



XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

Positive effects of an Atlantic Forest program of payment for ecosystem services on native vegetation and pasture quality

Ramon Felipe Bicudo da Silva

Núcleo de Estudos e Pesquisas Ambientais, Unicamp

Abstract: In recent decades, Brazil has implemented several payments for ecosystem services programs, including the *Projeto Conexão Mata Atlântica* (PCMA), a partnership between the Brazilian federal government, states and the Global Environmental Facility. The PCMA was co-designed by state organizations with many stakeholders, including landowners. The innovative polycentric approach of the program prompted exploration of different schemes, including one to conserve and restore natural vegetation cover ('protection scheme') and another to enhance the multi-functionality of individual properties with focus on pasture quality ('multiple-use scheme'). Using a propensity score matching approach, I assessed the PCMA's effects on natural vegetation cover and pasture quality of private rural properties that did and did not participate in this PES program between 2017 and 2022. Properties participating in the 'protection scheme' exhibited an average 'additional' increase in natural vegetation cover of 1 ha compared to non-participants. Properties participating in the 'multiple-use scheme' exhibited 7-10% less pasture quality degradation.

Keywords: Remote sensing, propensity score matching, natural vegetation, pasture quality, rural property

Financiamento: FAPESP 2022/16002-1, 2023/15877-7

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

1. Introduction

It is well-known that humans are the main source of current environmental transformations around the world (Brondizio et al., 2016). Along with the combustion of fossil fuels, changes in land use/cover (LULC) drive most of the greenhouse gas (GHG) emissions (Curtis et al., 2018), especially in countries like Brazil where deforestation and agricultural expansion are still taking place across large spatial extents (Rajão et al., 2020; Silva et al., 2023a). To reverse environmental degradation, a series of tools and mechanisms have been created under different environmental governance frameworks (Steiner et al., 2003), including the development of sustainability standards for supply chains (e.g., eco-certifications; Lambin and Thorlakson, 2018), and the development and implementation of programs of Payment for Ecosystem Services (PES; Liu and Yang, 2013). PES are known as a key mechanism that uses incentives (e.g., cash, in-kind transactions, rural assistance) to foster changes in resource-use practices or to conserve and restore natural areas (Grima et al., 2016). PES programs implemented within private rural properties are considered effective tools for increasing the efficiency of conservation investments worldwide (Ferraro and Simpson, 2002).

Implemented in 2017 with a total budget of R\$33 million/≈US\$6.5 million, the “*Projeto Conexão Mata Atlântica*” (PCMA) initially involved 1,091 private rural properties in the Paraíba and Ribeira valleys, São Paulo state (Oliveira et al., 2024). Through the use of economic incentives and technical support for conservation/restoration, the PCMA promoted a several schemes that foster natural vegetation cover (NVC) conservation and restoration (‘protection’ scheme), and to improve management practices in agricultural systems, as recovering pasture quality (‘multiple-use’ scheme) (Oliveira et al., 2024).

The implementation of these schemes enhanced the expectation that the PES program would generate ‘additionality’—i.e., benefits resulting from an intervention that would not occur in its absence (Tacconi, 2012). In other words, if non-participant rural properties experience NVC gains through land

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

abandonment or restoration initiatives, NVC gains in properties participating in the PCMA would need to occur at a higher rate for the program to be generating ‘additionality’. This additional effect is an important component of public policy evaluation (and key for inferring causality; Bayles et al., 2016) but constitutes a challenge in real world situations, as it requires the use of data from observations rather than from formal controlled experiments (Schaefer and Figueiredo Filho, 2023). Hence, this study uses a propensity score matching along with remote sensing data on land-use and land-cover and vegetation index for pasture quality to evaluate the impacts of the PCMA on the property level.

