Multiple Use Protected Areas Can Reduce Poverty And Deforestation:

evaluating two types of PA impact given a competition for land allocation

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Abstract

Protected areas (PAs) are the leading policy to conserve forest because they restrict land use. PAs are expected to reduce local economic returns (lacking any transfer policies or tourism). Yet in our model of land allocation following profit, where high and low capital compete, we formalize one reason PAs could help poorer actors: since low tend to lose in land allocations, PA restrictions may reduce returns more for high capital and thereby yield land reallocation. Poorer groups might rightly view some PAs as 'the enemy of my enemy and thus my friend'. Qualitative accounts concerning Chico Mendes Extractive Reserve in the Brazilian Amazon, Yaigoje-Apaporis indigenous lands in the Colombian Amazon that are newly a National Park and Lore Lindu National Park in Indonesia support the relevance of this model. Evaluating Mendes' impact on deforestation shows that such PAs can achieve emissions reductions too.

Keywords deforestation, protected areas, livelihoods, Brazil, Acre, Indonesia, Colombia

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1. INTRODUCTION

For tropical forest countries such as Brazil, Colombia and Indonesia, the total emissions of greenhouse gases are significantly affected by decisions that affect the use of forested lands.[1] The desire for reductions in emissions from deforestation and degradation (REDD) has joined longstanding interests in species' habitats, plus other ecoservices provided by tropical forests, to help justify policies that, relative to baseline, intend to conserve forests by limiting uses of land.

Yet any vision of sustainable development that involves local welfare also must consider the costs of limiting land uses (World Bank 2008, 2010a,b). The typical model of costs presumes they will fall on all local groups.[2] When costs are considered at all, often it is in the aggregate, though surely costs differ across groups. Corbera et al. (2007) and Scharlemann et al. (2010) note that policy choices may involve not only forests and economic aggregates but also distribution.

We push such reasoning further to identify conditions for some groups to benefit, on net. In particular, we consider settings in which land use by one group crowds out land use by others. When groups compete over land allocations, with winner and losers, policies may aid one group.

Specifically, we model theoretically a land-allocation process driven by profitability, in order to show that multiple-use PAs can aid those less able to generate profit based on land use. When PA restrictions constrain the more profitable actors more, less profitable actors can view PAs as 'the enemy of my enemy' and, thereby, welcome regulations that lead others to cede land. Next we provide qualitative support for the model's relevance in Brazil, Indonesia and Colombia as well as empirical evidence from the Brazil case that such PAs can reduce deforestation too. [3]

In the context of literature on conservation policy impact, we aim to add by integrating in evaluation a relevant and important development dynamic: competition for lands among groups. Protected areas generally are assumed to lower deforestation and local economic options for all. Questioning the assumption of lower deforestation, recent literature aids evaluation by pointing out spatial variation in forest baselines (review in Joppa and Pfaff 2010a[4]), i.e., by including the economics of land use across a landscape.[5] Questioning the assumption of economic losses, here we suggest improving baselines by noting spatial variation in to whom land is allocated and, for some settings, highlighting that PAs may change outcomes of competition for land allocation. Groups unable to access land in the baseline might gladly accept even restricted access in PAs. We consider the implications of such a development setting for both economic and forest impact.

We are far from being early commentators upon community-PA interactions, of course. Many have considered reasons why categories of features we associate with multiple use PAs, i.e., roles for local actors, could be good for the forest. Since monitoring costs are significant in developing countries, especially when PAs are large (Banana and Gombya-Ssembajjwe 2000), locals with the right incentives might help (Ostrom and Nagendra 2007, Danielsen et al. 2009). Property rights can be critical to such incentives, affecting such monitoring (Somanathan 1991). Yet community-based management may not always work (Blaikie 2006). There is evidence that common-property-resource management has been associated with high levels of breakdown in local institutions in Zimbabwe (Campbell et al. 2001). One issue can be distribution, e.g., how property rights are given might benefit some at the expense of others (Shackleton et al. 2002).

Concerning the acceptance of the land-use restrictions implied by a PA − noting here the underlying conception as PAs as costly, which of course is true for some and can be true for all − it matters whether local communities are part of, and thus legitimate, the process of PA creation. The potential importance of integration with the processes of community institutions is noted for many countries including Uganda, Panama and Nepal (Oestreicher et al. 2009, Nagendra et al. 2007) and many others. Without such local involvement in the the setting of limits, which even can include moving local actors out, claims of conflict generated by PAs are many, including for example in Costa Rica (Rodriguez 1997), Uganda (Blomley 2003), Ecuador (Fiallo and Jacobson 1995) and Honduras (Pfeffer et al. 2005), among others (Brockington and Schmidt-Soltau 2004).

