Agricultural Systems 184 (2020) 102861

Contents lists available at ScienceDirect

Agricultural Systems

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

Reconciliation of cattle ranching with biodiversity and social inclusion objectives in large private properties in Paraguay and collective indigenous lands in Bolivia

Lilian Painter[a,b,*], Rodolfo Nallar[b], Maria del Carmen Fleytas[c], Oscar Loayza[b], Ariel Reinaga[b], Laura Villalba[c]

[a] Yale School of Forestry and Environmental Studies, USA
[b] Wildlife Conservation Society, Bolivia
[c] Wildlife Conservation Society, Paraguay

ARTICLE INFO

Keywords:
Sustainable ranching
Indigenous lands
Deforestation
Wildlife conflict
Sustainable development goals

ABSTRACT

Livestock ranching is one of the most important economic activities of the planet but is also associated with negative environmental impacts. Ranching can also exacerbate social inequality by displacing vulnerable rural populations from access to land and decisions over land use. The large-scale ranching typical of the Paraguayan Chaco, and the small scale ranching typical of northwestern Bolivia, represent two contrasting cases of livestock expansion in Latin America. These two distinct contexts are used to evaluate best practices for sustainable ranching at different scales. In particular, how ranching practices can contribute to achieving the Sustainable Development Goals. Technical assistance was provided to both the large private ranchers as well as to the indigenous communities focusing on pasture cultivation and management, recovery of native pastures, rotational grazing, improved fire management through the use of burn calendars and no burn zones. The success of these interventions in reducing forest loss was measured by evaluating the increase in carrying capacity, considered synonymous with stocking rates in Paraguay and hrough measurement of above green matter. Success in improving animal health and reproductive output was monitored through interviews and periodic blood and fecal sample analysis. Interviews were also carried out to evaluate mitigation of conflicts between carnivores and livestock. The impact of interventions to promote participation and equity was evaluated using complementarity of planning instruments with indigenous territorial plans and indigenous population size.

Intensification of agricultural production, this is increasing productivity rates through more efficient gazing management per unit of land already in use as an alternative to horizontal land use expansion, helped reduce forest loss both in areas managed by large private ranchers as well as those managed by small scale indigenous ranchers, and contributed to the achievement of SDG 15. In the case of Paraguay improved ranching practices that minimize environmental impacts while increasing profitability of production, have enabled positive results for conservation but, the limited progress in the recognition of indigenous territorial rights and more recent development of territorial planning capacity at the municipal level are obstacles to achieving greater co-benefits for social equity (SDG 10). Indigenous territorial rights and territorial management capacity in the Leco and T'simane Mosetene indigenous lands reduce inequality (SDG 10) by empowering indigenous small-scale ranchers, and securing their equal access to land and natural resources. Clear land allowed them to implement conservation and sustainable ranching plans leading to improved productivity relevant for SDG 2 and also enabled them to leverage respect and support for their territorial management vision from protected area and municipal authorities.

The impact of improved ranching practices with large private ranchers resulted in greater impacts on the reduction of forest loss (SDG 15) but impacts on social inclusion (SDG 10) were only achieved in Bolivia due to the existence of indigenous territorial capacity.

* Corresponding author at: Wildlife Conservation Society, Bolivia, Calle Gabino Villanueva No 340, La Paz, Bolivia.
E-mail address: lpainter@wcs.org (L. Painter).

https://doi.org/10.1016/j.agsy.2020.102861
Received 18 July 2017; Received in revised form 2 January 2019; Accepted 14 May 2020

Table 1
Summary of Impact of Different Contexts on supporting relevant SDGs.

Context	SDG 15	SDG 2	SDG 10
Large ranches, high technological input, access to market.	Reduced deforestation over larger area	Improved management for large number of cattle	N/A
Small indigenous community low technological input context	Reduced deforestation over smaller areas	Improved productivity for a small number of cattle	Indigenous territorial rights and territorial management capacity. Numerous indigenous population.

1. Introduction

Livestock ranching is one of the most important economic activities of the planet, moving in excess of a trillion dollars annually and generating 1.5 billion jobs (Thornton, 2010). Globally, it is also one of the fastest growing economic activities and accounts for 50–80% of the global Gross Domestic Product (GDP) of the agriculture sector, which itself represents 4% worldwide (World Bank, 2016). The growing demand for meat and its derivatives and the consequent increase in the number of heads of livestock worldwide is due to the increase in human population, wealth and urbanization (Thornton, 2010). Yet ranching is associated with negative environmental impacts including biodiversity loss, wildlife-cattle conflicts, deforestation, fires, soil degradation, loss of water quality and quantity, and greenhouse gas emissions. Ranching can also exacerbate social inequality by displacing vulnerable rural populations from access to land, natural resources and ecosystem services, and by excluding their interests from being taken into account in land use decisions. Across Latin America, ranching spreads and intensifies as human populations growth, roads are improved, and meat consumption rises.