2. Methods

2.1 Data

This study took advantage of remotely-derived land use/cover and pasture quality data from 2017 to 2022 at high spatial resolution (both from MapBiomas, collection 8), rural property data from then *Rural Environmental Cadastre*—CAR, and on the participation in the PCMA in the Paraíba (Figure 1a) and Ribeira (Figure 1b) Valleys of São Paulo state (Figure 1) Brazil, and a set of socioeconomic and biophysical datasets. This dataset was used to develop a procedure for assessing some of the environmental effects of the implementation of the PCMA. Thus, our study evaluated the performance of a public program for PES using observational data. Based on the propensity score matching approach (Zhou et al., 2022), the developed procedure allowed evaluating the significance of the additionality generated by the schemes under the PCMA, while removing the confounding effects of covariates. Covariate selection: To evaluate the impacts of payment for ecosystem services programs on the outcome variables evaluated (i.e., increase in NVC and change in pasture quality), I used ‘transportation cost,’ ‘slope,’ ‘mean precipitation,’ and ‘municipality’ as covariates, and added the ‘percentage of NVC in 2017’ for the NVC model. These variables are significantly

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

associated with both the NVC regeneration process and agri-livestock activities in the study region (Silva et al., 2018). The dataset used included a total of 934 rural properties (ranging in size from 0.2 to 1,400 ha) that participated in the PCMA program (890 of which executed at least 10% of their action plan), and 18,688 non-participating properties. The dataset used included a total of 934 rural properties (ranging in size from 0.2 to 1,400 ha) that participated in the PCMA program (890 of which executed at least 10% of their action plan), and 18,688 non-participating properties.

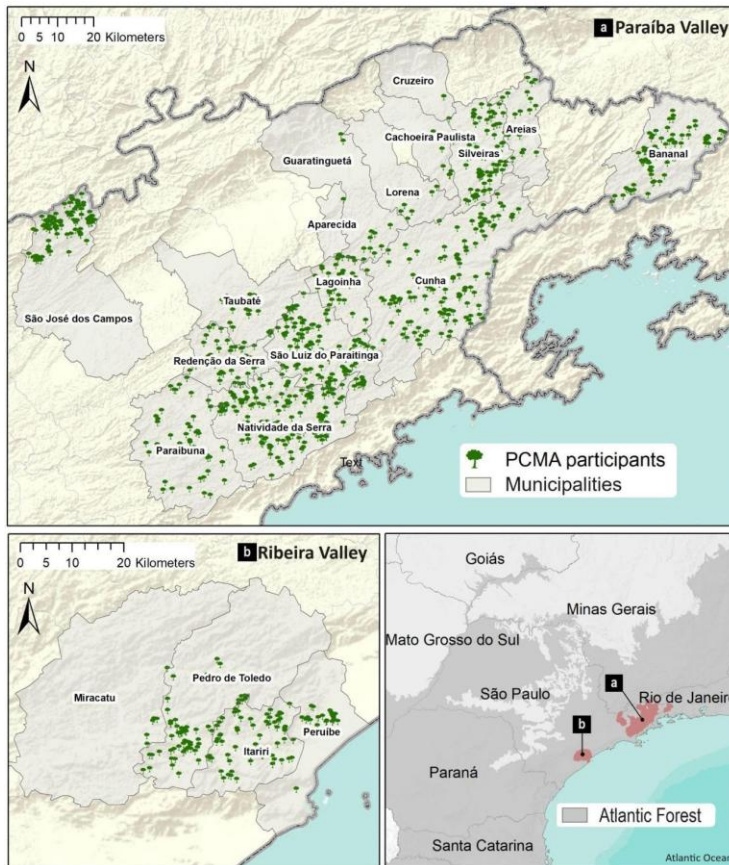


Figure 1. Geographical distribution of rural properties participating in the “*Projeto Conexão Mata Atlântica*” (PCMA) in the Brazilian state of São Paulo. **a**, Distribution of 823 participants in the Paraíba Valley region, across sixteen municipalities. **b**, Distribution of 151 participants in the Ribeira Valley region, across four municipalities.

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

2.2 Statistical analysis

To evaluate the effects of the PES schemes under the PCMA on the recovery of natural vegetation cover (NVC) and on changes in pasture quality between 2017 and 2022, I utilized a *quasi-experimental design* by adopting the propensity score matching approach (Zhou et al., 2022). This approach has been successfully applied in previous studies to evaluate the causal effects of specific policy interventions (Bayles et al., 2016) by comparing outcomes of samples under an intervention (i.e., treatment) against counterfactual no-intervention samples. Our analysis comprised the period starting in 2017, as it constitutes the first year of the PCMA implementation, and concluding in 2022, the year of the completion of the payments following the action plans agreed at the beginning of the *Conexão* (Oliveira et al., 2024).

