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Take What You Can: Property Rights, Contestability and Conflict

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Abstract

Weak property rights are strongly associated with underdevelopment, low state capacity and civil conflict. In economic models of conflict, outbreaks of violence require two things: the prize must be both valuable and contestable. This paper exploits spatial and temporal variation in contestability of land title to explore the relation between (in)secure property rights and conflict in the Brazilian Amazon. Our estimates suggest that, at the local level, assignment of secure property rights eliminates substantively all land related conflict, even without changes in enforcement. Changes in land use are also consistent with reductions in land related conflict.

Keywords: property rights, land titling, conflict, deforestation
JEL Classifications: O12, Q15, D74, Q23

1 Introduction

Weak property rights are strongly associated with underdevelopment (Acemoglu et al., 2001; Acemoglu and Johnson, 2005). The threat of expropriation by state or non-state actors leads to inefficiently low investment in (contestable) productive assets and inefficiently high investment in guard labour (Besley, 1995; Besley and Ghatak, 2010). Where the state fails to develop a monopoly on violence, weak property rights may lead to civil conflict.

In economic models, for conflict to be profitable two conditions must be satisfied. First, there must be something worth taking—the prize must be valuable.[1] Second, it must be possible to take it—the prize must be contestable.[2] For civil conflict between non-state actors, the second condition captures the ability of the state to enforce and protect property rights.

Much of the micro-oriented empirical conflict literature has focussed on the role of the value of the prize (relative to the outside option).[3] Consequently, despite a prevailing view—backed by cross country evidence (e.g. Fearon and Laitin, 2003)—that weak institutions and ineffective states provide the necessary conditions for conflict, we are still only beginning to unpack the role of specific policies and institutions.

This paper provides evidence for one such institution. Using variation in the municipal share of land with contestable title in the Brazilian Amazon, we show that (in)secure property rights are strongly associated with (land related) conflict. As in many developing countries (USAID, 2013), land related conflict is widespread in the Brazilian Amazon. Between 1997 and 2010 at least 280 murders, and many more lesser events are directly attributable to land disputes. Our results suggest that weak property rights, and the resulting contestability of land title, is a primary cause of this conflict. Indeed, we cannot reject the hypothesis that, *at the municipal*

[1] A lower (opportunity) cost of conflict (Collier and Hoeffler, 2004; Chassang and Miquel, 2009), is the flip side of a bigger prize, and would be expected to have the same effect.

[2] In models of conflict as contest functions (e.g. Grossman, 1991; Skaperdas, 1992; Hirshleifer, 1995; Fearon, 2008), contestability would speak to the mapping of conflict 'effort' into success.

[3] For the effect of shocks to the value of the outside option see e.g. Miguel et al. (2004); Hidalgo et al. (2010); Vanden Eynde (2011); Ferrara and Harari (2013), for the value of the prize see e.g. Dube and Vargas (2013); Berman and Couttenier (2013); Nunn and Qian (2014); Bazzi and Blattman (2014). The results of Hidalgo et al. are of particular interest for this study: squatting increases in Brazil when the value of the outside option is low.

level, substantively all land related violence is due to insecure titling. However, because our empirical strategy is a comparison across municipalities over time, and much of the Amazon remains contestable, our results may not indicate large falls in overall conflict. It is a possible that some conflict was diverted to places where property rights remained insecure—our evidence will be suggestive of this.

Contestability of property rights over land is enshrined into the Brazilian constitution. Land not in 'productive use' is vulnerable to invasion by squatters, who can develop the land and appeal to the government for title.[4] We proxy for the amount of contestable land in a municipality by exploiting the expansion of ecological and protected areas. Once land is protected, it fulfils the productive use requirement, and is thus no longer contestable—even in the absence of economic activity. We construct a new panel for 1997 to 2010, which provides the share of land under protection for the 792 municipalities in the Amazon states. During this period, the share of land under some sort of protection in these municipalities increased markedly, from 16% to 44%, providing substantial variation in municipal level availability of contestable land.

Because the placement of protected areas may be endogenous—indeed, many protected areas were explicitly placed to prevent further encroachment along the South East Amazon's 'arc of deforestation'—we develop a quasi-event study methodology that exploits variation in protection provided by individual protected areas that span multiple municipalities. For the intuition behind this approach, consider a protected area that straddles two municipalities, A and B, but covers a large portion of A and a small portion of B. We compare the trajectory of violence in these municipalities before and after the protected area is established. As property rights are no longer contestable in a large portion of A, we would expect violence in A to fall relative to B after establishment. Zooming in on the establishment of individual protected areas in this way substantially relaxes the identification assumption. All that is required is that these neighbouring municipalities would have followed parallel trends in land conflict if the areas had never been established. Because municipalities are relatively small, neighbouring municipalities are similar in terms of

[4] Mandates that property must fulfil a 'social function' are common. See, for example, Article 14 of Germany's constitution. Similar provisions can be found in many European, and most Latin American, constitutions. Under common law, laws relating to 'Adverse Possession' (squatters rights) often perform a similar function.

land endowments, distance to the Amazon frontier, enforcement and reporting technology, and so provide a plausible counterfactual. This approach also allows us to provide evidence in support of the key parallel trends assumption.

While land related conflict is strongly predicted by the availability of contestable land, there is no detectable relationship with non-land related violence (proxied by homicides). We also do not observe differential changes in economic activity or an increase in environmental enforcement efforts (proxied by the number of fines written for environmental infractions). The changes in land conflict do not appear to have been a by-product of general changes in violence, the increased presence of park rangers or differential effects on economic activity that establishing a protected area might entail.

We also provide suggestive evidence that other inputs into the production process of land conflict increase. In order to gain land title, settlers must clear the land and put it into productive use. Deforestation, and particularly permanent deforestation and agricultural conversion, is a key input into land conflict. Using high resolution land cover data, we verify that protection is associated with an increase in forest cover. We then use sequences of land cover data to provide evidence that protection is particularly associated with falls in 'permanent' deforestation, the type of deforestation associated with establishing title. Conversely, short run deforestation of the type associated with illegal logging, single season pasture and other temporary activities increases. These results are consistent with falls in settler activity in protected areas, and suggest a mechanism by which protected areas may have been successful in reducing deforestation despite limited enforcement.

This paper is most directly related to a recent literature exploring how specific institutions and policies affect civil conflict. For instance, Fetzer (2013) explores how social insurance can mitigate 'opportunity cost' type violence by providing state-contingent payoffs in the event of adverse productivity shocks; Dell (2015) shows that anti drug trafficking activities can create a power vacuum that contribute to conflict between gangs; Bazzi and Gudgeon (2015) show how redistricting can reduce violence by reducing ethnic polarisation; and Vanden Eynde (2015) demonstrates that governments respond to fiscal incentives by cracking down on dissidents. By focussing on land property rights in the Brazilian Amazon, this paper is closely related to Alston et al. (1999, 2000), which show that, in the cross section, the presence of settlers and a government agency that assists settlers in claiming title are correlated with land conflict in Brazil. Our results complement and improve on these findings by exploring the effect of property rights over land in a robust empirical framework.

This paper is also related to the large literature exploring the microeconomics of property rights with relation to credit (Besley, 1995; Field and Torero, 2006; Besley et al., 2012), investment (Place and Hazell, 1993; Jacoby et al., 2002; Goldstein and Udry, 2008) and, particularly, guard labour (Field, 2007). Unlike these papers, we focus directly on the link between property rights and conflict—an essential implicit ingredient in these papers. Our results suggest that, in addition to providing economic benefits, secure property rights are an integral function of an effective and peaceful state, and that even in the presence of a relatively well functioning government, failure to secure and define monopoly rights can undermine the states monopoly on violence. Moreover, they suggest that assigning property rights can reduce conflict—even in the absence of additional enforcement.

Finally, the paper makes a contribution to a growing literature that demonstrates how political and economic factors shape the demand for deforestation. For instance, Burgess et al. (2012) suggest, that a rent extraction incentives of local politicians drive deforestation in Indonesia; Assunção and Gandour (2013) suggests that part of the recent decline in Amazon deforestation may be attributable to a conditional rural credit program; Gandour (2013) shows that falls in the cost of monitoring and enforcement, thanks to almost real-time deforestation data, may have reduced Amazon deforestation dramatically. Our paper contributes to this literature by highlighting the unintended consequences of redistributive land reform policies in driving deforestation.

The remainder of the paper proceeds as follows. Section 2 provides background on land conflict, property rights and protected areas in Brazil. Section 3 provides a brief description of the data and how it was constructed, with more detail provided in Online Appendix A. Section 4 provides the empirical strategy and results. Section 5 concludes.

2 Background

2.1 Land Ownership and Conflict

Land ownership in Brazil is highly concentrated. Just 3% of the population own more than two-thirds of all arable land and land inequality is the highest of the eighteen developing countries in Griffin et al. (2002). The high concentration of land ownership is a lasting consequence of colonial land policy. Grants of large estates to colonialists, under a system similar to feudalism, were later converted into private holdings. Primogeniture ensured that land ownership did not fragment over time. After independence, land could be purchased directly from the state or through secondary markets, but for a long time, sales by the state were restricted to the elite.

Perhaps in response to high levels of inequality, organisations in favour of land reform, such as the Brazil Landless Rural Workers Movement, have become increasingly popular and influential. The text of the current (and previous) constitutions reflect this popular demand for land reform; requiring that land be adequately and rationally used in order to fulfil its 'social function'. If land is not adequately used, it is vulnerable to invasion by squatters, who are able to appeal for use rights after a year of productive use, and title after five years. The threshold for productive use is vaguely defined (and varies across space), but in the Amazon it certainly requires a significant share of land to be cleared.

The expropriation of land is managed by the National Institute of Colonisation and Agrarian Reform (INCRA). To obtain title and use rights, squatters must apply to INCRA. The extent of INCRA's activities are limited by budgetary constraints—chiefly the requirement that INCRA compensate incumbent landowners at 'market rates'. Nevertheless, since 1988, INCRA have settled over a million households on more than 75 million hectares of land. In many cases, squatting is an entrepreneurial act. According to de Almeida and Campari (1996), settlers often move ahead of the Amazon frontier, clear land and develop a legal claim, before ultimately selling the land to commercial ranchers as nearby infrastructure improves. For these squatters, gaining title is central to their business model.

Despite the requirement that landowners be compensated for their loss, the involuntary nature of expropriations, and often inadequate level of compensation, mean that land invasions have the potential to create conflict between squatters and incumbent landowners. For instance, Schmink and Wood (1992) argues that pioneer settlers' lack of property rights makes them vulnerable to force used by ranchers who also want to establish a claim to land. Of particular relevance to the present study are Alston et al. (1999, 2000), which show that the presence of INCRA, the agency which grants title to settlers, is strongly associated with more violence in the cross section, suggesting that fear of losing title may exacerbate conflict. However, because the presence of INCRA is endogenous to the presence of settlers, and other factors associated with land conflict, it is not clear the extent to which the relationship is causal or how important it is as an overall driver of conflict.

2.2 Protected Areas in the Brazilian Amazon

The Amazon is among the last remaining ecosystems not subject to anthropogenic changes. It is also a major carbon trap, absorbing 2.2 billion tons of CO2 each year (Espírito-Santo et al., 2014). If climate change and biodiversity loss are to be minimised, limiting Amazon forest loss will be crucial. Despite this, until relatively recently, the prevailing view in Brazil was that the Amazon was a frontier to be conquered and incorporated into the productive sector (Andersen et al., 2002; Angelsen, 2010).

In recent years, Brazilian policy towards the Amazon has focussed on protection rather than exploitation. The share of Amazon land that private landowners are legally required to keep forested was increased to 80% in 1996 (with little immediate impact). Large swathes of the Amazon have been designated as ecologically or tribally protected.[5] The establishment of the Brazilian Forestry Service (Serviço Florestal Brasileiro) in 2006, improved satellite monitoring, and the blacklisting of municipalities with excessive deforestation (Cisneros et al., 2015) have led to more effective enforcement. Together, these policies seem to have substantially reduced

[5]While tribal protection does not *de jure* provide as stringent formal protection as some forms of ecological areas, it does close the land to settlers and ranchers and curtail resource extraction. Nolte et al. (2013) finds that tribal protection is more effective than ecological protection, suggesting that the presence of tribes aid enforcement.

the rate of deforestation; official (PRODES) figures indicate virgin forest loss declined from around 13,000km^2 in 1997 to 7,000km^2 in 2010.[6]

Protection and Contestability. This paper will exploit a side effect of protection: that when land is protected, title is effectively secured. This happens because when land is protected for ecological purposes, it is automatically considered to satisfy its 'social function', even in the absence of economic activity. Land clearance no longer provides squatters with a legal claim on the land, and hence protection 'eliminates the expectation of future possible legalisation of land tenure' (Senior official in charge of deforestation control cited in Abranches, 2013, p. 25). Similarly, when land is tribally protected, indigenous groups are granted exclusive rights over land use, although not underlying mineral rights, and claims by non-indigenous third parties are annulled (Hutchison et al., 2006, p.13). At a municipal level then, an increase in either indigenous or environmental protection represents a reduction in the availability of land with contestable title.

In the results, we will show that falls in the amount of land with contestable title in a municipality (via increases in protected area) are associated with relative declines in land related violence. Full details of the empirical strategies and identification assumptions will be provided later. However, a discussion of how protected areas are established will aid in understanding the threats to identification and for interpreting our results.

Where gets Protected. Our empirical strategy will exploit the expansion of protected areas, and hence changes in the amount of land with insecure property rights, to explore the effect of insecure property rights on violence. Understanding how protected areas were placed will be crucial for the interpretation of the results, as non-random placement will create the potential for bias.

The principle stated reason for ecological protection is the preservation of forest and forest ecosystems (and most evidence suggests that they have been successful in this, e.g. Laurance and Albernaz, 2002; Nepstad et al., 2006; Nolte et al., 2013). However, because planners have used ecological (and most likely, economic, An-

[6] This overall trend disguises a sharp initial increase in deforestation to 2004, followed by an even sharper subsequent decline.

derson et al., 2015) criteria to decide where to place protected areas, they are not likely to have been randomly assigned.

