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# Evaluating REDD+ at subnational level: Amazon fund impacts in Alta Floresta, Brazil

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ABSTRACT

The Amazon Fund is the world's largest program to reduce emissions from deforestation and forest degradation (REDD+), funded with over US $1b donated by Norway and Germany between 2008 and 2017 to reward Brazil for prior deforestation reductions. Olhos D'Água da Amazônia is cited as a leading project success − with over one thousand small-to-medium-sized crop and livestock producers in the municipality of Alta Floresta, Mato Grosso State receiving more from the Amazon Fund than all but two other municipalities. To secure property rights, aid environmental planning, and raise farmers' productivity and output diversity, the project helped farmers register in Brazil's environmental cadaster and receive property certificates. Furthermore, Olhos D'Água supported milk and honey production and paid farmers to conserve riverine forest sites. We estimate causal effects of Olhos D'Água, versus a counterfactual estimate of what would have happened without the project, using a synthetic-control method. We build from the pool of blacklisted municipalities weighted averages (synthetic controls) that best match pre-treatment outcomes for Alta Floresta. Project effects are estimated as post-treatment differences between Alta Floresta and the synthetic controls. We find that the project increased new CAR registrations, and INCRA certifications, and may have moderately increased honey and milk production. Alta Floresta's annual forest losses remained historically low but we find no clear causal effect of the project on deforestation rates. Our results support that rigorous impact evaluation can motivate and guide project improvements.

## 1. Introduction

The Amazon Fund, established in 2008 by the Brazilian government, is the world's largest results-based funding program to reduce emissions from deforestation and forest degradation (REDD+). It received over USD 1 billion in donations, mainly from Norway, and it disbursed USD 50 million per year, on average, during 2008 and 2017. With the Fund's support, governments (federal, state and municipal) and non-governmental organizations (NGOs) implemented a range of projects that benefited over 140,000 people in the Amazon region. The Brazilian government itself invested USD 1 billion annually, on average, to control deforestation and promote sustainable production (de S. Cunha et al., 2016). Those actions made Brazil, until recently, a role model for countries with tropical forests (Angelsen, 2017; de Carvalho, 2012; Turnhout et al., 2017; van der Hoff et al., 2015).

Yet while Brazil achieved impressive results in reducing its deforestation between 2004 and 2012, scholars note a lack of evidence concerning the effectiveness of Amazon Fund projects (Forstater et al., 2013; van der Hoff et al., 2018; Wolosin et al., 2016). That might not matter, as donations to the Fund could have been a reward for past deforestation reductions – a reward that may well have functioned as a significant incentive. Yet the Fund's self-descriptions, and many projects that applied for and received funding from the Amazon Fund, mention reducing deforestation as a goal. Thus, it is important to assess whether those projects did in fact lower deforestation rates or not. The Fund's own impact assessments have documented progress via the usual project performance indicators − see extensive documentation of Amazon Fund expenditures in Correa et al. (2019) − but impact evaluations of flagship programs using counterfactuals still are missing (Ferraro, 2009).

Across the Fund's investments, the *Olhos D'Água da Amazônia* project in Alta Floresta stands out as a project at the municipal level, in this

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case for REDD+. Alta Floresta ranks 3rd in Fund transfers among the 775 Amazon municipalities that received support directly or indirectly from the Fund (Correa et al., 2019). The project proposed a number of actions to address drivers of deforestation by focusing on small and medium-sized crop and livestock producers, starting in 2009 (Section 2), in order to raise compliance with forest laws. *Olhos D'Água* is often referred to as a success story in terms of the timely achievement of all implementation milestones (BNDES, 2018; GIZ, 2016).

To go beyond those process milestones to outcomes, we provide a counterfactual-based evaluation of impacts from the *Olhos D'Água* project in Alta Floresta. Deforestation is the core outcome of interest. We also study intermediate outputs tied to deforestation in the project's theory of change: [1] farms in the rural environmental registry (CAR); [2] property certifications by the National Institute for Colonization and Agrarian Reform (INCRA); and [3 & 4] milk and honey production.

Because this project "treated" only one municipality, our evaluation relies on the Synthetic Control Method (SCM). SCM uses temporal data on outcomes, and their determinants, for treated as well as control municipalities. Controls are weighted to best match the pre-treatment outcomes in Alta Floresta, drawing from the pool of municipalities that, like Alta Floresta, were on a "blacklist" for having high illegal deforestation. That list was created by Brazil's Environment Ministry in 2008. The impacts from the *Olhos D'Água* project are estimated as the differences in outcomes between Alta Floresta and the weighted control, generating an impact estimate for each post-treatment year. Below, Section 2 summarizes *Olhos D'Água* and its context. Section 3 documents our evaluation methods and related assumptions. Results are presented in Section 4, then discussed in Section 5.

## 2. Background: region, project & theory of change

### 2.1. Regional deforestation

Between 2004 and 2012, rates of deforestation in the Brazilian Amazon dropped by approximately 80%. Researchers attribute this to a paradigm shift in governance during the early 2000s (Pan et al., 2011; Rajão et al., 2012; Sitch et al., 2005). It included federal initiatives such as the expansion of protected areas, creation of a high-frequency monitoring system (DETER), increased funding for the environmental enforcement agency (IBAMA), and public restrictions upon private credit.

