

Achieving conservation through cattle ranching: The case of the Brazilian Pantanal

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Abstract

Cattle ranching in the ~140,000 km² Brazilian Pantanal is considered one of the most important cases of sustainable use of natural resources in the global south. The region has had a successful history of balancing environmental protection with the production of >3.8 million cattle. However, global change, infrastructure projects, and deforestation, threaten the sustainable use of the Pantanal. Here, using Ostrom's design principles as a framework, we interviewed 49 local stakeholders and conducted a review of secondary information aiming to evaluate the sustainability of cattle ranching practices across the region and the threats to it. We show that well-defined property boundaries, congruence between appropriation and provision rules through low-intensity cattle ranching, and co-management of resources, are all key components for achieving sustainability in the Pantanal. However, we documented shortcomings in satisfying critical aspects of Ostrom's design principles. Specifically, we argue that the Pantanal needs better biodiversity and behavior monitoring, the creation of platforms or mechanisms to solve local conflicts around resource access and use, recognition by governments and international bodies of the local efforts to promote local sustainability, and the creation of networks effectively connecting existing sustainability initiatives.

KEYWORDS

sustainable cattle ranching, the Pantanal, wetlands, working landscapes

1 | INTRODUCTION

Cattle or livestock ranching (hereafter, “ranching”) and biodiversity conservation co-occur together in the vast Pantanal wetland. In the Brazilian Pantanal alone, there are approximately 3000 cattle ranches occupying ~90% of the region. These ranches produce over 3.8 million cattle

per year (Tomas et al., 2019). At the same time, the Pantanal is one of the most conserved wetlands on the planet, with over 80% of its native vegetation still conserved (Guerra et al., 2020). In addition, incidents of human-wildlife conflict are relatively few, and hunting is largely restricted to one invasive species, the feral pig (*Sus scrofa*) (Desbiez et al., 2011). As a consequence, the

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Pantanal supports healthy populations of nationally threatened and endangered species, such as jaguar (*Panthera onca*), marsh deer (*Blastocerus dichotomus*), white-lipped peccary (*Tayassu pecari*), and jabiru (*Jabiru mycteria*) (Tomas et al., 2019).

The balance between biodiversity and ranching in the Brazilian Pantanal has been a product of complex and interconnected historical, ecological, social, cultural, and meta-economic processes (Kauffman, 2015). The first cattle ranches in the Brazilian Pantanal were established in the 18th century during the Portuguese colonization (Abreu et al., 2010). Colonizers encouraged the development of large ranches aiming to decimate Amerindian groups and occupy areas set aside to the Spanish Crown. In the early 20th century, Pantanal cattle ranching stood out as an important economic activity. World War I (1914–1918) and World War II (1939–1945) created a large demand for protein, and Brazilian Pantanal ranchers specialized in producing dried meat for export to Europe (Kauffman, 2015). During this period, there were several attempts to intensify cattle ranching across the Pantanal through dams, highways, railways, and waterways. However, unpredictable ecological dynamics (e.g., unforeseen large floods), along with issues such as corruption during the implementation of development projects, and geographical distances from important financial centers have hampered most of these projects. Thus, local ranching expanded in the region mainly through extensive cattle grazing and low-intensity deforestation (Abreu et al., 2010).

Ecological sustainability in the Pantanal is, however, threatened. Recent trends in land use and land cover changes represent severe risks to ecosystem health and function (Tortato et al., 2022), and a regional deforestation arc has advanced into the floodplain (Guerra et al., 2020). These major threats are exacerbated by the rapid expansion of invasive species (e.g., the Chinese mussel (*Limnoperna fortunei*), water buffalo (*Bubalus bubalis*), the fishes tucunaré (*Cichla piquiti* and *Cichla kelberi*) and tambaqui (*Colossoma macropomum*), mining, the arrival of intensive livestock production schemes, climate change, and less restrictive policies (Marengo et al., 2016). Finally, several major infrastructure projects such as the Paraguay River Waterway, as well as smaller hydroelectric power dams in the surrounding areas of the Pantanal, threaten the integrity of the region's hydrological systems and its ecological dynamics (Marques & Rodriguez, 2022). Combined, these diverse threats are creating a “perfect storm” of challenges, paving the way for significant declines in the ecological health of the Pantanal (Tortato et al., 2022).

