One Earth

Halting the expansion of pasture in the Brazilian Amazon

--Manuscript Draft--

Manuscript Number:	
Full Title:	Halting the expansion of pasture in the Brazilian Amazon
Article Type:	Commentary
Keywords:	livestock; land use change; land use policy; land tenure
Corresponding Author:	Erasmus Klaus Helge Justus zu Ermgassen UCLouvain Louvain-la-Neuve, BELGIUM
First Author:	Erasmus Klaus Helge Justus zu Ermgassen
Order of Authors:	Erasmus Klaus Helge Justus zu Ermgassen
	Marcos Adami
	Michel E.D. Chaves
	Andrea Garcia
	Leonie Hodel
Abstract:	Summary There are growing hopes that improved supply chain traceability can break the link between pasture-based cattle ranching and deforestation in the Amazon. Here, we caution that supply chains are but one part of the puzzle - a combination of policies are needed to end the expansion of pasture.
Opposed Reviewers:	
Suggested Reviewers:	
Additional Information:	
Question	**Response**
Standardized datasets A list of datatypes considered standardized under Cell Press policy is available here. Does this manuscript report new standardized datasets?	No
Original code Does this manuscript report original computer code, algorithms, or computational models?	No

Title: Halting the expansion of pasture in the Brazilian Amazon

Authors:

Erasmus KHJ zu Ermgassen[1] erasmus.zuermgassen@uclouvain.be
Marcos Adami[2] marcos.adami@inpe.br
Michel E.D. Chaves[3] michel.dantas@unesp.br
Andrea Garcia[1] andrea.garcia@uclouvain.be
Leonie Hodel[4] hodel2@wisc.edu

Affiliations:
[1] Earth and Life Institute, UCLouvain, Place Pasteur 3, 1348 Louvain-la-Neuve, Belgium
[2] Earth Observation and Geoinformatics Division, National Institute for Space Research (INPE), São José dos Campos, São Paulo, 12227-010, Brazil
[3] São Paulo State University (UNESP), School of Sciences and Engineering, Tupã, São Paulo, 17602-496, Brazil
[4] Center of Sustainability and the Global Environment (SAGE), University of Wisconsin-Madison, USA

Summary: *There are growing hopes that improved supply chain traceability can break the link between pasture-based cattle ranching and deforestation in the Amazon. Here, we caution that supply chains are but one part of the puzzle - a combination of policies are needed to end the expansion of pasture.*

Within the last 40 years alone, more than 10% of the Amazon's forests have been cleared (1), resulting in a massive loss of biodiversity and ecosystem services, not least the capture of greenhouse gases, generation of rainfall, and provision of forest-derived foods and raw materials. What replaces these forests? Across the Amazon, 70% of deforested land is occupied by pasture (1), with cattle ranching considered the primary driver of deforestation in Brazil, Bolivia, Colombia, and Ecuador (2).

Here, we reflect on how the advance of pasture may be halted, drawing insights from Brazil, which is home to almost two-thirds of the Amazon and where the dynamics of cattle ranching and deforestation are best studied (2). While there is growing emphasis on supply chain solutions – the Brazilian government is advancing the implementation of a national traceability system for cattle, prompted by growing demand for deforestation-free beef from financial and commodity markets – we caution that these will be far from sufficient. Cattle ranching is multi-purpose - it is both a way of earning from the land and a low-cost way of claiming land itself (3). Breaking the link between cattle ranching and deforestation requires a combination of policies to clean up cattle supply chains and discourage land grabbing.

Cattle and deforestation in the Amazon

Since the 1980s, cattle ranching in the Amazon has expanded rapidly - with the pasture area growing 3.5-fold (from 15.3 to 53.8 million hectares) and the cattle herd growing 11-fold (from 6.6 to 76.0 million heads). Cattle in the Amazon supply beef to a growing local urban population, as well as feeding consumers further afield, both within Brazil and abroad (Figure 1). In recent years, there has been a notable increase in exports to China, though the domestic market remains king - the destination for more than 70% of Brazil's beef and the main consumer of embedded deforestation (Figure 1).

[Insert Figure 1 here]

Figure 1 - (A) The destination markets of beef from the Brazilian Amazon (2010-2020; sub-national export data not available for 2018). (B) The deforestation exposure of consumer markets sourcing this beef (2015-2017). Data from (4, 5).

