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# Conservation frontiers: understanding the geographic expansion of conservation

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## ABSTRACT

Land-use frontiers, such as agriculture expanding into forests, remain a major driver of biodiversity loss, and often lead to conservation responses. To better understand the geographies of conservation, connecting conservation with tools used widely in Land System Science – particularly the frontier concept – allows assessing the patterns, actors, and drivers of conservation. We propose that land conservation can be analysed through three different perspectives. First, conservation can be framed as efforts to slow or stop other frontiers. Second, the expansion of conservation could itself be described as a frontier process, similarly leading to institutional and cultural reorganization, and sometimes conflicts (e.g. green grabbing). Third, frontiers can be seen as spaces where multiple land uses, including conservation, interact. Analysing conservation through these perspectives could be particularly powerful to thoroughly consider the social-ecological contexts in which conservation happens, and thus to bridge the disciplines of Land System Science and Conservation Science.

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## Introduction

Land-use change, and particularly the expansion of agriculture into natural ecosystems, is the principal driver of biodiversity loss (Laurance et al., 2014; Newbold et al., 2015). These losses occur on all levels of biological organization, from the loss of genetic variation to populations to entire ecosystems, suggesting a human-triggered mass extinction event (Dirzo et al., 2014; Johnson et al., 2017; Pimm et al., 2014). Biodiversity loss is of major concern, because of the intrinsic value of biodiversity, and because biodiversity underpins the many contributions of nature to humankind (Díaz et al., 2018; MEA, 2005). Pressure from land-use change is expected to increase further as human population grows and demand for land-based products surges (Kehoe et al., 2017; Leclère et al., 2020). Halting and reversing biodiversity loss on the one hand and shifting to more sustainable land use on the other, are therefore two, deeply intertwined major challenges of the 21<sup>st</sup> century.

As pressure on biodiversity has been increasing, so have global conservation efforts. The extent of protected areas has increased four-fold between 1970 and 2020, now covering 17% of the terrestrial land surface (UNEP-WCMC & IUCN, 2021), making conservation a major land use (Maxwell et al., 2020). In parallel, bold global conservation policies that seek further protected areas expansion have

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been proposed (e.g. Díaz et al., 2020; Johnson et al., 2017). The goals, approaches and outcomes of conservation have also diversified considerably over the last decades. Whereas conservation has historically mainly aimed to protect species or ecosystems, central goals of conservation today include ensuring sustainable natural resource use, achieving livelihoods and well-being objectives, and maintaining globally-important ecosystem services, such as carbon storage or climate stability (Kremen & Merenlender, 2018; Mace, 2014). Conservation efforts have both supported local land rights struggle and created them, leading to conflict or displacement of people and land uses (Schwartzman & Zimmerman, 2005; Spence, 1999). Conservation efforts are also diversifying by increasingly relying on private, subsidies and incentives-based approaches, expanding the network of actors, including land use actors, that convey conservation goals (Adams, 2019; Fairhead et al., 2012). Finally, just like other land uses, conservation has been globalizing, with an increasing amount of conservation funding spent internationally, and conservation projects increasingly targeting areas in the Global South, where commodity agriculture expands (Kuemmerle et al., 2019; Laurance et al., 2014; Waldron et al., 2013).

Despite these clear links between the expansion of conservation and of other land uses, research has assessed these two processes so far largely separately. Land system science, the discipline dealing with understanding the patterns, drivers and outcomes of land-use change, has typically treated conservation as exogenous, static and binary (e.g. protected areas vs. other land). Conversely, Conservation Science, and here particularly conservation planning, typically approximates land use through land cover, for example to understand the impact of land use on biodiversity or to allocate area-based conservation measures. This neglects key systemic aspects of land use, such as land-use dynamics, the actor networks that drive these dynamics, or the linkages and feedbacks that exist across scales both in terms of drivers and outcomes of land-use change (Verburg et al., 2013). Considering land as an integrated social-ecological system, which is at the core of Land System Science, therefore has considerable potential for improving how land use is treated in conservation and vice versa (Cumming & Allen, 2017; Iwamura et al., 2018; Verburg et al., 2013).