Given the multitude of threats, the future of low-impact cattle ranching in the Pantanal will depend on a functional governance structure around resource use and access. In this paper, we aim to identify the main challenges, from a governance perspective, to maintain the balance between cattle ranching and biodiversity conservation in the Pantanal. We used Elinor Ostrom's principles of sustainable use of natural resources. Ostrom (1990) identified eight governance principles commonly shared across socio-ecological systems that if adhered to, may insulate communities or groups from environmental and social collapse (Table 1).

2 | MATERIALS AND METHODS

2.1 | Study area and ecological dynamics

The Pantanal (179,300 km²) stretches across Paraguay, Bolivia, and Brazil, with Brazil encompassing approximately 78% (~140,000 km²) of the entire ecoregion (Figure 1) (Tomas et al., 2019). The wetland is characterized by a seasonal, monomodal flood pulse, which takes over 4 months to cross the floodplain moving from the north and east to the south and west, largely due to the extreme flatness of the terrain (i.e., 2–3 cm/km from north to south; 5–25 cm/km from east to west) (Junk et al., 2006). The extent of the flood pulse varies strongly with intra- and inter-annual hydrological periods. Depending on the year, the size of the flooded area may vary from as small as 11,000 km², to over 110,000 km² (Hamilton et al., 1996).

The marked seasonal climate, with low rainfall during the dry period (1300–1000 mm/year), also makes the region susceptible to fire events. Records confirm fires in the region as far back as 12,000 years ago. However, the frequency, intensity, and occurrence of fire have changed since the first archeological records (8000 years before the present), which shows a clear human usage of fire in the area (Filho et al., 2021).

Not surprisingly, both fire and flood play key roles in shaping the ecology of the Pantanal landscape. Fire can stimulate or prevent germination, depending on the vegetation species, and also consume large amounts of biomass opening spaces for new species. Floods may also prevent or stimulate germination depending on the adaptation of the roots of each species to oxygen deprivation. Thus, the composition and distribution of different vegetation types in the Pantanal will change according to flood extent, and with the frequency and intensity of fires (Damasceno-Junio & Pott, 2021).

TABLE 1 Ostrom's governance principles and how each of them was approached during the research.

Number	Ostrom's principal	Approach in the research
1	Clearly defined boundaries	Land tenure and conflicts over trespassing.
2	Congruence between rules of appropriation and provision	Management practices and perspectives on possible land use/land cover changes
3	Collective-choice arenas	Collective ability to deal with the flood pulse, fire, and other challenges
4	Monitoring	Monitoring of ranchers' behavior, and environmental changes in the region
5	Graduated sanctions	Presence and implementation of penalties on rule breakers
6	Conflict resolution should be easily accessible	Conflicts around land use and land change, and how that has been addressed or remedied
7	Minimal recognition of rights to organize	Initiatives that recognize the sustainability of the Pantanal and its cattle-ranching system
8	Nested enterprises	Initiatives that aim to gather cattle-ranching groups from different areas of the Pantanal or with different goals

2.2 | Data collection

We used Ostrom's proposed eight principles to better assess the main challenges of keeping cattle-ranching in the Brazilian Pantanal relatively low impact on the environment. To do this, we used two sources of information. First, we evaluated secondary information that could help us to relate cattle ranching and the eight governance principles. This included both secondary data, as well as peer-reviewed papers presenting empirical information.

