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Domestic and Foreign Drivers of the Brazilian Legal Amazon Deforestation

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Background

The Legal Amazon (LAM) is a **legal delimitation** that includes the entirety of the Brazilian Amazon Basin, encompassing the tropical forest and adjacent Cerrado areas.

It amounts to 5 Mkm2 (roughly half the size of Canada) – **59% of the Brazilian territory**.

With about **28 million inhabitants** and an average Human Development Index below 0.58, it fully covers the states of Acre, Amazonas, Amapá, Pará, Rondônia, Tocantins and Mato Grosso, in addition to part of Maranhão.

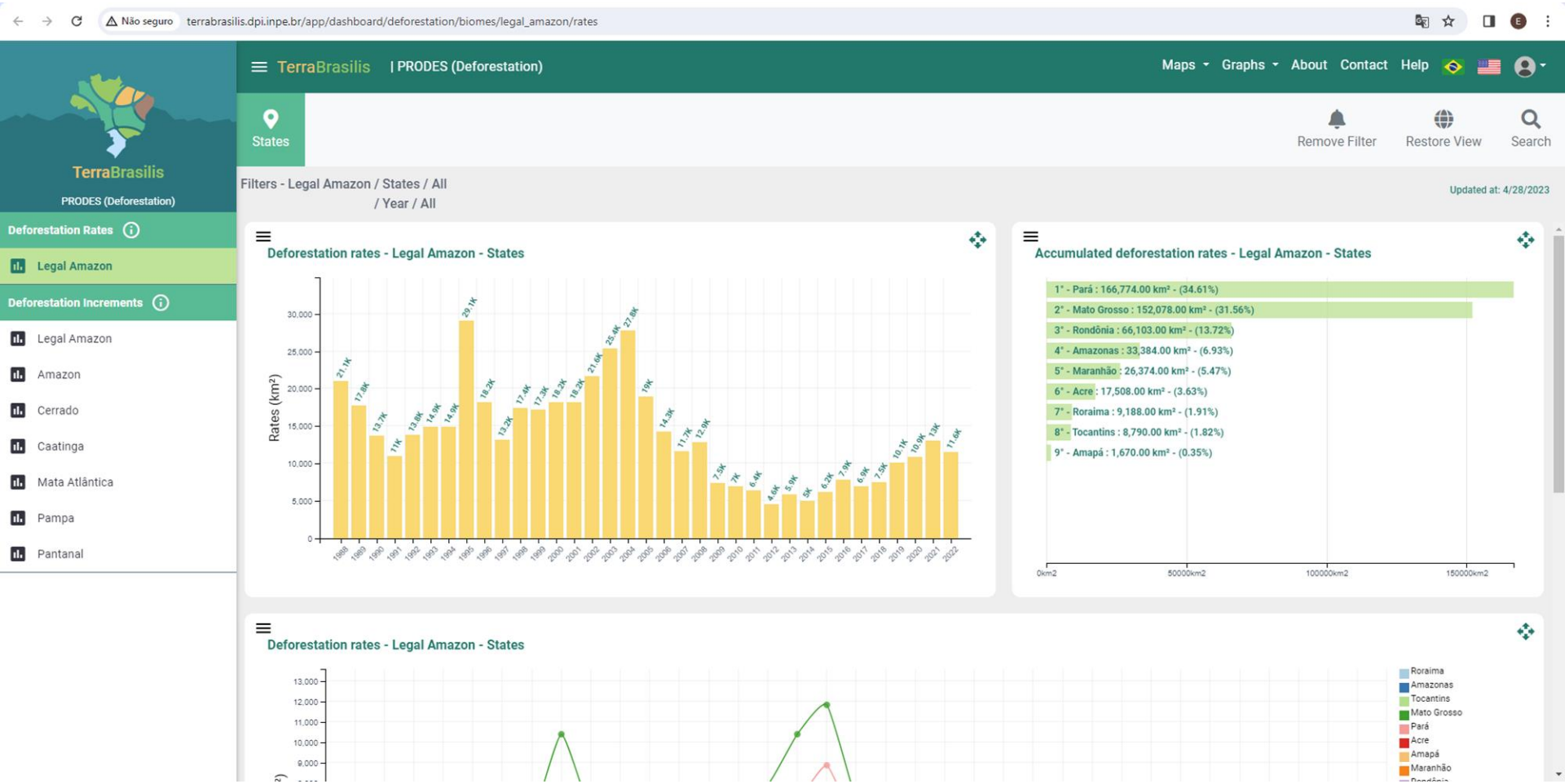
Issues

Accountability for the pressure on the use of the world's natural resources