Following such research on distribution and conflicts relevant for the outcomes for forest, we take some conflict within land allocation as the underlying process in which PAs intervene. Since there are many types of land conflict, we model a land-allocation process between groups who generate different levels of profit from the land. That could be various forms of competition, from rich versus poor farmers to mining firms versus all farmers, with various specific allocation processes for land from markets to concessions to zoning. The key is that the different groups would use the land differently, such that any such PA affects these groups' profits differentially. Further, the PA needs to be a multiple-use PA, so that 'the last group standing' gets some benefit. After our formal model, we provide examples from three countries (Brazil, Indonesia, Colombia) which support the idea here that sometimes underempowered groups do form beneficial alliances with environmental authorities, who help by limiting some more empowered competitor. Finally, for the Brazilian case, we demonstrate statistically that this is compatible with saving the forest.

The paper proceeds as follows. Section 2 provides our model of land allocation among competing groups, i.e., a new context for examining potential distributional impacts of PA types. Section 3 adds qualitative evidence supporting our model from Brazil, Indonesia and Colombia. Section 4 shows a relatively high deforestation impact for the extractive reserve in Brazil whose history was presented within Section 3, while Section 5 discusses analogs as well as challenges.

2. MODELING PA IMPACTS: ADDING LAND ALLOCATION ACROSS GROUPS

Our model assumes a fixed quantity of Land that we normalize to one. We are also going to assume that land quality, in terms of productivity, is decreasing in position, i.e. portions close to zero are highly productive while, as we get closer to one, land productivity steadily decreases.

The model features two types of actors: those with high capital (H); and those with low or small capital (S). H can invest in a technology to increase profits for the highest land quality, at least relative to S. However, its profits fall more quickly with land quality than the profit for S. One example is that the capital is a tractor while lower land quality is much more steeply sloped, where we assume that land quality and capital are complements, i.e., the tractor does far better on flat land (note Appendix A finds similar results for capital as a substitute for land, e.g., fertilizer).

We also have a Government that allocates land by renting it to the actor with the highest willingness to pay. The same Government decides whether or not to set up a PA on each parcel. That decision is made using a voting with each group equally represented. The protected area can be of two types: Strict or Sustainable Use. Strict PAs allow no economic activity but Sustainable PAs allow restricted extraction. We discuss first Sustainable Use PAs which constrain only H, leaving Sustainable Use and Strict PAs that constrain both H and S to the end of this section.

(a) Production On The Land

The groups' profit functions are:

$$\Pi_H = \alpha - \beta L \qquad \Pi_S = \gamma - \delta L \qquad \alpha \geq \gamma \qquad \delta \leq \beta$$

Each profit function is determined by two terms. The first is a fixed term (α for H, γ for S) that represents the output (and with fixed price for all actors also the revenue) achievable on every single parcel. The second is costs of producing that output, which increase with L (βL and δL), as quality falls. Here, we are making the assumption that both types are price takers on the final product market and that the H type is able to extract more of that product from the same parcel of land than is the S type but that this comes at a cost that increases faster as land quality decreases.

(b) Default Land Allocation

Government allocates land, renting it to the actor with the highest willingness to pay through a second-price auction. Thus, allocations without policies could mimic what the land market would bring about. The land will be sold to either H or S according to the allocation rule:

$$q_H = \begin{cases} 1, & \text{if } b_H > b_S \\ 0, & \text{if } b_H < b_S \\ 1/2, & \text{if } b_H = b_S \end{cases} \qquad q_S = \begin{cases} 0, & \text{if } b_H > b_S \\ 1, & \text{if } b_H < b_S \\ 1/2, & \text{if } b_H = b_S \end{cases} \qquad b = \begin{cases} b_S, & \text{if } b_H \geq b_S \\ b_H, & \text{if } b_H < b_S \end{cases}$$

where q_i is the probability that land is allocated to actor i = H, S and b is the price it is sold for. Hence, the government allocates the land to H if she makes the highest bid in the land auction. For a second-price auction, the winner pays the amount of the losing bid, yielding utility:

$$U_i = \Pi_i - b_i$$

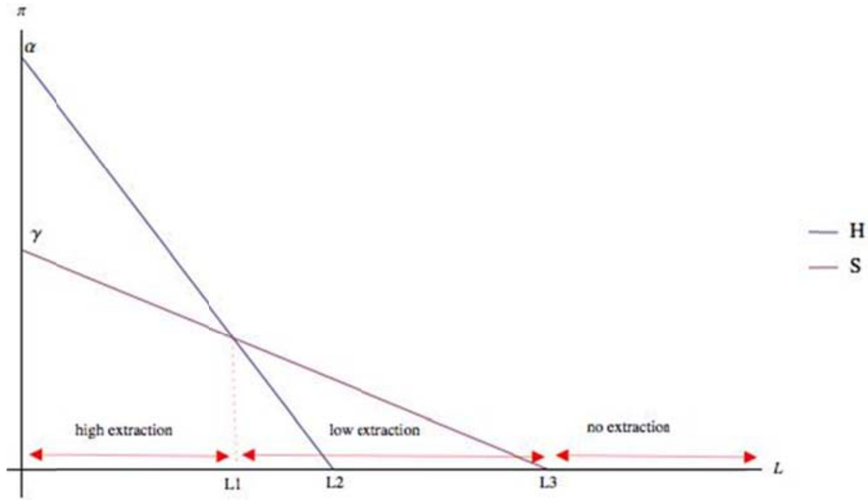
Each type bids up to their profit level on each land parcel in order to maintain positive utility:

$$\begin{cases} b_H \leq \alpha - \beta L = \Pi_H \\ b_S \leq \gamma - \delta L = \Pi_S \end{cases}$$

The bidding within the auction results in a land allocation, as depicted in Figure 1, such that:

- For $L \in [0, L_1]$ $with$ $L_1 = \frac{\alpha - \gamma}{\beta - \delta}$ both types bid and the H type wins the auction.
- For $L \in (L_1, L_2]$, $with$ $L_2 = \frac{\alpha}{\beta}$ both types bid, but the S type wins the auction.
- For $L \in (L_2, L_3]$, $with$ $L_3 = \frac{\gamma}{\delta}$ only the S type bids and gets the land for free.
- For $L \in (L_3, 1]$ no one bids and we have an unexploited area.

Figure 1: land allocation conditional upon not having a PA



(c) Protected Areas & Impacts

Now we allow the Government to set up a PA, or not, at any given on the land spectrum. Within our model, a PA is defined as an upper bound on the total output allowed from the land. As noted, to start we will focus on the case where a cap of intermediate magnitude affects the potential revenues for H type but not for S. Hence we set a total cap in revenues and profits as:

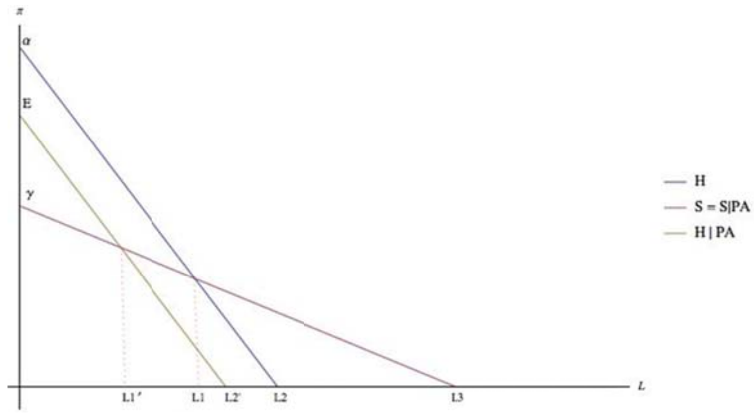
$$\bar{E} \in (\gamma, \alpha)$$

$$\begin{cases} \Pi_H = \bar{E} - \beta L \\ \Pi_S = \gamma - \delta L \end{cases}$$

Following the same bidding system as the previous section, in Figure 2 land allocation becomes:

- For $L \in [0, L_1']$ $with$ $L_1' = \frac{\bar{E}-\gamma}{\beta-\delta} < L_1$ both types bid and the H type wins.
- For $L \in (L_1', L_2']$ $with$ $L_2' = \frac{\bar{E}}{\beta} < L_2$ both types bid, but the S type wins the auction.
- For $L \in (L_2', L_3']$ $with$ $L_3' = \frac{\gamma}{\beta} = L_3$ only the S type bids and gets the land for free.
- For $L \in (L_3', 1]$ nobody bids and we have undisposed land.