Second, we carried out semi-structured interviews with local stakeholders, with the aim to understand their perception about the link between cattle-ranching in the Brazilian Pantanal, and Ostrom's principles. We interviewed 49 people, including 21 cattle ranch owners, five ranch managers (i.e., in those cases where we were unable to speak directly with the owner), two ranch foreman (i.e., "*capataz*") (also in cases where we did not talk

with the owner or the manager). These interviews represented around 2% of all ranches in the Pantanal. We also interviewed four people whose businesses supported the agribusiness supply chain (e.g., they delivered goods such as salt, or transported cattle), four conservation practitioners (including conservationists from NGOs), and three policy makers. Finally, we also interviewed 10 researchers working in the region, who helped to identify all secondary information available to us. All interviews were held between April 2019 and March 2021. Prior to March 2020, all interviews were conducted in person. However, after March 2020, we conducted interviews over the phone due to new Covid-19 isolation and social distancing measures implemented in Brazil. Many interviews were spread out over multiple conversations (1–4) with the same person. We did this to build enough interaction for developing rapport with each subject, thus, allowing us to conduct our research more effectively, and to be able to address sensitive topics requiring greater trust.

To ensure we interviewed people from different parts of the Pantanal, we used a mix of structured and snowball sampling approach (Bernard, 2006). We first interviewed the heads of cattlemen associations ("sindicatos rurais" in Portuguese) from all cities in the Pantanal. Association heads then introduced us to other ranchers, who then continued to introduce us to even more ranchers that would be also willing to talk. We were also introduced to ranchers by researchers and policy makers working in the region. While our sampling method was not random, it allowed us to reach a group that is rather difficult to contact. Most ranchers constantly moving between locations, or reside in places with no internet and working phone service. The number of interviews was based on the results of the content analysis described below. We collected information up to such a point that answers did not add more new information to satisfy the general goals of the project (Bernard, 2006).

All interviews were structured based on the eight Ostrom's principles (Table 1). Participants, however, were free to shift their answers and the conversation, towards topics s/he was more familiar with, or interested in. Most of the time, through subsequent interviews, we covered topics that were not covered in the first approach, and to review some of the original answers provided. We note that this research design was approved by the Brazilian Ethics Committee (process number: CAAE 34296720.7.0000.5161) and by Smithsonian Institution Human Subjects Review Board (protocol number: HS20024).

2.3 | Data analysis

We sought a quantitative and qualitative measure of the extent to which the Brazilian Pantanal cattle ranching

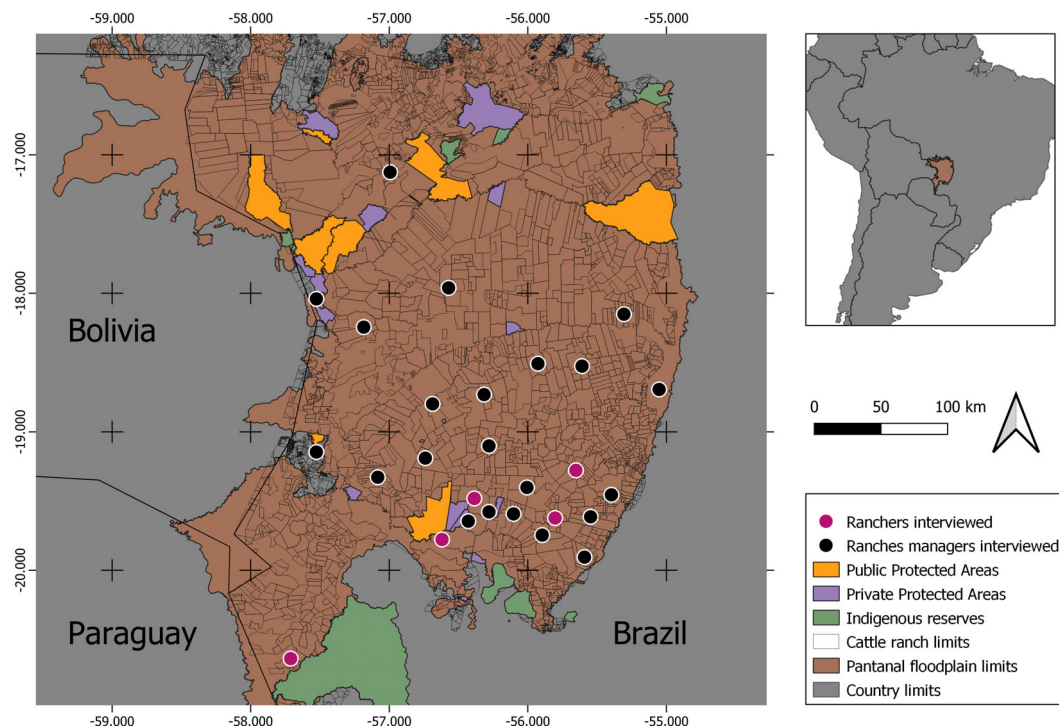


FIGURE 1 The geographic extent of the Pantanal, including national and international borders, as well as Private and Public Protected Areas and Indigenous Territories in Brazil. We also highlight private properties boundaries and the location of the interviews.