A widely used notion in Land System Science is the 'frontier', broadly conceived as spaces with abundant resources and rapid expansion of land use to exploit these resources (Barbier, 2010; Meyfroidt et al., 2018; Le Polain de Waroux et al., 2018; Rindfuss et al., 2007). Developing methodological and theoretical approaches to understand land-use dynamics in frontiers, the role of distinct actors and institutions, and how to intervene in such frontier contexts has been a priority in Land System Science (Eigenbrod et al., 2020; Le Polain de Waroux et al., 2018; Rindfuss et al., 2007). Land-use frontiers have an evident connection with conservation, given that in many frontier regions biodiversity, nature or ecosystem services are lost rapidly (Pacheco et al., 2021). Simultaneously, conservation actors and agencies aspire to increase the footprint of conservation, particularly where biodiversity is considered as under threat. We still lack a proper conceptualization of the interactions between land-use frontier dynamics and expanding conservation efforts in such frontiers.

Building on the rich theoretical toolbox that accompanies frontier concepts, we here articulate the concept of 'conservation frontiers' as a way to understand the integrated geographies of expanding conservation within other land uses. Prior work has highlighted the potential value of frontier concepts, for example, to analyse territorialization processes of conservation efforts, or the appropriation of land for environmental concerns (e.g. Alvarado, 2019; Bluwstein & Lund, 2018; Freitas, 2020; Guyot, 2011; Schmink et al., 2019). Building on this body of research, we here use frontier conceptualizations common in Land system Science to propose three perspectives in which the notion of conservation frontiers can help to understand the relations between the expansion of conservation and other land uses: (1) conservation as a response to advancing land-use frontiers, (2) conservation as an expanding frontier in itself, and (3) conservation as embedded in land use frontier processes. For this purpose, we draw from LSS and conservation science and as well political ecology, anthropology and human geography research where conservation actors', institutions, technologies

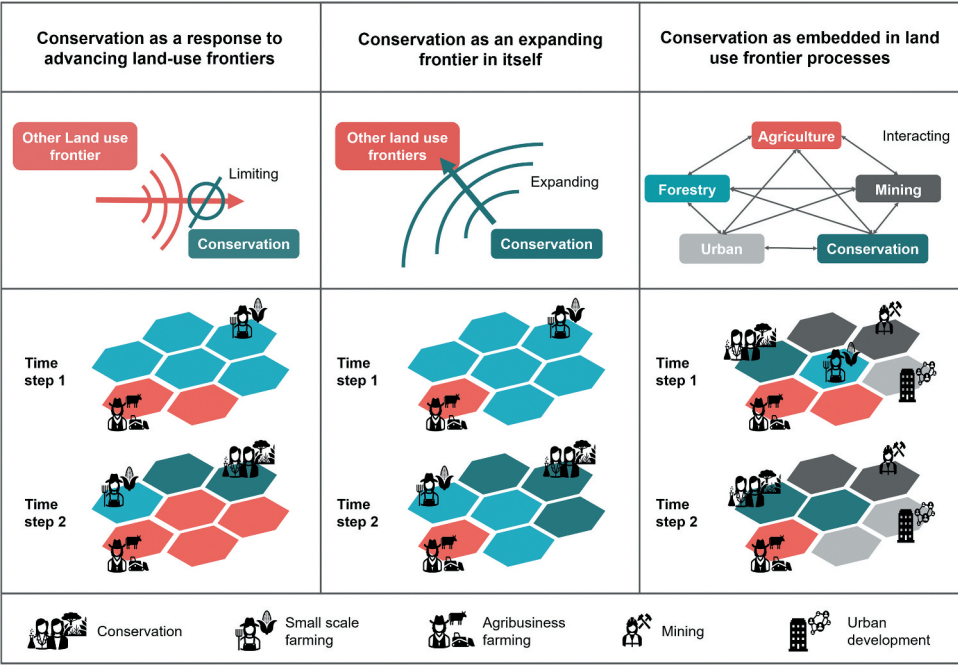
and their interactions have been more extensively examined, to develop the conceptual framework of conservation frontiers. We then examine the three perspectives by which conservation frontiers could be assessed and understood.

