

OCTOBER 2025

EMBARGOED FOR RELEASE UNTIL 00:01 GMT ON WEDNESDAY, OCTOBER 29, 2025

EXECUTIVE SUMMARY FOR PUBLIC POLICIES TO CONTROL DEFORESTATION

The Importance of Protected Areas
in Reducing Deforestation in the
Legal Amazon

Breno Pietracci

Economist, Ph.D. & Doctor Europaeus in Economics from Università Ca'Foscari di Venezia.
Consultant, Environmental Defense Fund

About Environmental Defense Fund

Guided by science and economics, Environmental Defense Fund (EDF) tackles our most urgent environmental challenges with practical solutions. EDF is one of the world's largest environmental organizations, with more than 2.5 million members and a staff of 700 scientists, economists, policy experts, and other professionals around the world.

Contents

Executive Summary	4
Introduction	2
Goals of This Study.....	4
Data.....	5
Econometric Model	6
Simulation of the Effect of Protected Areas on Reducing Jurisdictional Deforestation	7
Designating Undesignated Public Forests	16
Conclusions.....	17
Acknowledgements.....	18
Contact Us	18

Executive Summary for Public Policies to Control Deforestation

Breno Pietracci, Consultant, Environmental Defense Fund

Executive Summary

This study aims to estimate, using an econometric model and simulations, the contribution of Protected Areas — Indigenous Lands and Conservation Units — in reducing deforestation in the 9 states of the Brazilian Legal Amazon from 2022 to 2030.

The presence of current protected areas — indigenous lands and conservation units — prevents a projected deforestation of 4.3 million hectares in the 9 states of the Legal Amazon from 2022 to 2030, in areas located inside and outside them, avoiding the emission of 2.1 GtCO_{2e}.

Without the presence of protected areas, projected deforestation would be 35% higher and CO_{2e} emissions would be 45% higher than in the baseline scenario, which predicts deforestation of 12.4 million hectares from 2022 to 2030 in the 9 states of the Legal Amazon (an average of 1.4 million hectares per year) and emissions of 4.6 GtCO_{2e}.

What's more, the region also has 63.4 million hectares of undesignated public forests. The designation of these forests as conservation units or indigenous lands would reduce deforestation by between 1.5 and 2.5 million hectares and reduce emissions by between 0.75 and 1.2 GtCO_{2e} by 2030 compared to the projected in the baseline scenario. This represents a reduction of 12% to 20% in deforestation and a reduction of 16% to 26% in emissions compared to the projected in the baseline scenario.

Introduction

The 9 states of the Legal Amazon — Acre, Amapá, Amazonas, Mato Grosso, Maranhão, Pará, Rondônia, Roraima and Tocantins — have a total area of 510 million hectares.¹

Of this total, in 2022, around 393 million hectares were covered by native vegetation in the Amazon, Cerrado and Pantanal biomes, and by 2021, 112.5 million hectares had been deforested as shown in Figures 1A and 1B, with a spatial resolution of approximately 5 km.²

Figure 1A
Native Vegetation in 2022 (~393 M ha)

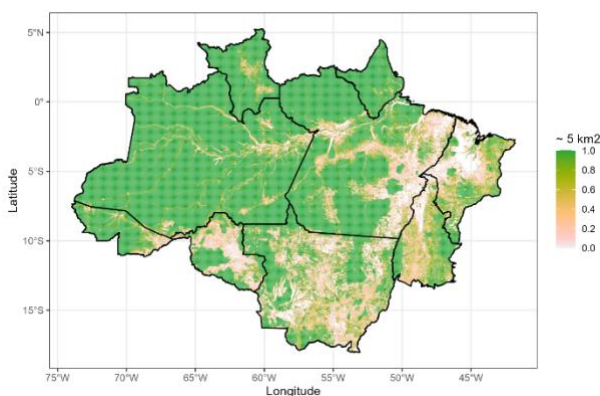
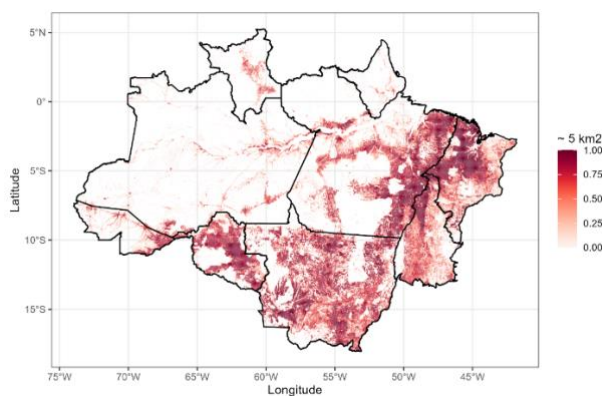


Figure 1B
Deforestation until 2021 (~112.5 M ha)



Source: INPE – National Institute for Space Research (PRODES)

Much of the remaining native vegetation in these states are in protected areas, which in 2021 totaled 240 million hectares, of which 113 million hectares were indigenous lands³ and 127 million hectares were conservation units⁴, as shown in the maps in Figures 2A and 2B.

