellan's tuco-tuco (Tuco-tuco)	Chordata	Mammalia	Rodentia	Ctenomyidae
<i>Theristicus melanotis</i>	Black-faced ibis (Bandurria)	Chordata	Aves	Pelecaniformes	Threskiornithidae
<i>Chloephaga picta</i>	Upland goose (Avutarda)	Chordata	Aves	Anseriformes	Anatidae
<i>Cygnus melancoryphus</i>	Black-necked swan (Cisne)	Chordata	Aves	Anseriformes	Anatidae
<i>Phoenicopterus chilensis</i>	Chilean flamingo (Flamenco)	Chordata	Aves	Phoenicopteriformes	Phoenicopteridae
<i>Cyanoliseus patagonus</i>	Burrowing parrot (Loro)	Chordata	Aves	Psittaciformes	Psittacidae
<i>Mimus patagonicus</i>	Patagonian mocking bird (Calandria)	Chordata	Aves	Passeriformes	Mimidae
<i>Geranoaetus polyosoma</i>	VARIABLE hawk (Pecho blanco)	Chordata	Aves	Accipitriformes	Accipitridae
<i>Bubo virginianus magellanicus</i>	Great-horned owl (Nucu)	Chordata	Aves	Strigiformes	Strigidae
<i>Rhea pennata</i>	Lesser Rhea (Avestruz)	Chordata	Aves	Struthioniformes	Rheidae

Araujo et al. 2005; Coetzee et al. 2014) or movements of livestock (Coetzee et al. 2014), helping farmers to survive and cope with natural phenomena.

### 3.3 What signs are given by animal ethno-indicators?

Signs from the animals, whether domestic or wild, are perceived through observation and interpretation of biophysical characteristics (BioC, 47%) and/or behavioural characteristics (BehC, 53%), which the farmers take to indicate the likelihood of imminent change. BioC refer to characteristics related to the physical condition of the animals, such as dry meat, worn teeth and weak wool, while BehC refer to changes perceived in behaviour, such as grazing habits, absence of oestrus and the behaviour of animals during snowfalls (Table 2).

In Table 2 we describe 30 different signs interpreted from different animal ethno-indicators, which shows their considerable importance as elements that contribute to the constant monitoring of change or anticipation of a new event. Our interpretation has revealed that most of the registered signs of change, 83% (25), are biophysical in nature (BP) (drought, rains, snowstorms, etc.) and the remaining 17% (5) are sociocultural (SC) (good or bad omens, alerts, warnings, etc.) (binomial test,  $p < 0.05$ ). In addition, 63% (19) of the signs perceived refer to long-term changes (LT) (drought or lack of food on the land), and the remainder (37%, 11 records) to short-term events (ST) related to climate (snow, rain, cold), (binomial test,  $p = 0.0508$ ).

In Table 2 we also show the case where signs are given by humans to animals. This is an example showing that the dialogue established between farmers and the elements in their surroundings is bidirectional and permanent. Just as animals bring news to the people, people also convey messages to the wild animals. For example, in order to prevent predators like the puma (*Puma concolor*), Zorro Colorado (*Pseudalopex culpaeus*) and gato montés (*Leopardus geoffroyi*) attacking their domestic animals, locals often hang remains of animals they have hunted on the fences around their farms. By means of these signs, they seek to warn off wild predators and reduce future attacks.

Of the 29 signs detailed in this work relating to biophysical changes (including those given by humans to animals), 18 cases (62%) are perceived through domestic animals and 11 (38%) through wild animals (Binomial test,  $p = 0.0644$ , Table 2).

Most of the 18 biophysical signs perceived through domestic animals, 94.44% (17), are long term (drought or lack of food on the land). In contrast, the short-term signs related to climate (snow, rain, cold) are mainly perceived through wild animals, and in this case, of the 11 biophysical signs perceived, 81.81% (9) are short term in character (Chi square test,  $p < 0.05$ ). It is necessary to interpret the fact that the domestic animals were introduced into the region more than 100 years ago and have generated profound changes in the environment due to grazing (Bisigato and Bertiller 1997). These results represent an example of how the adaptive and dynamic adjustment of the TEK held by inhabitants enables them to make decisions related to management of their livestock, as they perceive the long-term signs (such as lack of forage on the land and drought) which are in part a consequence of the erosive processes brought about by the livestock themselves.

Of the 5 sociocultural signs registered, 4 (80%) are perceived through wild animals and 1 through domestic (Binomial test,  $p = 0.1563$ ) (Table 2). It is also worthy of note that the sociocultural signs arise mainly (80%, 4) from animals belonging to the class Aves, and the remainder from the class Mammalia (binomial test,  $p = 0.1563$ ).