The dependent (outcome) variables for the matching approach were NVC and pasture quality, while a set of biophysical and socioeconomic covariates were used to control for the effects between participants and non-participants. The treatment variable used to assess the impact of PES ‘protection’ scheme on NVC was participation by rural properties, (**model 1**; with participants assigned a value of 1, and non-participants a value of 0). For the two outcome variables representing changes in pasture quality (to evaluate trends in *low quality*—**model 2**, and *high quality*—**model 3** between 2017 and 2012), the treatment variable was represented by the PES ‘multiple-use’ scheme. Selected covariates for propensity score matching were those demonstrated to have an association with the outcome variables in previous studies of land-use decisions in the Atlantic Forest, and include land abandonment, cattle ranching activities, conservation practices and ecosystems restoration.

The matching approach estimated the Average Treatment effect on the Treated (ATT) to assess the effects of an intervention (Zhou et al., 2022). Here, the ATT was defined as the difference between the average outcome (e.g., NVC increase) in properties participating in the PCMA (treatment group) and the

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

average outcome in non-participants (control group). For each property in the treatment group, the matching method finds a property in the control group that is similar in terms of the observable attributes (called confounding factors; Zhou et al., 2022). After controlling for confounding factors (i.e., the covariates), the difference in the values of the dependent variable (e.g., NVC increase) between treatment and control groups represents the effect of the program—i.e., the ATT.

To perform the matching approach, I first ran the ‘Genetic Matching’ (GenMatch) algorithm with replacement, to reduce bias (Sekhon, 2011). One-to-one matching entails pairing each treated unit with a corresponding control unit, a strategy that safeguards precision by mitigating the risk of leaving excessive control units unmatched and subsequently excluded from the matched sample (Rosenbaum, 2020). With the balance for covariates found through the GenMatch, I ran the ‘match’ algorithm for causal effect estimates (two-sided *t*-test) with bias adjusted and using the Abadie-Imbens estimator to obtain standard errors (Abadie and Imbens, 2006).

Hence, the propensity score matching approach was employed specifically to control for observed covariates and create a balanced set of control properties, allowing us to isolate and evaluate the effects of program participation. In such studies, covariates are included solely to minimize confounding effects, without the intention of assessing their impact on the response variable (Austin, 2011).

3. Results

3.1 Impacts of the PCMA on natural vegetation cover

The total area occupied by all rural properties is around 936,000 ha, while between 2017 and 2022, NVC exhibited an increase of 1.7%, equivalent to a net gain of 8,283 ha (from 477,000 ha in 2017 to 485,000 ha in 2022). This result constitutes a remarkable indicator of the regeneration/recovery of natural ecosystems at

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

local scales in the Atlantic Forest biome (Figure 2). Based on the PES ‘protection’ scheme (**model 1**), I found a significant result (Table 1, **model 1**), which indicates that the ‘protection’ scheme is in fact improving the trend of NVC increase in the region by providing significant additional gains in PCMA participants—in this case an additional increase of 1 ha. Furthermore, from a set of 310 rural properties participating in the PCMA ‘protection’ scheme, 177 exhibited a mean NVC increase of 2.67 ha, which is 1.7 times higher than that of non-participating properties (mean of 1.57 ha across 7,420 properties). In summary, the results from **model 1** allow inferring that, after controlling for covariates, the PCMA scheme focusing on NVC provided a significant increase of NVC in participating properties compared to non-participating properties, with a mean additional gain of 1 ha.

Table 1. Impacts of the payment for ecosystem service schemes under the *PCMA* on natural vegetation cover (NVC) and pasture quality identified using the propensity score matching approach. Dependent variables are NVC increase (model 1), low and medium pasture quality change (model 2) and high pasture quality change (model 3), all for the period 2017-2022. All models exhibited values equal or larger than the threshold of 1.5 in sensitivity, and $SMD < 0.25$ indicating that they are robust to hidden biases.