South America is one of the regions with the largest beef production and livestock densities in the world, and represents close to 25% of global beef production (FAO, 2016). The Chaco and Bohas regions in Western Paraguay and Santa Cruz Department in Bolivia have the highest deforestation rates in the world linked to agricultural expansion, including cattle ranching (Hansen et al., 2013). In order to achieve a sustainable economic development, it is necessary to adapt local production systems through an environmentally sustainable approach. The large-scale ranching typical of the Paraguayan Chaco, and the small scale ranching typical of northwestern Bolivia, represent the archetypal patterns of livestock expansion in Latin America.

The Paraguayan economy is highly dependent of the agricultural sector, which contributes with 30.4% of the gross domestic product. Cattle ranching generates around 40% of Paraguay exports of primary products, and employs more than 40% of the labor force in the country (Banco Central del Paraguay, 2014). At present there are more than 123,000 cattle ranchers and 13.2 million heads of cattle, or two animals per person in Paraguay (World Bank, 2016) and projections from the Rural Association of Paraguay estimate 20 million heads of cattle by 2020. On the other hand, in Bolivia the agricultural sector grew by close to 44% since 2004 (UDAPE, 2015), largely related to the production of animal feed for the cattle industry. At present, the agricultural sector in Bolivia represents 15% of the GDP (Gross Domestic Product), employs about 50% of the Active Economic Population (AEP) and is accountable for approximately 4% of the country's exports (INE, 2017). Outside of Santa Cruz and Beni departments cattle ranching in Bolivia is largely carried out by small scale indigenous producers (UDAPE, 2015). This is the case in Northern La Paz where the Lecos, Tacana and T'simane Mosetene indigenous people carry out extensive cattle ranching, increasingly as a result of government development projects.

Because of their distinct contexts these provide an ideal setting in which to qualitatively evaluate best practices for sustainable ranching at different scales. In particular, how ranching practices can contribute to achieving the Sustainable Development Goals. Firstly, by evaluating if ranching practices can result in reduced forest loss, and therefore contribute to the achievement of SDG 15 on reducing land degradation and biodiversity loss, since forest cover is critical for conserving biodiversity in the Amazon (provides habitat for 80% of the world's terrestrial biodiversity (Potapov et al., 2016). Secondly, if improved ranching practices can contribute to achieving SDG 10 by taking steps to promote the participation of vulnerable indigenous populations in governance platforms to guide sustainable development and finally if improved ranching can contribute to SDG 2 on ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture. Or in other words, do improved ranching practices in these two contexts result in different contributions to the SDGs? This study is qualitative and is lacking in statistical measurements of these differences or the impacts because of the limited sample size in each case but clear qualitative trends are reported. For a summary of the impact of different contexts on the role of sustainable ranching on supporting relevant SDGs see Table 1.

2. Methods

2.1. Study areas

In Paraguay, research was carried out in the northern part of the Gran Chaco, a vast plain which is the second-largest ecoregion in South America after the Amazon, spanning northern Argentina, southeastern Bolivia, northwestern Paraguay, and a portion of the Brazilian states of Mato Grosso and Mato Grosso do Sul. This wooded grassland is the second-largest eco-region in South America after the Amazon (Riveros, 2014). Activities to improve cattle ranching practices were carried out with six large ranches which all have more than 500 herds of cattle, and three of which have more than 10,000. These six ranches cover 84.440 ha and their operations can be differentiated from those of smaller ranchers by the genetic management of the herd, engagement along the meat commercial chain, sanitation practices required to access markets and capital investments based on business plans (WCS Paraguay and WCS Bolivia, 2016). These practices enable large producers to access 61% of the total market share. In Paraguay, modern meat processing plants and veterinary controls meet national and international standards and supply is geared mostly for export. Nevertheless, despite these commercially high standards business practices in general do not address biodiversity and environmental conservation concerns, leading to high rates of forest loss, soil degradation and also retaliatory killing of jaguar as a result of predation of cattle.

In Bolivia, we focused on two indigenous territories of Northern La Paz department found where the Andean foothills meet the Amazon lowlands in an area of global conservation importance. In a context of low technological development indigenous communities have smaller sized herds, from less than 10 to 300 per community, poor animal health management, poor soil management, make extensive use of native grasslands and clear forest through slash and burn to open new grassland areas. Both the Lecos Apolo and T'simane Mosetene indigenous lands have been recognized by the Bolivian Plurinational State as collective property of the indigenous communities represented by their respective territorial organizations.