## A conceptual framework of conservation frontiers

Broadly conceived, frontiers occur where natural resources are still abundant. Often, these resources remain unexploited due to the relative scarcity of production factors, such as labour or capital, or other constraints, such as a lack of infrastructure or a history of conflict (Barbier, 2010; Kronenburg García et al., 2021). These imbalances can create a rush of the actors that have the necessary resources to rapidly expand land use (Barbier, 2010; Meyfroidt et al., 2018). The notion of frontier has multiple interlinked dimensions. First, frontiers are places where specific actors (e.g. with capital, information, power relations) interact to capture natural resources and/or economic rent (Le Polain de Waroux et al., 2018). The actors operating in frontiers typically have heterogeneous assets, skillsets, motivations, and decision-making logics, resulting in complex land-use dynamics (Abeygunawardane et al., 2020). Second, frontiers are spaces of political, institutional and cultural reorganization, through processes of territorialization (i.e. processes through which institutional actors, such as states, corporations or non-governmental organizations structure an area to turn it into a manageable territory; Rasmussen & Lund, 2018). This involves processes of increasing legibility (e.g. naming, inventorying and mapping the space and its resources; Rasmussen & Lund, 2018) as well as processes of land control (e.g. fixing or consolidating access, claiming land and resources, excluding other actors; Kronenburg García & van Dijk, 2019; Peluso & Lund, 2011).

Land-use actors often seek to acquire land that can be used for agriculture, giving rise to agricultural frontiers and, where agriculture expands into forests, deforestation frontiers (Eigenbrod et al., 2020; Pacheco et al., 2021). Other expanding land uses can also constitute frontiers, including logging or mining (Davis et al., 2020; Foley et al., 2007; Luckeneder et al., 2021). Frontiers can be seen as places of opportunities for actors (Imamura, 2015), where the frontier process often starts by the discovery (or the reinvention) of the availability of resources (Rasmussen & Lund, 2018), such as when a new crop variety allows for cropping in formerly unsuitable areas or when a certain mineral suddenly gains value in an emerging technology. Frontiers can emerge abruptly when previous successive efforts have contributed to an accumulation of legacies that can help to overcome constraints to resource exploitation (Kronenburg García et al., 2021). Yet, frontiers are also spaces of interactions and frictions between actors with different backgrounds, cultures, socio-political systems, goals and worldviews, often leading to conflicts (Peluso & Lund, 2011; Rodseth & Parker, 2005; Tsing, 2005).

Conceptualizing conservation as a form of land use allows to define “conservation frontiers” as spaces where conservation expands, through territorialization processes, resulting from being seen by conservation actors, as areas in need of conservation activities. Other land uses aligned with conservation goals exist, such as areas managed by indigenous or local communities, or remote areas that are passively protected, yet we don’t focus on those. Once information on conservation needs is developed, conservation actors seek to implement conservation activities in these regions and regulate how land is used there. Here, we focus on conservation efforts that have the objective to protect terrestrial areas important to biodiversity and/or nature’s contribution to people (we refer to those efforts as “land conservation” hereafter), hence introducing the conservation land use (Maxwell et al., 2020). These include conservation efforts that target a spatially-defined area, such as state-designated protected areas, community or private reserves, as well as less traditional forms of conservation such as payments for ecosystem services or zero-deforestation commitments, which would work over a designated area (Garrett et al., 2019; Lambin et al., 2018). We recognize that there are valuable conservation approaches that seek outcomes that are not land-based (e.g. preserving genetic diversity, *ex situ* breeding of a threatened species, or protecting freshwater and marine ecosystems), but we do not further discuss them here.



**Figure 1.** Illustration of the three conceptual perspectives to assess conservation in frontier regions. For each perspective, we show in the upper part a simple diagram that encapsulates each perspective and, in the bottom, an explanatory example of land-use dynamics. Perspective 1 explores how conservation actions respond to other land uses, for instance, by seeking to limit further land-use expansion. Perspective 2 conceptualizes how area-based conservation can itself resemble a frontiers process, by expanding in area. Perspective 3 focuses on how conservation interacts with other land uses to shape the land-use arrangement in frontier regions.