¹ Source: The Interstate Consortium for Sustainable Development of the Legal Amazon. Legal Amazon Green Recovery Plan.

² Source: INPE – National Institute for Space Research (PRODES).

³ Source: FUNAI – National Indigenous People Foundation, complemented with data from ISA – Socioenvironmental Institute.

⁴ Source: MMA – Ministry of Environment and Climate Change.

Figure 2A
Indigenous Lands in 2021 (~113 M ha)

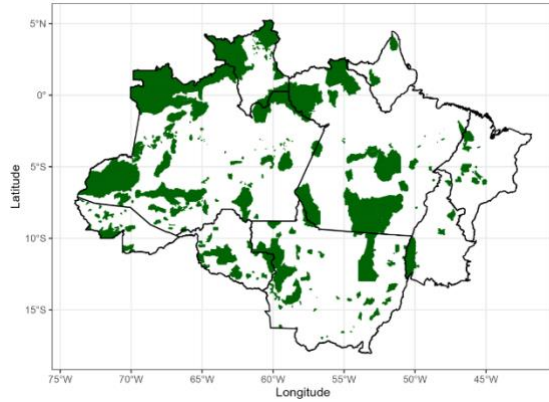
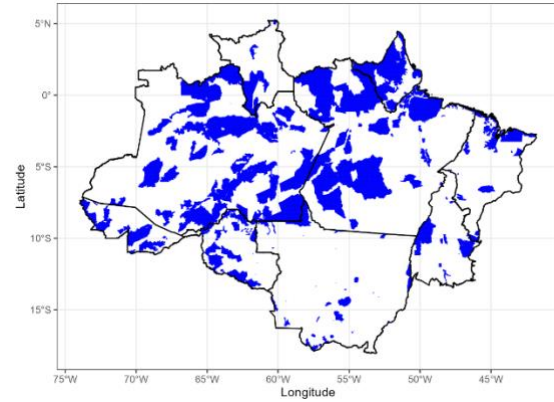


Figure 2B
Conservation Units in 2021 (~127 M ha)



Source: 2A) FUNAI – National Indigenous People Foundation, complemented with data from ISA – Socioenvironmental Institute.
2B) MMA – Ministry of Environment and Climate Change.

These protected areas are extremely important for the preservation of native vegetation, carbon stocks, biodiversity, the provision of ecosystem services, and the livelihoods of traditional people and local communities.

Goals of This Study

This study aims to estimate, using an econometric model and simulations, the contribution of Protected Areas — Indigenous Lands and Conservation Units — in reducing deforestation in the nine states of the Brazilian Legal Amazon from 2022 to 2030.

The model allows for projecting deforestation until 2030 with a spatial resolution of approximately 5 km² in a baseline (business-as-usual) scenario, which consists of keeping land prices constant at 2020 levels and existing protected areas in 2021.

Next, we project deforestation in alternative counterfactual (hypothetical) scenarios of what would happen in the absence of protected areas. The difference between results in each scenario allows us to understand and quantify the importance of protected areas in reducing deforestation.

Finally, we made projections for deforestation if existing undesignated public forests were allocated as protected areas.

Data

To estimate the econometric model, we use data from several sources. Deforestation data from 2009 to 2021 and remaining native vegetation, in raster format, are from PRODES from INPE (National Institute for Space Research).

Land prices for cattle ranching and agriculture, in reais per hectare, from 2008 to 2020 are from S&P Global - Land Reports. Maps of states and biomes boundaries are from IBGE (Brazilian Institute of Geography and Statistics).

Data on Indigenous Lands are from FUNAI (National Indigenous People Foundation), complemented with data from ISA (Socioenvironmental Institute). Data on Conservation Units are from MMA (Ministry of Environment and Climate Change). Data on Rural Settlements are from INCRA (National Institute for Settlements and Agrarian Reform).

Data on the main roads in 2013 and 2022 are from the Ministry of Infrastructure.

Data on carbon stocks are from IPAM (The Amazon Environmental Research Institute).

Data on undesignated public forests in 2022 are from MMA – SFB (Ministry of Environment and Climate Change – Brazilian Forest Service).

Econometric Model

The econometric model is calibrated using historical data with a spatial resolution (cells) of approximately 5 km². That is, for each cell of approximately 5 km² in the nine states of the Legal Amazon, we use information about the data described above over time.

In particular, we are interested in quantifying how deforestation in each cell varied as a function of land prices for cattle ranching and/or agriculture. The economic theory behind this relationship is that land prices for cattle ranching and/or agriculture in a given region capture the net present value of expected future profits from agricultural activities in that region. Therefore, local land prices for cattle ranching and/or agriculture serve as an indicator of the expected profitability of deforestation for agricultural activities in the region. Thus, the higher the land prices for agricultural activities in a region, the greater the expected deforestation of the remaining native vegetation in that region.

