Cost-benefit analysis of Forest Concessions in the Brazilian Legal Amazon

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Abstract

In recent years, particular attention has been given to the role of jurisdictional-scale approaches for the conservation and sustainable management of forests. For this reason, many studies have been carried out to assess such programs' contributions in reducing carbon emissions and, given the wider sustainability goals of REDD+ projects, in producing other non-carbon benefits. In Brazil, the federal Forest Concession program, which started in 2010, is expected to reduce carbon emissions and create local livelihood opportunities. Nevertheless, the impacts of this policy remain largely unidentified, both in terms of its consequences for conservation and of the benefits accrued by different sectors of society. For this reason, this paper analyzes the policy's impact on forest conservation and CO_2 emissions. It also examines whether the program produces net positive benefits and which actors within the jurisdiction are most impacted by it. I find that, during the first two to six years following the implementation of the program, municipalities with Forest Concessions have between 31-88 km^2 more deforested areas than control ones. Concerning the impacts of Forest Concessions on the access of local communities to traditional forest products, the estimates suggest no statistically significant differences on the extraction of Açai. On the other hand, municipalities containing Forest Concessions have higher Latex production than their counterparts in all years following treatment. The latter effect increases with exposure to treatment, ranging between 5.9 and 51.3 additional Tonnes of Latex per year. With regards to the Cost-benefit Analysis, I find that if effects on deforestation are not considered, the program is Net Positive for Brazilian Society under all sensitivity analysis scenarios. Nevertheless, the large social costs caused by the increase in deforestation in the first 6 years of the program lead cons to heavily outweigh pros in any scenario.

Contents

Acronym Table and Glossary

CBA . . . . . Cost-benefit Analysis

DETER . . . . . Real-Time System for Detection of Deforestation

DiD . . . . . Differences-in-Differences

FNDF . . . . . National Fund for Forestry Development

IBAMA . . . . . Brazilian Institute for the Environment and Renewable Natural Resources

IBGE . . . . . Brazilian Institute of Geography and Statistics

ICMBio . . . . . Brazilian Ministry of the Environment

INPE . . . . . National Institute for Space Research

NPV . . . . . Net Present Value

PEVS . . . . . Silviculture and Forestry Extraction Production database

PPM . . . . . Municipality Livestock Production database

PRODES . . . . . Project for Monitoring Deforestation in the Legal Amazon

REDD+ . . . . . Reducing Emissions from Deforestation and forest Degradation

RGFP . . . . . Public Forest Management Reports

SFB . . . . . Brazilian Forest Service

Brazilian Forest Service (SFB): The government agency responsible for public forest management. It is the agency most involved with Forest Concessions, from enabling stages to implementation and monitoring.

IBAMA: Brazilian Ministry of the Environment's administrative arm responsible for monitoring deforestation all across the country. The IBAMA acts like a sort of environmental police.

ICMBio: Brazilian Ministry of the Environment's administrative arm responsible for the management of Conservation Units/Protected Areas, as well as endangered species.

National Fund for Forestry Development (FNDF): promotes environmental conservation and sustainability through capacity building and technological innovation

National System of Protected Areas: Also known as Conservation Units divided into Strict protection areas, in which usage of natural resources is strictly prohibited; and sustainable use areas, in which human settlements and sustainable usage of natural resources is allowed.

National Forests: a type of Sustainable use area in which traditional communities are allowed to remain, and where visitation by the public and scientific research is permitted.

Forest Concession: areas inside National Forests whose management was granted to private actors who retain the right to use certain products and services, provided sustainable management plan is followed.

Opportunity Costs: value or benefit given up by an actor with the creation of Forest Concessions in the National Forest Intervention Costs: costs incurred with the actual implementation of a given intervention: ranging from planning, operational and monitoring costs.

Enabling Costs: costs not directly tied to the implementation itself but without which the implementation would be impossible. In the case of Forest Concessions: delimiting the National Forest area and conducting scoping studies to understand the context (local communities, biodiversity, etc).

1 Introduction

Avoiding deforestation is among the most promising and cost-effective ways of decreasing carbon emissions (Souza-Rodrigues. 2018). Brazil, once the world's largest deforesting country (Sills et al. 2014), has made considerable efforts to reduce land clearing in the Amazon in the past two decades. In doing so, command-and-control policies based on satellite monitoring of deforestation and degradation proved to be the country's most effective tool to promote forest conservation in the Legal Amazon (Sills et al, 2014). Nevertheless, concerns have been raised that such interventions are more costly than their incentive-based counterparts (Souza-Rodrigues, 2019), as they require large government-incurred monitoring expenses and place disproportionate cost on land users (Sills et al. 2014).

Indeed, Souza-Rodrigues (2018) finds that restrictions on land use, such as a mandatory share of forest to be kept intact in the property, will achieve the same level of avoided deforestation as incentive-based policies. However, the costs of such command-and-control policies are much higher, given the requirement that all land users decrease their activities, irrespective of productivity. For this reason, farmers' willingness to pay to avoid the policy's enforcement is high and, empirically, their resistance to it has been significant (Souza-Rodrigues, 2019), casting doubt on the sustainability of this type of approach.

Combining command-and-control measures with alternatives that present lower costs to society and more sustainable perspectives is therefore necessary (Sills et al, 2014). Considering this objective and the relative importance of the logging sector in the region, which accounted for gross income of USD 2.3 billion in 2005 (Lentini et al., 2005), Forest Concessions would offer the advantage of allowing extractive economic activity to take place, while guaranteeing that logging is carried out using sustainable forest management practices and potentially reducing the incidence of illegal activities in the National Forest area. The latter is especially important as the scarcity of private lands in Brazil has led to an increase in illegal logging in National Forests in Brazil (ITTO, 2013).

Awarding forest concessions to private entities can generate significant opportunities for curbing deforestation in tropical countries with a large share of public forests, provided that these arrangements are well managed by the relevant government agencies (Tegegne et al., 2018). Indeed, in the past three decades, the share of the world's public forests under a concession regimen increased from 3 to 15 percent, with the majority of these concessions being located in Southeast Asia and West Africa (Hensbergen, 2018).

The increasing popularity of this arrangement can be partly explained by the plethora of potential benefits promised by forest concessions, ranging from boosting economic activity and government revenues, to increasing employment and skills in local populations and protecting forests. Never-

theless, the private management of public forests is potentially high on costs, both in terms of inputs (monitoring and enforcing of contract rules) and of potential negative impacts that might originate from improper management (deforestation, disregard of the customary rights of local communities, etc).

Given the large magnitude of potential costs and benefits, as well as the context-dependent nature of the Net Present Value of these projects, considerable scope exists for conducting country-specific Cost-benefit Analyses of this sustainable management model. In Brazil, with the exception of Ribeiro et al (2020)'s Synthetic Control evaluation of the impacts of Forest Concessions on local forest jobs in the municipality of Itapu a do Oeste, little empirical evidence is available on the environmental and social impacts of Forest Concessions. Similarly, a Cost-benefit analysis of Forest Concessions is yet to be conducted. As a consequence, what is known about the impacts and costs of this type of forest program is limited to government reports on specific indicators, which are conducted on an ad hoc basis and do not use experimental data.

2 Background

2.1 Deforestation in Brazil

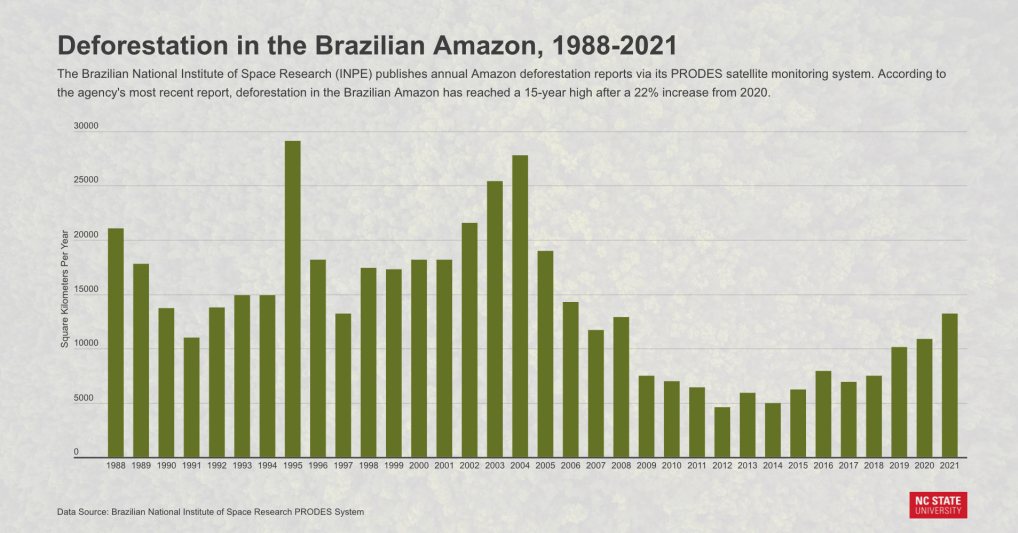
The Legal Amazon is a socio-geographic delimitation in Brazil which contains two-thirds of the world's largest tropical forest (Sills et al. 2014). Seventy five percent of its area is forested, and it covers roughly 59% of Brazil's territory, enclosing 9 states and 772 municipalities (Imazon, 2021).

Pasture expansion accounts for approximately 80% of deforestation in the Amazon (Barona et al., 2010; Tyukavina et al., 2017) and Brazil has long held one of highest deforestation rates in the world, which reached its peak between the years of 1995 and 2004. Due to the global importance of this region, however, the Brazilian government committed to preserving its rainforest through the establishment of the National System of Protected Areas (conservation units) in 2000 (OECD, 2015). Indeed, 45% of the Legal Amazon is now located within conservation units (Imazon, 2021).

Nevertheless, governmental measures to halt deforestation have historically faced organized resistance, as the international competitiveness of Brazil's livestock sector hinges on the low-costs of pasture grazing, which leads to a quick degradation of grassland areas and pressures the agricultural frontier to expand (Oliveira Silva et al, 2018). To solve this conundrum, the government has advocated for the adoption of agricultural technologies that would allow the country to preserve forested areas, while maintaining steady growth rates of livestock production (De Oliveira Silva et al, 2018).

After the election of President Luiz Inácio Lula da Silva in 2003, the country was successful in reducing its carbon emissions. This reduction was mainly made possible by the DETER system, which allows to coordinate satellite-based deforestation alerts with command-and-control measures

undertaken by the IBAMA. This system allowed the enforcement of Protected areas, leading them to account for a big share of avoided deforestation in the region (West et al., 2022; Blackman Veit, 2018; Soares-Filho et al., 2010).



Nevertheless, Dilma Roussef's impeachment in 2016, and the subsequent election of an administration that dismantled the effective environmental regulations previous governments had put in place (West et al., 2022), led deforestation rates to steadily grow. Because of the relative importance of Protected Areas in the promotion of forest conservation, policies that reduce commercial grazing activities in conservation units are especially important. Additionally, approximately 3.3 million commercialized livestock heads either originated from Protected Areas or were linked to indirect suppliers located in them (West et al., 2022). Given this scenario, in addition to more traditional command-and-control interventions, creating Forest Concessions within Brazil's National Forests could prove to be an effective way to avoid land clearing for cattle grazing.

2.2 Federal Forest Concessions in Brazil

In 2006, Brazil created a legal framework allowing state-owned forests to be managed under the newly created Forest Concession system. With this arrangement, private entities including enterprises, community associations or cooperatives have the possibility of paying to manage forest goods and services for a limited period of time.

These arrangements are expected to promote economic activity in the region, generate revenue

for federal, state and municipal governments, and promote environmental benefits in the form of avoided deforestation, as permit-holders would have incentives to safeguard their concessions from fires and illicit logging. Additionally, the economic activities undertaken by private entities are expected to foster local development through the generation of employment and through the mandatory investment in local communities.

To ensure that the forest coverage isn't depleted, contracts establish that economic activities in the concession must be carried out using sustainable forest management techniques, such as limiting the amount of logging in a given area and establishing long restoration periods for areas that have reached their logging quota. Additionally, in order to safeguard local communities' acquired rights, specific rules apply to traditional forest crops: while contract-holders are not allowed to forage them, local populations retain the right to collect them inside of Forest concessions. Contract holders therefore only have foraging rights over timber and non-timber forest products which do not fall in the traditional category. Furthermore, they also have commercial rights over forest and ecosystem services such as tourism.