**Table 2** Animal ethno-indicators of biophysical (BP) and/or sociocultural (SC) signs perceived by Patagonian livestock farmers; long term (LT) and short term (ST)

Common name	Signs	Changes	Type of change
<i>Sheep</i>	The herd gets together and comes down from the plateau (BehC)	Snow	BP ST
<i>Sheep</i>	Sheep stay for longer chewing on the same branches instead of going from one bush to another (BehC)	Lack of food on the land	BP LT
<i>Sheep</i>	Wool on the bushes (BioC)	Lack of food on the land	BP LT
<i>Goat</i>			
<i>Sheep</i>	The animals go further into the bushes to look for the little grass there is. They don't have the strength to get out again. The animals begin to go under the big bushes (BehC)	Lack of food on the land	BP LT
<i>Goat</i>			
<i>Sheep</i>	Poor-quality wool (weak) on the animal. "The yield of wool is not good"(BioC)	Lack of food on the land	BP LT
<i>Goat</i>			
<i>Sheep</i>	Dead animals, trapped in bushes (BioC)	Lack of food on the land	BP LT
<i>Goat</i>			
<i>Sheep</i>	Loss of oestrus (BehC)	Drought	BP LT
<i>Sheep</i>	Animals dying in snowstorms, not knowing how to protect themselves (BehC)	Drought	BP LT
<i>Sheep</i>	Thin animals (BioC)	Drought	BP LT
<i>Goat</i>			
<i>Sheep</i>	Worn teeth (BioC)	Drought	BP LT
<i>Sheep</i>	The meat is dry (BioC)	Drought	BP LT
<i>Sheep</i>	Pink eye in sheep (BioC)	Drought	BP LT
<i>Sheep</i>	<i>Peciato</i> (BioC)	Drought	BP LT
<i>Dog</i>	Barking "at nothing" (BehC)	Ill omen: Presence of supernatural beings	SC ST
<i>Black-faced ibis</i>	When you see them flying north (BehC)	Wind	BP ST
<i>Upland geese</i>	When you see them flying north (BehC)	Snow	BP ST
<i>Black-necked swans</i>	When you see them flying north (BehC)	Cold	BP ST
<i>Chilean flamingos</i>			
<i>Great-horned owl</i>	When the great-horned owl comes to your house it is bad news. When it sings at night (BehC)	Bad omen: bad news is coming	SC ST
<i>Burrowing parrots</i>	When they come close to your house and "scream" (BehC)	Omen: visit	SC ST
<i>Patagonian mocking bird</i>	When you are out camping (BehC)	Omen: company	SC ST

**Table 2** continued

Common name	Signs	Changes	Type of change	
<i>Variable hawk</i>	When they appear on the road, at night (BehC)	Omen: if it shows its white chest things will go well, but if it shows its back something bad will happen	SC	ST
<i>Lesser Rhea</i>	When they have a lot of young (BioC)	Good years: the population is growing	BP	LT
<i>Guanaco</i>	When you find stones in their stomachs (BioC)	Good omen: the population is growing	BP	LT
<i>Magellan's tuco-tuco</i>	When it sings at night (BehC)	Frost	BP	ST
<i>Geoffroy's Cat*</i>	When dead animals are hung on the fences	Warning: to prevent predator attacks	BP	ST
<i>Puma*</i>				
<i>Grey fox*</i>				
<i>Culpeo fox*</i>				

\* In this case, humans convey messages to wild animals

*BehC* behavioural characteristics, *BioC* biophysical characteristics

### 3.3.1 Domestic animal signs

Diverse behavioural aspects of sheep forecast short-term climatic events. The fact that sheep “*come down from the plateau and crowd together*” indicates that snowstorms are not far away; this happens because the geomorphology of the plateau means it is higher, and the animals seek milder weather. Another behaviour considered as a sign is when sheep remain for a longer time than normal feeding on the same bush, instead of going more quickly from one to another, as they do when food is abundant (tender shoots, flowers, fruits), and so this is associated with a shortage of food on the land. “When there is food, the animals eat here, eat from a few branches, and over there there’s another so they go there... they don’t finish it... they eat here, they eat there, then over there... they don’t finish a plant that’s all green...” AL-E.

In addition, according to meticulous daily observation, the variations demonstrated by domestic animals in their way of feeding on certain species in particular are used to forecast scarcity of food on the land. For example, the common stork’s bill *alfilerillo* (*Erodium cicutarium*) represents a highly valued food item in spring, associated with milk production in mothers and wellbeing of their young. Variations in the behaviour of animals when feeding on this plant are associated with a future decrease in its abundance; for example, as one informant described: “the plant used to have long branches... now as soon as the goats are born they eat the branches and scratch around, dig a hole around it, they take out the root and that’s the end of it... the plant doesn’t get a chance to develop and no new seeds are sown...” DD-E.

