


Brazil's Next Deforestation Frontiers

Maurício Schneider¹ , Ana Alice Biedzicki de Marques², and Carlos A. Peres³

Tropical Conservation Science
Volume 14: 1–9
© The Author(s) 2021
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/19400829211020472
journals.sagepub.com/home/trc


Abstract

Public land grabbing, concomitant with hinterland colonization and agrarian reform programs, translocated millions of rural migrants into remote regions of Brazil, most recently to the Amazonian forest domain. Despite state-of-the-art command-and-control and remote sensing monitoring systems in Brazil, effective law enforcement in a country of ~8.5 million km² remains a huge challenge, and particularly difficult in times of lenient central-government environmental policies. Cropland and pasture expansion is the most important factor in land use change in Brazil, and the leading driver of primary habitat conversion worldwide. This essay discusses the most likely business-as-usual agricultural frontiers in Northern and Central Brazil to make room for new farmland: the MaToPiBa region in the transitional Cerrado-Caatinga biogeographic zone; the northernmost Cerrado areas of Amapá; and the opening-up of Indigenous Lands to industrial scale agriculture. We discuss the origins, recent developments and implications to conservation of these new agricultural frontiers.

Keywords

Brazil, land grabbing, agricultural frontier, deforestation, environmental policy, indigenous lands

Land Rush

The global demand for agricultural commodities of up to \$1.6 trillion/year (zu Ermgassen et al., 2020), implies that import countries have willingly or unwillingly subsumed deforestation in their supply chains (Hoang & Kanemoto, 2021), which poses as a great threat to tropical biodiversity. Species-rich ecosystems both in Amazonia and other Brazilian biomes have been relentlessly converted to fuel cropland and pastureland expansion and land grabbing (Green et al., 2019, Escobar et al., 2020, Probst et al., 2020).

Land reclamation is a quintessential issue in Brazil since colonial times, when so-called *capitanias hereditárias* and *sesmarias* were granted by the Portuguese monarchs to loyal subjects eager to exploit the New World. Even after Brazil's independence in 1822, the Portuguese Law of Sesmarias (public allotments, enacted in 1375) remained applicable. In the wake of abolitionism, Brazilian rulers established the Land Law of 1850, regulating all land belonging to the new Empire of Brazil, in practice establishing private properties in rural areas – plantations, pastures, homesteads and neighbouring forests – that were officially transferred to ever more farmers (Brasil, 1850). This law prohibited any deforestation or burning in public lands and determined that

further real-estate acquisitions could only be made if farmers purchased land from the Crown, thereby preventing former slaves from gaining access to land ownership while slavery was gradually abolished in years to come. Rather than halting deforestation, this law ignited a historical land rush, as influential farmers pushed farther inland into previously remote hinterlands to secure larger landholdings, whereas poor squatters established subsistence smallholdings that were virtually invisible to 19th-century bureaucracy and technology (Silva, 2015).

Following the occupation of coastal areas, Brazilian geopolitics encouraged several waves of migrants to settle farther inland, strategically laying claim to and populating the interior, developing regional economies and reducing poverty. This also led to forest conversion,

¹Câmara dos Deputados, Consultoria Legislativa, Brasília, Brazil

²Câmara Legislativa do Distrito Federal, Assessoria, Legislativa, Brasília, Brazil

³University of East Anglia, School of Environmental Sciences, Norwich, UK

Received 12 March 2021; Accepted 7 May 2021

Corresponding author:

Schneider Maurício, Câmara dos Deputados, Consultoria Legislativa, Brasília, Brazil.

Email: mauricio.schneider@camara.leg.br



followed by successive legislative amendments, in order to promote land tenure regularization throughout the countryside (the latest of which, Law 13.465/2017, increased the legal allotment size to 2,500 hectares). Sadly, public land has been an inexpensive asset throughout Brazilian history, and land grabbing, concomitant with colonization and land reform programs, translocated millions of migrants and their descendants to remote regions of the country, most recently to Amazonian forests under the public domain (Schneider & Peres, 2015).

This situation, incentivized by successive governments, led to vast expanses of unauthorized deforestation, mostly in the last few decades, boosted by the growing importance of agricultural exports to national GDP. Illegal conversion of natural vegetation was largely pardoned by the significantly revised Forest Law (Law 12,651, Brasil, 2012). Now that the country desperately struggles to recover from an economic downfall, coupled with both severe political and epidemiological crises, a pro-development geopolitical agenda will likely further brush aside any environmental concerns. Brazilian agricultural production benefits from enhanced productivity and mainstreaming technological advances, but too many farmers still rely on outdated methods, resulting in low agricultural productivity. Nonetheless, further forest conversion continues unabated, and rather than restoring millions of hectares of previously degraded pastures to increase carrying capacity (Strassburg et al., 2014), mechanized croplands have expanded at the expense of primary habitats more than threefold since 1985. Under these circumstances, what are to become the most important deforestation frontiers in Brazil in the 2020s?

Frontier Expansion in Northern and Central Brazil

Land grabbing throughout the Amazon has been the most important driver of deforestation, regardless of any law-and-order enforcement by environmental agencies (Brito et al., 2019). The small risk of conviction simply pales in comparison with tempting financial incentives such as land-tenure regularization, rural credit, short-term profits, and amnesties for illegal deforestation (Azevedo-Ramos et al., 2020; Freitas et al., 2018; Trancoso, 2021). A perverse policy novelty now comes from squatters using an official online system of the Brazilian Forest Service (SFB) to legally lay claim to land inside existing protected areas.

The Forest Law of 2012 established the Environmental Rural Registry (*Cadastro Ambiental Rural*, CAR), a mandatory national electronic public record of landholdings that identifies legal ownership, physical boundaries, agricultural land and native

vegetation cover. As of 31 October 2018, over 5.4 million landholdings had been self-declared in this database (SFB, 2018), but many records are plagued with inconsistencies and only a small fraction of the records has been independently validated by local authorities. Landholdings overlapping Indigenous Lands and nature reserves (in Brazil, Conservation Units) were soon identified, and those records have been invalidated. Although entirely illegal, those served as a political argument when the National Congress voted to downsize protected areas in the Amazon (Provisional Measure 756/2016; although the bill was passed, it was later vetoed by the then sitting President). This strategy confirmed warnings that, although the CAR does not officially validate a landholding title deed, it would be used by land squatters to claim land regularization, even within protected areas and indigenous territories (Moreira, 2016). Unsurprisingly, 16 out of 27 DDD (reserve degazettement, downsizing or downgrading) bills affecting federal protected areas in Brazil were motivated by land claims, four of which were enacted (Marques & Peres, 2015).

The Amazon biome comprises 49.2% of Brazil's ~8.5 million km² territory and on average experienced 6,494 km² of forest loss each year during a whole decade (2009–2018), but this suddenly leaped to 10,129 km² in 2019 and 11,088 km² in 2020 (Instituto Nacional de Pesquisas Espaciais [INPE], 2021). The Cerrado wooded savannas of Central Brazil (23.9% of the national territory), on the other hand, on average faced clear-cuts of 15,017 km² each year since 2001, according to official data from remote sensing time series (INPE, 2021; Figure 1). Hence, the two largest terrestrial biomes in Brazil have lost 5.6% and 14.4% of their respective **original** vegetation cover in the 21st century alone.

Even though Brazilian legislation protects all types of native vegetation, we believe there is a strong cultural bias to protect forests, rather than shrublands or grasslands, and landowners tend to see all open vegetation types as legitimate “low-hanging” areas for agricultural conversion. Even within the Cerrado biome, mandatory set-asides (legal reserves) are predominantly established in forested areas of private properties, leaving most of the burden of land use change to savannas and prairies (Bonanomi et al., 2019). Two Cerrado regions have become promising agricultural frontiers raising serious environmental concerns. Next, we briefly outline the key regions earmarked for imminent deforestation trends (Figure 2).

Cerrado Clearcuts in MaToPiBa and Amapá

A 730,700-km² region encompassing 337 municipal counties within the four major states of Maranhão,

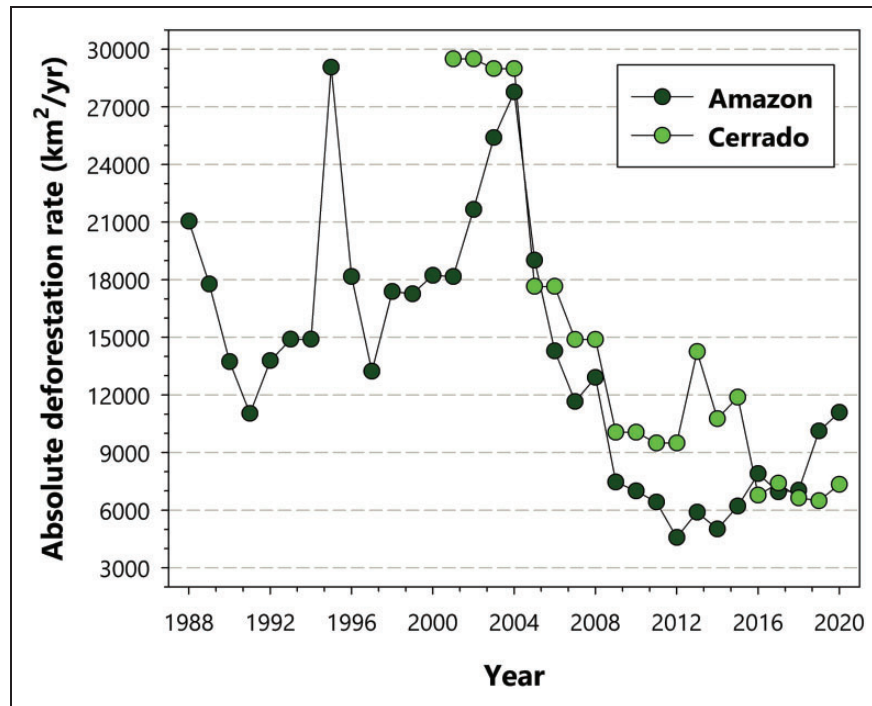


Figure 1. Annual Deforestation Area (km²/year) in the Brazilian Amazon and the Cerrado Biomes (Official Data From INPE, 2021). Note the hike in Amazonian deforestation from 2019.