Parameters	Model 1	Model 2	Model 3
Impact estimated using matching	1.00* (0.39)	-10.66* (4.00)	7.22** (2.28)
Γ Sensitivity	2.1	1.8	1.5
Standardized Mean Difference (SMD)	< 0.1	< 0.1	< 0.1
Number of treatments	177	79	245
Number of matched	177	79	245
Number of observations	7,909	5,908	13,012

* p -value < 0.05; ** p -value < 0.01. Abadie-Imbens standard errors in parentheses.

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

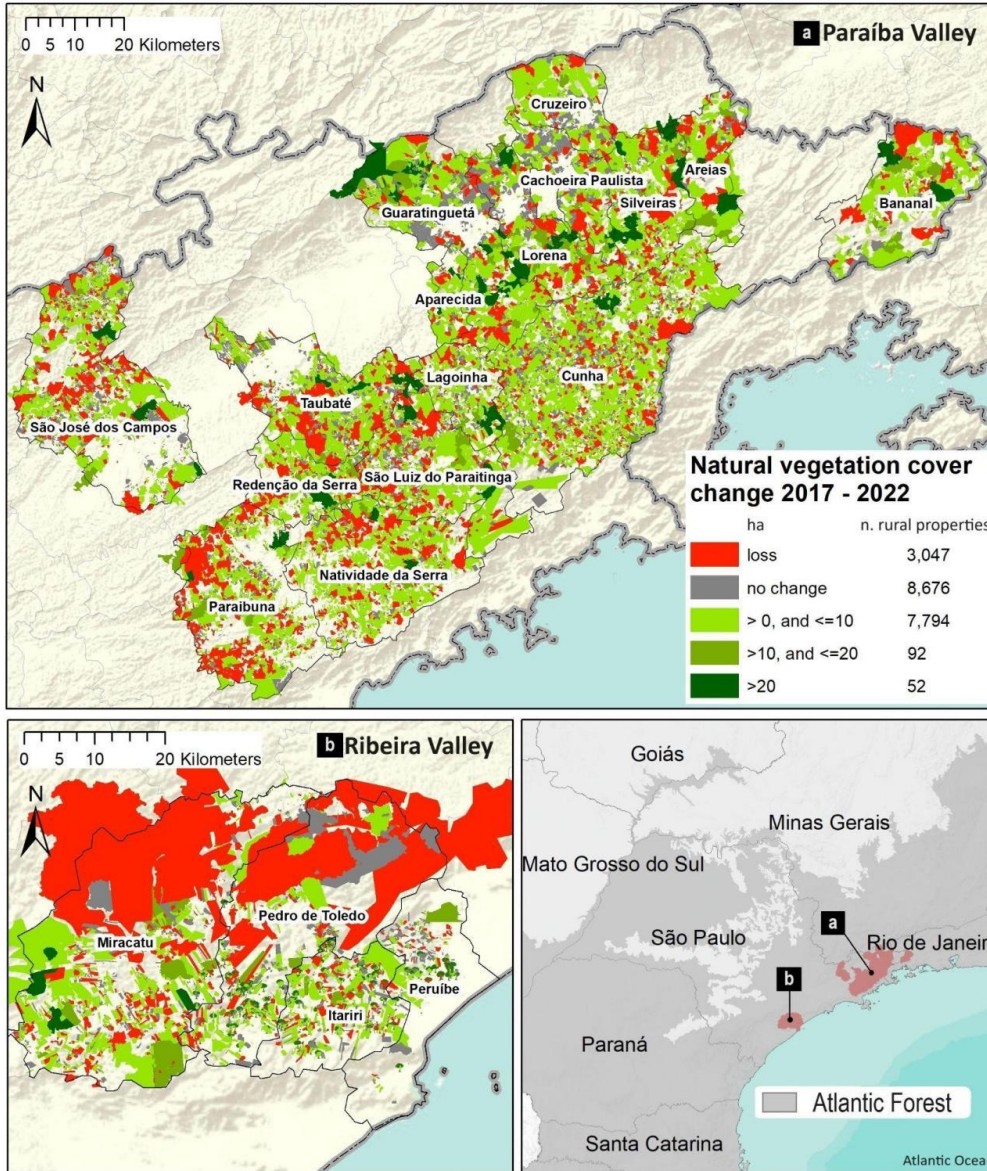


Figure 2. Geographical distribution of the natural vegetation cover (NVC) change at the rural property level in the study region. **a**, NVC change in rural properties in the Paraíba Valley; **b**, NVC change in rural properties in the Ribeira Valley.