One key element for controlling illegal deforestation was a "blacklist", an administrative naming-and-shaming campaign shown to effectively reduce deforestation in municipalities in the "arc of deforestation" (Arima et al., 2014; Cisneros et al., 2015). Following federal decree 6321/2007, the Ministry of Environment listed the municipalities with the largest accumulated deforested areas and growing deforestation rates (MMA, 2007). Farmers in blacklisted municipalities were banned from public agricultural credit lines and not allowed to sell or otherwise transfer inherited lands. To avoid liability as well as reputational damage, as a response some slaughterhouses, supermarket chains, and other market actors avoided buying soy and livestock from blacklisted municipalities.

To be removed from the blacklist, a municipality had to reduce its deforestation to under 40 $km^2$, have at least 80% of the eligible area registered under an environmental registration system (CAR), and reduce the rate of deforestation by 60% relative to the average of the prior three years (Decree 6321/2007; Ordinances 28/2008, 102/2009, 67/2010, 138/2011, 139/2011, 175/2011, 187/2012, 323/2012, 324/2012, 412/2013, 2010). When the blacklist was created, though, Alta Floresta had already achieved two of the three steps to get off the list. The final barrier was that many private properties were yet to be registered with the CAR, failing the 80% rule. Interviews with policymakers suggested that the municipality sought support from the Amazon Fund to help overcome administrative challenges encountered in registering farms and keeping deforestation at low levels. Further reductions in deforestation would not appear to have been required to get off the blacklist (analogous to municipalities in the Green Municipality Program in the Amazonian state of Pará, where that local program held the line on deforestation while lowering the costs (Sills et al., 2020)).

The CAR is one of the main implementation tools for the Brazilian Forest Code, which requires landholders to maintain 80% forest cover for properties within the Amazon biome (i.e., a 'Legal Reserve'). This requirement goes beyond what is implied by the conservation of slopes, riversides, springs, and other areas of permanent preservation (Federal Law 12651, 2012; Soares-Filho et al., 2014). The CAR's goal is to map all rural properties digitally − replacing antecedents (Azevedo et al., 2017; Costa et al., 2018). CAR enrollment requires a plan for how and when noncompliant properties will comply with the Forest Code within 20 years (Azevedo et al., 2014; Rajão et al., 2012). A related land-tenure policy requires rural properties to have their georeferenced perimeters certified by the national institute for agrarian reform (INCRA) (see Federal Law 10267, 2001).

### 2.2. The Olhos D'Água project

By the end of 2017, over half of the USD 1.22 billion in donations to the Amazon Fund had been committed to 96 projects. Alta Floresta stands out among the blacklisted municipalities as a funds recipient. It received over USD 10 per hectare in funding, well above the average of USD 1.27 (Correa et al., 2019). Funding started with support for the 1st phase of the *Olhos D'Água* project, between March 2011 and December 2013. Over USD 1.5 million went to municipal environmental management for equipment and personnel to geo-reference rural properties. These subsidies finally made registration feasible for small rural landowners as CAR registration costs fell from BRL 6500 to under BRL 600 per property. All that resulted in an additional 1220 properties being georeferenced, with some submitted to INCRA for certification. This also supported the generation of 2040 submissions to enroll 2801 properties within the CAR (GIZ, 2016; SECMA, 2016, 2013).

*Olhos D'Água* supported sustainable production as well, such as agroforestry systems, intensified livestock production, and the restoration of degraded areas. The project selected 20 demonstration farms to test alternative production systems. With the help of universities, NGOs, and the Brazilian Enterprise for Agrarian Research (EMBRAPA), 1720 farmers were trained in related techniques: rotational pasture management; soil quality testing; installation of irrigation systems; protective fencing; planting of seedlings; and supplementary feeding to maintain milk production throughout the year, with a focus on small properties under 55 ha (BNDES, 2017; GIZ, 2016; SECMA, 2013).

In 2012, Alta Floresta was removed from the blacklist. By that time, 82% of the eligible municipal area had been registered in CAR, while 1738 ha of Permanently Protected Areas were reforested. *Olhos D'Água*'s Phase 1 was over by the end of 2013 (BNDES, 2017; GIZ, 2016; SECMA, 2013).

From October 2013 to June 2016, the Amazon Fund supported the 2nd phase of *Olhos D'Água* with USD 3.33 million. Another 530 georeferenced property perimeters were submitted for certification by INCRA. Over 400 CAR records from the 1st phase were further processed, in accord with the Forest Code approved in 2012 (Federal Law 12651, 2012), with an associated migration to national from the state registry systems occurring during 2014 (BNDES, 2017; GIZ, 2016; SECMA, 2016).

Phase 2 funding supported sustainable production, including of honey, while 17 dairy and 3 beef-cattle properties becamse demonstration sites. A program of payments for environmental services (PES) was created to protect the watersheds relevant to municipal water supply and BRL 240 per ha per year was paid to family farms located in the Mariana I and II basins. Of the 172 farms in these basins, 72 enrolled. Yet given limited financial benefits for properties smaller than

1 ha, 12% dropped out. Additionally, 22% of the properties were not eligible, as they lacked permanent preservation areas or access to watercourses. (BNDES, 2017; GIZ, 2016; SECMA, 2016). This initiative was brief and featured poorly defined services that lacked any monitoring or sanctioning.

The 2nd-phase funding saw improvements in sustainable production of cattle, milk, and honey. Over 50 workshops and field visits supported improvements in cattle production through artificial insemination and pasture management. Hundreds of farmers learned to use subsidized veterinary inputs for disease control. Milk productivity rose 51% on demonstration farms. For honey, 600 beehives were installed to support a municipal honey facility. Of those, 300 were donated to 64 farms between August 2014 and March 2016. Phase 2 also installed 80 fish tanks and provided seeds and tools to start vegetable production on farms. (BNDES, 2017; GIZ, 2016; SECMA, 2016).

Both the 1st and 2nd phases officially delivered on stated objectives. Given their relatively modest investments, it is not surprising that the project is considered successful by the Amazon Fund. Yet those outputs do not imply forest impact. Below we present the project's theory of change to link outputs documented above to potential project forest impacts, as a basis for subsequent evaluation.

### 2.3. Project theory of change (and its challenges)

As do many Amazonian municipalities, Alta Floresta depends upon agriculture, livestock, mining and logging — sectors historically associated with deforestation – for employment and livelihoods. Many locals see deforestation as synonymous with development, consistent with the 1970s federal occupation and colonization policies (Hayes and Rajão, 2011; Rajão and Vurdubakis, 2013). After 2004, though, federal law enforcement was more present. In 2008, Alta Floresta was blacklisted, restricting its access to subsidized agricultural loans until its removal from the list in 2012. As shown in Fig. 1, however, deforestation rates in Alta Floresta had already fallen dramatically by 2008, a consequence of enforcement, including fines (see, e.g., Hargrave and Kis-Katos, 2013). Therefore, the main obstacle to exiting the blacklist was the cost to register thousands of farmers in CAR, not deforestation reduction. This context suggests that such a project might not naturally focus on further reducing deforestation, as opposed to mainly restoring credit for the municipality.

It was in this context that the municipality of Alta Floresta, in collaboration with NGOs, submitted the *Olhos D'Água* project to the newly created Amazon Fund. All applications must propose a "Theory of Change" to link actions to be supported by the Fund with objectives of the Fund, which include deforestation and emissions reduction. The *Olhos D'Água* project proposed: [a] supports for registering with the CAR and INCRA; [b] incentives for restoring degraded riparian forests; and [c] subsidies for intensifying cattle production and diversifying agriculture. It is not clear how these link to deforestation, though they all could: registrations could help in the enforcement of all forest laws; restoration could increase forest to lower net deforestation; diversifications could shift production away from high-deforestation options; and intensifications could lower the land used.

Yet it was unclear a priori even if registrations would rise. Farmers worried that CAR registrations would inform and guide law enforcement. Thus, to reach 80% CAR registration, actors supporting implementation had to organize many farmer meetings, though registration at no cost was said to help. Farmers were also not convinced about restoring degraded riparian forests. Water benefits were not contested but costs of restoration included less pasture and crop area. Again, incentives mattered, e.g., for cattle-production intensification and agricultural diversification to financially offset production losses due to restoration. Notably, the project included only positive incentives for deforestation reductions, without mechanisms to punish farmers who kept deforesting illegally, even though the municipality had the authority to issue fines. According to a project manager for *Olhos D'Água*, sanctioning rules were left for state and federal authorities to avoid local conflicts.

This model effectively outsourced uses of 'deforestation-based sticks' to external actors (L'Roe et al., 2016) while locally dispensing 'carrots' for intermediate steps'. In practice, this seems likely to affect deforestation only if state and federal environmental agencies use CAR for enforcement purposes. Yet Azevedo et al., (2014) and Rajão et al., (2012) find no evidence that farmers stop deforesting illegally due to enforcement following CAR registrations. Further, CAR is a required step for obtaining any authorization for *legal* deforestation. For this reason, in some cases, overall deforestation increased rather than decreased inside of those properties registered with the CAR (Angelsen, 1999; Azevedo et al., 2014; Chomitz et al., 2007; L'Roe et al., 2016; Rajão et al., 2012).

Furthermore, that intensification of cattle production will conserve forests is controversial claim. It could raise deforestation (Fearnside, 2002; Kaimowitz and Angelsen, 2008). For an open frontier where expansion is possible, subsidies might not even be enough to spatially concentrate the cattle production. Historically, cattle production has been more intensive on frontiers when responding to the intensity of law enforcement and the scarcity of land – e.g., when protected areas increase. This can make increasing pasture areas via deforestation risky (Merry and Soares-Filho, 2017).

Thus, the literature raises important questions about the likelihood that the *Olhos D'Água* project's "theory of change" really predicted the results that were intended. In the next section, we adopt a synthetic control method to assess the actual impacts of the project – intermediate and final — to provide an empirical perspective concerning these issues highlighted by various previous studies.

## 3. Empirical approach & data

### 3.1. Synthetic control method

To assess the impact of specific conservation intervention, one must compare its performance to that of a control group. This control is

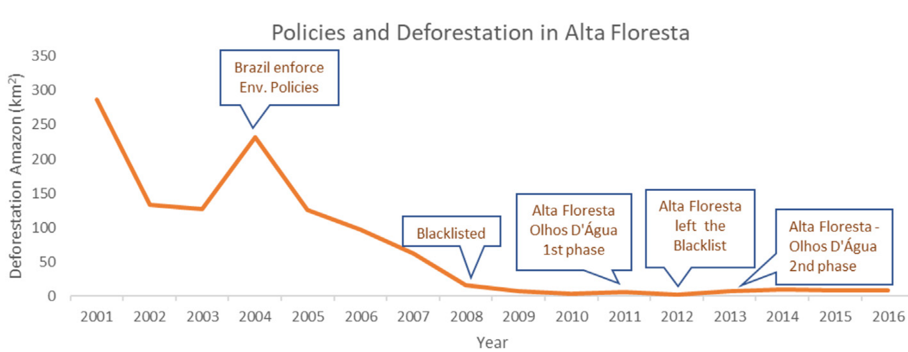


**Fig. 1.** Deforestation and relevant policies over time in Alta Floresta.

composed of other territories that were not impacted by the intervention but are similar to the intervention location. When conservation interventions are not randomized – and most are not – quasi-experimental methods that construct similar control groups to establish bases for comparison have increasingly been used (Arima et al., 2014; Assunção et al., 2012; Börner et al., 2015; CEPAL et al., 2011; Hargrave and Kis-Katos, 2013; Nolte et al., 2013; Soares-Filho et al., 2010). In this study, since there was only one municipality that received the intervention, we applied a Synthetic Control Method (SCM) (Abadie and Gardeazabal, 2003). Through the SMC, we constructed statistically valid comparisons to the *Olhos D'Água* project intervention to serve as the controls. These comparisons were based on a set of municipalities that got little or no Amazon Fund resources but that have similar environmental and economic profiles.