The signs described by farmers which are related to drought and lack of food on the land refer to physical characteristics of the animals (76%) (poor-quality wool, thin animals, worn teeth, dry meat, dead animals, etc.) and behavioural characteristics (24%). The lack of food on the land is also perceived through other *signs* given by domestic animals. The tufts of sheep or goat wool found hanging from branches indicate, on the one hand, that the animals’ wool is weaker due to lack of food, and on the other hand, that they are being



obliged to *push further into the bushes* in search of food, leading to greater likelihood of becoming tangled up in the plants. It should be pointed out that most plant species eaten by the animals have spines as an adaptation to the dry climate and herbivores (Golluscio et al. 2011). This animal behaviour leads to extreme situations, particularly in the case of goats when they are small or weak; they can die if they become trapped and are not saved in time. "... the animals push further into bushes to find the little grass there is. They are not strong enough to get out again (due to lack of food). The animal starts to get under the big bushes, and gets stuck there... the goat may even die under the mesquite [*algarrobbillo*, *Prosopis denudans*] if you don't see it or can't get it out—that happens with goats" AP-SR. Crianceros emphasise the importance of checking over the land every day to prevent these situations, which is an example of the value of TEK in this way of life, as it helps in the care of livestock and development of adaptive management measures.

Amongst the long-term processes, *drought* is also perceived and confirmed in time through the behaviour of domestic animals; for example, by the loss of oestrus, or when they die easily in any snowstorm. This can be explained by the fact that in times of drought snowstorms are very sporadic, so the adult animals didn't learn when they were young how to behave in order to survive this climatic event. "... the animals aren't used to snow... they hang around here, eat whatever is around and don't dare to go out. So the snowfall killed many animals. Before, (when snows were common, when there was no drought) they opened up the path themselves, looking for food..." AL-E.

The biophysical signs given by domestic animals that are related to drought have to do with their being thin, having worn teeth, weak wool, and when the meat is cooked it tastes *dry*. Drought is perceived as something bad that affects the land in diverse ways; for example, when it is related to the occurrence of illnesses that affect the sheep (such as pink eye "*la ceguera*" and "*el peciato*") (Table 2). As previously mentioned, there is a strong connection between the short- and long-term processes; according to locals, lack of food on the land is an environmental process related to drought, which in turn is related to short-term environmental processes which have altered in frequency over approximately the last 12 years, such as a decrease in humidity due to a decrease in rains, an increase in the strength of the winds, a decrease in winter snows and heavy rains and sporadic snowfalls (Paruelo et al. 2005).

The results found agree with Rivero-romero et al. (2016) on the importance of monitoring behavioural and biological aspects of the livestock in this pastoral lifestyle. *Goat* (*Capra aegagrus hircus*) behaviour is used as an indicator: when they show cheerful and impetuous behaviour it means good weather, whereas passive or sad behaviour heralds drought. The perception of drought as a process involving different factors allows *crianceros* to take possible adaptive management measures; those mentioned in the interviews are: supplementary fodder, pregnancy controls, pre-birthing shearing, daily checks, reduction of the herd, improvement of infrastructure and separation of animals. Nevertheless, the underlying conditions are so precarious they limit possibilities for adjustment. For example, the herds are too small to be reduced in number, and there is a lack of infrastructure for separation of the animals or storage of supplementary fodder. The economic difficulties involved in buying fodder, the problem of storage and the behavioural changes generated in the livestock are all difficulties given by the *crianceros*.

### 3.3.2 Signs given by wild animals

These include signs given by *burrowing parrots* (*Cyanoliseus patagonus*) and *black-faced ibis* (*Theristicus melanopis*) announcing wind. *Black-necked swans* (*Cygnus melancoryphus*)

and *Chilean flamingos* announce cold, and the *upland goose* (*Chloephaga picta*) announces snow. As well as these, the rodent known as *Magellan's tuco-tuco* (*Ctenomys magellanicus*) announces frost when it sings at night. As also found by Serrano-González et al. (2011), wild animals are of great importance in forecasting events which are social in nature and which may bode well or ill, and may be more or less specific (omens). For example, in our study the case of the parrots that announce a *visitor* in a general way, and the Patagonian mocking bird that signifies *company* during the long days of work entailed by the farming lifestyle "... When you are out camping, when you are maybe working on the fences, or getting firewood, and you stay out and spend the night with the goats, they come up close to sing. There are two kinds, one is brown and the other is white. The white one comes up close..." JG-ST.

Amongst the animal ethno-indicators, those which predict more personal circumstances stand out. The *pecho blanco* (*variable hawk*, *Geranoaetus polyosoma*) is a useful bird on the roads; its presence tells you whether you should continue on your journey, in which case it shows you its white chest, or whether you should turn round and go back, when it shows its back, predicting that something bad is going to happen. The *nuco* (*great-horned owl*, *Bubo virginianus magellanicus*) is a bird that comes close to houses to announce *bad news*, with a spine-chilling song. "When it comes to the house it's bad news. When it sings at night. It's been proven. It's not a joke. If the owl comes to screech near your house it's because there is bad news. It has a head like a cat's, ears like a cat, it's barred, brownish. It's so ugly it scares you when you see it..." JG-ST.