The principles underpinning the expansion of the system of ecologically protected areas were outlined in proposals emerging from the 1999 workshop on the establishment of protected areas (Capobianco et al., 2001). Two principles were emphasised: protected areas should constrain the advance of the Amazon frontier and/or protect parts of the Amazon of particular ecological value. While specific recommendations for the location of protected areas were not not closely followed, the principles survived. New protected areas have encircled encroaching deforestation near the Amazon river and in the South-East Amazon (see figure 3).

The systematic placement of protected areas in the path of encroaching deforestation could downward bias our estimates of the effect of insecure property rights on violence. As the frontier approached, land will have become more valuable, and hence more desirable to squatters and incumbent landowners, increasing the intensity of conflict. On the other hand, if planners sought to minimise the economic cost of protected areas, they may have been placed in relatively low value locations, biasing our estimates upwards. To mitigate these types of bias, our preferred strategy will exploit variation only from neighbouring municipalities, where underlying desirability is similar.

In some respects, the placement of indigenous areas is more straightforward: they are historic tribal territories. The demarcation of Indian lands is the responsibility Fundaçäo Nacional do Índio (FUNAI), a Brazilian government agency responsible for Indian affairs. The process of demarcation is quite formalised, beginning with an anthropological survey and ending with a presidential decree. In practice, the establishment of tribal areas and their boundaries are frequently contested (Hutchison et al., 2006) and incumbent landowners have sometimes been successful in preventing, or at least delaying, the establishment of tribal lands. As both ecological and indigenous areas both ultimately establish secure property rights, we pool them in our main analysis.[7]

[7]The results in Online Appendix A2, where we show that both types of protected area have a similar effect on conflict, support this pooling.

Process of Environmental Protection. Since 2000, the creation of new protected areas, and the status of existing areas, has been governed by Brazil's National System of Conservation Units (Crawford and Pignataro, 2007). Environmentally protected areas fall into two main types, 'Complete Protection' and 'Sustainable Use'. The regulations for the creation of the areas, and exploitation of resource within, differ by type. However, in all cases settlers are no longer able to develop a claim on title by clearing land.

Before ecological protected areas of any kind can be established, a consultation must be held with the local population and conservation experts. For indigenous reserves, an ethnographic survey is carried out, which results in a proposal for demarcation. Protected areas can be established by federal, state and municipal governments, as well as by private landowners, although, in practice, the overwhelming majority of protected areas are created by state or federal level governments. On establishment, for most types of reserve, any private land is subject to compulsory purchase by government, in principle, at fair market value.[8]

While the precise formula for compensation is not clear, systematic deviations from fair market value could lead to anticipatory effects on land related conflict, as protected areas can be 'proposed' for many years before final approval. If compensation was above (below) the market value of land, we would expect an increase (decrease) in conflict in the run up to establishment. Because of this, we will later be careful to document the absence of a significant anticipatory effect.

In addition to compensation for landowners, some states have implemented fiscal transfers to municipalities which provide ecological services (including having land protected). Of the nine state which encompass the legal Amazon, five currently apportion some revenues in this way. For most municipalities these transfers are a tiny portion of total revenues, so one would not expect a large effect on public service provision. Nevertheless, in Online Appendix B.1, we show that our results are robust to excluding municipalities that could ever have been eligible for these types of transfers.

[8]For some types of sustainable use reserves, landowners may retain title if their plans for the land are consistent with the rules governing that type of area. If not, government must purchase the land at the prevailing rate.

3 Data

The previous section suggested that insecurity of property rights could be an underlying cause of land related conflict in the Brazilian Amazon; that deforesting land may be a key way of obtaining title; and that protected areas may securely assign property rights and hence reduce the scope for conflict. This section describes the data on conflict, deforestation and protection used to explore the importance of these things.

3.1 Conflict Data

We obtain data on land conflict from the annual reports of the Comissão Pastoral da Terra (CPT). The CPT was founded by the Catholic Church to highlight the plight of landless workers, small farmers and squatters. Since 1985, it has published an annual report on land related violence (Conflitos no Campo). This report includes municipal level data on measures of land related conflict, including land related murders, attempted murders, death threats, and other disputes.[9]

We link the data to the municipalities defined in the 2000 census. Because Brazilian municipalities are occasionally subdivided, we assign violence data from municipalities formed after 2000 to their parent municipalities. In the early 1990s, municipality splitting was widespread, so, to maximise the number of comparable units, we focus on years from 1997.

The CPT compile the data from local newspapers and reports from church organisations. As such, the data will inevitably understate the true level of conflict and suffer from reporting error. To increase power, our principle outcome measures will combine types of violent conflict together. To reduce measurement error, our focus will be on the most extreme events. Our most inclusive measure, *escalations*, combines murders, attempted murders and death threats. Our most preferred measure, *violence*, drops death threats to reduce the scope for reporting error. To ensure our results are not driven by a few outlying observations, we also report results for a dummified measure of violence (*any violence*). For reference, we also provide our baseline results for each of the disaggregated measures of violence. Finally,

[9] Further information on the data, and details of how we constructed the panel, are provided in Online Appendix A.1

although not preferred, we present results based on the broadest measure of land conflict published by the CPT, *disputes*, which captures disputes over land boundaries, irrigation and other such conflicts, and is hence most subject to reporting error.

Figure 2 shows the geographic distribution of *violence* (left) and *escalations* (right) across Brazil for the period 1997-2010: violence was overwhelmingly concentrated in the Amazon region, so we focus on municipalities in the Amazon states.[10] Summary statistics are included in Table 1. Land related violence was a common occurrence in our sample: there were an average of 21 land related murders per year, a similar number of land related attempted murders and many more death threats.

3.2 Protected Areas

To identify the expansion of protected areas in Brazil, we use digital maps detailing the location and original boundaries of each protected area and the date the protected area was established. We combine this data with the 2000 census municipal boundaries to produce a municipal level panel. The data allow us to calculate the share of municipal land area that is protected for each year up to 2010. Details of sources, and how the data were created, are provided in Online Appendix A.2.

There was a substantial increase in the share of the Amazon under ecological or tribal protection over our sample period. Figure 1 plots the protected share of land over time. In 1997 16% of the Amazon region was under protection, by 2010 44% was. Figure 3 shows which areas were protected. Not surprisingly, protection was concentrated in forested areas.

As both ecological and tribal protection effectively establish secure property rights, we pool them in the main analysis. Nevertheless, in Online Appendix Table A2 we provide our main results for indigenous and ecological areas separately; they are very similar to the pooled results.

3.3 Forest Cover and Deforestation

Deforestation and agricultural conversion is the primary means of establishing legal claim over land. Protected areas reduce the amount of land where title can

[10] Acre, Amazonas, Amapa, Maranhao, Mato Grosso, Para, Rondonia, Roraima and Tocantins.

be claimed and, in principle, increase the penalties associated with exploitation of forest resources. This should reduce deforestation, but particularly—because enforcement is weak—permanent deforestation, which is more associated with attempts to gain or retain land title.

To explore the impact of protection on land use change we use MODIS land cover data (Channan et al., 2014). MODIS classifies land cover into 19 categories, at a 500m resolution, for each year since 2001. We collapse the 19 raw categories into 4 groups, 'forest' (MODIS categories 1-5), 'shrubland' and grassland, (6-10), 'cropland' (12 and 14), and 'other' (water and urban areas). In the Amazon region, 97% of pixel-years are either forested, shrubland or cropland. We attach the MODIS data, and a large quantity of other geographic data including information on protected status, to 793,928 randomly drawn coordinates and generate a coordinate level panel of land cover data.

4 Empirical Strategy and Results

In this section, we first consider how the availability of land with contestable property rights drives land related conflict in the Amazon. Our results will indicate that, *at the local level*, substantively all land related violence appears to be a consequence of weakly defined property rights. (Although, our results will also suggest that at least some local conflict was diverted elsewhere.) We then turn to a key input into land related conflict, land clearance, to provide suggestive corroborating evidence of a decline in conflict by considering changes in land use patterns. We show that while protection appears to reduce deforestation, it does so only by preventing the permanent deforestation required to obtain and retain title—temporary deforestation actually increases.

4.1 Contestable Land and Conflict

Panel Specification. We use two main empirical specification to explore how poorly defined property rights contribute to land conflict in Brazil. The first is based on the full panel of Amazon region municipalities. We estimate the following OLS specification:

$$Y_{ijt} = \alpha_i + \gamma_{jt} + \beta ProtectedShare_{ijt} + \epsilon_{ijt} \tag{1}$$

Where Y_{ijt} is some measure of land conflict, α_i is a municipality fixed effect, γ_{jt} is a state-by-time fixed effect. The inclusion of this rich set of fixed effects non-parametrically controls for time invariant differences in municipal levels of conflict, and state specific economic, cultural and policy changes over time. As a consequence, this specification exploits only within state variation. As protection securely assigns property rights, the protected share of land provides a time varying proxy for the municipal level (inverse) share of land with contestable title.

Panel Results. Columns 1-3 of Table 2 Panel A report results for our preferred aggregated measures of violence: escalation, violence, and a dummy indicating violence > 0. For reference, columns 4-6 provide results for disaggregated measures of violence. Column 7 contains results for all recorded disputes, including minor incidents.

For each outcome, an increase in the share of land under protection—and hence a decrease in the availability of contestable land—is associated with lower levels of land conflict. The estimated effects are large, similar in magnitude (relative to the mean), and are generally consistent with *local* conflict being completely driven by poorly defined property rights. Two out of three of our preferred 'aggregated violence' measures, which maximise power, are significant at the 5% level. Not surprisingly, disaggregating the measures of violence reduces statistical power, and only the effect on attempted murders remains statistically significant (and this at the 10% level). The effect on disputes, which may suffer from quite uneven reporting, is also insignificant.

To interpret these estimates as causal, we require that—conditional on the fixed effects—the error term is uncorrelated with the share of protected land. In practice, this assumption has two components. First, that protection is assigned in an 'as good as random' fashion. Second, that the reporting of conflict is not itself endogenous to the protected share of land. The first would be violated if, for example, changes in protection and conflict were both consequences of an advancing

Amazon frontier (the distance of the forest from undeveloped land). The second would be violated if, for example, protected areas made local newspapers differently interested in land related issues.

We can reassure ourselves somewhat by exploring the extent to which the estimated effect of secure property rights changes when estimated under different specifications. In Online Appendix Table A1, we provide results for specifications with less demanding time fixed effects and/or municipality specific time trends. In each case the estimated coefficients are similar, mitigating concerns over the presence of geographically correlated shocks or differential municipal trends.

Quasi-Event Study Specification. Despite the robustness of the results to changes in specification, concerns over whether the documented relationship is a causal one must remain. To help establish causality, we refine our approach, and significantly relax the identification assumption, by exploiting the geographic features of the data.

The intuition behind this 'quasi-event' approach is straightforward. Many protected areas have boundaries which span more than one protected area. We think of each of these protected areas as an event that treats all intersecting municipalities. These municipalities are not, however, treated equally, and the intensity of treatment varies depending on how much of the municipality is protected. Figure 4 illustrates the approach. The blue areas are four municipalities that are treated by the red protected area: while almost 1/3 of Monte Alegre's land area is protected, only a small share of Obidos' is.

The dataset for the quasi-event study approach is constructed as follows. For each protected area, we identify the set of municipalities where some land is newly protected. We calculate treatment intensity for each municipality, by calculating the share of municipal land protected by that specific area.[11] The conflict data is added, and the dataset stacks the set of municipality-year observations for all protected areas.[12] With this data, we estimate the following difference-in-differences

[11]For consistency with our panel results, we define intensity as the share of land in the municipality that is newly protected by the particular protected area. However, very similar results (modulo scaling effects) are obtained if treatment intensity is defined as the share of unprotected land area protected (see Online Appendix table A3).

[12]Because some municipalities contain parts of more than one protected area the same munici-

specification

$$Y_{ikt} = \alpha_{ik} + \gamma_{kt} + \beta Post \times ShareProtected_{it} + \epsilon_{ikt} \quad (2)$$

where α_{ik} is a municipality-by-protected area fixed effect and γ_{kt} is a protected area-by-time fixed effect.

The identification assumption is that of parallel trends: in the absence of the establishment of the protected area, changes in conflict in municipalities more affected by the protected area would not have been different to less affected neighbouring municipalities. The demanding set of fixed effects employed mean we are exploiting only variation that exists within sets of municipalities sharing common protected areas (like the four illustrated in figure 4). On average, protected areas (or expansions of protected areas) that span more than one municipality intersect with 2.98 municipalities. There are 209 protected areas of this type in our data. Because municipalities are small, the areas we are zooming in on are extremely similar geographically, and are much more likely to have comparable data reporting quality due to the presence of shared local media and church groups. One weakness of this approach is that, to the extent that land invasions are diverted to nearby municipalities, the results will overstate the impact of well defined property rights on land related conflict.[13] Indeed, we will present evidence suggestive of exactly this type of diversionary effect.

Quasi-Event Study Results. Table 2 Panel B contains the results. They are broadly consistent with those estimated in the panel setting: clearly assigning property rights dramatically reduces land related conflict. The estimated coefficients are larger (in absolute terms) than those estimated in the panel specification, suggesting that either some of the effect of protection is to divert conflict into nearby unprotected areas or that protected areas tend to be placed in areas where conflict would otherwise increase (like the Amazon frontier). Later results will be indicative of both effects. Coefficients on our preferred aggregate outcomes are significant

pality can appear in the data more than once. To obtain consistent standard errors in spite of this constructed auto-correlation, we two-way cluster our errors at both the municipality and 'protected area' level.

[13]While the basic panel specification is also likely to suffer from this, the effects are greatly exacerbated by using only neighbouring municipalities as controls.

at the 5% level or better, while those on disaggregated measures are significant at at least the 10% level.