To assess and understand the dynamics and impacts of land conservation in shaping land-use frontiers, we here propose three complementary perspectives (Figure 1). The first explores how conservation actions respond to other land-use frontier processes. The second, conceptualizes how land-based conservation can itself resemble a frontier process. Finally, the third, focuses on the systemic and complex interactions among different land-use actors, institutions, and drivers, including conservation, in frontier regions. These three perspectives highlight different aspects of the expansion of land conservation and thus can be applied to the same geographic context. These perspectives, we argue, can help to explore how the frontier concept can bring new insights of land-use processes and contribute to better conservation planning and action. Specifically, these different frontier perspectives highlighting how conservation as a land use interacts with other land uses in complex social-ecological systems, through re-arrangements of institutions, actor networks and discourses, and their embeddedness in wider land governance processes. In the next section, we further explore these three proposed perspectives and their potential contributions to research in Land System Science and Conservation Science.

### Perspective 1: conservation as a response to advancing land-use frontiers

Conservation, in many cases, can be understood as a response to expanding land uses, including commercial or smallholder agriculture, logging, mining, or infrastructure and urban development. Since the beginning of the modern Western conservation movement, concern over the loss of ‘wilderness’ areas, and the biodiversity they contain, has been a major argument of conservation action, and remain so until today (Watson et al., 2018; WWF, 1961). The concern over further expansion of settlement, logging, and private development led to the establishment of the first

US national parks in Yosemite and Yellowstone (U.S. Congress, 1890; Langford, 1873). Today, places experiencing rapid expansion of deforestation are also emphasized as priority places for engagement by many conservation actors (Habel et al., 2019; Pacheco et al., 2021). An increasing focus on conservation effectiveness and additionality, might also lead to more conservation activities targeting land-use frontiers, as conservation interventions tend to have more impact in threatened regions (Joppa & Pfaff, 2011; Pfaff et al., 2014). Beyond establishing protected areas, conservation responses to limit the expansion of other land use frontiers also take forms of incentives (e.g. PES) or voluntary commitment such as Zero Deforestation Commitment (Lambin et al., 2018).

Conservation responses might come from both local and distal actors, often a collaboration of them, and increasing with both conservation and development objectives. For instance, when logging and agricultural frontiers encroached on landscapes traditionally used by Indigenous people and local communities in Brazil, joint responses from distal conservation and local social movements led to the establishment of a network of multi-use reserves (Gomes et al., 2018; S.B. Hecht & Cockburn, 2010; Wallace et al., 2018). Importantly, major international conservation actors are often highly concentrated, located within a limited number of countries mainly in the global north, forming conservation telecouplings (i.e. distal, distinct social-ecological systems responding to local conservation; Kuemmerle et al., 2019). Finally, conservation interventions may also involve wider networks of actors that shape primarily other land-uses, e.g. through supply chains commitments (Heilmayr et al., 2020).

Like other land uses that are driven by actors seeking opportunities in frontier regions, conservation actors identify and respond to land-use introduced threats to biodiversity and environment. To do so, conservation actors often require information about the expansion of undesired land use, and of the importance of the region being threatened (Myers et al., 2000). The perceptions of conservation urgency often build from the field data and reports, and recently more so from remotely sensed information (Pereira et al., 2013). Such perceptions involve the definition, identification, categorization, thresholding, and prioritization of conservation targets and perceived threats. This might transform certain ecoregions into hotspots of conservation efforts (e.g. the Amazon, Jenkins & Joppa, 2009), whereas others remain overlooked despite high land-use pressure (e.g. Cerrado or the Gran Chaco, Brannstrom, 2009; Kuemmerle et al., 2017) or could even be framed as ‘sacrifice zones’ (Hecht, 2005).

Finally, because of the expansion of both conservation frontiers and resource extraction frontiers, conservation now actively competes with other land uses in many areas (Haberl et al., 2014). Land-use actors creating rapidly expanding frontiers, such as agri-businesses, are often more powerful (e.g. in terms of capital, institutional strength, influence) than conservation actors, so the latter are often disadvantaged in such context (Xie et al., 2020). This leads to most conservation areas historically being located in regions where they compete less with other land uses (d’Albertas et al., 2021; Joppa & Pfaff, 2009), yet where that changes, PAs come under considerable pressure of downgrading, downsizing, or degazettement (Keles et al., 2020; Kroner et al., 2019). In contrast, the hotspot approach aims to identify and focus on areas with high rates of change and threat, counterbalancing the default biases of conservation activities (Myers et al., 2000).

In sum, viewing conservation as a response to frontiers expanding into natural areas provides an entry point to understand the dynamics, processes, and spatial footprint of conservation in frontier regions. This perspective can help to answer research questions such as:

- Why are certain ecoregions hotspots of conservation efforts whereas others remain neglected despite high land-use pressure?
- Do certain types of land-use frontiers (e.g. driven by agri-businesses vs. smallholders) or certain frontier stages (e.g. emerging vs. established) trigger faster or more conservation efforts than others?
- How do local and distant actors identify, interpret, and respond to advancing land-use frontiers? When and how do these actors interact?



- Which conservation approaches are most effective in certain frontier stages, and how will their effectiveness change as the agricultural frontier progresses?

Given rapidly advancing land-use frontiers in many of the world's most biodiverse regions, answering such questions is important to guide land-use and conservation planning.

## **Perspective 2: conservation as an expanding frontier in itself**

Conservation can be seen as not merely responding to other land-use frontiers, but be framed as an expanding frontier itself. Several lines of argument support such a view. First, the area under public protection status has been increasing, and non-profit organizations or private conservation actors are increasingly acquiring land for conservation purposes (Adams, 2019). Likewise, 'greening' subsidies, multi-use reserves with clear conservation goals, and conservation commitments by companies are gaining popularity (e.g. 'Business for Nature', 2019; EC, 2017). Moreover, recent conservation discourses have been framed around ambitious visions for drastically ramping up the footprint of conservation-oriented land uses, including the 'Nature needs half' and "Half Earth" (Adams, 2019; Locke, 2014; Wilson, 2016), the 'Global Deal for Nature' or the proposed Convention on Biological Diversity goal of increasing protected area coverage to 30% of the terrestrial surface by 2030 ('30 by 30'; CBD, 2018; Dinerstein et al., 2019). Likewise, there is a growing momentum of 'rewilding' and restoration initiatives seeking to bring back 'nature' across large areas (Perino et al., 2019; Strassburg et al., 2020). Finally, reforestation is now framed as major mitigation strategy for climate change, with ambitious visions on expanding tree cover (Bastin et al., 2019; Strassburg et al., 2020). These trends and aspirations percolate and can fuel on-the-ground conservation initiatives. Through this, conservation initiatives have become a major force influencing (and sometimes preventing) land-use change in some world regions (Heilmayr et al., 2020; Mascia & Mills, 2018).

Second, conservation actors and their activities actively reshape frontier regions through institutional and cultural reorganization brought about by the diffusion of environmental discourses, new actor networks and the power relations within them (Alvarado, 2019; Bluwstein & Lund, 2018; Mascia & Mills, 2018; Ramutsindela et al., 2020). This leads to territorialization processes that asserts legibility and control over lands for conservation actors and goals and lead to concrete management decisions on how land is used. Such processes include, for example, the direct acquisition of land (e.g. by state, NGOs or private conservation actors), a reorganization of institutional arrangements to put a stronger emphasis on conservation (e.g. territorial planning or land-use zoning by government agencies) or the establishment of local presence by conservation actors (e.g. local offices of NGOs, protected area headquarters). For example in Tanzania, when Selous Game Reserve was formalized by mapping and boundary making, it has as well brought conservation aspirations and discourse from government bodies and NGOs to the region and have resulted in a considerable reconfiguration of its buffer areas, leading to the transformation of communal lands towards the establishment of community-based conservation (Bluwstein & Lund, 2018).