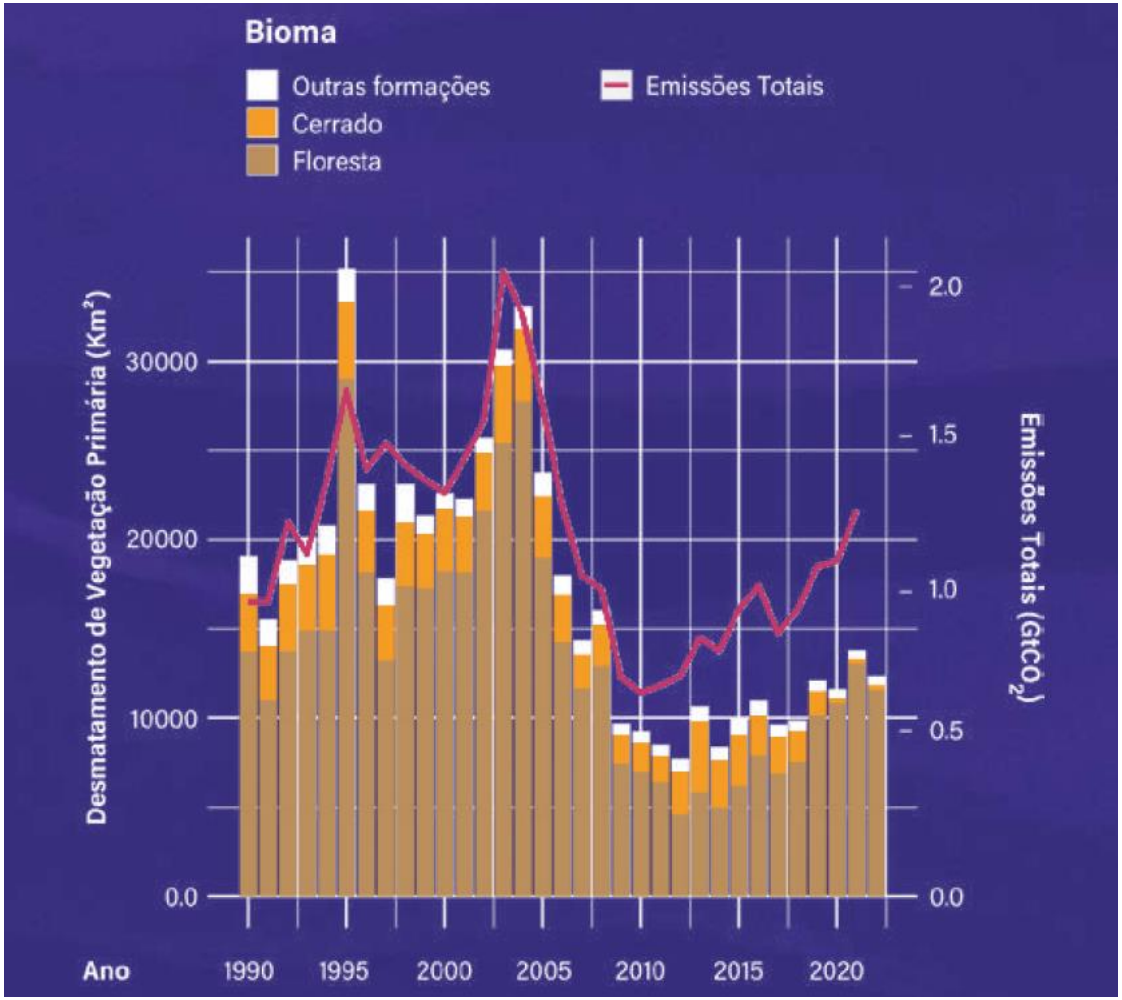
In the case of the Brazilian Amazon, local deforestation is often closely tied to the structure of the global economy.

Here we show that economic demand originating in the more developed Brazilian center-south imposes a much stronger pressure on Amazon's deforestation than local (within Amazon) and foreign export demand.

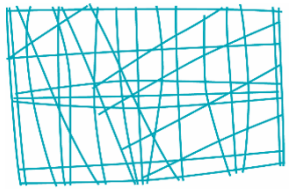
Deforestation monitor



Deforestation and CO2 emissions



Inter-Regional Input-Output Matrix (IIOM-LAM)



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Matriz Inter-regional de Insumo-Produto para a Amazônia

Referência: Haddad, E. A. (coord.) (2021). *Matriz Inter-regional de Insumo-Produto para a Amazônia Legal, 2015* . Fundação Instituto de Pesquisas Econômicas.