Simultaneously, for each cell over time, we control for other factors that influence economic agents' deforestation decisions. The model identifies the state, biome, latitude and longitude of each cell's location and their distance from main roads in 2013.

Additionally, the model identifies whether each cell is located on indigenous lands, conservation units or rural settlements.

Finally, the model considers deforestation within the cells in previous years, as well as deforestation in neighboring cells. To assess the impact of deforestation of neighboring cells in previous years on the deforestation of the cell of interest, we use a matrix of dimension 11 by 11. In total, we consider past deforestation in a square with 120 neighboring cells.⁵

A limitation of the model is that it does not capture deforestation for mining.

⁵ The matrix has 11 x 11 cells = 121 cells. Minus the central cell itself, we have 120 neighboring cells.

Simulation of the Effect of Protected Areas on Reducing Jurisdictional Deforestation

With the econometric model calibrated, the first step is to compare historical deforestation data from INPE/PRODES with deforestation data simulated by the model for the same period, to assess whether it captures reality satisfactorily.

Figure 3A presents historical deforestation data from PRODES for the 2009 to 2021 period and Figure 3B presents the data simulated by the econometric model for the same period. From 2009 to 2021, 15.9 million hectares were deforested in the region and the model simulates a total of 16.3 million hectares.

Figure 3A

PRODES Deforestation 2009-2021 (~15.9 M ha)

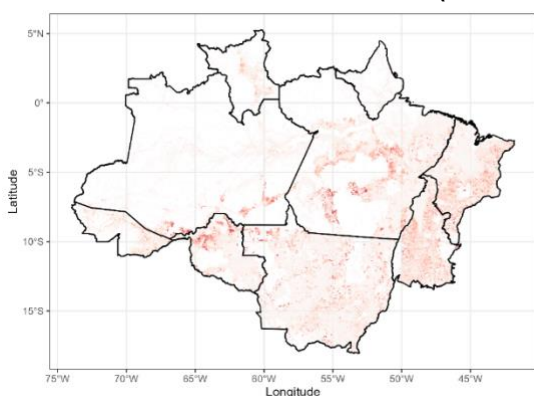
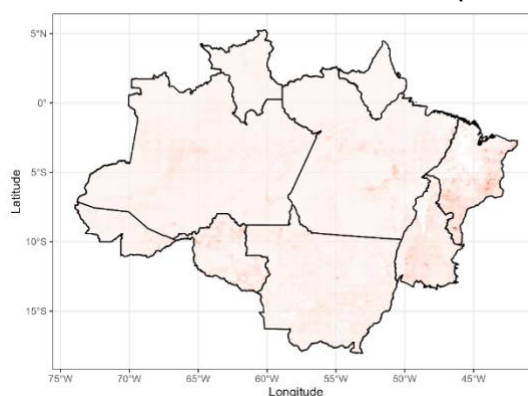


Figure 3B⁶

Simulated Deforestation 2009-2021 (~16.3 M ha)



Source: 3A) INPE – National Institute for Space Research (PRODES). 3B) Econometric Model.

We then use the econometric model to project deforestation from 2022 to 2030 in the baseline (business-as-usual) scenario. The baseline scenario consists of keeping, during the simulation, land prices constant at the 2020 real values — the last year with available data — and keeping the existing protected areas in 2021 fixed.

Additionally, the distance of each cell to main roads is updated for the year 2022, and the total deforestation within each cell, as well as deforestation in neighboring cells, is updated annually.

Under these conditions, in the baseline scenario, the model projects deforestation of 12.4 million hectares from 2022 to 2030 (average of 1.4 million hectares per year) as shown in Figure 4A, causing emissions of 4.6 GtCO₂e.

⁶ The model assigns a small amount of deforestation, but greater than zero, to almost all cells. Therefore, deforestation appears more diffuse in the simulation.

Lastly, to estimate the importance of protected areas in reducing deforestation at a jurisdictional scale, we simulated a counterfactual (hypothetical) scenario in which the model projects deforestation if these areas were not protected, keeping all other parameters the same as in the baseline scenario.

In this counterfactual (hypothetical) scenario, projected deforestation would be 16.7 million hectares by 2030 (average of 1.9 million hectares per year) as in Figure 4B, with associated emissions of 6.7 GtCO_{2e}.

Figure 4A
Deforestation in Baseline Scenario
2022-2030 (~12.4 M ha)