It is impossible to directly verify whether the parallel trends assumption required for a causal interpretation of the coefficients would have held in the absence of the establishment of protected areas. We can, however, evaluate whether parallel trends held before establishment. To this end, we estimate coefficients on the area protected by specific protected areas for the seven years surrounding establishment:

$$Y_{ikt} = \alpha_{ik} + \gamma_{kt} + \sum_{s=-2}^{3} \beta_s \left(\mathit{ShareProtected}_i \times \mathbb{1}[\mathit{TimeToProtection} = s] \right) + \epsilon_{ikt} \quad (3)$$

Here, the β_s captures the correlation between the share of land to be protected and violence in the years before and after the introduction of the protected area. We focus on protected areas where outcome data is available for at least three years before and after establishment, and drop observations outside this seven-year window—each coefficient is estimated on a consistent set of protected areas.

The coefficients for our three main measures are plotted in figure 5. Not surprisingly, the estimated coefficients on each year are not generally significant. However, for each measure of violence the pattern is clear. There were no differential trends in violence before or after the establishment of the protected area, but there was a pronounced fall in violence around the time of establishment. Because landowners are compensated for conversion of land to protected status, conflict over land rights continues right up to demarcation.

The large effect size we observe when zooming into neighbouring municipalities suggests that securing property rights in one location may lead to conflict in nearby locations. One natural question is, how far do these local spillovers extend? To explore this, we re-estimate our event study specification, but expand the 'control' region, by first adding the municipalities adjacent to the intersecting municipalities, *first degree adjacency*, and then second, adding the municipalities that are adjacent to the adjacent municipalities, *second degree adjacency*. We also re-estimate our panel specification with a variable indicating the share of land that is unprotected but less than 10km from the boundary of a protected area.

Table 3 contains these results. Panel A contains the panel results, the estimated coefficients on the share of land within 10km of a protected area are suggestive of local spillovers, but the coefficients are imprecisely estimated and not statistically significant.[14] Panels B and C extend the event study control region to first and second degree adjacent municipalities. The estimated coefficients halve in absolute size in both specifications. There may be significant local redirection of violence, but the effect declines relatively rapidly with distance. This is consistent with either the majority of the redirection taking place over relatively short distances, or with many settlers not having strong preferences over location. Given the coordinating role played by organisations such as the *Movimento dos Trabalhadores Sem Terra*, which help direct settlers to suitable locations and coordinate large groups of settlers, we should not discount the latter possibility. These diversionary effects of local property rights on conflict are consistent with the negative externalities associated with mafia protection of property rights (Bandiera, 2003) and the dislocating effects of anti drug-trafficking activity (Dell, 2015).

Effects through other channels? We argue that the changes in land related conflict observed are due to decline in the availability of contestable land. However, if the establishment of protected areas was associated with improved policing, changes in economic activity, or more environmental enforcement, then this could suggest other factors at work. In Table 4 we document that this does not appear to have been the case.

Columns 1 and 2 indicate that there was no statistically significant effect on either homicides in general, or homicides of indigenous persons in particular, and the estimated coefficients are of opposite sign. These results do not indicate an accompanying improvement in general law and order. (Unfortunately, data on other crimes are not available at the municipal level.)

Columns 3 and 4 indicate no statistically significant effect on fines levied by the environmental protection agency (IBAMA). Fines levied in the Amazon typically sanction violations of the forest code. The vast majority of the fines are never collected, though the fact fines are levied is suggestive of the degree of state presence. We distinguish between the total number of fines and the number of fines classified as 'flora' violations (which constitute 75% of all fines in the Amazon). Notably, and

[14]The average municipality has 13% of land within 10km of a protected area, compared to 20% inside one. Other sized buffer regions had similar inconclusive effects (not reported).

despite statistical insignificance, the estimated effect in the panel specification is large and positive compared to the mean, whereas in the event-study specification it is relatively small and negative. This difference is consistent with the Brazilian governments stated policy of placing protected areas to encircle encroaching deforestation (and, consequently, with our panel estimates of the effect of protection on conflict likely being too small in absolute terms).

Columns 5 and 6 indicate no statistically significant effects on either municipal GDP, or municipal agricultural GDP. Protection is not accompanied by significant economic changes. As with enforcement, the estimated coefficients are positive in the panel specification and negative in the quasi-event specification, which is again suggestive of protected areas being placed to constrain encroaching deforestation.[15]

In section 2, we noted that some states provide fiscal transfers to municipal governments based on the amount of land under protection. We show that our results are not driven by these transfers in Online Appendix Section B.1. From 2007 some municipalities were 'blacklisted' on the basis of poor performance in environmental protection, one consequence of which is that there was greater subsequent focus on deforestation and land policy in these municipalities. In Online Appendix Table A5, we show that our results are robust to excluding these counties. Lastly, Alston et al. (1999, 2000) emphasise the crucial role of INCRA in facilitating land conflict and property rights uncertainty. In Online Appendix Section B.2, we show that our results are not driven by an association with protection and INCRA activities.

4.2 Protection, Deforestation and Patterns of Land Use Change

As we have seen, weakly defined property rights appear to be an important contributory factor to Brazil's high levels of land related conflict. As discussed in section 2, clearing land is a key way settlers establish property rights and a key way landowners can prevent expropriation. Thus, we would expect increases in land conflict to be accompanied by increased deforestation (and vice versa). In this section we show that protection is associated with decreased deforestation. Of course, despite anecdotal evidence that land title, rather than farmland, is often the

[15]Given that protection is intended to limit economic exploitation of the forest, the true effect ought to be weakly negative.

principal aim of settlers (de Almeida and Campari, 1996), and that South American deforestation is driven overwhelmingly by land conversion and not logging (Ferretti-Gallon and Busch, 2014), protection may also discourage deforestation resulting from other motivations.

However, while a fall in settler activity would be expected to reduce deforestation on aggregate, it is particularly expected to reduce permanent deforestation. Logging (both illegal and legal) and short term pasturing often result in only temporary deforestation. Settlers as well as landowners need to clear forest in order to maintain 'productive use'. The different types of resource exploitation should result in distinctive land cover change patterns. We provide evidence consistent with this hypothesis: while protected areas substantially reduce the incidence of 'permanent' deforestation, we observe an increase in temporary deforestation. Protected areas appear to discourage long term settlers, plausibly by removing the possibility of gaining land tenure, while low enforcement capacity limits the extent to which they can prevent illegal loggers, and short term ranchers.[16]

Protection and Forest Cover. We estimate the effect of protection on forest cover in a 'long difference' specification. The unit of observation is a coordinate c. We drew a random sample of 793,928 coordinates from across the Amazon and attached them to the land cover and protected area data described in section 3. We compare changes in forest cover F_{ci}^{t} between 2001-2010 to changes in protected status, using both matched and unmatched samples. Our baseline estimating equation is

$$\Delta F_{ci} = \gamma_i + \beta \times \Delta ProtectedArea_{ci} + \epsilon_{ci} \tag{4}$$

Where $\Delta F_{ci} = F_{ci}^{2010} - F_{ci}^{2001}$ and F_{ci}^{t} is a dummy indicating whether a coordinate is forested at time t. We include coordinate and either state or municipality γ_i fixed effects, so we are exploiting only within-state or within-municipality variation.

Table 5 columns 1 and 2, contain the unmatched estimates. In practice, we only observe transitions from unprotected to protected status. Coordinates that

[16]For example, on average there is just one warden for every 1872km^2 of protected area (p. 35, Veríssimo, 2011), and the majority of protected areas are managed inadequately (Onaga and Drumond, 2007).

are protected are around 1 percentage point more likely to remain forested (or become reforested) than coordinates whose protection status does not change. This is around half the baseline rate of deforestation. The estimates are significant at the 1% level.

Because protection is not randomly assigned, it is possible that selection into protected status is biasing the results. As with conflict, it is not clear what the expected direction of bias should be. If areas are protected because they were very remote, and had low economic value, we would expect the estimates to overstate the effectiveness of protected areas in reducing deforestation. Conversely, if areas are protected because they are at immediate risk of deforestation, the estimated effectiveness of protected areas would be understated. To mitigate these types of bias, we provide additional results for a matched subsample of coordinates. We match (without replacement) coordinates whose protection status changes between 2001 and 2010 (treated coordinates) with coordinates whose protected status never changes (control coordinates) based on their propensity score, or estimated probability of being in each group. We retain observations where the absolute difference in propensity score between the matched pairs is less than 0.001.[17]

Propensity scores are estimated with probit using a large number of geographic and economic inputs. Online Appendix table A9 contains the results of the matching regression. Coordinates whose protection status changed tended to be at intermediate distances from human habitation (as proxied by distance from nightlights), closer to rivers, further north-west, and be expected to have relatively high value agricultural yields. On this basis, it is unclear whether we should expect protected areas to be more or less at risk from deforestation. Nevertheless, summary statistics in Table 1 highlight that the average coordinate that was protected between 2001 and 2010 is quite different from the average unprotected coordinate; 88% of coordinates in our matched sample are forested, while just 68% are in the full sample.

Table 5 columns 3 to 6, contain the matched sample estimates. If anything, protection is associated with a slightly larger reduction in deforestation in the matched sample. The average rate of deforestation in the matched sample is much lower

[17]We show that the results are robust to other choices of thresholds in Online Appendix Tables A10 and A11.

than the unmatched sample, and the coefficients indicate that forest cover actually increased in protected areas. In columns 5 and 6 we also include matched-pair fixed effects, which allow for non-parametric differential trends by propensity score and increase precision. The matched estimates are significant at the 1% level. Our findings that protection reduces deforestation are consistent with those of previous studies (e.g. Nepstad et al., 2006; Nolte et al., 2013).

Temporary or Permanent Deforestation? While not definitively causal, protection is robustly associated with lower levels of deforestation. Given limited enforcement capacity—and no observed increase in enforcement activities after protected areas are established—this is in some sense surprising. However, our conflict results suggest that by removing the possibility of claiming title, protected areas may have reduced the total economic returns to deforestation, even in the absence of strict enforcement.

To claim title, farms must be established and land cleared. However, other uses of the forest, such as logging and short term pasture, do not require permanent deforestation. At the margin, protected areas may discourage permanent deforestation with the aim of obtaining title and encourage other short term land use.

These potential behavioural changes are hard—if not impossible—to measure using standard economic data. Hence, we infer different types of land use by studying longer *sequences* of land use. As a baseline, we classify land use into sequences of length 5. As described in Section 3.3, in a given year a coordinate can be forested F, shrubland S, or cropland C. Four sample sequences could be $FFFFF$, $FSSFF$, $CCCSC$, and $FCCCC$. The first would represent a coordinate that is permanently forested, the second a coordinate that was temporarily deforested, while the third and fourth are consistent with permanent deforestation. There are 243 possible sequences of length five, of which 242 are observed in the data.

To avoid a highly subjective classification of each individual sequence, we use a common machine learning method—k-means clustering—to classify the set of possible sequences into (six) groups of 'similar' sequences using the algorithmic implementation by Hartigan and Wong (1979). We then manually classify each of these groups of sequences as either permanently forested, temporarily deforested or permanently deforested.[18] In addition to removing the human factor from the classification of individual sequences, one advantage of this approach is that we can use the same criteria for sequences of any length, and we show that our results are not specific to picking sequences of length 5 in Online Appendix Table A12. Classifying land use sequences in this way allows us to study the potential behavioural changes at the margin relevant for understanding the results of reduced land related conflict.

The MODIS land cover data covers 2001-2012, so we focus on two five year periods 2001-05 and 2008-12. As before we estimate a differenced specification (comparable to equation 4) including state fixed effects, so we exploit only within state variation. Our outcome variables are differenced sequences i.e. $\Delta S_{ci} = S_{ci}^{2008-12} - S_{ci}^{2001-05}$, where S_{ci}^{t} is a dummy indicating permanent forest cover or temporary deforestation or permanent deforestation. Our differenced protection measure takes the difference between protection status in 2001 and 2008, the first year of each of the five year sequences, rather than between 2001-10.[19] As there are two periods, this specification is equivalent to a standard panel specification with coordinate and state-by-time fixed effects.

The results are contained in Table 6. Columns 1-3 contain results estimated in the full panel of coordinates. Columns 4-6 on the matched set of coordinates.[20] Regardless of the sample, the results are striking. Protection decreases the probability of permanent deforestation by roughly 1 percentage point (somewhat more in the unmatched data, less in the matched data) and this change is significant at the 5% level or greater in both the matched and unmatched samples. This decrease in permanent deforestation is offset by increases in the share of sequences indicating temporary deforestation and permanent forestation of roughly equal size. Half the area that was not permanently deforested was instead subject to temporary deforestation. In the full sample these estimates are significant at at least the 5% level, but only the effect on temporary deforestation is significant (at the 5% level)

[18] A full description of this how we implement this classification is provided in Online Appendix A.3.

[19] The results are robust to differencing by other years, see Online Appendix Table A14.

[20] For consistency with the results of Table 5, we use the same set of matched coordinates. Note however, that not all coordinates whose protection status change between 2001-10, will have their protection status change between 2001-08.

in the matched sample. Compared to the baseline probability of being temporarily or permanently deforested in the matched sample the estimated effects are large. Protection increases the probability of a sequence being temporarily deforested by around 1/3 of the mean, and reduces the probability of permanent deforestation by around 8% of the mean.

Put together, these results suggest that protected areas reduce deforestation, and that they do so by discouraging permanent deforestation. Indeed, consistent with the weak enforcement of protected areas, temporary deforestation actually increases suggesting some substitutability between types of forest exploitation. Given the empirical specification, these results are suggestive rather than definitive. Nevertheless, this pattern is consistent with the idea that protected area reduce deforestation by eliminating the possibility of gaining land title through forest clearance—exactly what one would expect given the effect of protection on violence.