SCM uses a data-driven approach to constructing the comparison, searching for a weighted blend of comparison units that best match the pre-treatment trajectory of the outcome for the treated unit. Since the blacklist was an important motivator for Alta Floresta to start the *Olhos D'Água* project, blacklisted municipalities were considered as potential good matches for composing the synthetic control (Arima et al., 2014; Cisneros et al., 2015). Because only Mato Grosso and Pará had CAR being implemented at this point in time, we restricted the comparison units to those two states. We excluded the municipality of Paragominas in Pará since it was able to quit the blacklist in 2010, before *Olhos D'Água* started. That left us with 29 potential comparison municipalities (Fig. 2).

Once a good pre-treatment match had been constructed, post-treatment outcome trajectories were compared between the treated unit – i.e., the Alta Floresta municipality – and the synthetic control, i.e., weighted control blending comparison units (Abadie et al., 2010; Abadie and Gardeazabal, 2003). Weights were chosen in two steps to minimize the differences between the past outcomes and covariates for the synthetic control (weighted blend) and Alta Floresta. In the first step, the covariates themselves were assigned weights per their predictive power for the outcome. In the second step, the wights on control units were adjusted to improve the 'closeness' of the outcome, to Alta Floresta pre-project. The measure used was the mean squared prediction error (MSPE),

$$(Y_1 - Y_0 W^*)'(Y_1 - Y_0 W^*)$$

where $Y_1$ is pre-intervention outcomes in Alta Floresta, $Y_0$ is outcomes for all of the untreated units pre-intervention, and $W^*$ is the optimal weight for each untreated unit that is a candidate control. To evaluate the pre-project fit, we focused on years after the blacklist, i.e. 2008–2010. Abadie et al., 2010 show that with a good fit in pre-treatment outcomes – e.g., eliminating the difference pre-treatment – SCM's impact estimates, or post-treatment differences, effectively are differences in differences. The estimates offer a treatment effect on the treated every year (Abadie et al., 2010).

Fig. 3 illustrates this approach. The search is for a good weighted blend synthetic control, i.e., a good fit in the pre-intervention period. In such a good fit, weights on the control units (left panel) yield a match to past outcomes for the treated unit (right panel) better than the mean of the pool. Impacts are then calculated as the differences between the treated and synthetic control outcomes, with one estimate per unit of time (see Fig. 3's shaded triangle for the post-intervention period).

Given such estimates, we needed to evaluate their statistical significance. We used placebo tests of the form recommended in the literature (Abadie et al., 2010), i.e., estimating effects where there were no interventions, focusing on candidate control municipalities. Following Sills et al. (2015), we also used a bootstrapping method to construct confidence intervals around the synthetic control: in each of 1000 rounds, we randomly excluded units from the comparison pool and redid impacts estimations for Alta Floresta. Both are seen in our appendix and are reflected in the results below.

### 3.2. Data

Our two main outcomes were deforestation and geo-spatial registrations at the rural environmental registry (CAR) as well as at the National Institute for Colonization and Agrarian Reform (INCRA). Forest loss is from INPE's PRODES system (Prodes, 2017), i.e., newly