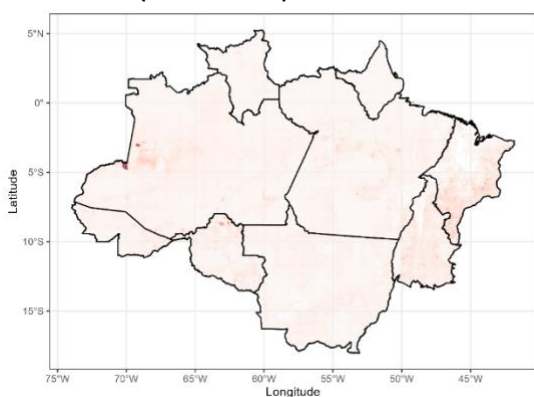
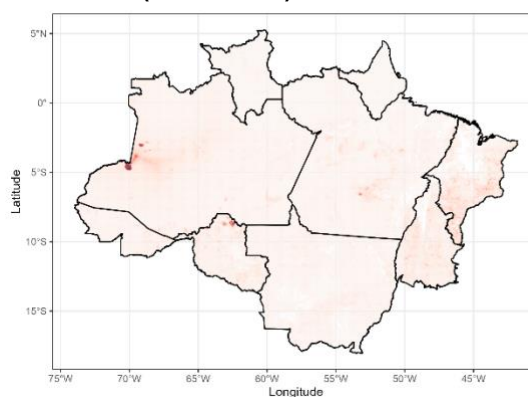


Figure 4B
Deforestation in Counterfactual Scenario
2022-2030 (~16.7 M ha)

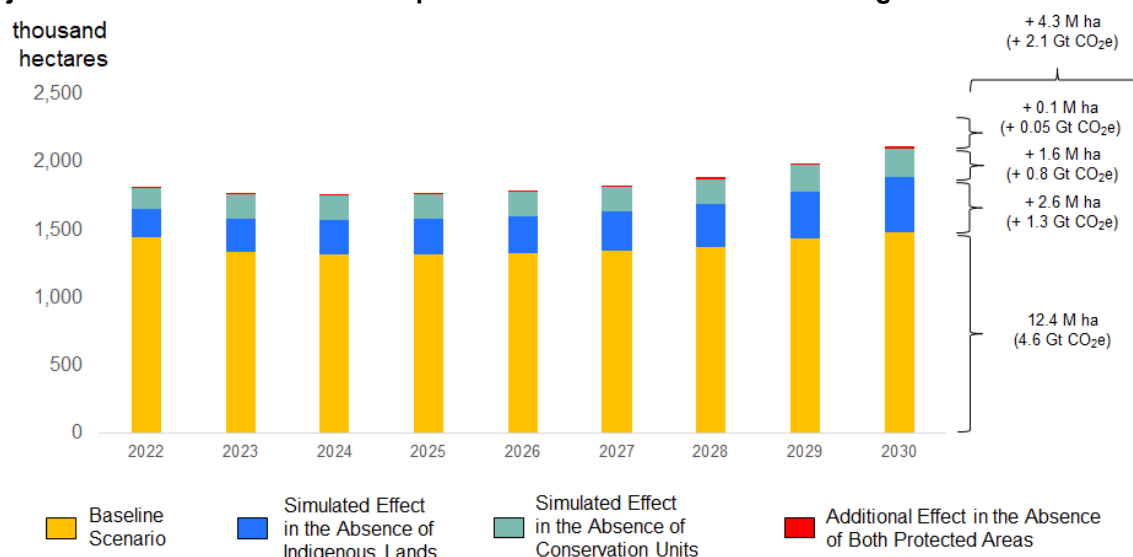


Therefore, according to the econometric model, the presence of protected areas — indigenous lands and conservation units — avoids the deforestation of 4.3 million hectares in the 9 states of the Legal Amazon from 2022 to 2030 (an average of 482 thousand hectares per year), avoiding emissions of 2.1 GtCO_{2e} in the same period.

That is, the projected deforestation in the nine states of the Legal Amazon from 2022 to 2030 would be 35% higher without the presence of protected areas and CO_{2e} emissions would be 45% higher.

Figure 5 presents the results of the model's deforestation projections year by year until 2030 in the baseline scenario, and in the counterfactual (hypothetical) scenarios of the absence of indigenous lands, absence of conservation units, and the additional effect of the absence of both types of protected areas simultaneously.

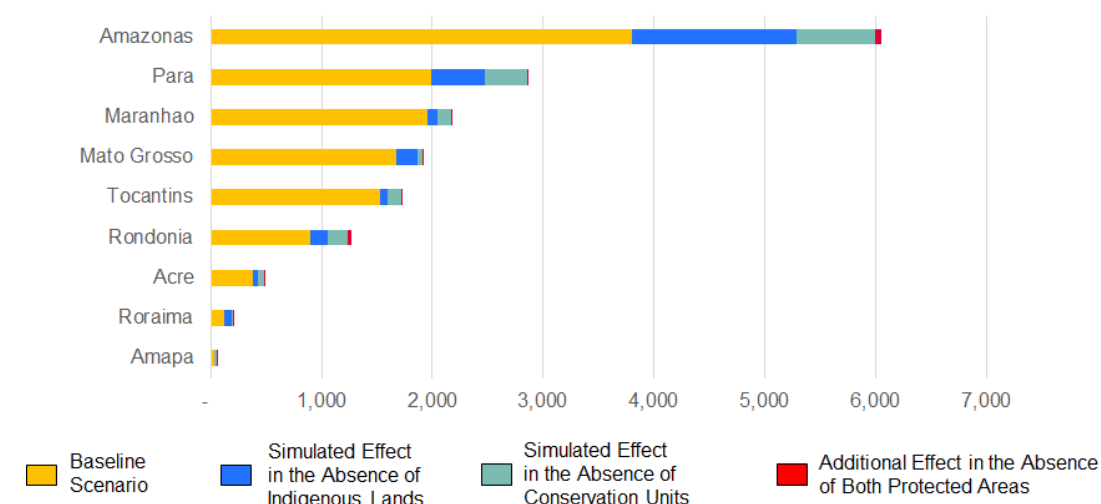
Figure 5

Projected deforestation scenarios up to 2030 in the nine states of the Legal Amazon