Figure 2: land allocation conditional upon having a PA

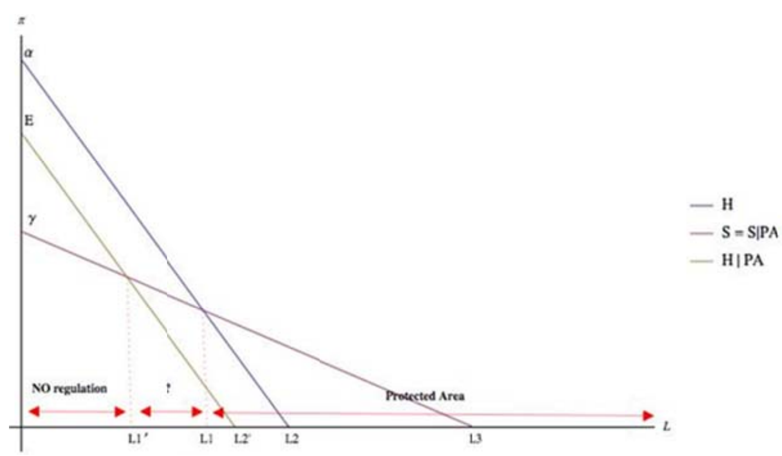


Already we find our result that 'a PA can be the enemy of my enemy', from the perspective of S. It is easy to prove that − as $L_1' < L_1$ and $L_3' = L_3$ − the aggregate profits for S increase, while the aggregate profits for H fall. That helps the poor, plus we have positive environmental outcome.

(d) Location of the Protected Areas.

Here we ask: will the Government set up a PA on a given land parcel? In order to do that, we assume that the Government samples the preferences of each type, equally weights them, and then decides whether to set up the PA. If both H and S vote 'yes' or 'no', Government follows. If the votes are discordant, the Government will break the tie by flipping a fair coin, i.e., a PA will be set up with probability ½ . Each type will prefer the outcome that gives her greater final utility and will vote for that land allocation. Hence, we distinguish five cases, as depicted in Figure 3.

Figure 3: decision about PA location



For $L \in [0, L_1']$, H's strictly dominant strategy is to vote 'no' to a PA, which would lower H's profits on those parcels, while S is indifferent as her profits are zero with or without the PA. Therefore, S randomly votes yes or no, with probability ½. The expected utility of H will be:

$$
\begin{aligned}
\Rightarrow E[U_H] \quad & = P(\text{S, 'no'}) \int_0^{L_1'} \alpha - \beta L - b_S \, dL \\
& + P(\text{S, 'yes'}) \Big(P(\text{G, 'yes'}) \int_0^{L_1'} \bar{E} - \beta L - b_S \, dL + P(\text{G, 'no'}) \int_0^{L_1'} \alpha - \beta L - b_S \, dL \Big) \\
& = \frac{3}{4} \int_0^{L_1'} \alpha - \beta L - (\gamma - \delta L) \, dL + \frac{1}{4} \int_0^{L_1'} \bar{E} - \beta L - (\gamma - \delta L) \, dL \\
& = \frac{(\bar{E} - \gamma)^2}{8(\beta - \delta)} - \frac{3(\bar{E} - \gamma)(-2\alpha + \gamma + \bar{E})}{8(\beta - \delta)} > 0
\end{aligned}
$$

Given that, H has an incentive to offer a transfer T to S, in order to get her to vote 'no' for sure. The transfer is described by the following equation. Facing this offer or bribe to vote against the PA, S's strictly dominant strategy will be to accept the bribe and vote 'no' with probability one.

For $L \in (L_1', L_1)$, the profits for H decrease with the PA, while the profits of S increase. Hence, H will vote 'no', while S will vote 'yes'. The expected utilities of the two types are then:

$$
\begin{aligned}
\Rightarrow E[U_H] \quad & = P(\text{G, 'yes'})0 + P(\text{G, 'no'}) \int_{L_1'}^{L_1} \alpha - \beta L - (\gamma - \delta L) \, dL \\
& = \frac{1}{2} \frac{(\bar{E} - \alpha)^2}{2(\beta - \delta)}
\end{aligned}
$$

$$
\begin{aligned}
\Rightarrow E[U_S] \quad & = P(\text{G, 'yes'}) \int_{L_1'}^{L_1} \gamma - \delta L - (\bar{E} - \beta L) \, dL + P(\text{G, 'no'})0 \\
& = \frac{1}{2} \frac{(\bar{E} - \alpha)^2}{2(\beta - \delta)}
\end{aligned}
$$