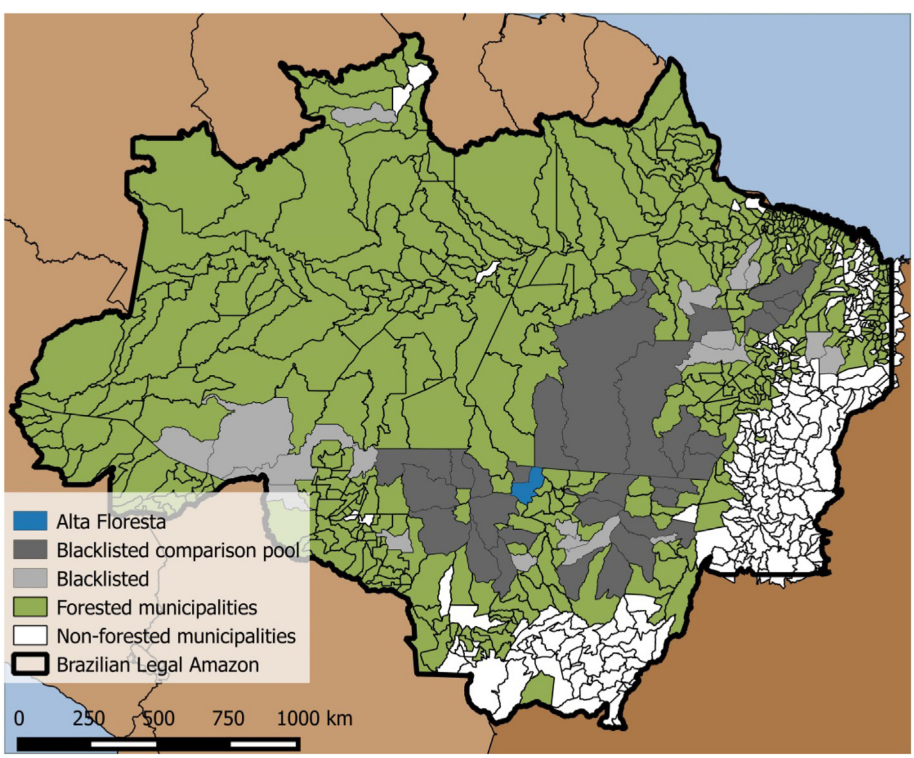


**Fig. 2.** Alta Floresta & the other blacklisted municipalities in 2008.

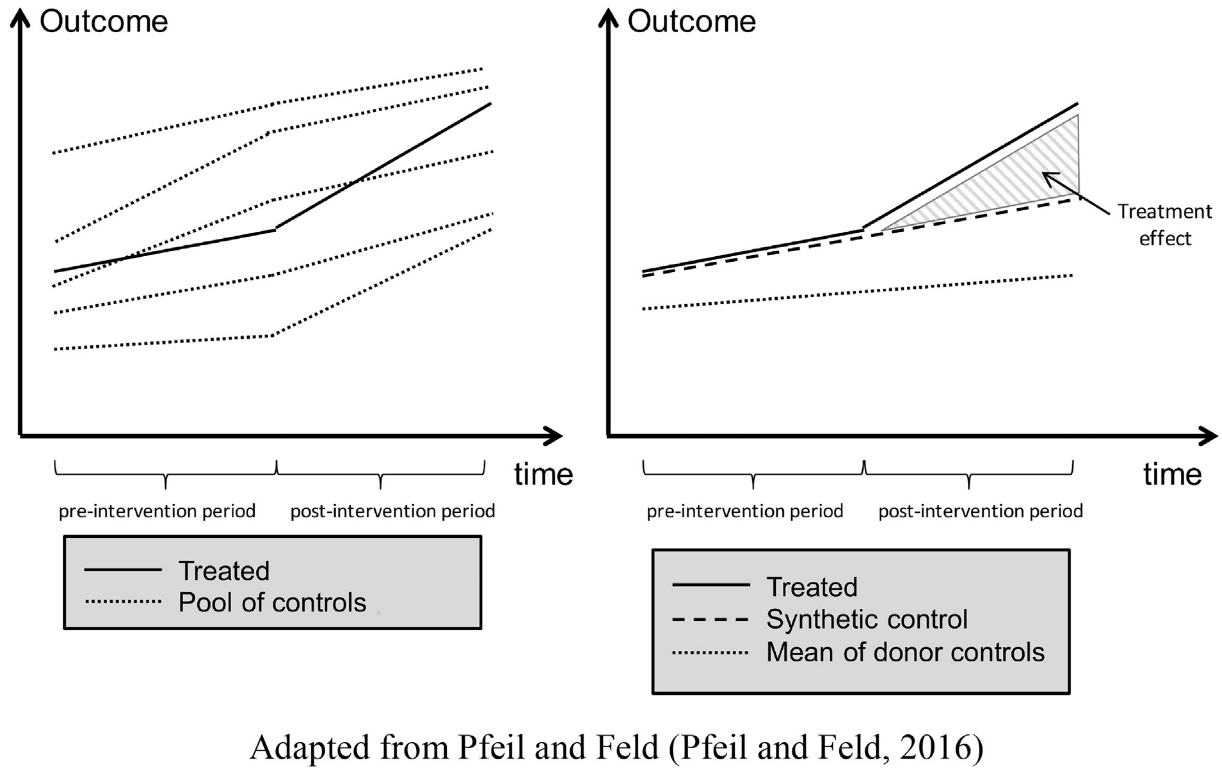


**Fig. 3.** The Synthetic Control Method. Adapted from Pfeil and Feld (2016).

deforested area each year.

The CAR registrations data were obtained from the respective Secretaries of the Environment of the states in question, in collaboration with the Institute of Environmental Research of the Amazon (IPAM). They were collected through 2012 (Azevedo et al., 2014). Records indicated land areas in polygons, permitting calculations regarding CAR area relative to the area of the municipality (when excluding the protected areas – both strict and sustainable use – and indigenous territories).

To construct the synthetic control, we used as the outcome the annual percentage increase in the CAR coverage. Our measure consistently fell below official CAR statistics since the CAR is self-registered by landowners and the databases present several overlaps and duplications. Overlaps and duplications were eliminated in our analysis using a geoprocessing tool (Appendix Fig. 13).

Georeferenced records were obtained from INCRA (INCRA, 2017). The SNCI (National System of Properties Certifications) was the main database until 2013. In late 2013, INCRA adopted the SIGEF (Land Management System) to make it easier to do these registrations without going to INCRA headquarters but instead doing remote analyses that can be approved by INCRA. The two systems coexisted for some time but no significant overlaps were noted between the two databases.

We also examined aggregate agricultural production of the types directly supported by the project. We use official statistics for the production of both honey and milk. Honey production data were obtained from IBGE Livestock Research and measured in kilograms. Annual milk production was obtained from IBGE, measured in liters (IBGE, 2017a, 2017b, 2017c, 2017d, 2017e, 2007, 2006).

We used pre-treatment socioeconomic and biophysical characteristics as covariates. Demographic data are from IBGE and the Brazilian Central Bank (BCB, 2016). Administrative and geophysical data are from EMBRAPA, IMAZON, and IBGE. We also included the number of inspections by IBAMA (IBAMA, 2017a, 2017b). We used mean distance of each municipality to rivers (from the National Water Agency) and the mean distance of each municipality to roads (from IMAZON) and municipality headquarters. Distance to rivers and roads were calculated from pixel centroids, using the Euclidean distances. As relevant geophysical and geological characteristics, we included soil quality from EMBRAPA, agriculture suitability from IBGE, and slope from CSR/UFMG.

## 4. Results

### 4.1. CAR & INCRA registrations

Given its context (Section 2), the main intervention in *Olhos D'Água* was support for farmers to register with CAR and regularize titles with INCRA. During the 1st phase (2011 – 2013), 2040 CAR projects registered 2801 properties. The 2nd phase (2013–2016) rectified 400 of these, migrating to the national CAR system. Likewise, in total 614 properties were registered at INCRA. These were significant additions, with an increase of 595 properties in INCRA versus only 19 in 2010. Yet to assess project impacts, it is important to compare with other municipalities with similar profiles. We used synthetic control methods to estimate what would have happened without the project.

Fig. 4 juxtaposes Alta Floresta's yearly new CAR registrations – as a share of municipal area – with the best synthetic fit, plus the bootstrapped confidence interval around that synthetic best fit. In 2011, there was a huge jump in the CAR registrations within Alta Floresta. The weighted blend for CAR registrations in the other blacklisted municipalities, in contrast, remained steady or even fell a bit (raising the possibility of a negative spillover through a shifting of registration resources). Given a good pre-project fit in Fig. 4, we estimate an impact for that 2011 spike in registration.

Georeferenced registrations with INCRA for title regularizations also showed an upward jump for Alta Floresta, albeit a different one. INCRA registrations remained low in Alta Floresta (and the synthetic control) until the second year of the *Olhos D'Água* project in 2012. This slow start can be explained by a strike at INCRA between May and September 2012. At this point, the rate of INCRA registrations rose in the synthetic

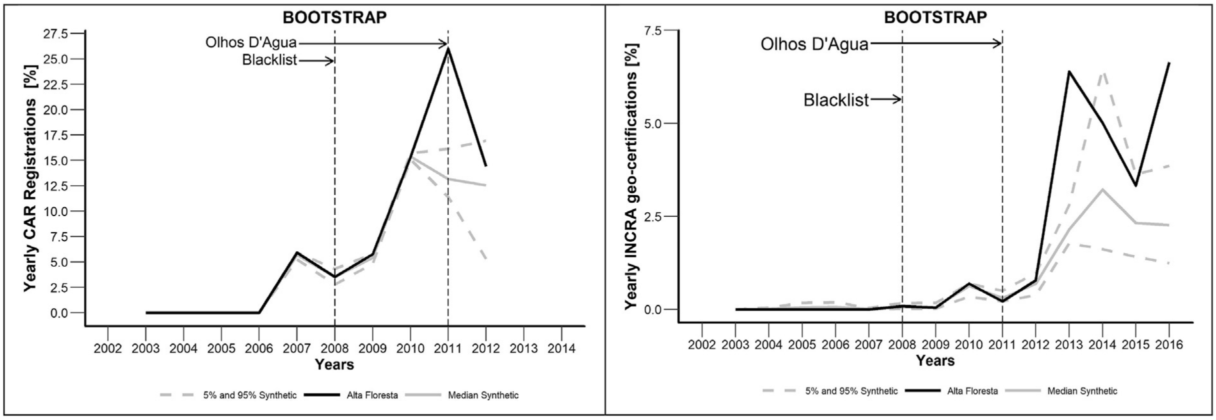


**Fig. 4.** Comparing the CAR & INCRA trends in Alta Floresta with our synthetic controls.

control (the weighted control municipalities). This rise can be linked with a Decree which stated that properties over 100 ha must be certified by INCRA by December 2016. Registrations rose far faster in Alta Floresta, though, above the median of the synthetic control and its confidence interval during most of the project. For INCRA registrations, it is clear the *Olhos D'Água* project increased the rate in Alta Floresta of this intermediate output.

### 4.2. Honey & milk production

We evaluated impacts of *Olhos D'Água* on milk and honey production versus synthetic controls. In Fig. 5, after the blacklist, honey production fell in Alta Floresta and the synthetic control. Yet while that trend continues for honey elsewhere, after *Olhos D'Água* honey production in Alta Floresta rose well above that of the synthetic control − if not clearly its (noisy) confidence interval.

Milk production may have been affected by the *Olhos D'Água* project, although this is less clear. In the synthetic control, we see falling milk production after the blacklist (as we saw with honey production). In Alta Floresta, however, milk production continued to rise for the subsequent pre-project years, yielding higher production in 2011 than the value for the best synthetic control. After 2011, milk production dropped in Alta Floresta too. By 2014, though, it was again well above the synthetic control. Yet whether this difference implies an impact is not clear: given the difference in 2011, a difference-in-differences estimate for an impact of *Olhos D'Água* could be insignificant.

It is worth considering why these quantities of agricultural outputs produced would be falling in Alta Florest at this time – either without or with the *Olhos D'Água* project. One explanation is that after 2012, there was a regional change in outputs with rapid growth of soybeans, as well as corn, mainly replacing pasture. Fig. 6 confirms post-2011 outputs trends went in opposite directions.

### 4.3. Deforestation

The *Olhos D'Água* project's theory of change stated that activities supported by the Amazon Fund were to lower deforestation and thus greenhouse-gas emissions. As such, it is important to assess deforestation in Alta Floresta versus a synthetic control. Fig. 7 shows Alta Floresta deforestation fell consistent with 2004–2007 regional trends. It fell more sharply than synthetic controls by 2008, after which deforestation remained low until *Olhos D'Água* started as well as during the project.

In Fig. 7, that the deforestation in Alta Floresta was relatively low is conveyed by even our best synthetic control having slightly higher deforestation than Alta Floresta when the project started. The difference-in-differences question about impacts from *Olhos D'Água* is, then, whether the gap widened during the project. If so, that would suggest the project was holding deforestation down.

In Fig. 7, deforestation was increasing in the synthetic control after the project started, whereas it stayed low in Alta Floresta. Nonetheless, despite the initial gap, Alta Floresta's deforestation remained inside the margin of the lower bound of the 5–95% confidence interval for the synthetic control. This cannot indicate a large impact, though we cannot categorically rule out some impact.

When utilizing the bootstrapping to evaluate significance, the 90% confidence interval had higher deforestation in the synthetic control than Alta Floresta both for 2008–2010 and after the treatment. Thus, again, it is not immediately clear that our preferred difference-in-differences shows impacts. In sum, given challenges in perfectly fitting synthetic controls, and the uncertainties we document, from our evidence we cannot state strongly that *Olhos D'Água* had zero impacts on deforestation, since it might have held deforestation down from 2013.

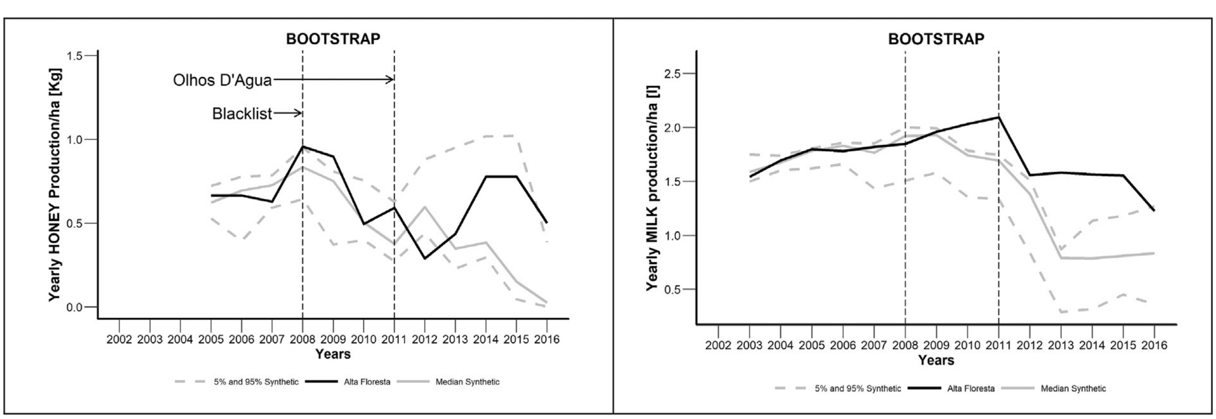


**Fig. 5.** Comparing the honey & milk trends in Alta Floresta with our synthetic controls.

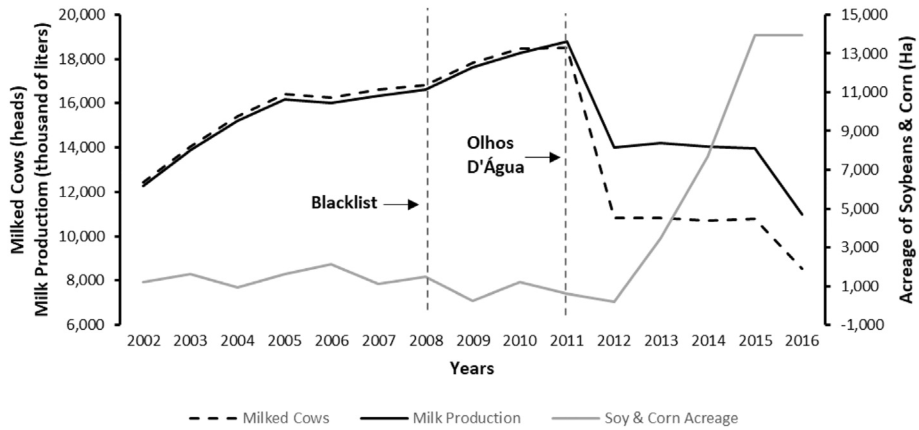


**Fig. 6.** Juxtaposing milk with soy & corn trend.

Yet any impacts it did have were limited.

## 5. Discussion and conclusions

The *Olhos D'Água* project set out to influence land registration, restoration, output diversification in agriculture and the intensification of cattle production. Yet, as per the project's theory of change, those were intermediary goals, alongside the stated ultimate goal of reducing rates of deforestation. We evaluated which goals were achieved by this project. We employed an empirical method that found the weighted blend of comparison municipalities that best matched past outcomes for the project municipality, Alta Floresta. That weighted blend was compared to the project's outcomes.

We found that this Amazon Fund project had positive impacts on both CAR and INCRA registries. We also detected significant impacts on honey production, in a context of significant agricultural transition in the region. Milk production may also have been increased by the project, although a difference-in-difference estimate may be insignificant, given differences before the project started. Given direct support, it would not be surprising if some gains in these outputs were in fact attained. More clear in the data, though, is that the project very likely generated economic gain by increasing access to credit, since our results suggest that it helped Alta Floresta increase CAR registrations. Given already lowered deforestation, that was the key to get the municipality off of the "blacklist".

The fact that Alta Floresta had lowered its deforestation rate considerably even before the *Olhos D'Água* project makes it hard to provide strong evidence for the project's impact on deforestation. Deforestation remained low in Alta Floresta, while from 2013 it rose in comparison municipalities. That suggests a potential project impact. On the other hand, despite already being lower by 2011, Alta Floresta's deforestation rate remained within the confidence interval for the synthetic control.

It might not come as a surprise that intermediate achievements may not have lowered deforestation. As indicated by Azevedo et al. (2014), little deforestation reduction was achieved by the SLAPR in 2000–2008 or CAR in 2008–2012. Perhaps that should have cast doubt on the theory of change, since Federal and state agencies had not made use of the CAR in enforcement. Perhaps they chose not to do so, as punitive actions could have threatened the short-run priority of getting landholders to register with the CAR. Yet that lack of enforcement would have weakened CAR's forest impact.

Our results could help to improve the Amazon Fund as well as other REDD+ initiatives worldwide. Such initiatives explicitly or implicitly posit important questions about the validity, in application, of a variety of theories of change that underlie REDD+ projects and are conceptually sensible for some conditions. For this case, our results suggest that in practice local incentives for deforestation were not meaningfully changed. Further, for these conditions, that was probably quite

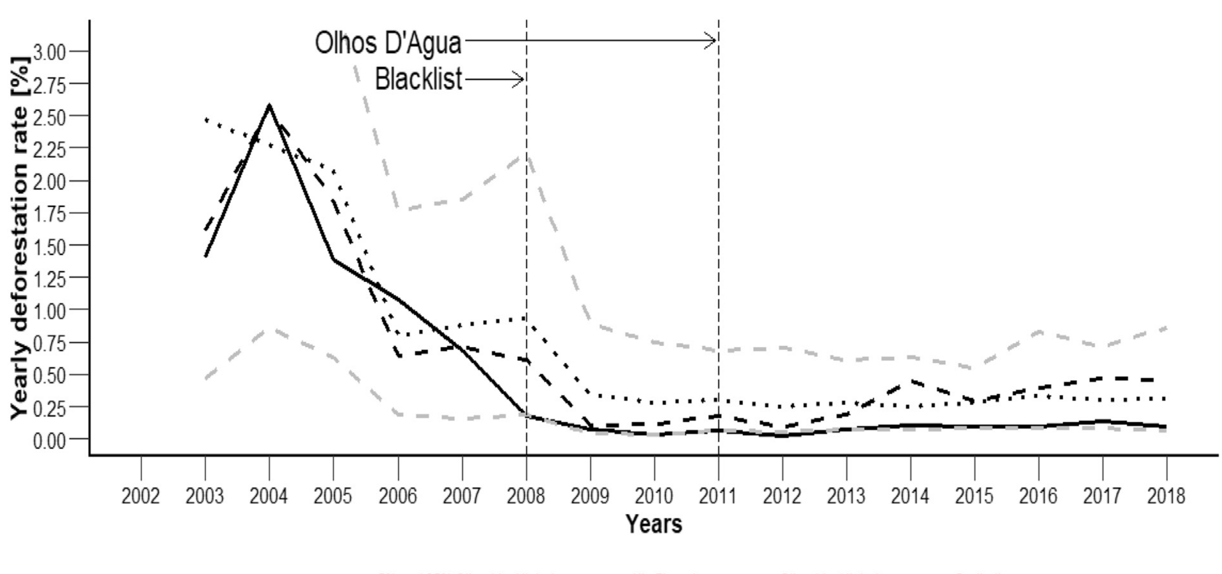


**Fig. 7.** Comparing the Deforestation Trends in Alta Floresta with our synthetic control.

predictable. Outcomes could differ for future policies. Yet at the least, our results suggest that those allocating scarce resources across projects should not take for granted the assumptions in theories of change. They should instead assess ongoing policy impact, in order to allow for any necessary adjustments.

Finally, the data and the empirical approach we utilized highlight that both project implementers and project evaluators alike may want to keep in mind the temporal dimension of evolving impacts. Here, for instance, we cannot point to clear evidence for any short-term reductions of deforestation. However, the project municipality has remained low while other, comparable municipalities rise. It is quite possible that, over time, the data will more clearly reveal an impact of *Olhos d'Água*.

Local actors have diverse reasons for implementing REDD+ projects, though. Alta Floresta wanted to be removed from the blacklist. It was the lack of CAR registrations and not high deforestation that was keeping them listed. Thereby, and quite predictably, Alta Floresta's main interest was not in further deforestation reductions. This serves as an example to illustrate that management for the Amazon Fund and related initiatives could benefit from an informed and nuanced understanding of the incentives of critical local actors at multiple levels (Paul, 2015). Those allocating resources for conservation want to be sure there are explicit incentives in place for key project proponents − meaning not only delivery on intermediate goals but also contributions towards the ultimate goals.

Stepping back, the Amazon Fund has diverse reasons for projects too, and those projects can have impacts in a variety of ways. Many of the projects of the Amazon Fund were not intended to yield measurable short-term deforestation reductions. For instance, the Amazon Museum in Manaus and research supported by the fund provide long term and indirect yet still important contributions to forest conservation. Further, independent of all project implementation the Amazon Fund provides a “carrot” that may incentivize the federal and state governments to lower deforestation to receive results-based payments. Still, for Amazon Fund projects that aim to influence deforestation for specific locations, like *Olhos d'Água*, it is important to quantitatively and robustly assess impacts. This is not to assess Fund or deforestation success or failure overall, since those are broader issues. Rather, impact evaluations can provide important insights to improve the management of specific Amazon Fund projects and, thus, contribute towards the sustainable development of the Amazon.

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## Declaration of Competing Interest

The authors declare no conflict of interest.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.forpol.2020.102178.

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