5 Conclusion

This paper provides evidence that insecure property rights are an important force behind Brazil's high levels of land related conflict. We exploited the fact that, at the municipal level, expansion of protected areas reduces the amount of land with contestable title. Regardless of specification, municipalities with less contestable land experienced less land related violence. There was no evidence of accompanying changes in enforcement, non-land related homicides, or prosperity. The setting thus provided a unique opportunity to study the effect of property rights on conflict holding other factors constant. To highlight the mechanism, we showed that protected areas reduce deforestation, but only permanent deforestation—the type of deforestation associated with land related conflict—with temporary deforestation actually increasing. This paper contributes to an emerging literature which explores the effect of specific policies and institutional factors on civil conflict and begins to unpack the robust cross-country correlation between civil conflict and weak institutions.

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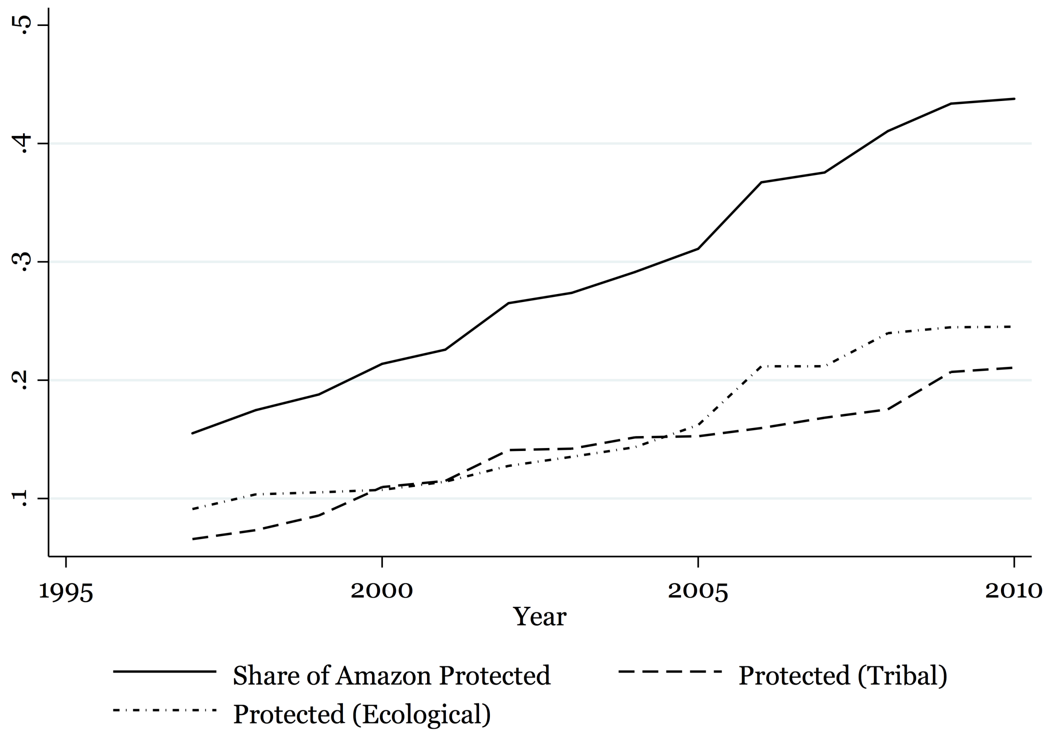

Figure 1: Share of land in the Amazon states under ecological or tribal protection

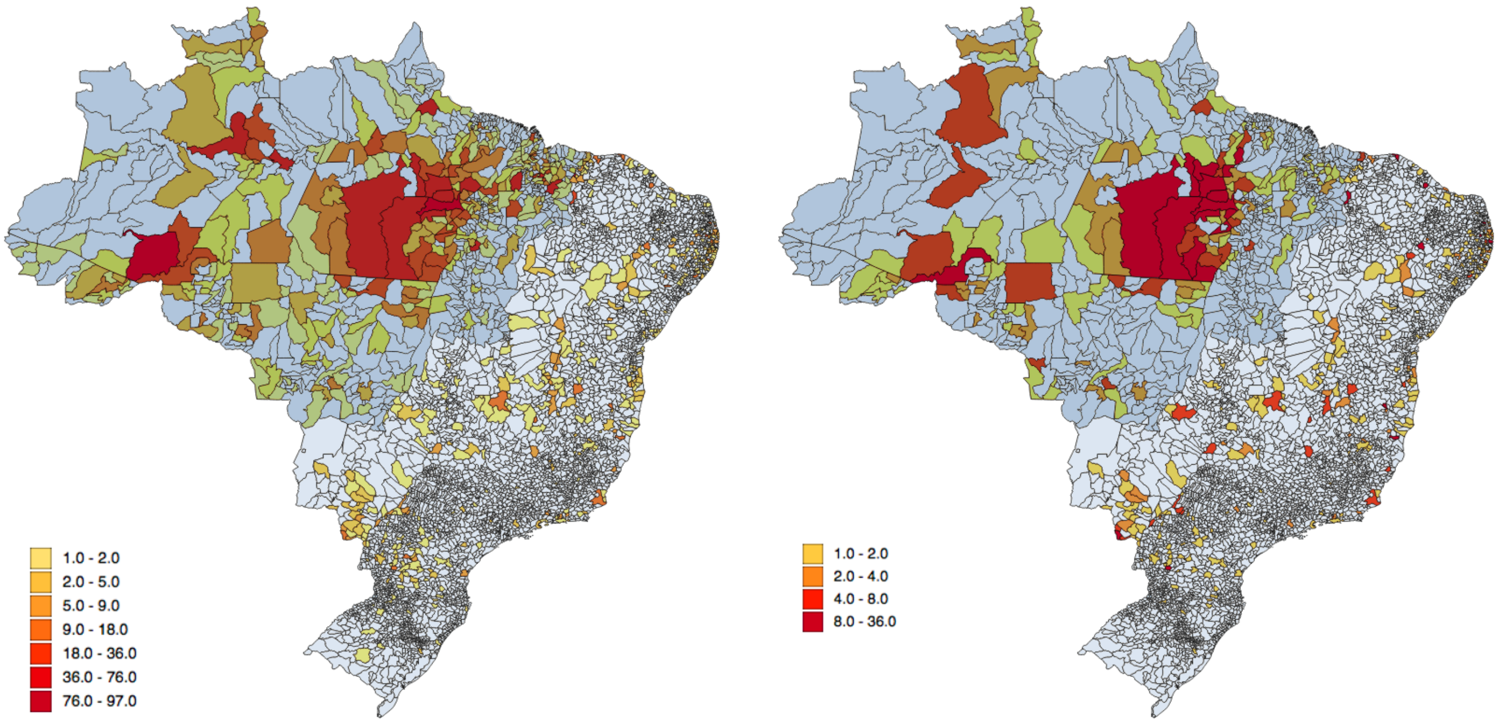

Figure 2: Municipality level counts of *escalations* (left) and *violence* (right) over 1997 to 2010: land related conflict was concentrated in the Amazon states (shaded). Violence is the sum of land related murders and attempted murders, escalations adds death threats.

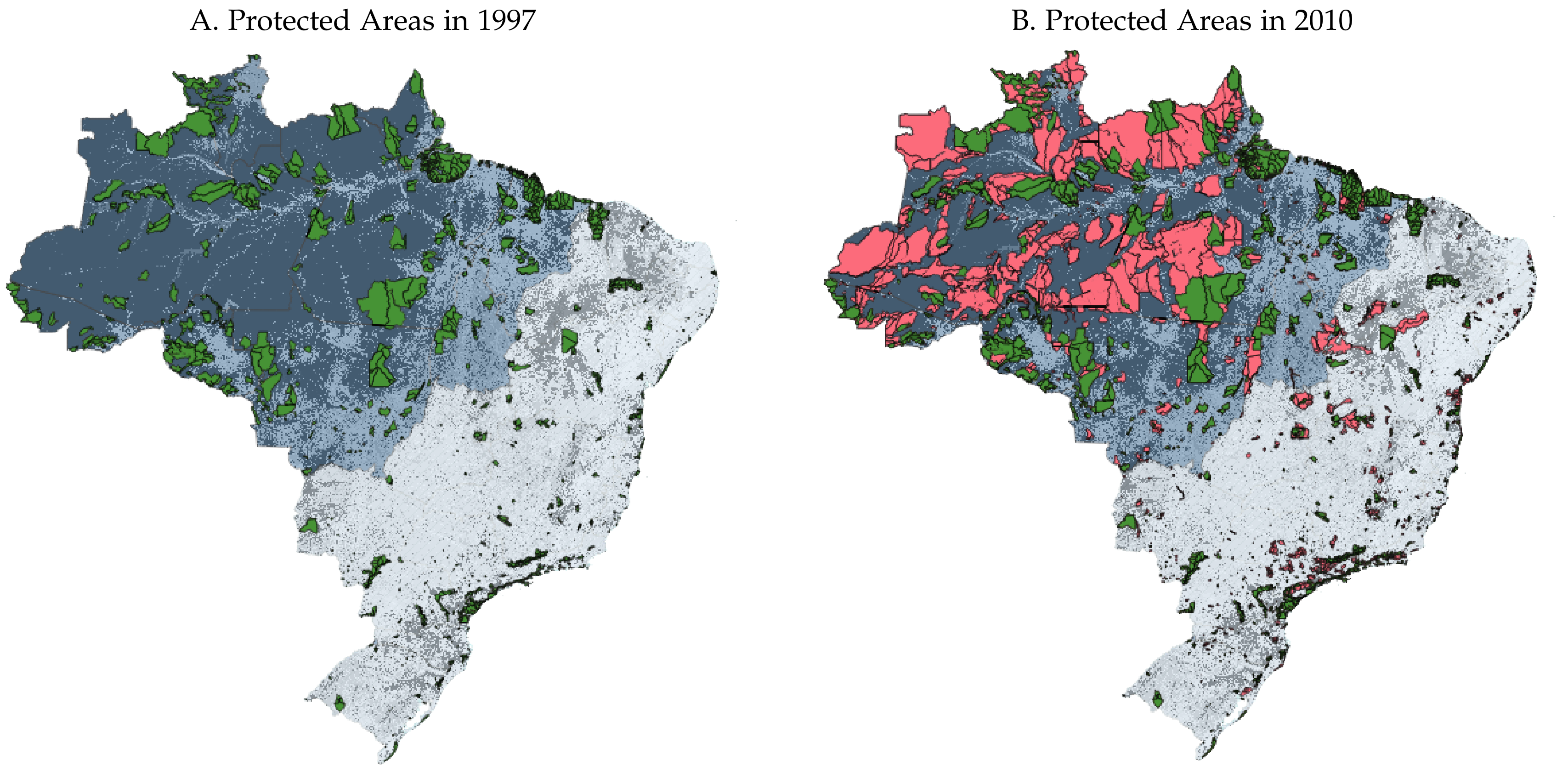

Figure 3: Figures illustrating the expansion of protected areas between 1997 and 2010. The Amazon states are shaded. Forested areas are darkened.

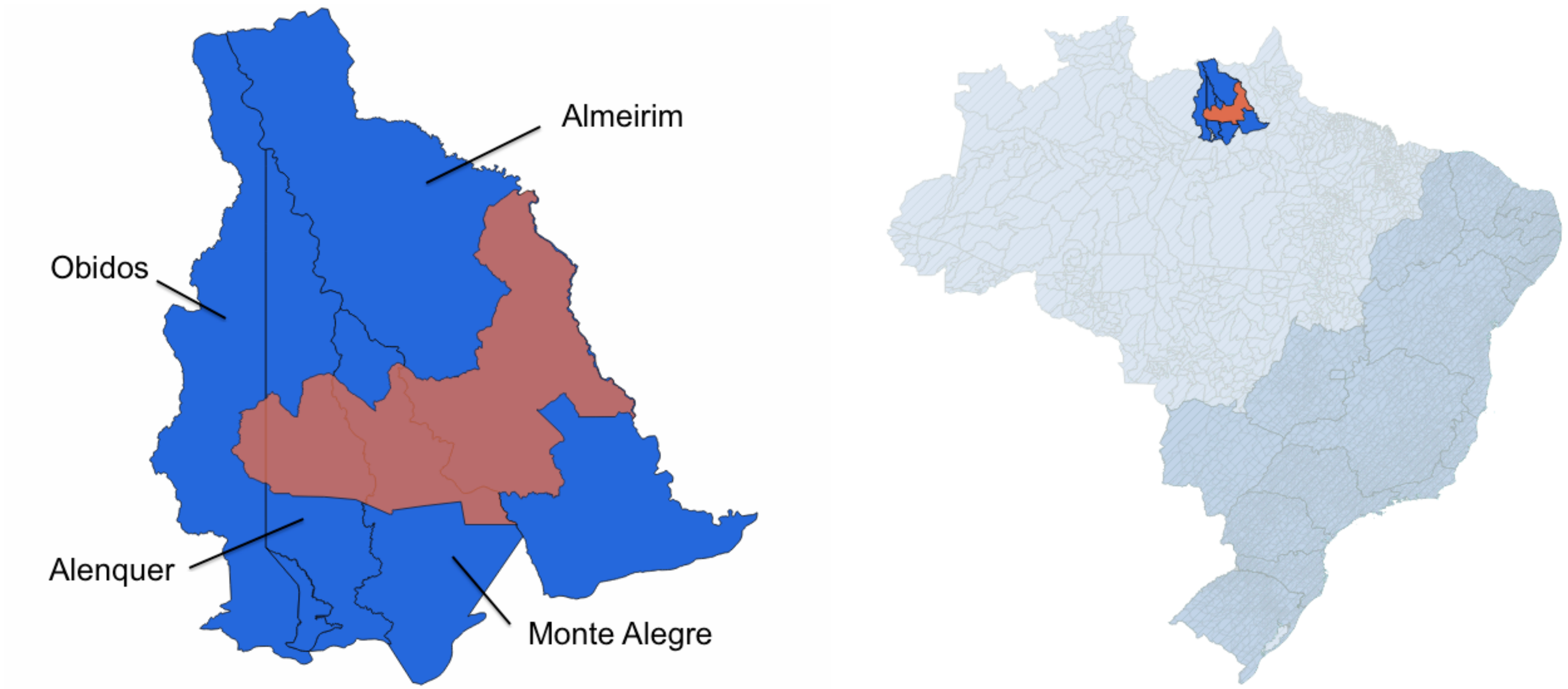

Figure 4: Illustrates the intuition for the quasi-event study specification: we compare municipalities that are differently treated by the same protected area. Here, the blue area is the four municipalities that intersect, and are hence treated by, the red protected area. The red protected area does not treat each municipality equally—Monte Alegre is much more affected then Obidos—and the quasi-event study exploits this differential intensity of treatment and compares conflict before and after the protected area was established.