system satisfies the criterion of each specific principle. For instance, with respect to “clearly defined boundaries” (Principle 1), we used data from the Rural Environmental Registration (CAR = Cadastro Ambiental Rural)—a governmental on-line platform requiring all public and private land owners to register the limits of their properties and the land use zones inside it (Brasil, 2020), papers reporting land tenure conflicts in the Pantanal, and people’s perception about land tenure and property rights collected through the interviews.

The answers to our semi-structured questionnaires were coded according to the eight design principles (Table 1). We did not consider or integrate answers that were very specific or unique to one particular case or scenario. Rather, our main goal was to capture the recurrence of answers across respondents, or those comprising a subject theme (Bernard, 2006). We added quotes to our analysis to better illustrate and represent the collective perspective and understanding among the respondents.

3 | RESULTS

3.1 | Clearly defined boundaries

CAR data show that 96.94% of the Brazilian Pantanal has a clear land tenure rights, demonstrating that most

property boundaries in the Brazilian Pantanal are well-defined. Most of these are private properties (88.3%), which also includes Private Reserves that encompasses 1.92% of the Pantanal. Strictly Protected Areas represented 2.82% of the region, whereas Sustainable Use Protected Areas (excluding Private Reserves) represented 0.03% of total land area. Indigenous Reserves represented 2.89% of the Pantanal. Most private properties belonged to families who staked a claim to the original ranch between 1880s and 1900s. After the Triple Alliance War (1860–1864), fought over the region between Argentina, Uruguay and Brazil against Paraguay, colonizers were granted title to large portions of land (Leite, 2018).

We did not find records of land tenure conflicts among cattle ranchers, or between cattle ranches and local communities. Interestingly, we found that fishermen and ranchers have informal agreements regarding use of the floodplain (Chiaravalloti et al., 2017). However, we did observe records of conflict between ranchers and indigenous groups in the indigenous reserves “Baia dos Guatós” and “Taunay-Ipegue,” where ranchers continue to claim ownership of part of these areas (Oliveira, 2007). We also recorded a conflict between strictly protected areas, and local fishermen along the western boundary of the Brazilian Pantanal; in this region, several ranches were set aside as private reserves, and traditional fishing communities were prevented from accessing some of lakes they have historically used (Chiaravalloti et al., 2017).

3.2 | Congruence between rules of appropriation and provision

The Pantanal is a well-preserved ecosystem: 84.37% of the Pantanal still retains its native vegetation. Most reaches have a low rate of deforestation, and satellite images show that approximately 30% of them have <5% deforestation. Most of the deforestation occurring in the region is related to the replacement of native grassland with an exotic one (“braquiaria”). Native grasses support an average of 0.3 head of cattle/ha, whereas, areas with exotic pastures can support up to 1 head/ha (Itavo et al. 2008). However, we found that ecological dynamics impose barriers on some of the land use changes. As pointed out by one rancher: “most of my ranch is covered by water during the flood period, which would kill the ‘braquiaria’ [exotic grass]. So, I keep the native grassland”; or another, who said that “out of the 38,000 ha of my ranch, none is exotic pasture.”

The Pantanal also faces logistical constraints. As acknowledged by an interviewee: “there are no roads; you always have to find new paths people are constantly creating; the last time I went to the Pantanal it took me three days to drive 140 km.” Consequently, the cost of deforesting native vegetation is very high, which further places constraints on the extent to which many ranchers can change the landscape.