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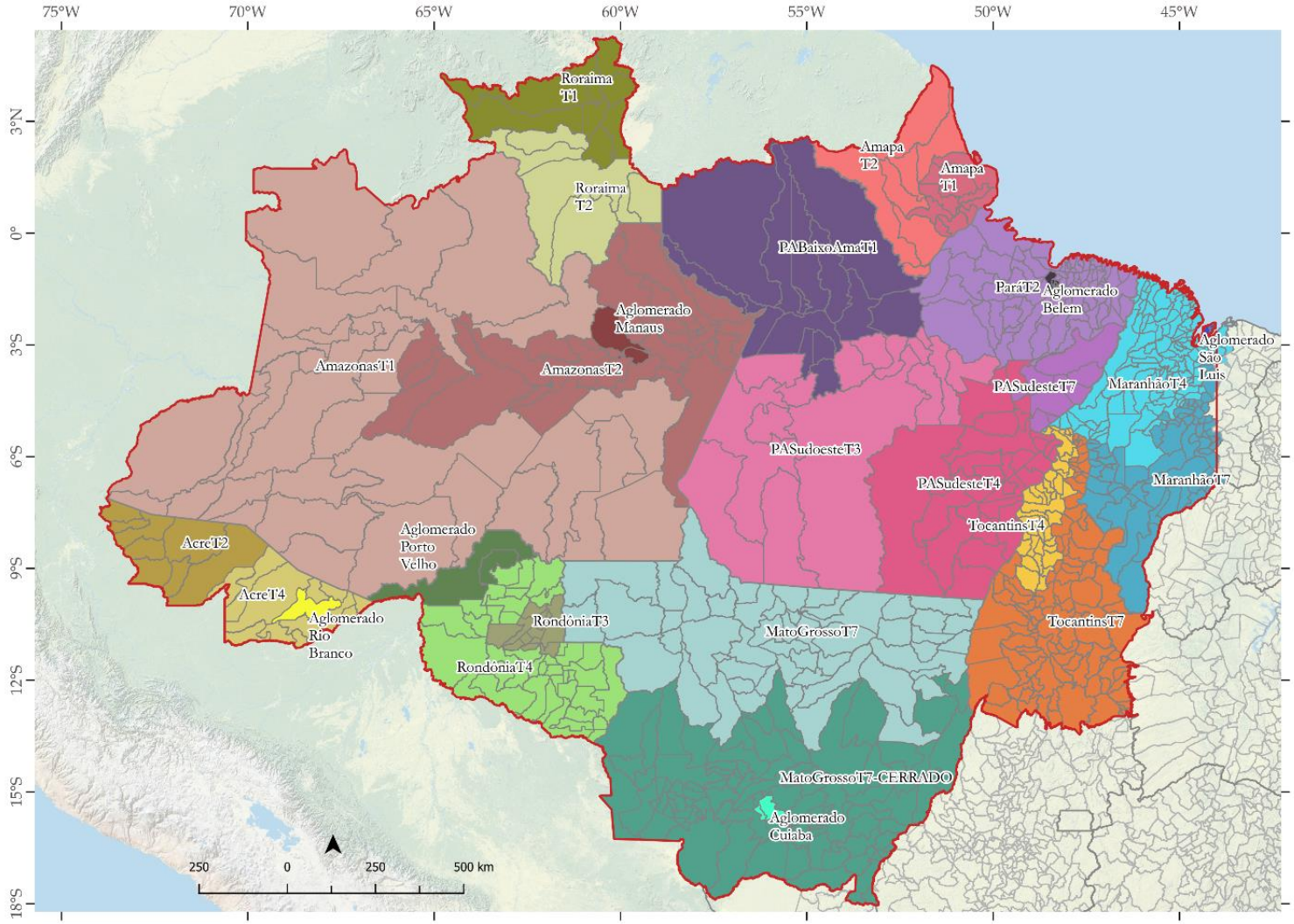
https://www.wribrasil.org.br/nova-economia-da-amazonia

Regional setting



International versus interregional trade

Table 1. The Prevalence of International and Interregional Trade in the Brazilian Legal Amazon (LAM)

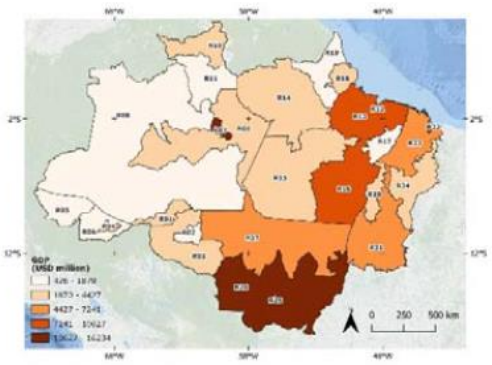
	Exports	Imports	Total
All products			
International trade	17.70	15.22	2.48
Interregional trade	55.12	73.42	-18.30
Agriculture products			
International trade	7.10	0.26	6.84
Interregional trade	9.21	2.83	6.38

Note: The table reports LAM's trade flows as a percentage of regional GDP. The column Total is the sum of Exports and Imports. The data correspond to the year 2015. Source: IIOM-LAM