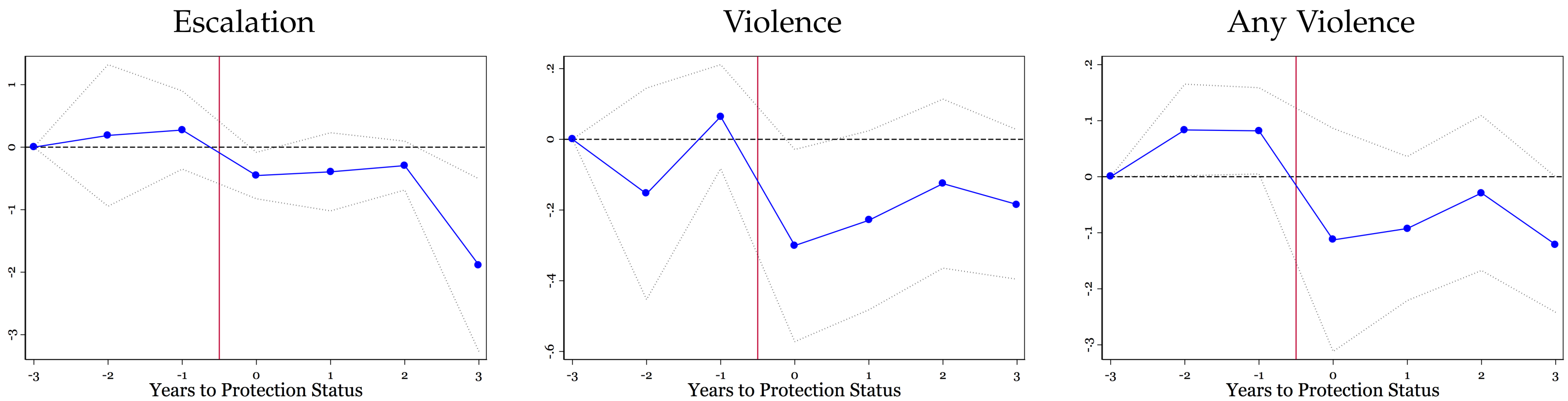

Figure 5: Conflict before and after the establishment of protected areas. The vertical line indicates the introduction of a protected area. The blue line plots OLS estimates of the interaction between the time to the introduction of protected area and the share of the municipality protected. Estimates obtained using the quasi-event specification with a balanced panel of protected areas covering the seven years surrounding the introduction of the protected area. Dotted lines indicate 90% confidence intervals. Errors two-way clustered at the municipality and protected area levels.

Table 1: Selected Summary Statistics

	Mean	s.d.	*N*
Municipality Level Land Conflict Variables			
Escalations	0.173	1.141	11,088
Violence	0.045	0.38	11,088
Violence Dummy	0.024	0.153	11,088
Murders	0.026	0.247	11,088
Attempted Murders	0.019	0.229	11,088
Death Threats	0.128	0.993	11,088
Disputes	0.315	1.114	11,088
Other Municipal Variables			
Homicides for any Reason (all)	6.479	32.35	11,088
Homicides for any Reason (Indigenous)	0.030	0.286	11,088
Environmental Fines Issued (count all)	12.655	42.13	11,088
Environmental Fines Issued (count flora)	9.548	35.023	11,088
Log GDP (1999-2010)	10.918	1.264	9,504
Log Agricultural GDP (1999-2010)	9.572	1.114	9,504
Protected Share of Land (1997)	0.155	0.277	792
Protected Share of Land (2010)	0.243	0.328	792
Coordinate Level Data			
Forested (2001-2010)	0.683	0.465	7.93m
... if matched sample	0.878	0.327	1.67m
Shrubland (2001-2010)	0.239	0.427	7.93m
... if matched sample	0.083	0.276	1.67m
Cropland (2001-2010)	0.049	0.216	7.93m
... if matched sample	0.017	0.128	1.67m
Protected (2001)	0.225	0.417	0.79m
Protected (2010)	0.437	0.496	0.79m
Coordinate Level Level Use Sequences (2001-2005 and 2008-2012)			
Sequence Indicates Permanently Forested	0.686	0.464	1.58m
... if matched sample	0.886	0.317	0.33m
Sequence Indicates Temporary Deforestation	0.028	0.165	1.58m
... if matched sample	0.016	0.127	0.33m
Sequence Indicates Temporary Deforestation	0.286	0.452	1.58m
... if matched sample	0.098	0.297	0.33m

Land Conflict and Other Municipal data provided for the 792 municipalities in the Amazon states for 1997-2010 (unless otherwise indicated). Land conflict data from the CPT. Escalation is the sum of land related murders, attempted murders and death threats. Violence is the sum of murders and death threats, and hence captures serious violence. Disputes captures total the number of land related disagreements for a variety of reasons. Homicide data is from the Mortality Information System. Environmental fines are from IBAMA. GDP data is from IBGE. The Protected Share of Land is the share of a municipality that is under ecological or indigenous protection. Coordinate level land cover data are dummies based on groupings of MODIS classifications as described in Section 3.3. Coordinate level sequences are dummies based on grouping of sequences of landcover data as described in Online Appendix Section A.3.

Table 2: Protection and Land Related Conflict in the Amazon States

	Aggregated Violence			Disaggregated Violence			Other
	(1) Escalation	(2) Violence	(3) Any Violence	(4) Murders	(5) Attempts	(6) Threats	(7) Disputes
A. Panel Regression Results							
Protected Share	-0.208	-0.071**	-0.047**	-0.020	-0.051*	-0.137	-0.183
	(0.139)	(0.035)	(0.020)	(0.018)	(0.026)	(0.131)	(0.172)
Mean of DV	.173	.0452	.0241	.0257	.0195	.128	.315
N	11088	11088	11088	11088	11088	11088	11088
Municipalities	792	792	792	792	792	792	792
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
B. Quasi-Event Study Results							
Protected Share	-0.605***	-0.156**	-0.097**	-0.070*	-0.085**	-0.449**	-0.773***
	(0.233)	(0.063)	(0.037)	(0.036)	(0.039)	(0.200)	(0.183)
Mean of DV	.332	.0977	.0474	.0595	.0382	.234	.406
Municipalities per Protected Area	2.98	2.98	2.98	2.98	2.98	2.98	2.98
Municipalities	285	285	285	285	285	285	285
Protected Areas	209	209	209	209	209	209	209
Observations	8722	8722	8722	8722	8722	8722	8722
Protected Area $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Protected Area $\times$ Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Table reports results from OLS regressions on outcome measures indicating land related conflict in the Amazon states. Outcome data is from the annual Conflitos no Campo Brasileiro publication. Data covers 1997-2010. Panel A presents results for the municipality level balanced panel. Panel B presents the results from the quasi-event study specification. Standard errors are clustered at the municipality level (panel A) and two-way clustered at the municipality and protected area levels (panel B). Stars indicate *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3: Some Violence May be Diverted to Nearby Areas

	Aggregated Violence			Other
	Escalation	Violence	Any Violence	Disputes
A. Panel Estimation				
Protected Share	-0.211	-0.072**	-0.047**	-0.177
	(0.140)	(0.035)	(0.020)	(0.171)
$0 < \text{DTPA} < 10\text{km}$	0.040	0.014	0.008	-0.092
	(0.070)	(0.022)	(0.011)	(0.149)
Mean of DV	.173	.0452	.0241	.315
Observations	11088	11088	11088	11088
Municipality FE	Yes	Yes	Yes	Yes
State × Year FE	Yes	Yes	Yes	Yes
B. Quasi-Event (plus 1st degree adjacent municipalities)				
Protected Share	-0.314*	-0.044	-0.029	-0.317**
	(0.171)	(0.036)	(0.020)	(0.150)
Mean of DV	.299	.0884	.0424	.378
Observations	43064	43064	43064	43064
Protected Area × Municipality FE	Yes	Yes	Yes	Yes
Protected Area × Year FE	Yes	Yes	Yes	Yes
C. Quasi-Event (plus 2nd degree adjacent municipalities)				
Protected Share	-0.315**	-0.068*	-0.041**	-0.275
	(0.124)	(0.038)	(0.020)	(0.185)
Mean of DV	.296	.0871	.0415	.368
Observations	108654	108654	108654	108654
Protected Area × Municipality FE	Yes	Yes	Yes	Yes
Protected Area × Year FE	Yes	Yes	Yes	Yes

Notes: Table reports results from OLS regressions on outcome measures indicating land related conflict in the Amazon states. Outcome data is from the annual Conflitos no Campo Brasileiro publication. Data covers 1997-2010. Panel A provides estimates based on our panel specification. ($0 < \text{DTPA} \leq 10\text{km}$) is the share of land in a municipality that is within 10km. The average municipality year observation has 13% of it's land within 10km of a protected area (compared to an average of 20% of land actually under protection. Panel B estimates the quasi-event study specification including municipalities adjacent to the municipalities intersecting each protected area as additional controls. Panel C also includes municipalities adjacent to these adjacent municipalities. Standard errors are clustered at the municipality level (panel A) and two-way clustered at the municipality and protected area levels (panels B and C). Stars indicate *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Protection Not Accompanied by Changes in Total Homicide Rates, Environmental Enforcement or Municipal Output

	Homicides		Enviro. Fines		Output	
	(1) All	(2) Indigenous	(3) All	(4) Flora	(5) GDP	(6) Ag. GDP
A. Panel Regression Results						
Protected Share	-3.578	0.044	9.861	5.900	0.019	0.062
	(3.456)	(0.052)	(6.406)	(5.420)	(0.063)	(0.111)
Mean of DV	6.48	.0301	12.7	9.55	10.9	9.57
Municipalities	792	792	792	792	792	792
Observations	11088	11088	11088	11088	9504	9504
Muncipality FE	Yes	Yes	Yes	Yes	Yes	Yes
State × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
B. Quasi-Event Study Results						
Protected Share	-3.144	0.073	-5.316	-6.567	-0.009	-0.040
	(2.046)	(0.078)	(5.274)	(4.693)	(0.071)	(0.144)
Mean of DV	7.38	.101	23.8	17.9	11.3	9.81
Municipalities per Protected Area	2.98	2.98	2.98	2.98	2.98	2.98
Municipalities	285	285	285	285	285	285
Protected Areas	209	209	209	209	209	209
Observations	8722	8722	8722	8722	7476	7476
Protected Area × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Protected Area × Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Table reports results from OLS regressions relating protected status to various municipal level outcome measures. Data on municipal level homicides is from the Mortality Information System (1997-2010). Data on environmental fines was obtained from IBAMA (1997-2010), the outcome variable is a count of either the total number of fines issued, or the number of fines relating to flora offences. Data on local GDP from IBGE (1999-2010). As GDP data is only available from 1999 there are fewer observations. Standard errors are clustered at the municipality level (panel A) and two-way clustered at the municipality and protected area levels (panel B). Stars indicate *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: Protection and Changes in Forest Cover

	Full Sample		Matched Sample			
	(1)	(2)	(3)	(4)	(5)	(6)
Newly Protected	0.015***	0.011***	0.019***	0.015***	0.019***	0.014***
Between 2001 and 2010	(0.005)	(0.004)	(0.005)	(0.005)	(0.004)	(0.003)
N	793928	793928	167336	167237	167336	167142
Mean of DV	-.026	-.026	-.0059	-.00587	-.0059	-.00589
State FE	Yes		Yes		Yes	
Municipality FE		Yes		Yes		Yes
Matched Pair FE					Yes	Yes
Matched Observations Only			Yes	Yes	Yes	Yes

Notes: Table reports results from OLS regressions relating changes is protected status to changes in forest cover. The data is a random sample of 793,928 coordinates across the Brazilian Amazon. The dependent variable is a categorical variable indicating whether the coordinate was reforested (1), deforested (-1), or had no change in forest cover status (0). For columns 4-6, coordinates which were protected between 2001 and 2010 are matched to observationally identical coordinates that were either never protected or always protected on the basis of propensity scores (see Online Appendix Table A9 for the matching regression). We retain only matched pairs with absolute differences in propensity score of less than 0.001. Standard errors are clustered at the municipality level. Stars indicate *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6: Protection and Changes in Land Use Patterns

	Full Sample			Matched Sample		
	(1) Forested	(2) Temp. Def.	(3) Perm. Def	(4) Forested	(5) Temp. Def.	(6) Perm. Def
Newly Protected	0.008**	0.008***	-0.016***	0.003	0.005**	-0.008*
Between 2001 and 2008	(0.004)	(0.002)	(0.004)	(0.006)	(0.002)	(0.004)
Mean of DV	-.0123	-.0103	.0226	-.00313	-.00412	.00725
N	792317	792317	792317	167147	167147	167147
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Matched Observations Only				Yes	Yes	Yes

Notes: Table reports results from OLS regressions relating changes in protected status to changes in land use sequence type. The data is a random sample of 793,928 coordinates across the Brazilian Amazon. We drop coordinates which fall in urban areas or water. Two five year sequences are used for each coordinate, 2001-2005 and 2008-2012. The land use sequences are categorised into three groups, stable forest, temporarily deforested and permanently deforested, using the approach described in A.3. The dependent variable is a categorical variable which takes the difference between dummies indicating a particular classification. The independent variable indicates whether the coordinate was protected between 2001 and 2008 (the first year of each five year sequence). For columns 4-6, coordinates which were protected between 2001 and 2010 are matched to observationally identical coordinates that were either never protected or always protected on the basis of propensity scores (see Online Appendix Table A9 for the matching regression). We retain only matched pairs with absolute differences in propensity score of less than 0.001. We match on changes between 2001 and 2010 for consistency with table 5. Standard errors are clustered at the municipality level. Stars indicate *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Online Appendices

(Not necessarily for publication.)