The Lecos Apolo indigenous land is found over 530,426 ha in a forest, natural and anthropogenic savannah matrix (Killeen et al., 2005) around 1500 m.a.s.l. Cattle ranching in this region was first carried out within the Franciscan missions from the late 15th Century and has

continued as an important activity in the Apolo region led by local non-indigenous elites and employing indigenous people as laborers. Historical poor management of natural grasslands and forests caused degradation of pasture, soil, watersheds and loss of forest cover.

The Pilon Lajas Indigenous Territory and Biosphere Reserve covers 400,000 ha in a forested area neighboring the Beni grasslands at 250–400 m.a.s.l. The eastern boarder of the indigenous land neighbors a road which was opened up in the early 1970s and which has served as access for colonization to the lowlands of Northern La Paz. A cycle of local poverty and degradation began with extraction of valuable timber by urban elites followed by slash and burn agriculture and finally to pastures due to poor soil management.

In response to increasing national urban demand for meat and poverty reduction goals, the Bolivian government is promoting cattle ranching amongst rural communities and as a result Lecos and T'simane Mosetene indigenous people are increasingly engaged with cattle ranching although it is carried out in a manner characterized by its inefficiency, low technological input, and links limited to local markets (Ministerio de Desarrollo Rural y Tierras, 2014). In the case of both indigenous groups government programs have provided breeding animals to improve the genetic characteristics of the local herds, grass seeds and barbed wire to build corrals. Unfortunately, without technical support these government programs can increase environmental degradation and fail to provide the intended social benefits. Map 1 presents the location of the study areas in both Bolivia and Paraguay.

2.2. Sustainable ranching interventions

Technical assistance was provided to both the large private ranchers as well as to the indigenous communities focusing on pasture cultivation and management, recovery of native pastures, rotational grazing or the shifting of livestock across padocks to permit sequential grazing and recovery of the pasture, improved fire management through the use of burn calendars and no burn zones, and reduction of predation risk from jaguars. Ranch management plans were developed for each private property and a cattle ranching strategy guided interventions in both participating indigenous lands (CIPLA, 2016; CRTM, 2016). In the case of the indigenous communities, veterinary assistance was provided to improve animal health and animal management practices (Nallar et al., 2017). In the case of the intervention plans for the larger ranches in Paraguay, greater emphasis was placed on providing technical guidance on the selection, installation and use of water collection systems and reduction of predation risk by jaguars through the use of deterrents during calving season, and conservation of wild prey species. The deterrents used were automated Led lights in paddocks as well as cowbells during calving season. (WCS Paraguay - Project report, 2016).

2.2.1. Evaluation of impact of sustainable ranching interventions

The success of these interventions in reducing loss of forests, using forest cover as an indicator of biodiversity and ecosystem services, was measured by evaluating the increase in carrying capacity through improved pasture management, and reduced deforestation rates and fire use as a result of this reduction in pressure for new pastures upon surrounding forests. Success in improving animal health and reproductive output was monitored through interviews and periodic blood and fecal sample analysis.

Carrying capacity in the participating ranches in Paraguay was considered synonymous to stocking rate and was determined visually, both as a baseline and exit evaluation. In the case of the indigenous communities three $1m^2$ plots of ungrazed pasture were sampled between November 2016 and March 2017 in each of the three areas of improved pastures established in Alto Colorado, in six different occasions; Puente Yucumo in seven different ocassions and Tupili, in five different occasions. In each plot, all the grass above ground was cut and wet green matter was weighed using a portable hook scale. This measurement is a more reliable estimation of carrying capacity than stocking rates in this case because two years is not a sufficient time period for an increase in the number of cattle held by indigenous communities. In order to calculate a theoretical stocking rate we considered that 60% of the wet green matter produced was digestible and that an average animal unit weighed 350 Kgs and required 10% of its weight in green matter per day (FEDEGAN, 2005).

Mitigation of conflicts between carnivores and livestock was evaluated through base line and exit interviews, which were sensitive, to record retaliatory killing of jaguars and cattle losses to wild predators. Retaliatory killing of jaguars in each private property and both indigenous lands was established through informal interviews and were sensitive because they are illegal in both Paraguay and Bolivia. Because of this monitoring of jaguar kills was triangulated with information of cattle losses to jaguar predation, also gathered through interviews.