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

3.2 Impacts of the PCMA on pasture quality

Over the study period a general trend of pasture quality decrease was observed for the entire study area. Considering the total number of rural properties with pasturelands in 2022 (14,648), the average quality decreased from 1.32 (considering the quality scale of 1-*low*, 2-*medium*, and 3-*high*) in 2017 to 1.18 in 2022 (a decrease of 0.14). Over the same period, Iobserved a general trend in pasture area decrease of 12,375 ha (1.3% of the study area). For the group of rural properties participating in the PCMA ‘multiple-use’ scheme, the average decrease in pasture quality was slightly lower, at 0.12. However, when our model focused on pasture quality classes 1-*low* and 2-*medium*, **model 2** (considering only the 5,908 properties with increased trends in these classes), non-participating rural properties exhibited a 31.33% increase in these classes combined. For the properties participating in the ‘multiple-use’ scheme (79 properties), the increase was 25.65%. After controlling for covariates, our model found a slightly higher and statistically significant difference of -10.66% (Table 2-**model 2**). This result indicates that the ‘multiple-use’ scheme effect on participating properties prevented an increase of 1-*low* and 2-*medium* pasture quality classes of around 10.66%.

Regarding exclusively the pasture quality class 3-*high*, between 2017 and 2022 the study area lost 52,600 ha (9.5%). In **model 3**, Iaimed to evaluate the changes in this pasture quality class, after establishing an adequate covariate balance. Results from this model show a significant (Table 2-**model 3**) difference between rural properties participating in the ‘multiple-use’ scheme (245) against non-participating properties (12,767) of 7.22%. While the general trend for properties participating in the ‘multiple-use’ scheme was a decrease of 4.43%, non-participating properties exhibited a decrease of 11.89%. Results from models 2 and 3 allow us to infer that the ‘multiple-use’ scheme provided the capacity of properties participating in PCMA to significantly mitigate the degradation of pasture quality over the study period.

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

3.3 Cost comparison analysis for restoration

The PCMA program in São Paulo state, invested a total of R\$32.3 million between 2017 and 2022, corresponding to an average of R\$31,500 per participating rural property. Considering just the rural properties participating in the ‘protection’ scheme, the total value reached R\$8.3 million (R\$27,000 on average per property—310 properties). Considering just the 177 properties with NVC increase of the ‘protection’ scheme, the total R\$6 million paid respective to these properties reached a cost per ha of R\$12,600—due to the observed increase of 476 ha of new NVC for this specific group. From a local Paraíba Valley restoration business, the average cost for active restoration in 2024 was R\$68,900 per ha (for this estimate cost the local business includes fencing, which is the same procedure adopted by landowners participating in the PCMA). Here I note that for the properties participating in the ‘protection’ scheme were conducted mainly through assisted restoration (i.e., natural regeneration with some, but limited, tree planting), which is cheaper compared to active restoration (Brancaion et al., 2019). In this case, taking into consideration the cost from the local Paraíba Valley business for assisted restoration at R\$23,000 per ha, the results achieved by the PCMA at R\$12,600 indicate that better returns for the monetary investments are more likely to be achieved under policy frameworks such as PES.

4. Discussion

Brazil has a large deficit of natural vegetation cover – estimated at ≈ 27 Mha – that needs to be fulfilled to achieve legal compliance with the national Forest Code (Silva et al. 2023a). Nonetheless, to ensure rural landowners comply with this code it is necessary to go beyond command-and-control strategies (Uehara and Casazza, 2011) and incorporate land-use planning (Silva et al., 2023b) together with monetary incentives

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

(Lemos et al., 2023). Our analysis found that the PCMA program has the potential to accelerate NVC gains at affordable costs considering current market prices for restoration. Despite the considerable range between major studies on restoration costs in the Atlantic Forest (MMA, 2017; Brancalion et al., 2019, and local Paraíba Valley estimates), our results suggest that the PCMA program achieved more affordable restoration outcomes. Previous economic modeling efforts in the Atlantic Forest have demonstrated the potential of PES programs to promote NVC restoration, while reducing landowners' restoration costs (Lemos et al., 2023). Hence, our cost comparison analysis provides useful insights into the costs for restoration under a PES policy framework, which was expected to lower restoration costs by applying 'reverse auctions' (SI 6) to attract landowners to participate in the PCMA (Oliveira et al., 2024), while engaging them into a participatory process (Pereira, 2024).

