Deforestation Slowdown in the Brazilian Amazon: Prices or Policies?

*Executive Summary**

Juliano Assunção, Clarissa C. e Gandour, and Rudi Rocha

Climate Policy Initiative Rio de Janeiro
Núcleo de Avaliação de Políticas Climáticas, PUC-Rio

January 2012

Introduction

Deforestation and biomass decay have accounted for approximately 17% of global greenhouse gas emissions (IPCC, 2007).[1] This raises concerns about the extent of forest clearings in the Amazon, the planet's largest rainforest tract. The region has long been the world's most active agricultural frontier in terms of forest loss and CO_2 emissions. In Brazil, the conversion of forest areas in the Amazon biome has contributed nearly half of the country's total net CO_2 emissions (MCT, 2010).

Yet, the deforestation rate in the Brazilian Amazon experienced a substantial decrease during the second half of the 2000s, from a peak of 27,000 km^2 in 2004 to 7,000 km^2 in 2009. Two alternative explanations for this stand out. On the one hand, falling agricultural prices may have inhibited the clearing of forest areas for the expansion of farmland (see Figure 1). On the other hand, conservation policies introduced after two policy turning points in 2004 and 2008 may have contributed to the curbing of deforestation. Indeed, Figure 1 shows that the adoption of policies following these turning points coincide with sharp subsequent decreases in the deforestation rate.

Approximately half of the deforestation that was avoided in the Amazon in the 2005 through 2009 period can be attributed to conservation policies introduced in the second half of the 2000s.

Identifying whether the deforestation slowdown was due to economic circumstances or resulted from conservation policies introduced during that period could provide critical input for policymakers in Brazil and in other countries. We assess the contribution of Brazil's policies to decreased deforestation rates by using regression techniques to disentangle the impacts of the policies from those of other potential explanatory factors, such as agricultural price cycles and other possible drivers of deforestation.

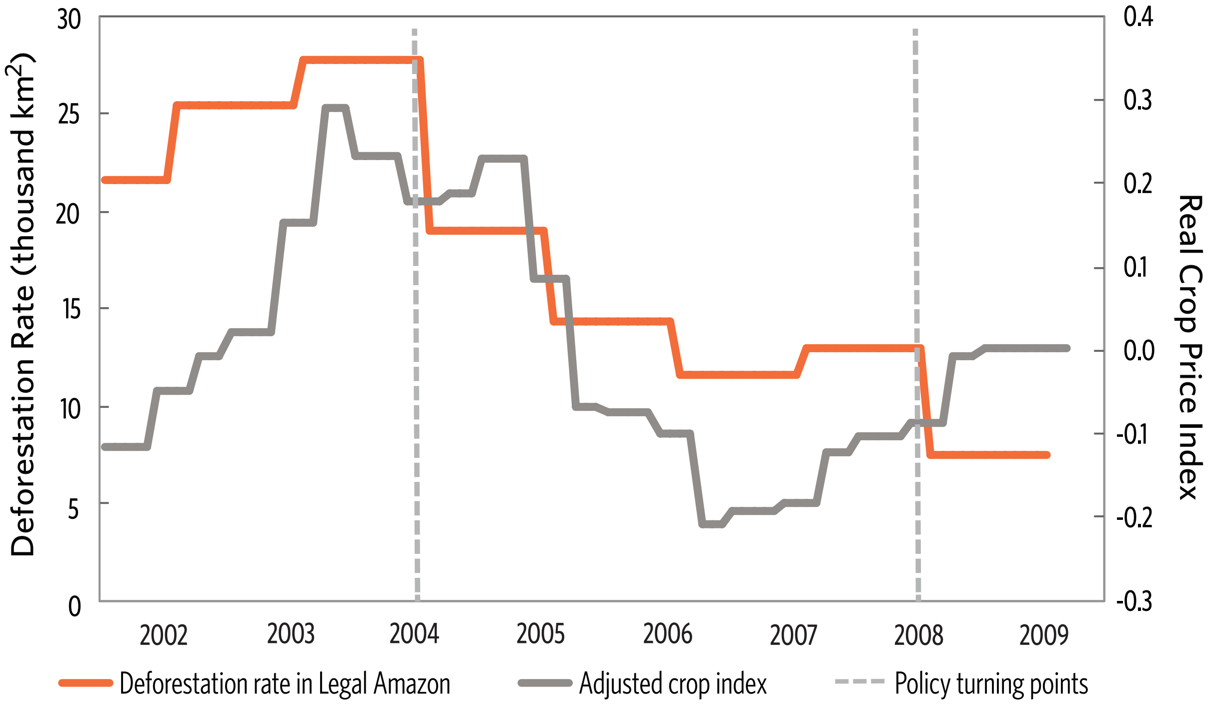
Our analysis shows that approximately half of the deforestation that was avoided in the Amazon in the 2005 through 2009 period can be attributed to conservation policies introduced in the second half of the 2000s. This is equivalent to an avoided loss of 62,000 km^2 of forest area, or approximately 620 million tons of stored C (2.3 billion tons of stored CO_2), which our estimates value at 11.5 billion US dollars.[2]

* This document is the executive summary of the paper "Deforestation Slowdown in the Legal Amazon: Prices or Policies?" Please refer to the original paper for a complete discussion of the institutional context, theoretical model, methodology, and results.

1 IPCC data refers to total emissions in 2004.

2 Calculations are based on conversion factors of 10,000 tons of C

Figure 1: Deforestation and price trends



Policy Turning Points

Brazilian conservation policies for the control and prevention of deforestation in the Amazon underwent significant revisions during the 2000s, with two years standing out as key turning points within the country's policy landscape: 2004 and 2008.

2004

The first turning point occurred with the launch of the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm) in 2004, which introduced a new form of dealing with deforestation in the Legal Amazon. From that moment on, conservation efforts were based on a large set of strategic measures that were to be implemented and executed as part of a collaborative effort between federal, state and municipal governments, alongside specialized organizations and civil society. Moreover, the mobilization of key organizations - the National Institute of Spatial Research (INPE), the Federal Police, the Federal Highway Police, and the Brazilian Army - and the contribution of the Chief of Staff as orchestrator of integrated action facilitated the implementation of innovative procedures for monitoring, environmental control and territorial management.[3]

Mutual cooperation between different levels and agencies of government provided support for stricter monitoring activities. In 2004, remote sensing-based forest monitoring capacity in the Legal Amazon improved significantly with the implementation of INPE's Real-Time System for Detection of Deforestation (DETER) and the creation of the Center for Environmental Monitoring (CEMAM) at the Brazilian Institute for the Environment and Renewable Natural Resources (Ibama). Collaboration between INPE and Ibama allowed for the regular production and distribution of georeferenced digital maps containing information on recent changes to forest cover in critical areas, providing important tools for the targeting of law enforcement activities. In 2005, Ibama also launched a program aimed at improving the qualification of its environmental monitoring personnel.

per square kilometer and 5 US dollars per ton of CO_2 (MMA, 2011).

3 The Chief of Staff of the Presidency of the Republic is the highest-ranking member of the Executive Office of Brazil.

Parallel to the PPCDAm's command and control efforts, the creation of protected areas gained momentum in the mid-2000s with the extensive expansion of conservation units (protected land) and recognition of indigenous lands.

2008

The second turning point was inaugurated with the signing of Presidential Decree 6.321 in 2007, which established the legal basis for singling out municipalities with very high deforestation rates and taking differentiated action towards them. In 2008, the Ministry of the Environment Ordinance 28 listed thirty-six municipalities classified as in need of priority action to prevent, monitor and combat illegal deforestation. Rural establishments in priority municipalities henceforth became subject to more rigorous monitoring of irregular activity and harsher registration and licensing requirements. Additionally, the passing of Presidential Decree 6.514 in 2008 reestablished directives regarding federal administrative processes for the investigation of environmental infractions and their respective sanctions, enabling such processes to be completed more quickly.

New credit policies were also introduced in 2008, with the approval of the National Monetary Council Resolution 3.545, which determined that rural credit for agricultural activities in the Amazon biome were to be conditional upon presentation of proof of the borrower's compliance with environmental legislation and legitimacy of land claims.

Results

The Effect of Agricultural Prices

Our results indicate that agricultural prices have a causal effect on the rate of deforestation in the Legal Amazon, but that the relationship between deforestation and agricultural prices differs for crop and cattle goods. Crop prices have a positive and significant impact on forest clearings, such that increases in crop prices in a given year are associated with higher deforestation observed between that year and the next. This effect is particularly strong for price variations occurring prior to the sowing season of the reference year.

Cattle prices, however, exert a heterogeneous effect on deforestation. While increases in cattle prices in a given year are associated with increased deforestation observed between that year and the next, results point to a negative relationship between current cattle prices and current deforestation. This can be explained by the fact that cattle is both a consumption and a capital good. On the one

Brazil's 2000s Environmental Policy Landscape: Turning Points

2004 | The launch of the PPCDAm integrated actions across different government agencies and introduced new procedures for monitoring, environmental control and territorial management. Highlights include:

- Coordinated activities among government agencies;
- Introduction of real-time remote-sensing forest monitoring technology; and
- Extensive expansion of protected territories.

2008 | The implementation of novel policy measures affected command and control and credit policies. Highlights include:

- Targeting of priority municipalities for stricter prevention, monitoring, and combating of illegal deforestation;
- Revision of legislation concerning environmental infractions and respective sanctions; and
- Conditioning of rural credit upon the presentation of proof of the borrower's compliance with environmental regulations.

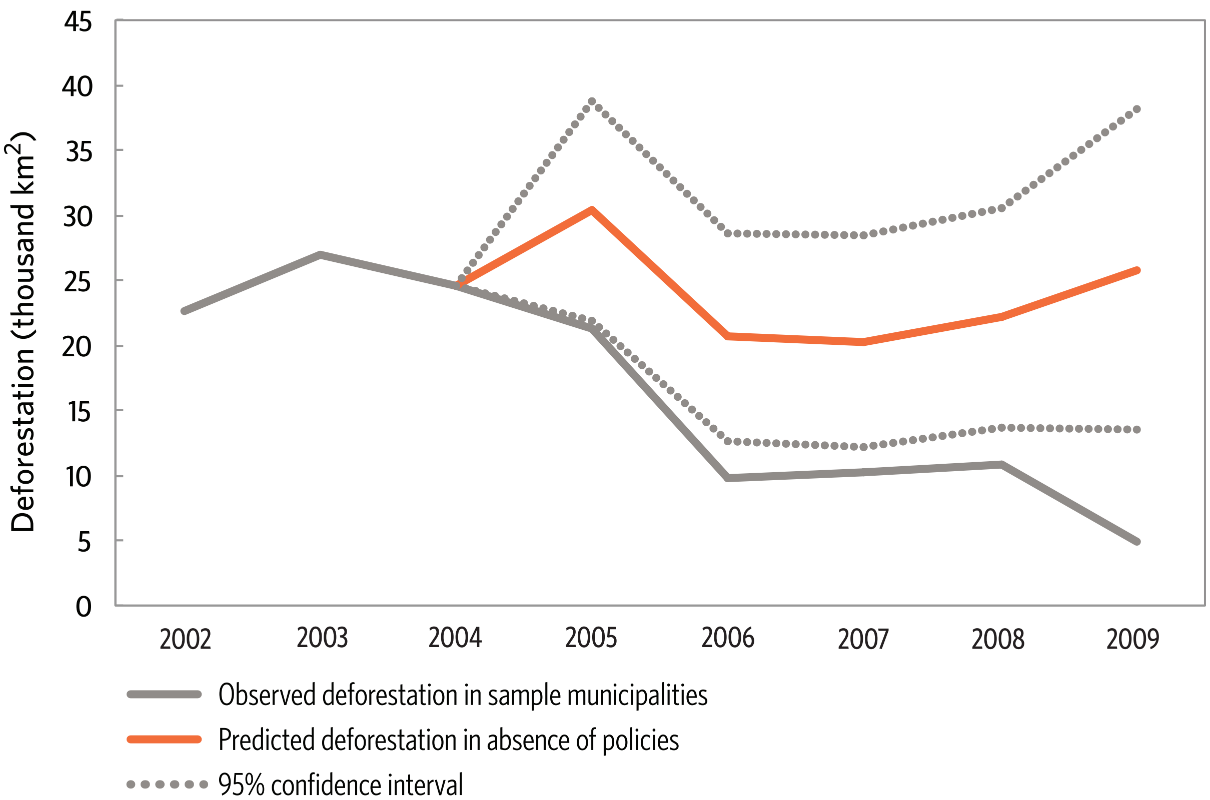
hand, producers may take high prices in the present as an indication of potential future gains and retain more cows to realize such gains. This investment would increase herd and pasture size, and thus push for more forest clearings. On the other hand, producers may wish to realize present gains during periods of high prices by increasing the supply of cattle destined for consumption. This would decrease herd and pasture size, and thereby alleviate the pressure on the forest.

The Effect of Policies

Our core analysis isolates the effects of agricultural prices and other potential drivers of forest clearings to estimate the contribution of policies to the deforestation slowdown in the Legal Amazon. In doing so, we find that conservation policies adopted beginning in 2004 and 2008 were effective in curbing deforestation in the Amazon. According to our calculations, policies helped avoid 62,000 km^2 of deforested area in the 2005 through 2009 period (see Figure 2). This represents approximately half of the forest area that would have been cleared had the policies introduced following the 2004 and 2008 turning points not been implemented. This is equivalent to an avoided loss of approximately 620 million tons of stored C, or 2.3 billion tons of stored CO_2, which our estimates value at 11.5 billion US dollars.

Figure 2 further illustrates how policies played a particularly important role in containing forest clearings at two specific moments during the second half of the 2000s. First, deforestation would have peaked in 2005 had the policies introduced beginning in 2004 not been implemented. This is consistent with the peak in agricultural prices observed in early 2004, as high observed prices could have led to more forest clearings during that year's dry season. Second, the deforestation trajectory would have shown an upward trend beginning in 2007 had the policies introduced beginning in 2008 not been implemented. This result suggests that deforestation would have increased with recovering agricultural prices in the late 2000s.

Figure 2: What would have happened in the absence of policies?



Conclusion

Throughout the 2000s, the Brazilian Federal Government and the Ministry of the Environment sought to inhibit forest clearings and promote forest conservation by directing their attention towards three main policy efforts: the strengthening of command and control strategies; the extensive expansion of protected territory; and the adoption of conditional credit policies. Key policy changes were introduced beginning in 2004 and 2008. Our results reveal these policies' valuable contribution to conservation efforts in the Amazon, especially during periods of rising agricultural prices. We show that the observed decline in deforestation levels has not been solely a response to market conditions and economy dynamics, but rather that the set of implemented policies has been effective in curbing deforestation.

We have yet to identify the relative contribution of each implemented policy. Given the level of detail of our data set, we are currently unable to evaluate the impact of individual policy measures. Further research will allow us to identify which mechanisms and specific policies were more effective in combating deforestation. Over the coming year, we intend to investigate the effect of three main policy changes: the post-2004 strengthening of command and control operations, the mid-2000s boost in creation of protected territory, and the 2008 implementation of conditional rural credit policy.

Our goal with these projects is to provide rigorous quantitative analysis to help Brazil maintain, refine, and improve the effectiveness of its conservation policies.

Acknowledgements

Ana Carolina Ribeiro, Luiz Felipe Brandão, Pedro Pessoa and Ricardo Dahis provided excellent research assistance.

We gratefully thank David Nelson, Ruby Barcklay, Anne Montgomery, and participants at the 2011 ANPEC meeting, for helpful comments.

Bibliography

IPCC (2007). Climate Change 2007: Synthesis Report, Intergovernmental Panel on Climate Change. New York: Cambridge University Press.

Ministério de Ciência e Tecnologia (2010). Inventário Brasilieiro de Emissões Antrópicas por Fontes e Remoções por Sumidouros de Gases de Efeito Estufa não Controlados pelo Protocolo de Montreal. Brasília: Ministério de Ciência e Tecnologia.

MMA (2011). Ratificação da Estimativa de Redução de Emissões de CO_2 pelo Desflorestamento na Amazônia Legal com Base no PRODES 2010. Nota Técnica 22/2011 DPCD/SECEX. Brasília: Ministério do Meio Ambiente.

Appendix: Methodology

Data Sources

Our analysis is based on a municipality-by-year panel data set covering the 2002 through 2009 period. The sample includes 380 municipalities located in the Legal Amazon states of Amazonas, Mato Grosso, Pará, and Rondônia. This selection refers to the four states that had at least one of their municipalities classified as a priority municipality in the Ministry of the Environment Ordinance 28/2008. It is further restricted to those municipalities with variation in forest cover during the period.

Data on deforestation is built from satellite-based images from INPE's Project for Monitoring Deforestation in the Legal Amazon (PRODES/INPE). Deforestation is defined as the annual deforestation increment, normalized at the municipality level. We build crop price series at the municipality level in two steps. First, we interact agricultural annual prices (data originally from the Agriculture and Supply Secretariat of the State of Paraná, SEAB-PR, for soybean, corn, rice, sugarcane, and cassava prices formed in southern Brazil) and the share of municipal area used as farmland for each crop in each sample municipality averaged over the 2000 through 2001 period. This term captures the relative importance of each crop within each municipality's agricultural production in the years immediately preceding the sample periods. Second, we use principal component analysis to condense variation in prices of the five crops and thereby derive a synthetic index of crop prices. We derive cattle prices analogously, using an interaction between cattle price series and the size of the cattle herd in each sample municipality averaged over the 2000 through 2001 period.

According to our conceptual framework, conservation policies should be binding whenever optimal farmland size exceeds that of the farmer's landholding. Consequently, such policies should be particularly effective in localities where land constraints are tight. Given this result, we derive policy variables based on interactions between: (i) the 2004 and 2008 policy turning points, represented by dummy variables indicating either or ; and (ii) a proxy for tightness of land constraints at the municipality level, which introduces cross-sectional variation into our policy variables. We explore two alternative proxy variables for tightness. The first one uses data from the 2006 Agricultural Census to measure the amount of unavailable land beyond landholdings relative to each municipality's total area. The second proxy, used in robustness checks, is the normalized annual deforestation increment for each municipality in 2004, which followed the 2003 peak of agricultural commodity prices. This proxy captures how binding the land constraint was in a period of high pressure on forest areas.

Overview of the Empirical Strategy

In order to examine the role played by conservation policies in the Amazon deforestation slowdown, we use the following municipality fixed effects specification:

$$D_{it} = \alpha_i + \phi_t + \beta_1 M_{it} + \beta_2 P_{i,t-1} + \beta_3 (Tight_i * Post2004) + \beta_4 (Tight_i * Post2008) + \epsilon_{it}$$

where D_{it} is defined as the normalized deforestation increment in municipality *i* between the 1st of August of year *t - 1* and the 31st of July of year *t*. The first two terms on the right-hand side are municipality and year fixed effects that control for unobservable fixed municipality characteristics and common time trends, respectively. In order to strengthen the control for municipality-specific time trends, we introduce a separate time trend for each municipality in the sample, M_{it}. The term $P_{i,t-1}$ includes lagged values for both the annual index of crop prices and the cattle price index. We use lagged price indices to account for the timing of agricultural production in the Legal Amazon. We assume that, in order to maximize their expected end of season profits, farmers use prices observed during the early months of year *t-1* to decide the size of the area to be sown and harvested from mid-*t-1* onwards. Prices in year *t-1* should thus be associated with forests cleared between August of year *t-1* and July of year *t*. We include the cattle price index calculated for the first half of the year *t* as an additional control to account for the potential cattle ranching cycles.

As $P_{i,t-1}$ is based on an interaction between price trends and municipality farmland use before 2002, the coefficient β_2 captures the exogenous effect of variations in the price indices on the municipal deforestation increment over the 2002 through 2009 period. The policy variables $Tight_i$*Post2004* and $Tight_i$*Post2008* absorb the remaining within-municipality variation in the deforestation increment between the years before 2004 (or 2008) and those afterwards. We enable the policy effect to be heterogeneous on our proxy for tightness of land constraint since our conceptual model suggests that conservation policies will only exert an effect when land constraint is binding. In more complete specifications we also add interactions between prices and policy variables.

The model relies on the identification hypothesis that β_3 and β_4 capture the effects of increases in policy stringency on deforestation once agricultural commodity prices and municipality time trends have been controlled for. The observed variation in $Tight_i$ across municipalities gives us a baseline for comparison among municipalities that are more or less prone to respond to variations in conservation policy stringency from either 2004 or 2008 onwards. Formally, the model tests whether, after the 2004 and 2008 policy turning points, deforestation has declined relatively more in municipalities where land constraint is tighter, conditional not only on agricultural commodity price trends at the municipal level, but also on common and municipality-specific time trends.

Finally, we use counterfactual simulations to quantify the contribution of conservation policies to the 2000s Legal Amazon deforestation slowdown in terms of avoided forest clearings and avoided losses in carbon storage. First, we estimate the baseline specification presented above and keep the coefficients. Second, we re-calculate the predicted values for the dependent variable D_{it} had the set of conservation policies implemented beginning in 2004 and 2008 not been adopted. That is, we use the estimated coefficients in order to predict the deforestation increment if the values of $Tight_i$*Post2004* and $Tight_i$*Post2008* were equal to zero. The difference between the observed deforestation trend and the counterfactual one gives the amount of avoided deforestation (or losses in carbon storage) that are attributable to policy.