Deforestation was evaluated between 2014 and 2016 for both indigenous lands in Bolivia, using Landsat 8 images from the Earth Explorer server. We followed standard procedures to identify loss of forest cover, such as: orthorectification, atmospheric correction and non-supervised classification. All the processes were performed using Erdas Imagine software. Once forest cover was identified using the non-supervised classification of the satellite images for 2014 and 2016 we calculated the rate of forest loss by comparing the area covered by forest in each case. The exponential formula used is derived from the Compound Interest Law and is expressed as follows (Puyravaud, 2003):

$$r = \frac{1}{t_2 - t_1} ln \frac{A_2}{A_1}$$

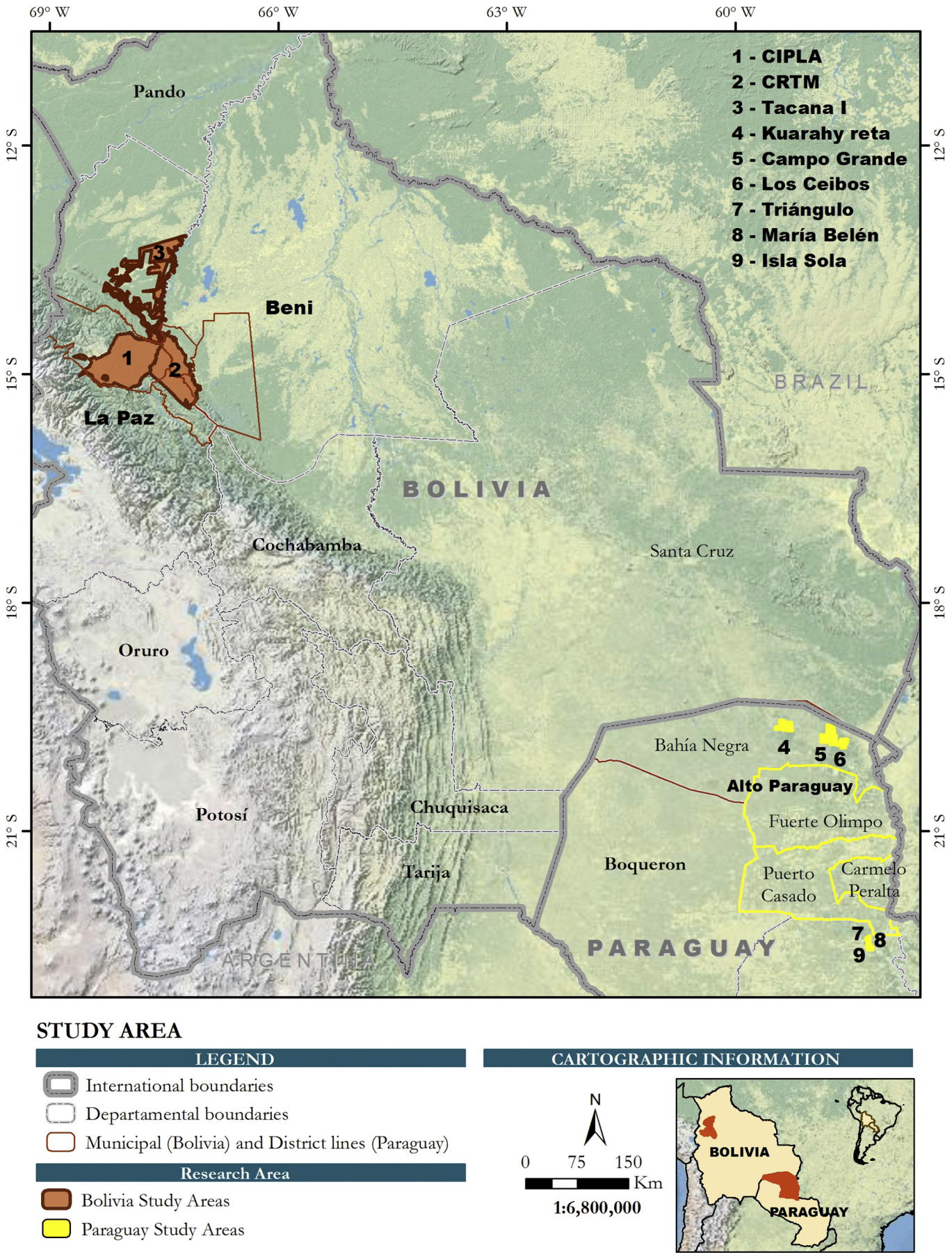
In the case of the T'simane Mosetene indigenous land, where the cattle ranching interventions where carried out along the edge of the indigenous land and along the Yucumo-Rurrenabaque road; we compared deforestation rates along this road within areas under indigenous management with deforestation rates within neighboring areas outside the indigenous land along the same road. In the case of the Apolo indigenous land average deforestation rates within the Apolo municipal area where calculated and allowed us to estimate the areas that would have been deforested in the absence of an indigenous land use plan.