The PCMA program shows potential to harness the ongoing natural regeneration process by adding 1 ha to each hectare that increases without any incentive (i.e., this is the additionality promoted by the PES 'protection' scheme; Table 1-**model 1**). This result demonstrates the capacity of such initiatives to enhance environmental restoration, thus strengthening the argument that policy interventions may achieve successful outcomes when designed and implemented through participatory processes (collaborative approaches involving policymakers, technicians, rural extension professionals, and landowners; Henderson et al., 2020).

Pasture degradation and its recovery is a major challenge in Brazil, affecting not only livestock production (Bolfe et al., 2024) but compromising soil and water quality (Lemos et al., 2023). Although there was an overall general trend of pasture quality improvements over the last decades in Brazil (Santos et al., 2022), our study found a declining trend since 2017. However, for rural properties participating in the PCMA 'multiple-use' scheme, Iobserved a significantly lower decreasing trend. Our propensity score matching models estimate that participant properties had, on average, a 7% higher increase in *high*-quality

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

pastures and a 10% lower increase in *low*- and *medium*-quality pastures compared to similar non-participant properties. These differences represent the additional effects attributed to the program. These findings suggest that the concerted efforts within participating properties contributed to the resilience of producers, contrasting with the stronger declining trend observed throughout the entire study region. In this context, I argue that in rural properties under active sustainable management practices, pasture degradation may be significantly mitigated.

Our results show that 8% of the rural properties initially participating in the PCMA did not achieve the targets assumed through their ‘action plans’—i.e., executed less than 10% (the average execution was 74%). Taking all this into account, the PCMA was successful in maintaining the adherence of participants across 2017-2022, which included the occurrence of the global COVID-19 pandemic and constituted a significant challenge for the implementation of the program (Oliveira et al., 2024). This is a key finding, since consistent participation of rural people in government conservation programs in Brazil constitutes an important challenge—the higher levels of non-compliance with the ‘Forest Code’ being a prominent example (Silva et al., 2023a). According to Pereira (2024), the PCMA is an improved policy design built upon decades of previous conservation policies designed for rural properties in the São Paulo state (under the leadership of SEMIL)—i.e., ‘institutional learning’. For Pereira (2024), the PCMA innovated by investing in a concerted action involving policymakers, the executive team, rural extension professionals, and landowners, to ensure continued assistance in fieldwork activities.

Although policy/program evaluation has become a growing concern in public administration (Jacob, 2024), it remains challenging due to limitations such as budget constraints, ethical and political concerns regarding the application of randomized selection methods for participants (i.e., treatment and control groups), which significantly compromise the ability to rigorously evaluate such interventions (Januzzi,

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

2023). Despite the increasing recognition of the importance of public policy evaluation in the Brazilian context, as expressed by the Federal Public Administration in technical publications on the subject (*Avaliação de Políticas Públicas*, Casa Civil 2018), this practice remains largely neglected in most contexts (Januzzi, 2023). Given these challenges, I emphasize the importance of alternative approaches, such as the *quasi-experimental* method used in this study. This method, combined with environmental spatial data, remote sensing, information from local administrative units (i.e., municipalities), and data on individual rural properties from the CAR (a critical public dataset for environmental policy evaluations in Brazil; Rajão et al., 2020; Silva et al., 2023a), helps to address significant limitations and supports the development of policy impact evaluations. Although useful, the CAR data have no socioeconomic information about landowners (e.g., income, farm credit access, or level of education), which would be key for understanding rural-to-landscape level dynamics of conservation and sustainable land-use practices.