Third, conservation land claims, conservation actors and ideas, as they are introduced into a region, can result in frictions, such as conflicting ideas about who has the rights over such lands, or how land should be managed (Dowie, 2011; Ramutsindela et al., 2020). How this competition plays out depends on the constellations and power relations between actors and institutions, from public to private and local to global, and heavily influences the effectiveness and legitimacy of conservation itself (Adams, 2019; Alvarado, 2019). Importantly, such relations built on pre-existing power dynamics, which are often imbalanced such as through legacies of colonial and neo-colonial histories, or racial, class or gender struggles. For example, in the case of the Selous Game Reserve, the establishment of community-managed conservation areas was met with local resistance, as communities were not included in the decision of establishing such areas, turning this area into a space of conflicting perceptions and claims (Bluwstein & Lund, 2018). Competing claims can result in considerable conflicts, sometimes resulting in the displacement, sometimes in violent ways, or

marginalization of local people (Lindenmayer et al., 2018). For example, the establishment of the Yellowstone and Yosemite National Park largely disregarded historical use rights by indigenous communities and displaced some of them from their traditional lands (Spence, 1999). More recently, in Maine, communal lands were privatized for later sale of conservation easements and carbon offset credits, effectively excluding locals that depended on long-standing common access to these lands (Kay, 2016, 2017). Such examples highlight how conservation interventions, when building on existing power dynamics, might risk resulting in neo-colonial projects leading to forms of green grabbing, when land and resources are appropriated for conservation purposes, and fortress conservation, when protected areas displace or exclude existing inhabitants through coercion (Apostolopoulou & Adams, 2015; Corson & MacDonald, 2012).

Framing the expansion of conservation as a land-use frontier itself can thus contribute to understanding how and where conservation establishes and reshapes regions. Examples of research questions that could be meaningfully observed using our second perspective include:

- How and when do conservation frontiers get activated, for instance, when institutional change creates a window of opportunity?
- Are there specific sequences through which conservation frontiers unfold, such as with pioneering conservation actors, followed by consolidating actors?
- What are favourable conditions for specific conservation actions in frontier regions, and how do conservation actors take advantage of these conditions?
- How can territorialization processes, and the distribution of power among actors driving these processes, contribute to more just, and effective conservation outcomes?

Seeing conservation as a frontier itself, particularly the territorialization and social-ecological reorganization process, can help identify the challenge and opportunities for just conservation action, which is now more important than ever as bold conservation visions are being discussed (Díaz et al., 2020; Ellis, 2019b; Strassburg et al., 2020).

### **Perspective 3: conservation as embedded in land use frontier processes**

Our third perspective frames conservation as embedded in and inseparable from the wider frontier dynamics taking place in a region. First, conservation can be a way to assert or reinforce the power of governments and further opportunities for regulation and zoning (Peluso, 1993), and a major sector and concern in the consolidation process of resource frontiers (Larsen, 2015). For example, in southeastern Myanmar, under the claims of biodiversity conservation, the conservation areas were implemented by the state in landscapes under insurgent authority. Those landscapes were consequently officially demarcated as under state control and administration took over customary use and ownership rights (Woods, 2019). This can be the case in other places where control is not fully established, for example as a way of securing borders or controlling contested regions (Diallo, 2015; Guyot, 2011). In contrast, in the Peruvian Amazon, the resource frontiers are no longer a space that lack governance, but instead are influenced by spatial planning and monitoring, regulations, zoning, and land claims, with conservation being one of the major sectors (Larsen, 2015). This could also be the case in many parts of the world, as multiple prioritizations and planning for conservation are taking place at regional to global levels, and defining (or competing for the definition of) future land and resource use scenarios (Klingler & Mack, 2020; Larsen, 2015).

Second, within processes of land consolidation, conservation and other actors forge different alliances, to reshape the distribution of lands for different purposes, as well as the rules governing how land and its resources should be managed (Larsen, 2015). For instance, in the Amazon, Indigenous people, rubber tappers, and other local communities are recognized as important defenders of nature, and form coalitions with conservation actors to achieve joint objectives of land and livelihoods rights on the one hand, and conservation on the other (Hope, 2021;