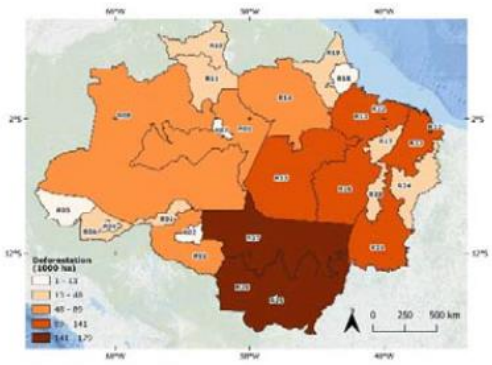
LAM is not homogeneous internally

Figure 1. Regional Indicators for the Brazilian Legal Amazon

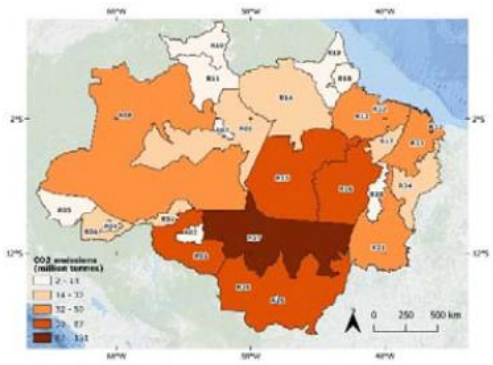
Regional GDP



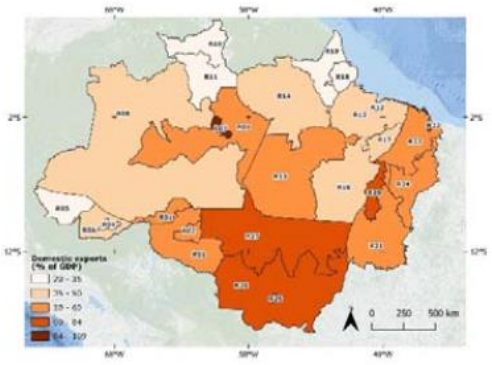
Deforestation



CO2 emissions

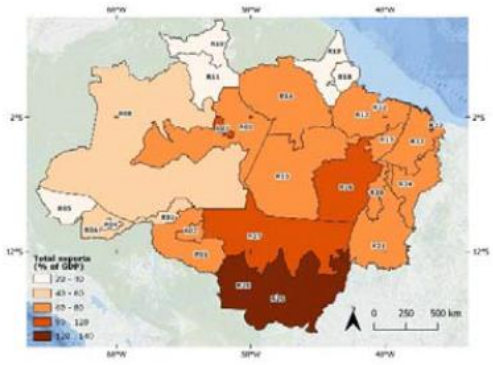


Domestic exports coefficient



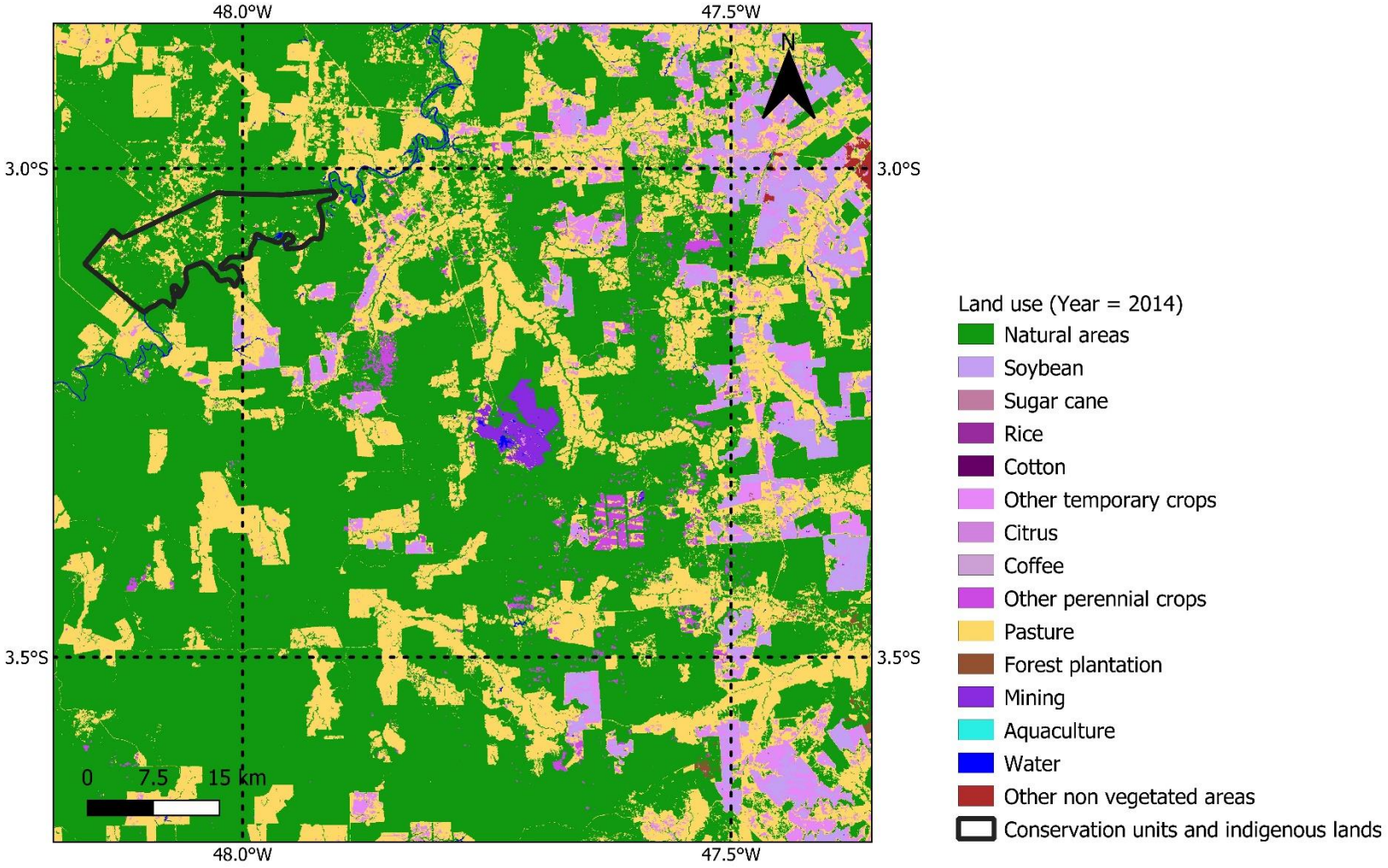
Foreign exports coefficient

Total exports coefficients

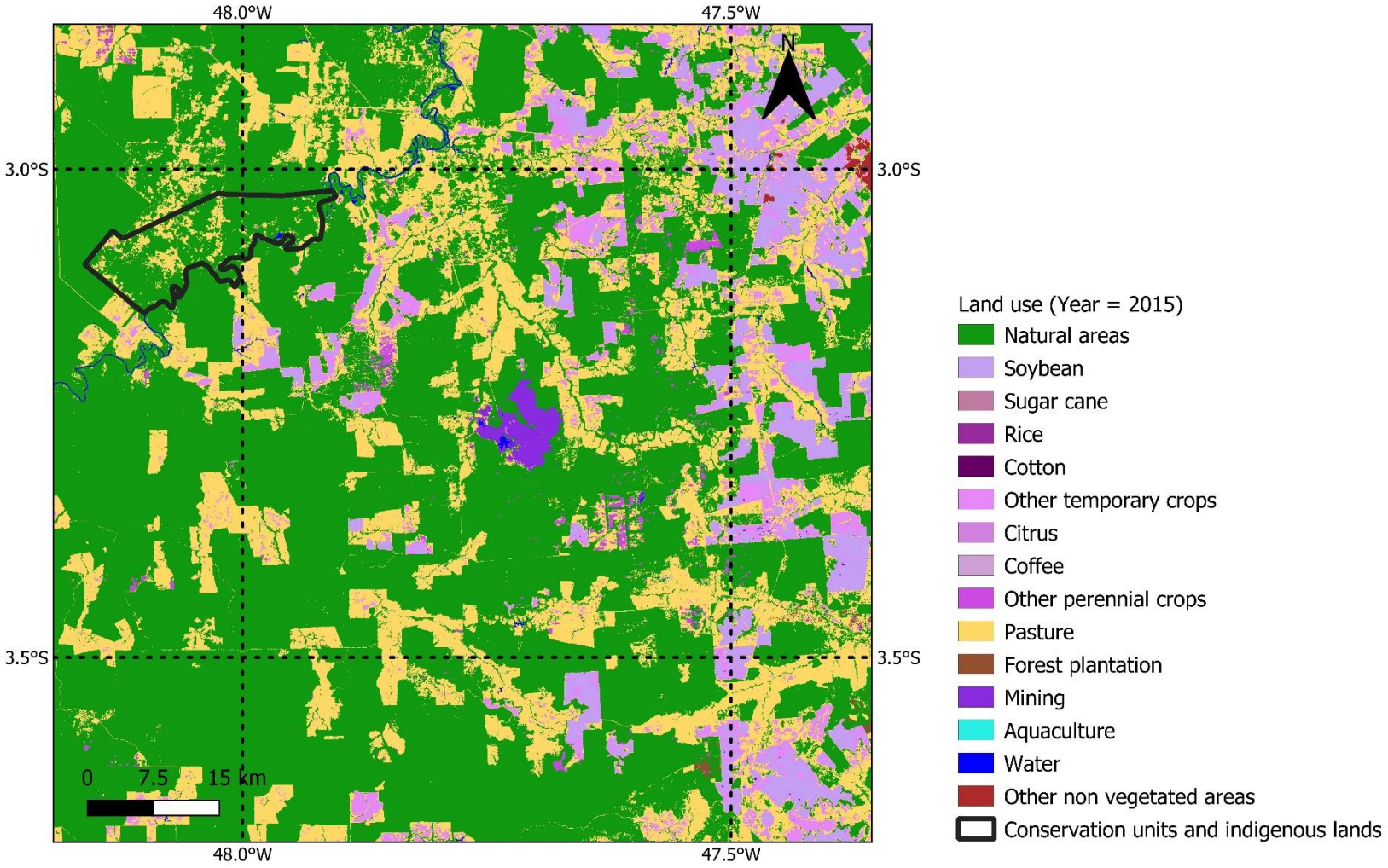


Note: R01 – Aglomerado Porto Velho; R02 – Ji-Paraná; R03 – Ariquemes-Guaporé; R04 – Aglomerado Rio Branco; R05 – Juruá-Tarauacá; R06 – Acre-Purus; R07 – Aglomerado Manaus; R08 – Interior do Amazonas; R09 – Central do Amazonas; R10 – Boa Vista; R11 – Caracaraí; R12 – Aglomerado Belém; R13 – Marajó/Baixo Tocantins; R14 – Baixo Amazonas Paraense; R15 – Sudoeste Paraense; R16 – Sudeste Paraense; R17 – Paragominas; R18 – Macapá; R19 – Oiapoque; R20 – Norte do Tocantins; R21 – Cerrados do Tocantins; R22 – Aglomerado de São Luís; R23 – Oeste do Maranhão; R24 – Chapadas do Maranhão; R25 – Aglomerado de Cuiabá; R26 – Centro Sul do Mato Grosso; R27 – Norte do Mato Grosso. The data correspond to the year 2015.