In the model's simulation, the presence of indigenous lands avoids the deforestation of 2.6 million hectares and emissions of 1.3 GtCO₂e by 2030. The presence of conservation units avoids the deforestation of 1.6 million hectares and emissions of 0.8 GtCO₂e by 2030. Furthermore, the combined effect of the presence of both protected areas avoids an additional deforestation of 0.1 million hectares and emissions of 0.05 GtCO₂e by 2030. Overall, protected areas avoid the deforestation of 4.3 million hectares and the emission of 2.1 GtCO₂e by 2030.

Figure 6 presents the results of the econometric model's deforestation projections, in different scenarios, by state of the Legal Amazon until 2030.

Figure 6

Projected deforestation by state of the Legal Amazon until 2030 (thousand hectares)

The states with the highest projected deforestation up to 2030 in all scenarios are, Amazonas, Pará and Maranhão, in that order. In the baseline scenario, projected deforestation by 2030 in the state of Amazonas is 3.8 million hectares and around 2 million hectares in the states of Pará and Maranhão.

Table 1 presents a summary of historical deforestation and the results of the econometric model's deforestation simulations for the main scenarios by state and totals.

Table 1

Summary of deforestation projections results until 2030 (thousand hectares)

State	Deforestation PRODES 2009 - 2021	Simulated Past Deforestation 2009 - 2021	Simulated Future Deforestation 2022 – 2030 (Baseline Scenario)	Simulated Effect in the Absence of Indigenous Lands	Simulated Effect in the Absence of Conservation Units	Additional Effect in the Combined Absence of Indigenous Lands and Conservation Units	Total Simulated Deforestation in the Absence of Indigenous Lands and Conservation Units [*]
Acre	517	515	381	+ 45	+ 59	+ 1	486 [+ 28%]
Amazonas	1,201	4,132	3,804	+ 1,484	+ 702	+ 59	6,049 [+ 59%]
Amapá	35	36	35	+ 3	+ 13	+ 0	51 [+ 46%]
Mato Grosso	3,385	2,975	1,678	+ 186	+ 45	+ 0	1,910 [+ 14%]
Maranhão	2,416	2,498	1,955	+ 88	+ 123	+ 0	2,166 [+ 11%]
Pará	4,142	2,637	1,994	+ 483	+ 375	+ 9	2,861 [+ 43%]
Rondônia	1,349	1,322	900	+ 156	+ 185	+ 26	1,266 [+ 41%]
Roraima	273	162	118	+ 73	+ 10	+ 0	202 [+ 71%]
Tocantins	2,595	2,011	1,523	+ 73	+ 129	+ 11	1,736 [+ 14%]
Total	15,913	16,289	12,388	+ 2,591	+ 1,641	+ 107	16,727 [+ 35%]

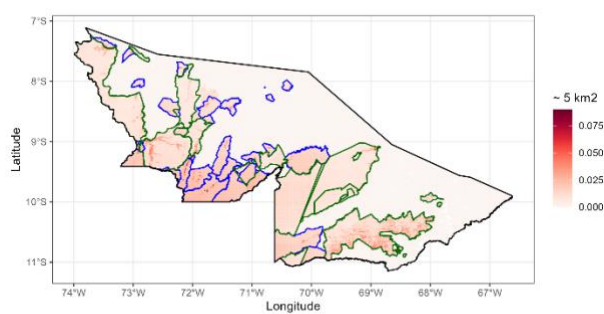
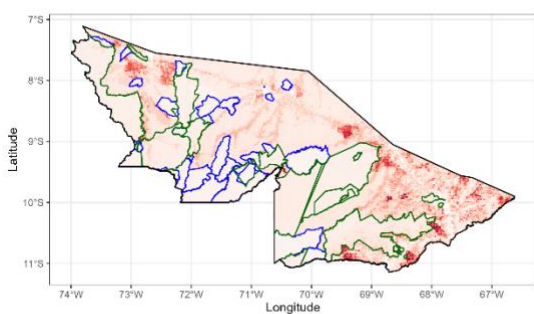
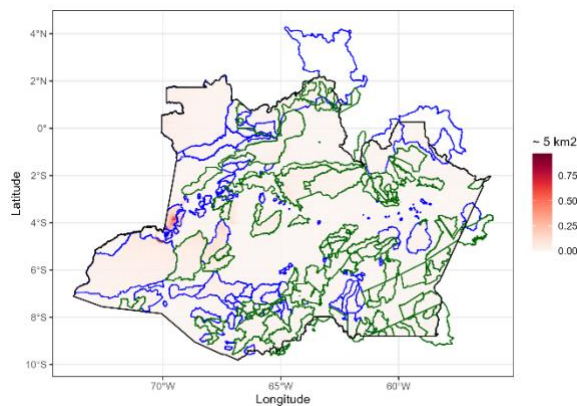
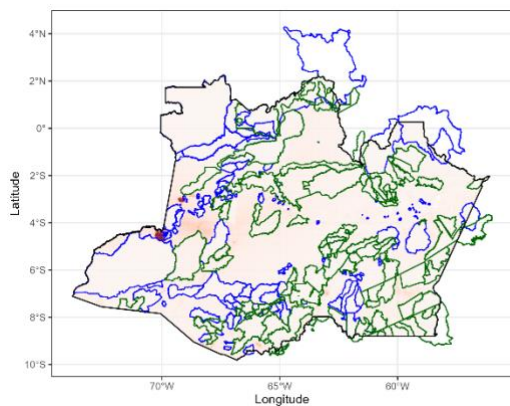
* Percentage increase compared to the baseline scenario.