In the case of Paraguay, we evaluated our impact on deforestation rates comparing forest loss within the areas of intervention with the rest of the region using a 2014–2016 deforestation analysis for the Paraguayan Chaco performed month to month by a local NGO: Asociacion Guyra Paraguay (Guyra, 2016) and whose data is considered reliable at the national and international level.

Animal health was also evaluated through base line and exit evaluation of parasite load in fecal samples obtained from cattle held by indigenous communities. Fecal samples were conserved in plastic bottles with 10% formaldehyde and transported for laboratory analysis. Success in improving reproductive output was monitored through interviews with indigenous cattle owners in 2014 and 2016.

2.3. Interventions to promote participation and equity in local territorial governance platforms

In Bolivia, the Leco people used the indigenous territorial plan (CIPLA, 2010) over their legally titled collective ancestral land to engage with the municipal government of Apolo, Madidi protected area and the Joint Mechanism for Climate Change Adaptation and Mitigation. In the case of the municipal government of Apolo and Madidi protected area joint workshops were held to reconcile zoning plans. The zoning plan for Madidi protected area and the Leco zoning plan were overlapped, conflicts between areas of strict conservation and subsistence use were identified, and an analysis of the relative importance of each area under conflict for conservation or local livelihoods was used to guide adjustments using maps and a geographic information platform. These agreements were then validated on the ground through the use of handheld GPS units and joint commissions between protected area staff and indigenous representatives (Muiba Núñez et al., 2012).



Map 1. Location of the study in Bolivia and Paraguay.

The Leco indigenous organization also used its territorial plan to engage with the process of development of the Integrated Development Territorial Plan for Apolo municipality, a document which integrates strategic guidelines of municipal development with a land use plan that considers environmental disaster risk management in the face of climate change.

On the other hand, the T'simane Mosetene people worked through their representative association with the protected area authority to develop a joint indigenous land use plan and protected area management plan to protect the rights of the indigenous peoples within an area collaboratively managed between the indigenous territorial organization and the Bolivian National Protected Area Service (SERNAP and CRTM, 2009). This involved establishing a joint planning team, consisting of indigenous representatives and protected area staff, to carry out community diagnostics and participatory mapping; as well as jointly developing the strategic and zoning proposal (United Nations Development Program (UNDP), 2012).

2.3.1. Evaluation of impact of interventions to promote participation and equity in local territorial governance platforms

The impact of interventions carried out to promote participation and equity in territorial governance platforms, contributing to achieving SDG 10, was evaluated using two measures: complementarity of planning instruments with indigenous territorial plans and presence of 17 Leco communities and an important population of 4943 indigenous people living in the Lecos and T'simane Mosetene indigenous lands (Instituto Nacional de Estadística, 2012). In order to evaluate the complementarity between overlapping jurisdictions we reviewed indigenous land use plans, protected area and municipal plans (Gobierno Autónomo Municipal de Apolo, 2016; CIPLA, 2016; SERNAP and CRTM, 2009; Muiba Núñez et al., 2012). The criteria used were specific mentions of strategic plans of overlapping jurisdictions, existence of established agreements between different stakeholders and interviews with representatives of the different jurisdictions.

3. Results

3.1. Evaluation of sustainable ranching interventions

3.1.1. Carrying capacity

In Paraguay, the average carrying capacity was 0,3 heads/ha before ranch management plans were implemented. As a result of improved water management and rotational grazing carrying capacity remained the same in two ranches, and was increased by 25%, 33%, 50% and 100% in the four remaining ranches. The average carrying capacity after three years of improved pasture management interventions was 19% higher, which is considered significant given the short period of testing.

In Bolivia, the carrying capacity in 2014 was 0,03 animal production unit /ha (APU/ha), based on green matter production of 3000 Kg/ha, in the unmanaged pastures within the Lecos Apolo indigenous land; and 0,8 APU/Ha in Alto Colorado; based on green matter production of 18,000 Kg/ha. By 2017 the managed area in Tupili had increased its biomass six-fold to 19,722 kg/ha and through the use of rotational grazing management had a carrying capacity of 1.06 APU/ha. In the case of the lower lying area around Alto Colorado and Puente Yucumo green matter production was 17,000 kg/ha. By 2017 the managed pastures in Alto Colorado had increased its biomass to 25,514 kg/ha, or sufficient productivity for a carrying capacity of 1.27 APU/Ha using rotational grazing; while the nearby area of Puente Yucumo had increased its biomass to 30,813 kg/ha, or sufficient productivity for a carrying capacity of 1.45 APU/ha using rotational grazing. Although sampling was limited to three plots, variations between these each month was very small (Fig. 1).

3.1.2. Mitigation of conflicts between carnivores and livestock

Baseline interviews with representatives of the six private ranchers in Paraguay reported between 3 and 4 cases of retaliatory killing incidents in each ranch over a 5-year period. Between 2014 and 2016 no jaguar killings were observed in the field or during exit interviews, and additionally no predation events of calves were registered after the use of Led lights and cow bells as deterrents.

3.1.3. Deforestation

In Paraguay, the six properties receiving continuous technical assistance had a total deforestation rate of 36.56% in the period 2010–2014 (previous to the intervention). This resulted in the loss of 8515 ha. After the project intervention (2014–2016) this rate declined to 4.58% and the forest loss was only 961 ha. This deforestation rate is almost half the total rate of 7.5% in the rest of the Paraguayan Chaco in the period 2010–2016.

Within the Bolivian intervention areas, GIS analysis showed a 2.51% rate of forest loss during the full period between 2014 and 2016 along a 4 km buffer either side of the road along the edge of the T'simane Mosetene indigenous land. In comparison, areas along the same road but not under indigenous land tenure and management showed deforestation rates of 5.12%, or twice as high. If we double the hectares of forest lost within the indigenous land during that period we can show that through improved ranching practices we prevented the loss of 92 ha along that road between 2014 and 2016. In the case of the Lecos indigenous land such a comparison was not possible because the indigenous land is still in the process of land titling and therefore a clear geographical limit has not been established. Nevertheless, it is possible to extrapolate average deforestation rates in the municipal jurisdiction and project these rates of forest loss onto the areas zoned for activities compatible with forest conservation within the Lecos indigenous land (430,844 ha), leading to an avoided potential loss of 2154 ha between 2014 and 2016, under a scenario of implementation of the indigenous land use plan (CIPLA, 2010). The gains for biodiversity by avoiding forest loss are considered more important than losses to more intensive grazing because of the relatively small size of the paddocks, in comparison to avoided deforestation areas: 21.3 ha in Alto Colorado, 41 ha in Puente Yucumo and 40 ha in Tupili.

3.1.4. Animal health

During the development of the health baseline in 2014 we found 10 types of pathogens in a sample of 129 bovines, including the Infectious Bovine Rhinotracheitis virus, 6 roundworms, a tapeworm and two protozoan parasite species. In 2016, exit evaluations with 67 bovines registered two roundworms and a protozoan. Interviews carried out in 2014 with 55 indigenous cattle owners reported 32.9% natality rates and 19.17% mortality of calves. Exit interviews with 83 indigenous cattle owners showed a modest increase in natality to 33.2% and a reduction in mortality of calves of 17.24%.

3.2. Evaluation of impact of local territorial governance platforms

The Leco people, through their territorial organization representing 4078 people have been able to concert their indigenous land use plan over 130,298 ha of overlap with Madidi protected area and 527,087 ha of overlap with the Apolo municipal government. In the case of the 2804 indigenous T'simane Mosetene people they have been able to concert their land use plan with 340,379 ha of overlap with the Pilon Lajas protected area. These understandings have been formalized within the Apolo municipal development plan, for the overlap between the Leco indigenous land and the municipal jurisdiction. In the case of Madidi protected area and the Leco indigenous land, through an agreement between the National Protected Area Service and the indigenous organization; and within the Pilon Lajas Biosphere Reserve and Indigenous Management Plan and Life Plan.

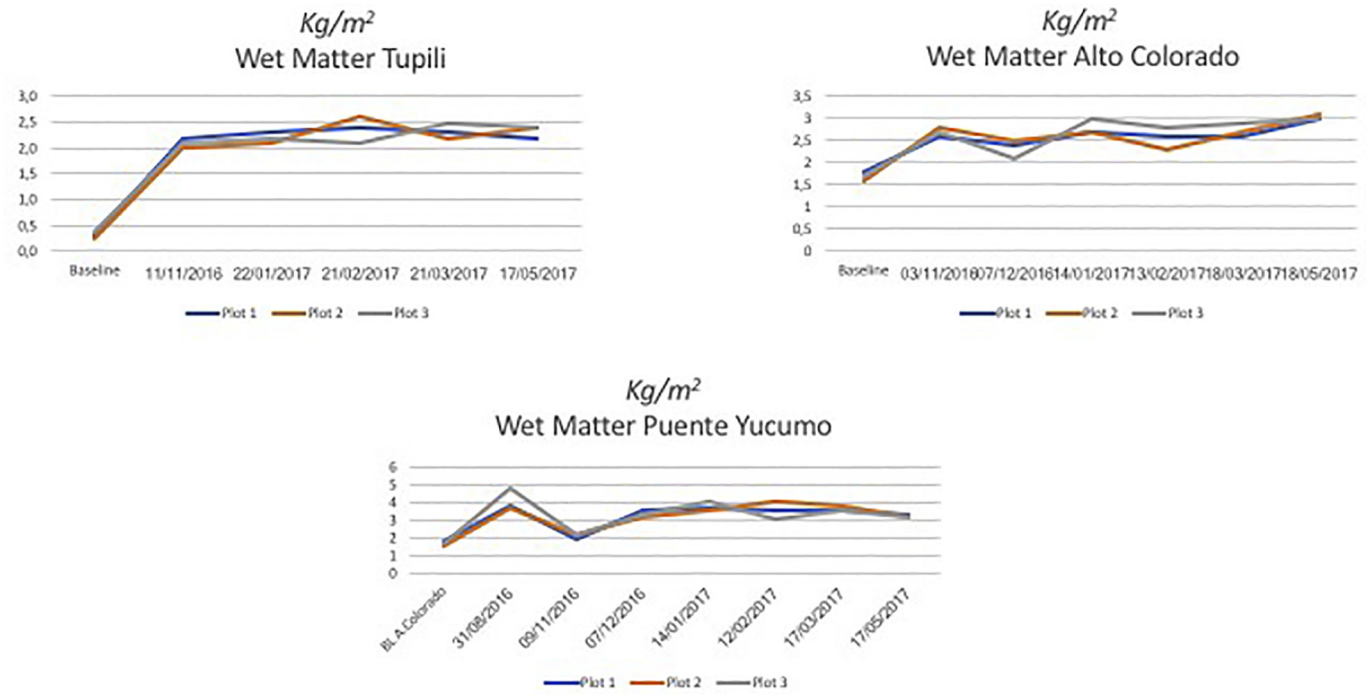


Fig. 1. Wet matter production in Tupili, Alto Colorado and Puente Yucumo.

4. Discussion

Agriculture is a key driver impacting ecosystems (Millenium Ecosystem Assessment, 2005) but productive practices can be improved and forest loss can be reduced by limiting the expansion of agricultural land and reducing the pressure on natural habitats. More efficient grazing management reduced forest loss both in areas managed by large private ranchers as well as those managed by small scale indigenous ranchers, and is therefore relevant to help achieve SDG 15.

Indigenous territorial rights and territorial management capacity in the Leco and T'simane Mosetene indigenous lands reduce inequality (SDG 10) by empowering indigenous small-scale ranchers, and securing their equal access to land and natural resources. Indigenous participation in local municipal and protected area management platforms, relevant for contributing to achieving SDG 2, was possible because of the existence of legitimate indigenous organizations to represent the interests of their constituency. Indigenous land use plans and supporting natural resource use regulations established what land use practices are permissible, how access rights to collective resources are established and what sanctions can be imposed for infractions of these regulations. These capacities allowed them to implement conservation and sustainable ranching plans leading to improved productivity, contributing to SDG 2, and also enabling them to leverage respect and support for their territorial management vision from protected area and municipal authorities. Their strong internal cohesion enabled them to engage in local governance platforms so that their territorial boundaries are respected, and their conservation and natural resource management objectives, as expressed in their indigenous land use plans are reflected in local development plans.

In the case of Paraguay improved ranching practices have enabled positive results for conservation but, the limited progress in the recognition of indigenous territorial rights and more recent development of territorial planning capacity at the municipal level are obstacles to further contribution in social equity (SDG 10). Bolivia is the Latin American country which has carried out the greatest efforts to legally recognize indigenous territories, titling 20 million hectares of indigenous collective lands to date. Whereas, land distribution inequality in Paraguay is the highest with 2.5% of people owning 85% of the land (CEPAL, 2013).

The impact of improved ranching practices with large private ranchers resulted in greater impacts on the reduction of forest loss, thus contributing to achievement of SDG 15, but impacts on social inclusion (SDG 10) were only achieved in Bolivia due to the existence of indigenous territorial capacity. Contribution towards the achievement of SDG 10 through the recognition of indigenous land rights and the development of inclusive governance platforms are important to develop better interactions between contributions to SDG 2 and SDG 15. In order to reconcile cattle ranching with biodiversity and social inclusion objectives efforts should focus on strengthening the capacity of small scale indigenous ranchers to implement improved management practices, respecting and strengthening their internal legitimate decision making structures and social bridges with overlapping jurisdictions. In Paraguay, local government platforms to guide land use planning are an important gap that needs to be filled in order to achieve more inclusive development.

Acknowledgements

The work was carried out through an alliance between Wildlife Conservation Society, Lecos Apolo (CIPLA) and T'simane Mosetene (CRTM) indigenous territorial organization. It was supported by Darwin Initiative funded by the UK Government and the Civil Society Support Fund (FOSC) of the Danish International Development Agency program in Bolivia.