Within this situation of contrasting preferences for land allocations, each type has an incentive to offer a transfer to the other to get them to vote as preferred. Hence, T_H and T_S will be such that:

$$E[U_S] < T_H \leq \int_{L_1'}^{L_1} \alpha - \beta L - (\gamma - \delta L)\, dL - E[U_H] = \frac{1}{2}\int_{L_1'}^{L_1} \alpha - \beta L - (\gamma - \delta L)\, dL = \frac{1}{2}\frac{(\bar{E}-\alpha)^2}{2(\beta-\delta)}$$

$$\Rightarrow \frac{1}{2}\frac{(\bar{E}-\alpha)^2}{2(\beta-\delta)} \leq T_H \leq \frac{1}{2}\frac{(\bar{E}-\alpha)^2}{2(\beta-\delta)}$$

$$\Rightarrow T_H = \frac{1}{2}\frac{(\bar{E}-\alpha)^2}{2(\beta-\delta)}$$

$$E[U_H] \leq T_S \leq \int_{L_1'}^{L_1} \gamma - \delta L - (\bar{E} - \beta L)\, dL - E[U_S] = \frac{1}{2}\int_{L_1'}^{L_1} \gamma - \delta L - (\bar{E} - \beta L)\, dL = \frac{1}{2}\frac{(\bar{E}-\alpha)^2}{2(\beta-\delta)}$$

$$\Rightarrow \frac{1}{2}\frac{(\bar{E}-\alpha)^2}{2(\beta-\delta)} \leq T_L \leq \frac{1}{2}\frac{(\bar{E}-\alpha)^2}{2(\beta-\delta)}$$

$$\Rightarrow T_S = \frac{1}{2}\frac{(\bar{E}-\alpha)^2}{2(\beta-\delta)}$$

As the two transfers being offered by the actors are equal, the model cannot predict who wins in this bargaining process. Who prevails will probably depend on characteristics of the individuals, such as budget constraints, timing of the move or a power relationship between the two actors.

For $L \in (L_1, L_2']$, H is indifferent while the S type votes ‘yes’. Following the same line of reasoning as above, S has incentive to bribe H using the transfer to vote yes with probability one. Very much analogous to above, H has a clear incentive to accept the transfer and vote for the PA.

$$\begin{aligned} 0 < T \leq \int_{L_1}^{L_2'} \gamma - \delta L - (\bar{E} - \beta L)\, dL - E[U_L] \qquad &= \frac{1}{4}\int_{L_1}^{L_2'} \alpha - \bar{E}\, dL \\ &= -\frac{(\beta(-\alpha+\gamma+\bar{E}) - \delta\bar{E})(\bar{E}(\beta+2\delta) - \beta(\alpha+2\gamma))}{16\beta^2(\beta-\delta)} \end{aligned}$$

For $L \in (L_2', L_2]$, again H is indifferent while the S type votes ‘yes’ and, through the same reasoning, we have that the H type will be induced to vote for the PA by a transfer of size:

$$0 < T \leq \int_{L_2'}^{L_2} \gamma - \delta L\, dL - E[U_L] = \frac{1}{4}\int_{L_2'}^{L_2} \alpha - \beta L\, dL = \frac{1}{4}\frac{(\bar{E}-\alpha)^2}{2\beta}$$

For $L \in (L_2, 1]$ H and S are indifferent, so Government sets up a PA with probability ½.

(e) Technological Change

Imagine now two periods. In the first, both H and S profit functions remain as described. In the second, H will have access to new capital allowing more extraction from each land parcel, at the same cost. Hence, H and S profit functions for period 1 and period 2 become, respectively:

$$\Pi_H^{(1)} = \alpha - \beta L$$

$$\Pi_S^{(1)} = \gamma - \delta L$$

$$\alpha > \gamma, \beta > \delta$$

$$\Pi_H^{(2)} = \begin{cases} \alpha - \beta L, & \text{with probability}\, p \\ \alpha' - \beta' L, & \text{with probability}\, 1 - p \end{cases}$$

$$\Pi_S^{(2)} = \gamma - \delta L$$

$$\alpha' > \alpha, \beta > \beta' > \delta$$

Following the reasoning above, the initial allocation of land as driven by a Second Price Auction, without any PAs, is as depicted in Figure 4. Then once we introduce votes in order to set up PAs, which as noted always are formalized as a cap on extraction (and hence revenues of $\bar{E} \in (\gamma, \alpha)$), the voting and bargaining processes lead to an allocation of PAs of the type depicted in Figure 5.

