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Essays and Perspectives

Human-wildlife conflicts in Brazil: Navigating through shared and spared landscapes

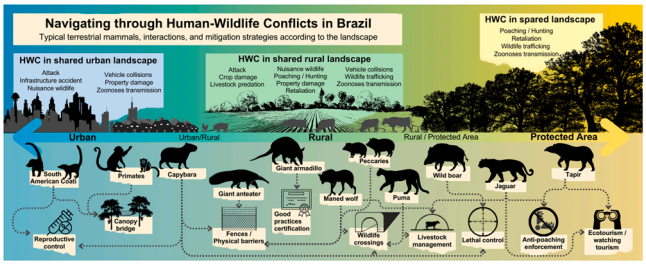
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HIGHLIGHTS

- Human-Wildlife Conflicts with iconic mammals in Brazil are highlighted.
- Main conflicts are divided between shared and spared landscapes.
- Calls for inclusive, community-driven paths to foster coexistence.
- Mitigation measures across species and landscapes are presented.

GRAPHICAL ABSTRACT



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ABSTRACT

Human-wildlife conflict (HWC) is a growing global and political concern as human activities expand into natural habitats. In Brazil, one of the world's most biodiverse countries, HWCs are a particularly complex and still neglected issue. This study highlights the typical HWCs in urban and rural (shared) and protected (spared) landscapes related to emblematic terrestrial mammals, emphasizing the importance of correct assessment and mitigation of their impacts, aiming for sustainable coexistence. Species-specific conflicts include livestock depredation by jaguar (*Panthera onca*) and puma (*Puma concolor*), crop damage by capybara (*Hydrochoerus*

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hydrochaeris) and tapir (*Tapirus terrestris*), and zoonotic disease transmission by capybaras, primates (*Sapajus* spp. and *Callithrix* spp.), and South American coati (*Nasua nasua*). Wildlife-vehicle collisions are a typical threat to several species, including the giant anteater (*Myrmecophaga tridactyla*) and the maned wolf (*Chrysocyon brachyurus*). The invasive species wild boar (*Sus scrofa*) further exacerbates HWCs, causing extensive ecological and economic impacts. Mitigation strategies include physical barriers, wildlife crossings, habitat modification, and community-based initiatives such as ecotourism and local engagement programs. However, the management of less studied conflicts, particularly those involving non-threatened or invasive species, remains inadequately addressed and concerning. This study underscores the need for integrated approaches that balance ecological, social, and economic considerations to promote human-wildlife coexistence. Bridging knowledge gaps through research, stakeholder collaboration, and inclusion of overlooked species and conflicts is essential to evidence-based policies and mitigation strategies. By addressing both human and wildlife needs, conservation efforts in Brazil can create a coexistence paradigm that benefits biodiversity and human communities together.

Introduction

Humanity's expansion has transformed natural landscapes into shared and spared areas (McKee et al., 2004). Shared landscapes are spaces where human activity and wildlife overlap, often leading to interactions, while spared landscapes are regions designated for conservation with minimal human interference (Fischer et al., 2014). As human settlements grow, interactions between people and wildlife increase, driven by proximity and competition for natural resources (Marchini and Crawshaw, 2015). With the global human population increasing, such conflicts are expected to escalate in the coming years (Ma et al., 2024).

Human-wildlife conflicts (HWC), which arise when wildlife behavior and presence pose threats to human interests or safety, have become a pressing global issue (IUCN, 2023; Secretariat of the Convention on Biological Diversity, 2022). Beyond the immediate impacts on livelihoods and ecosystems, these conflicts heighten tensions among stakeholders with differing views on biodiversity management (Young et al., 2010). Responses to HWC often remain reactive, addressing critical hotspots while neglecting systemic challenges (Marchini et al., 2021). The International Union for Conservation of Nature (IUCN) advocates for proactive, balanced approaches that minimize harm and promote coexistence (Zimmermann and Stevens, 2021; IUCN, 2023).

In Brazil, one of the most biodiverse nations on Earth, the contrast between shared and spared landscapes is striking. Spared landscapes typically include legally protected areas, which cover only a fraction of the country's territory.[1] These areas are often embedded within rural regions dominated by agriculture and livestock farming, Brazil's economic backbone. This proximity creates hotspots for human-wildlife interactions (HWI) (Marchini and Crawshaw, 2015), including livestock depredation by jaguars and pumas or crop damage by peccaries (Sowls, 1997; Carvalho and Pezzuti, 2010). Shared landscapes, such as urban parks, agricultural fields, and suburban areas, host more direct HWI. These spaces often see overlapping resource use, leading to conflicts such as crop damage by capybaras (Ferraz et al., 2003) or wildlife-vehicle collisions (WVCs) with species like tapirs and anteaters in areas with high road density (Abra et al., 2020).

The urgency of addressing HWC is amplified by the uneven attention given to conflicts and species in research and policy, especially in the Neotropics. High-profile conflicts often gain visibility due to economic or ecological implications, while others remain underreported, silently escalating and threatening livelihoods and biodiversity. This article spotlights Brazil's emblematic terrestrial mammal species and their roles in HWC across urban, rural, and natural landscapes. Additionally, we highlight the underrepresentation of certain species or taxa in the scientific literature, particularly non-threatened species, despite their significant role in HWI. By synthesizing these dynamics, we aim to inspire inclusive and effective strategies for human-wildlife coexistence (HWCo).

[1] https://cnuc.mma.gov.br/.

Brazil's most emblematic terrestrial mammal species

In this section, we selected typical species that play significant roles in the context of HWC in Brazil. For each species, we summarize their ecological and behavioral traits, landscape distribution (urban landscapes, rural landscapes, natural landscapes), and the most significant forms of HWC in which they are involved (Fig. 1).

Capybara (Hydrochoerus hydrochaeris)

The capybara, the largest rodent in the world, is an herbivorous, highly social, and prolific species common in natural landscapes only found near water bodies and grasslands (Herrera and Macdonald, 1989). The low densities of apex predators and the great availability of anthropogenic food sources, such as grasslands, cornfields, and neighborhood lawns, are responsible for the high growth rate of capybara populations, resulting in their high densities in rural and urban landscapes (Lopes et al., 2021).

The most significant conflicts with capybaras are related to zoonotic disease transmission, such as Brazilian Spotted Fever (Labruna, 2013), crop damage (Ferraz et al., 2003), and WVC, with capybaras being the most frequently run-over species in southeastern Brazil (Huijser et al., 2013). All these conflicts are related to the overabundant capybara populations in urban landscapes. Due to zoonotic disease conflicts, capybara management (reproductive or lethal control, according to risk classification for each area) may be authorized by environmental agencies to prevent zoonosis (São Paulo State, 2023), with the purpose of controlling population growth rate, disease risk, and conflict. Especially when lethal control is recommended, being aware of past conflicts between different groups of people over what to do with the capybara is relevant for decision makers.

Giant anteater (Myrmecophaga tridactyla)

The giant anteater is classified globally as Vulnerable and Brazil's official conservation index due to its declining populations (IUCN, 2024; MMA, 2022). It inhabits tropical forests, savannas, and open grasslands, with a geographic distribution ranging from Central America to northern Argentina (Miranda et al., 2014). This predominantly terrestrial and solitary mammal is highly specialized, feeding almost exclusively on ants and termites (Redford, 1985). The feeding habit makes the giant anteater a key regulator of insect populations, contributing to ecosystem balance (Redford, 1985).

Conflict with this species is mostly WVC due to its large size and slow movements, particularly in rural landscapes with high road densities such as the Cerrado and Atlantic Forest biomes (Ascensão and Desbiez, 2022). The *Bandeiras e Rodovias Project*[2] assesses road impacts on wildlife, identifying conflict zones and proposing mitigation to reduce

[2] https://www.icasconservation.org.br/projetos/bandeiras-e-rodovias/?lang=en.

roadkill and habitat fragmentation. Additionally, giant anteaters are involved in conflicts that include occasional attacks on humans and domestic animals (Haddad et al., 2014; Bertassoni, 2012), as well as retaliatory killing motivated by folkloric beliefs (Bertassoni, 2012).

Giant armadillo (Priodontes maximus)

The giant armadillo, the largest living armadillo species, is endemic to South America and is adapted to diverse ecosystems, including

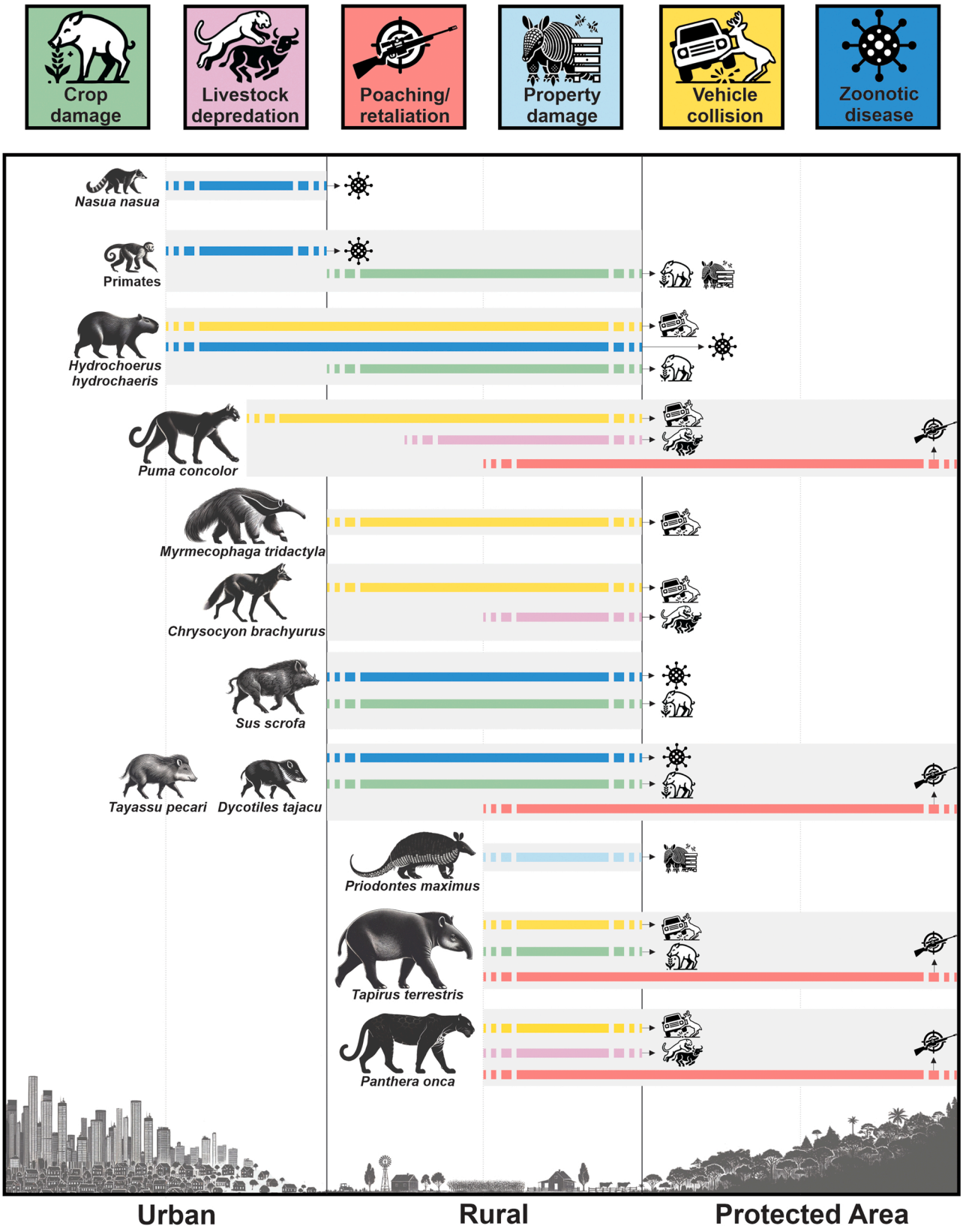


Fig. 1. Illustration of the most typical human-wildlife conflicts with terrestrial mammal species across shared and spared landscape gradients in Brazil.

tropical forests, savannas, and wetlands (Lemos et al., 2018). Classified as Vulnerable by the IUCN (IUCN, 2024), its global population is declining due to threats such as habitat loss, poaching, WVC, and illegal wildlife trade (Desbiez and Attias, 2022). This species plays a crucial ecological role as ecosystem engineers once their burrows provide shelter and resources for over 70 other species, contributing to biodiversity and maintaining ecosystem health (Desbiez and Attias, 2022).

Human-giant armadillo conflicts primarily involve property damage in rural landscapes, particularly to apiaries in the Cerrado biome, resulting in significant economic losses for beekeepers (Desbiez et al., 2020). This has led to retaliatory killings that further threaten the species. In response, the *Canastras e Colmeias Project*[3] has successfully implemented strategies to reduce such conflicts. Additionally, giant armadillos are known hosts of *Amblyomma sculptum* ticks, raising concerns about potential disease transmission between wildlife and domestic animals (Miranda et al., 2010).

Jaguar (Panthera onca)

The jaguar, the largest felid in the Neotropics, is an apex predator vital for maintaining ecosystem health. It is currently classified as Near Threatened by the IUCN (IUCN, 2024) and Vulnerable in Brazil's official conservation index (MMA, 2022), with most subpopulations endangered or critically endangered (de la Torre et al., 2018).

Historical deforestation and the conversion of landscapes into pastures have exacerbated human-jaguar conflicts (Quigley et al., 2023), particularly in rural landscapes and natural landscapes edges. One of the greatest threats to jaguar populations is killing, primarily driven by conflicts related to livestock farming and subsistence hunting (Quigley et al., 2023). Livestock depredation is the most significant driver of big cat hunting and persecution (Carvalho and Pezzuti, 2010), as both the real and perceived threats to livestock impact most felid species (Inskip and Zimmermann, 2009), but other local factors (Marchini and Macdonald, 2012) also contribute to the killing of jaguars. Poaching during chance encounters (Carvalho and Pezzuti, 2010) and to supply local (Arias et al., 2024) and international trade markets (Morcatty et al., 2020) can happen during subsistence hunts, though the impact is generally low on a large scale (Jędrzejewski et al., 2017). WVC is another important conflict, especially in the Atlantic Forest (Srbek-Araujo et al., 2015). Lastly, attacks on humans by jaguars are extremely rare (Marchini and Macdonald, 2012), with very few reported cases in Brazil.

Lowland Tapir (Tapirus terrestris)

The largest terrestrial mammal in South America, the lowland tapir is classified as Vulnerable by both the IUCN (IUCN, 2024) and Brazil's official conservation index (MMA, 2022). The lowland tapir is a generalist herbivore that plays a critical role as a seed disperser and ecosystem engineer in Neotropical forests (Padilla and Dowler, 1994). Highly adaptable to diverse habitats, including rainforests, grasslands, and wetlands, the species has a wide distribution across South America (dos Santos et al., 2020). However, this adaptability often brings tapirs into conflict with humans, particularly in rural and natural landscapes, where natural and agricultural areas intersect.

Among the most significant threats to the species are WVC, especially in the Cerrado and Atlantic Forest biomes, where expanding road networks fragment critical habitats (Abra et al., 2020). Due to their large size, these accidents pose a dual risk to tapir populations and human safety. Retaliatory killing, poaching, and hunting for cultural or medicinal purposes further threaten the species, with some practices deeply rooted in local traditions (Flesher and Medici, 2022; Paolino et al., 2024). Crop damage is another common source of conflict, leading to economic losses for farmers (Flesher and Medici, 2022).

Maned wolf (Chrysocyon brachyurus)

The maned wolf, the largest wild canid in Brazil, is classified as a Near Threatened species by the IUCN (IUCN, 2024) and Vulnerable by Brazil's official conservation index (MMA, 2024b). Endemic to South America, it was historically distributed across the Cerrado, Pampa, and Chaco regions, preferring open grasslands and savanna habitats (Coelho et al., 2008). However, anthropogenic pressures such as cattle ranching and deforestation in the Atlantic Forest biome have driven the species' distribution further eastward in Brazil (Queirolo et al., 2011). The maned wolf is an omnivorous species with a diet that consists largely of fruits, small vertebrates, and insects, making it an important seed disperser in its ecosystems (Bueno et al., 2002). As natural habitats shrink, human-maned wolf interactions have intensified, particularly in rural and urban landscapes, increasing the frequency of conflicts (Hilário et al., 2021).

The most common conflicts involve poultry predation, resulting in economic losses for rural communities and occasionally triggering retaliatory killings (Bickley et al., 2020). With a large home range and low population density, maned wolves often cross highways, where WVC constitute a significant cause of mortality (Barbosa et al., 2020). Encounters with domestic dogs also pose risks, as they can lead to disease transmission such as sarcoptic mange and canine parainfluenza (Fiori et al., 2023).

Peccaries (Tayassu pecari and Dycotiles tajacu)

Peccaries, including white-lipped peccaries (*T. pecari*) and collared peccaries (*D. tajacu*), are widely distributed across Brazilian biomes. *T. pecari* is classified as Vulnerable by the IUCN, whereas *D. tajacu* remains classified as Least Concern (IUCN, 2024). Both species play pivotal roles in Neotropical ecosystems as seed dispersers and fruit predators, helping maintain forest dynamics (Keuroghlian et al., 2009). However, increasing human-peccary conflicts present significant risks to their conservation status (Marinho et al., 2019).

Hunting and retaliatory killing in rural and natural landscapes are among the most severe threats to peccaries, often driven by crop damage or competition for natural resources (Marinho et al., 2019). Additionally, peccaries are known to harbor and transmit pathogens, including those shared with domestic swine, such as *Brucella* and *Leptospira* spp., posing potential risks to public health and livestock (de Castro et al., 2014; Baraldi et al., 2019). Other conflicts involving peccaries include property damage, WVC, and occasional aggressive encounters (Sowls, 1997; Grilo et al., 2018). Such incidents have increased with the expansion of human settlements into wildlife habitats, particularly along the edges of protected areas, exacerbating human-wildlife interactions (Treves, 2008).

Primates (Sapajus spp. and Callithrix spp.)

Primates are widely distributed across Brazil, occupying shared and spared landscapes (Estrada et al., 2017). The conservation status of the species varies, with *C. jacchus* and *C. penicillata* listed as Least Concern, while *S. libidinosus* and *S. nigritus* are classified as Near Threatened (IUCN, 2024). They have a central ecological role, contributing to tropical biodiversity, forest regeneration, and ecosystem balance (Estrada et al., 2017). Their behavioral flexibility and dietary adaptability facilitate their survival in diverse habitats, from urban parks to agricultural lands. This adaptability to different environments has also led to increasing HWC, particularly involving the aforementioned species.

In rural landscapes, capuchins are known to raid crops such as corn and sugarcane (Freitas et al., 2008) and damage commercial pine and

[3] https://www.icasconservation.org.br/projetos/canastras-e-colmeias/?lang=en.

eucalyptus plantations by stripping bark to feed on the phloem, which slows tree growth and causes economic losses (Liebsch and Mikich, 2015; Mikich and Liebsch, 2017). In urban landscapes, both capuchins and marmosets access anthropogenic food, either provided intentionally by humans or scavenged from waste (Lousa et al., 2024). These interactions increase the risk of conflicts, including aggressive encounters that pose health risks, such as rabies transmission, which has been documented in marmosets (Benavides et al., 2022), or human diseases transmitted to wild primates, such as herpes (Ehlers et al., 2021; Wilson et al., 2022). As primates navigate fragmented landscapes, they face hazards such as electrocution from power lines and WVC (Pereira et al., 2019; Pessanha et al., 2023). Another severe threat is illegal wildlife trade. Between 1999 and 2006, marmosets and capuchins were the most trafficked primates in Brazil (Levacov et al., 2011).

Puma (Puma concolor)

The puma, the second largest felid of the Americas, is classified as Least Concern by the IUCN (IUCN, 2024) and Not Threatened in Brazil, except in certain states (Azevedo et al., 2023). As the most widely distributed terrestrial mammal in the western hemisphere (Sunquist and Sunquist, 2002), the puma exhibits remarkable adaptability. It is a generalist hypercarnivore with a highly versatile diet (LaBarge et al., 2022), capable of surviving close to urban landscapes (Moss et al., 2016). Evidence that pumas have high behavioral plasticity (Magioli et al., 2014) and increasing sightings of the species in unexpected urban landscapes in Brazil (Marchini and Crashaw, 2015), with associated captures and translocations (Guerisoli and Schiaffini, 2022), contributes to the rise of human-puma conflicts in rural and urban landscapes.

Livestock depredation is one of the primary causes of conflicts with pumas (Carvalho and Pezzuti, 2010), often leading to retaliatory killings (Díaz-Vaquero et al., 2024). However, this conflict is generally restricted to rural landscapes, where livestock farming predominates. WVC also happens in many regions around Brazil (Grilo et al., 2018), and sightings near cities raise concerns about the safety of people and domestic animals. Although attacks on people have been documented (Guerisoli and Schiaffini, 2022), they are rare, and, to date, no fatalities have been reported in Brazil. Lastly, the illegal trade of puma specimens or body parts in Brazil does exist, but they are infrequent and stable (Morcatty et al., 2020).

South American coati (Nasua Nasua)

The South American coati is native to South America and widely distributed across all Brazilian biomes. It is considered a common and highly adaptable species (Beisiegel and Campos, 2013), and its conservation status is Least Concern (IUCN, 2024). It is an omnivorous species with a highly flexible diet that includes arthropods, fruits, organic waste, and small vertebrates (Alves-Costa et al., 2004). Its dietary plasticity is further demonstrated by observations of coati groups frequently feeding on food scraps discarded in garbage cans in urban landscapes (Barreto et al., 2021; Ferraz et al., 2025), such as parksand in recreational places inside natural landscapes (Rodrigues et al., 2021).

Consumption of human food can impact their health and increase the risk of zoonotic disease transmission (Rodrigues et al., 2023). The growth of coati populations in urban landscapes has intensified conflicts with humans, making people consider this species as nuisance fauna. People also fear being attacked by coatis, even though reports are rare (Bittner et al., 2010). Human-coatis interactions remain underreported in the scientific literature (Ferraz et al., 2025), with most records found in gray literature or by personal communication of managers, researchers, and visitors to both urban landscapes and natural landscapes.

Wild boar (Sus scrofa)

The wild boar, an exotic and invasive species in Brazil, is now found across all biomes after escaping captivity and establishing feral populations (Hegel et al., 2022). Its high reproductive rate, omnivorous diet, and adaptability have allowed it to thrive and outcompete native fauna, posing severe ecological and economic challenges (Doutel-Ribas et al., 2019). Their presence has been linked to significant damage in rural landscapes, where they destroy crops like corn and sugarcane, damage infrastructure such as fencing and irrigation systems, and compete with livestock for resources (Pedrosa et al., 2015).

Conflicts between humans and wild boars are intensifying, particularly in rural landscapes, where economic losses from crop destruction are substantial. Their aggressive behavior makes them a direct threat to human safety, as evidenced by documented attacks, including fatal incidents in Brazil (Marchini and Crawshaw, 2015). Wild boars are also reservoirs for diseases like brucellosis and tuberculosis, which they can transmit to humans and livestock, posing serious public health and economic risks (Silva et al., 2022).

Navigating from conflict to coexistence

This paper presents emblematic cases of HWCs across shared and spared landscapes, emphasizing their socio-ecological complexity. While each conflict involves specific species and stakeholders, common patterns emerge, highlighting opportunities for scalable, context-sensitive mitigation strategies.

From species-specific challenges to conflict typologies

The diversity of species involved in HWCs, ranging from jaguars and wild boars to capybaras and coatis, illustrates a wide spectrum of ecological and social dynamics. In rural landscapes, economic losses from crop raiding and livestock depredation often result in retaliatory killings (Quigley et al., 2023; Pedrosa et al., 2015). In urbanized areas, species such as capybaras, coatis, and primates raise public health concerns due to zoonotic disease transmission and aggressive interactions (Labruna, 2013; Benavides et al., 2022; Ferraz et al., 2025). Across all landscapes, WVC remains a pervasive threat to both biodiversity and human safety (Grilo et al., 2018).

Despite this diversity, HWCs can often be categorized into broader typologies, such as predator-livestock (e.g., jaguars and pumas), crop raiders (e.g., capybaras, lowland tapirs, peccaries), zoonotic disease vectors (e.g., primates, South American coatis), and invasive species (e.g., wild boar). These typologies enable the development of more scalable and generalizable policy frameworks, while maintaining flexibility for localized patterns that require specific adaptations for problem-animal management (see Supplementary Material Table SM1). For instance, large carnivores and herbivores in rural landscapes typically provoke economic conflicts, while overabundant or charismatic species generate disputes between stakeholder groups over ethical or practical control measures (Crowley et al., 2017).

Notably, these patterns are not unique to Brazil. Similar conflicts are documented across other biodiverse countries in South America, such as Argentina, Bolivia, Colombia, and Peru, involving species like pumas (*Puma concolor*), spectacled bears (*Tremarctos ornatus*), and capybaras (*Hydrochoerus hydrochaeris*), particularly along agricultural frontiers and rural–forest mosaics. In these regions, institutional weaknesses, lack of systematic monitoring, and fragmented governance are common challenges (García-Alaniz et al., 2017; Nyhus, 2016). Furthermore, comparative studies have emphasized the role of local cultural perceptions and historical relationships with wildlife in shaping conflict responses (Espinosa and Jacobson, 2012). These shared conditions underscore the value of cross-country collaboration and knowledge exchange in designing context-sensitive yet scalable coexistence strategies that address the socio-ecological realities of South America.

From a governance perspective, conservation decisions are frequently shaped by trade-offs, resource constraints, and political dynamics. In this context, the typological approach supports more

practical and adaptive decision-making. Scalable, evidence-based frameworks, especially those grounded in social-ecological system thinking, are needed to navigate these complexities while acknowledging local diversity.

Mitigation and coexistence strategies: toward scalable and systemic solutions

A variety of mitigation tools have been applied across Brazilian landscapes, often with varying levels of effectiveness. Collectively, these strategies illustrate that while no single measure fits all scenarios, a suite of mitigation tools, tailored to ecological context, stakeholder dynamics, and institutional capacity, offers promising pathways to reduce conflict (Soto-Shoender et al., 2021). The challenge lies not only in tool development, but in ensuring institutional coordination, funding continuity, and adaptive governance to monitor and improve implementation over time (Marchini and Macdonald, 2012).

Physical barriers, such as electrified fences and wildlife crossing have proven effective at reducing livestock predation and road mortality, but it can be costly and require maintenances (Vercauteren et al., 2006; Abra et al., 2020). Complementary measures, such as planting non-preferred vegetation, can discourage species from accessing highways and urban parks (Nogueira et al., 2024). For overabundant species like capybaras, which threaten the economy and public health, environmental agencies may authorize reproductive or lethal control under specific conditions (São Paulo State, 2023). Although it remains controversial and can undermine conservation messaging if not coupled with monitoring and public transparency.

Community engagement and education are pivotal in fostering coexistence, as they help transform attitudes, change paradigms, and promote protagonism among those involved. Well-succeed Coexistence Programs like *Amigo do Lobo*[4] (maned wolves) and *Canastras e Colmeias* (giant armadillos) demonstrate the importance of involving local stakeholders in conservation, reducing conflicts by aligning conservation objectives with local values, traditions, and livelihoods. These programs emphasize community-based monitoring, knowledge exchange, and stakeholder empowerment, elements often missing from top-down mitigation policies.

The establishment of a close relationship based on trust, respect, and appreciation for diverse types of knowledge has proven to be a valuable tool in planning and implementing actions to mitigate HWC in coexistence projects. These are strategies employed by the *Onças do Iguaçu* Project. The initiative has achieved positive ecological results, such as reducing retaliatory hunting and increasing jaguar populations. It has also generated social benefits, including greater tolerance among people and the socioeconomic development of communities linked to human–wildlife coexistence.

Ecotourism provides a pathway to transform conflicts into conservation opportunities, generating income and fostering positive attitudes toward wildlife. The *Onçafari* Project[5] in the Pantanal exemplifies how jaguar-focused tourism can reduce retaliatory killings and shift local perceptions. Still, such initiatives face limits in urban or peri-urban landscapes, where habituation and incidental captures remain major risks (Guerisoli and Schiaffini, 2022).

For invasive species like wild boars (*Sus scrofa*), lethal control remains a widely used strategy in Brazil (IBAMA, 2013). However, its long-term efficacy and ethical implications are increasingly debated. Population rebound, dispersal to new areas, and disruption of social structures are common unintended consequences of lethal removal (da Cunha Nogueira et al., 2007). As such, there is growing interest in alternative, more sustainable approaches. Reproductive management, such as immunocontraception, has shown promise in reducing population growth rates without the ethical and ecological costs associated with culling, although logistical and financial barriers remain (Massei and Cowan, 2014). Habitat modification, including the removal of food attractants and the use of exclusion fencing in conflict-prone zones, can reduce human–wild boar interactions and crop damage (Barrios-Garcia and Ballari, 2012). Together, these approaches offer integrative solutions that balance ecological integrity, animal welfare, and socioeconomic concerns.

While mitigation strategies and species-specific action plans offer important tools, they are not sufficient to address the full scope of HWC in Brazil. Several National Action Plans (NAPs) incorporate HWC as objectives and goals to be prioritized and managed. The NAPs for Big Cats, Canids, and Ungulates include actions targeting anti-poaching enforcement, WVC mitigation, disease control, and community engagements (MMA, 2024a, b).

The National Plan for Wild Boar Control and Damage Mitigation provides technical recommendations and promotes collaboration among stakeholders, including farmers, protected area managers, and certified hunters (MMA and MAPA, 2017). However, such frameworks remain fragmented and uneven, with many conflict-prone species, particularly non-threatened or invasive ones, lacking coordinated management plans.

Rethinking conflict management: from fragmented responses to systemic coexistence

Many conflicts, especially those involving non-threatened or generalist species, go underreported and unaddressed, particularly in rural landscapes near natural areas. This gap is exacerbated by the absence of systematic monitoring, the limited incorporation of gray literature and local ecological knowledge, and a bias toward more “charismatic” or threatened species, even though others (e.g., snakes, parrots, bats) may play key roles in zoonotic dynamics and human perceptions of conflict (Ferraz et al., 2025).

To move forward, we argue that HWC must be addressed through a socio-ecological systems approach that sees conflict not as isolated events, but as outcomes of complex, dynamic interactions among wildlife ecology, land use, governance structures, and social values (Schultz et al., 2015; Carter and Linnell, 2023). This perspective demands integrated, adaptive responses that move beyond reactive or sectoral logics. For instance, while initiatives like *Amigo do Lobo* and *Canastras e Colmeias* exemplify successful local partnerships and the co-production of knowledge, their long-term effectiveness hinges on institutional continuity, funding, and legal clarity. Similarly, citizen science and participatory monitoring have shown promise for democratizing data and building legitimacy for coexistence strategies (Marchini et al., 2021, 2024).

A key dimension that remains insufficiently explored in HWC literature is how different landscape configurations, particularly land-sharing versus land-sparing approaches, shape the types, intensities, and governance challenges of these conflicts. While the land-sharing vs. land-sparing debate has been widely discussed in relation to biodiversity conservation and agricultural production (Fischer et al., 2014), there is a marked gap regarding how these spatial strategies influence the emergence, persistence, and resolution of conflicts with wildlife.

Our study introduces this conceptual distinction not to revisit the debate per se, but to highlight its relevance in shaping socio-institutional and ecological conditions for conflict. Shared landscapes are characterized by overlapping land uses, fragmented governance, and heterogeneous human-wildlife interactions. These areas are often sites of chronic conflicts shaped by complex socio-political histories, cultural perceptions of wildlife, and limited state presence. In contrast, spared landscapes operate under stricter regulatory regimes. While they may limit direct anthropogenic pressures, they often suffer from rigid institutional mandates, resource constraints, and jurisdictional mismatches, making it difficult to respond adaptively to transboundary or edge-based

[4] https://linktr.ee/amigodolobo.
[5] https://oncafari.org/en/.

conflicts (e.g., livestock predation, crop raiding, retaliatory killings).

Despite their institutional and ecological interdependence, few empirical studies have systematically analyzed how HWC dynamics unfold across these landscape types, particularly in the Brazilian context. This represents a conceptual and practical blind spot. By identifying how different governance regimes, land tenure systems, and socio-political histories intersect with landscape configuration, future research can uncover key leverage points for cross-scale coordination, institutional innovation, and more context-sensitive policy design.

To support more effective coexistence strategies, we propose that HWC governance be embedded as a cross-cutting axis in environmental and territorial policy. This involves integrating conflict risk assessment and mitigation planning into instruments such as ecological-economic zoning, biodiversity strategies, and environmental licensing procedures. Public funding mechanisms, including rural credit, environmental compensation, and payments for ecosystem services, should be redirected to support landholders who adopt evidence-based coexistence practices, such as predator-proof enclosures, wildlife-friendly fencing, or deterrent systems. In parallel, technical assistance and rural extension programs must be strengthened to disseminate context-appropriate, low-cost mitigation technologies. Clarifying the legal frameworks that govern the management of synanthropic, overabundant, or invasive species (e.g., *Sus scrofa*) is also essential to avoid regulatory ambiguity and ensure coordinated responses.

Finally, national and regional platforms for HWC monitoring and early warning should be established, combining citizen science, local knowledge, and institutional cooperation. Embedding feedback and evaluation mechanisms into HWC interventions can foster adaptation and learning over time. Only through such systemic and reflexive governance can Brazil move from fragmented, reactive responses to a model of coexistence that is resilient, inclusive, and ecologically grounded.

Bridging knowledge gaps

Effective HWC management in Brazil faces significant challenges due to underreporting and limited assessment of conflicts, especially in rural landscapes near natural landscapes and for non-endangered species. Many interactions are documented only in gray literature or through anecdotal accounts, restricting the data available for evidence-based policies and mitigation strategies. Less “charismatic” species (snakes, parrots, and bats) are often excluded from broader discussions, despite their ecological importance and cultural impact. Neglecting these interactions risks overlooking critical public health concerns, such as zoonotic disease transmission, and the vital ecological roles these species play.

To address these gaps, systematic monitoring and assessment programs are essential (Ferraz et al., 2025). Such programs can identify conflict patterns and establish baselines for evaluating the effectiveness of mitigation measures. While wildlife crossings and barriers are widely implemented, their effectiveness in mitigating HWC remains poorly understood. Similarly, population control measures for overabundant species like capybaras and wild boars require ongoing evaluation to ensure they achieve desired outcomes without unintended ecological consequences. Furthermore, the effectiveness of educational actions to change behavior, attitude, and perception needs to be monitored and evaluated.

Co-producing knowledge with non-academic stakeholders is crucial to bridging the gap between science and practice towards coexistence (Zimmermann and Stevens, 2021). Collaborative efforts, such as participatory workshops and citizen science programs, involve local communities, farmers, conservationists, and policymakers, tailoring strategies to regional needs while fostering shared responsibility for conservation (Marchini et al., 2021). These initiatives not only improve data collection but also integrate local ecological knowledge, offering valuable insights into species behavior and conflict patterns often overlooked in formal studies. By addressing these gaps, HWC research can better inform actionable policies and align conservation goals with human well-being. Programs like *Amigo do Lobo* and *Canastras e Colmeias* show the value of co-produced knowledge and stakeholder engagement, while citizen science and participatory monitoring have helped integrate local ecological knowledge into decision-making (Marchini et al., 2021, 2024).

Final considerations

This article highlights emblematic terrestrial mammal species involved in HWCs across spared and shared landscapes in Brazil, while also underscoring the broader governance and data challenges that hinder effective conflict resolution. Overcoming these challenges requires moving beyond isolated mitigation tools toward systemic, scalable, and context-sensitive strategies rooted in socio-ecological resilience.

By emphasizing the ecological, economic, and social dimensions of HWC and drawing on successful examples of stakeholder engagement, participatory science, and adaptive governance, this paper calls for a rethinking of conservation priorities in the Global South. Promoting transdisciplinary research, inclusive community engagement, and ongoing monitoring will be crucial to building durable coexistence pathways.

Only by treating each conflict as both context-specific and structurally connected to broader patterns can Brazil ensure that its conservation efforts are both effective and equitable, matching the scale of its biodiversity and the complex challenges it faces.

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CRediT authorship contribution statement

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Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.pecon.2025.08.004.

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