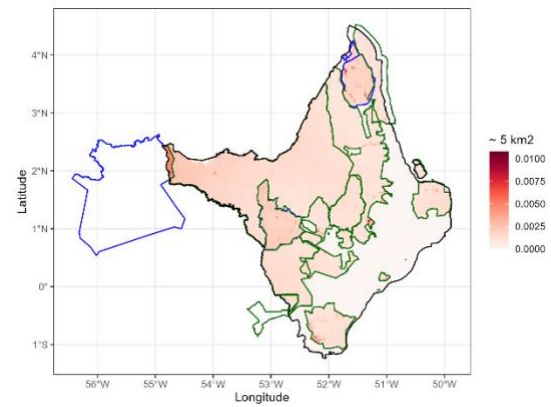
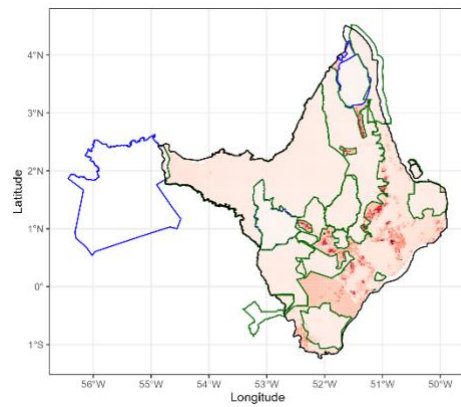
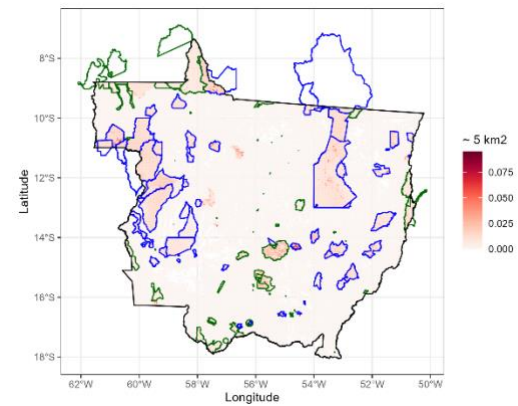
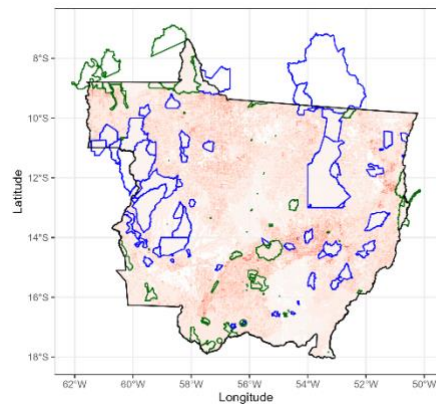
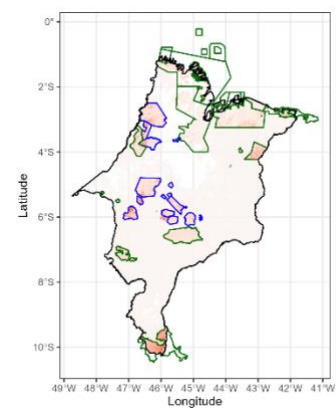
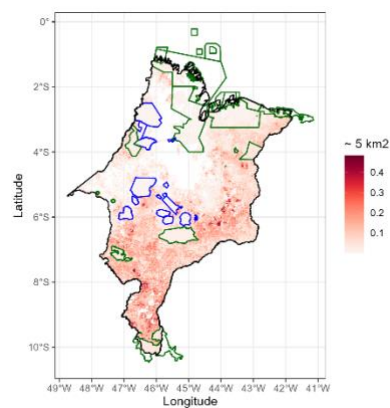
Figures 7A-7I present maps, by state, with projected deforestation in the baseline scenario from 2022 to 2030 and additional deforestation in the counterfactual (hypothetical) scenario of absence of protected areas.