Policies to clean cattle supply chains

In response to national and international concern, the cattle sector has developed a series of commitments and supply chain solutions to tackle deforestation. Notably, from 2009 onwards, the Brazilian Federal Prosecution Office (Ministério Público Federal, in Portuguese) began signing legally-binding agreements (known as the TAC) with slaughterhouses to monitor supply chains and avoid purchases of cattle from properties with illegal deforestation. The rollout of the TACs has been shown to reduce deforestation, but by no means eliminate it. Specifically, the TACs are estimated to have helped reduce deforestation by 15% between 2010 and 2018 (6). Reasons for the only partial effectiveness include that there are still many non-signatory slaughterhouses – in the state of Pará an estimated one-third of cattle are slaughtered by establishments that have not adopted the TAC. Moreover, compliance by signatory slaughterhouses is imperfect – the 2023 audit found that twelve percent, on average, of cattle purchases by TAC slaughterhouses were non-compliant – and the TAC only applies to slaughterhouses' direct suppliers. It therefore does not address deforestation that occurs among slaughterhouse's indirect suppliers – i.e. the many properties which raise and sell calves or immature cattle to fattening ranches, which in-turn supply slaughterhouses.

The Federal Prosecution Office is ratcheting up the TAC year-on-year. Initially, only slaughterhouses in the state of Pará were publicly audited, though 2023 was the first year that a harmonized audit protocol was applied across the Brazilian Amazon. One barrier to the expansion of the TAC is, however, the lack of incentive for slaughterhouses to sign up. Signatory slaughterhouses face increased scrutiny and legal risk. Transparency initiatives such as Trase and 'do Pasto ao Prato', which highlight to international and domestic consumers, respectively, whether meat is sourced from signatory or non-signatory slaughterhouses can help transmit market signals for sustainably-sourced beef, rewarding companies who have implemented supply chain monitoring through the TAC. Similarly, enshrining the TAC in procurement policies of major retailers and government (for example Brazil's $500 million USD/year school meal program) could be important shifters in market demand.

Ultimately, however, expanding the TAC will never be sufficient, in of itself, to eliminate deforestation. It is estimated that if all slaughterhouses in the Amazon adopted current best-practices for supply chain monitoring, deforestation could perhaps be halved (6). Besides the exclusion of indirect suppliers from monitoring protocols, a fundamental barrier to greater efficacy is the challenge of implementing comprehensive and reliable traceability systems. Current approaches, even when including indirect sourcing, can only link properties hosting 50% of pasture and 29% of deforestation to specific cattle supply chains (7). The remainder includes cattle production which is unmatched because of inconsistencies and mismatches in supply chain data (animal movement records, property identifiers), cattle raised on unregistered properties or animal sales that are not registered in official statistics, or properties which are truly not motivated by cattle production, per se, rather they are properties where the primary product is the land itself.

The push and pull of pasture expansion in the Amazon

Arguably, the expansion of cattle ranching in the Amazon is as much a symptom as the cause of larger land use change dynamics. The total area of pasture in Brazil has been stable since the early 2000s – though there has been a marked spatial shift. Pasture in the South and South-East of Brazil has contracted, while expanding in the Amazon (8). This shift toward the Amazon has been driven by a combination of push and pull factors (Figure 2).

Demand for land-based products - not least sugarcane- and corn-based biofuels, wood-derived products (paper, charcoal, and wood) and meat (and in-turn, soy and maize for animal feed) - is the underlying driver of agricultural expansion nationwide, and a key factor pushing cattle farming into frontier regions such as the Amazon (8). Growing demand has led to rising land prices, in particular near to urban markets across southern, south-eastern, and central Brazil, where low-rent cattle pasture has been displaced by higher-rent production systems, notably for soy, sugarcane, and timber (8). This process is self-reinforcing, as capital surpluses gained from agricultural production are then re-invested, incentivising further growth and agricultural expansion (9).

[Insert Figure 2 here]

Figure 2 - To break the link between cattle ranching and deforestation requires combining supply chain interventions with efforts to address the push and pull factors which drive expansion into the Amazon.

Alongside these push factors operating outside the Amazon, a combination of ‘pull’ factors then attract low-productivity, pasture-based cattle ranching into the region. Notably, the Amazon has large areas of unprotected and undesignated forests, weak disincentives against deforestation, and ever increasing market access.

The Brazilian Amazon has 49.8 million hectares (Mha) of undesignated public forests, lands without any clear land tenure status, the uncertain future of which incentivizes land grabbing - inevitably accompanied by the establishment of pasture post-clearance - to secure the valuable

land. Between 1997 and 2018, 11.6 Mha of undesignated lands were illegally registered as "private property" in the Brazilian Environmental Rural Registry (CAR), with 2.6 Mha of subsequently cleared (10). These undesignated lands make up an increasing share of deforestation: 18% of deforestation in 2021, up from 11% of deforestation in 2008 (15).

Unfortunately, enforcement efforts are only able to tackle a small share of deforestation. As much as 99% of deforestation may be illegal, though only 6.1% of deforested areas from 2019 to 2020 were subject to fines or embargoes by the Brazilian environmental enforcement agency, Ibama. Even where land is embargoed, and should be reforested at the landowner's expense, embargoes are often not respected – with landowners continuing to maintain pasture and agriculture on 86.9% of embargoed areas (11). This impunity is itself a product of politics - with budget cuts undermining Ibama's ability to enforce environmental protections and political rhetoric, in particular during the Bolsonaro presidency (2019-2022), encouraging landowners to expand without repercussion (12). In some cases, the cost of clearing land has even benefited from direct government subsidy. Between 2020 and 2022, 31% of deforesting properties in Brazil were recipients of subsidized rural credit (13).

Finally, infrastructure investments improve the profitability of agricultural expansion by increasing access for land grabbers and access to markets. 95% of deforestation in the Amazon is within 5.5 kilometers of a road or navigable river (14), with infrastructure development also having knock-on effects at larger scales. The construction of the Ferrogrão railroad, for example, which would connect soy producing regions in southern Mato Grosso with the Amazon river (and hence sea transport to international markets), is predicted to unleash 400 km^2 of deforestation within a decade, occurring across a wide region in Mato Grosso affected by the change in market access (15).

Prospects for ending pasture expansion in the Amazon

How might pasture expansion ultimately be halted? Improvements in traceability are one piece of the puzzle, with the European Union's new deforestation due-diligence legislation providing much needed impetus. This legislation is particularly innovative in explicitly addressing indirect sourcing, requiring suppliers of the EU to trace cattle back to the ranch of birth - a demand which has accelerated plans for a national cattle traceability system in Brazil. The EU, however, is ultimately a small market for Brazilian beef, and to have a meaningful impact on deforestation, traceability and environmental controls must also be rolled out for other international customers, notably China, and the domestic market.

Addressing the pull and push factors displacing cattle into the Amazon requires a different set of policies to tame capital market flows, enforce forest protections, and guide sustainable infrastructure development. Deforestation will forever remain challenging as long as the demand for land-based products and capital investments in agriculture continue to grow. New initiatives to increase visibility over the environmental impacts of financial investments - both the EU's Corporate Sustainability Reporting Directive (CSRD) as well as market-led initiatives, such as the Taskforce on Nature-related Financial Disclosures (TFND), are innovative. It remains to be seen, however, what impact they may have in curbing harmful financial flows. Better

enforcement of existing protections of forests on private properties, indigenous lands, and protected areas are essential, as well as clarifying the tenure status of undesignated lands. Finally, transparent environmental impact assessments are needed for infrastructure projects to determine if the benefits truly outweigh the costs (16). Here, recent policy developments paint a mixed picture. On the one hand, the planned opening of Highway BR-319 (from Manaus to Porto Velho, with various secondary roads), threatens to increase access to a vast area of currently undesignated public land and forests (16), on the other hand, the Lula government has moved to demarcate 310,000 square kilometers of these lands, potentially ending the limbo over their land tenure status. Resourcing for Ibama has also improved, leading to an increase in embargoes (1), with banks required to check for embargoes before granting agricultural credit (13).

Because of the dual motivation for pasture expansion in the Amazon - both as a means to claim land (often illegally) and to support cattle production - efforts to discourage deforestation are essential to tilt the land use dynamic in favour of law-abiding actors in the cattle sector, foster cleaner supply chains for domestic and international markets and incentivise improvements in production practices rather than expansion. The potential for such a switch was seen in the 2010s, when supply chain policies and environmental enforcement stimulated productivity gains in the cattle sector. Around this time, front-runner meatpackers introduced supply chain monitoring and Ibama implemented its “Priority List” policy, targeting municipalities with high deforestation rates with increased field inspections and fines for illegal deforestation. The land use dynamic switched from one dominated by pasture expansion toward investments in production on already cleared land, with targeted municipalities experiencing a 50-56% decline in deforestation and 14-36% boost in cattle productivity (measured as improvements in stocking rates) (17, 18). Altogether, it is essential to improve monitoring of cattle supply chains and close loopholes which permit the commercialisation of cattle raised on illegally-cleared land. But ending the expansion of pasture in the Amazon, as well as in other frontier regions, has as much to do with non-cattle policies as it does with supply chains.

Acknowledgements

We thank Stefan Jünger & Anne-Kathrin Stroppe for open sharing of the code used to produce Figure 2. This research benefited from funding from Norway's International Climate and Forest Initiative (BRA-22/0017).

References

1. Mapbiomas, Mapbiomas Amazônia. (2024). Available at: https://amazonia.mapbiomas.org/ [Accessed 8 August 2024].
2. A. Hänggli, *et al.*, A systematic comparison of deforestation drivers and policy effectiveness across the Amazon biome. *Environ. Res. Lett.* **18**, 073001 (2023).
3. M. S. Bowman, *et al.*, Persistence of cattle ranching in the Brazilian Amazon: A spatial analysis of the rationale for beef production. *Land Use Policy* **29**, 558–568 (2012).
4. E. K. H. J. zu Ermgassen, *et al.*, Brazil beef supply chain (2010-2020) (Version 2.2). Trase. https://doi.org/10.48650/AYAA-HH56. Deposited 2023.
5. E. K. H. J. zu Ermgassen, *et al.*, The origin, supply chain, and deforestation risk of Brazil’s

beef exports. *Proc. Natl. Acad. Sci.* **117**, 31770–31779 (2020).
6. S. A. Levy, F. Cammelli, J. Munger, H. K. Gibbs, R. D. Garrett, Deforestation in the Brazilian Amazon could be halved by scaling up the implementation of zero-deforestation cattle commitments. *Glob. Environ. Change* **80**, 102671 (2023).
7. M. E. Skidmore, *et al.*, Cattle ranchers and deforestation in the Brazilian Amazon: Production, location, and policies. *Glob. Environ. Change* **68**, 102280 (2021).
8. E. K. zu Ermgassen, C. Renier, A. Garcia, T. Carvalho, P. Meyfroidt, Sustainable commodity sourcing requires measuring and governing land use change at multiple scales. *Conserv. Lett.* **17**, e13016 (2024).
9. P. Richards, E. Arima, Capital surpluses in the farming sector and agricultural expansion in Brazil. *Environ. Res. Lett.* **13**, 075011 (2018).
10. C. Azevedo-Ramos, *et al.*, Lawless land in no man's land: The undesignated public forests in the Brazilian Amazon. *Land Use Policy* **99**, 104863 (2020).
11. V. C. S. da Silva, *et al.*, Marked non-compliance with deforestation embargoes in the Brazilian Amazon. *Environ. Res. Lett.* **17**, 054033 (2022).
12. K. V. Conceição, *et al.*, Government policies endanger the indigenous peoples of the Brazilian Amazon. *Land Use Policy* **108**, 105663 (2021).
13. J. Mourão, M. Stussi, P. Souza, "Credit Where It's Due: Unearthing the Relationship between Rural Credit Subsidies and Deforestation" (PCI, 2024).
14. C. P. Barber, M. A. Cochrane, C. M. Souza, W. F. Laurance, Roads, deforestation, and the mitigating effect of protected areas in the Amazon. *Biol. Conserv.* **177**, 203–209 (2014).
15. R. Araujo, J. Assunçao, A. Bragança, "The Effects of Transportation Infrastructure on Deforestation in the Amazon: A General Equilibrium Approach" (World Bank, 2023).
16. L. Ferrante, M. B. T. Andrade, P. M. Fearnside, Land grabbing on Brazil's Highway BR-319 as a spearhead for Amazonian deforestation. *Land Use Policy* **108**, 105559 (2021).
17. N. Koch, E. K. H. J. zu Ermgassen, J. Wehkamp, F. J. B. Oliveira Filho, G. Schwerhoff, Agricultural Productivity and Forest Conservation: Evidence from the Brazilian Amazon. *Am. J. Agric. Econ.* **101**, 919–940 (2019).
18. F. Moffette, M. Skidmore, H. K. Gibbs, Environmental policies that shape productivity: Evidence from cattle ranching in the Amazon. *J. Environ. Econ. Manag.* **109**, 102490 (2021).

Figure 1

Click here to access/download;Figure;Figure1.tiff

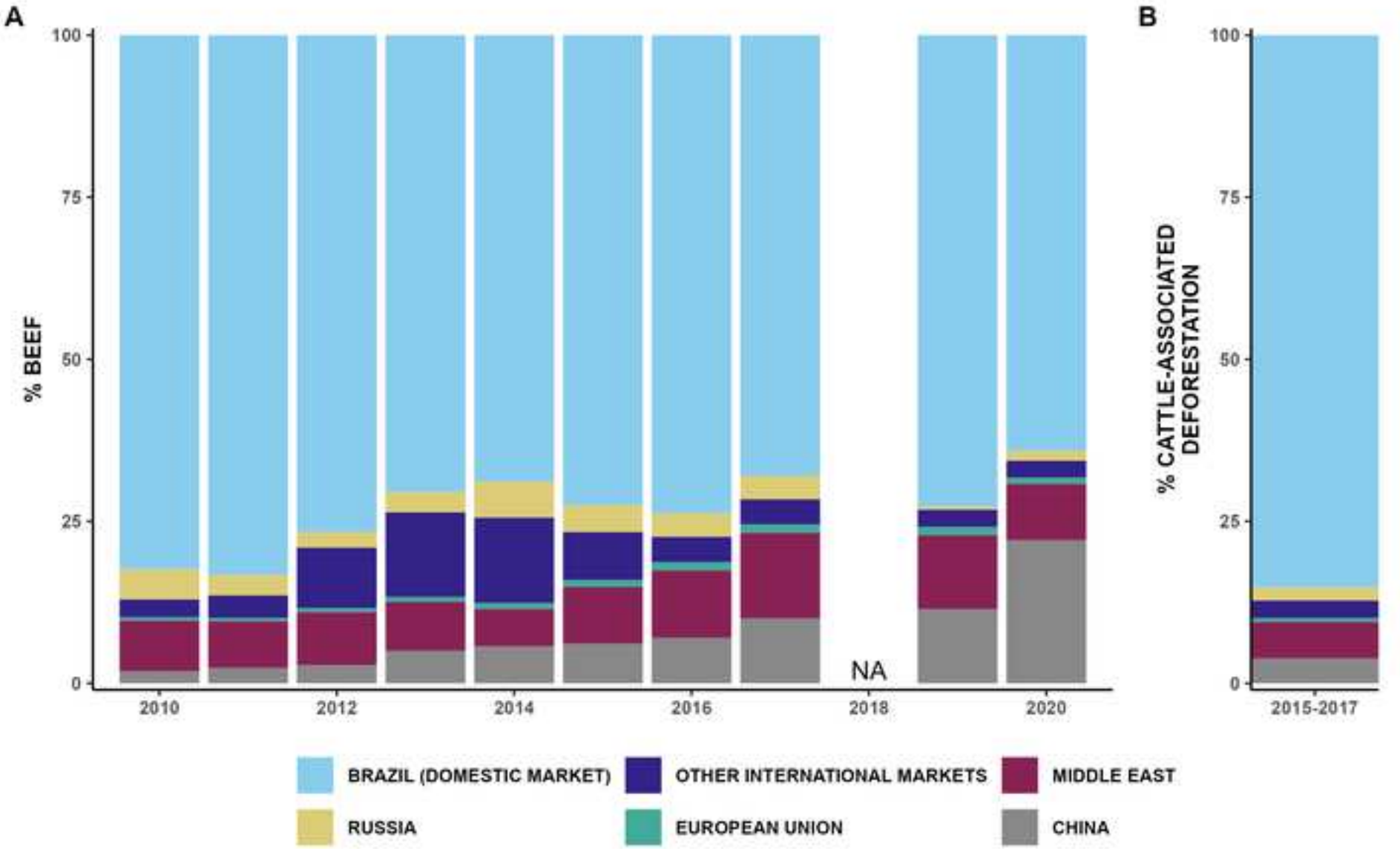

Figure 2