3.3 | Collective-choice arenas

Our interviews showed that management strategies in the Pantanal are constantly discussed and debated among different stakeholders. According to interviewees, people help one another to deal with the seasonal flood pulses in the Pantanal. For example, due to the lack of roads, most cattle are transported out of the region through “comitivas”; these are essentially “cattle drives” with large herds of cattle (e.g., up to 1500 head) herded by cowboys to a central auction location. During *comitivas*, cowboys use “free grazing” areas of ranches, which are strategically located on the way to a central auction location.

An important ritual in the Pantanal aiming to collectively deal with the local challenges is the *mate* (*tereré*) tea-drinking session. Typically, this is when a group of people sit together to drink this regionally important, traditional beverage, while pondering life and the challenges of work, sharing stories, and in particular, discussing ranching management strategies and needs. According to some informants, *WhatsApp*, the social media messaging service App, now sometimes replaces this ritual. On the other hand, it also allows them to

exchange information with more people who are not necessarily physically close to them.

3.4 | Monitoring

The monitoring of others with respect to their environmental behavior and sustainable practices, was mentioned by respondents over the course of several interviews. Traditional cattle ranchers, who identify themselves as “traditional Pantaneiros,” argue that they are the ones who have “protected the Pantanal from deforestation.” They blame outsiders for the recent changes that have begun occurring across the region in more recent years. As illustrated by the remarks of three informants, all self-identified as traditional *Pantaneiro* ranchers: (1) “the traditional cattle ranchers are disappearing, the new ones are coming with high technology to intensify production”; (2) “in the future, there will be no *Pantaneiro*, the extensive cattle ranching in the Pantanal will go extinct”; (3) “entrepreneurs are coming with lot of money to deforest the Pantanal.”

Several initiatives have been established to monitor land use changes occurring in the Pantanal. More recently, a consortium of several institutions (including Embrapa Pantanal, but also WWF, Conservation International, Ecoa, SOS Pantanal, etc.), as well as MapBiomias (a network of NGOs and companies), have been actively producing data showing land-use changes and impacts in the region (Mapbiomas, 2022).

3.5 | Graduated sanctions

We did not identify the presence of informal or formal penalties or sanctions on people infringing the collective management rules around use and access of natural resources (e.g., collective support, free-grazing for *comitivas*). We did however note examples of potentially shifting norms with respect to relationships with neighbors in the context of day-to-day activities. Although *Pantaneiros* prize their “solidarity culture,” some people argue that their neighbors do not help them, as best illustrated by the quote from one interviewee: “when my pasture was burning, no one helped me; I had to do everything by myself.”

3.6 | Conflict resolution should be easily accessible

We found two illustrative examples of how conflict can scale up to more pervasive, unresolved issues around

resource use and access. One major case involved the permanent flooding of an area of over 6000 km² in the Taquari River delta, which was largely caused by soil erosion on agricultural land outside of the floodplain which accelerated an otherwise natural erosion process (Louzada et al., 2023). Many of the pasture areas in the region were permanently flooded, and some ranchers built barriers around the riverbank to block the water. Since these practices were not authorized by the local environmental agency, ranchers have been subject to heavy fines, as exemplified by one rancher complaint: “Public prosecutors gave me a fine of 4 million reais [~US \$800,000].” According to the environmental agency, most of the fines were only partially paid. There is no clear solution to this conflict, and scientific studies in the region suggest that there is not much that can be done given the dynamic nature of the Pantanal rivers and water bodies (Louzada et al., 2023).

The second example concerns the recent 2019/20 wildfires in the region which saw a better result, at least in the northern Pantanal. The use of fire to manage native grasslands has a long history as common practice in the Brazilian Pantanal cattle ranching system. Essentially using fire in the rainy period and with strict control measures. However, in 2019, the Pantanal saw 40% less rain than the historical annual average, which exacerbated and expanded the intensity, impact, and extent of these otherwise normally small-scale fires (Marengo et al., 2021). As a consequence, in 2019/20, 30% of the Pantanal burned, with fires killing at least 17 million vertebrates (Tomas et al., 2021). As a means to prevent similar fires in the future, the state environmental agency of Mato Grosso (SEMA), and Embrapa Pantanal, established a partnership to create a new state policy focused on grassland conservation and restoration, and the related use of fire as a management strategy (Mato Grosso State Decree no.785, January 18th 2021).