Schwartzman & Zimmerman, 2005). This gives rise to stewardship approaches where local communities are taking part in conservation interventions themselves, thus blending conservation, livelihood and justice objectives (Ellis, 2019a). Yet, in Tanzania, poachers were seen as a threat to biodiversity conservation, and a conservation-mining partnership was created to militarize the Selous Game reserve (Holterman, 2020). Taking a more global perspective, international forestry, agriculture, and mining companies that drive the expansion of resource frontiers are also increasingly playing bigger roles in bringing conservation to these regions, through eco-certifications or supply-chain commitments that translate into specific forms of land conservation, or the considerable power they can have when land claims are negotiated (Zu Ermgassen et al., 2020; Leijten et al., 2020). Symmetrically, conservation actors can team up with private investors in partnerships aimed to develop economic activities that can facilitate or support conservation or that build upon the success of conservation interventions, such as high-value niche crops or ecotourism – as for example, in the Gorongosa national park in Mozambique, which is largely privately funded (Branco et al., 2020; Pringle, 2017). Some multilateral actors, such as the World Bank, can support both actors investing in agricultural frontiers as well as those involved in conservation activities (Shihata, 1992; WBG, 2012). As a result, the linkages between conservation and other actors are increasingly complex. Depending on whether conservation interventions are aligning with the more vulnerable or more powerful actors, such coalitions might lead to different ecological and social impacts.

Third, conservation frontiers not only constrain the expansion of specific resource frontiers but also enable, displace, and attract other land use frontiers. Returning to the Selous game reserve, the partnership between conservation and mining actors led to the advance of the mining frontier, by allowing the exploitation of mining resources inside the reserve for some time (Holterman, 2020). Conservation can create leakages and spill-overs, sometimes in distal regions, such as displacement of deforestation frontiers across Southeast Asia (Ingalls et al., 2018) and agriculture frontiers across South America (Le Polain de Waroux et al., 2019), or even across South America and Southern Africa (Gasparri et al., 2016). The implementation of conservation areas can also attract other land uses and lead to their expansion. For example in the USA, as homebuyers were drawn to natural amenities, housing growth rates were higher in areas close by protected areas than further away (Radeloff et al., 2010). Additionally, the line between conservation interventions and other land use expansion can be blurry, such as in the case of carbon forestry, which could be considered as conservation or forestry, depending on the outcomes (Fisher et al., 2018; Fleischman et al., 2021). Finally, the spatial relations through which environmental governance develops can also be seen as a frontier process itself (Thaler et al., 2019).

Seeing conservation as a part of frontier dynamics enables further understanding of the rationale behind different conservation interventions and their social-ecological impacts. This can address important questions such as:

- How do conservation actors interact with other land-use actors in wider actor networks, and how does this network change over time?
- When and how does conservation align with the interests of more vulnerable vs. more powerful stakeholders, and what are the socio-ecological outcomes?
- How are conservation ideas, practices and actors articulating with wider land use actors and dynamics?
- What forms of spillovers does conservation create on other land uses, and where and how are such spillovers likely to occur?

Understanding conservation frontiers within wider land-uses processes allows for a more nuanced understanding of conservation and its role in complex social-ecological systems. Such a perspective is increasingly important as conservation actors and get entangled with other resource actors in frontier regions, jointly shaping their dynamics.

## Conclusion

Using the conceptual framing of frontiers, we here connect Land System Science and Conservation Science to reinterpret the expansion of land conservation areas. Adopting a frontier perspective allows viewing conservation as a land use taking part in frontier dynamics, and through that shaping the geography of conservation areas. This, in turn, is promising to better understand how the actors, drivers and dynamics of frontiers relate to conservation challenges and opportunities. As we highlight here, adopting the conceptual lens of frontiers can facilitate deeper consideration of the social-ecological contexts under which conservation happens, the motivations and decision-making logics of conservation actors, and can support more reflexive, effective, and just conservation planning in anticipation of the possible frontier dynamic and actors' interactions.

The three perspectives developed here to relate conservation interventions and land-use frontier dynamics can shed light on and systematize such contexts. Each of the perspectives might better describe conservation in specific social-ecological contexts, but all three could be applied to the same geographic context to highlight different aspects, approaches and actors of land conservation dynamics. A useful next step will be to systematically review which perspectives have been applied so far, in what ways and contexts are they useful, and what insights each of them brings. More generally, closer collaboration between Conservation Science and Land System Science research communities and practitioners provides considerable potential to better integrate conservation as a core component of dynamic land systems.

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