The role of birds, particularly owls, as portents has been documented in several areas of the world. For example, the *horned owl* (*Bubo bubo*) is perceived in Asia as a bad omen when it comes close to a house (Bagde and Shampa 2015), and the *southern ground-hornbill* (*Bucorvus leadbeateri*) in South Africa, Zimbabwe and Malawi is considered a bringer or signifier of death/destruction/loss/deprivation when it comes close to a village or homestead (Coetzee et al. 2014). Villagrán et al. (1999) in Chile have highlighted the symbolism associated with birds in the Mapuche cosmovision, where birds represent ancestors, which act as good or bad omens. The *kongkong* or *concón* (*Strix rufipes*), for example, is considered a bad omen (Villagrán et al. 1999). On the other hand, the level of vocalisation of these birds and their prominent physical and behavioural characteristics compared to other species (large eyes, large body size, nocturnal habits) have been associated with the fear or uncertainty these traits produce, hence their classification as bringers of bad news (Silva-Rodríguez et al. 2006; Bezerra et al. 2013; Coetzee et al. 2014; Restrepo and Enríquez 2014).

The most unusual sign is the one that indicates the presence of *stones* (mineral concretions that form in the animals' stomachs), which are found in *guanaco* (*Lama guanicoe*) stomachs. To locals this is a sign that indicates *the population of guanacos is increasing*. In the case of the *avestruz* (*Rhea pennata*), the presence of *charitos* (the local name given to its young) is also a sign of *a growing population* and *good years*. These results agree with Costa Neto (2006) as to the value of signs given by animals as augurs which act as metaphors. In this case, a high abundance of *charitos* would indicate high abundance of other elements of the biota, a symbolic interpretation leading to tranquillity in the face of uncertainty.

## 4 Conclusions

As proposed in our hypothesis, our results show that the populations living in the interior of the Chubut plateau are in constant, multidirectional dialogue with wild and domestic animals and also with the different elements of their natural, social and supernatural

surroundings. But our study mainly revealed the role of non-human actors indirectly involved in livestock management. Animals, particularly birds, are endowed with a soul, with human properties that communicate permanently with livestock farmers. This animistic relationship was described in the Tehuelche (Echeverría Baleta 1998; Hernández 2003) and the Mapuche cosmovisions (Villagrán et al. 1999; Aillapan and Rozzi 2004; Aguas Deumacán and Clavería Pizarro 2009). In both cultures, birds are considered incarnations of ancestors that transmit messages to people.

Our results also show how TEK possessed by rural farmers provides valuable tools for the interpretation and prediction of the future of their herds and fate of their lands. This knowledge enables them to face inclement weather and other unexpected climatic events, as well as environmental and socio-economic change. Although these situations may not represent perfect solutions due to the marginal conditions locals are subject to, they do constitute resilience processes which should be recognised. These signs provide a pool of information that improves livestock farmers' adaptive capacity to cope with recurrent environmental or social changes (Cardoso et al. 2013; Richeri et al. 2013a, b; Reyes-García et al. 2014). These ethno-indicators are crucial, because management of this declining system largely depends on the capacity of farmers to learn by absorbing new information during their livestock farming activities.

Domestic animal ethno-indicators (sheep and goats) provide a greater number of biophysical signs, mainly long-term signs, while wild animals provide mainly short-term ones. The capacity to predict their long-term future so that good decisions can be made is held by the domestic animals, as they give a general overview.

In contrast, wild animals provide finer information, no less important to livestock management and farm life, but more subtle or detailed. As pointed out by Molaes and Ladio (2009), this detailed knowledge could be associated with the longer period of interaction between humans and native resources, in contrast to exotics. This wisdom was established historically and forms part of the farmers' social memory (Ramos and Delrio 2008).

One particularly important result emerging from this work concerns the significance of TEK when it comes to perceiving complex biophysical processes of change, such as desertification, through signs given by domestic animals. As shown in Fig. 2, we can illustrate here, in synthesis, a concept map of the TEK possessed by inhabitants of the Chubut plateau. This summarises the diverse aspects of the livestock perceived as ethno-indicators of drought and lack of food on the land. Included are local measures such as the lowest number of new shoots on the bushes, a decrease in the species preferred by the animals and a decline in *greenery* (*verdín*, the local name used to name annual species considered to be of high value as food for the livestock) in spring. These observations are of great use in forecasting environmental sustainability and making decisions such as lowering livestock density or incorporating new technologies. These ethno-indicators should be included in the indices drawn up by technicians and consultants in the region, given that they would add aspects of the local cosmovision, local solutions and more accurate contextualisation of the Patagonian socio-environmental system.

Finally, our findings show that ethno-indicators can be dynamic and capable of incorporating new actors (i.e. exotic animals), while at the same time maintaining the bulk of the accumulated body of knowledge, in a process of continuity and change. These signs seem to be constantly evolving in response to changing environmental and socio-economic conditions, which supports the idea that changes in traditional knowledge must be seen as a

part of its natural self-organising process (Ladio and Albuquerque 2014; Reyes-García et al. 2014).

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**Compliance with ethical standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

## References

- Abraham, E. M., & Beekman, G. (2006). *Indicadores de la Desertificación para América del Sur*. Mendoza: IICA.
- Aguas Deumacán, W. M., & Clavería Pizarro, N. A. (2009). *Wera Wenu Werken Mensajeras del cielo, Primera edición*. Chile: Lautaro.
- Aigo, J., & Ladio, A. H. (2016). Traditional Mapuche ecological knowledge in Patagonia, Argentina: fishes and other living beings inhabiting continental waters, as a reflection of processes of change. *Journal of Ethnobiology and Ethnomedicine*, 13, 1–17.
- Aillapan, L., & Rozzi, R. (2004). Una etno-ornitología mapuche contemporánea: Poemas alados de los bosques nativos de Chile. *Ornitología Neotropical*, 15, 419–434.
- Albuquerque, U. P., Cunha, L. V. F. C., Lucena, R. F. P., & Alves, R. R. N. A. (2014). *Methods and techniques in ethnobiology and ethnoecology*. New York: Springer.
- Alves, R. R. N., Mendonça, L. E. T., Confessor, M. V., Vieira, W. L. S., & Lopez, L. C. S. (2009). Hunting strategies used in the semi-arid region of northeastern Brazil. *Journal of Ethnobiology and Ethnomedicine*, 5, 12.
- Alves, R. R. N., Neta, R. O. D. S., Trovão, D. M. D. B. M., Barbosa, J. E. D. L., Barros, A. T., & Dias, T. L. P. (2012). Traditional uses of medicinal animals in the semi-arid region of northeastern Brazil. *Journal of Ethnobiology and Ethnomedicine*, 8, 41.
- Alves, R. R. N., Rosa, L., & Santana, G. G. (2007). The role of animal-derived remedies as complementary medicine in Brazil. *BioScience*, 57(11), 949–955.
- Andrade, L. (2002). Territorio y ganadería en la Patagonia Argentina: Desertificación y rentabilidad en la Meseta Central de Santa Cruz. *Economía, Sociedad Y Territorio*, 3(12), 675–706.
- Arenas, P. (2009). *Las aves en la vida de los tobas del oeste de la provincia de Formosa (Argentina)*. Asunción: Tiempo de Historia.
- Ares, J., Beeskow, A. M., Bertiller, M. B., Rostagno, C. M., Irisarri, M. P., Anchorena, J., et al. (1990). Structural and dynamic characteristics of overgrazed lands of northern Patagonia, Argentina. In A. Breymer (Ed.), *Managed grasslands* (pp. 149–175). Amsterdam: Elsevier.
- Bagde, N., & Shampa, J. (2015). Study of traditional man–animal relationship in Chhindwara district of Madhya Pradesh, India. *Journal of Global Biosciences*, 4(2), 1456–1463.
- Bandieri, S. (2005). *Historia de la Patagonia*. Sudamericana: Buenos Aires.
- Barbarán, F. R. (2004). Usos mágicos, medicinales y rituales de la fauna en la Puna del noroeste argentino y sur de Bolivia. *Contribuciones al manejo de vida silvestre en Latinoamérica*, 1(1), 1–26.
- Beeskow, A. M., del Valle, H. F., & Rostagno, C. M. (1987). *Los Sistemas Fisiográficos de la Región Árida y Semiárida de la Provincia de Chubut*. Pto. Madryn: SECYT. Centro Nacional Patagónico.
- Bendini, M., & Steimbregger, N. (2010). Dinámicas territoriales y persistencia campesina: Redefinición de unidades y espacios de trabajo de los crianceros en el norte de la Patagonia. *Revista Transporte y Territorio*, 3, 59–76.
- Bendini, M., Tsakoumagkos, P., & Nogues, C. (2005). Los crianceros trashumantes del Neuquén. In M. Bendini & C. Alemany (Eds.), *Crianceros y chacareros en la Patagonia*. La Colmena: Buenos Aires.
- Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*, 10(5), 1251–1262.
- Bertiller, M. B., Elissalde, N., Rostagno, C. M., & Defosse, G. E. (1995). Environmental patterns and plant distribution along a precipitation gradient in western Patagonia. *Journal of Arid Environments*, 29, 85–97.

- Bezerra, D., Araujo, P., Alves, A., & Alves, R. (2013). Birds and people in semiarid northeastern Brazil: Symbolic and medicinal relationships. *Journal of Ethnobiology and Ethnomedicine*, 9, 3.
- Bisigato, A. J., & Bertiller, M. B. (1997). Grazing effects on patchy dryland vegetation in northern Patagonia. *Journal of Arid Environment*, 36, 639–653.
- Cardoso, M. B., Ladio, A. H., & Lozada, M. (2013). Fuelwood consumption patterns and resilience in two rural communities of the northwest Patagonian steppe. *Argentina. Journal of Arid Environments*, 98(1), 46–152.
- Chebez, J. C., Pardiñas, U., & Teta, P. (2014). *Mamíferos terrestres de la Patagonia, sur de Argentina y Chile*. Vázquez Massini: Buenos Aires.
- Cheli, J. (2016). Efecto de los gradientes de pastoreo ovino sobre la vegetación y el suelo en Península Valdés, Patagonia, Argentina. *Ecología Austral*, 26, 200–211.
- Coetzee, H., Nell, W., & Van Rensburg, L. (2014). An exploration of cultural beliefs and practices across the Southern Ground-Hornbill's range in Africa. *Journal of Ethnobiology and Ethnomedicine*, 10, 28.
- Coronato, F. (2011). *El rol de la ganadería ovina en la construcción del territorio de la Patagonia*. París: AgroParisTech.
- Costa Neto, E. M. (2006). Cricket singing means rain: semiotic meaning of insects in the district of Pedra Branca, Bahia State, northeastern Brazil. *Anais da Academia Brasileira de Ciências*, 78(1), 59–68.
- Delrio, W. M. (2010). *Memorias de expropiación: Sometimiento e incorporación indígena en la Patagonia (1872–1943)*. Primera edición. Bernal: Universidad Nacional de Quilmes.
- Echeverría Baleta, M. (1998). *Vida y Leyendas Tehuelches: Leyendas Mitológicas*. Río Gallegos: Centro gráfico.
- Ejarque, M. (2006). Hacia un estado de la cuestión sobre las representaciones sociales sobre la desertificación. *Acta académica*. <http://www.aacademica.org/000-089/179>. Accessed 20 December 2015.
- Elissalde, N., Buono, G., Escobar, J. M., Nakamatsu, V., Santiago, B., & Llanos, E. (2001). Disponibilidad de forraje para el ganado ovino de los pastizales naturales de las zonas áridas y semiáridas del Chubut. *Sitio Argentino de Producción Animal*. [http://www.produccion-animal.com.ar/produccion\\_y\\_manejo\\_pasturas/pasturas%20naturales/97-chubut.pdf](http://www.produccion-animal.com.ar/produccion_y_manejo_pasturas/pasturas%20naturales/97-chubut.pdf). Accessed 20 December 2015.
- Enríquez, P. L., & Mikkola, H. (1998). Creencias populares sobre los búhos en Centroamérica y África: Un estudio comparativo. *Quercus*, 150, 22–25.
- Enríquez, P. L., & Rangel-Salazar, J. L. (2004). Conocimiento popular sobre los búhos en los alrededores de un bosque húmedo tropical protegido en Costa Rica. *Etnobiología*, 4, 41–53.
- Franco, A. D. (2005). Tenencia de la tierra y servicios públicos: razones de la movilidad poblacional, en aldeas escolares de la provincia de Chubut, República Argentina. *Observatorio Geográfico de América Latina*. <http://observatoriogeograficoamericalatina.org.mx/egal10/Geografiasocioeconomica/Geografiaagraria/06.pdf>. Accessed 20 December 2015.
- Golluscio, R. A., Cavagnaro, F. P., & Valenta, M. D. (2011). Arbustos de la estepa patagónica: ¿adaptados a tolerar la sequía o el pastoreo? *Ecología Austral*, 21, 61–70.
- Hernández, G. B. (2003). Orden cósmico, roles de género y relaciones interétnicas en la mitología tehuelche. *Cuadernos del Sur, Historia*, 32, 195–219.
- Hernandez, J., Campos, C. M., & Borghi, C. E. (2015). Medicinal use of wild fauna by mestizo communities living near San Guillermo Biosphere Reserve (San Juan, Argentina). *Journal of Ethnobiology and Ethnomedicine*, 11, 15.
- ISE. (2006). International society of ethnobiology. *Code of Ethics*. <http://ethnobiology.net/code-of-ethics/>. Accessed 20 December 2015.
- Ladio, A. H., & Albuquerque, U. P. (2014). The concept of hybridization and its contribution to urban ethnobiology. *Ethnobiology and Conservation*, 3, 2.
- Ladio, A. H., & Lozada, M. (2009). Human ecology, ethnobotany and traditional practices in rural populations inhabiting the Monte region: Resilience and ecological knowledge. *Journal of Arid Environments*, 73(2), 222–227.
- Lema, V. S. (2013). Criar y ser criados por las plantas y sus espacios en los Andes Septentrionales de Argentina. In A. Benedetti & J. Tomasi (Eds.), *Espacialidades altoandinas. Nuevos aportes desde la Argentina: Miradas hacia lo local, lo comunitario y lo doméstico* (pp. 301–338). Buenos Aires: Editorial de la Facultad de Filosofía y Letras Universidad de Buenos Aires.
- León, R. J. C., Bran, D., Collantes, M., Paruelo, J., & Soriano, A. (1998). Grandes unidades de vegetación de la Patagonia extra andina. *Ecología Austral*, 8, 125–144.
- Marques, J. G. W. (1999). *Da Gargalhada ao Pranto. Inserção Etnoecologia da Vocalização de Aves em Ecosistemas Rurais de Brasil. Tese*. Brasil: Universidade Estadual de Feira de Santana.
- Martínez, G. J. (2013). Use of fauna in the traditional medicine of native Toba (qom) from the Argentine Gran Chaco region: An ethnozoological and conservationist approach. *Ethnobiology and Conservation*, 2(2), 1–43.

- Medrano, C. (2012). Etnozoología, usos y abusos de los cuestionarios. *Papeles de trabajo - Centro de Estudios Interdisciplinarios en Etnolingüística y Antropología Socio-Cultural*, 23, 59–81.
- Molares, S., & Ladio, A. H. (2009). Ethnobotanical review of the Medicinal Mapuche Flora: Use patterns on a regional scale. *Journal of Ethnopharmacology*, 122, 251–260.
- Mortimore, M. J., & Adams, W. M. (2001). Farmer adaptation, change and “crisis” in the Sahel. *Global Environmental Change*, 11(1), 49–57.
- Nakamatsu, V., Elissalde, N., Buono, G., Escobar, J., Behr, S., & Villa, M. (2013). *Disponibilidad de forraje para el ganado ovino en pastizales naturales de la zona árida y semiárida del Chubut*. Buenos Aires: Ediciones INTA.
- Narosky, T., & Babarskas, M. (2001). *Aves de la Patagonia. Guía para su reconocimiento*. Argentina: Vázquez Mazzini editores.
- Ochoa, J. J., & Ladio, A. H. (2014). Ethnoecology of *Oxalis adenophylla* Gillies ex Hook. & Arn. *Journal of Ethnopharmacology*, 155, 533–543.
- Paruelo, J., Golluscio, R., Jobbágy, E., Canevari, M., & Aguiar, M. (2005). Situación ambiental en la estepa patagónica. In A. Brown, U. Martínez Ortiz, M. Acerbi, & J. Corcuera (Eds.), *La situación ambiental argentina* (pp. 303–313). Buenos Aires: Fundación Vida Silvestre Argentina.
- Pereira de Araujo, H. F., Paiva de Lucena, R. F., & da Silva Mourão, J. (2005). Prenúncio de chuvas pelas aves na percepção de moradores de comunidades rurais no município de soledade-pb, brasil. *Inter-ciencia*, 30(12), 764–769.
- Pérez, L. (2010). *Cautivos, crianceros, criadas y creyentes Pervivencias y cambios en comunidades campesinas Telsen–Chubut 1890–1940*. Dissertation, Argentina: Universidad Nacional de La Pampa.
- Pérez, L. (2012). Tels'en *Una historia social de la Meseta Norte del Chubut Patagonia 1890–1940*. Colección Memoria e identidad, Secretaría de Cultura de la Provincia del Chubut. Rawson: Remitente Patagonia.
- Prates, L. (2009). El uso de recursos por los cazadores-recolectores posthispanicos de Patagonia continental y su importancia arqueológica. *Relaciones de la Sociedad Argentina de Antropología*, 34, 201–229.
- Ramos, A., & Delrio, W. (2008). Corrales de piedra, campos abiertos y pampas de camaruco: Memorias de relacionalidad en la Meseta Central de Chubut. *Memoria Americana*, 16(2), 149–165.
- Restrepo, J. S., & Enríquez, P. L. (2014). Conocimiento popular sobre los búhos en poblaciones rurales del suroccidente de Manizales, Caldas, Colombia. *Etnobiología*, 12, 41–48.
- Reyes-García, V., Aceituno-Mata, L., Calvet-Mir, L., Garnatje, T., Gómez-Baggethun, E., Lastra, J. J., et al. (2014). Resilience of traditional knowledge systems: The case of agricultural knowledge in home gardens of the Iberian Peninsula. *Global Environmental Change*, 24(1), 223–231.
- Richeri, M., Cardoso, B., & Ladio, A. (2013a). Soluciones locales y flexibilidad en el conocimiento ecológico tradicional frente a procesos de cambio ambiental: Estudios de caso en Patagonia. *Ecología Austral*, 23, 184–193.
- Richeri, M., Ladio, A., & Beeskow, A. M. (2013b). Conocimiento tradicional y autosuficiencia: La herbolaria rural en la Meseta Central del Chubut (Argentina). *Blacpma*, 12, 44–58.
- Río + 20. (2012). *Conferencia de las Naciones Unidas sobre el Desarrollo Sostenible*, Río de Janeiro. [http://www.uncsd2012.org/content/documents/778futurewewant\\_spanish.pdf](http://www.uncsd2012.org/content/documents/778futurewewant_spanish.pdf)
- Rivero-Romero, A. D., Moreno-Calles, A. I., Casas, A., Castillo, A., & Camou-Guerrero, A. (2016). Traditional climate knowledge: A case study in a peasant community of Tlaxcala, Mexico. *Journal of Ethnobiology and Ethnomedicine*, 12, 33.
- Rostagno, C. M., & Degorgue, G. (2011). Desert pavements as indicators of soil erosion on aridic soils in north-east Patagonia (Argentina). *Geomorphology*, 134(3–4), 224–231.
- Serrano-González, R., Guerrero, F., & Serrano-Velázquez, R. (2011). Animales medicinales y agoreros entre Tzotziles y Tojolabales. *Estudios Mesoamericanos*, 11, 29–42.
- Silla, R. (2004). *La Cordillera Celosa: Percepción de lo natural y lo sobrenatural de los crianceros del Alto Neuquén (Argentina)*. Ginebra: Sociedad Suiza de Americanistas.
- Silva-Rodríguez, E. A., Ortega-Solís, G. R., & Jiménez, J. E. (2006). Aves silvestres: Actitudes, prácticas y mitos en una localidad rural del sur de Chile. *Boletín Chileno de Ornitología*, 12, 2–14.
- Toledo, V. M., & Barrera-Bassols, N. (2008). *La Memoria Biocultural: la importancia ecológica de las sabidurías tradicionales*. Barcelona: Icaria Editorial.
- Torres, L. M., Abraham, E. M., Montaña, E., & Torres, E. (2005). Las dimensiones socioeconómicas de la desertificación: avances en la utilización de indicadores. Un ejercicio en el caso de Mendoza, Argentina. In C. Morales & S. Parada (Eds.), *Pobreza, desertificación y degradación de los recursos naturales* (pp. 215–234). Santiago de Chile: CEPAL.
- Ulicsni, V., Svanberg, I., & Molnár, Z. (2016). Folk knowledge of invertebrates in Central Europe-folk taxonomy, nomenclature, medicinal and other uses, folklore, and nature conservation. *Journal of Ethnobiology and Ethnomedicine*, 12(1), 47.



- UNCCD. (1994). *United Nations convention to combat desertification in Countries experiencing serious drought and/or desertification, particularly in Africa*. <http://www.unccd.int/Lists/SiteDocumentLibrary/conventionText/conv-eng.pdf>. Accessed 22 February 2017.
- Valipour, A., Plieninger, T., Shakeri, Z., Ghazanfari, H., Namiranian, M., Lexer, M.J. (2014). Traditional silvopastoral management and its effects on forest stand structure in northern Zagros, Iran. *Forest Ecology and Management*, 327(1), 221–230.
- Van Kessel, J., & Enríquez Salas, P. (2002). *Señas y señaleros de la santa tierra agronomía andina*. Iquique: IECTA.
- Vilela, A., Bolkovic, M. L., Carmanchahi, P., Cony, M., de Lamo, D., & Wassner, D. (2009). Past, present and potential uses of native flora and wildlife of the Monte Desert. *Journal of Arid Environments*, 73(2), 238–243.
- Villagra, E. S. (2005). *Does product diversification lead to sustainable development of smallholder production systems in Northern Patagonia, Argentina? Doctoral Dissertation*. Göttingen: Georg-August University.
- Villagrán, C., Villa, R., Hinojosa, L. F., Sanchez, G., Romo, M., Maldonado, A., et al. (1999). Etnozoología Mapuche: Un estudio preliminar. *Revista Chilena de Historia Natural*, 72, 595–627.
- Viveiros de Castro, E. (1996a). Os pronomes cosmológicos e o perspectivismo ameríndio. *Mana*, 2(2), 115–144.
- Viveiros de Castro, E. (1996b). Images of nature and society in Amazonian ethnology. *Annual Review of Anthropology*, 25, 179–200.
- Viveiros de Castro, E. (2002). O nativo relative. *Mana*, 8(1), 113–148.