Tocantins, Piauí and Bahia (therefore nicknamed MaToPiBa) is widely extolled as an emergent agricultural frontier, following rapid transformation from small scale, low productivity farming to intensive, high-yield, irrigation-dependent modern mechanized agriculture (Miranda et al., 2014). Although this region was underdeveloped until the late 1980s, it yielded 10% of Brazil's cropland production in 2015 (Belchior et al., 2017), and grain production is expected to increase fourfold by 2028 (Ministério da Agricultura, Pecuária e Abastecimento [MAPA], 2018).

Cropland prices for mechanized agriculture in the MaToPiBa region are around US\$1,235/ha, about half the average cost of that in Mato Grosso (MAPA, 2018, 2019), now the leading agricultural state in Brazil. Cheap lands combined with a climate similar to that of the remaining Cerrado and a favourable flat topography ideal for large-scale mechanized croplands suggest that pressure upon forest remnants in this region will only increase. Current deforestation forecasts by 2050 range between 29.1 and 34.6 million hectares depending on an optimistic, business-as-usual or pessimistic scenario (Aguilar, 2016), and include semiarid areas prone to desertification (Garcia & Filho, 2018). Soy monoculture in MaToPiBa comes with environmental degradation, illegal irrigation in a water-stressed region, corruption in land titling (Procuradoria Geral

da República, 2021), and limited inclusiveness for the rural poor (Lopes et al., 2021).

The state of Amapá encompasses 142,829 km², mostly north of the Equator, 8,897 km² of which consists of naturally open Cerrado vegetation. EMBRAPA, a government agronomic agency linked with the Ministry of Agriculture, has proposed agricultural expansion of over 6,050 km² of Amapá's Cerrado vegetation (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2016). This recommendation was welcomed by local authorities, who expressed unreserved enthusiasm for agribusiness development, following many years of frustrated expectations with forest carbon payments for environmental services, particularly considering that some three quarters of this state has been allocated to protected areas and Indigenous Lands. Although the desire to boost the state's economy is understandable, in all likelihood the EMBRAPA study may legitimize a new cycle of transferring Cerrado land rights to private ownership and deforestation, as previously recorded (Hilário et al., 2017). Regardless of official zoning efforts to designate the spatial arrangements of agricultural and protected areas, land squatting already happens in the region (Procuradoria da República no Amapá, 2020), and is likely to be maximized with prospective land regularization.

From 1975 the Cerrado Development Program (Programa de Desenvolvimento dos Cerrados,

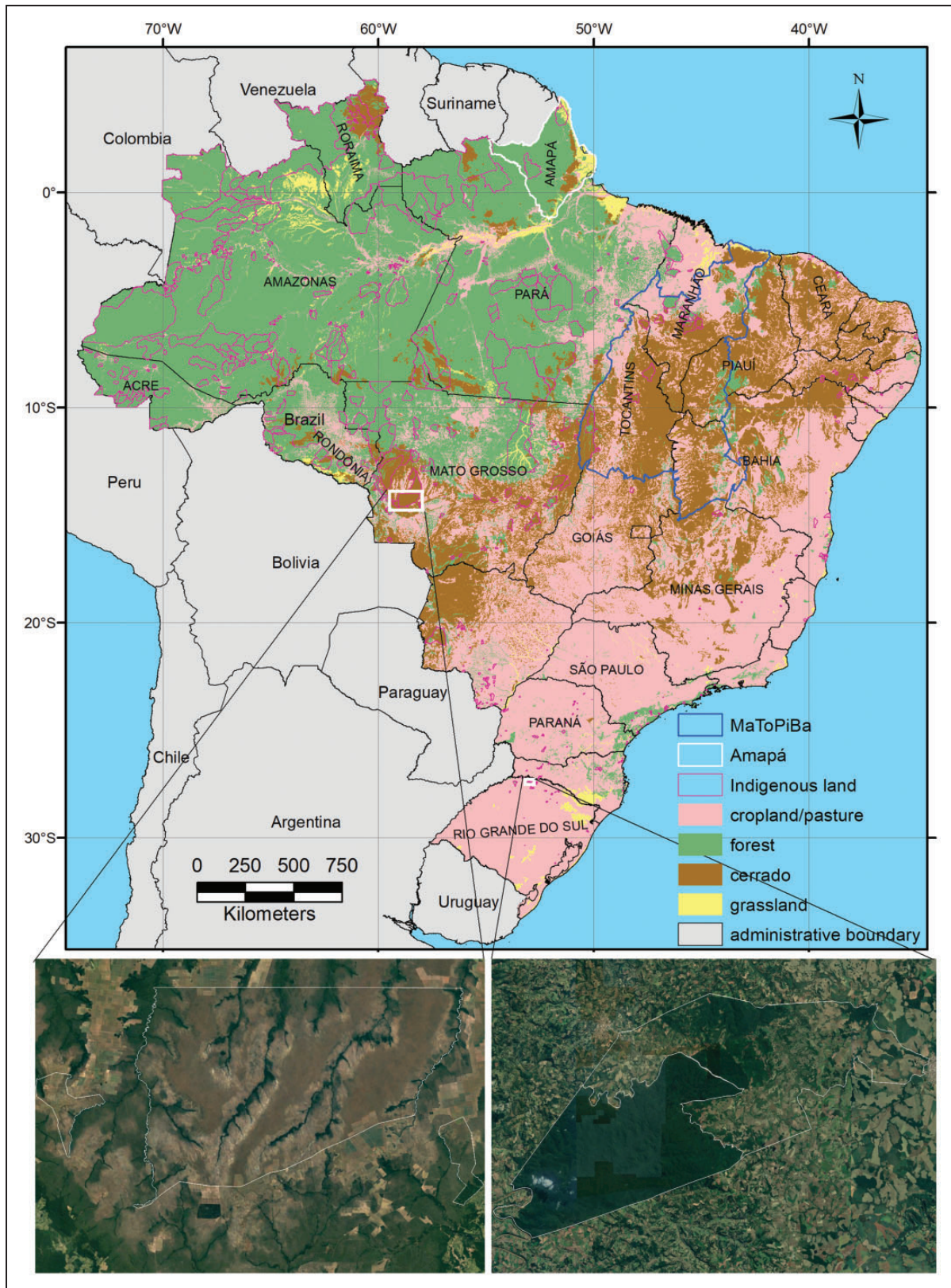


Figure 2. Simplified Land Cover Throughout Brazil, Boundaries of Indigenous Lands (Magenta Polygons), the MaToPiBa Region (Outlined in Blue) and the Cerrado Remnants of the State of Amapá (Outlined in White). The insets illustrate examples of the reality of land-use change within Indigenous Lands: Terra Indígena dos Parecís in the Cerrado domain (previously embargoed; left inset map) and the Terra Indígena Nonoai in the Atlantic Forest domain (already two-thirds deforested; right inset map).

POLOCENTRO) consisted of federal policies designed to boost the regional economy and accommodate migrants from other parts of the country (Farias & Zamberlan, 2014), which included investments in infrastructure, rural credit, and the successful establishment of research and technology centres to adapt seed varieties and agricultural systems to the region. Cerrado conversion in Matopiba and Amapá are likely to follow the same pattern of deforestation frequently witnessed in Central Brazil, where rural subsidies, transport infrastructure and modern agricultural techniques have drastically transformed land use since the 1970s. Land titling coupled with land concentration are further incentives to expand consolidated agricultural frontiers into regions where native vegetation is only partially forested, and wildfire control has been weakened by severe budget cuts and environmental policy shifts (Schmidt & Eloy, 2020).

Indigenous Lands

Formally sanctioned Indigenous Lands (ILs) have long been regarded as synonymous to protected areas in Brazil, often deterring legitimate mining claims and performing better than parks and biological reserves in curbing deforestation (Nepstad et al., 2006; Ricketts et al., 2010). Their legal status, however, is very specific, and indigenous peoples retain the right to exploit natural resources under traditional norms, including subsistence hunting and slash-and-burn agriculture (Statute of the Indian – Law 6001/1973).

Indigenous Lands in the Amazon are often as large as entire countries, and their inhabitants were historically semi-nomadic. To access public services, such as education and healthcare, some native Brazilians are now settling ever closer to stable villages with reliable infrastructure, thereby abandoning ancient migration patterns. In contrast, indigenous lands outside the Amazon are much smaller, have lost most of their native vegetation to other land uses, and exhibit little or no internal migration.

This more sedentary settlement pattern led to the emergence of new demands. The federal environmental agency (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis [IBAMA]) has received applications for deforestation permits within indigenous lands over the last decade, for agriculture, commercial logging and charcoal production, and there is a legal discussion in the National Congress about the extent to which modern, mechanized agriculture can be defined as subsistence use of natural resources, and how far it may escalate to the point of becoming a commercial enterprise.

There is also a vigorous legislative discussion about to what extent indigenous peoples should be permitted to

align their interests with those of non-indigenous farmers, or even lease out their lands. Agribusiness encroachment within Indigenous Lands has resulted in several cases of illegal deforestation, including the TI Parecis, where 22,000 hectares were embargoed by IBAMA after genetically-modified soy monoculture was discovered (the embargo was lifted in 2019).

Land leases and agricultural partnerships between indigenous and non-indigenous farmers are currently unlawful, but these areas span 3 million hectares (Carvalho, 2019). There is an emerging divide among representatives of different ethnic groups, some of whom support a more traditional sociocultural lifestyle, whereas others propose to boost economic activity within their territories, literally including "... large-scale agriculture and large-scale beef farming" (the reader may watch a committee hearing at Câmara dos Deputados, 2021:13'40"). Illegal agricultural agreements between indigenous groups and commercial farmers are now rampant, and they may eventually be sanctioned as legal.

Indigenous territories in Brazil remain largely intact, particularly in the Amazon (Begotti & Peres, 2020). However, a joint venture between indigenous peoples and traditional farmers could unleash unprecedented pulses of deforestation in every Brazilian biome. Brazilian Indigenous Lands span over 1 million km², only 1.6% of which has been deforested (Table 1). Should Brazil witness the dawn of large-scale modern agriculture in ILs, 275,824 km² of natural vegetation, including pristine forests, will become eligible to deforestation permits (if the maximum legally permissible proportion of forest conversion is authorized). This would represent an increase in forest loss of 1,449% within ILs.