References

1. Abadie, A., Imbens, G. 2006. Large sample properties of matching estimators for average treatment effects. *Econometrica* 74, 235-267. <https://doi.org/10.1111/j.1468-0262.2006.00655.x>
2. Austin, P.C. 2011. An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate Behavioral Research* 46(3), 399–424. <https://doi.org/10.1080/00273171.2011.568786>
3. Bayles, B.R., Brauman, K.A., Adkins, J.N., Allan, B.F., Ellis, A.M., Goldberg, T.L., Golden, C.D., Grigsby-Toussaint, D.S., Myers, S.S., Osofsky, S.A., Ricketts, T.H., Ristaino, J.B. 2016. Ecosystem Services Connect Environmental Change to Human Health Outcomes. *EcoHealth* 13, 443-449. <https://doi.org/10.1007/s10393-016-1137-5>
4. Bolfe, E., Sano, E., Massruhá, S., Victoria, D., Bayma, G., Oliveira, A. 2024. Potential for agricultural expansion in degraded pasture lands in Brazil based on Geospatial Databases. *LAND* 13, 200. <https://doi.org/10.3390/land13020200>

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

5. Brancalion, P.H.S., Meli, P., Tymus, J.R.C., Lenti, F.E.B., Benini, R.M., Silva, A.P.M., Isernhagen, I., Holl, K.D. 2019. What makes ecosystem restoration expensive? A systematic cost assessment of projects in Brazil. *Biological Conservation* 240, 108274.
<https://doi.org/10.1016/j.biocon.2019.108274>
6. Brondizio, E.S., O'Brien, K., Bai, X., et al. 2016. Re-conceptualizing the Anthropocene: A call for collaboration. *Global Environmental Change* 39, 318-327.
<https://doi.org/10.1016/j.gloenvcha.2016.02.006>
7. Curtis, P.G., Slay, C.M., Harris, N.L., et al. 2018. Classifying drivers of global forest loss. *Science* 361, 1108-1111. <https://doi.org/10.1126/science.aau3445>
8. Ferraro, P.J., Simpson, R.D. 2002. The cost-effectiveness of conservation payments. *Land Economics* 78, 339-353. <https://doi.org/10.2307/3146894>
9. Grima, N., Singh, S.J., Smetschka, B., et al., 2016. Payment for Ecosystem Services (PES) in Latin America: analysing the performance of 40 case studies. *Ecosyst. Serv.* 17, 24-32.
<https://doi.org/10.1016/j.ecoser.2015.11.010>
10. Henderson, F., Steiner, A., Farmer, J., Whittam, G. 2020. Challenges of community engagement in a rural area: The impact of flood protection and policy. *Journal of Rural Studies* 73, 225-233.
<https://doi.org/10.1016/j.jrurstud.2019.11.004>
11. Jacob, S. 2024. Navigating the challenges of policy evaluation. *Canadian Public Administration* 67, 282-290. <https://doi.org/10.1111/capa.12571>
12. Januzzi, P.M. 2023. Delineamentos experimentais na avaliação de políticas públicas: usos e abusos. *Estudos em Avaliação Educacional* 34, 9956. <https://doi.org/10.18222/eae.v34.9956>
13. Tacconi, L. 2012. Redefining payments for environmental services. *Ecological Economics* 73, 29-36. <https://doi.org/10.1016/j.ecolecon.2011.09.028>
14. Lambin, E.F., Thorlakson, T. 2018. Sustainability standards: interactions between private actors, civil society, and governments. *Annual Review of Environmental Resources* 46, 6.1-6.25.
<https://doi.org/10.1146/annurev-environ-102017-025931>
15. Lemos, C.M.G., Beyer, H.L., Runting, R. K., Andrade, P.R., Aguiar, A.P.D. 2023. Multicriteria optimization to develop cost-effective pes-schemes to restore multiple environmental benefits in the Brazilian Atlantic Forest. *Ecosystem Services* 60, 101515.
<https://doi.org/10.1016/j.ecoser.2023.101515>

Apoio:

Realização:

Financiamento:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

16. Liu, J., Yang, W. 2013. Integrated assessments of payment for ecosystem services programs. *Proceedings of the National Academy of Sciences* 110, 16297-16298. <https://doi.org/10.1073/pnas.1316036110>
17. MMA (Ministério do Meio Ambiente). 2017. *Recuperação da Vegetação Nativa do Brasil: caracterização das técnicas e estimativas de custo por hectare*. Brasília, 52pp.
18. Oliveira, L.R., et al. 2024. Projeto Conexão Mata Atlântica em São Paulo. SEMIL, São Paulo, 234p. <https://smastr16.blob.core.windows.net/fundacaoflorestal/2024/03/Conexao-Mata-Atlantica-interativo.pdf>
19. Pereira, M.E. 2024. *Trajatórias de reconciliação entre meio ambiente e agricultura: três políticas públicas ambientais no estado de São Paulo (2005-2024)*. TESE de doutorado, Universidade Estadual de Campinas.
20. Rajão, R., Soares-Filho, B., Nunes, F., et al. 2020. The rotten apples of Brazil's agribusiness. *Science* 369, 246-248. <https://doi.org/10.1126/science.aba6646>
21. Rosenbaum, R.R. 2020. *Design of Observational Studies (Second Edition)*. Springer Series in Statistics, 529pp.
22. Santos, C.O., Mesquita, V.V., Parente, L.L., Pinto, A.S., Ferreira, L.G. 2022. Assessing the Wall-to-Wall Spatial and Qualitative Dynamics of the Brazilian Pasturelands 2010-2018, based on the Analysis of the Landsat Data Archive. *Remote Sensing* 14, 1024. <https://doi.org/10.3390/rs14041024>
23. Sekhon, J.S. 2011. Multivariate and Propensity Score Matching Software with Automated Balance Optimization. *Journal of Statistical Software* 42, 1-52. <https://doi.org/10.18637/jss.v042.i07>
24. Silva, R.F.B., Batistella, M., Moran, E. 2018. Regional socioeconomic changes affecting rural area livelihoods and Atlantic Forest transition. *LAND* 7, 125. <https://doi.org/10.3390/land7040125>
25. Silva, R.F.B., Victoria, D.C., Nossack, F.A., Viña, A., Millington, J.D.A., Vieira, S.A., Batistella, M., Moran, E., Liu, J. 2023a. Slow-down of deforestation following a Brazilian forest policy was less effective on private lands than in all conservation areas. *Communications Earth and Environment* 4, 111. <https://doi.org/10.1038/s43247-023-00783-9>
26. Silva, R.F.B., Millington, J.D.A., Viña, A., Dou, Y., Moran, E., Batistella, M., Lapola, D.M., Liu, J. 2023b. Balancing food production with climate change mitigation and biodiversity conservation in the Brazilian Amazon. *Science of the Total Environment* 904, 166681. <https://doi.org/10.1016/j.scitotenv.2023.166681>

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:





XII
ENANPPAS

ENCONTRO NACIONAL
DA ASSOCIAÇÃO NACIONAL
DE PÓS-GRADUAÇÃO E PESQUISA
EM AMBIENTE E SOCIEDADE

COP 30 - ENFRENTAMENTO ÀS DESIGUALDADES SOCIAIS E EMERGÊNCIA CLIMÁTICA

27. Steiner, A., Kimball, L. A., Scanlon, J. 2003. Global governance for the environment and the role of Multilateral Environmental Agreements in conservation. *Oryx* 37, 227-237.
<https://doi.org/10.1017/S0030605303000401>
28. Uehara, T.H.K., Casazza, E.F. 2011. Avaliação da efetividade do Projeto de Recuperação de Matas Ciliares do Estado de São Paulo: uma contribuição ao desenvolvimento de instrumentos de políticas públicas para a conservação da biodiversidade. São Paulo, SMA.
http://www.sigam.ambiente.sp.gov.br/sigam3/Repositorio/378/Documentos/Produtos_Tecnicos_03_Efetividade.pdf
29. Zhou, T., Shen, W., Qiu, X., Chang, H., Yang, H., Yang, W. 2022. Impact evaluation of a payment for ecosystem services program on vegetation quantity and quality restoration in Inner Mongolia. *Journal of Environmental Management* 303, 114113. <https://doi.org/10.1016/j.jenvman.2021.114113>

Apoio:



Realização:



PROGRAMA DE PÓS-GRADUAÇÃO EM
SUSTENTABILIDADE



Financiamento:

