Reassessing the role of cattle and pasture in Brazil's deforestation: a response to "Fire, deforestation, and livestock: When the smoke clears"

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ABSTRACT

Silva et al. (Land Use Policy, 21 July 2020) offer an assessment of the links between deforestation, livestock production and exports in Brazil. Their analysis, based on relative changes in beef production and pasture area across the whole of Brazil, showed an "apparent decoupling of the link between beef production and deforestation in Brazil". In reanalysing these links, we find that Silva et al. underestimate the strong, positive and significant associations between Brazilian livestock production and deforestation. Moreover, despite focusing the title, abstract and the beginning of their manuscript on the Amazon, their analyses are conducted at the national level, and fail to recognise marked differences in the development trajectories of Brazilian biomes, and that most of the recent pasture expansion in Brazil has replaced Amazonian forests. To progress any debate and aid decisionmaking regarding land-use changes in the Amazon, a region often in the spotlight and subjected to many debates that lack evidence, scientists must be open and scrupulous with their data sources and analyses.

In exploring links between livestock production and pasture area in Brazil between 1985 and 2018, Silva et al. (2021) suggesta decoupled relationship between deforestation and land used for beef production. Silva et al. alleged that narratives surrounding Amazonian fires in 2019 were strongly based on political and emotional beliefs, yet their analysis do not explore the links between deforestation and wildfires. Moreover, by conducting their analysis at the national rather than regional scales, the authors obscure clear evidence showing that the expansion of Brazilian cattle production has come at the expense of Amazonian forests. Here, we show that their conclusions are erroneous both at national and, especially, at the biome scales.

First, Silva et al. claim that "*sustainable intensification of predominant livestock pastures may be acting as a significant buffer between meat demand and livestock production and consequent land use change and deforestation*". Using alternative datasets, we show that livestock intensification (i.e. increased cattle herd size; Fig. 1A) in Brazil over that past 35 years did not prevent pasture expansion in the Amazon biome (Fig. 1B). Our analysis also shows that livestock intensification outside the Amazon has brought around relative modest changes in stocking densities between 1985 and 2019 (from 1.09 to 1.28 cattle heads per hectare), and that stocking densities in the Amazon are already very close to those levels (1.2 in 2019; Fig. 1C). Contrary to Silva et al., our analysis therefore suggest that intensification has played a relatively small role in buffering the impact of livestock demand, and has not prevented pasture expansion in the Amazon. This is particularly worrying for a country like Brazil, which is both home to Earth's largest remaining tropical rainforest and a global leader in beef production and exportation (FAOSTAT, 2020) and deforestation (Turubanova et al., 2018).

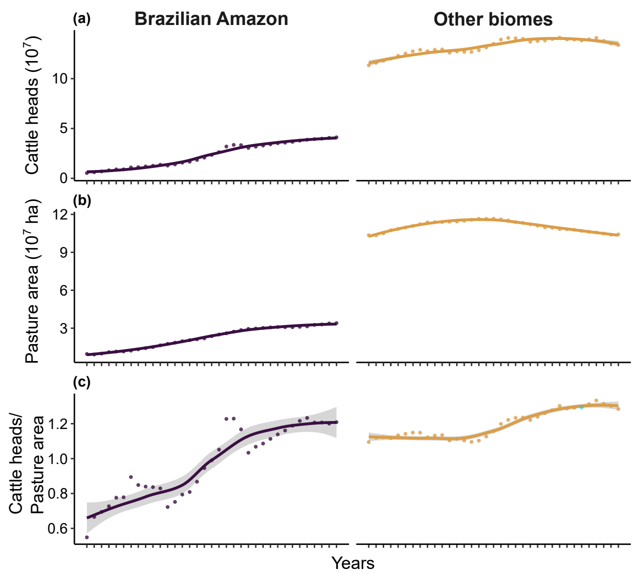

Fig. 1. Annual values for (a) cattle herd size, (b) pasture area, and (c) ratio of cattle heads and pasture area, separated between the Amazon biome (purple; left panels) and other Brazilian biomes (beige; right panels) between 1985 and 2019. We used data from S IDRA-IBGE (2020) for state-level cattle head numbers, while biome-specific pasture area was obtained from MapBiomas (2020). The raw data, data sources and analyses details are provided in Table S1 and Table S2, respectively.

Silva et al. also state that "*an increase of around 5% in beef production over the period 1986–1988 correlated with a 3% increase in pasture area. From 2006, positive variations in production caused no pasture expansion. Increased production is instead explained by gains in productivity" and indicated that pasture area had stabilized "at around 180 million hectares since 2006, while livestock production has continued to grow*". The latter claim is supported by a figure displaying pasture area, beef productivity and beef exports in Brazil. As no further detail is provided in the manuscript, our analyses of their raw data (Silva et al., 2021: Supplementary Table "Raw data Fig1") reveals that the authors have summed pasture area across all six Brazilian biomes (red dotted line in their Fig. 2; Silva et al., 2021). Even though such stabilization in pasture extent is also apparent in our analyses at the national level (Fig. 2), the analyses of Silva et al. ignores (i) region-specific increment in pasture area (i.e. deforestation; Fig. 1B) and the fact that (ii) most of the "smoke" they refer in their title is due to deforestation-related fires in the Amazon (Barlow et al., 2020; Brando et al., 2020). For instance, in the Amazon, the area of pasture (relative to the total pasture area in Brazil) has increased from 11.8 % in 1985 to 29.1 % in 2018 (Fig. 2; Table S3). Brazilian beef production has indeed continued to rise, growing 184 % over the same period (Fig. 2). Yet, this rise may be a consequence of a sharp increase from 5.3–41.81 million animals in the Amazonian cattle herds between 1985 and 2019 (an increase of 680 %, Fig. 1A; IBGE, 2020) and in pasture expansion (Fig. 1B).

From 1985–2019, the total pasture area in the Brazilian Amazon biome rose from 16.4–52.7 million hectares (MapBiomas, 2020), a 221 % increase in the land area converted to pasture. Importantly, these figures do not account for the rise in deforestation rates that occurred in 2020, when the Brazilian Amazon lost over 1.1 million hectares of forests (TerraBrasilis and INPE, 2020) – the highest annual loss since 2008. Although most of the Brazilian agricultural production is legally deforestation-free, at least 17 % of beef and 20 % of soy exports to the Europe Union have been associated with illegal deforestation in the Amazon and Cerrado biomes (Raj˜ao et al., 2020).

Third, according to Silva et al., "*linking ruminant production and consumption to land clearance, greenhouse gas emissions (GHGs) and biodiversity loss is a plausible sell for international campaigners and global media eager for a simple narrative on culpability*". Yet, these links are demonstrated by the data (e.g. Green et al., 2019) and not narratives, as lagged prices of soy and beef commodities explained over 75 % of the total variation in forest loss rates between 1995 and 2007 (Arima et al., 2014). Not unexpectedly, deforestation in the Brazilian Amazon is concentrated inside the soy and pasture belt on the south-eastern edge, the so-called 'Arc of Deforestation' (Vieira et al., 2008). Also, decades of research shows that as tropical forest loss and degradation increases so do (i) biodiversity losses (Barlow et al., 2016); and (ii) greenhouse-gas emissions (Pearson et al., 2017), given that trees cleared and burned to make way for pastures release back to the atmosphere the carbon they naturally capture whilst growing (Soares-Filho et al., 2006). Finally, the FAO – the same data source Silva et al. used for some of their analyses – has reported that ruminant production through enteric fermentation is responsible for around 65 % of the global greenhouse-gas emissions from the entire livestock sector and 14.5 % of all human-induced emissions (Gerber et al., 2013). Not surprisingly, the total CO_2 emissions of Brazilian agriculture were highly correlated not only with pasture area but also with beef production and exports (Figure S1; both Pearson's ρ ≥ 0.85). Although more research is needed, these findings call attention to the fact that intensification of livestock production may continue to generate negative environmental externalities such as increased greenhouse gas emissions (Balmford et al., 2018).

The recent surge in deforestation in the Amazon finally extinguished any hope that Brazil would meet its targets of reducing deforestation rates in the biome by 80 % of the 1996–2005 historic rates by 2020 (Government of Brazil, 2008). If agricultural expansion continues, we may lose more than 40 % of the entire Amazon by 2050 (Soares-Filho et al., 2006), pushing the entire ecosystem closer to a dangerous tipping point (Nobre et al., 2016). Despite the recent reductions in funding for environmental management, the suspension of the Amazon fund and reassignment of environmental agency duties (Pelicice & Castello, 2021), we are still hopeful that Brazil can rediscover its environmental leadership (Ferreira et al., 2014). However, we will need coordinated efforts between public policies (e.g. Hansen et al., 2020), investors (Nazareno and Laurance, 2020) and supply-chain initiatives aiming to reduce deforestation (Lambin et al., 2018). The zero-deforestation

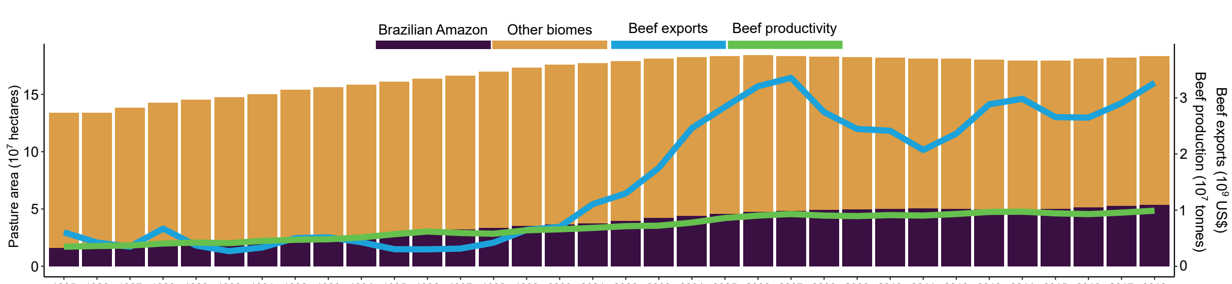

Fig. 2. Pasture area in Brazil, separated between the Amazon biome (purple) and other Brazilian biomes (beige; primary y -axis), and the Brazilian beef productivity (green line) and beef exports (blue line; secondary y -axis) between 1985 and 2018. Data sources and datasets are provided in Table S1 and Table S3, respectively.

agreements that major soybean and beef traders signed in 2006 and 2009, respectively, provide examples of how this could work (Gibbs et al., 2016, 2015). Their effectiveness, however, depends on strengthening the integration between agrarian and environmental legislation(Carvalho et al., 2019), law enforcement (Arima et al., 2014) and increasing the supply chain transparency and traceability (Gardner et al., 2019; Garrett et al., 2019). Finally, dismissing important environmental concerns as a "*simple narrative on culpability*" is counterproductive and will detract from the benefits that can emerge when science is used to inform agricultural development and biodiversity conservation (Ciência e Sociedade, 2020).

Author contributions statement

FMF designed the study. FMF analysed the data with input from RS, JB and LPM. All authors contributed to the manuscript writing and approved the final publication.

Code availability

Code for the analyses is available from the corresponding author upon request.

Data availability

Datasets and data sources are provided in the supplementary material.

Declaration of Competing Interest

The authors report no declarations 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.landusepol.2020.105195.

References

Arima, E.Y., Barreto, P., Araújo, E., Soares-Filho, B., 2014. Public policies can reduce tropical deforestation: lessons and challenges from Brazil. Land Use Policy 41, 465–473. https://doi.org/10.1016/j.landusepol.2014.06.026.

Balmford, A., Amano, T., Bartlett, H., Chadwick, D., Collins, A., Edwards, D., Field, R.,Garnsworthy, P., Green, R., Smith, P., Waters, H., Whitmore, A., Broom, D.M., Chara, J., Finch, T., Garnett, E., Gathorne -Hardy, A., Hernandez-Medrano, J., Herrero, M., Hua, F., Latawiec, A., Misselbrook, T., Phalan, B., Simmons, B.I.,Takahashi, T., Vause, J., zu Ermgassen, E., Eisner, R., 2018. The environmental costs and benefits of high-yield farming. Nat. Sustain 1, 477–485. https://doi.org/10.1038/s41893-018-0138-5.

Barlow, J., Lennox, G.D., Ferreira, J., Berenguer, E., Lees, A.C., Nally, R.Mac, Thomson, J.R., Ferraz, S.Fde B., Louzada, J., Oliveira, V.H.F., Parry, L., Ribeiro de Castro Solar, R., Vieira, I.C.G.G., Aragão, L.E.O.C., Begotti, R.A., Braga, R.F., Cardoso Jr, T.M., Souza Jr, R.C.D.O., C.M, Moura, N.G., Nunes, S.S., Siqueira, J.V., Pardini, R., Silveira, J.M., Vaz-de-Mello, F.Z., Veiga, R.C.S., Venturieri, A., Gardner, T.A., 2016. Anthropogenic disturbance in tropical forests can double biodiversity loss from deforestation. Nature 535, 144–147. https://doi.org/10.1038/nature18326.

Barlow, J., Berenguer, E., Carmenta, R., França, F., 2020. Clarifying Amazonia's burning crisis. Glob. Chang. Biol. 26 https://doi.org/10.1111/gcb.14872 gcb.14872.

Brando, P.M., Soares-Filho, B., Rodrigues, L., Assunção, A., Morton, D., Tuchschneider, D., Fernandes, E.C.M., Macedo, M.N., Oliveira, U., Coe, M.T., 2020. The gathering firestorm in southern Amazonia. Sci. Adv. 6, eaay1632. https://doi.org/10.1126/sciadv.aay1632.

Carvalho, W.D., Mustin, K., Hilário, R.R., Vasconcelos, I.M., Eilers, V., Fearnside, P.M., 2019. Deforestation control in the Brazilian Amazon: a conservation struggle being lost as agreements and regulations are subverted and bypassed. Perspect. Ecol. Conserv. 17, 122–130. https://doi.org/10.1016/j.pecon.2019.06.002.

Ciência-Sociedade, 2020. O agronegócio brasileiro continua precisando do conhecimento científico.

FAOSTAT, 2020. Food and Agriculture Data. URL http://www.fao.org/faostat/en/#home (Accessed 8.10.20).

Ferreira, J., Aragao, L.E.O.C., Barlow, J., Barreto, P., Berenguer, E., Bustamante, M., Gardner, T.A., Lees, A.C., Lima, A., Louzada, J., Pardini, R., Parry, L., Peres, C.A., Pompeu, P.S., Tabarelli, M., Zuanon, J., 2014. Brazil's environmental leadership at risk. Science (80-.). 346, 706–707. https://doi.org/10.1126/science.1260194.

Gardner, T.A., Benzie, M., Borner, J., Dawkins, E., Fick, S., Garrett, R., Godar, J., Grimard, A., Lake, S., Larsen, R.K., Mardas, N., McDermott, C.L., Meyfroidt, P., Osbeck, M., Persson, M., Sembres, T., Suavet, C., Strassburg, B., Trevisan, A., West, C., Wolvekamp, P., 2019. Transparency and sustainability in global commodity supply chains. World Dev. 121, 163 –177. https://doi.org/10.1016/j.worlddev.2018.05.025.

Garrett, R.D., Levy, S., Carlson, K.M., Gardner, T.A., Godar, J., Clapp, J., Dauvergne, P., Heilmayr, R., le Polain de Waroux, Y., Ayre, B., Barr, R., Døvre, B., Gibbs, H.K., Hall, S., Lake, S., Milder, J.C., Rausch, L.L., Rivero, R., Rueda, X., Sarsfield, R., Soares-Filho, B., Villoria, N., 2019. Criteria for effective zero-deforestation commitments. Glob. Environ. Chang. 54, 135–147. https://doi.org/10.1016/j.gloenvcha.2018.11.003.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., Tempio, G., 2013. Tackling Climate Change Through Livestock – A Global Assessment of Emissions and Mitigation Opportunities. Rome.

Gibbs, H.K., Rausch, L., Munger, J., Schelly, I., Morton, D.C., Noojipady, P., Soares-Filho, B., Barreto, P., Micol, L., Walker, N.F., 2015. Brazil's soy moratorium. Science (80-.) 347, 377–378. https://doi.org/10.1126/science.aaa0181.

Gibbs, H.K., Munger, J., L'Roe, J., Barreto, P., Pereira, R., Christie, M., Amaral, T., Walker, N.F., 2016. Did ranchers and slaughterhouses respond to zero -defore station agreements in the brazilian amazon? Conserv. Lett. 9, 32–42. https://doi.org/10.1111/conl.12175.

Government, 2008. Presidential decree 6.263, 21 November 2007. National Climate Change Plan.

Green, J.M.H., Croft, S.A., Durán, A.P., Balmford, A.P., Burgess, N.D., Fick, S., Gardner, T.A., Godar, J., S uavet, C., Virah-Sawmy, M., Young, L.E., West, C.D., 2019. Linking global drivers of agricultural trade to on-the-ground impacts on biodiversity. Proc. Natl. Acad. Sci. 116, 23202 –23208. https://doi.org/10.1073/pnas.1905618116.