A Data Appendix

A.1 Building the Municipality Level Conflict Panel

We obtain data on land conflict from the Annual Reports of the Comissao Pastoral da Terra (CPT). The CPT was founded by the Catholic Church to highlight the plight of landless workers, small farmers and squatters. Since 1985, it has published an annual report on Conflitos no Campo (Violence in the Countryside). The report includes a multitude of conflict measures. We focus on the set of conflict measures that have been reported consistently between 1997 and 2010. The variables are 'Disputes', 'Murders', 'Attempted Murders' and 'Death threats'. We discuss how each variable is constructed in turn.

Disputes This is a general measure of land conflicts and ongoing (legal) disputes between individuals or legal entities claiming title to land. These were contained in the original documents under the headings 'Conflitos por Terra' from 1997-2004 and 'Areas em conflito' from 2004-2010. Under the heading land conflicts are subsumed all incidences relating to 'land conflict', which are broadly defined as actions to resist and confront the possession, use and ownership of land when involving squatters, settlers of, quilombos (descendants of freed slaves), colonisers, small leaseholders, small proprietors, occupiers, landless and rubber tappers. Throughout, the CPT records a conflict in a given year if that conflict broke out in that year; old and unresolved conflicts are only included in a given report if there has been a significant event relating to it.

For each conflict, we have the following information:

- State
- Municipality Name

- Name of conflict, typically relating to the name of a farm or location description.
- Date of dispute recorded
- Area in dispute (often missing)
- Number of families affected (often missing)

Murders, Attempted Murders and Death Threats Throughout the time period, we have data for Murders (Assassinatos), Attempted Murders (Tentativas de Assassinato) and Death Threats (Ameacados de Morte). For each event, we have the following information.

- State
- Municipality name
- Name of conflict
- Date of event
- Name of victim
- Age of victim (often missing)
- Category of victim, e.g. land less, occupier, fisherman, indigenous, rural labourer (often missing)

We create a variable called 'Escalations', which combines Murders, Attempted Murders and Death Threats into a single time-varying measure at the municipality level, and a variable called 'Violence' which combines Murders and Attempted Murders.

Matching to 2000 Census Municipalities We use the 2013 shapefile of administrative boundaries for Brazilian municipalities to provide a gazetteer of municipality names for the states in the Amazon states. This can be thought of as the most extensive list of municipality names, as when a municipality splits, one usually retains the name of the original municipality. While there have been a significant number of municipality splits in the early 1990s, few new municipalities were created since 2000. We match conflict events to municipalities performing fuzzy string matching on the set of municipality names within the state in which the conflict event was recorded. This creates a mapping matching conflict events to 2013 municipality names. We then build a cross walk to match 2013 municipalities to municipalities in the 2000 census shapefile. We use this to build a balanced panel across 792 municipalities in the Amazon states for the period 1997-2010 for the conflict variables described above.

A.2 Construction of Protected Area Data

Data on protected areas was produced by combining digital maps from several sources. The principle source was the UN World Database of Protected Areas. This database provide a digital map outlining the original extent ecologically protected areas in Brazil created up to 2007 and tribally protected areas designated up to 2010.

To calculate the area in a municipality under protection in say 2003, we simply calculate the total area in a municipality covered by one or more protected areas established up to (and including) 2003. For around 3% of reserves, data on the start date is missing. We assume these reserves came into existence prior to 1997 (i.e. before the start of our panel). For some of the reserves, we have been able to verify that this was indeed the case, but to the extent that some were established subsequently, this assumption introduces measurement error into our protected area data.

We supplement the data on ecological areas with data from the Brazilian Ministèrio do Meio Ambiente (Environment Ministry). Despite being based on the same underlying set of polygons, the Environment Ministry data includes the extent of protected areas in 2014, rather than their original extents. This means that if a new protected area X supersedes part of an existing protected area, following the procedure used on the UN data would mean we would erroneously assign land to unprotected status for the years up to the establishment of X. We try to minimise this by using the UN data to provide a baseline extent of protection in 2007. So, for 2008, we then add areas that the Environment Ministry data suggests would have been protected in 2008 to the areas the UN data indicates were protected in 2007.[21]

[21] Note, because the data are based on the same underlying sources, that the UN data indicates

Thus, we are only using the data on current extent of protected areas for the most recent few years, when the problem of new protected areas superseding old ones is relatively small.

A.3 Land Use Patterns Classification

To study the effect of protection on permanent relative to temporary deforestation, we need to consider land use for periods longer than one year. To begin with, we categorise land use into three broad classes, *F*orested, *S*hrubland or *C*ropland (as described in Section 3.3). We can then generate sequences of patterns that are suggestive of either permanent deforestation and settled agriculture, temporary deforestation (e.g. due to selective logging, or short term agriculture), or permanent forest cover. For example, a pattern such as $FSCCC$ suggests that an initially forested coordinate was cleared and converted to cropland in the course of a five year period. On the other hand, a pattern such as $FSSFF$, suggests that a coordinate was temporarily cleared, with the forest regrowing. Clearly, the first pattern suggests stationary land use by a farmer, while the second may indicate temporary extraction of valuable timber.

In order to study patterns of land use, we need to categorise or group repeating patterns into use clusters. Given that we have data for 12 years, we can create two sets of such five letter series and categorise the resulting patterns into permanent forest cover, temporary deforestation, or permanent deforestation, and then study, how conservation changes this pattern. The resulting state space $\mathcal{S} = \{F, S, C\} \times ... \times \{F, S, C\}$ can have at most $3^5 = 243$ different series; the data almost exhausts the state space, with 242 distinct series.

The idea is to group series together into dominant clusters. This could be done manually, but would likely be very subjective from case to case. In order to arrive at an objective grouping, we apply a powerful tool from machine learning: k-means clustering.

K-means clustering solves a simple optimisation problem, assigning observations to clusters $C_1, ..., C_K$, such that the total within-cluster variation is minimised,

is protected is a superset of that indicated by the Environment Brazilian Data—it is all the areas still protected by the same park in 2014 *plus* the areas where the identity of the protected area had changed, but protection status did not.

i.e.

$$\min_{C_1,...,C_k} \sum_{k=1}^{K} W(C_k)$$

where

$$W(C_k) = \sum_{i \in C_k} \sum_{j=1}^{p} (x_{ij} - \bar{x}_{kj})^2$$

For a given number of clusters K, the solution is an assignment of data coordinates $\mathbf{x}_i$ to clusters $C_1, ..., C_K$, which maximises intra-cluster homogeneity and minimises inter-cluster similarity. There exist very fast implementations of K-means clustering algorithms in statistical programming packages, which provide a local approximation to the above optimisation problem. These algorithms are guaranteed to converge to a local optimum; performing multiple iterations with different initial conditions ensures that the routine does not converge to a particularly bad local optimum.

In order to separate the data, we need to extract numeric information from the five character length series, which may be informative about the underlying transitions and land use patterns. We construct eight numeric variables: Number of transitions to state F, number of transitions from state F to some other state, the number of times the coordinate is in state F, an indicator for whether the series is ever in state C, the number of times the coordinate is in state S, the number of repeating non F states and the number of repeating F states, as well as the length of repeating pairs (to capture regularity e.g. in patterns such as $SCSCS$).

As noted, the number K is a choice and, mechanically, larger values of K improve the fit (for $K = n$, each observation would be its own cluster and the objective function would be minimal at zero). In order to estimate the total number of clusters, we perform the statistical test described by Tibshirani et al. (2001), which computes a measure of goodness of clustering. The idea of the test is simple: for every number of clusters k it computes the gap between the expected value of the objective function and the actual, $f(k) = E^*[\log(W(k))] - \log(W(k))$, where $E^*[\log(W(k))]$ is obtained via bootstrapping. A large value of $f(k)$ indicates that we are overfitting the data. As a decision criterion for the optimal number K^*, Tibshirani et al. (2001) propose to choose the smallest k such that $f(k) \geq f(k+1) - se(f_{k+1})$. This choice effectively requires that the improvement in the sum of the within cluster variations for k clusters needs to within one standard deviation of the increase that is expected with $k+1$ clusters

Throughout, we see that the optimal number of clusters is $K = 6$. Table A7 below provides details over how well the clustering performs in terms of separating five letter sequences into dominant clusters based on the measures $\mathbf{x}_i$. Clusters 1 through 3 can clearly be interpreted as permanent deforestation clusters; they will have, at any point, been assigned a status of being cropped and their sequence is dominated by repetitions of states S and C. Cluster 4 could arguably capture permanent or temporary deforestation. The dominant states are F and S, with the state C being rarely observed. Cluster 5 has a significant number of transitions to and from states F, consistent with periodic temporary deforestation. Cluster 6 is clearly permanently forested, with very rare instances of coordinates transitioning from F to C state. Table A8 presents the most common five letter sequences and their respective overall or within cluster shares.

As mentioned, it is not clear whether temporary or permanent deforestation is the best way to describe the sequences in cluster 4. In the baseline table we classify it as 'permanent deforestation' (the broad definition of permanent deforestation). However, the results are robust to classifying it as temporary deforestation (the broad definition of temporary deforestation), or as neither permanent or temporary deforestation (the narrow definition of both temporary and permanent deforestation). Table A13 contains these results.

B Description of Additional Robustness Checks

B.1 Robustness to allowing for fiscal transfers are made on the basis of ecological services.

Some states use a small proportion of ICMS (Value Added Tax) revenues to compensate municipalities for the loss of land set aside for environmental protection. Of the nine Amazon states, five currently apportion revenues some revenues in this way.[22] For three of these states, Acre (2010), Tocantins (2003) and Mato Grosso

[22] The states that currently make transfers of this type are Acre, Tocantins, Mato Grosso, Rondonia and Amapa. So it is Amazonas, Roraima, Maranhao and Para that do not.

(2002), the transfers were introduced within the time period we study. If transfers are made, the size and distribution of the pot varies depending on state law. Rondonia and Mato Grosso currently make the largest provision, with 5% of ICMS revenues remitted to municipalities primarily on the basis of protected area. Even within these states, for most municipalities the amount at stake is small: in Mato Grosso in 2009, these transfers account for around 1% of municipal revenue and in 84% of municipalities these transfers are less than 5% of revenue.[23] Given the large stock of existing protected areas, we think it unlikely that the variation in protected areas exploited by this study had a substantial effect on either local public finances or services. Our main analysis thus includes data from all of the Amazon region.

Nevertheless, to mitigate concerns over endogenous municipal budgets, we undertake two exercises. In Table A4 Panel A, we repeat our panel analysis but include a control which proxies for the value of transfers. Specifically, for each municipality-year we calculate the share of protected land in the state which is in the municipality and interact this with the share of state level ICMS revenues that the state remits on the basis of ecological service provided. The coefficients on our main variable of interest are robust to the inclusion of this control. If anything, higher transfers seem to be associated with more violence not less, although given the scale of our proxy for transfers the economic significance of these findings is limited. In Table A4 Panel B, we repeat our quasi-event study analysis omitting protected areas which any part of fall in a state that ever provide transfers. The results are very similar to those estimated on the full sample.

B.2 Robustness to controlling for INCRA activity

Alston et al. (1999, 2000) persuasively argue that the presence of INCRA activity is an important factor in facilitating land conflict. As the body responsible for expropriating landowners on behalf of settlers, INCRA are a key contributor to weak property rights in Brazil. Consequently, if INCRA activity tended to be located far from protected areas, our results could be picking up the pacifying effects of a lack of INCRA activity, rather than that of secure assignment of property rights

[23] Author's calculations based on official data from the Brazilian Institute for Geography and Statistics (IBGE) and the State Government of Mato Grosso.

represented by the expansion of protected areas.

To test this, we obtained digital maps of the location of INCRA land reform settlements. As a proxy for INCRA activity, we produced the share of the surface of a municipality that was under INCRA settlement for each year in our data. We distinguish between INCRA settlements inside and outside protected areas. In our panel specification, we include these INCRA land shares as additional controls. In our event study specification, we drop protected areas that intersect with INCRA areas at any time.

Table A6 contains the results. In neither case are our main coefficients of interest significantly affected. There is, however, suggestive evidence that more INCRA activity is associated with higher levels of violence—as found by Alston et al.—but only when the INCRA settlements are not inside protected areas.

B.3 Robustness of land use change results

There are at least two concerns that arise from the semi-supervised clustering of the land use sequences and the subsequent study of patterns of land use change. First, there is some arbitrariness in terms of the chosen length of sequences that are clustered into land use types. Second, the creation of longer land use sequences creates a degree of arbitrariness in terms of the timing of protection status since it is unclear whether to consider a sequence as treated in case it switched status halfway through a five letter sequence. We address each of these concerns in turn.

Sequence Length and Clustering We perform clustering on slightly shorter sequences of length four, as well as clusters on sequences of length six. As in the main example for sequences of length five, we perform determine the optimal number of clusters using the test described in Tibshirani et al. (2001). Throughout, the statistically optimal number of clusters as per the gap statistic test is six. We transform the six resulting clusters into the three groups of sequences, forested, temporarily deforested, permanently deforested, and perform the same analysis as in the main table, relying on variation in the protection status coming from status changes between 2001 and 2009 for the four letter sequences and on status changes between 2001 and 2006 for the six letter sequences. The results are presented in Table A12 and are consistent with the results presented in our main analysis. Our results are robust to the choice of sequence length.