Policies and Politics

Forest conversion in Amazonian agricultural frontiers continues to be subsidized by (1) land tenure regularization that incentivizes land-grabbing, (2) land reform programs, (3) rural credit that is decoupled from formal land ownership, (4) downgrading of environmental legislation, (5) downsizing of protected areas, and (6) amnesty to glaring violations of illegal deforestation (Azevedo-Ramos et al., 2020; Marques & Peres, 2015; Schneider & Peres, 2015). Even in consolidated agricultural frontiers, 15% of the bovine beef and soya production and exports still result from relatively recent deforestation (Rajão et al., 2020).

The post presidential election institutional vulnerability and threats to Brazilian conservation goals are widely acknowledged in the literature (Rodrigues-Filho et al., 2015). During the 2018 elections, amid an economic recession, Brazil welcomed a pro-development agenda and a record low re-election of representatives in the National Congress (47% of deputies and 85% of

Table 1. Brazilian Indigenous Lands (km² per Biome; Water Bodies Excluded), Percentage of Deforested Areas and Minimum Required Legal Reserve Within Private Landholdings (Ranging From 20% to 80%) and Acreage Still Eligible for Deforestation Permits if Large Scale Agriculture Is Authorized; Figures Calculated by Overlapping IL Polygons (Fundação Nacional do Índio [FUNAI], 2020) With Land Cover in the Year 2019 (MapBiomias, 2021) (see Supplemental Material).

Biome	Indigenous lands	Current deforestation	Legal reserve	Eligible deforestation area	% potential deforestation
Amazon	1,056,779.0	9,364.9	845,423.2	201,990.9	19.3
Atlantic Forest	7,547.1	3,522.7	1,509.4	2,514.9	62.5
Pantanal	4,317.2	383.2	863.4	3,070.5	78.1
Cerrado	88,406.6	4,395.5	17,681.3	66,329.7	79.0
Caatinga	4,039.3	1,330.6	807.9	1,900.8	70.2
Pampa	73.9	41.8	14.8	17.3	53.9

senators were newcomers). The proposal to abolish the Ministry of Environment in 2019, merging its agencies with the Ministry of Agriculture (Araújo, 2020) also signalled a newly entrenched administration prejudice, and enforcement protocols were reviewed by federal environmental agencies, largely weakening command and control measures against illegal deforestation (Brasil, 2021).

The Federal Government proposed, among its legislative priorities for 2021 (Baptista, 2021), a new Indigenous Peoples Statute (Bill 119/2015), an Indigenous Lands Mining Act (Bill 191/2020), another land tenure regularization (Bill 2633/2020) and a Public Forest Concession Law amendment (Bill 5518/2020). The first two bills are likely to open a vast area within indigenous lands to economic development, while the latest two grant private use of public lands. All of these bills signal further forest conversion in every region of the country, not only in the Amazon. On top of that, 57 regulations have been enacted in the last two years to weaken existing environmental legislation (Vale et al., 2021), and a proposed comprehensive review of already established protected areas threatens those sanctuaries with downsizing and downgrading (Barbosa et al., 2021).

Recent experience on land titling decoupled with environmental enforcement has led to deforestation in Brazil (Probst et al., 2020), and a combination of business-as-usual with permissive policies will likely boost land cover change in all agricultural frontiers mentioned above. The darkest scenario seems to confront Indigenous Lands, which are often extolled for inhibiting deforestation, but represent a potential 275,824 km² of additional deforestation due to modern agriculture in the foreseeable future.

Amidst record wildfires, the Brazilian Minister of Environment was strongly criticised during a meeting of the OECD Environmental Policy Committee, leaving its accession process in virtual standby (Schneider, 2020), and several large investment funds (both national and international brokers and companies) have voiced the importance of a positive ESG (Environmental, Social and Governance) agenda and the detrimental

impacts of deforestation on the country's reputation. In the post-pandemic recovery, expected to be greener than a typical business-as-usual economy, we enumerate a few simple, albeit not necessarily easy, steps to protect remnants of wild nature while Brazil seeks further economic growth:

1. Address farmer's non-compliance by ensuring a path to legality and effective law enforcement;
2. Protect environmental agencies from political influence and budget bottlenecks;
3. Prosecute land grabbers, rather than promote new land-tenure regularization loopholes;
4. Repel bills that downsize, downgrade and degazette hard-won protected areas;
5. Repel bills that grant further amnesties to previous deforestation;
6. Enact strict regulations regarding legal deforestation within indigenous territories.

None of the steps above have been taken by the Executive branch during the first half of its current mandate, quite the opposite. How exactly the government will manage its own idiosyncrasies, negotiate bills with the National Congress, and reassure domestic and international investors in relation to environmental policies is yet to be seen, but any responsible development policies depend on reconciling incentives for both farmers and nature conservation, and effective enforcement of command-and-control measures. In order to avoid current agricultural conversion of natural ecosystems, which brings about dramatic hydroecological consequences (e.g. disrupting the water cycle, Cooper et al., 2020), it is also crucial that Brazilian agribusiness understands the sector's dependence on free-of-charge environmental services.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Maurício Schneider  <https://orcid.org/0000-0002-1563-6111>

Supplemental Material

Supplemental material for this article is available online.

References

- Aguiar, A. S. (2016). *Modelagem da dinâmica do desmatamento na região do MATOPIBA até 2050* [Modeling the dynamics of deforestation in the MATOPIBA region by 2050]. Universidade de Brasília.
- Araújo, S. M. V. G. (2020). Environmental policy in the Bolsonaro government: The response of environmentalists in the legislative arena. *Brazilian Political Science Review, São Paulo, 14*(2), e0005. <https://doi.org/10.1590/1981-3821202000020005>
- Azevedo-Ramos, C., Moutinho, P., Arruda, V. L. D. S., Stabile, M. C., Alencar, A., Castro, I., & Ribeiro, J. P. (2020). Lawless land in no man's land: The undesignated public forests in the Brazilian amazon. *Land Use Policy, 99*, 104863. <https://doi.org/10.1016/j.landusepol.2019.104362>
- Baptista, R. (2021). *Senadores avaliam lista de prioridades do governo no Congresso* [Senators evaluate list of government priorities in Congress]. <https://www12.senado.leg.br/noticias/materias/2021/02/05/senadores-avaliam-lista-de-prioridades-do-governo-no-congresso>
- Barbosa, L. G., Alves, M. A. S., & Grelle, C. E. V. (2021). Actions against sustainability: Dismantling of the environmental policies in Brazil. *Land Use Policy, 104*, 105384. <https://doi.org/10.1016/j.landusepol.2021.105384>
- Begotti, R. A., & Peres, C. A. (2020). Rapidly escalating threats to the biodiversity and ethnocultural capital of Brazilian indigenous lands. *Land Use Policy, 96*, 104694. <https://doi.org/10.1016/j.landusepol.2020.104694>
- Belchior, E. B., Alcântara, P. H. R., & Barbosa, C. F. (2017). Perspectivas e desafios Para a região do matopiba [Perspectives and challenges for the Matopiba region]. *Fronteira Agrícola, 16*, 1–3.
- Bonomi, J., Tortato, F. R., Gomes, R. S., Penha, J. M., Bueno, A. S., & Peres, C. A. (2019). Protecting forests at the expense of native grasslands: Land-use policy encourages open-habitat loss in the Brazilian Cerrado biome. *Perspectives in Ecology and Conservation, 17*(1), 26–31. <https://doi.org/10.1016/j.pecon.2018.12.002>
- Brasil. (1850). *Lei nº 601, de 18 de setembro de 1850. Dispõe sobre as terras devolutas do Império* [Law No. 601, of September 18, 1850. Provides for the vacant lands of the Empire]. http://www.planalto.gov.br/ccivil_03/LEIS/L0601-1850.htm
- Brasil. (2012). *Lei nº 12.651, de 25 de maio de 2012. Dispõe sobre a proteção da vegetação nativa; altera as Leis nos 6.938, de 31 de agosto de 1981, 9.393, de 19 de dezembro de 1996, e 11.428, de 22 de dezembro de 2006; revoga as Leis nos 4.771, de 15 de setembro de 1965, e 7.754, de 14 de abril de 1989, e a Medida Provisória no 2.166-67, de 24 de agosto de (2001), e dá outras providências* [Law No. 12,651, of May 25, 2012. Provides for the protection of native vegetation; amends Laws 6,938, of August 31, 1981, 9,393, of December 19, 1996, and 11,428, of December 22, 2006; repeals Laws 4,771, of September 15, 1965, and 7,754, of April 14, 1989, and Provisional Measure No. 2,166-67, of August 24, (2001), and makes other provisions]. http://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2012/Lei/L12651compilado.htm
- Brasil. (2021). *Instrução Normativa Conjunta MMAIBAMAICMBIO nº 1, de 12 de abril de 2021* [Joint Normative Instruction MMAIBAMAICMBIO n ° 1, of April 12, 2021]. <https://www.in.gov.br/en/web/dou/-/instrucao-normativa-conjunta-mma/ibama/icmbio-n-1-de-12-de-abril-de-2021-314019923>
- Brito, B., Barreto, P., Brandão, A., Jr., Baima, S., & Gomes, P. H. (2019). Stimulus for land grabbing and deforestation in the Brazilian amazon. *Environmental Research Letters, 14*(6), 064018. <https://orcid.org/0000-0002-6573-2996>
- Câmara dos Deputados. (2021). *Debate Para expor a situação socioambiental nas terras indígenas* [Debate to expose the socio-environmental situation in indigenous lands]. <https://www.camara.leg.br/evento-legislativo/61084>
- Carvalho, L. A. (2019). *Os contratos agrários e as atividades agrícolas de larga escala em terras indígenas: Aspectos jurídicos e práticos* [Agrarian contracts and large-scale agricultural activities on indigenous lands: Legal and practical aspects]. Câmara dos Deputados. <https://bd.camara.leg.br/bd/handle/bdcamara/37320>
- Cooper, G. S., Willcock, S., & Dearing, J. A. (2020). Regime shifts occur disproportionately faster in larger ecosystems. *Nature Communications, 11*(1), 1175. <https://doi.org/10.1038/s41467-020-15029-x>
- Empresa Brasileira de Pesquisa Agropecuária. (2016). *Zoneamento socioambiental do cerrado do estado do Amapá* [Socio-environmental zoning of the savannah of the state of Amapá]. SETEC; IEPA; NOT; EMBRAPA. http://www.iepa.ap.gov.br/biblioteca/publicacoes/relatorio_cerrado_2016_17.pdf
- Escobar, N., Tizado, E. J., zu Ermgassen, E. K., Löfgren, P., Börner, J., & Godar, J. (2020). Spatially-explicit footprints of agricultural commodities: Mapping carbon emissions embodied in Brazil's soy exports. *Global Environmental Change, 62*, 102067. <https://doi.org/10.1016/j.gloenvcha.2020.102067>
- Farias, G. M., & Zamberlan, C. O. (2014). Expansão da fronteira agrícola: Impacto das políticas de desenvolvimento regional no centro-oeste brasileiro [Expansion of the agricultural frontier: Impact of regional development policies in the Brazilian Midwest]. *Revista Brasileira de Planejamento e Desenvolvimento, 2*(2), 58–68.
- Freitas, F. L. M., Sparovek, G., Berndes, G., Persson, U. M., Englund, O., Barretto, A., & Mörtberg, U. (2018). Potential increase of legal deforestation in Brazilian amazon after Forest act revision. *Nature Sustainability, 1*(11), 665–670. <https://doi.org/10.1038/s41893-018-0171-4>
- Fundação Nacional do Índio. (2020). *Terras Indígenas* [Indigenous lands]. <http://www.funai.gov.br/index.php/shape>

- Garcia, J. R., & Filho, J. E. R. V. (2018). O papel da dimensão ambiental na ocupação do MATOPIBA [The role of the environmental dimension in the occupation of MATOPIBA]. *Confins*, 35. <https://doi.org/10.4000/confins.13045>
- Green, J. M., Croft, S. A., Durán, A. P., Balmford, A. P., Burgess, N. D., Fick, S., Gardner, T. A., Godar, J., Suavet, C., Virah-Sawmy, M., Young, L. E., & West, C. D. (2019). Linking global drivers of agricultural trade to on-the-ground impacts on biodiversity. *Proceedings of the National Academy of Sciences of the United States of America*, 116(46), 23202–23208. www.pnas.org/cgi/doi/10.1073/pnas.1905618116
- Hilário, R. R., de Toledo, J. J., Mustin, K., Castro, I. J., Costa-Neto, S. V., Kauano, E. E., Eilers, V., Vasconcelos, I. M., Mendes-Junior, R. N., Funi, C., Fearnside, P. M., Silva, J. M. C., Euler, A. M. C., & de Carvalho, W. D. (2017). The fate of an Amazonian savanna: Government land-use planning endangers sustainable development in Amapá, the most protected Brazilian state. *Tropical Conservation Science*, 10, 194008291773541. <https://doi.org/10.1177/2F1940082917735416>
- Hoang, N. T., & Kanemoto, K. (2021). Mapping the deforestation footprint of nations reveals growing threat to tropical forests. *Nature Ecology & Evolution*. Advance online publication. <https://doi.org/10.1038/s41559-021-01417-z>
- Instituto Nacional de Pesquisas Espaciais. (2021). *Dashboard de Desmatamento Prodes—Taxas anuais e incrementos de desmatamento na Amazônia Legal e Cerrado* [Prodes deforestation dashboard—Annual rates and increments of deforestation in the Legal Amazon and Cerrado]. <http://terrabrasilis.dpi.inpe.br/>
- Lopes, G. R., Lima, M. G. B., & dos Reis, T. N. (2021). Maldevelopment revisited: Inclusiveness and social impacts of soy expansion over Brazil's. *World Development*, 139, 105316. <https://doi.org/10.1016/j.worlddev.2020.105316>
- MapBiomias. (2021). *Projeto—Coleção 5 da Série Anual de Mapas de Cobertura e Uso de Solo do Brasil* [Project—Collection 5 of the annual series of coverage and land use maps of Brazil]. <http://mapbiomas.org/>
- Marques, A. A. B., & Peres, C. A. (2015). Pervasive legal threats to protected areas in Brazil. *Oryx*, 49(1), 25–29. <https://doi.org/10.1017/S0030605314000726>
- Ministério da Agricultura, Pecuária e Abastecimento. (2018). *Projeções do Agronegócio—Brasil 2017/18 a 2027/28—Projeções de longo prazo* [Agribusiness Projections—Brazil 2017/18 to 2027/28—Long-term projections].
- Ministério da Agricultura, Pecuária e Abastecimento. (2019). *Relatório de análise de mercado de terras no estado de Mato Grosso/SR (13)—RAMT/MT* [Land market analysis report in the state of Mato Grosso/SR (13)—RAMT/MT].
- Miranda, E. E., Magalhães, L. A., & Carvalho, C. A. (2014). *Proposta de Delimitação Territorial do MATOPIBA* [MATOPIBA territorial delimitation proposal]. GITE/EMBRAPA.
- Moreira, E. (2016). *O cadastro ambiental rural: A nova face da grilagem na Amazônia?* [The rural environmental registry: The new face of land grabbing in the Amazon?] <https://www.abrampa.org.br/site/?ct=noticia&id=230>
- Nepstad, D., Schwartzman, S., Bamberger, B., Santilli, M., Ray, D., Schlesinger, P., Lefebvre, P., Alencar, A., Prinz, E., Fiske, G., & Rolla, A. (2006). Inhibition of amazon deforestation and fire by parks and indigenous lands. *Conservation Biology*, 20(1), 66–84. <https://doi.org/10.1111/j.1523-1739.2006.00351.x>
- Probst, B., BenYishay, A., Kontoleon, A., & dos Reis, T. N. (2020). Impacts of a large-scale titling initiative on deforestation in the Brazilian amazon. *Nature Sustainability*, 3(12), 1019–1026. <https://doi.org/10.1038/s41893-020-0537-2>
- Procuradoria da República no Amapá. (2020). *Ex-deputado é denunciado pelo MPF por grilar terras da União para cultivar soja* [Ex-deputy is denounced by MPF for grabbing Union land to grow soybeans]. <http://www.mpf.mp.br/ap/sala-de-imprensa/noticias-ap/ex-deputado-e-denunciado-pelo-mpf-por-grilagem-de-terras-da-uniao-para-cultivar-soja-no-amapa>
- Procuradoria Geral da República. (2021). *Operação Faroeeste: MPF denuncia organização criminosa com participação de desembargadora do TJBA* [Operation Western: MPF denounces criminal organization with participation of judge of TJBA]. <http://www.mpf.mp.br/pgr/noticias-pgr/operacao-faroeeste-mpf-denuncia-organizacao-criminosa-com-participacao-de-desembargadora-do-tj-ba>
- Rajão, R., Soares-Filho, B., Nunes, F., Börner, 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 (New York, N.Y.)*, 369(6501), 246–248. <https://doi.org/10.1126/science.aba6646>
- Ricketts, T. H., Soares-Filho, B., da Fonseca, G. A. B., Nepstad, D., Pfaff, A., Petsonk, A., Anderson, A., Boucher, D., Cattaneo, A., Conte, M., Creighton, K., Linden, L., Maretti, C., Moutinho, P., Ullman, R., & Victurine, R. (2010). Indigenous lands, protected areas, and slowing climate change. *PLoS Biology*, 8(3), e1000331. <https://doi.org/10.1371/journal.pbio.1000331>
- Rodrigues-Filho, S., Verburg, R., Bursztyn, M., Lindoso, D., Debortoli, N., & Vilhena, A. M. (2015). Election-driven weakening of deforestation control in the Brazilian amazon. *Land Use Policy*, 43, 111–118. <https://doi.org/10.1016/j.landusepol.2014.11.002>
- Schmidt, I. B., & Eloy, L. (2020). Fire regime in the Brazilian savanna: Recent changes, policy and management. *Flora*, 268, 151613. <https://doi.org/10.1016/j.flora.2020.151613>
- Schneider, M. (2020). *Acesso do Brasil à OCDE: Aspectos gerais e temas ambientais* [Accession of Brazil to the OECD: General and environmental issues]. Câmara dos Deputados. <http://bd.camara.gov.br/bd/handle/bdcamara/39920>
- Schneider, M., & Peres, C. A. (2015). Environmental costs of government-sponsored agrarian settlements in Brazilian Amazonia. *PLoS One*, 10(8), e0134016. <https://doi.org/10.1371/journal.pone.0134016>
- Serviço Florestal Brasileiro (SFB). (2018). *Cadastro Ambiental Rural—Boletim Informativo—Dados até 31 de outubro de 2018* [Rural Environmental Registry—Information Bulletin—Data until October 31, 2018]. <http://www.florestal.gov.br/documentos/car/boletim-do-car/3936-tabela-calculos-boletim-sicar-outubro2018-rev-rej/file>

- Silva, M. A. B. (2015). Lei de terras de 1850: Lições sobre os efeitos e os resultados de não se condenar “uma quinta parte da atual população agrícola” [1850 Land Law: Lessons on the effects and results of not condemning “a fifth part of the current agricultural population”]. *Revista Brasileira de História*, 35(70), 87–107. <http://dx.doi.org/10.1590/1806-93472015v35n70014>
- Strassburg, B. B., Latawiec, A. E., Barioni, L. G., Nobre, C. A., Da Silva, V. P., Valentim, J. F., Vianna, M., & Assad, E. D. (2014). When enough should be enough: Improving the use of current agricultural lands could meet production demands and spare natural habitats in Brazil. *Global Environmental Change*, 28, 84–97. <https://doi.org/10.1016/j.gloenvcha.2014.06.001>
- Trancoso, R. (2021). Changing amazon deforestation patterns: Urgent need to restore command and control policies and market interventions. *Environmental Research Letters*, 16(4), 041004. <https://doi.org/10.1088/1748-9326/abee4c>
- Vale, M. M., Berenguer, E., de Menezes, M. A., de Castro, E. B. V., de Siqueira, L. P., & de Cássia, Q. P. R. (2021). The COVID-19 pandemic as an opportunity to weaken environmental protection in Brazil. *Biological Conservation*, 255, 108994. <https://doi.org/10.1016/j.biocon.2021.108994>
- zu Ermgassen, E. K. H. J., Godar, J., Lathuilière, M. J., Löfgren, P., Gardner, T., Vasconcelos, A., & Meyfroidt, P. (2020). The origin, supply chain, and deforestation risk of Brazil's beef exports. *Proceedings of the National Academy of Sciences*, 117(50), 31770–31779. www.pnas.org/cgi/doi/10.1073/pnas.2003270117