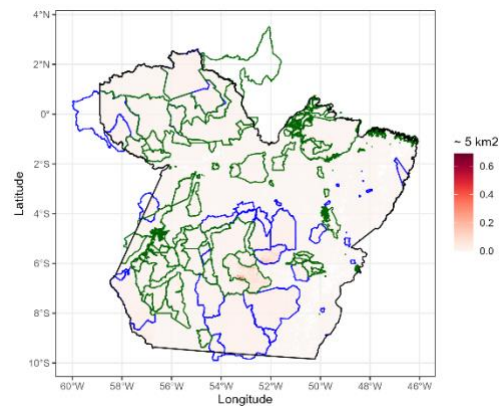
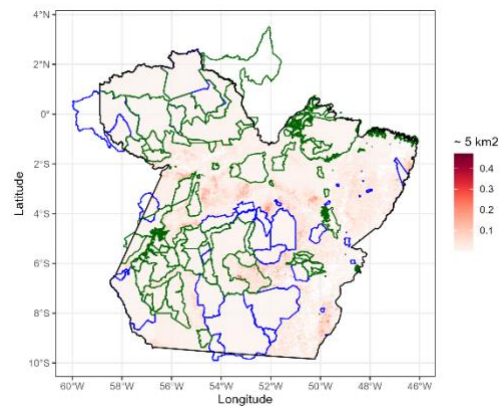
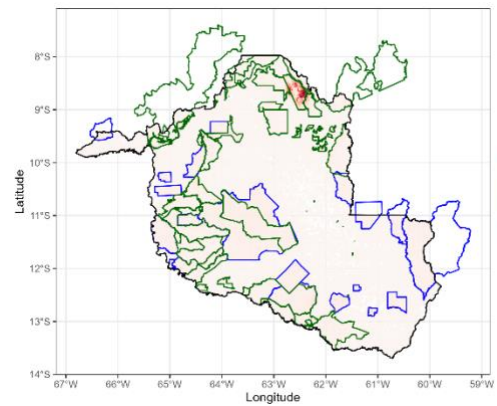
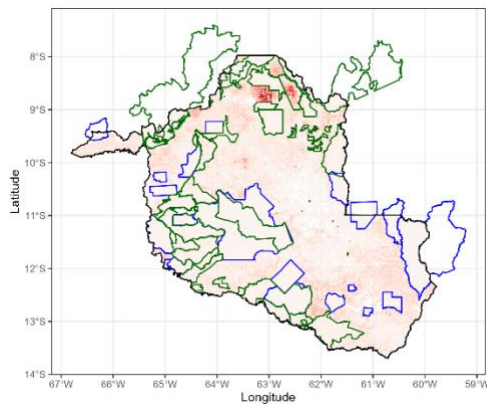
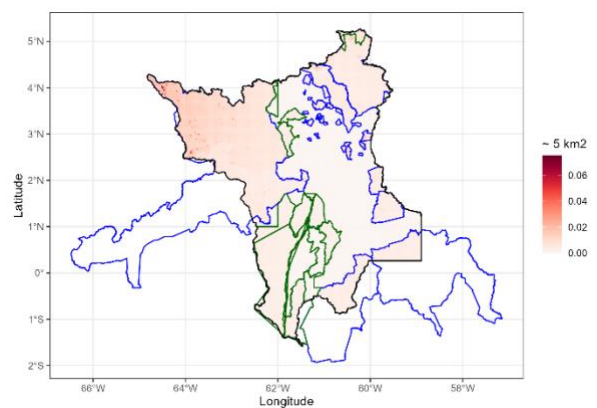
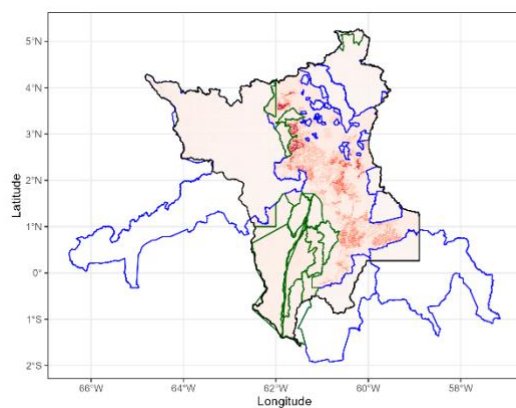
Figures 7A-7I