Treatment Timing As noted, we infer behavioural changes of settlers by studying patterns of land use focusing on longer time series of land use patterns. This creates a degree of arbitrariness in terms of the treatment timing. In the main table we assign a coordinate as being protected if in the initial year of each five letter sequence, it was classified as protected. Hence, the resulting variation in protection status is coming from coordinates whose protection status changed between 2001 and 2008.

In table A14 we explore other treatment timings. Panel A presents the baseline results. In Panel B, we narrow in by focusing on coordinates changing protection status between 2003 and 2008. Panel C focus on coordinate changing protection status between 2003 and 2010 and Panel D exploits the maximal variation by focusing coordinates changing status between 2001 (first year) and 2010 (last year).

Table A1: Robustness to Alternative Panel Specifications

	Aggregated Violence			Other
	(1) Escalation	(2) Violence	(3) Any Violence	(4) Disputes
A. Municipality FE + Time FE				
Protected Share	-0.113	-0.079***	-0.051***	0.208
	(0.113)	(0.026)	(0.018)	(0.138)
B. Municipality FE + State-by-Time FE				
Protected Share	-0.208	-0.071**	-0.047**	-0.183
	(0.139)	(0.035)	(0.020)	(0.172)
C. Municipality FE + Time FE + Municipality Trends				
Protected Share	-0.656**	-0.195**	-0.111***	0.018
	(0.286)	(0.090)	(0.043)	(0.132)
D. Municipality FE + State-by-Time FE + Municipality Trends				
Protected Share	-0.556**	-0.151*	-0.088**	-0.033
	(0.265)	(0.085)	(0.038)	(0.133)
Mean of DV	.173	.0452	.0241	.315
Observations	11088	11088	11088	11088

Notes: Table reports results from OLS regressions on different outcome measures reflecting land related conflict in the Brazilian Amazon region. The data is a municipal level balanced panel of conflict data. Standard errors are clustered at the municipality level with stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A2: Ecological and Indigenous Protected Areas Have a Similar Effect on Violence

	Aggregated Violence			Other
	(1) Escalation	(2) Violence	(3) Any Violence	(4) Disputes
A. Quasi-Event: Indigenous Protected Areas Only				
Protected Share	-0.700**	-0.199**	-0.123*	-0.484**
	(0.333)	(0.091)	(0.064)	(0.218)
Mean of DV	.334	.0864	.0418	.334
Municipalities per Protected Area	2.68	2.68	2.68	2.68
Municipalities	154	154	154	154
Protected Areas	114	114	114	114
Observations	4284	4284	4284	4284
B. Quasi-Event: Ecologically Protected Areas Only				
Protected Share	-0.518*	-0.116	-0.073**	-1.036***
	(0.307)	(0.073)	(0.031)	(0.229)
Mean of DV	.329	.109	.0527	.475
Municipalities per Protected Area	3.34	3.34	3.34	3.34
Municipalities	195	195	195	195
Protected Areas	95	95	95	95
Observations	4438	4438	4438	4438
Protected Area x Year FE	Yes	Yes	Yes	Yes
Protected Area x Municipality FE	Yes	Yes	Yes	Yes

Notes: Results obtained using data on municipal level violence covering the period 1997-2010 using the quasi-event study specification as in Panel B of table 2. The difference here is that in Panel A, we restrict the set of protected areas which are established for the purpose for protecting indigenous lands, while in Panel B, we restrict only to environmentally protected areas. Due to the relatively small number of strictly protected areas established, it is not possible to break down ecologically protected areas by type. Standard errors two-way clustered at the municipality and protected area levels with stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A3: Robustness: Quasi-Event Alternative Definition of Protected Share

	Aggregated Violence			Other
	(1) Escalation	(2) Violence	(3) Any Violence	(4) Disputes
Protected Share of Hitherto Unprotected Land	-0.358*	-0.120**	-0.070**	-0.543***
	(0.185)	(0.054)	(0.032)	(0.138)
Mean of DV	.33	.0962	.0465	.39
Municipalities per Protected Area	2.92	2.92	2.92	2.92
Municipalities	264	264	264	264
Protected Areas	199	199	199	199
Observations	8148	8148	8148	8148
Protected Area x Year FE	Yes	Yes	Yes	Yes
Protected Area x Municipality FE	Yes	Yes	Yes	Yes

Notes: Results obtained using data on municipal level violence covering the period 1997-2010 using the quasi-event study specification as in Panel B of table 2. In that table, the variable of interest was the share of all land in a municipality that is newly protected, here it is the share of land in a municipality that was unprotected last year that is newly protected. Compared to the the main results, this change in variable is expected to mechanically reduce the estimated coefficients, as the rescaling increases the variance of our independent variable without affecting the variance of our outcome. There are 574 fewer observations in this specification as we can no longer calculate the share of land protected for protected areas established in 1997. Standard errors two-way clustered at the municipality and protected area levels with stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A4: Robustness: Controlling for Ecological Transfers or Dropping Protected Areas Affected by Them

	Aggregated Violence			Other
	(1) Escalation	(2) Violence	(3) Any Violence	(4) Disputes
A. Panel: Control For Transfers				
Protected Share	-0.326*	-0.097*	-0.073***	-0.096
	(0.172)	(0.050)	(0.027)	(0.204)
Fiscal Transfers Proxy	0.065**	0.023	0.012	0.044**
(MSP × State Tax Share)	(0.031)	(0.014)	(0.008)	(0.018)
Municipal Share of State	0.789	0.061	0.209	-1.705
Protected Area (MSP)	(1.512)	(0.448)	(0.197)	(1.667)
Mean of DV	.173	.0452	.0241	.315
Observations	11088	11088	11088	11088
Muncipality FE	Yes	Yes	Yes	Yes
State × Year FE	Yes	Yes	Yes	Yes
B. Quasi-Event: Drop Protected Areas That May Have Induced Ecological Transfers				
Protected Share	-0.707**	-0.122*	-0.085**	-0.666***
	(0.280)	(0.069)	(0.041)	(0.168)
Mean of DV	.463	.127	.0559	.418
Municipalities per Protected Area	2.92	2.92	2.92	2.92
Municipalities	147	147	147	147
Protected Areas	118	118	118	118
Observations	4816	4816	4816	4816
Protected Area × Year FE	Yes	Yes	Yes	Yes
Protected Area × Municipality FE	Yes	Yes	Yes	Yes

Notes: Results obtained using data on municipal level violence covering the period 1997-2010. Panel A provides results based on the full panel. The municipal level proxy for fiscal transfers is the interaction between the municipal share of all of a states protected land and the share of VAT revenues set aside for ecological transfers. Panel B uses the quasi-event specification as in Panel B of table 2. The difference here is that protected areas that have any of their land in states which had positive fiscal transfers at any point during the sample are excluded. Standard errors clustered at the municipal level (panel A) or two-way clustered at the municipality and protected area level (panel B) with stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A5: Robustness: Dropping Municipalities Which Were Ever Blacklisted for Excessive Deforestaion

	Aggregated Violence			Other
	(1) Escalation	(2) Violence	(3) Any Violence	(4) Disputes
A. Panel: Dropping Blacklisted Municipalities				
Protected Share	-0.290**	-0.060*	-0.048**	-0.250
	(0.121)	(0.033)	(0.020)	(0.171)
Mean of DV	.125	.0289	.0165	.284
Observations	10402	10402	10402	10402
Municipalities	743	743	743	743
Municipality FE	Yes	Yes	Yes	Yes
State × Year FE	Yes	Yes	Yes	Yes
B. Quasi-Event: Dropping Blacklisted Municipalities				
Protected Share	-0.521**	-0.076	-0.064*	-0.772***
	(0.263)	(0.052)	(0.036)	(0.195)
Mean of DV	.104	.0298	.0157	.279
Municipalities per Protected Area	2.96	2.96	2.96	2.96
Municipalities	244	244	244	244
Protected Areas	170	170	170	170
Observations	7056	7056	7056	7056
Protected Area × Year FE	Yes	Yes	Yes	Yes
Protected Area × Municipality FE	Yes	Yes	Yes	Yes

Notes: Results obtained using data on municipal level violence covering the period 1997-2010. Panel A provides results based on the full panel. We drop 50 municipalities that from 2008 onwards were on a blacklist of municipalities due to bad performance in terms of deforestation and environmental protection. Panel B uses the quasi-event specification as in Panel B of table 2. Standard errors clustered at the municipal level (panel A) or two-way clustered at the municipality and protected area level (panel B) with stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A6: Robustness: Controlling for INCRA settlement expansion across municipalities inside and outside of protected areas.

	Aggregated Violence			Other
	(1) Escalation	(2) Violence	(3) Any Violence	(4) Disputes
A. Panel: Controlling for INCRA settlements				
Protected Share	-0.157	-0.066*	-0.043**	-0.240
	(0.135)	(0.035)	(0.020)	(0.214)
INCRA (and Unprotected) Share	0.458**	0.081	0.035	0.184
	(0.230)	(0.065)	(0.028)	(0.306)
INCRA (and Protected) Share	-0.319	0.009	-0.013	1.177
	(0.227)	(0.066)	(0.027)	(1.499)
Mean of DV	.173	.0452	.0241	.315
Observations	11088	11088	11088	11088
Municipality FE	Yes	Yes	Yes	Yes
State × Year FE	Yes	Yes	Yes	Yes
B. Quasi-Event: Dropping events affected by INCRA settlements				
Protected Share	-0.497	-0.190**	-0.150**	-1.083***
	(0.413)	(0.080)	(0.066)	(0.370)
Mean of DV	.201	.0558	.0299	.342
Municipalities per Protected Area	2.67	2.67	2.67	2.67
Municipalities	155	155	155	155
Protected Areas	96	96	96	96
Observations	3584	3584	3584	3584
Protected Area × Year FE	Yes	Yes	Yes	Yes
Protected Area × Municipality FE	Yes	Yes	Yes	Yes

Notes: Results obtained using data on municipal level violence covering the period 1997-2010. Panel A provides results based on the full panel, controlling for the share of a municipalities surface area that is dedicated to INCRA settlements lying inside or outside of protected areas. Panel B performs the quasi-event specification as in Panel B of table 2, with the exception that we remove individual protected area events that are in some way affected by having (mostly very marginal) INCRA activity within them. Standard errors clustered at the municipal level (panel A) or two-way clustered at the municipality and protected area level (panel B) with stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A7: K-Means Clusters and Separation on Features

Cluster	Interpretation	Clustering Variables									Freq
		to F	from F	Ever C	len(F)	len(S)	len(repeat S, C)	len(repeat F)	repeat pairs		
1	Permanent Deforestation	0.056	0.204	1.000	0.157	3.361	4.668	0.000	0.229	SC	1.4%
2	Permanent Deforestation	0.155	0.416	1.000	0.495	0.676	4.467	0.216	0.147	C	1.9%
3	Permanent Deforestation	0.000	0.083	0.000	0.000	5.000	5.000	0.000	0.000	S	20.5%
4	Permanent/Temporary	0.493	1.012	0.064	1.545	3.387	3.400	0.653	0.215	FS	0.7%
5	Temporary Deforestation	0.466	0.984	0.222	3.430	1.236	1.454	3.151	0.057	FS	1.1%
6	Forest	0.001	0.002	0.002	4.998	0.000	0.000	4.998	0.000	F	74.4%

Notes: Table presents the eight numeric features used to represent the landcover sequences of length five. The eight features are: the number of transitions to state F, the number of transitions from F, whether the sequence was ever in state C, the overall length in state S, the length in repeated non F states, the length of repeating F states and the length of repeating pairs. These features were used to separate the individual sequences into six different clusters using the k-means clustering algorithm as implemented by Hartigan and Wong (1979). The table presents the mean of each clustering variable indicated in the column head in the respective cluster. This allows an understanding of which features help in separating the individual clusters.

Table A8: K-Means Clusters and common class sequences

Cluster	Interpretation	Sequence	Share within cluster	Overall share	N
1	Permanent Deforestation	SSSSC	18.4%	0.8%	11081
1	Permanent Deforestation	CSSSS	15.5%	0.6%	9344
1	Permanent Deforestation	SSSCC	12.8%	0.5%	7699
1	Permanent Deforestation	SSSCS	12.0%	0.5%	7219
1	Permanent Deforestation	CCSSS	11.4%	0.5%	6864
1	Permanent Deforestation	SCSSS	6.1%	0.3%	3677
1	Permanent Deforestation	SSCSS	3.7%	0.2%	2226
1	Permanent Deforestation	SCSCS	3.7%	0.2%	2206
1	Permanent Deforestation	CSSSC	2.7%	0.1%	1649
1	Permanent Deforestation	SSCCS	2.6%	0.1%	1585
2	Permanent Deforestation	SSSSS	100.0%	20.5%	297609
3	Permanent Deforestation	CCCCC	39.5%	1.9%	27451
3	Permanent Deforestation	CCCSS	8.0%	0.4%	5537
3	Permanent Deforestation	SSCCC	7.5%	0.4%	5216
3	Permanent Deforestation	SCCCC	6.9%	0.3%	4785
3	Permanent Deforestation	CCCCS	6.3%	0.3%	4413
3	Permanent Deforestation	CCCSC	4.5%	0.2%	3161
3	Permanent Deforestation	SCCCS	2.9%	0.1%	1991
3	Permanent Deforestation	CCCFF	2.4%	0.1%	1691
3	Permanent Deforestation	CSCSC	2.3%	0.1%	1604
3	Permanent Deforestation	CSCCC	2.3%	0.1%	1585
4	Permanent/Temporary	FSSSS	20.8%	0.4%	5474
4	Permanent/Temporary	FFSSS	16.8%	0.3%	4413
4	Permanent/Temporary	SSSSF	15.8%	0.3%	4163
4	Permanent/Temporary	SSSFF	11.3%	0.2%	2957
4	Permanent/Temporary	SSSFS	5.2%	0.1%	1374
4	Permanent/Temporary	FSSSF	4.0%	0.1%	1053
4	Permanent/Temporary	FSFSF	3.2%	0.1%	830
4	Permanent/Temporary	SFSSS	3.0%	0.1%	775
4	Permanent/Temporary	SSFSS	2.9%	0.1%	760
4	Permanent/Temporary	SSFSF	2.3%	0.0%	598
5	Temporary Deforestation	FFFSS	18.3%	0.6%	8153
5	Temporary Deforestation	FFFFS	16.5%	0.5%	7351
5	Temporary Deforestation	SFFFF	11.2%	0.3%	4997
5	Temporary Deforestation	SSFFF	7.5%	0.2%	3360
5	Temporary Deforestation	FFFSF	7.0%	0.2%	3111
5	Temporary Deforestation	CCFFF	4.8%	0.1%	2143
5	Temporary Deforestation	FFFCC	4.1%	0.1%	1814
5	Temporary Deforestation	FSFFF	4.1%	0.1%	1804
5	Temporary Deforestation	FFSFF	2.2%	0.1%	977
5	Temporary Deforestation	FFFSC	1.9%	0.1%	848
6	Forest	FFFFF	99.5%	74.4%	1081436
6	Forest	CFFFF	0.2%	0.2%	2605
6	Forest	FFFFC	0.2%	0.1%	2090
6	Forest	FFCFF	0.0%	0.0%	271

Notes: Table presents the results from performing k-means clustering on landcover sequences of length five. The optimal number of clusters as determined using the gap statistic test in Tibshirani et al. (2001) is six. The ten (or less in case there are fewer than 10 sequences types per cluster) most frequent sequences that comprise each cluster and their respective share within and across the clusters is provided. We interpret the six clustered sequences as being either Forest, Temporary Deforestation or Permanent Deforestation.