Hansen, A.J., Burns, P., Ervin, J., Goetz, S.J., Hansen, M., Venter, O., Watson, J.E.M., Jantz, P.A., Virnig, A.L.S., Barnett, K., Pillay, R., Atkinson, S., Supples, C., Rodríguez-Buritica, S., Armenteras, D., 2020. A policy -driven framework for conserving the best of Earth's remaining moist tropical forests. Nat. Ecol. Evol. https://doi.org/10.1038/s41559-020-1274-7.

IBGE, 2020. Tabela 73 - Efetivo Dos Rebanhos, Por Tipo De Rebanho - Pesquisa Da Pecuária Municipal. URL https://sidra.ibge.gov.br/Tabela/7 3 (Accessed 8.11.20).

Lambin, E.F., Gibbs, H.K., Heilmayr, R., Carlson, K.M., Fleck, L.C., Garrett, R.D., le Polain de Waroux, Y., McDermott, C.L., McLaughlin, D., Newton, P., Nolte, C., Pacheco, P., Rausch, L.L., Streck, C., Thorlakson, T., Walker, N.F., 2018. The role of supply-chain initiatives in reducing deforestation. Nat. Clim. Chang. 8, 109–116. https://doi.org/10.1038/s41558-017-0061-1.

MapBiomas, 2020. MapBiomas Project - Collection v4.1 of the Annual Land Use Land Cover Maps of Brazil. URL https://plataforma.mapbiomas.org/map#coverage (Accessed 8.11.20).

Nazareno, A.G., Laurance, W.F., 2020. Investors can help rein in Amazon deforestation. Science (80-.). 369, 635–636. https://doi.org/10.1126/science.abd7578.

Nobre, C.A., Sampaio, G., Borma, L.S., Castilla-Rubio, J.C., Silva, J.S., Cardoso, M., 2016. Land-use and climate change risks in the Amazon and the need of a novel sustainable development paradigm. Proc. Natl. Acad. Sci. 113, 10759 –10768. https://doi.org/10.1073/pnas.1605516113.

Pearson, T.R.H., Brown, S., Murray, L., Sidman, G., 2017. Greenhouse gas emissions from tropical forest degradation: an underestimated source. Carbon Balance Manag. 12, 3. https://doi.org/10.1186/s13021-017-0072-2.

Pelicice, F.M., Castello, L., 2021. A political tsunami hits Amazon conservation. Aquatic Conserv: Mar Freshw Ecosyst. 31 (5), 1221–1229.

Rajão, R., Soares-Filho, B., Nunes, F., Borner, J., Machado, L., Assis, D., Oliveira, A., Pinto, L., Ribeiro, V., Rausch, L., Gibbs, H., Figueira, D., 2020. The rotten apples of Brazil's agribusiness. Science (80-.). 369, 246–248. https://doi.org/10.1126/science.aba6646.

SIDRA-IBGE, 2020. Sistema IBGE de Recuperação Automática. Pesquisa Pecuária Municipal. Tabela 3939 - Efetivo dos rebanhos, por tipo de rebanho. URL https://sidra.ibge.gov.br/tabela/3939 (Accessed 12.5.20).

Silva, R.D.O., Barioni, L.G., Moran, D., 2021. Fire, deforestation, and livestock: when the smoke clears. Land Use Policy 100, 104949. https://doi.org/10.1016/j.landusepol.2020.104949.

Soares-Filho, B.S., Nepstad, D.C., Curran, L.M., Cerqueira, G.C., Garcia, R.A., Ramos, C. A., Voll, E., McDonald, A., Lefebvre, P., Schlesinger, P., 2006. Modelling conservation in the Amazon basin. Nature 440, 520–523. https://doi.org/10.1038/nature04389.

TerraBrasilis, INPE, 2020. TerraBrasilis | PRODES (Desmatamento). URL http://terrabrasilis.dpi.inpe.br/en/home-page/ (Accessed 9.27.19).

Turubanova, S., Potapov, P.V., Tyukavina, A., Hansen, M.C., 2018. Ongoing primary forest loss in Brazil, Democratic Republic of the Congo, and Indonesia. Environ. Res. Lett. 13, 074028 https://doi.org/10.1088/1748-9326/aacd1c.

Vieira, I., Toledo, P., Silva, J., Higuchi, H., 2008. Deforestation and threats to the biodiversity of Amazonia. Brazilian J. Biol. 68, 949–956. https://doi.org/10.1590/S1519-69842008000500004.