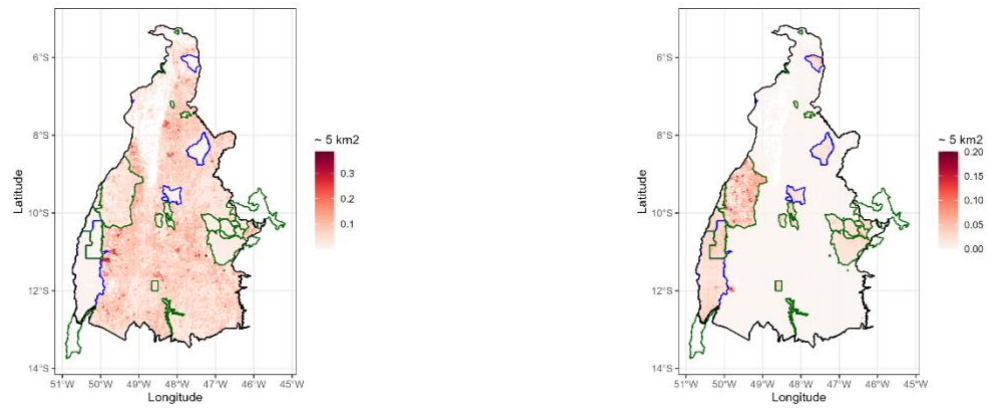
Projected deforestation by state in the baseline scenario from 2022 to 2030 and additional deforestation in the counterfactual (hypothetical) scenario of absence of protected areas*

* Note that projected deforestation scales change in each map.

Legend: ■ Indigenous Lands ■ Conservation Units**Deforestation in the Baseline Scenario
(2022 – 2030)****Additional Deforestation in the Counterfactual
(Hypothetical) Scenario (2022 – 2030)****7A: Acre****7B: Amazonas**

7C: Amapá**7D: Mato Grosso****7E: Maranhão**

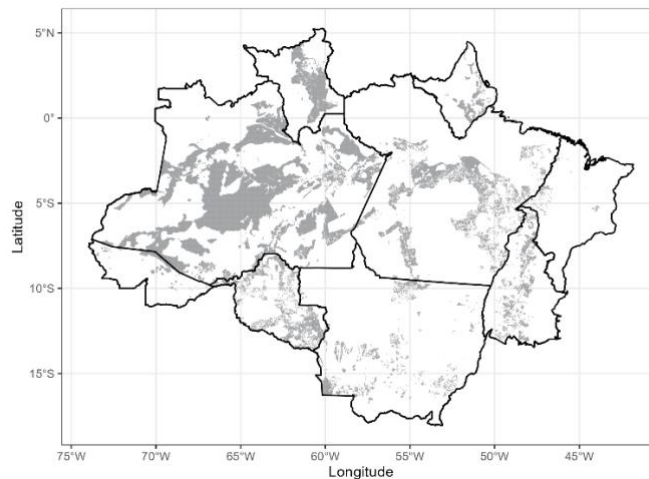
7F: Pará**7G: Rondônia****7H: Roraima**

7I: Tocantins

Designating Undesignated Public Forests

The 9 states of the Brazilian Legal Amazon had in 2022 an area of 63.4 million hectares of undesignated public forests, as depicted in Figure 8. Out of this total, 41.5 million hectares (65%) are located in the state of Amazonas.

Figure 8
Undesignated public forests in 2022



Source: Ministry of Environment and Climate Change – Brazilian Forest Service

The designation of these public forests as protected areas — conservation units or indigenous lands — could avoid the deforestation of 1.5 to 2.5 million hectares by 2030 and avoid emissions of 0.75 to 1.2 GtCO₂e in comparison with the baseline scenario. This would represent a reduction of 12% to 20% in deforestation and of 16% to 26% in emissions compared to the baseline scenario.

Conclusions

The econometric model projects in its baseline scenario the deforestation of 12.4 million hectares from 2022 to 2030 in the nine states of the Legal Amazon (1.4 million hectares per year on average), causing emissions of 4.6 GtCO_{2e}.

According to the econometric model, the presence of existing protected areas — indigenous lands and conservation units — prevents the projected deforestation of an additional 4.3 million hectares in the nine states of the Legal Amazon from 2022 to 2030, in areas located inside and outside them, avoiding further emissions of 2.1 GtCO_{2e}. Without existing protected areas, projected deforestation would be 35% higher and CO_{2e} emissions would be 45% higher than in the baseline scenario.

The structure, estimation, parameters and results of the econometric model identify two ways in which protected areas contribute to reducing deforestation at the jurisdictional scale. The first and most important consists of avoiding deforestation inside the perimeter of protected areas. The second consists of reducing the likelihood of deforestation in cells near protected areas. This occurs because there is a higher risk of deforestation in areas of native vegetation close to areas that have already been deforested.

The designation of 63.4 million hectares of undesignated public forests as protected areas would also contribute to reduce deforestation in the region. In this case, the model estimates a reduction in deforestation of around 1.5 to 2.5 million hectares and a reduction in emissions of 0.75 to 1.2 GtCO_{2e} compared to the baseline scenario. This represents a reduction of 12% to 20% in deforestation and a reduction in emissions of 16% to 26% compared to the baseline scenario.

Finally, it is worth remembering that models are attempts to reproduce reality and have their limitations.

Acknowledgments

We would like to acknowledge the support of the Eaglemere Foundation

Contact Us

Breno Pietracci – Economist, EDF Consultant - bpietracci@gmail.com

Steve Schwartzman – EDF, Associate Vice President, - sschwartzman@edf.org