Vicuñas (*Vicugna vicugna*), Wild Andean Altiplano Camelids: *Multiple Valuation for Their Sustainable Use and Biocultural Role in Local Communities*

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ABSTRACT In these case studies, vicuñas are presented as biocultural components of the Andean altiplano's socioecological landscape. The environmental history of vicuñas is related to the multiple values of the species, especially of its appreciated fiber as a nature contribution to people. Vicuñas were in risk of extinction, but thanks to conservation policies, the engagement of local communities, and the efforts of scientists and naturalists, this species has recovered to an extent than allows sustainable, community-based management via chakus, a traditional method involving the capture and release of wild vicuñas to harvest their fiber. We describe two cases where the VICAM research team (former MACS) was summoned by local institutions in Cieneguillas and Santa Catalina, both localities belonging to the Pozuelos UNESCO MAB Biosphere Reserve in Jujuy, Argentina. The process to launch and maintain the sustainable use of vicuñas is presented, focusing on the emerging challenges, dilemmas, and conflicts that shaped decision-making processes. The obstacle that seemed the most challenging beforehand—the capture itself and its biological consequences for the animals—was overcome with the development of adaptive management. Vicuña management has great potential for the sustainable development of indigenous peoples and local communities, but achieving this goal is a process ridden with difficulties, including the commercial interests of non-Andean actors. For vicuña management to become a driver of sustainable local development, a series of challenges must be overcome: power asymmetries between local communities and other stakeholders due to the monistic economic valuation of vicuña fiber, the incorporation of relational values with strict welfare protocols recognizing vicuñas as sentient beings, and the intrinsic valuation of the ecological role of the species, also considering their indisputable position as Andean ancestral biocultural heritage. KEYWORDS Vicuñas, South American camelids, sustainable use

INTRODUCTION

The vicuña (*Vicugna vicugna*; figure 1) is a wild South American camelid (SAC), the smallest member of the Camelidae family, which includes three other SACs—the wild guanaco (*Lama guanicoe*) and the domesticated llama (*Lama glama*) and alpaca (*Vicugna pacos*), the Old World humped dromedary (*Camelus dromedarius*), and Bactrian camel (*Camelus bactrianus*). Vicuñas live in the semidesert, high-altitude (>3,500 masl) Andean steppes of the *puna* or *altiplano* region of Perú, Bolivia, Chile, and Argentina.

SACs present multiple contributions to people and interactions with diverse stakeholders of Andean and extra-Andean societies, as has been described in a recent paper by Vilá and Arzamendia [1]. Vicuñas and guanacos (*Lama guanicoe*) are the only wild ungulates in Latin America that can be sustainably "harvested" through fiber shearing [2] in a nonconsumptive way, with minimal impact to the animals' welfare.

Vicuñas have been instrumentally valued—that is, as a source of services and benefits that nature provides to human beings, as a "means to an end," sensu Arias Arevalo et al. [3]—since the early peopling of South America. The close relationship between vicuñas and people initiated when hunter-gatherer groups arrived at the Andes

Case Studies in the Environment, 2020, pps. 1–14. electronic ISSN 2473-9510. DOI: https://doi.org/10.1525/cse.2020.1232692.

FIGURE 1. Vicuñas (bachelor group) in Santa Catalina area.

over 11,000 years ago, and they used this animal as a source of food, fur, fiber, bones, and dung [4]. Wild vicuñas were also one of the main biocultural components in the evolution of Andean civilizations. For example, the Tahuantinsuyu, or Inca Empire, placed a high economic and symbolic value on vicuña fiber and incorporated vicuña management policies into the imperial economic governance system [5]. Only a few selected women—"virgins of the sun"—were authorized to spin and weave vicuña textiles and garments, typically ponchos or uncus worn by the Inca elite as a symbol of their power and prestige [6]. The few textiles that survive today in museums are of extraordinary beauty, demonstrating the exquisite craftsmanship and care that went into their making.

Pre-Hispanic peoples developed a technique to capture wild vicuñas, the chaku, which consisted of people walking with ropes to drive thousands of vicuñas into large stone corrals where their ultrafine fiber was sheared and a few individuals were culled [7]. Vicuña chakus had great ceremonial significance and in some cases could even include the participation and leadership of the Inca[1] [5, 8]. Vicuñas were not immune to the impact of the Spanish conquest, since their precious fiber was renowned for its quality and soon became a highly demanded commodity in Europe. The vicuña population suffered dramatic losses due to massive hunting, first by the implementation of chakus with killings and later with the use of firearms. Their skins were exported to Europe and indigenous peoples also paid taxes to Spaniards using vicuñas skins, among other factors that drove intensified hunting. The exports legally registered in the Port of Buenos Aires shipped to European destinations averaged 20,000 skins annually during the eighteenth century. The killing had reached such magnitude that the Spanish Crown dictated a "Real Cedula" (Royal Law) in 1777 forbidding "the Indians to kill the vicuñas under any circumstance at those hunts, either voluntarily or under order of their priests or corregidores," and vicuñas were declared personal property of the King of Spain [4]. Two leaders of the South American independence process, Bolivar and Belgrano, dictated regulations for the conservation of vicuñas [9–11]. During Republican times, the killing and export of vicuña skins and fiber continued [5]. At the onset of the twentieth century, the explorer and biodiversity researcher Holmberg warned about their possible extinction [4], which almost became a reality in the mid-century when the global vicuña population in the Andes was calculated in less than 10,000 individuals [12]. The reasons behind this process were the high price of vicuña fleece and increasing demands for this product in the international luxury market, which promoted poaching. Several actors intervened to save the vicuñas at the international scale: The Convention for the Conservation and Management of the Vicuña in 1969 (also known as the Vicuña Convention) was signed by the governments of Bolivia, Peru, Chile, Argentina, and later, Ecuador; CITES classified vicuñas within its Appendix I in 1975; and from 1982 to 1994 vicuñas were classified as a Vulnerable Species in the International Union for Conservation of Nature (IUCN) Red list. Bolivia, Peru, Chile, and Argentina passed national laws to protect the species,

1. The term *Inca* also refers to the monarch or emperor of the Tahuantinsuyu.

declared conservation zones, and established sanctions for poachers. At the local level, the commitment of Andean communities as guardians of the vicuñas was fundamental for conservation, as well as the development of scientific research and education programs.

After many decades of effective conservation, several vicuña populations were recovered, leading to the species' reclassification as "LEAST CONCERN" [13, 14]. Today, the global Andean vicuña population is estimated at 500,000 animals. Andean countries have developed management plans to manage vicuñas and obtain the fiber in the only authorized way by CITES, that is, "by shearing of live animals" in a "neo-chaku" scheme that integrates pre-Hispanic capture techniques with modern animal welfare protocols.

At present, several vicuña populations of Peru, Bolivia, Northern Chile, and Argentina are live-shorn through neo-chakus, including both wild management and captive projects. Acebes and colleagues [13] have estimated that nearly 60% of all vicunas in Peruvian territory are undergoing live-shearing schemes.

The intrinsic value of the species—as "an end in itself," sensu Arias Arevalo et al. [3]—is based in its unique physiological, morphological, ecological, and ethological adaptations to their high-altitude, semidesert habitat [15, 16]. Vicuñas are the foremost wild ungulates in high-altitude grasslands of South America, with several hematological (smaller elliptic red cells and greater number by volume), digestive (extra retention in the pseudo rumen, highly efficient use of physiological water), and anatomic (fiber, amble step, higher ligaments in the legs, and padded feet) adaptations, among others (compiled in [17]). Their reproductive system includes events with a marked seasonality, synchronizing the increased energy demands for gestation and breastfeeding with the pasture growing season (also wet season). Calves weigh 10% of their mothers' weight. Vicuña groups hold year-round territories, with males defending both these areas and females [15, 16]. Despite being a polygynous species with aggressive males, vicuñas do not show sexual dimorphism as expected [18]. It is a very interesting life form, a mammal adapted to life in a harsh environment that has been saved from extinction [15].

The relational value of the species—the importance attributed to meaningful relations and responsibilities between humans and between humans and nature, sensu Arias Arevalo et al. [3]—initiated in prehistoric times. The depictions of vicuñas in rock art bear witness to their significance in Andean ideology and could be the origin of the symbolism of this species as "herd of the gods" [19]. In Inca times, the use of this sacred animal followed strict rules of sustainability. Vicuñas have a prominent role in the worldview of indigenous people and local communities (IPLC), were they are considered to have a direct relationship with the gods. They are even under the protection of their own divine shepherd, Coquena, who guards them against poachers [20]. Aymara and Quechua ethnic communities hold this animal in high respect and have cultural taboos in place against its killing, although it is already forbidden by law. Vicuñas have inspired numerous artists and they are the subject of many legends, poems, and songs. In terms of Noss's classic classification [21], vicuñas are a flagship species, a charismatic symbol of the altiplano landscape and culture, as well as a symbol of the capacity of recovering from near extinction. Vicuñas are also an "umbrella species" [22], meaning that if they are provided with a sufficiently protected and adequately large habitat area, this protection would extend to other species.

As explained above, vicuñas have one of the finest natural fibers in the world (mean thickness: 12 microns), and their destiny, circumstances, and incidents have been mostly driven by the use and demand for their fiber, which under the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services framework [23] can be considered a nature contribution to people (Category 13).

The vicuña's fine fiber has intrinsic value as a biological adaptation to living in a cold environment, with very wide daily temperature ranges (up to 30°C). Due to its fineness, vicuña fiber also has an extraordinary instrumental value for the textile industry, where a garment woven from vicuña fleece can reach a price of 20,000 euros (*Wall Street Journal*). In a Parisian textile fair, the price of vicuña fleece ranges between 399 and 600 USD/kg, compared to 75–85 USD for cashmere and 5–6 USD for sheep wool [24].

However, it was mainly their relational value that rescued the species from near extinction. In its Article 1, the Vicuña Convention recognizes that "the conservation of vicuñas constitutes an alternative of economic production for the benefit of the Andean people and [the Parties] commit to its gradual use, under strict control of the State" (translation by the authors). This article establishes a clear value relation between the use of the animals and

its beneficiaries, rooted in ethnicity and geographical belonging. Thus, by formally declaring the relational value of vicuñas, Article 1 of the Vicuña Convention constrains the development of extra-Andean projects involving these animals, which are only based on the instrumental value of vicuña fiber. The Vicuña Convention also involves other relational values, such as the adoption of the IUCN SCC GECS (International Union for Conservation of Nature, Species Survival Commission, Grupo Especialistas en Camélidos Sudamericanos, SAC Specialist Group) welfare protocols for vicuñas, based on the consideration of all animals as sentient beings [25]. This has prompted the development of new recommendations to the Parties, some of which are politically relevant and have been integrated into national legislation. These welfare measures include partial shearing, so that the animals have enough fiber left on the chest and abdomen to overcome thermal stress and the non-use of drugs or preventive medicines to maintain wild strength.

The sustainable use of vicuñas via neo-chaku techniques has great potential to boost economic growth and social development among the local people, who live in a resource-poor area [26, 27]. However, the market analysis conducted by Kasterine and Lichtenstein [28] showed that only 2–6% of the garment retail price actually reaches altiplano communities.

Poaching is still occurring today, posing a great risk for the species [29]. The high market value of the fiber has inspired several "creative" ways to obtain a similar material from sources other than Andean vicuñas. The fertile paco-vicuñas are hybrids between vicuñas and alpacas (i.e., the domestic derivation of vicuña) and, due to their hybrid nature, are not subject to conservation policies and restrictions placed on the capture of wild species, allowing them to be shipped to other countries. Another mechanism devised to circumvent these restrictions is to implant vicuña embryos in llama surrogate mothers, then move the llama out of the altiplano. The newborn vicuña would be owned by the llama owner, who can be located anywhere in the world. We have strongly opposed these projects with considerable success, via expert reports [30] and our participation in meetings and workshops, but we must always be vigilant.

Large luxury textile companies have also bought massive stretches of land in the altiplano of Peru and the province of Catamarca, Argentina. In both countries, these companies received permission by the local government to share the vicuñas, so in this case instead of mere buyers, who could potentially drive local communities to sustainably manage vicuña populations, these large companies are also producers. The way in which the companies have managed the animals has not complied with the GECS welfare recommendations, specially the provision regarding partial shearing. The Vicuña Convention has issued several resolutions on the matter, pointing out noncompliance of the convention's core principles.

CASE EXAMINATION: SUSTAINABLE USE OF VICUÑAS IN CIENEGUILLAS AND SANTA CATALINA, JUJUY, ARGENTINA

In this work, we are going to present two successive case studies regarding projects carried out in two nearby altiplano towns located within the limits of the Pozuelos UNESCO MAB Biosphere Reserve in the province Jujuy, Argentina: Cieneguillas (2000–2006) and Santa Catalina (2007–present). The development of these projects and the involvement of our research team, VICAM (former MACS), was prompted by request from local institutions.

Cieneguillas (65° 52′W, 22° 06′S) and Santa Catalina (66° 03′W 21° 56′) are both small towns in the Andean altiplano of Jujuy, NW Argentina, in the Argentina-Bolivia border. They are located within the Pozuelos UNESCO-MAB Biosphere Reserve, at 3,700–4,000 masl. The Reserve extends over an endorheic basin that encompasses a central depression and a permanent lake—the core area of the Reserve—flanked by two north-to-south ridges. The Reserve is part of the initiative that aims to generate socioeconomic development compatible with conservation (UNESCO-MAB Biosphere Reserve Directory). Both towns are situated in morpho-dynamic environments: the Western and Eastern sierras, piedmont, and paleo-lake, which constitutes the buffer area of the Reserve, where pastoral activities are allowed [31]. Founded in the seventeenth century, Cieneguillas and Santa Catalina consist mainly of adobe (dried mud) houses clustered around a historical heritage church. Both concentrate the administrative, political, sanitary, commercial, religious, festive, and educational functions in the northern and eastern areas of the Reserve, including an elementary and a high school. The main rural activity in the area is the herding of sheep and llama on natural vegetation, to produce fiber, skins, and meat. Governmental aid programs also constitute a significant source of income for many households.

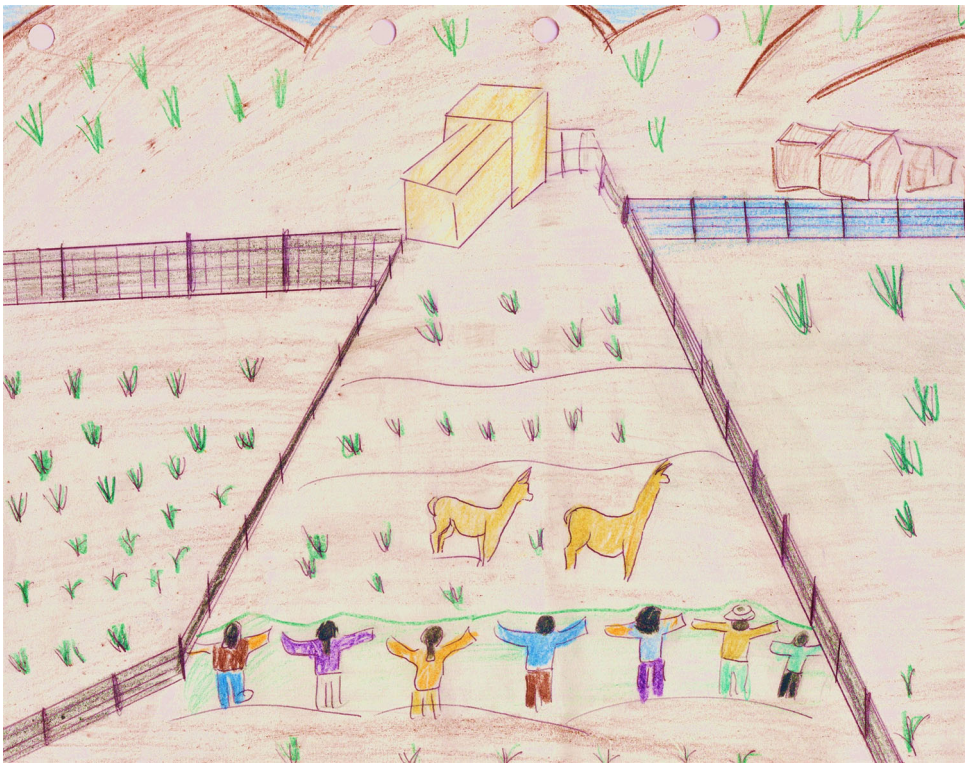

FIGURE 2. Drawing from a girl in Cieneguillas showing the capture.

Local climatic conditions are cold, dry, and with a wide diurnal temperature range due to the high altitude and low moisture content of the air. Average annual temperature is 7.7°C and the mean annual precipitation is 375 mm, concentrated primarily in the summer [32]. The Pozuelos Reserve is part of the Puna Ecoregion, specifically the Semiarid Puna Complex [33], formerly phytogeographically classified as Dry Puna [34, 35], where the dominant plant formation is shrub-steppe with patches of grasslands and wetlands [36].

Stakeholders:

(1) VICAM (former MACS) group: We are a research group dedicated to the conservation and sustainable management of vicuñas, other camelids, and the environment, initiated by the behavioral ecology research on vicuñas undertaken by Dr. Vila in 1985. In 2000, a group or researchers became the Argentinean partner of the MACs project (an INCO-DEV-Eu project), and in 2007, several of them—us included—founded the VICAM (Vicuñas, camelids, and environment) research group.

Since the beginning of VICAM's history, we have been convinced of the need to incorporate IPLC participation in our projects, which drove us to start intercultural ethnobiological dialogues, especially with the local school communities [37–40].

(2) Local institutions: "Los Pioneros de Cieneguillas" Association (Los Pioneros) and Santa Catalina Cooperative of Agro-livestock Producers (COOPASAC). They are both self-organized groups of Andean livestock producers (llamas and sheep). Both institutions own the land where they work.

(3) Schools and University: Our project has an important educational component in both towns. The children and teachers participate as observers of vicuña management activities and are involved with the species in an experiential way (figure 2).

In Santa Catalina, the management plan also involves university students. To date, we have trained over 150 students of the National Universities of Jujuy and Luján in vicuña management and handling techniques.

(4) Governmental authorities: Since Argentina is a federal country, each province has the custody of wildlife. At the time when the Cieneguillas project was developed, this custody was exercised by the Provincial Director of Environment and Natural Resources or DPMAyRN. Later on, this office was promoted to ministry status and constituted the Provincial Ministry of Environment of Jujuy, under whose authority the Santa Catalina project was conducted. In 2009, the Provincial government passed a law for the management of vicuñas, based in part on policy recommendations developed by VICAM [22], which was enacted and regulated in 2014.
(5) Funders: The Cieneguillas project was part of an EU INCO-DEV (MACs) project, and all fieldwork expenses were covered. A black polyethylene net (2 kms long) and poles to build a corral were purchased. The Santa Catalina project was carried out with subsidies from the Argentinean science and technology system, and the equipment purchased for the MACs project, particularly the nets, was reused. The professionals did not get paid to do the work since they are employed as researchers by the national science and technology system, who pays their salaries.
(6) Participants: In both cases, the participants in the chaku were local people, several of them belonging to indigenous communities (approximately 200 individuals). University students were recruited by VICAM researchers who were also faculty members at the university to participate in the chaku as trainees in environmental sciences.

Process

The first modern vicuña chaku in Argentina was performed in 2003 in Cieneguillas by our research team and local people, in collaboration with Chilean colleagues who had previous expertise in wild animal captures and animal welfare [41–44].

Precapture in Cieneguillas

A BOTTOM-UP INITIATIVE: The project in Cieneguillas was born by requirement from the Association Los Pioneros, who called one of the researchers and invited her to the field to observe what they perceived to be an excessive quantity of vicuñas—for which they had no use—grazing in their lands. This was presented as a serious (relational) problem that needed a solution. The challenge was to transform the local view of this situation as a problem and turn it into that of an opportunity [45] by bringing focus to the instrumental value of the species as well as its relational value. We decided to start the project by conducting a vicuña population study in 2001. The area was approximately 10,000 ha large and had the vicuña density was 12 individuals/km^2, a density sufficiently high to allow for a chaku to take place [46].

In March 2002, a cooperation agreement was signed between Los Pioneros and the MACS project and supporting documents were prepared to declare Cieneguillas a "town of vicuña guardians." The National House of Representatives declared this officially through Order 481, file 3072-D-02. A specific program for environmental education was launched and the school community decided to rename themselves as "Escuela Puna Argentina" (Argentinean Puna school). MACS project also signed an agreement with the Provincial Secretary of Natural Resources and Environment. In September 2002, a meeting was held in Cieneguillas to cocreate (Pioneros-MACS) the Management Plan to submit for governmental approval, which was passed under Resolution No. 038/2003, 130/2004, and 203/2005 of DPMAyRN. The provincial government also granted Los Pioneros the ownership of 80% of the fiber obtained, while the remaining 20% was earmarked to fund upscaling of this initiative to other communities (Resolution 146/2003).

Precapture in Santa Catalina

The Santa Catalina Agro-livestock Cooperative (COOPASAC) was founded with the purpose of promoting cooperative work among local farmers to breed llamas and sheep and manage vicuñas, as well as to facilitate the commercialization of derived products. The chairman of COOPASAC met with Dr. Arzamendia at her place of work in the University of Jujuy to discuss the Cooperative's concerns, and again, the research team responded to this demand by proposing a bottom-up scheme for local development. In 2010, VICAM researchers surveyed the vicuña population in COOPASAC's lands, finding a vicuña density of 14 individuals/km^2, and assessed other

environmental and social factors to put together a management plan that was submitted to the authorities for approval. The first vicuña capture took place in 2012. New legislation had reduced the percentage of fiber withheld by local authorities to 10% (by new laws), while the rest could be handled directly by COOPASAC. We are still working with this cooperative today.

The main challenge faced by our team was to ensure that the capture of vicuñas was made in compliance with high standards of animal welfare. The relational value between our work and its consequences for the vicuña populations was one of the main concerns within our research group. We felt a great sense of responsibility for the outcomes of our project, which was translated into the development of a protocol of adaptive management. Adaptive wildlife management (AWM) seeks to improve the integration of science and management by focusing decision making on hypothesis testing and structuring management actions as field experiments [47]. Our AWM included an assessment to evaluate the management effects on the vicuñas and other environmental impacts [22, 41, 42]. We were convinced that if the local communities can perceive benefits from the vicuña fiber trade, the instrumental value of the species would save them.

As is the case when pursuing any sustainability goal, our work involved balancing trade-offs between efficiency—for example, to capture the vicuñas and obtain the fiber—and constraints—for example, partial shearing (only the back and the flanks) to protect the animals from thermal stress. In this case, multiple values are at stake: the instrumental value that drives the obtention of the fiber, as well as the intrinsic and relational values involved in taking care of the sentient animal and ensuring long-term sustainability.

Captures

We developed a technique that proved to be safe for the animals and the people involved that can be summarized in several steps (figure 3).

We captured a total of 965 vicuñas, 478 in Cieneguillas and 487 in Santa Catalina. The methods used guaranteed animal welfare, with only one death occurring in 2004. Postcapture sampling also showed that the vicuñas population recovered their precapture demographic parameters and behaviors. Birth rates and mortality among the control (noncaptured) and shorn vicuñas were similar; both showed a consistent population increase trend that reached a stable density [46]. The capture did not affect the size and composition of social groups. The behavioral changes documented among managed animals were of equivalent magnitude to seasonal and other changes driven by stochastic events, such as drought, observed in the control group.

The estimated annual survival rate was 97% and it remained constant in time, suggesting that capturing and shearing vicuñas under strict animal welfare protocols did not significantly increase total annual mortality [48, 49].

The instrumental results of the captures are shown in table 1.

As can be observed in table 1, not all animals were sheared. Animals that (a) were under 1 year of age, (b) were in poor physical condition, (c) were females in an advanced state of pregnancy, and (d) whose fiber were under 3 cm long (due to shearing in previous years) were excluded. Vicuñas need at least 2 years between successive shearing to allow their fiber to regrow to sufficient lengths. We obtained an average of 207.2 g per shorn individual, indicating that 5 animals are needed to get a kilogram of fiber. The market value for vicuña fiber is variable and depends on a fixed price set by a few textile companies. Over the past few years, it has decreased to less than 400 dollars/kg [28]. In view of the great drought that affected the region between 2015 and 2017, the COOPASAC and VICAM agreed not to capture vicuñas during that period.

Costs of the Activity

The costs of the capture can be categorized into (a) infrastructure (corral, nets, poles, ropes, tape, wires, construction tools, and among other supplies), (b) consumables (food, photography, medicines, sampling and veterinary supplies, and fuel), (c) travel expenses, and (d) expenses of support personnel, including daily wages for the assembly of the funnel and the corral and shearing. In 2003, we conducted a study to estimate these costs and evaluate the economic sustainability of the activity. At that time, the cost was estimated at 11,500 USD, of which most was spent in purchasing the nets used to drive vicuñas into the corral. In 2018, the cost of the neo-chaku was 3,000 USD, since the nets were reused.

Postcapture Situations

In Cieneguillas, a serious conflict arose between Los Pioneros and the provincial government. Under the terms of

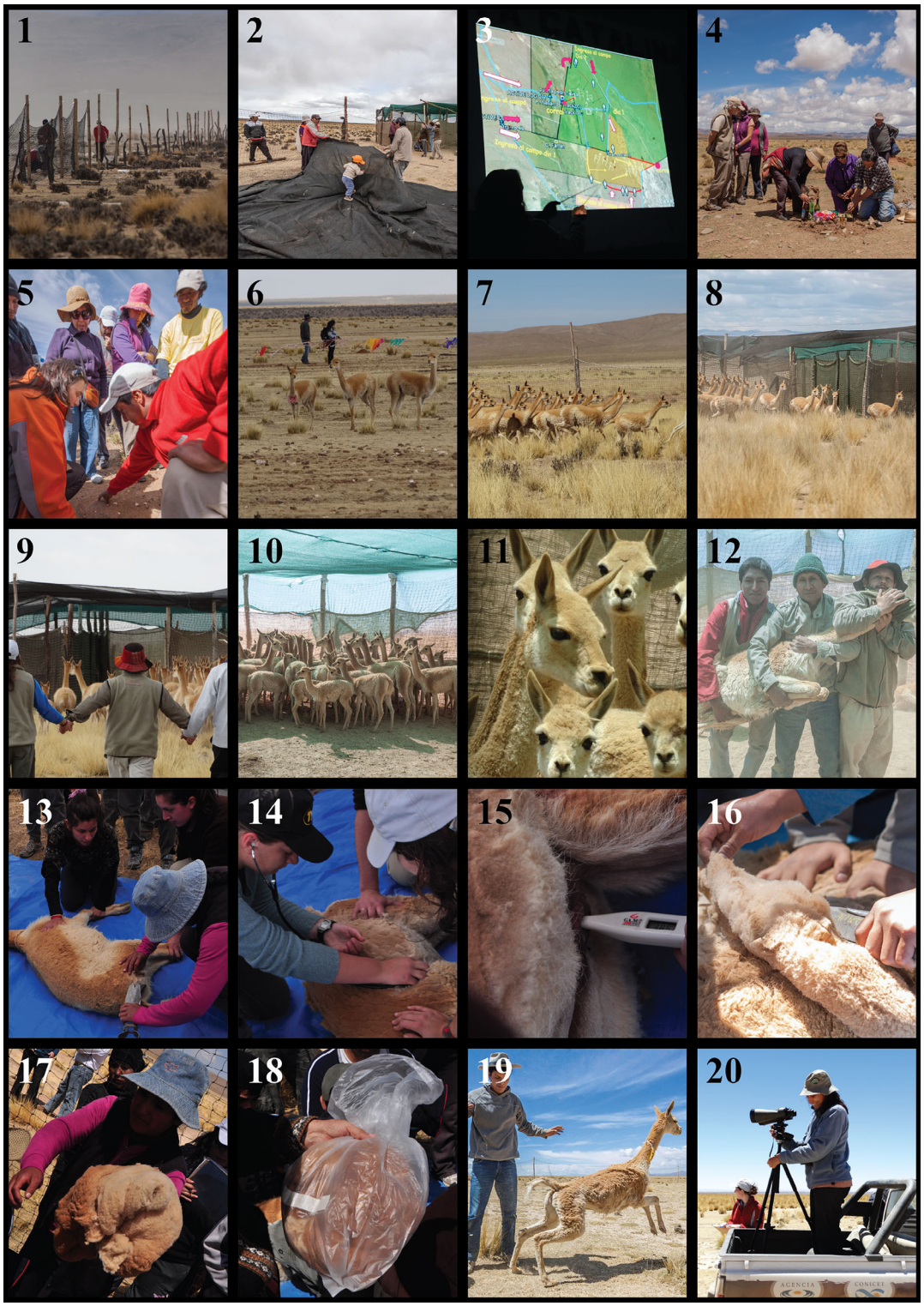

FIGURE 3. Steps in the chaku process: 1. Construction of the funnel. 2. Construction of the corral. 3. Meeting with maps to discuss capture technique. 4. Chayada: Relational value, ceremony to ask the Pachamama to help with the capture of her creatures. 5. Last minute scientific-local dialogue to fine-tune the last details of the capture strategy. 6. Walking slowly driving the vicuñas to the funnel. 7. Vicuñas in the funnel. 8. Vicuñas near the corral. 9. Pushing vicuñas into the corral. 10. Vicuñas in the corral. 11. Trapped vicuñas. 12. Taking vicuñas from the corral to the shearing area. 13. Local woman shearer starting her job. 14. Controlling physiological parameters. 15. Taking temperature. 16. Getting the fleece. 17. Individual fleece. 18. Packing the fleece. 19. Vicuña back to the wild. Postcapture studies.

TABLE 1. Instrumental (in fiber weight) Results of the Captures.

Place	Year	Date	Captured Vicuñas	Sheared Vicuñas	Weight of Fiber Obtained (g)
Cieneguillas	2003	May 23–25	43	—	—
	2003	November 7–9	114	75	16,303
	2004	November 18–21	168	129	27,492
	2005	November 18–19	153	117	23,325
	Total	2003–2005	478	321	67,120
Santa Catalina	2012	November 19–20	106	54	10,339
	2013	November 16–17	146	56	12,516
	2014	November 15–16	164	55	10,093
	2018	November 17–18	71	36	8,077
	Total	2012–2014/2018	487	201	41,025
Total			965	522	108,145

provincial Resolution No. 146/2003, Los Pioneros were authorized to sell the fiber obtained from the neo-chaku through a public tender with the Provincial Direction of Environment and Natural Resources acting as overseer. As explained above, 20% of the proceeds were to be allocated to the management, investigation and protection of vicuñas, and escalation of the experience to other communities in the Jujuy altiplano. These funds were to be directed to and managed by the Wildlife Protection and Promotion Fund within the framework of provincial Act 3014/73 and its regulatory Decree 5096. Through a letter dated July 22, 2006, Los Pioneros addressed the environmental authorities of the Jujuy Province, stating that they would implement a system of their own devising, similar to a public bidding, setting the base price and notifying no fewer than five potential bidders via email. They also requested to keep the funds allocated to the Wildlife Protection and Promotion Fund, because it was considered "excessive and contrary to the interests of the producers," claiming that the captures were "a private activity of Andean inhabitants in the use of a renewable natural resource" and that "there was no outlay by the State to justify this percentage," not recognizing that this 80–20% distribution of funds was settled in the precapture agreement signed by all parties. Moreover, the Pioneros had already benefited from extensive support provided by different governments, including MACS funds and free assistance by professionals employed by the national science system. The governmental authorities responded by saying that "by original domain, the vicuñas, their products, by-products, and derivatives (art. 124 of the National Constitution) correspond to the Provincial State," due to which the sale of the fiber should be carried out through the allowed contracting mechanisms for governmental affairs (File 646-292/2006, page 6). This conflict has escalated to legal proceedings and, as of November 2020, the fiber has yet to be sold. Due to the almost 15 years passed since its procurement, the fiber has lost its properties—thus, its market value—and its existence has not been inspected by the authorities.

In Santa Catalina, the postcapture situation was not conflicting, although the community is suffering the risks and uncertainties that affect all pastoralist societies around the world. Currently, fewer people are choosing to remain in the rural Andean Altiplano, a local realization of a worldwide pastoralist situation. The pastoralist way of life is extremely vulnerable to global changes [50], as demonstrated by the decrease of pastoralist populations from 10% to 1.5% of the global population over the past five decades [51]. COOPASAC members are getting old, but the youngest members of their families are not interested in rural life. Most of them have emigrated away from the altiplano.

We are still working with COOPASAC, and although we have successfully reinstated the ancient practice of vicuña chakus, which appeared to be the greatest challenge when we began our collaboration, the most serious obstacle that COOPASAC faced was the nightmarish bureaucracy involved in selling the fiber. To state just one example, COOPASAC representatives traveled to the city of Buenos Aires, over 2,000 km from Santa Catalina, to apply for authorization from the Ministry of

Environment to sell the fiber. Once in the Ministry offices, they were asked for a document that had not been listed in the application requirements and they were not allowed to file the application. COOPASAC had previously attempted to conduct a project to weave vicuña fiber garments in collaboration with artisans from the province of Catamarca, where they faced similar bureaucratic barriers to the interprovincial transfer of fiber and garments.

Due to the reasons described above, the final aim of selling the vicuña fiber was either not achieved or only achieved partially. However, participation in the chakus contributed to increase local awareness of the great potential that this technique holds for the development of local communities, which has significantly reduced negative perceptions of and conflicts with these wild animals. As expressed by the president of COOPASAC, "the cooperative and all its members are at a time when we want to live in balance with the vicuñas. It has been my turn to learn from vicuñas, to stop thinking that they harm us, [to realize] that they are a productive resource."

We are planning to evaluate the challenges and opportunities in using vicuña fiber in a noncommodity way, considering its value not only in instrumental but also in cultural terms. To this end, we have just received funding to support a pilot experience of weaving a vicuña shawl by a local artisan using fiber purchased from COOPASAC. The overall purpose will be to obtain a detailed record of all procedures involved, including the weaver's attitudes and feelings, in a co-constructed data collection process including (but not limited to) the weight of the fiber before and after washing and dehairing, to calculate net yield; the amount of time invested in spinning the yarn, knitting, and conditioning the garment; and the experience, feelings, and attitudes of the weaver. This pilot experience will allow us to evaluate production costs and expected returns to assess the feasibility of promoting local artisanal production of high-quality vicuña fiber garments that can be sold at a fair price and with a "sustainable" label.

In terms of capacity building, these experiences in Cieneguillas and Santa Catalina had a component of environmental education, as well as training in practical vicuña management, including capture and handling skills, using published material in an accessible language, which provide resources and autonomy to the people who participate, whether locals or university students. In the words of three of the participant students:

RJ (female):

I consider that this experience that took place in the first years of my training as a biologist was a hinge instance, in which I was able to understand that [the study of] biology cannot be carried out without a serious social commitment where two factors are put in tension: our role as biologists, which has a great conservationist imprint, and the real application of a practice, which requires the incorporation of a social perspective that also considers the objectives of local people.

AV (male):

Those who study biology love to do fieldwork (. . .) any opportunity as students is a delight, it is an enormous joy that they bring you, the teacher who knows more and has more experience than you . . . and also you know that you are not going to take risks or get lost, and have new experiences in places you did not know. So, it is important to participate because there are many students who are not aware of the biodiversity of the province and the richness of the ecosystems, participating in these trips is being face to face with biodiversity . . . It is not the same to hear about vicuñas than to be there and see them. There are people like me, who were born in the puna [altiplano], and sometimes I don't have the opportunity to return to my place of origin, to my birthplace, and it is always nice to reconnect with the land where one comes from and to remember things that we sometimes forget in the city . . . . Things that grandparents tell you, and although they seem like stories and myths, they have an important value when it comes to being in the field (. . .) So all those things come together, biology, anthropology, ethnozoology, the Andean worldview and obviously respect for nature (. . .) It helps us to know each other more personally, as fellow students . . . Spending all those days together brings us closer and helps us to know each other, through the good and the bad . . . And we share and compare things that are mutual knowledge . . . .

AC (female):

I consider it an enriching experience in both theoretical and practical learning, because by taking the previous courses taught by VICAM professors and researchers, we are prepared and oriented for the field work to be carried out. During all the years that I have participated in the captures, I have always observed the responsibility, dedication and training on animal welfare by the teachers who always gave me confidence. I particularly consider that it is a unique experience and of great

value, [where we] manage to establish links with the inhabitants, colleagues, teachers and professionals.

In the current conditions, trading vicuña fiber as a commodity for international textile companies does not generate the desired income for local communities. As described in a paper by Lichtenstein [52], the value chain is perversely constructed and reinforces overwhelming disparities in political and economic power between local indigenous communities and the luxury textile industry, who has extensive lobbying capacity. This situation highlights the critical role of governance in reducing asymmetries and guaranteeing fair trade, which must be grounded in sound scientific research. One example of how basic scientific research can be policy-relevant and prescriptive for sustainable management is provided by the Guidelines for Conservation and Sustainable Use of Vicuñas in Jujuy [22]. This book synthesizes the results of many years of research on vicuñas and the environment in the Jujuy altiplano, including a perspective on their relational values, and has been used as the main document to regulate the current Provincial Law No. 5634–09, on Conservation and Sustainable Management of the Vicuña (Regulatory Decree No. 5175–14). This legislation positioned Jujuy and Argentina as the first country to incorporate a detailed protocol on animal welfare management for the species.

The capture of vicuñas in the Andes is widespread, with fluctuating degrees of success in terms of sustainability goals [13]. We can assume that increased poverty associated with the COVID-19 pandemic, acting synergistically with the low prices paid by the textile industry to local producers, will intensify vicuña poaching. One way to respond to this threat is engaging the local Andean people in a dialogue using a plural valuation framework, including several components that are easy to identify: Vicuñas are considered part of the salqa ("natural," "untamed"), they are protected by Coquena and the Pachamama (mother Earth), and their fleece can be sold at high prices using sustainable capture methods.

DISCUSSION AND CONCLUSION

The case studies presented show the potential for being a "model" in conservation through nonconsumptive, sustainable use of wildlife [26] is real and feasible. This project offers a way to reduce conflicts over pastures and reduce poverty among IPLCs. This is one of the few successful stories of a wild species recovering from extinction in a way that allows its sustainable use. The activity also had a very important impact on the students of the University of Jujuy. VICAM's project "Learning sustainability with vicuñas in the Andes" targeted to university students received the Highly Commended recognition of the International Green Gowns award of the UN Environment in the "Student Engagement" category, because the project encouraged and facilitated the involvement of students in working with native animals and ancestral techniques with an intercultural knowledge dialogue.

In order to attain long-term relevance, in situ vicuñas conservation through sustainable use must generate real observable economic and social development in the altiplano and integrate IPLC values and attitudes. Sahley et al. [27] noted that, although live-shearing by indigenous communities could make vicuñas the "ultimate" ecofriendly, wild animal product for the high-end fashion industry, intricate bureaucracy and poorly constructed legislation acted as barriers for peasant communities to participate in the chain of production and commercialize their fiber in Perú. Also, as Lichtenstein [52] has pointed out, the asymmetries in the relationship between IPLC and the luxury textile fiber markets greatly restrict the IPLCs' possibilities to overcome these limitations. Our two case studies are in line with these observations.

Here, we have presented two actual experiences of collaborative work between scientific conservation practitioners and local institutions to develop chakus, a traditional practice of capturing and live shearing of the wild Andean vicuña. At the beginning, we thought that the main challenge to the development of sustainable vicuña fiber procurement projects would be the capture of the animals and their return to nature, shorn but in good health and strong enough to overcome thermal stress. However, it was the socioeconomic variables that turned out to be the most critical factors in achieving successful results. The monistic economic value of the fiber as main driver of the process—including the disparities in telecouplings between the underdeveloped Andean communities and the wealthiest people in the world—was the most serious obstacle to success.

Multiple stakeholders in a plural valuation scheme that includes the worldviews of the locals must establish a different way for valuing and selling the fiber. The local authorities must have a prominent role in this process by facilitating the paperwork and providing support for the communities.

A spectrum of "green buyers" in wealthy countries exists that can afford to pay premium prices for consumer goods to contribute to the conservation and sustainability of the production system. These environmentally and socially conscious consumers are not just concerned about the monistic economic value of the purchased items but are also mindful of the relational and intrinsic values involved in the extraction of raw materials and the manufacturing of the product. It is clearly impossible to approach conservation successfully without an integrated plural valuation. These remarkable experiences with this beautiful animal species show that the economic power of the large textile companies and a complex market chain are not helping the sustainable development of the communities in the Altiplano. However, the existence of frames of thought that integrate multiple values is very encouraging, in terms of the possibilities they offer to empower the local people who share their daily existence with vicuñas. At the end of the day, without the raw fiber, there is no such thing as a luxury vicuña garment.

CASE STUDY QUESTIONS

1. In how many different ways can vicuñas be valued?
2. Vicuñas were on the verge of extinction. How is this related to the multiple valuation of the species?
3. Why is intercultural dialogue necessary to work with vicuñas? What does each partner contribute?
4. Do the vicuñas have enough intrinsic values to justify conservation efforts?
5. Is the fiber of vicuñas a blessing or a curse?
6. The pre-Hispanic chakus ended in 1700, neo-chakus began recently. Do these communities have an "ancestral memory" of these practices or do they have to be relearned?
7. What should a multiple valuation assessment be like to achieve sustainability in vicuña use?
8. How can imbalances of power between vicuñas fiber producers and buyers be controlled?
9. Are animal welfare protocols important when assessing the quality and value of fiber?
10. What environmental, biological, and social factors must be taken into account when deciding if a capture should take place?
11. In a climate change scenario, how would the answers to the previous questions differ?

AUTHOR CONTRIBUTIONS

Dr. Bibiana Vilá is the head of the VICAM research group. Co-author on conceptualization, methodology, original draft, review, and editing.

Dr. Yanina Arzamendia was responsible for the vicuña chakus. Co-author on conceptualization, methodology, original draft, review, and editing.

Dr. Veronica Rojo was the co-author of the management plan. Co-author on conceptualization, methodology, original draft, review, and editing.

The three authors work with the animals and the communities in the design of the vicuña management plans and collaborated equally in the writing and editing of this article.

ACKNOWLEDGMENTS

We want to thank our VICAM colleagues, Jorge Baldo, Gisela Marcoppido, Juan Atan, Ana Wawrzyck, Celeste Samec, Marcelo Morales, Mariela Borgnia, Malena Pirola, and Hugo Yacobaccio, as well as others who participated in the capture events. We are grateful to the Cieneguillas and Santa Catalina communities. We also appreciate the support of the students and authorities of the National University of Jujuy.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

FUNDING

The field work was funded by 2001–2005 INCO-DEV Shared Cost RTD Sustainable economic utilization of wild SACs: Strategies for improving rural productivity in pastoral communities in Latin America. MACS. 2005-9. Multi-year Research Project (PIP)-Conicet 6284 and 962. PICT Bicentennial. 2011–2014. VICUS: Vicuñas, Conservation, and Sustainable Use. Agency for Scientific and Technological Promotion. Secyt. Science and Technology Ministry (2010–0306). Ministry of Science, Technology and Productive Innovation Grant for Planning an experimental capture and shearing of vicuñas in Santa Catalina: Researchers and residents in a joint

project. Resolution 018/13. 2014–2017 PICT: Vicuñas in Jujuy: An interdisciplinary approach. Research, Conservation and Management. Agency for Scientific and Technological Promotion. Secyt. Ministry of Science and Technology (PICT-2013-0479). Midori Prize for Biodiversity (2014), Argentina's National Research Council (CONICET) and PUE-INECOA CONICET UNJU Project (N°22920170100027CO).

SUPPLEMENTAL MATERIAL

We enclosed the Handbook (manual) for local management of vicuñas (in Spanish, in PDF format), video of the capture (VOB video file), and artistic expressions involving vicuñas by Andean children (image JPG files).

AUTHORS' NOTE

All the photographs belong to VICAM research group and were taken in Santa Catalina. Extracted from [49].

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