Changes in land-use (2014)



Changes in land-use (2015)



Output decomposition

Departing from the conventional input-output model:

$$\mathbf{x} = \begin{bmatrix} \mathbf{x}^1 \\ \vdots \\ \mathbf{x}^R \end{bmatrix}; \mathbf{A} = \begin{bmatrix} \mathbf{A}^{11} & \cdots & \mathbf{A}^{1R} \\ \vdots & \ddots & \vdots \\ \mathbf{A}^{R1} & \cdots & \mathbf{A}^{RR} \end{bmatrix}; \mathbf{f} = \begin{bmatrix} \mathbf{f}^1 \\ \vdots \\ \mathbf{f}^R \end{bmatrix}; \text{ and } \mathbf{B} = \begin{bmatrix} \mathbf{B}^{11} & \cdots & \mathbf{B}^{1R} \\ \vdots & \ddots & \vdots \\ \mathbf{B}^{R1} & \cdots & \mathbf{B}^{RR} \end{bmatrix}$$

$$\begin{aligned} \mathbf{x}^1 &= \mathbf{B}^{11}\mathbf{f}^1 + \cdots + \mathbf{B}^{1R}\mathbf{f}^R \\ &\vdots \\ \mathbf{x}^R &= \mathbf{B}^{R1}\mathbf{f}^1 + \cdots + \mathbf{B}^{RR}\mathbf{f}^R \end{aligned}$$

Output decomposition

Monetary values of final demand expenditures from the domestic regions in Brazil and the foreign region:

$$\mathbf{V} = \begin{bmatrix} \mathbf{V}^{11} & \cdots & \mathbf{V}^{1R} \\ \vdots & \ddots & \vdots \\ \mathbf{V}^{R1} & \cdots & \mathbf{V}^{RR} \end{bmatrix}; \text{ and } \mathbf{e} = \begin{bmatrix} \mathbf{e}^{1} \\ \vdots \\ \mathbf{e}^{R} \end{bmatrix}$$

$$\begin{aligned} \mathbf{x^1} &= \mathbf{B^{11}}(\mathbf{V^{11}} + \cdots + \mathbf{V^{R1}} + \mathbf{e^1}) + \cdots + \mathbf{B^{1R}}\,(\mathbf{V^{1R}} + \cdots + \mathbf{V^{RR}} + \mathbf{e^R}) \\ &\vdots \\ \mathbf{x^R} &= \mathbf{B^{R1}}(\mathbf{V^{11}} + \cdots + \mathbf{V^{R1}} + \mathbf{e^1}) + \cdots + \mathbf{B^{RR}}\,(\mathbf{V^{1R}} + \cdots + \mathbf{V^{RR}} + \mathbf{e^R}) \end{aligned}$$

Regional output depends on demand originating in the region and also on demand from outside the region

VA & deforestation decomposition by source of FD

Table 2. Components of Decomposition of Regional GDP and Deforestation Based on the Sources of Final Demand

GDP (2015 USD billion)

	REGIONAL ORIGIN OF FINAL DEMAND			TOTAL
	LAM	RBR	FOR	
LAM	73.12	43.15	18.18	134.45
RBR	63.50	1196.94	155.83	1416.26
TOTAL	136.62	1240.09	174.01	1550.72

Deforestation (1000 ha)

	REGIONAL ORIGIN OF FINAL DEMAND			TOTAL
	LAM	RBR	FOR	
LAM	259.21	919.41	361.84	1540.46
RBR	41.47	580.14	185.50	807.11
TOTAL	300.68	1499.55	547.34	2347.57

(%)

	REGIONAL ORIGIN OF FINAL DEMAND			TOTAL
	LAM	RBR	FOR	
LAM	53.52	3.48	10.45	8.67
RBR	46.48	96.52	89.55	91.33
TOTAL	100.00	100.00	100.00	100.00

(%)

	REGIONAL ORIGIN OF FINAL DEMAND			TOTAL
	LAM	RBR	FOR	
LAM	86.21	61.31	66.11	65.62
RBR	13.79	38.69	33.89	34.38
TOTAL	100.00	100.00	100.00	100.00

(%)

	REGIONAL ORIGIN OF FINAL DEMAND			TOTAL
	LAM	RBR	FOR	
LAM	54.38	32.09	13.52	100.00
RBR	4.48	84.51	11.00	100.00
TOTAL	8.81	79.97	11.22	100.00

(%)

	REGIONAL ORIGIN OF FINAL DEMAND			TOTAL
	LAM	RBR	FOR	
LAM	16.83	59.68	23.49	100.00
RBR	5.14	71.88	22.98	100.00
TOTAL	12.81	63.88	23.32	100.00

