Human–wildlife conflicts in Patagonia: ranchers' perceptions of guanaco *Lama guanicoe* abundance

Celina Flores, Gabriela Lichtenstein and Adrián Schiavini

Abstract Conflicts between people and wildlife have become widespread as people move to areas previously home to wildlife and as wild populations recover. In Patagonia, one of the main threats to guanaco *Lama guanicoe* conservation is the animosity of sheep ranchers towards the species. As key stakeholders in guanaco conservation we assessed ranchers' perceptions regarding guanaco abundance in Isla Grande de Tierra del Fuego, Argentina. We contrasted these perceptions with estimated guanaco abundance and explored the socio-ecological factors influencing perceptions and how perceptions of overabundance are rooted in contextual factors rather than actual abundance. We performed semi-structured interviews with ranchers from Isla Grande and estimated guanaco abundance independently using density surface modelling. Ranchers were divided into three categories depending on their perception of guanaco abundance: 'too many', 'many' and 'normal'. Those in the 'many' and 'normal' categories perceived guanaco abundance as being similar to actual abundance, whereas those in the category 'too many' overestimated guanaco abundance. The perceived issues affecting livestock production varied between categories, although feral dogs emerged as the main problem. Negative perceptions of the guanaco stemmed from ranchers' beliefs that the species reduces forage availability for livestock, and from their disappointment about the government's handling of concerns regarding livestock production. Greater understanding and integration of the human dimension in conservation are needed to design more inclusive and resilient management plans.

Keywords Feral dogs, guanaco management, grazing competition, human–wildlife conflict, *Lama guanicoe*, perception, population abundance, socio-ecological factors

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Received 21 May 2022. Revision requested 3 August 2022.
Accepted 15 December 2022. First published online 5 June 2023.

The supplementary material for this article is available at doi.org/10.1017/S0030605322001508

Introduction

Human–wildlife conflicts have been defined as 'struggles that emerge when the presence or behaviour of wildlife poses actual or perceived, direct and recurring threats to human interests or needs, leading to disagreements between groups of people and negative impacts on people and/or wildlife' (IUCN, 2020). Human–wildlife conflicts are becoming more frequent, serious and widespread as the human population grows and people move to areas previously home to wildlife (Messmer, 2000; Nicole, 2019). Most studies of such conflicts have been in Africa and North America and include wildlife that poses a direct and recurring threat to the livelihood or safety of people, but there have been few studies involving conflicts as a result of competition for grazing, and even fewer from Latin America.

Several management programmes aim to mitigate stakeholder concerns about perceived wildlife damages (Dickman, 2010; Delibes-Mateos et al., 2011). These approaches often do not achieve long-term solutions because of the assumption that the level of wildlife damage is directly related to the level of conflict (Dickman, 2010; Zimmermann et al., 2020). However, deep-rooted conflicts are shaped by additional factors, resulting in mismatches between perceived and actual wildlife damages (Gillingham & Lee, 2003; Dickman, 2010). For example, referring to native species as pests in their native range derives from social perceptions rather than scientific assessments (Delibes-Mateos et al., 2011). Perceptions are 'the way an individual observes, understands, interprets, and evaluates a referent object, action, experience, individual, policy, or outcome' (Bennett, 2016, p. 4). Such observations are based on the sensory experience of individuals, but the interpretations are socially constructed and related to a myriad of contextual factors (e.g. socio-economic, individual and collective attributes such as gender, beliefs, knowledge about species or previous experiences; Conforti & Cesar Cascelli de Azevedo, 2003; Marchini, 2010). Thus, the perceived and actual level of damage posed by wildlife could differ (Dickman, 2010). The combined assessment of the perceived and actual dimensions of the problem facilitates identification of the underlying cause of a human–wildlife conflict (Gillingham & Lee, 2003).

Ranchers and pastoralists often have a negative perception of large wild herbivores because they believe them to compete with livestock for food (du Toit, 2011). Incursions of wild herbivores into paddocks, attracted by grass regrowth, or the damage to crops intended for livestock, are some of the behaviours that have negative impacts on livestock production (Grigg, 2002; Hegel et al., 2009). However, the major concern is direct competition, as producers prefer that the forage consumed by wild herbivores be available for livestock (Grigg, 2002; Ranglack et al., 2015; Vargas et al., 2021). The usual comparison of the grazing pressure between wild and domestic herbivory (dry sheep equivalent, e.g. one kangaroo consumes the equivalent of 0.7 dry sheep; Grigg, 2002), is rooted in rangeland ecology and explains the recurrence of concerns regarding wild herbivore abundance in the perceptions of ranchers (Grigg, 2002; Hegel et al., 2009; Hernández et al., 2017). Several studies have documented ranchers' claims of overabundant wild herbivores (Grigg, 2002; Hegel et al., 2009; Ranglack et al., 2015; Pozo et al., 2021).

The guanaco *Lama guanicoe* is the widest-ranging wild ungulate in South America and historically the most common large herbivore in the Patagonian steppe (Franklin et al., 1997). Prior to the arrival of Europeans, an estimated 30–50 million guanacos (Raedeke, 1979) provided food, clothes, shelter and medicines for people (De Nigris & Goñalons, 2004; Santiago & Vázquez, 2012). Abundance decreased to 3–7% of the original number as a consequence of land-use change and the negative perceptions of the new settlers regarding the species (Baldi et al., 2016). Extensive sheep-rearing occupied most of the original range of the guanaco, excluding Indigenous people as well as their use of native species (Lichtenstein et al., 2022), in a process similar to that which occurred in Australia with the introduction of sheep (Grigg, 2002). Ranchers viewed the guanaco as an obstacle to livestock production, justifying its legal and illegal hunting (Baldi et al., 2010). Overhunting, land degradation from overstocking and interspecific competition were the main causes of the reduction in guanaco numbers. Since the early 1990s, however, conservation measures have allowed guanaco population numbers to recover (Gonzalez & Acebes, 2016; Lichtenstein et al., 2022). The guanaco is categorized on the IUCN Red List as Least Concern because of its wide continental distribution and the presence of numerous protected areas across its range (IUCN, 2016). However, in three of the five countries where it historically occurred (Paraguay, Bolivia and Peru) it is categorized as Endangered (Baldi et al., 2016).

In Argentina two national management plans for the guanaco have been prepared but neither considered the views of all stakeholders (Lichtenstein et al., 2022). The first plan, in 2006, was agreed by national and provincial authorities, scientists and NGOs but with minimal participation of Patagonian ranchers. Despite this sound, science-based plan, the recovery of the guanaco in a scenario of increasing desertification intensified conflict with the livestock sector, resulting in a new national management plan in 2019 that allowed harvest of individuals. This new plan did not consider scientific expertise, underlying socio-economic conflicts or the heterogeneity of guanaco populations, and exacerbated pre-existing conflicts (Lichtenstein et al., 2022). As with other wild herbivores (Grigg, 2002; Delibes-Mateos et al., 2011; Ranglack et al., 2015), the perception of the guanaco population as overabundant is the origin of guanaco–rancher conflict (Hernández et al., 2017; Vargas et al., 2021). Ranchers believe that the increasing numbers of guanacos harm their livestock through grazing competition (Baldi et al., 2010; Hernández et al., 2017; Vargas et al., 2021). Additional factors (e.g. climate change and socio-political circumstances) also influence the complexity of this conflict (Vargas et al., 2021).

In the Argentinian part of the Isla Grande de Tierra del Fuego (hereafter Isla Grande), sheep production began at the end of the 19th century, using an extensive grazing system that prevails today and depends on natural rangelands (Livraghi, 2011). Between 1910 and the 1990s the sheep stock fell sharply, and a change to cattle rearing began in 1995, driven mainly by sheep losses from predation by feral dogs (Zanini et al., 2008; Schiavini & Narbaiza, 2015). The area of livestock rangelands affected by feral dogs increased from 2% to 69% during 1990–2012, leading to significant economic losses (14% of total income; Schiavini & Narbaiza, 2015). Ranching occupies 42% of the productive area of Isla Grande, overlapping with guanaco habitat (Bonino & Fernandez, 1994).

Although local ranchers are key stakeholders in guanaco conservation, their perceptions of the species have never previously been assessed in Argentina. Here, as guanaco abundance is the principal complaint in the guanaco–rancher conflict (Oliva et al., 2019; Vargas et al., 2021), we assess ranchers' perceptions of guanaco abundance in Isla Grande and contrast these perceptions with estimated guanaco abundances and socio-ecological factors. This approach facilitates an assessment of the complexity of the conflict between large herbivores and ranchers. Most research on human–wildlife conflicts has studied community or producer perceptions of, or attitudes towards, wildlife (e.g. König et al., 2020), or the potential mismatch between reality and perceptions of livestock depredation (e.g. Suryawanshi et al., 2013). However, the difference between the perceived and estimated abundance of the species of concern has rarely been explored, yet could potentially be a practical, evidence-based tool to help policymakers manage and mitigate human–wildlife conflicts and promote co-existence.

Study area

We conducted this study on 28 livestock ranches in the Argentinian part of Isla Grande (48% of all 58 ranches;

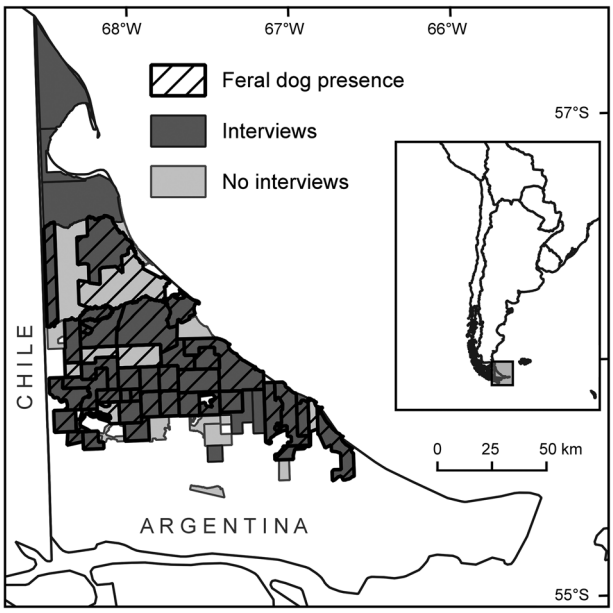

FIG. 1 Locations of the ranches on the Argentinian part of Isla Grande de Tierra del Fuego where the owners or managers were interviewed, and the presence of feral dogs.

Fig. 1). These ranches occupy 34% of Isla Grande and 60% of the area of all ranches. The three ecoregions of Isla Grande are the Magellan Steppe, the Forest–Steppe Ecotone and the Cordillera Mountain Range (Oliva et al., 2001). The Magellan Steppe has a semi-undulating relief with low mountains and glaciofluvial plains. A tussock grassland of *Festuca gracillima* dominates, with sub-shrubbery of *Chiliotrichum diffusum*, heaths of *Empetrum rubrum*, and short grasslands and meadows dominated by *Carex* sp., *Juncus* sp. and *Poa pratensis* (Oliva et al., 2001). The Forest–Steppe Ecotone is a mosaic of grasslands, shrubs and forest, with greater forest cover in the south. The Cordillera Mountain Region is characterized by forests, rivers and elevations up to 1,300 m. Three species of trees are dominant in the forest: *Nothofagus antarctica*, *Nothofagus pumilio* and *Nothofagus betuloides* (Oliva et al., 2001). The climate is temperate cold, with predominantly westerly winds (Oliva et al., 2001), a mean temperature of 4.0 °C (Forest–Steppe Ecotone) and 5.4 °C (Magellan Steppe), and mean annual precipitation of 270–540 mm, increasing southwards.

Methods

Ranchers' perceptions of the guanaco

We conducted semi-structured interviews (Supplementary Material 1) with landowners and/or ranch managers taking management decisions at the ranches (henceforth, 'ranchers') to assess their perceptions of guanaco abundance. We made contact with ranchers firstly through the ranchers' association (Sociedad Rural de Tierra del Fuego) and secondly through personal communication by phone or through ranchers who introduced us to other ranchers. We interviewed 17 ranchers at the National Institute of Agricultural Technology central office during 21 August–3 November 2018 (Supplementary Table 1). We visited 14 ranchers at their ranches or in Rio Grande City during 24 January–4 May 2019. We later communicated further with some ranchers via social media, to clarify some of their answers. Each interview lasted 40–60 min and was recorded and later transcribed by hand. Three interviews were discarded from the analysis. In the first case, the same person was managing two ranches so we retained the interview relating to the ranch where the manager had worked for the longest time. In the second case, two ranch managers worked on the same ranch so we kept the interview from the rancher who had worked for the longest time (21 years versus 6 months). The third interview that we discarded was with a ranch owner who was not aware of most of the issues and only replied to seven of the 13 questions. The final number of interviews analysed was 28 and represents 72% of the livestock ranches associated with the ranchers' association. Interviews comprised questions grouped into three themes: perceptions regarding guanaco abundance on their ranches, the socio-productive context, and the perceived limitations for livestock production.

Estimation of guanaco abundance

We estimated actual guanaco abundance with density surface modelling (Miller et al., 2013), used in previous studies of guanaco abundance (Flores et al., 2018, 2020). This approach links recorded individuals and covariates through a spatially explicit model to explain variability in abundance as well as to make predictions regarding abundance in unsampled areas (Miller et al., 2013).

Surveys were carried out in March 2017, during the late breeding season of guanacos, to facilitate differentiation of adults and calves (the latter known as *chulengos*; Raedeke, 1979). Strip transects (Buckland et al., 2001) were flown, following the main valleys, with the survey design constrained by the flight autonomy of the helicopter (Robinson R44). Flights were at 100 m above ground level at a constant speed of 111 km/h and between 10.00 and 17.00, when guanacos forage on the open rangelands (Raedeke, 1979). The main observer photographed the guanacos. Photographs were georeferenced and each guanaco group was geo-located on each transect using *QGIS 2.14* (QGIS Development Team, 2022).

Transects were 1,400 m wide (700 m each side of the flight trajectory), as previously used by Flores et al. (2018, 2020). The detection probability of guanacos on the transect was assumed to be constant and equal to 1. Following recommendations of Miller et al. (2013), the transects were

divided into segments of 1,400m. The number of adult guanacos per segment was defined as the response variable. Environmental covariates assessed were the geographical location of the centre point of each segment, and its distance to the nearest roads, ranch buildings and permanent water sources.

A generalized additive model was fitted linking the response variable to the explanatory variables. The models were fitted with the Tweedie overdispersion distribution and logarithmic link function. Smoothness selection was performed by restricted maximum likelihood (REML), varying between 3 and 14 knots for the additive model adjustment. To avoid multicollinearity, redundant explanatory variables (with a Spearman's correlation coefficient ≥ 0.7) were analysed in different models. Models were compared following a stepwise forward-selection approach. The model with the lowest Akaike information criterion (AIC) value was selected as the best and was extrapolated to a prediction grid covering the whole study area, comprising cells of the same size as the blocks (following Miller et al., 2013). Each cell holds the environmental covariates included in the best model. The prediction grid excluded cells with a forest surface $\geq 95\%$ (6.5% of the cells). The guanaco abundance per ranch was estimated by adding the number of predicted adult individuals for all the cells that lay within a ranch.

Analysis of perceptions vs actual guanaco numbers

We classified guanaco abundance perceived by ranchers into three categories: 'normal' (e.g. 'they are fine', 'they do not affect us', 'they are not a limiting factor for our production'), 'many' ('quite a few', 'pretty large numbers', 'there should be less', 'we are a bit concerned about their numbers') and 'too many' ('there are a lot', 'there are so many that they caused an economic breakdown').

We plotted the perceived guanaco abundance for each category vs the actual guanaco abundance and the spatial distribution of both the perceived and the actual abundance for each ranch, to explore spatial patterns. Perceived guanaco abundance and any difference from the actual guanaco abundance were modelled as response variables with negative binomial generalized linear models (Agresti, 2003), with the categories of guanaco abundance perceptions being the explanatory variable. We assessed the differences between the categories using β (the change in the response variable for a one-unit increase in the explanatory variable), with a P-value of 0.05 for significance. We analysed the relative frequencies of the answers given by ranchers per perception category. This analysis was done for each of the following themes: the production system, the kind of livestock, the changes in guanaco population, whether the presence of guanacos affected grasslands and/or livestock, the perceived changes in forage availability at the time, the changes to the production system and the reasons given by ranchers for their perceptions. We examined forage availability, stock number and stock density between perception categories using a Kruskal–Wallis test (Siegel & Castellan, 1988). We verified the homoscedasticity of the groups using the Levene test (forage availability, $F = 0.3$, $P = 0.74$; stock number, $F = 0.34$, $P = 0.72$; stock density, $F = 1.81$, $P = 0.19$). We estimated forage availability as the ratio of rangeland surface/total surface of the ranch. We obtained the rangeland surface for each ranch from the Environmental Secretary of Tierra del Fuego Province. We ascertained the number of stock during the interviews and we estimated stock density by dividing these values by the rangeland surface for each ranch.

We analysed the importance among the issues that ranchers perceived to affect livestock production using the Salience Index (S; Sutrop, 2001), an index that combines the frequency of an issue among the answers and the mean position in which the issue has been named:

$$S = F/N \times (\mathrm{mp})$$

where S is the salience of each problem, F is its frequency, N is the total number of interviewed ranchers and (mp) is the mean position of the issue in the list mentioned corresponding to the priority in which it was listed, ordered from more important, with a value equal to 1, to less important, with a value equal to the total number of listed issues. Therefore, the problems ranged from more salient ($S = 1$) to less salient ($S < 1$). We asked ranchers to rank problems according to their relevance. Many ranchers used this opportunity to comment on the role of the government in supporting the livestock sector to deal with human–wildlife conflicts. We recorded any such comments.

Results

Ranchers' perceptions of guanaco abundance

Ranchers estimated guanaco abundance in their ranches to be 35–4,000 adults. Eighty-one per cent of ranchers estimated there were c. $\leq$1,200 adults (Fig. 2). Of the 28 ranchers whose interviews were included in the final analysis, six (21%) perceived the guanaco numbers on their farms (which ranged from 35 to 500 adult guanacos per farm) as 'normal'. Seventeen ranchers (61%) perceived guanaco members as 'many' (53–2,100 adults) and five (18%) perceived them as 'too many' (560–4,000 adults). Perceived guanaco abundance differed significantly between perception categories (Supplementary Fig. 1). The actual abundance estimated for ranches was 34–1,531 adults, with 88% of ranches having $\leq$1,018 adults (Fig. 2). The perceived and actual abundances were similar for most of the ranchers in the 'normal' and 'many' categories (Fig. 2). The greatest differences were in the 'too many'

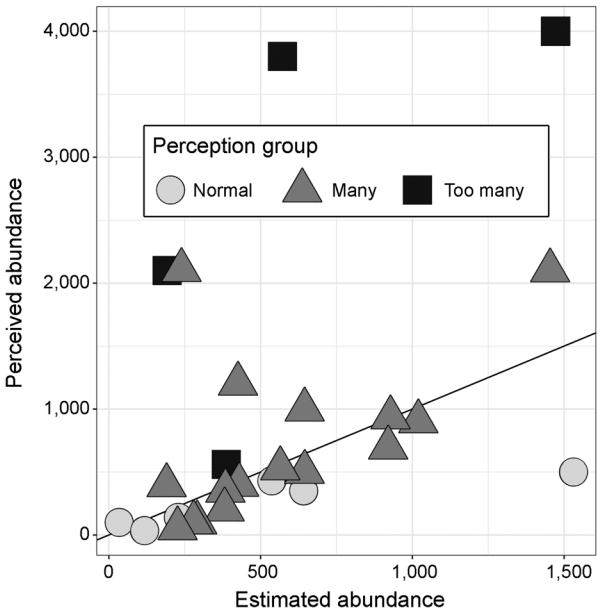

FIG. 2 Relationship between perceived and estimated (i.e. actual) abundance of adult guanacos, by perception category of ranchers (see text for details). The diagonal line represents the isoline where the estimated and perceived values are the same.

category, in which ranchers' perceived guanaco abundances were higher than the actual numbers (Fig. 2, Supplementary Fig. 2). Furthermore, similar actual abundances were perceived differently between ranchers (e.g. actual abundances of c. 250 adult individuals were perceived as either 'normal', 'many' or 'too many'; Fig. 2). This is also illustrated by the spatial distribution of perception categories and estimated guanaco abundance, as there is no evident spatial grouping for perception categories (Fig. 3).

The most common reason for perceiving the abundance of guanacos as 'many' or 'too many' was competition for forage (Fig. 4). Ranchers referred to this competition in various ways: the guanaco eats forage, how many livestock the consumption of forage by the guanaco is equivalent to, or the forage consumed by guanaco being reserved for livestock for the winter (Fig. 4). In contrast, those perceiving abundance as 'normal' recognized that guanacos consume pasture but they did not believe that they compete with livestock (Fig. 4). The reasons given for the latter belief were that the forage reserve is sufficient or that the guanaco is free to move around to seek its food and adapts to what is available; i.e. it is seen as a natural presence in the landscape by ranchers in this perception category (Fig. 4).

Not all ranchers answered all questions; the total number of ranchers in each category who answered a question is included in the following text as 'n', and percentages refer to that total number. Higher per cents of ranchers in the 'many' (82%, n = 17) and 'too many' (100%, n = 4) perception categories than in the 'normal' perception category (33%, n = 6) responded that the abundance of guanacos had increased in the previous 2–20 years. According to the ranchers, this increase was because of the decrease in hunting that had resulted from the legal protection of the guanaco, rural depopulation, decrease of sheep stock and milder winters.

Ranchers' perceptions of guanaco abundance in relation to the socio-ecological context

Livestock production and forage availability Ranches in the study area are a mean of 23,477 ha (4,998–66,173 ha) and have a mean stock density of 0.6 dry sheep equivalent

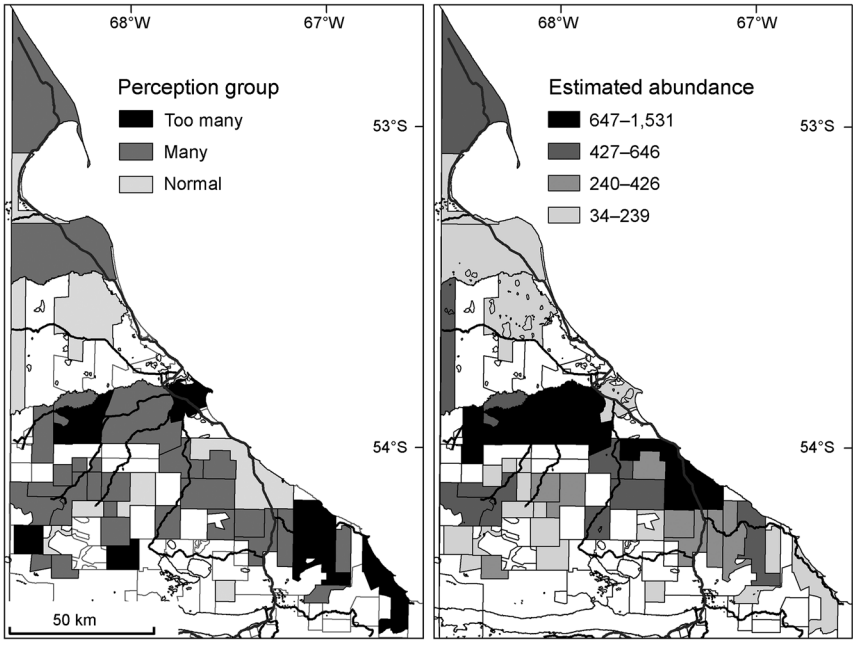

FIG. 3 Distributions of perceived and estimated guanaco abundances for ranches in the Argentinian part of Isla Grande. Estimated guanaco abundance is the sum of the number of adults per ranch. Black lines indicate the road network.

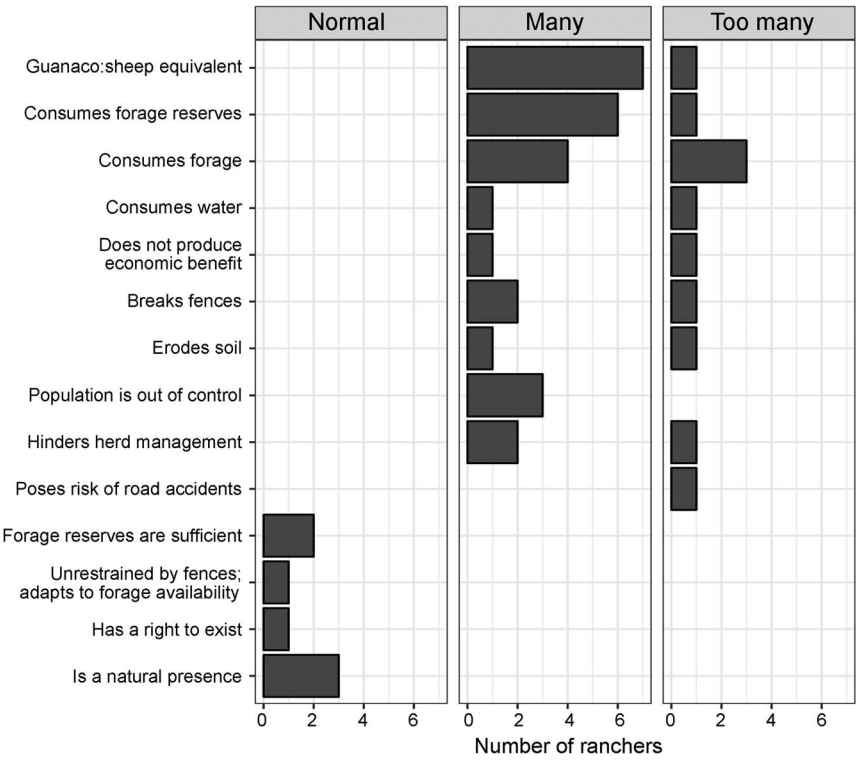

FIG. 4 Reasons given by ranchers for their perceptions of guanaco abundance, by perception category ('normal', 'many', 'too many'; see text for details). Values are the number of ranchers giving each reason. Guanaco:sheep equivalent is a way in which ranchers estimate the number of sheep they could have in the absence of guanacos.

TABLE 1 Reasons given by ranchers on Isla Grande, Patagonia, by perception category (see text for details), for why the presence of the guanaco *Lama guanicoe* affects forage availability. Ranchers could provide more than one reason, which is why some percentages sum to more than 100.

	Perception category		
The presence of the guanaco affects forage availability because of . . .	Too many (%, n = 3)	Many (%, n = 11)	Normal (%, n = 1)
decreasing quantity of forage	100	82	0
invasion by exotic plants offering lower quality forage	33	0	100
decreasing quality of forage	0	18	0

TABLE 2 Reasons given by ranchers on Isla Grande, Patagonia, by perception category (see text for details) for why the presence of the guanaco affects livestock. Ranchers could provide more than one reason, which is why some percentages sum to more than 100.

	Perception category		
The presence of the guanaco affects livestock because of . . .	Too many (%, n = 3)	Many (%, n = 12)	Normal (%, n = 0)
consumption of livestock forage	100	58	0
consumption of the best forage	0	42	0
invasion by exotic plants offering lower quality forage	33	0	0
disease transmission	0	8	0

per ha; one dry sheep equivalent equates to the forage consumed per year by a mature, 45 kg, non-pregnant, non-lactating ewe or wether (castrated male sheep). Most (57%) raise only cattle, 11% only sheep and 32% both cattle and sheep. Most ranchers in the 'many' and 'too many' perception categories perceived the presence of the guanaco to affect livestock (73%, n = 15, and 100%, n = 3, respectively) and grasslands (85%, n = 13, and 66%, n = 3, respectively). The main effect of guanacos was perceived as a decrease in the amount of forage available for livestock (Tables 1 & 2). Examples from the interviews include the following: '[The guanaco] leaves the grassland trimmed . . .'; '. . . affects the

quantity of forage … a meadow should have full grass because there is no livestock there, however it is eaten by the herd living there'.

Neither forage availability on the ranches nor its use for livestock production differed significantly between the perception categories (forage availability, $H = 0.53$, $P = 0.76$; stock number, $H = 2.7$, $P = 0.26$; stock density, $H = 0.5$, $P = 0.78$; Supplementary Fig. 3a–c). However, a high per cent of ranchers in the 'normal' category perceived an increase of forage availability (50%, n = 6), whereas the perception of the 36% (n = 14) of ranchers in the 'many' category was that forage availability had increased or was unchanged. A higher per cent of ranchers in the 'too many' category perceived forage availability as having decreased (60%, n = 5). Droughts were given as the main reason for the decrease in forage availability, with the guanaco as an additional factor (Fig. 5). The main reasons mentioned for the increase in forage availability were the decrease in livestock and the substitution of sheep for cattle, which allows the rangeland to recover because of the less selective feeding behaviour of cattle (Fig. 5).

Production system Most ranchers (80–83% of respondents for the three perception categories) used the winter–summer rotation regime, which is dictated by winter severity and forage availability (Fig. 5). The ranchers use the coldest zones (i.e. those with more snow and ice during winter and with south-facing exposure) during summer. Most ranchers (78%, n = 23) implemented changes to this system, such as rotations and changes of paddock size (100% of the 'too many' perception category, n = 5; 66% of the 'many' perception category, n = 12; and 66% of the 'normal' perception category, n = 6), mainly as a consequence of feral dog predation of their stock (Fig. 5). The ranchers affirmed that feral dogs decreased sheep production and forced the reconversion to cattle production, although cattle are less suited to cold weather than sheep and require changes to the production system in terms of paddock size, paddock allocation and rotation of grazing regimes. All of the ranchers in the 'too many' perception category reared only cattle (n = 5). Sheep-only ranches comprised 6% (n = 17) of the 'many' perception category and 33% of the 'normal' perception category (n = 6). Mixed production was carried out by 41% of ranchers in the 'many' and 33% of those in the 'normal' perception categories, respectively.

Issues regarding livestock production For all perception categories the problem perceived as most significant was the presence of feral dogs (Fig. 6 & Supplementary Table 2). As a consequence, 69% of ranchers had switched from sheep production to cattle rearing, a productive activity in which they had no previous experience and that required significant investments in stock and infrastructure.

The priority given to the guanaco as a problem decreased from the 'too many' through to the 'normal' perception categories (Fig. 6). The high values of salience for the categories 'many' and 'too many' are explained by the high frequency of the answers rather than by the priority given, suggesting that the guanaco is a more generalized concern than a severe one (Supplementary Table 2). Some ranchers did not perceive the guanaco as a significant problem: 'It is important, but the climate seems to be the most

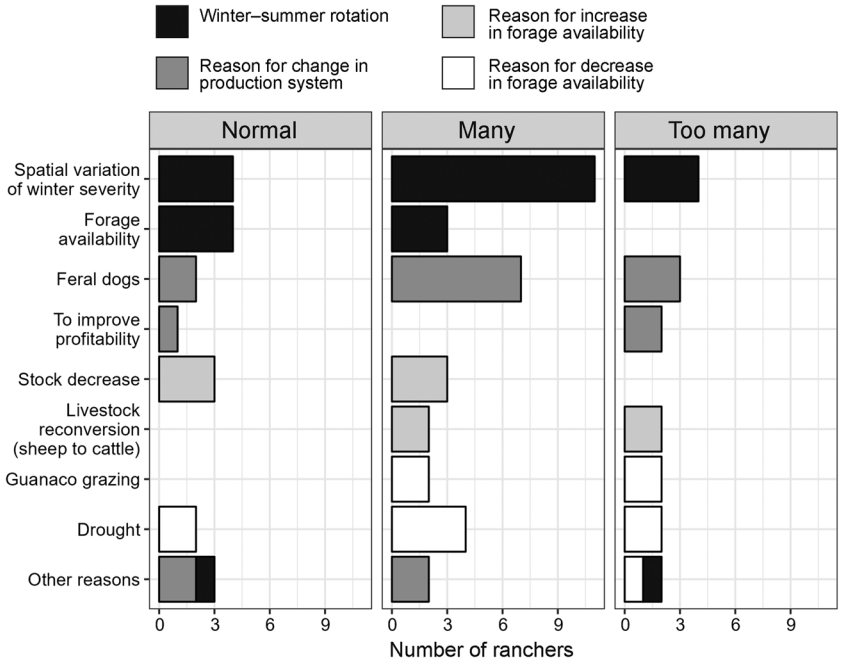

FIG. 5 Reasons given by ranchers for their perceptions regarding the winter–summer rotation system, change in the implementation of the production system, increase in forage availability and decrease in forage availability. Values are the number of ranchers giving each reason.

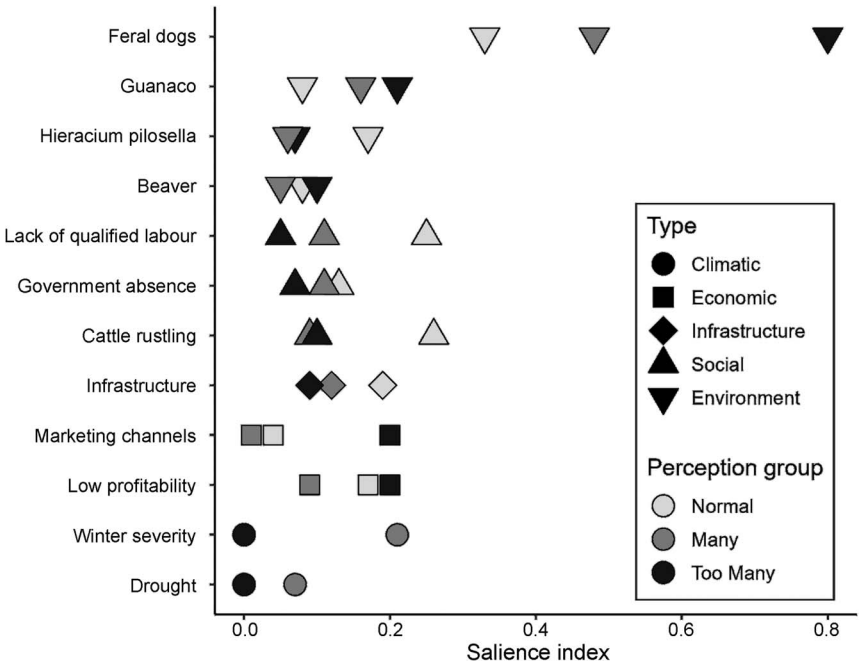

FIG. 6 Salience index (the degree to which some things stand out; the salience of an issue is determined by combining its frequency and mean position in the list in which the issue has been named; see text for details) of perceived issues for livestock production amongst ranchers, by perception category of guanaco abundance ('normal', 'many', 'too many'; see text for details). The salience index ranges from 0 (least salient) to 1 (most salient). *Hieracium pilosella* is an invasive plant species that is not eaten by livestock. Perceived issues by ranchers were grouped into five types: climatic, economic, infrastructure, social and environment. (e.g. winter severity and drought were grouped under climatic).

relevant'; '. . . it is a rangeland issue, but it is manageable'. However, the guanaco was also mentioned as a problem because 'it is present and competition is important', and 'keep in mind that the necessary time to look for a solution would be long'. Regardless of the issues they listed, many ranchers stated that the government neither promoted livestock-sector development nor helped to solve their production problems ('normal': 67%; 'many': 33%; 'too many': 100%).

Discussion

We found that the perceived abundance of the guanaco population may be overestimated as antagonism towards the species increases. Underlying contextual factors such as forage availability and disappointment with the inability of the government to address the problems that ranchers face may contribute to those perceptions. Nevertheless, the prevailing negative perception of the guanaco was driven mainly by the belief that the guanaco competes with livestock for forage.

For ranchers, who are driven by a value-laden perception of forage availability on their lands, competition with guanacos affects how many domestic herbivores a ranch could hold. Range managers traditionally base their livestock production on the receptivity of rangelands; i.e. establishing the number of animals that a range can support at a desirable production level without damaging the range (Kessler, 1994; McLeod, 1997). Assuming that diseases, predators and water availability are controlled, food supply is considered the main limiting factor for livestock production (Oesterheld et al., 1992). Therefore, if the goal of the rancher is to reach an equilibrium between pasture production and livestock requirements, the abundance of wild herbivores would be a concern. Ranchers link the abundance of guanacos to how many livestock could be sustained by the forage that the guanacos consume, disregarding the niche differentiation between wild and domestic herbivores (Marino et al., 2020). The guanaco occupies underused areas or areas inaccessible to livestock (Marino et al., 2020; Marino & Rodríguez, 2022), can digest low-quality vegetation (Engelhardt et al., 1992) and can modify the plants that compose its diet in the presence of cattle (Fernández Pepi et al., 2018). Therefore, consumption of forage by guanacos does not contribute directly to rendering forage unavailable for livestock. Some ranchers in Isla Grande were aware of the ability of the guanaco to exploit a wider range of food resources than livestock and noted that whether guanaco compete with livestock and, if so, the magnitude of such competition should be established by a qualified professional.

The use of resting paddocks (areas where livestock are temporarily removed to let forage recover) by guanacos is another concern of ranchers in terms of perceived grazing competition. Winter is the most critical season in the livestock production cycle and storing forage in winter paddocks is a key strategy for coping with winter forage shortages (Livraghi, 2011). Guanacos can enter empty paddocks that are left ungrazed by sheep during summer to improve regrowth for livestock to consume in winter, which leads to animosity towards the species. Although further studies are needed to assess the grazing pressure of guanacos in resting paddocks, their presence alone does not necessarily mean that grazing competition occurs (Raedeke, 1979). Marino & Rodríguez (2022) suggested that a higher degree of spatial overlap between sheep and guanacos in these paddocks may indicate that the

available food meets the demands of both species, resulting in an absence of competition. This means that the forage consumed by guanacos should not always be understood as an economic loss for ranchers. However, the use of key pastures by wild herbivores has been cited as a cause of conflict between ranchers and wild herbivore conservation in the Chilean part of Isla Grande and in several rangelands globally (Grigg, 2002; Bhatnagar et al., 2006; Doughnac et al., 2017). Management practices to decrease wild herbivore abundances may not resolve such conflict as the negative perceptions of such species have been found to remain even when abundance is low (Grigg, 2002).

According to our results, the perception of the guanaco as a problem relates to actual guanaco abundance: most ranchers were in the 'many' perception category, perceiving abundances to be similar to the actual numbers. However, although guanaco abundance is a driver of the negative perceptions of ranchers, other contextual factors also contribute to antagonism towards the species. The perceptions of ranchers were more negative when forage availability was perceived to be decreasing. Furthermore, guanaco abundance was perceived as 'normal' when forage availability was described as 'enough' or even as increasing. The antagonism towards wild herbivores such as kangaroos *Macropus* spp., the kiang *Equus kiang* and the guanaco is triggered or intensified during shortages of forage availability (Grigg, 2002; Bhatnagar et al., 2006; Vargas et al., 2021). This leads us to predict that antagonism towards wild herbivores may increase when forage availability is reduced as a result of more frequent droughts and climate change.

When local communities depend significantly on available resources, perceptions of the risk posed by wildlife could increase (Bhatia et al., 2020). It is important to assess the extent to which producers believe that decreasing forage availability can be attributed to grazing by wild herbivores rather than to their own livestock management. Ranchers seem to consider they manage rangelands sustainably (Hernández et al., 2017), so external factors such as droughts or wildlife are blamed for decreasing forage availability (Grigg 2002; Vargas et al., 2021). Ranchers on Isla Grande believed that stock decreases and livestock substitutions led to increased forage availability, whereas droughts (in addition to guanacos for the 'too many' perception category) led to decreased forage availability.

On Isla Grande, feral dog predation is perceived as a greater threat to livestock production than forage scarcity, which could explain why the guanaco was perceived as a secondary concern. Free-roaming and feral dogs are an emerging global problem because of their impacts on biodiversity, production systems and health (Gompper, 2014; Soto & Palomares, 2015; Home et al., 2018; Rodríguez et al., 2019; Nayeri et al., 2022). Being supported directly or indirectly by human activity, feral dogs can reach high densities (Gompper, 2014). Their impacts on livestock production systems could threaten the livelihoods of ranchers (Van Bommel & Johnson, 2014), especially on small-scale farms (Montecino-Latorre & San Martín, 2019), contributing to the loss of qualified labourers and the traditional knowledge of sheep production (Schiavini & Narbaiza, 2015).

The negative perceptions of guanacos held by ranchers on Isla Grande could also be influenced by their belief that the government is not providing them with sufficient support to address their livestock production concerns, such as improved marketing channels and infrastructure (e.g. roads), and environmental problems. Ranchers perceived the guanaco as an extra problem they had to face alone, in addition to other problems such as feral dogs. Additionally, the governmental policy of protecting guanacos, including a hunting ban that has been in force since 1993, precludes any action to remedy the perceived increasing guanaco abundance. Therefore, the perceived risk posed by guanaco grazing could have increased for those ranchers who have had to change their livestock production to deal with problems that should have been resolved by the government (e.g. feral dogs). An increased perception of the risk posed by wildlife is expected when trust in the intentions and capabilities of the agency responsible for mitigation is undermined (Bhatia et al., 2020). Faced with a high perception of risk, mismatches between the perceived and actual dimensions of the problem could emerge (Dickman, 2010).

As in other examples of human–wildlife conflict (e.g. Grigg, 2002; Alvarez & Zapata Rios, 2022), the guanaco–rancher conflict on Isla Grande is rooted in factors additional to those framed as the apparent problem. There is a history of unsatisfactory attempts to address these conflicts by the government and accumulated frustration regarding the situation. At such a point, human–wildlife conflicts require conflict resolution approaches that explicitly address the history of disputes and search for common ground among the parties (Zimmermann et al., 2020). A good framework is the adaptive co-managed approach, based on stakeholder engagement (Pozo et al., 2021), allowing the participation of ranchers in decision-making processes. Our study illustrates that detection of a mismatch between perceived and actual wildlife abundances provides a tool to identify such deep-rooted conflicts. This approach could be applied to other human–wildlife conflicts in which the central problem is the perceived species abundance. The integration of research methods from the social and natural sciences could be important for the study of such conflicts, as well as for policymakers, to help them prioritize geographical areas for planned interventions.

In 2021 the IUCN World Conservation Congress voted for resolution WCC-2020-Rec-097. This asks the Argentine government, amongst others, to suspend the implementation of the national management plan for the guanaco

and to draw up a revised national plan, by consensus with all sectors involved and the provinces within the guanaco range, and taking into account scientific management of the species and its conservation status across its national range. The new version of the national guanaco management plan should address the multiple layers of human–wildlife conflict, including the ways in which producers understand and relate to the ecological system. This will enable the bridging of the gaps between science, policymaking and local voices and should help achieve successful conflict resolution.

Acknowledgements We thank Asociación Rural de Tierra del Fuego and Sebastián Cabeza for arranging contact with livestock producers; Instituto Nacional de Tecnología Agropecuaria for support with interviews; Erio Curto and Secretaría de Ambiente, Desarrollo Sostenible y Cambio Climático de la Provincia de Tierra del Fuego, Antártida e Islas del Atlántico Sur, for managing financial support; the Ministerio de Ciencia, Tecnología e Innovación (through project PICT 2016-4301 and the Consejo Federal de Inversiones) for supporting this work; and two anonymous referees and Daniel Beauregard for reviewing the text.

Author contributions Study design, data analysis, writing: all authors; fieldwork: CF.

Competing interests None.

Ethical standards The study was requested originally by the environmental authority of the province of Tierra del Fuego, Antártida e Islas del Atlántico Sur (Secretaría de Ambiente, Desarrollo Sostenible y Cambio Climático), who approved the research strategy. Ranchers consented to participate in the interviews whilst maintaining their anonymity. Field activities did not include the capture or handling of animals, and the research otherwise abided by the *Oryx* guidelines on ethical standards.

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