3.7 | Minimal recognition of rights to organize

The Brazilian Pantanal's unique integration of cattle ranching and biological conservation has led international bodies to declare portions of it as a Biosphere Reserve (UNESCO Man & Biosphere Reserve), RAMSAR site, and UNESCO World Heritage sites. The Pantanal is also listed as a National Heritage ecosystem under the 1988 Brazilian Constitution. All the national and internal recognitions do not automatically impose restrictions on how local people use and access resources. They depend on local acknowledgement, the presence of

management plans, and sometimes, specific policies. However, most ranchers we interviewed do not see these designations as recognizing their practices, nor as having positive practical consequences for their businesses and daily lives.

Fortunately, there are emerging opportunities for “bottom-up” self-organization and governance approaches. For instance, a Model Forest approach is currently being implemented in the Baía Negra Environmental Protection Area, near Corumbá in the southern Pantanal, and a multi-stakeholder network of practitioners has been articulated for achieving sustainable cattle ranching, fisheries, and tourism in the region (Tomas et al., 2019). Another action that has been locally recognized is the Brazilian Association of Organic Producers (ABPO), which was created in 2001 by cattle ranchers in the Pantanal. The state created a specific policy for this group, and provides tax breaks for those who are certified as sustainable beef. The 5P Alliance (“Pantanal, Preservation, Ranching, Productivity and Partnership”) was another important group we identified in the region. They are a group of ranchers located in the southeast region of the Pantanal that aim to merge cattle ranching with ecotourism, and other sustainable activities. The Embrapa's “Fazenda Pantaneira Sustentável-FPS” (Sustainable Pantanal Ranch) is another important initiative that aim to support and certify sustainable cattle ranching practices using environmental, economic, and social-cultural dimensions of sustainability in the Pantanal (Santos et al., 2017).

3.8 | Nested enterprises

We identified different levels of organization among ranchers in the Pantanal. For instance, most ranchers belong to, at least, one cattlemen's association. Each city in the Brazilian Pantanal (and indeed all over the country) has its own local cattlemen's associations. The largest one, founded in 1918, is located in Corumbá - the largest municipality in the Pantanal. Cattlemen's associations can have strong political power; for instance, at the time of the interview, the head of Corumbá cattlemen's association was also the secretary of economic and sustainable development of the city. However, three of these associations located in the Pantanal are fighting with the government to expand deforestation in the Pantanal. In contrast, the other two interviewed were sympathetic to the idea that the Pantanal ranching system is a unique case that balances biodiversity conservation and cattle ranching and do not support further deforestation. In other words, there is no coordination in their collective agendas.

To better understand low environmental impact cattle ranching in the Pantanal, we can also expand the concept of nested enterprises to environmental legislation in the Pantanal. In Brazil, the national legislation on the environment, law number 12651 (May 25th 2012; also known as the “Forest Code”), states that Pantanal is an area of “restricted use” and therefore, “only ecologically sustainable use and practices” are permitted. Yet, it allows each state to define what they understand as “restricted use” and “ecologically sustainable use and practices.” According to some specialists interviewed: on the one hand, states are allowed to adapt the legislation to their own local ecological dynamics; on the other, they have “flexibility” to permit large-scale deforestation while claiming the process is “sustainable use.” For example, in Mato Grosso do Sul state, scientists developed a framework to define what is “restricted use” and “ecologically sustainable use for the region”; however, no scientific guidance was considered in the development of local environmental legislation. For many years, the state allowed ranchers to replace up to 60% of the native vegetation, depending on the type of vegetation covering the property (Mato Grosso do Sul State Decree no.14.273, October 8th 2015). In August 2023, the degree was revoked to be replaced with a new legislation. In contrast, in Mato Grosso, the state legislation allows up to 40% percentage of replacement of the native vegetation by cultivated pastures (Mato Grosso State Law number 561/2022).