Table A9: Matching Regression: Where Gets Protected?

	Change in Protected Status Between 2001 and 2010 Dummy
	(1)
ln(KM to River + 1)	-0.067*
	(0.035)
ln(KM to Road + 1)	0.124
	(0.080)
Mean Elevation	-0.000
	(0.000)
Var Elevation	0.015**
	(0.007)
Longitude (x)	-0.125***
	(0.029)
Latitude (y)	-0.064*
	(0.034)
ln(GAEZ Yield Cassava +1)	0.464
	(1.386)
ln(GAEZ Yield Maize +1)	0.036
	(0.416)
ln(GAEZ Yield Wetland Rice +1)	1.772
	(1.811)
ln(GAEZ Yield Soybean +1)	0.449
	(0.510)
ln(GAEZ Yield Oil Palm +1)	-0.072***
	(0.025)
ln(GAEZ Yield Dryland Rice +1)	0.476
	(0.607)
ln(max{GAEZ Yield x Price} +1)	2.064***
	(0.601)
Annual Temperature Average	-0.042
	(0.038)
Annual Rainfall Average	-0.000
	(0.000)
Annual Rainfall Standard Deviation	0.002*
	(0.001)
Distance to Nightlights	0.092***
	(0.015)
(Distance to Nightlights)^2	-0.001***
	(0.000)
Forested (MODIS)	0.313***
	(0.084)
Shrubland (MODIS)	0.190*
	(0.109)
Cropland (MODIS)	-0.127
	(0.148)
N	791406
Meso Region Dummies	Yes

Notes: Results from a probit regression. Outcome is a dummy indicating whether the protection status changed between 2001 and 2010. These changes are all changes from 'unprotected' status to 'protected' status. Propensity scores obtained from this regression used to construct the matched panel. Each observation is a randomly drawn coordinate within the Amazon states. Distances are straight-line distances to the nearest river (Natural Earth V. 3), national highway in 2001 (algorithmically generated based on maps and descriptions obtained from DNIT) and night-lights in 1999-2001 (from DMSP). Initial land cover from MODIS. Mean and Variance of elevation from GMTED. Yields are obtained from the FAO's GAEZ database which provides theoretical yields for a range of crops based on agronomic models and geographic inputs. Climatic variable are from MOD11A1 Land surface and CHIRPS for rainfall. Standard errors clustered at the municipality level with stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A10: Protection and Changes in Forest Cover: Robustness to other propensity score cutoffs

	Matched Sample			
	(1)	(2)	(3)	(3)
A. Propensity score < 0.1				
Newly Protected	0.015***	0.012***	0.015***	0.011***
Between 2001 and 2010	(0.004)	(0.004)	(0.003)	(0.003)
N	253836	253737	253836	253642
Mean of DV	-.00484	-.00482	-.00484	-.00483
B. Propensity score < 0.01				
Newly Protected	0.018***	0.014***	0.018***	0.014***
Between 2001 and 2010	(0.005)	(0.005)	(0.004)	(0.003)
N	198768	198669	198768	198574
Mean of DV	-.0059	-.00587	-.0059	-.00589
C. Propensity score < 0.001				
Newly Protected	0.019***	0.015***	0.019***	0.014***
Between 2001 and 2010	(0.006)	(0.005)	(0.004)	(0.003)
N	159848	159749	159848	159654
Mean of DV	-.00602	-.00598	-.00602	-.006

Notes: Table reports results from OLS regressions relating changes in protected status to changes forest cover. The data is a random sample of 793,928 coordinates across the Brazilian Amazon. The outcome variable is a categorical variable indicating whether the coordinate was reforested (1), deforested (-1), or had no change in forest cover status (0). Coordinates which were protected between 2001 and 2010 are matched to observationally identical coordinates that were either never protected or always protected on the basis of propensity scores (see Online Appendix Table A9 for the matching regression). We retain only matched pairs with absolute differences in propensity score less than indicated. Our baseline matched sample results were calculated with a propensity score cutoff of 0.001. Standard errors are clustered at the municipality level. Stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A11: Protection and Changes in Land Use Patterns: Robustness to propensity score cutoffs

	Matched Sample		
	(1) Forested	(2) Temp. Def.	(3) Perm. Def.
A. Propensity score < 0.1			
Newly Protected	0.003	0.004**	-0.007**
Between 2001 and 2008	(0.004)	(0.002)	(0.003)
N	253627	253627	253627
Mean of DV	-.00251	-.00287	.00538
B. Propensity score < 0.01			
Newly Protected	0.003	0.005**	-0.008**
Between 2001 and 2008	(0.006)	(0.002)	(0.004)
N	198575	198575	198575
Mean of DV	-.00322	-.00349	.00671
C. Propensity score < 0.0001			
Newly Protected	0.003	0.005**	-0.008*
Between 2001 and 2008	(0.006)	(0.002)	(0.005)
N	159660	159660	159660
Mean of DV	-.00319	-.0042	.0074

Notes: Table reports results from OLS regressions relating changes in protected status to changes in land use sequence type. The data is a random sample of 793,928 coordinates across the Brazilian Amazon. Two five year sequences are used for each coordinate, 2001-2005 and 2008-2012. The land use sequences are categorised into three groups, stable forest, temporarily deforested and permanently deforested, using the approach described in A.3. The dependent variable is a categorical variable which takes the difference between dummies indicating a particular classification. The independent variable indicates whether the coordinate was protected between 2001 and 2008 (the first year of each five year sequence). Coordinates which were protected between 2001 and 2010 are matched to observationally identical coordinates that were either never protected or always protected on the basis of propensity scores (see Online Appendix Table A9 for the matching regression). We retain only matched pairs with absolute differences in propensity score of less than indicated. We match on changes between 2001 and 2010 for consistency with table 5. Standard errors are clustered at the municipality level. Stars indicate *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A12: Protection and Changes in Land Use Patterns: Robustness to the choice of sequence length

	Full Sample			Matched Sample		
	(1) Forested	(2) Temp. Def.	(3) Perm Def.	(4) Forested	(5) Temp. Def.	(6) Perm Def.
A. Sequence of length 6						
Newly Protected	0.008**	0.009***	-0.017***	0.006	0.002	-0.008**
Between 2001 and 2007	(0.003)	(0.002)	(0.004)	(0.006)	(0.002)	(0.004)
Mean of DV	-.0117	-.0107	.0224	-.00418	-.00291	.00708
N	792317	792317	792317	167147	167147	167147
B. Sequence of length 4						
Newly Protected	0.009**	0.007***	-0.014***	0.006	0.003	-0.009**
Between 2001 and 2009	(0.005)	(0.002)	(0.004)	(0.007)	(0.003)	(0.004)
Mean of DV	-.0155	-.00823	.0213	-.00325	-.00392	.00612
N	792317	792317	792317	167147	167147	167147
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Matched Sample				Yes	Yes	Yes

Notes: Table reports results from OLS regressions relating changes in protected status to changes in land use sequence type. The data is a random sample of 793,928 coordinates across the Brazilian Amazon. We use two sequences of land use for each coordinate. In panel A, these are 2001-2006 and 2007-2012, in panel B these are 2001-2004 and 2009-2012. The land use sequences are categorised into three groups, stable forest, temporarily deforested and permanently deforested, using the approach described in A.3. The dependent variable is a categorical variable which takes the difference between dummies indicating a particular classification. The independent variable is a dummy indicating whether a coordinate was protected. In columns 4-6, coordinates which were protected between 2001 and 2010 are matched to observationally identical coordinates that were either never protected or always protected on the basis of propensity scores (see Online Appendix Table A9 for the matching regression). Standard errors are clustered at the municipality level. Stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A13: Protection and Changes in Land Use Patterns: Robustness to narrow and broad definitions of temporary and permanent deforestation

	Full Sample			Matched Sample		
	(1) Forested	(2) Temp. Def.	(3) Perm Def.	(4) Forested	(5) Temp. Def.	(6) Perm Def.
A. Narrow Temporary Deforestation, Broad Permanent Deforestation						
Newly Protected	0.008**	0.008***	-0.016***	0.003	0.005**	-0.008*
Between 2001 and 2008	(0.004)	(0.002)	(0.004)	(0.006)	(0.002)	(0.004)
Mean of DV	-.0123	-.0103	.0226	-.00313	-.00412	.00725
N	792317	792317	792317	167147	167147	167147
B. Broad Temporary Deforestation, Narrow Permanent Deforestation						
Newly Protected	0.008**	0.006***	-0.014***	0.003	0.006*	-0.009**
Between 2001 and 2008	(0.004)	(0.002)	(0.004)	(0.006)	(0.003)	(0.004)
Mean of DV	-.0123	-.00854	.0208	-.00313	-.00332	.00646
N	792317	792317	792317	167147	167147	167147
C. Narrow Temporary Deforestation, Narrow Permanent Deforestation						
Newly Protected	0.008**	0.008***	-0.014***	0.003	0.005**	-0.009**
Between 2001 and 2008	(0.004)	(0.002)	(0.004)	(0.006)	(0.002)	(0.004)
Mean of DV	-.0123	-.0103	.0208	-.00313	-.00412	.00646
N	792317	792317	792317	167147	167147	167147
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Matched Sample				Yes	Yes	Yes

Notes: Table reports results from OLS regressions relating changes protected status to changes in land use sequence type. The data is a random sample of 793,928 coordinates across the Brazilian Amazon. Two five year sequences are used for each coordinate, 2001-2005 and 2008-2012. The land use sequences are categorised into three groups, stable forest, temporarily deforested and permanently deforested, using the approach described in A.3. The dependent variable is a categorical variable which takes the difference between dummies indicating a particular classification. The different panels use either the broad or narrow definitions of forested and temporary deforestation. The independent variable is a dummy indicating whether a coordinate was protected between 2001 and 2008 (the first year of each sequence). In columns 4-6, coordinates which were protected between 2001 and 2010 are matched to observationally identical coordinates that were either never protected or always protected on the basis of propensity scores (see Online Appendix Table A9 for the matching regression). Standard errors are clustered at the municipality level. Stars indicating *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A14: Protection and Changes in Land Use Patterns: Robustness to the choice of treatment timing

	Full Sample			Matched Sample		
	(1) Forested	(2) Temp. Def.	(3) Perm. Def.	(4) Forested	(5) Temp. Def.	(6) Perm. Def.
2001-2008						
Newly Protected	0.008**	0.008***	-0.016***	0.003	0.005**	-0.008*
Between Years	(0.004)	(0.002)	(0.004)	(0.006)	(0.002)	(0.004)
2001-2010						
Newly Protected	0.008**	0.008***	-0.016***	0.004	0.005**	-0.009**
Between Years	(0.004)	(0.002)	(0.004)	(0.006)	(0.002)	(0.004)
2003-2008						
Newly Protected	0.011**	0.008***	-0.019***	0.002	0.004*	-0.006
Between Years	(0.004)	(0.002)	(0.004)	(0.007)	(0.003)	(0.005)
2003-2010						
Newly Protected	0.010***	0.008***	-0.018***	0.002	0.004*	-0.006
Between Years	(0.004)	(0.002)	(0.004)	(0.006)	(0.002)	(0.004)
Mean of DV	-.0123	-.0103	.0226	-.00313	-.00412	.00725
N	792317	792317	792317	167147	167147	167147
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Matched Sample				Yes	Yes	Yes

Notes: Table reports results from OLS regressions relating protected status to changes in land use sequence type. The data is a random sample of 793,928 coordinates across the Brazilian Amazon. Two five year sequences are used for each coordinate, 2001-2005 and 2008-2012. The land use sequences are categorised into three groups, stable forest, temporarily deforested and permanently deforested, using the approach described in A.3. The dependent variable is a categorical variable which takes the difference between dummies indicating a particular classification. The independent variable indicates whether the coordinate was protected between the years indicated. For columns 4-6, coordinates which were protected between 2001 and 2010 are matched to observationally identical coordinates that were either never protected or always protected on the basis of propensity scores (see Online Appendix Table A9 for the matching regression). We retain only matched pairs with absolute differences in propensity score of less than 0.001. We match on changes between 2001 and 2010 for consistency with table 5. Standard errors are clustered at the municipality level. Stars indicate *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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