In order to be awarded a Forest Concession permit, firms and civil society organizations (CSOs) must participate in a public bidding process. They are evaluated with respect to their technical proposal, in which they specify the activities they plan to implement in the concession and how many jobs would be created for the local population, and with respect to their pricing proposal: their willingness to pay for the natural resources available to them if awarded the permit.

Once the contract is signed, permit-holders have to refund the costs of the public bidding incurred by the Brazilian Forest Service (SFB), with the exception of small firms which are exempt from this refund obligation. They also have annual financial obligations to be paid to the SFB, namely, a "Minimum Annual Value" (VMA) based on expected revenues (irrespective of actual production), and "Other Values", which correspond to variable payments for actual timber extraction in the concession. Additionally, a deposit is to be made by concession-holders under "Social Indicator".

With the exception of the "Minimum Annual Value" (VMA), which is entirely destined for the Brazilian Forest Service (SFB), the other two financial obligations are to be further redistributed by the SBF. Forty percent of the "Other Values" go directly to the ICMBio, the Brazilian Ministry of the Environment's administrative arm, which is responsible for the management and administration of all National Forests. Similarly, yearly payments consisting of 20 percent of the "Other Values" go to the National Fund for Forestry Development (FNDF), which is implicated in innovations in the forestry sector.

The remainder of the "Other Values" budget is allocated to the State (20%) and Municipalities (20%) in which the Forest Concession is located, with the objective of supporting activities that promote the sustainable usage of forestry resources. However, redistribution to States and Munici-

palities is conditional on a set of rules which they often do not abide by, leading to long delays in the transfers of these resources. In the same line, "Social Indicator" values are destined to encourage infrastructure and service investment in Municipalities, but these resources are seldom redistributed to their intended public.

In case of non-payment of their financial obligations to the SFB for an extended period of time, the concession contract is promptly terminated. Otherwise, firms are given the possibility to repay their debts with the addition of interests and fines.

When compared to other Latin American countries, Brazil has a much lower share of public forests under concession, with only 0.27 percent of its public woodland falling under this management regime, against 2-53% in its Latin American counterparts (Hensbergen, 2018). Nevertheless, since September 2010, a total of fourteen Federal Forest Concessions have become operational in Brazil's Legal Amazon, with 849.164,59 ha of land being under concession. Seven more concession contracts have been signed and are yet to initiate their operations, with five of the uninitiated contracts dating from after January 2021.

This showcases the growing popularity of such arrangements in Brazil, in spite of the still incipient nature of Forest Concessions when compared to other countries in Latin America. Given the increasing importance of this type of management of state-owned forests, as well as their potential contribution for various Sustainable Development Goals (SDGs), there is a clear scope for an analysis on whether or not to continue this sustainable forest management approach.

Moreover, because of the avoided deforestation that could result from this type of sustainable management, an empirical analysis of the environmental impact of Forest Concessions is warranted. While the commercialization of carbon credits generated from avoided deforestation in state-owned forests is currently not allowed, a bill has been proposed to change current regulations regarding REDD+ carbon credits in Brazil (Projeto de Lei nº 5.518/2020). This indicates that, if Forest Concessions were to be effective in reducing illegal land clearing, large economic benefits could be derived from adopting this management model.

3 Data

This section describes the sources of information used in this paper. Three main sources of data were used to conduct the analysis. First, I constructed the balance sheets of all actors using annual reports published by the Brazilian Government detailing the values paid by permit-holder companies and the redistribution of said payments. The great detail of budgetary data present in the reports and in the Forest Concession website allowed me to construct an accurate database with money flows from and to the various governmental organizations, municipalities, states and firms that are related to Forest Concessions. Additionally, annual deforestation data was used to obtain empirical estimates

of the effect of Forest Concessions on forest cover. Thirdly, data on the extraction of forest corps was used to determine whether forest concessions impacted the production of traditional forest crops by local communities. Auxiliary data sources were used to fill the gaps in actor's balance sheets and in the empirical estimates of the impact of Forest Concessions. All prices were converted to 2010 Brazilian Reais. Descriptive statistics of the larger datasets used are available in Annex 6. Supplementary Materials for the calculation of the CBAs can be found in Annex 7.

3.1 Budgetary and Transfers data

Annual Public Forest Management reports called "Relatórios de Gestão de Florestas Públicas" (RGFP) are published in the government's website. They contain data on annual payments made by concession-holders to the SFB, as well as the percentage of these values to be redistributed to the States, Municipalities, and government agencies (ICMBio and FNDF), conditionally on their compliance to certain indicators. These yearly documents also have data on refunds of the costs of the public bidding (if applicable) and annual data on timber extracted by each company. I used the reports from 2009-2021 to compile the government's and the companies' balance sheets.

Additionally, other sources of data were used to complete the balance sheets. Bidding costs incurred by the government were found in each concession's Bidding Notice and related annexes, under the name "Custos de Edital". I compiled theses costs for forest concessions whose bidding process occurred between 2009 and 2018. Similarly, enabling and intervention costs of the SFB were taken from the SFB's Management Report ("Relatórios de Gestão do Exercicio"), which covered these costs from years 2008 to 2017, with the exception of 2010. Enabling and Intervention costs for 2010 were taken from the "Supplementary Material 2" from Cunha et al (2016). The costs relative to 2018 and 2019 were retrieved from the Brazilian Government's Transparency Portal [1]

Data on the redistribution of the "Other Values" and "Social Indicator" resources were collected using information present in the government's official website.[2]. Although the aforementioned source also includes transfers that took place in 2022, I only used the 2011-2021 period due to a lack of detail on this year's transactions as the 2022 RGFP report is not yet published.

3.2 Identification of Treatment and Control areas

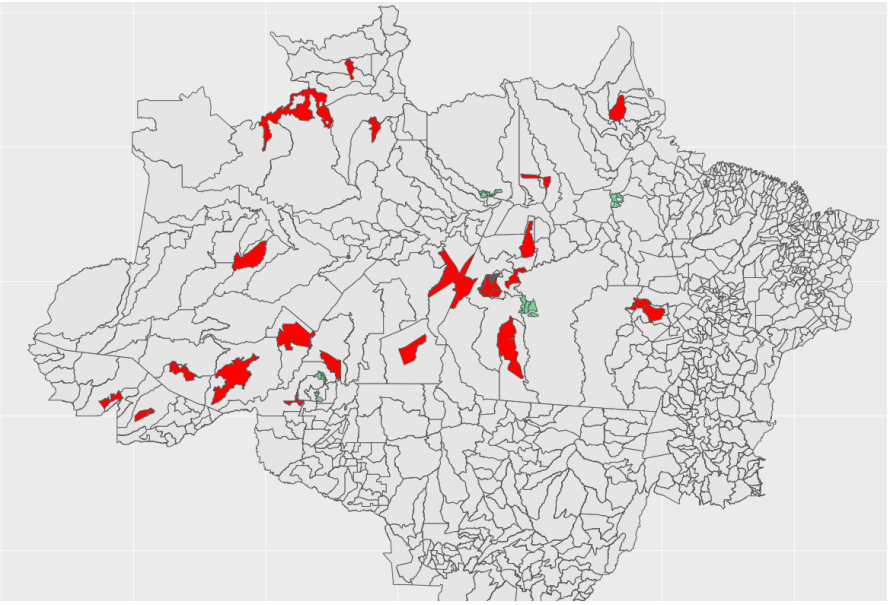
Allocation to treatment is determined by the creation of a Forest Concession within a National Forest in Brazil. While this means that treatment is not allocated to a specific municipality, as a concession can span across multiple ones, the smallest disaggregation of our outcomes of interest is at the municipality-level. For this reason, it was necessary to find the municipalities which had a big

[1] https://transparencia.gov.br/despesas/orgao?ordenarPor=orgaoSuperiordirecao=asc

[2] https://www.gov.br/agricultura/pt-br/assuntos/servico-florestal-brasileiro/concessao-florestal/valores-arrecadados

enough share of Forest Concessions located within them. By overlaying a shapefile of the National forests with one of municipality the boundaries, I was able to find all municipalities where at least 5% of a forest concession is located. These municipalities were considered as the ”ever treated=1” group, which became treated in different moments in time due to the staggered nature of the policy. On the other hand, using the same technique, I was able to find the municipalities which contain at least 5% of National Forests that have not yet been put under a Forest Concession arrangement, which were considered to be the smaller sample of the ”ever treated=0” or untreated group.

Municipality boundaries in the Legal Amazon, and National Forests with (green) and without (red) Forest Concessions:



In order to have a larger sample size for the quasi-experimental approaches proposed, the ”ever treated=0” group could also extend to all the Legal Amazon municipalities that did not have a Forest Concession in them in any point in time, regardless of having a National Forest within their boundaries or not. Whether this larger sample size is used was decided by analyzing if parallel trends assumption seems to hold in the larger dataset. I therefore start with the larger sample, and switch to the restricted one based on the existence of parallel trends in the pre-2010 period.

3.3 Deforestation data

In order to estimate the effects of Forest Concessions on deforestation, I used a yearly panel data on municipality-level deforestation and total forest coverage from the National Institute for Space

Research (INPE)[3] between the years of 2001 and 2021. This dataset was created in 1988 as a part of the PRODES project, with the objective of using satellite-based monitoring to identify forest loss in the Legal Amazon [4]. A given monitoring year of the PRODES database starts on August 1 of the previous year and spans until July 31 of the selected year.

To the initial data containing municipality-level deforestation throughout the years, I added a time-invariant variable describing whether National Forest areas exist within the municipality, and a variable specifying whether it contained a Forest Concession in a given year. Because of the specific definition of monitoring years in the PRODES database, treatment was considered to start one year after its actual start. For instance, if the Forest Concession in Municipality becomes operational in August 2011, the year in which treatment starts in the PRODES dataset is considered to be 2012, as the 2012 PRODES spans from August 1st (2011) to July 31st (2012).

Using the PRODES data, I have panel data of yearly deforestation in 11 "ever treated=1" and 32 "ever treated=0" municipalities containing National Forests over the course of a decade. All other municipalities in the Legal Amazon which do not contain a National Forest are part of the "ever treated=0" group, since initially Forest Concessions could only be granted inside National Forests. Annex 3 describes the "ever treated" status of all municipalities which contained a National Forest.

3.4 Forest Crop data

The IBGE's PEVS panel data contains information on the yearly municipality-level extraction of forest crops and silviculture, reported in terms of quantity and value. I used PUC-Rio's Datazoom Amazonia package to download the PEVS estimates between 2007 and 2019 and create a database of the traditional forest crops extracted in the Legal Amazon during the years before and after the implementation of forest concessions. Only the quantity of two forest crops was used in the analysis: Açai and a sum of liquid and coagulated Latex, which were the only ones that could be matched between the list of Forest-crops with restricted use by permit-holders in forest concessions and the PEVS data. Municipality-level estimates of the yearly prices for the forest crops were also estimated by dividing total forest crop values (in thousands of brazilian reais) by quantity (in tonnes).

I also added the same variables (described in the last subsection) specifying whether National Forest areas exist within the municipality, and whether it contained a Forest Concession in a given year. However, unlike the PRODES dataset, treatment was considered to start in the same year as the actual start of Forest Concession operations, since the definition of year in the PEVS dataset cor-

[3] Data points were collected using PUC-Rio's Datazoom Amazonia package.

[4] It uses data from the Landsat, CBERS and Sentinel Satellites. Unlike the DETER System, the PRODES deforestation database only reports yearly deforestation estimates and it is slightly less precise, as it can only identify low-cut deforestation in areas larger than 6.25 hectares. Nevertheless, the PRODES estimates were preferred to the DETER ones due to their simpler data structure and to the existence of data before 2015.

responds to the usual calendar. The binary variable ”ever treated” was defined in the same way as in the previous section, creating two possible datasets: one containing only treatment and control municipalities with National Forests, and another one containing additional control (”ever treated=0”) entries in municipalities without a National Forest.

3.5 Cattle Grazing

The regressions results in Annex 5, were constructed using the PPM (Municipality Livestock Production), a panel data by the IBGE on livestock farming in the Brazilian Municipalities from years 2006 to 2019.

These regressions aren't included in the official impact evaluation due to the illegal character of cattle grazing inside of National Forests, however, they are useful to understand how other sectors of society might be impacted by the policy.

3.6 Parameters based on existing evidence

3.6.1 Logging prices and timber extraction costs

Timber sale price wasn't readily available in the report, as the prices detailed in the document are the selling prices of wood by the government, which are designed to allow concessions to be economically feasible, rather than the prices actually practiced in the local timber market. Similarly, timber extraction prices in the municipalities were also not readily available.

Estimates for the extraction and market prices of timber were thus substituted with the parameters used by the SFB in feasibility reports of Forest Concessions in two Brazilian States. The Feasibility study in the Jamari Region (2007) gives approximate timber market prices and extraction costs in the State of Rondônia, and the Feasibility Study in the Saraca-Taquera Region (2009) gives the same estimates for the State of Pará. Forest Concessions in Rondônia were considered to have the same selling prices and extraction costs that were specified in the Jamari feasibility analysis, while the parameters for Forest Concessions in Pará were considered to be the same as the ones in the Saraca-Taquera analysis.

3.6.2 Employment

Employment resulting from the Forest Concessions is among the indicators to be monitored by the government. Nevertheless, social and environmental commitments are less thoroughly checked than financial ones. In practice, the employment impacts were seldom present in yearly reports: with only those from 2012 to 2016 being available (some official data was also taken Rodrigues Ribeiro et al., 2020). For this reason, precise estimates of direct impacts on employment were

not completely available. I therefore calculate a mean of yearly employment generated using the official data available. I find that, on average, 2.10 direct jobs are created by each 1000 ha of forest concessions, as per official 2012-2016 data. Empirical estimates from other studies were used to confirm these estimates. Gretzinger (2015) estimates that 1 job is created per 500 hectares of Forest Concessions, yielding very similar estimates to the average I used.

3.6.3 Wages

The direct job creation reported by the SFB concerns only formal, full time employment. Following Alfenas et al (2020)'s estimates, I consider that the average salary in Legal Amazon's formal sector that year corresponded to R$ 2418, which translates to R$ 1380 2010 Brazilian Reais; which is roughly two minimum wages, in accordance to the estimates for 2015 presented by Rodrigues Ribeiro et al (2020).

Since lowest possible value for formal employment is the minimum wage, I used annual data[5] on the minimum wages in Brazil from years 2010 to 2021, adjusted to 2010 price levels, in the sensitivity analysis.

4 Methodology

4.1 Cost-benefit analysis

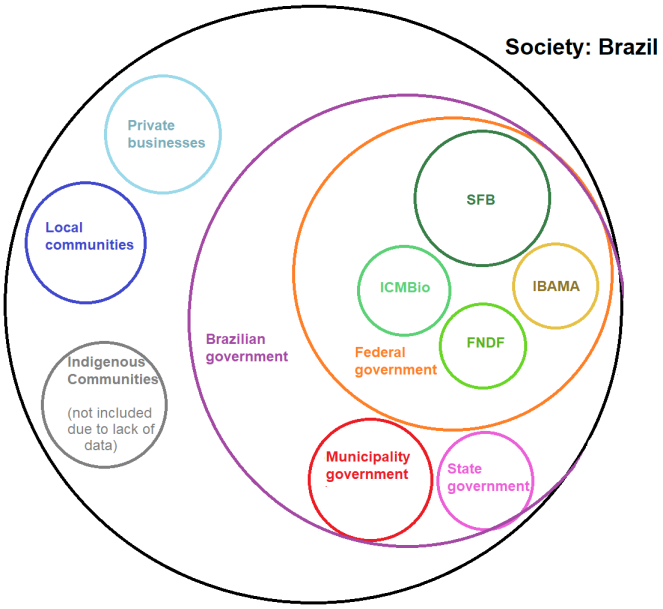
Objective of the CBA: The study aims to determine whether Federal Forest Concessions are potentially Pareto Improving. In order to do so, I will calculate costs and benefits to the involved stakeholders, producing a National CBA of the policy. This analysis will consider all benefits, including the change in carbon emissions that resulted from the intervention, valued by the social cost of carbon.

Jurisdictional Limits: Although Federal Forest Concessions are limited to the Legal Amazon, the jurisdictional definition of society for the CBA will be at the national level (Brazil). Parallel subnational analyses will also be conducted for each stakeholder (the 11 firms, the SFB, the ICMBio, the FNDF, the 11 Municipality government, and the 2 State governments). CBAs for Local communities and Society will also be reported.

Mapping of actors: As it is clear from the image below, federal-level organs such as the SFB, ICMBio and FNDF will be considered as the Federal government, which does not overlap with

[5] https://www.contabeis.com.br/tabelas/salario-minimo/

Municipality and State-level ones. Local communities and private businesses will be considered separately from the government's CBA. Additionally, society as a whole will consist of the summation of all individual costs and benefits, excluding intra-jurisdictional transfers and including, additionally, impacts of concessions on carbon emissions.



Standing: Standing was decided based on the stakeholders mentioned by the Brazilian federal government as being key actors who incur benefits and costs from the concession of forest permits. Additionally, stakeholders that receive direct payments or transfers originating from the logging profits of the permit-holders were also given standing. I will create parallel sub-national CBAs for all of these stakeholders, as well as a nation-wide CBA (the Jurisdictional definition of society will be Brazil). Nevertheless, standing will also be conditional on data availability, as some actors' costs and benefits might be difficult to estimate. This is the case with native communities, for which data isn't available but whose territory might be very close to areas with Forest Concessions (see Annex 2). It is also the case with the IBAMA, which plays an important role monitoring all deforestation across the Brazilian territory, thus also tracking forest clearing inside concessions. However, because its budget lines are not clearly attributable to the intervention I was not able to include this government organ in my analysis.

4.1.1 Composition of the Cost-benefit Analysis

Individual CBAs for each firm, for local communities, for the Brazilian Forest Service (SFB), for the ICMBio, for the FNDF and for governments at the State and Municipality level were created. All the costs and benefits that are thought to be incurred by each actor are detailed in Annex 1. Out of those, some were disregarded due to measurement difficulties, which are duly indicated in the "Data Source" column.

To compile these individual CBAs, I used existing budgetary data from public agencies and firms, as well as empirical estimates on deforestation and extraction of forest products. which were monetized using existing parameters. All prices in the CBAs were adjusted using the IPCA inflation rate to 2010 Brazilian Reais. A 3.5% discount rate was used.

Overall, firm's costs included timber extraction costs and payments to the SFB (refunds, debt payment, fixed annual contributions and variable ones). Firm's benefits consisted of revenues from timber sales. Using the SFB's Feasibility Analysis documents, fixed timber extraction and transportation rates were used for each state (Rondonia or Para). Similarly, timber market selling prices for each state was also based on the SFB's Feasibility Analysis rates for the two areas. They were multiplied by total yearly timber production for each firm to get total costs and revenues from logging. No benefits other than logging sales were considered for the firms, since no data is available on tourism services. Likewise, revenues from other forest products are expected to be minimal due to the restricted access given to permit-holders.

Brazilian Forest Service (SFB) costs included the direct payment of bidding notice, payment of enabling, monitoring and operational costs, as well as payments to other actors, such as the ICMBio, FNDF and States and Municipalities. Government benefits included all the payments received from the firms.

The ICMBio, FNDF, States and Municipalities only had benefits. Which, in the case of the ICMBio, FNDF correspond to yearly payments made by the SFB, and, in the case of Municipalities and States, correspond to sporadic payments received from the SFB, on the rare occasions in which they met all the requirements.

Local communities' CBA considers benefits the local population in a municipality may derive from the additional jobs created by the Forest Concessions. Data on job creation was partially obtained through official SFB reports (from years 2012 through 2016) and missing data was completed using the average job creation rate by hectare of Forest Concessions in Brazil (Hensbergen, 2018; Gretzinger, 2015). Local communities' benefits also covered additional revenues obtained through the expansion of Latex extraction activities. In the sensitivity analysis, Local communities also had an additional opportunity cost in the form of decreased access to Açai forest crops.

A CBA for society was obtained by adding costs and benefits included in the individual CBAs.

Payments received or made by the actors, however, were not included in the Society-level Cost-benefit analysis, since transfers from one actor to the other in the same jurisdiction are cancelled out. Sensitivity analysis was conducted whenever parameters from existing sources were used to monetize inputs and outcomes, and when empirical estimates did not give very robust results.

4.2 Empirical Estimation

4.2.1 Impact of Forest Concessions on Deforestation

As argued by the Brazilian Forest Service, in addition to promoting regional economic growth and creating sustainable livelihoods for local populations, one of the main societal benefits of Forest Concessions would be the adoption of sustainable forest management techniques and forest conservation. For this reason, in order to capture the full extent of benefits and costs generated by this arrangement, it is necessary to understand how Forest Concessions impact deforestation and carbon emissions.

Nevertheless, the deforestation in municipalities that did not implement Forest Concessions is not a good counterfactual for the policy, because National Forests that go into concession and those which do not presumably had different potential outcomes even without concessions.

Indeed, many factors affect the government's decision to create Forest Concessions in a given National Forest. Aspects such as local population characteristics, initial forest cover, and market access are likely to influence whether the management of a forest is granted to a private entity. Simultaneously, these attributes are also important determinants of deforestation, since both a firm's decision to bid on a permit and the deforestation in the municipality are correlated to the expected logging profits in the area.

I exploit the existence of deforestation panel data in treated and untreated units to estimate the effects of these management arrangements on forest cover. Using a differences-in-differences design allows us to filter out time-invariant differences in the potential outcomes of the municipalities, as well as time-varying trends that affect all municipalities in the same manner. Furthermore, the staggered implementation of Forest Concessions allows us to decrease the likelihood of confounding factors, such as contemporaneous trends other than the treatment, driving the results.

A necessary assumption to conduct a Differences-in-difference analysis is that of parallel trends. By using the entire sample of municipalities within the Legal Amazon, however, a trade-off between the number of observations and the parallel trends assumption exists, since including municipalities without a National Forest might increase the sample size, at the price of including areas that could be subject to different influences. For this reason, for each case, I select the sample by checking if the full sample pre-2010 trends are similar enough, or if more parallel trends can be achieved by limiting my analysis to municipalities containing National Forests.

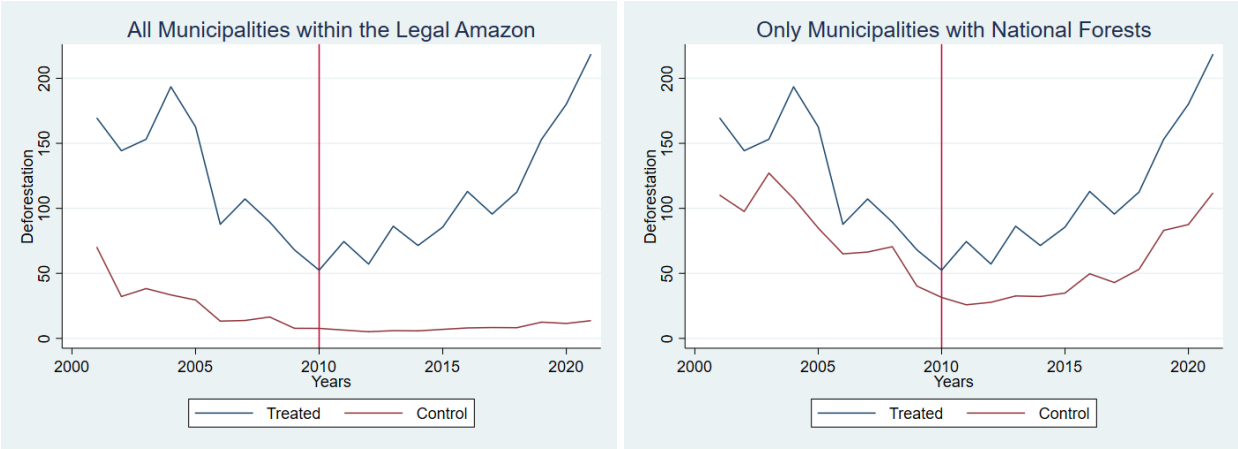


Figure 1: Trends in Deforestation in control and treatment groups

As it is clear by looking at Figure 1, the parallel trend assumption seems to only hold in the subset of municipalities of the Legal Amazon containing a National Forest (right side image). I therefore use this sub sample to conduct my analysis.

Similarly to Beck, Levine, and Levkov (2010), I first estimate a Differences-in-Differences model using a binary indicator of treatment in a given municipality and year.

$$DF_{i_t} = \alpha_i + \lambda_t + \beta^{DD} D_{i_t} + \delta_1 FC_{i_{t-1}} + \delta_2 \overline{DF}_{i_{2000,2001}} + \epsilon_{it} \tag{1}$$

In the regression equation, α_i and λ_t are municipality and year fixed effects, respectively. The coefficient of δ_1 represents the effect of lagged forest cover on current deforestation in a given municipality, which allows the model to account for unobserved differences between municipalities that might affect deforestation. Similarly, δ_2 represents the effect of initial levels of deforestation, in which $\overline{DF}_{i_{2000,2001}}$ is the mean of deforestation in the two years prior to the start of the database (2000 and 2001). The coefficient β^{DD} gives the differences-in-differences estimate of the effect of Forest Concessions on deforestation. The binary variable D_{i_t} is set to 0 if the municipality belongs to the "ever treated=0" group or, in an area that is treated at some point in time, D_{i_t} is 0 before the commencement of Forest Concessions operations and 1 afterwards. Standard errors are clustered at the municipality level, as the panel data structure means that, within the same municipality, error terms are likely to have temporal serial correlation.

A second model aims to understand how the different duration of the treatment might change its effect on Forest Concessions by using an Event-Study design. However, because of the staggered nature of the policy's rollout and to avoid the bias problems highlighted by Sun and Abraham (2020), I use their slightly modified event-study design: the interaction-weighted estimator.

$$DF_{i_t} = \alpha_i + \lambda_t + \sum_e \sum_{k \neq -1} \beta_{g,k} \left(1\left\{ G_g = g \right\} \cdot D_{i_t}^k \right) + \delta_1 FC_{i_{t-1}} + \delta_2 \overline{DF}_{i_{2004,2005}} + \epsilon_{it} \quad (2)$$

In the model, α_i and λ_t are municipality and year fixed effects, and δ_1 represents the effect of lagged forest cover on current deforestation and δ_2 the effect of historical deforestation means before the start of the database. In this specification, the relative cohort indicator $1\left\{ G_g = g \right\}$ are interacted with relative period indicators $D_{i_t}^k$. Standard errors clustered by municipality were also used in the second regression.

4.2.2 Impact of Forest Concessions on the Extraction of Traditional Forest Products

One of the main concerns with Forest Concessions is that they may limit local communities' access to forested areas and create barriers for their usage of traditional forest products. In order to prevent this from happening, the SFB has added protective clauses in the contract, restraining permit-holding companies' access to such crops and reinforcing local populations' foraging rights. Nevertheless, the effectiveness of such measures in avoiding that traditional livelihood activities are impacted by Forest Concessions is unclear, as companies might not be in full compliance of these rules. An accurate picture of how Forest Concessions might be impacting traditional communities' foraging is therefore needed.

However, the estimation of such impacts is difficult as, much like in the previous section, one would expect municipalities in which forest concessions are created to have different potential outcomes in terms of forest crops foraging than those who do not have their National Forests under such management regimes. I thus use the same quasi-experimental models to understand the impacts of concessions on local populations' extraction of traditional forest products.

The parallel trends assumption for the Açai production appears to only hold when considering all the untreated Municipalities in the Legal Amazon as a counterfactual, as observed in the Figure 2, in which only the graph to the left exhibits parallel trends before 2010. I therefore use the larger sample for the analysis.

Similarly, the Latex production in treated and never treated areas, which is indicated in Figure 3, seems to follow parallel trends only when considering all the Legal Amazon municipalities (left). For this reason, I use the entire sample for the analysis.

On the other hand, as one can notice from Figure 4, the Copaiba forest crop does not seem to have parallel trends in any of the samples. I was thus unable to estimate the effects of Forest Concession on the foraging of Copaiba.

The equation below illustrates the quasi-experimental approach used to estimate the impacts of Forest Concessions on traditional Forest Products.

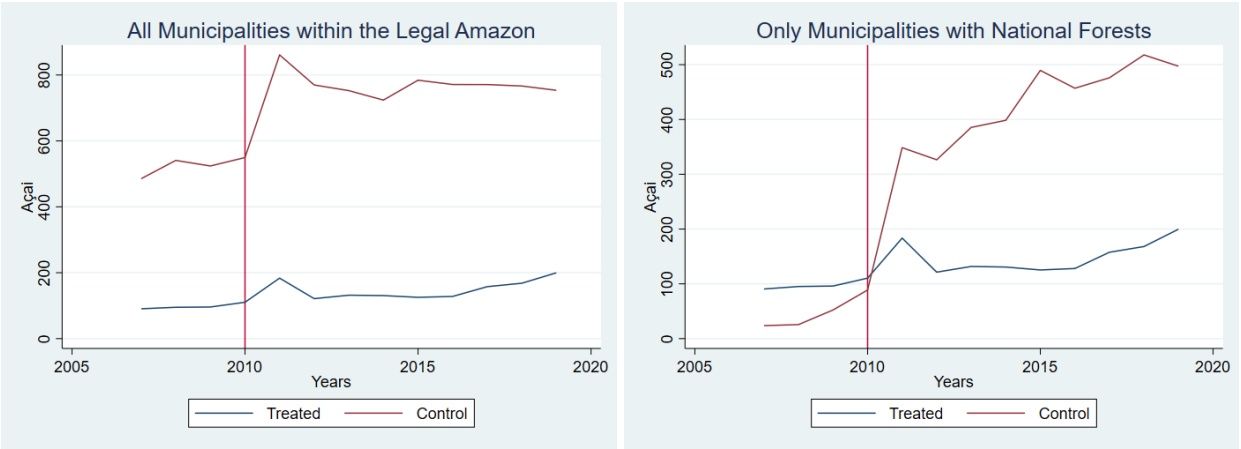


Figure 2: Trends in Açai production in control and treatment groups

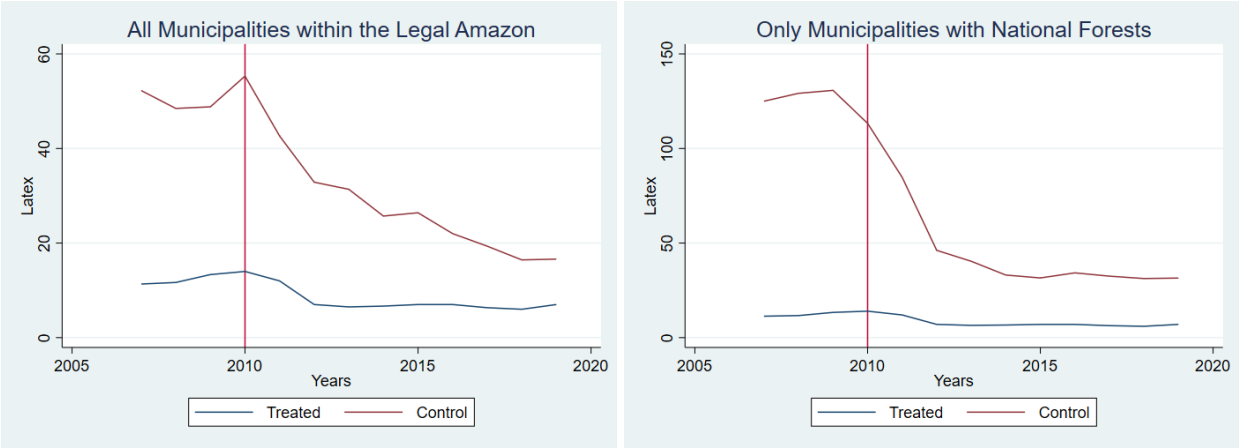


Figure 3: Trends in Latex production in control and treatment groups

Figure 4: Trends in Copaiba production in control and treatment groups

$$FP_{i_t} = \alpha_i + \lambda_t + \beta^{DD} D_{i_t} + \delta_1 FC_{i_{t-1}} + \delta_2 \overline{FP}_{i_{2004,2005}} + \epsilon_{it} \tag{3}$$

In equation 3, α_i and λ_t are municipality and year fixed effects and δ_1 represents the effect of lagged forest cover on current quantity (in tonnes) of forest products foraged in a given municipality, capturing possibly unobserved historical factors. Similarly, δ_2 represents the effect of initial levels of forest product extraction, in which $\overline{FP}_{i_{2004,2005}}$ is the mean quantity extracted in the two years prior to the start of the database. As in equation 1, the coefficient β^{DD} gives the differences-in-differences estimate of the effect of Forest Concessions on the quantity of Forest Products extracted. Standard errors are clustered at the municipality level.

A second model is used to incorporate the dynamic treatment effects. Equation 4 consists of the interaction-weighted event-study estimator proposed by Sun and Abraham (2020):

$$FP_{i_t} = \alpha_i + \lambda_t + \sum_e \sum_{k \neq -1} \beta_{g,k} \left(1 \left\{G_g = g\right\} \cdot D_{i_t}^k\right) + \delta_1 FC_{i_{t-1}} + +\delta_2 \overline{FP}_{i_{2004,2005}} + \epsilon_{it} \tag{4}$$

It contains municipality (α_i) and year (λ_t) fixed effects. A control variable represents the effect of lagged forest cover on current forest product foraging (δ_1). Similarly, (δ_2) is the effect of production means before the start of the database. In this specification, the relative cohort indicator $1\left\{G_g = g\right\}$ are interacted with relative period indicators $D_{i_t}^k$. Standard errors clustered by municipality were also used in the second regression.

5 Results

5.1 Empirical Results

5.1.1 Impact on Deforestation

Figure 8 presents the Differences-in-Differences estimates of the impact of creating Forest Concessions on deforestation. Column 1 gives the results of the DiD analysis using a binary indicator of treatment. Column 2 shows the event study estimates, indicating how the effects of Forest Concessions varied as municipalities spent more years under the management regime. The positive differences-in-differences coefficient presented in column 1 indicates that receiving treatment is correlated with higher levels of deforestation. Nevertheless, these estimates are not statistically significant, so I cannot claim that Forest Concessions have any effects on deforestation out of the DiD binary indicator estimates alone.

However, because of the Staggered treatment rollout, the causality relationships can be better understood by analyzing the event study estimates in column 2. It uses the deforestation levels one year before treatment (T=-1) as the omitted baseline. As mentioned previously, Figure 1 indicates

trends of both treated and untreated groups to be parallel if considering only municipalities containing National Forests. This can be further tested by looking at the event-study results before the start of the treatment, as "ever treated=1" units should not differ from "ever treated=0" before the start of their treatment. Column 2 shows the prior-treatment differences between these two groups, ranging from one year before treatment to fourteen years before treatment. I find that, on average, treated units before treatment were quite similar to never treated ones, except for units 7 to 5 years before being treated, as also observed in Figure 5.

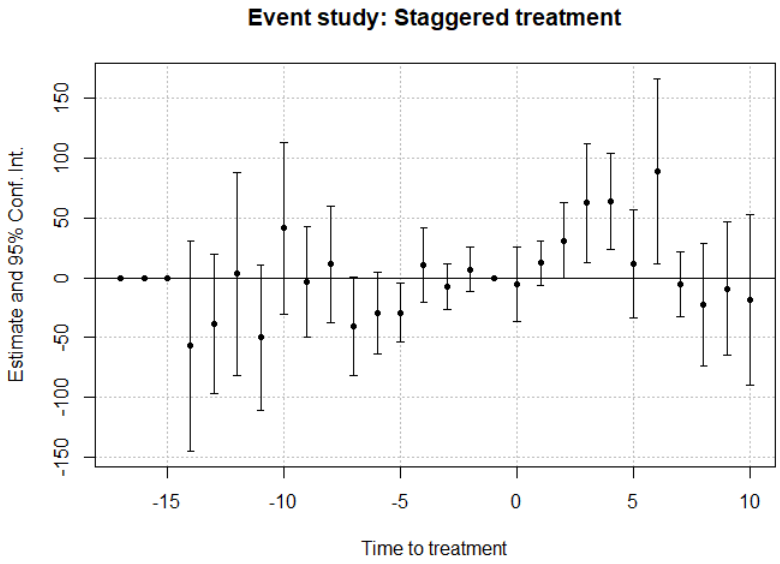


Figure 5: Interaction-weighted Event-study estimates of the impact on Deforestation by treatment year

Overall, the creation of Forest Concessions seems to increase deforestation in the first 6 years of implementation, with coefficients from years 2, 3, 4 and 6 being significant. While not statistically significant, the negative coefficients from years 7 to 10 after treatment indicate that, after an initial increase in deforestation, privately managed National Forests have a tendency to experience less tree-cutting than their counterparts, which could be a reflection of the lag with which contract indicators start to be monitored. When considered in conjunction with the coefficient in Column 1, the results seem to indicate that, at least in the first few years of treatment, Forest Concessions increase deforestation. The statistically significant year-to-year coefficients after the start of the treatment will be used to calculate society's costs with Forest Concessions. Namely, I consider that between the second and sixth year of treatment, forest concessions had the effect of increasing deforestation by 33 km^2 each significant year.

5.1.2 Impact on the extraction of Forest Products

Açai

Column 3 in Figure 8 reports the DiD results using a binary indicator of treatment. The negative and slightly statistically significant coefficient suggests that receiving treatment is correlated with lower extraction of Açai by the local municipality populations. However, the estimates in column 4, which more accurately model the dynamic component of this policy, suggest that Forest Concessions had no significant effect on Açai production.

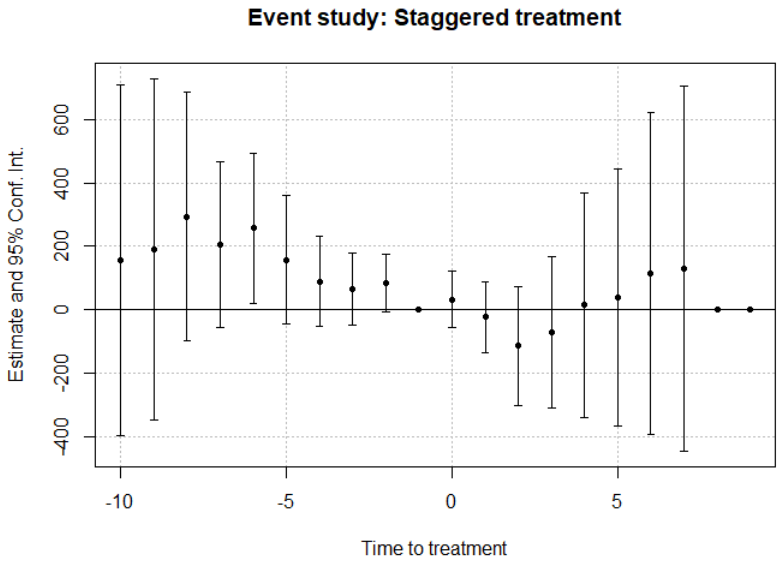


Figure 6: Interaction-weighted Event-study estimates of the impact on Açai production by treatment year

With the exception of 6 and 2 years before the treatment, pre-treatment coefficients (as presented in figure 6) are not statistically different from zero, leading me to believe that the parallel trend assumption probably holds. I therefore use the event-study estimates and conclude that the total costs to local communities of Forest Concessions, in terms of Açai production, are most likely not different from zero. I also conduct a sensitivity analysis considering the scenario in which costs local communities are negative (as indicated by the simple DiD) in the treatment years in which the event-study found negative (but not significant) coefficients: T-Year 1, 2 and 3.

Latex

Columns 5 and 6 of Figure 8 present the results from the binary indicator DiD and the event-study models, respectively. Column 5 indicates that Forest Concessions had a strong and statistically significant effect on the quantity of Latex extracted: on average, having a Forest Concession in a given

year increased Latex production by 33 tonnes. Similarly, the event-study estimates also indicate positive and statistically significant impacts of concessions on Latex production in the municipality. The increase in latex production stimulated by Forest Concessions is also seemingly stronger the longer a concession has been active, suggesting that the longevity of a local community's relationship with the permit-holders could be important for securing their access to the forest product.

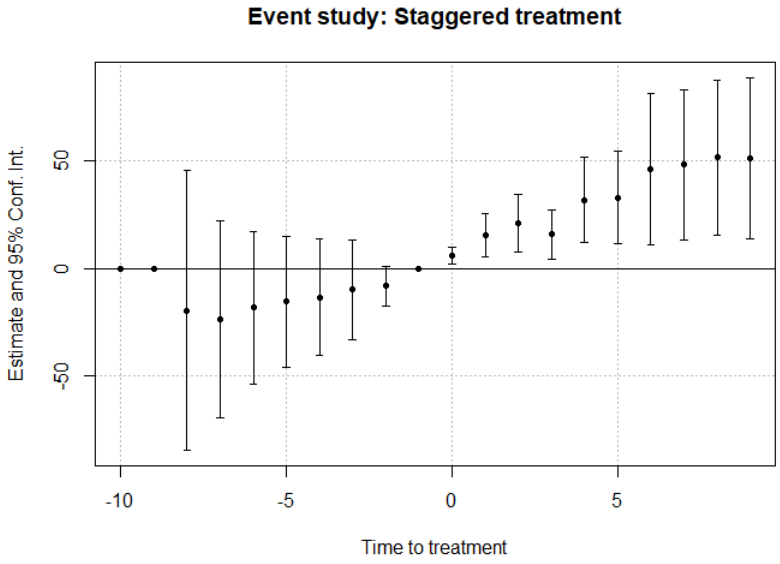


Figure 7: Interaction-weighted Event-study estimates of the impact on Latex production by treatment year

Additionally, the parallel trend assumption seems to generally hold, since the only pre-treatment year that has a statistically significant coefficient is -2, as one can notice by looking at Figure 7. I use the estimates in column 6 to calculate the benefits local communities accrue from Forest Concessions, in terms of Latex production.

		Deforestation		Açai (Forest Crop)		Latex (Forest Crop)	
		(1)	(2)	(3)	(4)	(5)	(6)
	DiD	**33.29614**	-	**-205.9977***	-	**33.29402*****	-
		22.17617	-	120.724	-	11.80684	-
	T. Year = -14	-	**-56.987**	-	-	-	-
		-	-44.897	-	-	-	-
	T. Year = -13	-	**-38.908**	-	-	-	-
		-	-29.642	-	-	-	-
	T. Year = -12	-	**3.224**	-	-	-	-
		-	-43.241	-	-	-	-
	T. Year = -11	-	**-49.837**	-	-	-	-
		-	-31.012	-	-	-	-
	T. Year = -10	-	**41.249**	-	**156.097**	-	-
		-	-36.611	-	-282.6	-	-
	T. Year = -9	-	**-3.534**	-	**190.817**	-	-
		-	-23.653	-	-274.714	-	-
	T. Year = -8	-	**11.128**	-	**293.65**	-	**-19.507**
		-	-24.841	-	-199.392	-	-33.159
	T. Year = -7	-	**-40.522***	-	**205.548**	-	**-23.658**
		-	-20.789	-	-132.701	-	-23.372
	T. Year = -6	-	**-29.262***	-	**256.969****	-	**-18.13**
		-	-17.365	-	-120.654	-	-18.074
	T. Year = -5	-	**-29.145****	-	**156.463**	-	**-15.359**
		-	-12.625	-	-103.554	-	-15.565
	T. Year = -4	-	**10.594**	-	**88.154**	-	**-13.36**
		-	-15.887	-	-72.505	-	-13.841
	T. Year = -3	-	**-7.614**	-	**64.096**	-	**-9.91**
		-	-9.587	-	-57.847	-	-11.882
	T. Year = -2	-	**6.834**	-	**82.253***	-	**-8.248***
		-	-9.448	-	-46.359	-	-4.669
	T. Year = 0	-	**-5.794**	-	**31.975**	-	**5.908*****
		-	-15.808	-	-45.801	-	-1.934
	T. Year = 1	-	**12.235**	-	**-23.779**	-	**15.528*****
		-	-9.315	-	-57.615	-	-5.07
	T. Year = 2	-	**31.062***	-	**-113.452**	-	**21.18*****
		-	-16.197	-	-95.39	-	-6.871
	T. Year = 3	-	**62.386****	-	**-71.477**	-	**15.772*****
		-	-25.324	-	-121.495	-	-5.778
	T. Year = 4	-	**63.906*****	-	**14.595**	-	**31.767*****
		-	-20.365	-	-180.83	-	-10.145
	T. Year = 5	-	**11.676**	-	**38.55**	-	**33.019*****
		-	-22.952	-	-206.185	-	-11.05
	T. Year = 6	-	**88.808****	-	**115.338**	-	**46.039****
		-	-39.605	-	-258.768	-	-17.956
	T. Year = 7	-	**-5.316**	-	**129.842**	-	**48.182*****
		-	-13.943	-	-294.189	-	-17.732
	T. Year = 8	-	**-22.34**	-	-	-	**51.542*****
		-	-26.049	-	-	-	-18.27
	T. Year = 9	-	**-8.979**	-	-	-	**51.368*****
		-	-28.432	-	-	-	-19.07
	T. Year = 10	-	**-18.264**	-	-	-	-
		-	-36.325	-	-	-	-
Num.Obs.		714	714	2382	2382	574	574
Fixed Effects	Municipality	X	X	X	X	X	X
	Year	X	X	X	X	X	X
	Mean two years prior to database	X	X	X	X	X	X

Figure 8: Table 1

5.2 Cost Benefit Analysis Results

The "Individual Net Present Value" column in Figure 9 shows the results of the individual Cost-Benefit Analysis for Local Communities, Firms, and Governments at the Municipality, State and Federal Levels. Its calculation included all benefits and costs incurred by each actor, as well as transfers received or sent to other actors. The sign in columns 2-6 indicates whether the input/outcome is a benefit or a cost for that specific actor.

Local communities' non-environmental benefits include increased access to Latex forest products and the economic benefits derived from additional employment. Enterprises' non-environmental benefits consist of logging revenues, and their implementation costs are composed of logging costs. On the other hand, firm's payments are composed of the yearly payments made to the SFB.

Municipality and State level governments, as well as the ICMBio and FNDF, only have benefits, which consist of redistributive payments received from the SFB. The SFB incurs two main costs: enabling costs (such as delimiting Forest Concessions, stakeholder engagement, feasibility analysis), and implementation costs (such as costs with the bidding process, as well as operational and monitoring costs). While there are outgoing transfers from the SFB to other agents, the payments are net positive due to many States and Municipalities lacking the requirements to be eligible to receive redistributed resources.

As Figure 9 indicates, with the exception of the SFB, Forest Concessions are overall Net Positive for each agent individually. However, while the SFB itself has more costs than benefits, once all the Federal agencies that participate in the intervention are considered, the Federal Government is also Net Positive. For this reason, the society-wide CBA indicates that benefits outweigh costs: Forest Concessions generate a Net Present Value of 387.7 million Brazilian reais[6] when the impacts on carbon emissions are not considered (last row).

Nevertheless, the conclusions change drastically when including the estimated losses to society originating from changes in CO_2 emissions. Here, a low-ball estimate of emissions resulting from the implementation of Forest Concessions is added: between years 2-6 after the start of operations, each year results in a 33km^2 increase in deforestation in a given municipality. Following Souza Cunha et al (2016), I considered the average emissions per deforested area to be 35553 tCO2/km2 and the Social Cost of Carbon in 2010 to be R$36.54, as converted from the dollar estimates of the SCC in the same year used by Souza-Rodrigues (2019).

Including these costs to society, categorized under "residual society" because they aren't specific to one actor, Forest concessions are no longer Net Positive: in fact, they generate a negative 1.9 billion NPV to Brazil. These results indicate that, while during the past decade Forest Concessions may have brought significant direct economic advantages to society as a whole, when adding up the

[6] At the 2010 price levels

less obvious social costs tied to the increase in deforestation, the program is no longer advisable.

Cost-Benefit Analysis							
Perspective	**Change in Emissions**	**Non- environmental benefits**	**Implementation Costs**	**Enabling Costs**	**Payments** (Net of incoming and outgoing payments)	**Individual Net Present Value**	**Net present Value excluding transfers (intra-jurisdictional payments)**
Local communities		112343250.8				112343250.8	112343250.8
Enterprises		460118601	-136362278.3		-66273580.23	257482742.4	323756322.7
Municipality Government					2004222	2004222	0
State Government					1890295.5	1890295.5	0
Federal Government (SFB + ICMBio + FNDF)						10752972.8	0
SFB			-40382500.83	-7918917.48	37678972.5	-10622445.81	-48301418.31
ICMBio					14250279.07	14250279.07	0
FNDF					7125139.54	7125139.54	0
Residual Society (not attributed to any particular	-2305081148						-2305081148
Brazilian Society (all impacts)							**-1917282993**
Brazilian Society (excluding environmental impacts)							**387798155.1**

Figure 9: Cost Benefit Analysis Results

Sensitivity Analysis Sensitivity analysis of the CBA outcomes was conducted whenever parameters from existing sources were used to monetize inputs and outcomes, and when empirical estimates did not give very robust results. In figure 10, the sensitivity of Local communities' NPV to salaries being below the Legal Amazon's average is tested by considering that local Forest Concession workers earn the minimum wage (approximately half of the average formal worker stipend considered originally). While the individual NPV for local communities continues to be positive, it is decreased by more than half, since the contribution of Latex production is small in comparison to that of wages.

Furthermore, figure 13 shows that adding opportunity costs in the form of decreased access to Forest Crops, in this case Açai, does not radically alter local communities' CBA, which continues to be positive. This indicates that, overall, the most important individual aspect for local communities is the creation of new jobs, since decreasing or increasing their access to traditional crops does not significantly alter the balance between costs and benefits for the local inhabitants.

Figure 11 presents the results for the sensitivity analysis with respect to timber extraction and transportation costs. If production costs are multiplied by 2.5, firms' individual NPV decreases considerably but remains positive. On the other hand, Figure 12 shows that firm's NPV are more sensitive to timber market prices than to their own extraction costs, as dividing the selling price by 2.5 leads the NPV of Forest Concessions to be negative for firms.

In all of the sensitivity analyses conducted, Society's CBA remains roughly unaltered: positive, if not considering emissions and strongly negative if adding up the Social Cost of increased defor-

estation. Overall, firms are the biggest individual winners from this policy, while local communities and the Federal Government also have positive gains.

6 Conclusion

Overall, I find that municipalities with Forest Concessions seem to experience a significant increase in deforestation between two to six years following their implementation. This effect gets stronger during that period, increasing from 31 km2 to 88 km2 of additional deforested areas. However, the effect dissipates after the sixth year of the program, becoming a negative but insignificant one.

While it is clear from these results that Forest Concessions have not delivered the expected conservation benefits since their start in 2010, these could possibly point to a lag in contract rule enforcement by the government. Indeed, most performance indicators are only monitored and reported consistently after the fourth year of operations, and a time lag could exist between the identification of environmental infractions and the actual incentives that may lead permit-holders to increase their compliance.

Furthermore, I examine two forest crops to which permit holders have limited access, while local communities hold unrestrained rights to their extraction. I find no apparent effects in the extraction of Açai by the surrounding communities. On the other hand, Latex extraction seems to increase in the municipalities in which Forest Concessions exist, with effects increasing with time after implementation. This could potentially signal that building a relationship with permit-holders is important for securing local communities' access to forest products.

Nevertheless, I find that Forest Concessions being Net Positive for the inhabitants of the area has less to do with the extraction of forest products, than with their employment by the logging firms. In fact, the individual NPV of local communities is largely altered when decreasing their wages, while it would not suffer much if the access of local populations to Açai forest crops were to decrease.

Similarly, permit-holding firms' NPV is also disproportionately affected by one particular aspect of their operations: timber market prices. On the other hand, fluctuations in the extraction and transportation costs of timber seem to have less consequences for the feasibility of the operations.

Moreover, even though costs outweigh benefits for the SFB, all government levels derive net benefits from the implementation of Forest Concessions. Society's CBA, on the other hand, is always Net Positive if excluding the effects on carbon emissions in the first 2-6 years, and negative otherwise.

6.1 Recommendations

The persistently negative NPV for Society indicates that Forest Concessions should not continue to exist, since in spite of the very visible economic benefits provided to various agents, the Social Cost of Carbon ends up making the policy much more costly than beneficial. Nevertheless, due to the high importance of deforestation outcomes in determining whether or not the program is Pareto Improving, further information should be gathered on the impacts of concessions on forest clearing.

Indeed, while these results aren't statistically significant, from the seventh year of implementation onward, Forest concessions appear to start having the opposite effect. It could therefore be the case that, while initially increasing deforestation, more mature forest concessions end up compensating the carbon emissions of the first six years of operations and yielding a positive NPV. For this reason, more needs to be understood about how longer implementation periods affect emissions in order to make any recommendations.

These findings would, however, indicate the need for more consistent monitoring and enforcement of environmental obligations since the very first years of operations. They also indicate that the initial contract duration of 40 years proposed by the government might not be enough to start producing the desired environmental benefits, since at an average avoided deforestation rate of 13 km2/year (corresponding to year 7 onward in Figure 8's model 2), initial deforestation would only be offset 26 years after the start of operations.

Additionally, if reducing CO2 emissions isn't the main goal of the program, other environmental benefits that weren't analyzed in this particular study could potentially make the program more worthwhile, such as increased biodiversity and other environmental services. Consequently, clarifying the objectives of Forest Concessions and carefully monitoring the metrics of all benefits is necessary before any true recommendations can be made.

6.2 Future research and Caveats

Many caveats exist to the findings of this paper.

Firstly, some costs and benefits were not included due to limited access to data. As mentioned in the previous section, Environmental impacts in terms of biodiversity and of other environmental services were not included, while being one of the potential benefits considered by the government.

Similarly, out of the forest products and services that could generate revenues for permit-holders, only data on logging was included due to its wide availability. However, the extraction of non-restricted forest crops, as well as the exploitation of ecosystem services such as tourism also provide additional income to companies. Calculating their total benefits, and thus the true dimension of benefits to society would therefore require more detailed data on firms' activities and revenues.

Thirdly, it is likely that opportunity costs exist for local populations in terms of a decrease in

cattle grazing and soy cultivation in Forest Concession areas. Nonetheless, National Forests are sustainable use areas, which means that, in addition to forested areas, the counterfactual land use presumes the ”Permanence of traditional communities that already lived there when the protected area was created” and their ”Sustainable Use of Natural Resources” (OECD, 2015).

It therefore would seem that any livestock ranching or soybean plantation happening in the area would constitute an illegal activity and should, thus, not be included in the CBA. Notwithstanding, I analyzed the effects of Forest Concessions on Livestock grazing, not finding any significant results (Annex 5) and alleviating concerns that the exclusion of these opportunity costs should be a problem. Data on soybean cultivation was not easily accessible, so I did not include it in the analysis.

Additional concerns arise due to the exclusion of certain stakeholders from the analysis. Namely, Native communities' perspective was not included because of a lack of data on them, in spite of potential impacts of Forest Concessions on certain groups (see Annex 2). Perhaps more importantly, the effect of Forest Concessions on IBAMA's expenditures were not considered. While IBAMA does not hold the specific mandate of monitoring the execution of Forest Concessions and their compliance with the established rules, which is done by the SFB, this government agency is responsible for enforcing command-and-control regulations across the entirety of the territory, acting as a sort of environmental police. Future research with access to better information on IBAMA's budget lines might be able to estimate the magnitude of this impact.

Considering methodology, Latex extraction revenue for local communities was considered, but not the extraction costs. While I did not have access to estimates on Latex extraction costs, it is important to calculate both costs and benefits of any activity. In the future, Cost-benefit analyses of Forest Concessions should therefore try to find reliable estimates of Traditional Forest Products' extraction and transportation costs.

Furthermore, considering the strong dependence on deforestation outcomes of the policy's NPV, a second estimation of the impacts on deforestation would be warranted to get more trustworthy results. Future research could therefore use Synthetic Control models to add robustness checks to the magnitude of deforestation found for the first 12 years of Forest Concessions.

Additionally, while not statistically significant, Table 1 indicates a possible decrease in deforestation with longer implementation times. Repeating this analysis in the future could thus be extremely valuable, as more years would be available to understand the dynamic impacts of the policy on deforestation. Doing so would not only allow to model dynamic effects more accurately, but also to obtain a considerably larger sample size due to more municipalities being set to enter the Forest Concession model in the years to come.

7 Annexes

7.1 Annex 1 - Mapping Costs and Benefits to each Actor

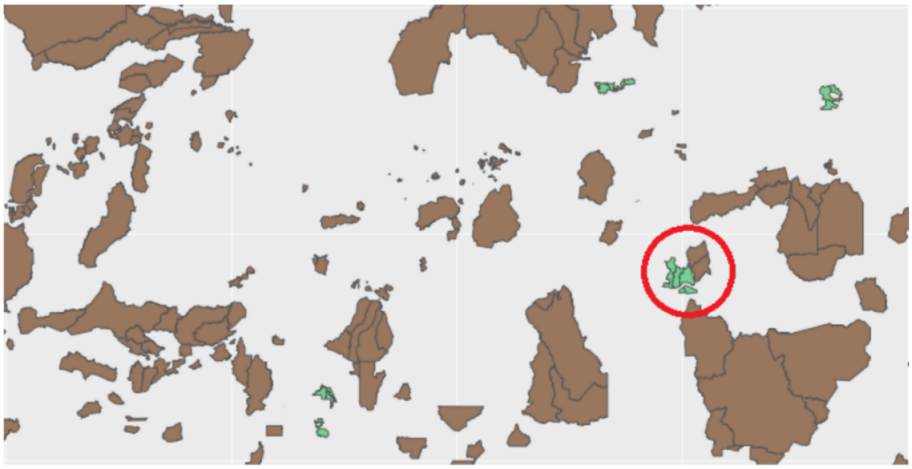
Stakeholder	Impact/Input			
	Costs (priced using 2010 real)		*Benefits (priced using 2010 real)*	
	Description	Data source	Description	Data source
Firms/ Permit-holders	**Total extraction and transportation costs** (estimated parameters for these costs * quantity of timber)	-Estimated parameters for extraction and transportation for each State: from government feasibility reports (conduct sensitivity analysis) adjusted by the area (%) of each quality type in the two States. - Timber quantity: the yearly reports give information on annual production.	**Profits from logging (estimated market price of timber * quantity of timber)**	-Estimated high and low market prices for each State: from government feasibility reports (conduct sensitivity analysis), adjusted by the area (%) of each quality type in the two States. - Timber quantity: the yearly reports give information on annual production.
	Refund of bidding notice	From yearly reports	Profits from environmental services (such as tourism)	Excluded because no data on this: detailed financial statements from these private companies would need to be available
	Minimum Annual Value (VMA)	From yearly reports	Other forest products	Excluded. Many forest crops aren't included in the concession because they are traditionally linked to local communities. Unclear which other products could be collected by permit-holders (and also information on production only available for timber)
	Other values (yearly payment for timber)	From yearly reports	Reputational benefits	Excluded because unclear how that could be estimated
	Social Indicator (mandatory investment in communities)	From yearly reports		
	Repaid debts to government	From yearly reports		
Brazilian Forest Service (SFB)	**Redistribution of collected resources to States and Municipalities (if meeting the requirements)**	From yearly reports	**Payments from the permit-holders**	From yearly reports
	Costs incurred with the bidding notice	From yearly reports; annex in the bidding document which mentions costs incurred with the notice		
	Monitoring and Management Costs	Taken from SFB's budget actions which the Management Reports described as having anything to do with the operational costs of Forest Concessions, with the following codes: 20MI, 20WC and 2D12. PS: Calculated using Management Reports from 2008-2017. Due to a change in government and subsequent decrease in accountability, the costs relative to 2018 and 2019 had to be retrieved from the governments' Transparency Portal, and costs for 2020 and 2021 were unavailable. The costs from 2010 weren't explicit in the Management Report and had to be derived from Souza Cunha et al (2016)'s Supplementary Material 2, which contained SFB's budget information disaggregated by budget action. The values had to be converted from dollar to real.		
	Enabling Costs	Taken from SFB's budget actions which the Management Reports described as having enabled the operations of Forest Concessions, with the following codes: 10F1, 2D13, 8300. Examples of such activities are the delimitation of federal public forest, trips made by the SFB to carry out consultations with local communities and technical meetings concerning the bidding notice of Forest Concessions and feasibility studies to better understand local conditions and needs. The same observations about data collection apply as above.		
	Opportunity costs of not utilizing the State Forest for another purpose	Excluded. Unclear what State Forests are usually used for by the government and if any income-generating activities exist.		
FNDF			**Payments from "Other values"**	From yearly reports

Stakeholder	Impact/Input			
	Costs (priced using 2010 real)		*Benefits (priced using 2010 real)*	
	Description	**Data source**	**Description**	**Data source**
ICMBio	**Monitoring and other intervention costs**	Excluded. Although the ICMBio is directly involved in the monitoring of Forest Concessions, its budget does not specify what resources are used for this purpose. Calculating these costs would therefore require more insight into the organization.	**Payments from "Other values"**	From yearly reports
IBAMA	Excluded. Although the IBAMA is directly involved in the monitoring of Forest Concessions, its budget does not specify what resources are used for this purpose. Calculating these costs would therefore require more insight into the organization.			
State-level government	**Expenses to comply with the regulations to receive the transfers from the SFB**	Excluded because this level of detail isn't available in sub-national governments.	**Payments from "Other values"**	From yearly reports
			Payments from "Social Indicator"	From yearly reports
Municipality-level government	**Expenses to comply with the regulations to receive the transfers from the SFB**	Excluded because this level of detail isn't available in sub-national governments.	**Payments from "Other values"**	From yearly reports
			Payments from "Social Indicator"	From yearly reports
Local population (municipality-level)	**Opportunity costs of foregone land usage and usage of traditional forest crops** (açai is a cost-impact- in the sensitivity analysis)	The Bidding Document Annexes for each concession contained information on traditional forest crops that can only be extracted by local communities (latex, açai, copaiba). The PEVS database contained information on the quantity and value of these crops' production. I used the information on quantity to run my DiD models on Latex and Açai, since Copaiba did not present parallel trends. I monetized the production by dividing value by quantity, obtaining prices for each municipality in a given year. In some rare cases, price data was missing so the production was monetized using the price from the year right before/after. Forest products or agricultural products (other than those specified in the Bidding Annexes) are not calculated, which might be overlooking important consequences of forest concessions on local populations. However, that would require a more in-depth understanding of how local communities use national forests. Furthermore, some crops that were cited in the Bidding Annexes did not have matching information in the PEVS data, which led to their omission.	**Increased production of traditional crops (latex)**	The Bidding Document Annexes for each concession contained information on traditional forest crops that can only be extracted by local communities (latex, açai, copaiba). The PEVS database contained information on the quantity and value of these crops' production. I used the information on quantity to run my DiD models on Latex and Açai, since Copaiba did not present parallel trends. I monetized the production by dividing value by quantity, obtaining prices for each municipality in a given year. In some rare cases, price data was missing so the production was monetized using the price from the year right before/after. Forest products or agricultural products (other than those specified in the Bidding Annexes) are not calculated, which might be overlooking important consequences of forest concessions on local populations. However, that would require a more in-depth understanding of how local communities use national forests. Furthermore, some crops that were cited in the Bidding Annexes did not have matching information in the PEVS data, which led to their omission.
			Increase in the number of jobs	Use yearly reported direct employment which were available only for the years of 2013 to 2016 (from two different sources: Ribeiro et al (2020) which reports data from the SFB and from the 2015 and 2016 SFB Management report). However, many years did not have SFB data on the number of jobs tied to Forest Concessions. I therefore used each concessions' size in hectares to calculate the total number of jobs in a year using estimates from the literature: "It is estimated that concessions create one job (full-time equivalent) for every 500 hectares under management in Brazil" (Gretzinger, 2015; FAO, 2018). The 1 job per 500 hectares of Forest Concession estimate was further confirmed by the actual data drawn from the SFB between 2013 and 2016. Which had an average of 1.05 jobs per 500 ha. Employment benefits were monetized using minimum wage each year, adjusted by the IPCA index to 2010 price levels (because the minimum wage is chosen to be the forestry salary arbitrarily, this could justify conducting a sensitivity analysis, which I did not do)
	Health impacts: Excluded. However, empirical estimates of the birth of stillborn births might be good estimates of potential health impacts of forest concessions in future studies.			
Indigenous communities	**Impact on Native Communities**: could be expected to be affected by Forest Concessions, especially due to the geographical proximity between one Indigenous Territory and a Forest Concession. However, data is lacking on these communities.			

Stakeholder	Impact/Input			
	Costs (priced using 2010 real)		*Benefits (priced using 2010 real)*	
	Description	Data source	Description	Data source
Brazil's society as a whole	**Adding all costs above** (excluding transfers because they are not costs).		**Adding all benefits above** (excluding transfers because they are not costs).	
	Increase in carbon emissions	The impact of Forest Concessions on deforestation each year was estimated using the PRODES database. I use the estimates from the event-study regression. (sensitivity analysis is conducted using the estimates from the simple DiD regression, which cannot rule out zero impact on deforestation) The emissions resulting from deforestation were calculated using the Brazilian average CO2 emissions per deforested area: which is 35553 tCO2/km2, according to Souza Cunha et al (2016). The negative impacts on society were then monetized using the Social Cost of Carbon in 2010 calculated by Greenstone et al (2013), as used in Souza-Rodrigues (2019). The SCC was converted from US Dollars to brazilian Reais.		

7.2 Annex 2 - Indigenous Territories and their proximity to Forest Concessions

In brown, Indigenous Territories in the Legal Amazon, in green, a subset of Forest Concessions (Source: Territórios Indígenas - RAISIG, 2012-12-04):



7.3 Annex 3 - Treatment Status by Municipality (reduced sample of municipalities which contain a National Forest):

Municipality	Has a forest concession?	Actual start of Forest Concession operations	Starting date of treatment in all datasets (except for PRODES)	Starting date of treatment in the PRODES dataset	State	Which Flonas it contains
Feijó	0					
Santa Rosa do Purus	0					
Sena Madureira	0					
Alvarães	0					
Apuí	0					
Barcelos	0					
Boca do Acre	0					
Canutama	0					
Humaitá	0					
Juruá	0					
Lábrea	0					
Maués	0					
Pauini	0					
Santa Isabel do Rio Negro	0					
Tefé	0					
Alto Alegre	0					
Mucajaí	0					
Rorainópolis	0					
Alenquer	0					
Aveiro	0					
Belterra	0					
Canaã dos Carajás	0					
Jacareacanga	0					
Marabá	0					
Monte Alegre	0					
Novo Progresso	0					
Parauapebas	0					
Rurópolis	0					
São Félix do Xingu	0					
Trairão	0					
Ferreira Gomes	0					
Pracuúba	0					
Altamira	1	Agosto /2016	2016	2017	Pará	Altamira (UMF 1, 2, 3 and 4)
Itaituba	1	Agosto /2016	2016	2017	Pará	Altamira (UMF 2 and 3)
Melgaço	1	Novembro /2018	2018	2019	Pará	Caixuna (UMF 1 and 2)
Portel	1	Novembro /2018	2018	2019	Pará	Caixuna (UMF 1, 2 and 3)
Porto Velho	1	Setembro / 2014	2014	2015	Rondônia	Jacunda (UMF 1 and 2)
Candeias do Jamari	1	Setembro / 2014	2014	2015	Rondônia	Jacunda (UMF 1 and 2)
Itapuã do Oeste	1	Setembro / 2010	2010	2011	Rondônia	Jamari (UMF I)
Cujubim	1	Setembro / 2010	2010	2011	Rondônia	Jamari (UMF IV)
Oriximiná	1	Setembro / 2012	2012	2013	Pará	Saraca Taquera Sul (UMF 2 and 3)
Terra Santa	1	Setembro / 2015	2015	2016	Pará	Saraca Taquera Sul (UMF 1a, mainly)
Faro	1	Junho / 2015	2015	2016	Pará	Saraca Taquera Sul (UMF 1b)

7.4 Annex 4 - Sensitivity Analysis Results

Sensitivity Analysis: Lower forestry wages (minimum salary)							
Perspective	**Change in Emissions**	**Non- environmental benefits**	**Implementation Costs**	**Enabling Costs**	**Payments** (Net of incoming and outgoing	**Individual Net Present Value**	**Net present Value excluding transfers (intra-jurisdictional payments)**
Local communities		44942816.62				44942816.62	44942816.62
Enterprises		460118601	-136362278.3		-66273580.23	257482742.4	323756322.7
Municipality Government					2004222	2004222	0
State Government					1890295.5	1890295.5	0
Federal Government (SFB + ICMBio + FNDF)						10752972.8	0
SFB			-40382500.83	-7918917.48	37678972.5	-10622445.81	-48301418.31
ICMBio					14250279.07	14250279.07	0
FNDF					7125139.54	7125139.54	0
attributed to any particular group	-2305081148						-2305081148
Brazilian Society (all impacts)							**-1984683427**
Brazilian Society (excluding environmental impacts)							**320397721**

Figure 10: Sensitivity Analysis: Lower Forestry Wages

Sensitivity analysis - Higher production costs for logging firms: (2.5* X)							
Perspective	**Change in Emissions**	**Non-environmental benefits**	**Implementation Costs**	**Enabling Costs**	**Payments** (Net of incoming and outgoing	**Individual Net Present Value**	**Net present Value excluding transfers (intra-jurisdictional payments)**
Local communities		112343250.8				112343250.8	112343250.8
Enterprises		460118601	-340905695.8		-66273580.23	52939324.94	119212905.2
Municipality Government					2004222	2004222	0
State Government					1890295.5	1890295.5	0
Federal Government (SFB + ICMBio + FNDF)						10752972.8	0
SFB			-40382500.83	-7918917	37678972.5	-10622445.81	-48301418.31
ICMBio					14250279.07	14250279.07	0
FNDF					7125139.54	7125139.54	0
attributed to any particular group	-2305081148						-2305081148
Brazilian Society (all impacts)							**-2121826410**
Brazilian Society (excluding environmental impacts)							**183254737.6**

Figure 11: Sensitivity Analysis: Higher Timber Production Costs

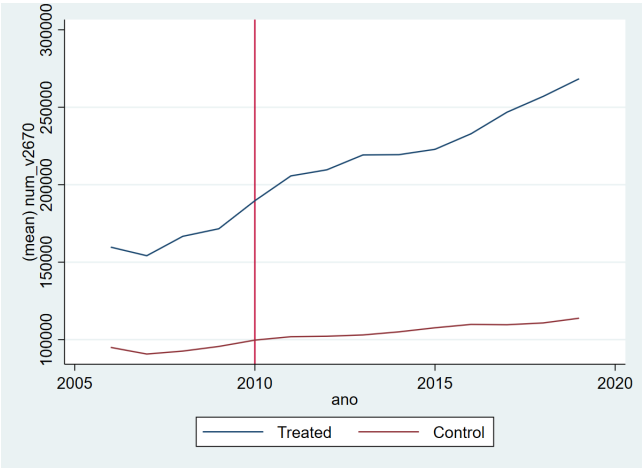
Sensitivity analysis - Lower timber selling prices for logging firms: (X/2.5)							
Perspective	**Change in Emissions**	**Non-environmental benefits**	**Implementation Costs**	**Enabling Costs**	**Payments** (Net of incoming and outgoing payments)	**Individual Net Present Value**	**Net present Value excluding transfers (intra-jurisdictional payments)**
Local communities		112343250.8				112343250.8	112343250.8
Enterprises		184047440.4	-136362278.3		-66273580.23	-18588418.16	47685162.07
Municipality Government					2004222	2004222	0
State Government					1890295.5	1890295.5	0
Federal Government (SFB + ICMBio + FNDF)						10752972.8	0
SFB			-40382500.83	-7918917	37678972.5	-10622445.81	-48301418.31
ICMBio					14250279.07	14250279.07	0
FNDF					7125139.54	7125139.54	0
Residual Society (not attributed to any particular group	-2305081148						-2305081148
Brazilian Society (all impacts)							**-2193354154**
Brazilian Society (excluding environmental impacts)							**111726994.5**

Figure 12: Sensitivity Analysis: Lower Timber Selling Prices

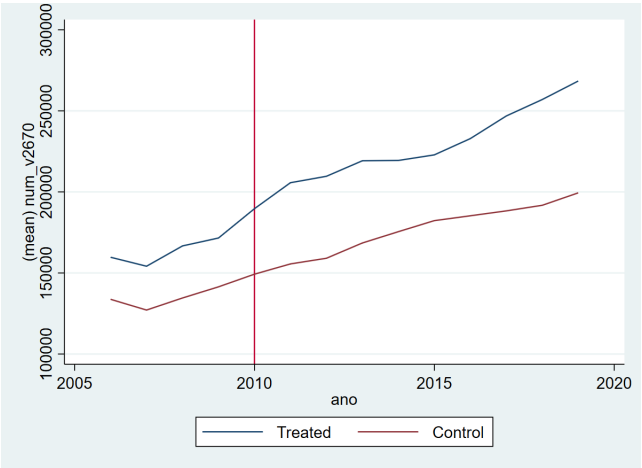
Sensitivity analysis: Decreased Açai Extraction in Local Communities								
Perspective	**Change in Emissions**	**Non-environmental benefits**	**Implementation Costs**	**Enabling Costs**	**Opportunity Costs**	**Payments** (Net of incoming and outgoing payments)	**Individual Net Present Value**	**Net present Value excluding transfers (intra jurisdictional payments)**
Local communities		112343250.8			-11413599.7		112343250.8	100929651.1
Enterprises		460118601	-136362278.3			-66273580.23	257482742.4	323756322.7
Municipality Government						2004222	2004222	0
State Government						1890295.5	1890295.5	0
Federal Government (SFB + ICMBio + FNDF)							10752972.8	0
SFB			-40382500.83	-7918917		37678972.5	-10622445.81	-48301418.31
ICMBio						14250279.07	14250279.07	0
FNDF						7125139.54	7125139.54	0
attributed to any particular group	-2305081148							-2305081148
Brazilian Society (all impacts)								**-1928696593**
Brazilian Society (excluding environmental impacts)								**376384555.5**

Figure 13: Sensitivity Analysis: Decreased Access to Açai Forest Crops

7.5 Annex 5 - Cattle grazing



(a) All Legal Amazon Municipalities without a Forest Concession as Control group

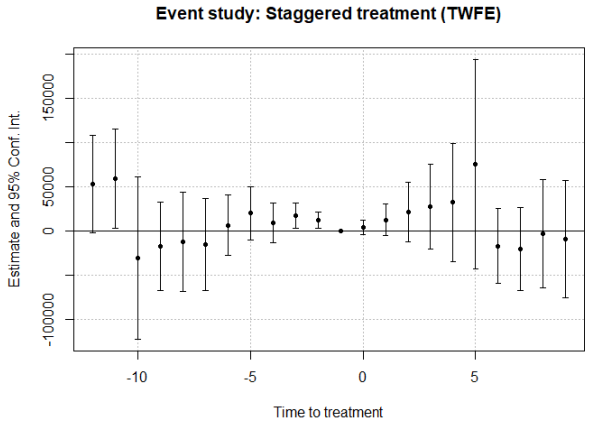


(b) Only Municipalities with a State Forest and without a Forest Concession as Control Group

Figure 14: Analysis of Parallel Trends - the Municipalities with State Forests subset gets chosen)

	Model 1	Model 2
DiD	**23630.83**	
	35298.01	
ano = -12		**52860.645***
		-27968.542
ano = -11		**58976.161****
		-28448.653
ano = -10		**-31046.806**
		-46771.525
ano = -9		**-17296.962**
		-25519.718
ano = -8		**-12518.508**
		-28678.818
ano = -7		**-15477.867**
		-26749.375
ano = -6		**6472.907**
		-17274.915
ano = -5		**19959.839**
		-15261.545
ano = -4		**9050.079**
		-11441.722
ano = -3		**17106.578****
		-7284.931
ano = -2		**12241.056****
		-4560.842
ano = 0		**3939.721**
		-4052.406
ano = 1		**12434.88**
		-9154.596
ano = 2		**21479.821**
		-17110.933
ano = 3		**27039.068**
		-24469.652
ano = 4		**32361.931**
		-34109.222
ano = 5		**75727.652**
		-60365.046
ano = 6		**-17156.333**
		-21441.698
ano = 7		**-20841.043**
		-23893.061
ano = 8		**-3146.935**
		-31221.687
ano = 9		**-9309.823**
		-34008.886
Num.Obs.	588	588
Std.Errors	by: Municipality	by: Municipality
Municipality FE	X	X
Year FE	X	X

(a) Regressions



(b) Event study

Figure 15: Cattle grazing results

7.6 Annex 6 - Descriptive Statistics

Latex				
Variable	**Obs**	**Mean**	**Min**	**Max**
Latex (in km2)	759	32.6614	1	550
		(64.18059)		
Contains State Forest	9108	0.055336	0	1
		(0.2286474)		
Per capita Income (mean)	9036	5273.544	763.362	100441.9
		(7691.911)		
Lagged Forest Cover in km 2 (t-1)	9108	3793.59	0	147682.9
		(11537.86)		
Latex (in km2) - mean two periods prior to start of database	816	63.32353	1	503.5
		(101.2263)		

Deforestation				
Variable	**Obs**	**Mean**	**Min**	**Max**
Deforestation (in km2)	840	3369 148.	0	1407.9
		(148.1087)		
Contains State Forest	840	1	1	1
		(0)		
Per capita Income (mean)	840	4524.596	1148.908	21480.04
		(3823.09)		
Lagged Forest Cover in km 2 (t-1)	714	26109.46	519.3	149423.6
		(29696.15)		
Deforestation (in km2) - mean two periods prior to start of database	840	120.6429	0	1690.4
		(276.2509)		

Açai				
Variable	**Obs**	**Mean**	**Min**	**Max**
Açai (in tonnes)	3223	704.2085	0	42000
		(2722.474)		
Contains State Forest	9108	0.055336	0	1
		(0.2286474)		
Per capita Income (mean)	9036	5273.544	763.362	100441.9
		(7691.911)		
Lagged Forest Cover in km2 (t-1)	9108	3793.59	0	147682.9
		(11537.86)		
Açai (in tonnes) - mean two periods prior to start of database	2412	512.01	0	17082
		(1782.964)		

Cattle				
Variable	**Obs**	**Mean**	**Min**	**Max**
Cattle heads	588	175527.5	22	2282445
		(353815.8)		
Contains State Forest	588	1	1	1
		(0)		
Per capita Income (mean)	588	4524.596	1148.908	21480.04
		(3824.067)		
Lagged Forest Cover in km2 (t-1)	588	25866.78	519.3	148685.6
		(29517.03)		

Figure 16: Descriptive statistics for each Dataset

7.7 Annex 7 - Supplementary Materials

Spreadsheet containing my calculation of the CBAs.

8 References

Alfenas, C., Cavalcanti, F., Gonzaga, G. 2020. Mercado de trabalho na Amazônia Legal. Uma análise comparativa com o resto do Brasil. Imazon.

Baker, A.C., Larcker, D.F., Wang, C.C.Y., 2022. How much should we trust staggered difference-in-differences estimates? Journal of Financial Economics 144, 370–395.

Barona, E., Ramankutty, N., Hyman, G., Coomes, O.T., 2010. The role of pasture and soybean in deforestation of the Brazilian Amazon. Environmental Research Letters 5, 024002. https://doi.org/10.1088/1748-9326/5/2/024002

Beck, T., Levine, R., Levkov, A., 2010. Big Bad Banks? The Winners and Losers from Bank Deregulation in the United States. The Journal of Finance 65, 1637–1667. https://doi.org/10.1111/j.1540-6261.2010.01589.x

Blackman, A., Veit, P., 2018. Titled Amazon Indigenous Communities Cut Forest Carbon Emissions. Ecological Economics 153, 56–67.

Cunha, F.A.F. de S., Börner, J., Wunder, S., Cosenza, C.A.N., Lucena, A.F.P., 2016. The implementation costs of forest conservation policies in Brazil. Ecological Economics 130, 209–220. https://doi.org/10.1016/j.ecolecon.2016.07.007

De Oliveira Silva, R., Barioni, L.G., Queiroz Pellegrino, G., Moran, D., 2018. The role of agricultural intensification in Brazil's Nationally Determined Contribution on emissions mitigation. Agricultural Systems 161, 102–112. https://doi.org/10.1016/j.agsy.2018.01.003

https://www.gov.br/agricultura/pt-br/assuntos/servico-florestal-brasileiro/concessao-florestal/concessoes-florestais-em-andamento-1/copy$_{o}f_{a}nexo_{9e}studo_{t}ecnico_{d}e_{v}iabilidade_{j}amari.pdf$

https://www.gov.br/agricultura/pt-br/assuntos/servico-florestal-brasileiro/concessao-florestal/concessoes-florestais-em-andamento-1/anexo$_{2v}iabiliidade_{t}ecnica_{e}conomica_{s}ociocultural_{ea}mbiental_{s}arac.pdf$

Gestão de Florestas Públicas - Relatório 2009. Brasília: MMA/SFB, 2010.

Gestão de Florestas Públicas - Relatório 2010. Brasília: MMA/SFB, 2011.

Gestão de Florestas Públicas - Relatório 2011. Brasília: MMA/SFB, 2012.

Gestão de Florestas Públicas - Relatório 2012. Brasília: MMA/SFB, 2013

Gestão de Florestas Públicas - Relatório 2013. Brasília: MMA/SFB, 2014.

Gestão de Florestas Públicas - Relatório 2014. Brasília: MMA/SFB, 2015.

Gestão de Florestas Públicas - Relatório 2015. Brasília: MMA/SFB, 2016.

Gestão de Florestas Públicas – Relatório 2016. Brasília: MMA/SFB, 2017.

Gestão de Florestas Públicas – Relatório 2017. Brasília: MMA/SFB, 2018.

Gestão de Florestas Públicas – Relatório 2018. Brasília: MMA/SFB, 2019.

Gestão de Florestas Públicas – Relatório 2019. Brasília: MMA/SFB, 2020.

Gestão de Florestas Públicas – Relatório 2020. Brasília: MMA/SFB, 2021.

Gestão de Florestas Públicas – Relatório 2021. Brasília: MMA/SFB, 2022.

Gestão Exercício SFB - Relatório 2008. Brasília: MMA/SFB, 2009.

Gestão Exercício SFB - Relatório 2009. Brasília: MMA/SFB, 2010.

Gestão Exercício SFB - Relatório 2010. Brasília: MMA/SFB, 2011.

Gestão Exercício SFB - Relatório 2011. Brasília: MMA/SFB, 2012.

Gestão Exercício SFB - Relatório 2012. Brasília: MMA/SFB, 2013.

Gestão Exercício SFB - Relatório 2013. Brasília: MMA/SFB, 2014.

Gestão Exercício SFB - Relatório 2014. Brasília: MMA/SFB, 2015.

Gestão Exercício SFB - Relatório 2015. Brasília: MMA/SFB, 2016.

Gestão Exercício SFB - Relatório 2016. Brasília: MMA/SFB, 2017.

Gestão Exercício SFB - Relatório 2017. Brasília: MMA/SFB, 2018.

Gretzinger, S. 2015. Latin American experiences in forest concessions. Draft report for FAO

Hensbergen, H.J. van. 2018. Rethinking forest concessions - Improving the allocation of state-owned forests for better economic, social and environmental outcomes. Forestry Working Paper No. 4. Rome, FAO. 84pp.

ITTO (2013)

Lentini, Marco Pereira, Denys Celentano, Danielle Pereira, Ritaumaria. 2005. Fatos Florestais da Amazônia 2005.

OECD (2015), "Protected areas", in OECD Environmental Performance Reviews: Brazil 2015, OECD Publishing, Paris.

Rodrigues Ribeiro, J., Azevedo-Ramos, C., Nascimento dos Santos, R.B. Impact of forest concessions on local jobs in central amazon, Trees, Forests and People, Volume 2, 2020, 100021, ISSN 2666-7193, https://doi.org/10.1016/j.tfp.2020.100021.

Santos, D., Salomão, R., Veríssimo, A. 2021. Fatos da Amazônia 2021. Imazon.

Sills EO, Atmadja SS, de Sassi C, Duchelle AE, Kweka DL, Resosudarmo IAP and Sunderlin WD, eds. 2014. REDD+ on the ground: A case book of subnational initiatives across the globe. Bogor, Indonesia: CIFOR.

Soares-Filho, B., Moutinho, P., Nepstad, D., Anderson, A., Rodrigues, H., Garcia, R., Dietzsch, L., Merry, F., Bowman, M., Hissa, L., Silvestrini, R., Maretti, C., 2010. Role of Brazilian Amazon protected areas in climate change mitigation. Proceedings of the National Academy of Sciences 107, 10821–10826. https://doi.org/10.1073/pnas.0913048107

Souza-Rodrigues, E., 2019. Deforestation in the Amazon: A Unified Framework for Estimation and Policy Analysis. The Review of Economic Studies 33.

Sun, L., Abraham, S., 2021. Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. Journal of Econometrics 225, 175–199. https://doi.org/10.1016/j.jeconom.2020.09.006

Tegegne,Y.T., Van Brusselen, J., Cramm, M., Linhares-Juvenal, T., Pacheco, P., Sabogal, C., and Tuomasjukka, D. 2018. FAO and EFI - Making forest concessions in the tropics work to achieve the 2030 Agenda: Voluntary Guidelines. FAO Forestry Paper No. 180, Rome. 128pp.

Tyukavina, A., Hansen, M.C., Potapov, P.V., Stehman, S.V., Smith-Rodriguez, K., Okpa, C., Aguilar, R., 2017. Types and rates of forest disturbance in Brazilian Legal Amazon, 2000x2013;2013. Science Advances 3, e1601047. https://doi.org/10.1126/sciadv.1601047

West, T. A. P., Rausch, L., Munger, J., Gibbs, H. K. (2022). Protected areas still used to produce Brazil's cattle. Conservation Letters, 00, e12916.