4 | DISCUSSION

By using Ostrom's principles we were able to uncover key elements of the Pantanal cattle ranching sustainability. Conservation of the Pantanal has mostly been understood through the lens of empirical ecological data. For instance, the Pantanal exhibits low deforestation and poaching rates, low incursions of exotic and invasive species, and healthy populations of key species of conservation importance (e.g. jaguar, hyacinth macaw, etc.) (Tomas et al., 2019). Despite these key accomplishments, policies, and practices in the Pantanal can miss critical governance aspects to the region. Sustainable use of natural resources, for example, is achieved when stakeholders are able to control individual interests and overcome the “collective action dilemma” (Ostrom, 1990). Therefore, by understanding how both formal and informal rules around resource use and access in the Pantanal are negotiated and managed, we were able to identify critical aspects to the balance between biodiversity protection and cattle ranching in the region.

Four aspects stood out as positive drivers of conservation in the Pantanal. The first one is “clearly defined

boundaries” (design principle 1). A clear understanding of who formally owns the land or water, plays a crucial role in the effectiveness of Protected Areas, payments for ecosystem services, and most site-specific conservation strategies (Robinson et al., 2018). Wetlands particularly are commonly under complex and sometimes unsolved tenure problems due to the seasonal changes (Adger & Luttrell, 2000). However, this does not seem to be an issue for the Pantanal. Over 95% of the region has clearly defined property rights. It does not mean that the Pantanal has no conflict related to trespassing, displacement, or other related problems (Chiaravalloti et al., 2017). However, overall, clear defined boundaries is not an issue for the cattle ranching sustainability.

The presence of “low impact resource use strategies” (design principle 2) stood out as another important component of conservation in the Pantanal. Over 80% of pasture areas in the Pantanal consist of native vegetation, which has led to a low-intensity cattle ranching production system that allows biodiversity and livestock to occupy the same area without much compromise to either.

Design principle 3, “collective-choice arenas,” was also an important positive contribution to Pantanal conservation. There is a growing body of literature that highlights the importance of local participation in the decision-making processes (e.g., Büscher & Fletcher, 2019). In the Pantanal, this is present through constant support among different groups (e.g., such *comitivas*, and the *terere* tea ritual) and discussions on how to use, access, and address challenges across the landscape (Tomas et al., 2019).

Conversely, we note several principles falling short of sustainability criteria for the Pantanal, a worrying indication of potential changes to the collective management of natural resources. Biodiversity and behavior monitoring (design principle 4) are an important ones that are lacking. Most of the monitoring that occurs in the Pantanal is focused on empirical evaluation around deforestation, forest fires, and biodiversity population trends (Mapbiomas, 2022). Initiatives focused on evaluating people's willingness to participate in certification programs, attitudes towards low-impact cattle ranching, the diffusion of good practices celebrating extensive cattle ranching, correct use of fire (e.g., dry season prescribed burning) and low deforestation management practices could play key roles in increasing knowledge about conservation, as well as point out pathways to promote better attitudes towards sustainable cattle ranching (Sok et al., 2020).

Graduated sanctions (Design principle 5) also stood out as an area that needs greater attention. We found an absence of guidelines or standards for dealing with violations of rules around poaching, deforestation, water contamination, and other types of environmental

TABLE 2 Comparison between Ostrom Principles and defining principles described in well-known approaches of working landscapes and comparable approaches.^a

Ostrom principles	Landscape approach	Working landscapes	Protected landscapes	Biosphere reserve	Model forest
Elinor Ostrom (1990)	Sayer et al. (2013)	Kremen and Merenlender (2018)	Brown (2004)	Nyhus and Adams (1995)	Besseau et al. (2002)
1 Clearly defined boundaries	No clear targets	No clear targets	The determination of the protected area boundaries	Well-defined zones	No clear targets
2 Congruent rules	Common concern entry point/resilience	Community-driven conservation initiatives	A systematic approach/planned with a view to links with the broader bioregion.	Conservation and development should be in balance	Flexibility/time limits
3 Collective-choice arenas	Multiple stakeholder/negotiated and transparent change logic	Intersectional coordination	Planning at all levels	Logistic and support for facilitating information exchange	Purpose driven/respect for diverse interests
4 Monitoring	Participatory and user-friendly monitoring	No clear targets	No clear targets	No clear targets	Implementation
5 Graduated sanctions	Clarification of rights and responsibilities	Environment regulations	A strong legal basis	Nuclear zones	Accountability
6 Conflict resolution should be easily accessible	Continual learning and adaptive management	Adaptive management	Planning systems should be flexible	No clear targets	Self-design/equal opportunity
7 Commons need the right to organize	Multifunctionality/strengthened stakeholder capacity	Innovative social and institutional arrangements	Land use planning/planning must involve participation	No clear targets	Voluntary participation
8 Nested enterprises	Multiple scales	Multiple grassroots organizations	Relevance of any international classification of protection/building a strong political and public constituency	No clear targets	Inclusive, not exclusive

^aWe used the same words presented in each reference; however, the cells were filled based on the explanation of the principle instead the meaning of the word. Therefore, although some words do not seem to be related with the Ostrom principles, one should verify the reference in order to check for consistence.

transgressions. In those cases where we confirmed that rules were broken, the consequence was a collapse of the collective management system, instead of the advent of a learning process that would improve future practices (e.g., Taquari flooding, Louzada et al., 2023).

Standards or procedures for conflict resolution (Design principle 6) were also lacking. In fact, we identified only one clear attempt to turn existing conflicts into learning opportunities: the fire legislation in the Mato Grosso state, which used local knowledge to establish a

new legislation. For most of the other examples, conflict has escalated to accusations, with no prospect of resolution. This lack of “collective learning” may be the reason for constant suspicion between conservation NGOs and cattle ranchers. It is essential to the sustainability of socio-ecological system that disputes lead to an environment of learning and positive discourse, otherwise it will always escalate to the point of dysfunction (Dietz et al., 2003).

“External recognition” (Design principle 7) of the historical sustainable use of natural resources in the

Pantanal were also not present. Instead, most actions were focused on protecting the natural resources by set aside strictly protected areas with no human presence. Only few actions were focused on celebrating the local practices. To succeed, conservation initiatives must incorporate local management strategies in tandem with a scientific and bioethical basis for establishing management rules. Recognition by external actors of local strategies would build trust around the importance of maintaining ecosystem services and biodiversity (Chiaravalloti et al., 2022).

Nested enterprises (Principle 8) started to emerge in the Pantanal, either through legislation or local groups. Yet this should be better celebrated. Despite being an enormous wetland, the Brazilian Pantanal is a complex ecosystem where the availability and distribution of natural resources are constantly changing. It is also occupied by groups with sometimes conflicting interests. Therefore, different solutions should be devised for different regions and groups, allowing for the growth of polycentric governance, and citizen participation at different levels or scales (Ostrom, 2007).

Finally, we also highlight the importance of using Ostrom's principles to generally evaluate the sustainability of a large, multi-stakeholder system. Whereas governance principles have historically been extensively debated for small-scale societies in scientific literature and practice (Forsyth & Johnson, 2014), the state of governance principles as applied to large, multi-stakeholders landscapes is still in its infancy (Brockington et al., 2018). There are at least 80 different concepts referring to the conservation of large and multi-stakeholder landscapes (e.g. eco-farming, smart landscape, sustainable production landscape, resilient biocultural landscape, whole landscape approach, multifunctional landscape, etc.), with each focusing on its own governance principles (Scherr et al., 2013). Herein, we show that Ostrom's design principles can in fact can be matched to existing concepts and strategies in the implementation of large, multistakeholder landscapes (Table 2).

5 | CONCLUSION

In this article, we evaluate the sustainability of the Brazilian Pantanal cattle ranching system through Ostrom's design principles. We show that there are at least five areas in which conservation should focus its efforts: biodiversity and behavior monitoring, graduated (putative) sanctions, conflict resolution processes, external recognition of practices, and nested enterprises. Therefore, although the Pantanal cattle ranching system is still a good case study of the sustainable use of natural

resources, there are some worrying signs that should be addressed or accounted for in future policy making, and conservation priority planning and actions.

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