Note: LAM = Brazilian Legal Amazon; RBR = Rest of Brazil; FOR = Foreign markets. The table reports, in the first row, the decomposition of LAM's GDP and deforestation driven by local (LAM) and external (RBR and FOR) demand. Analogous results are presented for RBR, in the second row. Results are presented in levels and percentage shares. The data correspond to the year 2015. Source: Authors' calculations using the IIOM-LAM

Measurement of regional value-added in interregional and international trade flows

The national interregional input-output model can be expressed as

$$\begin{bmatrix} \mathbf{x}^1 \\ \vdots \\ \mathbf{x}^n \end{bmatrix} = \begin{bmatrix} \mathbf{A}^{11} & \cdots & \mathbf{A}^{1n} \\ \vdots & \ddots & \vdots \\ \mathbf{A}^{n1} & \cdots & \mathbf{A}^{nn} \end{bmatrix} \begin{bmatrix} \mathbf{x}^1 \\ \vdots \\ \mathbf{x}^n \end{bmatrix} + \begin{bmatrix} \mathbf{f}^{11} & \cdots & \mathbf{f}^{1n} & \mathbf{f}^{\mathbf{1row}} \\ \vdots & \ddots & \vdots & \vdots \\ \mathbf{f}^{n1} & \cdots & \mathbf{f}^{nn} & \mathbf{f}^{\mathbf{nrow}} \end{bmatrix} \mathbf{i}$$

Following Los et al. (2016), the value-added in region 1 (VA_1) can be expressed as

$$VA_1 = \mathbf{v}_1(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}\mathbf{i}$$

where $\mathbf{v}_1$ is a row vector with ratios of value-added to gross output in industries in region 1 as first elements ($\widetilde{\mathbf{v}_1}$) and zeros elsewhere ($\mathbf{v}_1 = [\widetilde{\mathbf{v}_1} \quad 0]$); **A** is a technical coefficient matrix; **I** is an identify matrix; **f** is a final demand matrix; **i** is a summation vector

Measurement of regional value-added in interregional and international trade flows (cont.)

In order to attribute the amount of domestic/regional value-added in exports from region 1 to region *n*, we consider a hypothetical world where region 1 does not export anything to region *n*. In this case, the new *VA* or hypothetical *VA* can be represented by

$$VA^{*}_{1,n} = \mathbf{v}_1(\mathbf{I} - \mathbf{A}^{*}_{1,n})^{-1}\mathbf{f}^{*}_{1,n}\mathbf{i}$$

In addition, in order to attribute the amount of domestic/regional value-added in exports from region 1 to the RoW, we consider a hypothetical world where region 1 does not export to the RoW. In this case, the hypothetical VA can be represented as:

$$VA^{*}_{1,row} = \mathbf{v}_1(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}^{*}_{1,row}\mathbf{i}$$

Measurement of regional value-added in interregional and international trade flows (cont.)

We can define the domestic value-added in exports (*DVA*) from region 1 to region *n* as follows:

$$DVA_{1,n} = VA_1 - VA^*_{1,n}$$

We can define DVA in exports from region 1 to the RoW as

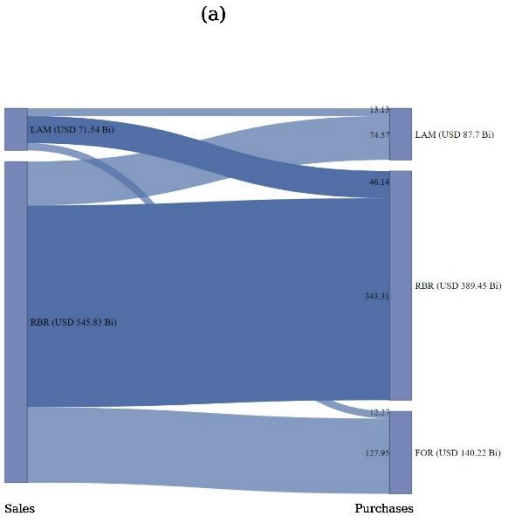
$$DVA_{1,row} = VA_1 - VA^*_{1,row}$$

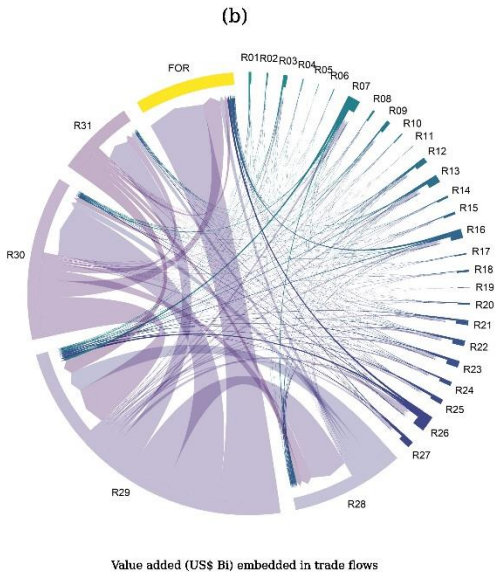
Domestic/regional value-added in trade flows (DVA)