References

Banco Central del Paraguay, 2014. Indicadores Económicos. Octubre. 2013. https://www.bcp.gov.py/userfiles/files/Resumen_prensa_Estimacion_PIB_2013_tercera_revision_octubre_2013.pdf.

CEPAL, 2013. Estadísticas de la Comisión Económica para América Latina y El Caribe. http://interwp.cepal.org.

CIPLA, 2010. Plan de Vida del Pueblo Leco de Apolo Wesra Leco Chajlasin. Resumen Ejecutivo, La Paz, Bolivia.

CIPLA, 2016. Plan de gestión ganadera para las comunidades de Tupili y Chirimayu del Pueblo Leco de Apolo: Apolo: CIPLA-WCS.

CRTM, 2016. Plan de gestión ganadera para las comunidades de Puente Yucumo y Alto Colorado de la Reserva de la Biosfera y Tierra Comunitaria de Origen Pilón Lajas:

Rurrenabaque: CRTM-WCS.
FAO, 2016. State of the World's Forests 2016. Forests and Agriculture: Land-Use Challenges and Opportunities. (Rome).
FEDEGAN, 2005. Plan Estrategico de la Ganaderia Colombiana 2019. Sanmartín Obregón & Cia, Bogotá. http://fedegan.org.co//plan-estrategico-de-la-ganaderia-colombiana-2019.
Gobierno Autónomo Municipal de Apolo, 2016. Plan Municipal de Desarrollo Integral 2016–2010. La Paz. (212 pp).
Guyra, 2016. Guyra Paraguay, Deforestation Report – December 2016. http://guyra.org.py/informe-deforestacion-2016/.
Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommaredy, A., Egorov, A., Chini, L., Justice, C.O., Townshend, J.R.G., 2013. Science (342), 850–853.
INE, 2017. Instituto Nacional de Estadística. In: Anuario Estadístico de Bolivia 2016. La Paz, Bolivia.
Killeen, T.J., Siles, T.M., Soria, L., Correa, L., 2005. Estratificación de Vegetación y Cambio de uso de Suelo en los Yungas y Alto Beni de La Paz. 40. Ecología en Bolivia Marino, G., M.F, pp. 32–69.
Millenium Ecosystem Assessment, 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington, DC.
Ministerio de Desarrollo Rural y Tierras, 2014. Plan Sectorial de Desarrollo. Sector Desarrollo Agropecuario 2014–2018. La Paz, Bolivia.
Muiba Núñez, S., Loayza Cossio, O., Dúran Laura, A., Gonzales Buitrado, L., 2012. Territorios Compartidos. Construyendo un modelo de gestión territorial para el Madidi y el pueblo leco de Apolo. Fundación PIEB, CIPLA, WCS, SERNAP, Embajada de Dinamarca.
Nallar, R., Rolón, W., Mollericona, J.L., 2017. Manual para la gestión de una ganadería sostenible. Wildlife Conservation Society. La Paz. Bolivia 124.
Potapov, P., Hansen, M.C., Laestadius, L., Turubanova, S., Yaroshenko, A., Thies, C., Smith, W., Zhuravleva, I., Komarova, A., Minnemeyer, S., Esipova, E., 2016. The last frontiers of wilderness: tracking loss of intact forest landscapes from 2000 to 2013. Sci. Adv. 3 e1600821.
Puyravaud, P., 2003. Standardizing the calculation of the annual rate of deforestation. For. Ecol. Manag. 177 (1–3), 593–596.
Riveros, F., 2014. The Gran Chaco. A bulletin of the Food and Agriculture Organization of the United Nations. http://www.fao.org/ag/AGP/AGPC/doc/BulletinGranchaco.htm.
SERNAP and CRTM, 2009. Plan de Manejo y Plan de Vida de la Reserva de la Biosfera y Tierra Comunitaria de Origen Pilón Lajas, 2007–2017. La Paz, Bolivia.
Thornton, P.K., 2010. Livestock production: recent trends, future prospects. Philos. Trans. R. Soc. Lond. B 365 (1554), 2853–2867.
UDAPE, 2015. Unidad de Análisis de Políticas Sociales y Económicas – Diagnósticos Sectoriales, Tomo 8. Sector agropecuario, La Paz Bolivia.
United Nations Development Program (UNDP), 2012. T'simane Mosetene Regional Council, Pilón Lajas. Bolivia. Equator Initiative Case Study Series, New York, NY.
World Bank, 2016. World Bank National Accounts Data, and OECD National Accounts Data Files.