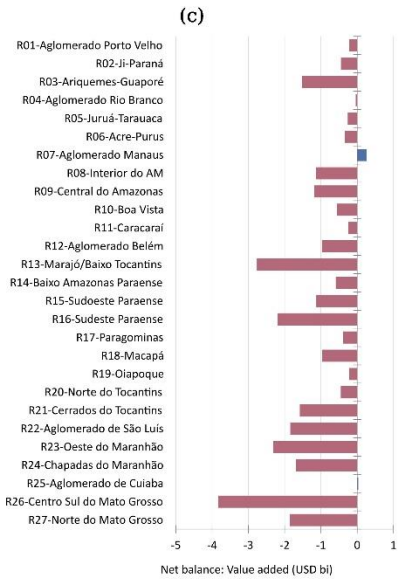
Hypothetical no export	to					
from	R_1	R_2	…	R_{n-1}	R_n	RoW
R_1		$DVA_{1,2}$	…	$DVA_{1,n-1}$	$DVA_{1,n}$	$DVA_{1,row}$
R_2	$DVA_{2,1}$		…	$DVA_{2,n-1}$	$DVA_{2,n}$	$DVA_{2,row}$
⋮	⋮	⋮		⋮	⋮	⋮
R_{n-1}	$DVA_{n-1,1}$	$DVA_{n-1,2}$	…		$DVA_{n-1,n}$	$DVA_{n-1,row}$
R_n	$DVA_{n,1}$	$DVA_{n,2}$	…	$DVA_{n,n-1}$		$DVA_{n,row}$

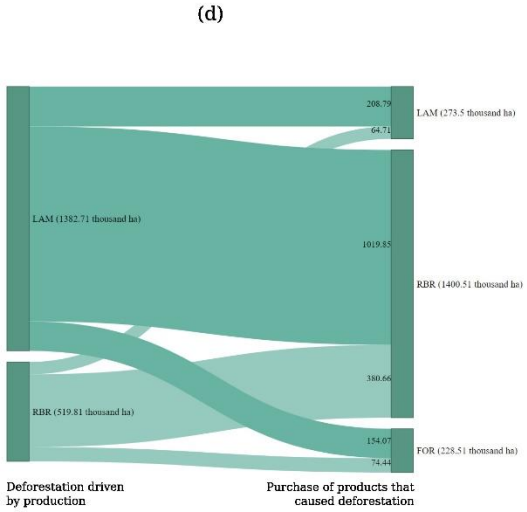
Total value added content in exports from R1 to R2

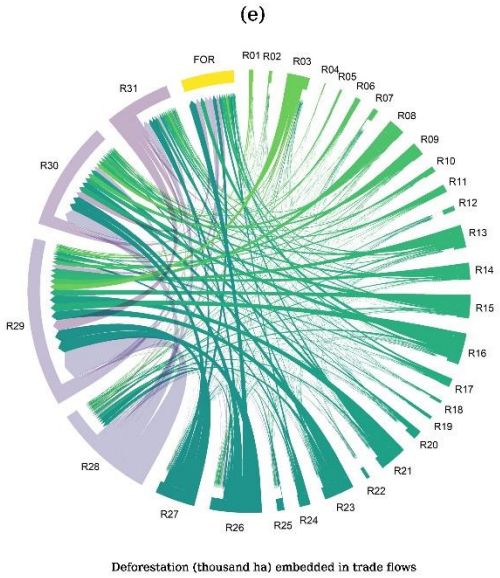
Regional traded value-added and deforestation in exports, by origin of demand

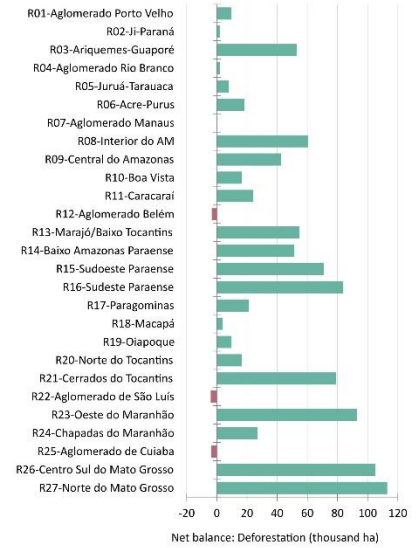










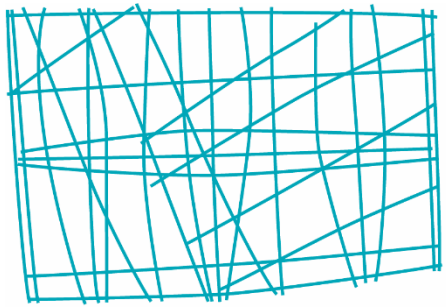


Final remarks

Our results demonstrate how the emphasis on international trade in the current literature on economic drivers of land-use change neglected internal sources of interactions.

Acknowledging domestic markets as a critical driver of changes in forest cover in the region switches the focus of the debate emphasizing the need for increased engagement by national stakeholders to be part of concerted efforts to find solutions to the problem.

Attribution of co-responsibility to specific regions must be considered to inform policymakers about potential future stress in Amazon’s resources.



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