We highlight that the second section of land where a PA is set up will be occupied by S, while the absence of regulation implies high extraction by H on all of the land between 0 and L_4. Thus, the threat of regulation not only has environmental benefits but also will increase the profit for S in the presence of possible technological change, at the expense of the profits of the H type.

Figure 4: Land use with technological change

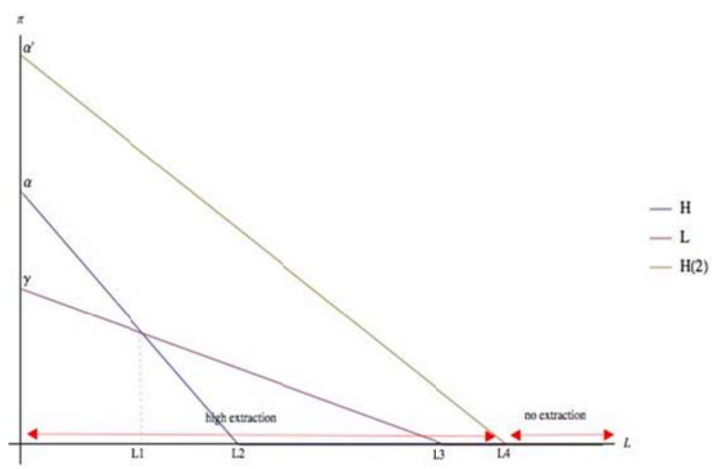
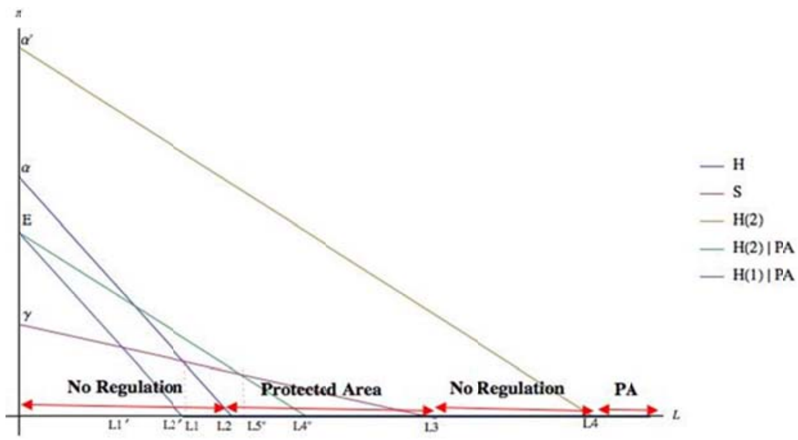


Figure 5: PA location with technological change



(f) Strict PAs

When regulation is more strict ($\bar{E} \leq \gamma$ or $\bar{E} = 0$), we find that both in the baseline case and after the PA is introduced, the profits of H are greater or equal than the profits of S. Thus, H can bribe S to vote against the PA by offering a transfer whose upper bound is the difference between profits without regulation and the expected profits before the voting process is resolved and whose lower bound is zero. Hence PAs are set up only in the most unproductive lands, ones which would have not been used (which does seem to describe the isolation found to characterize many PAs (see, e.g., Joppa and Pfaff 2009)). Yet the threat of regulation creates redistribution.

(g) Conclusions

The model proposed above, then, provides three main conclusions (the second is our core point):

- PAs are more likely to be put in place in areas where they are not binding on local activity
- weaker actors are willing to be regulated when it restricts strong competitors for land more
- in fact, not only can a PA encourage more equitable distribution of lands but also the threat of a PA, even if not enacted, can create economic redistribution through political processes

3. QUALITATIVE EVIDENCE ON LAND ALLOCATION AND PA IMPACTS ON GROUPS

(a) Brazilian Amazon, Acre State, Chico Mendes Extractive Reserve

In 1990, the Chico Mendes Extractive reserve was one of the first four extractive reserves created by IBAMA as a Reserva Extrativista. The concept of such an alliance of relatively small scale extractors from the forest, linking to the state, dates from the very first National Meeting of Rubber Tappers in Brasilia, in 1985. It reflected the experiences of the unionized rubber tappers in the Acre River Valley dating to the late 1970s (Allegretti ####, #### and Schwartzman 1991).

By the 1970s in the Acre River valley, the collapse of rubber prices even with subsidies was such that the ostensible owners of the old rubber estates (patrões seringalistas, or “rubber barons” as historian Barbara Weinstein translated it) basically abandoned the rubber estates and the previous bonded ('company store') labor system ended. Tappers were then free to sell rubber where they could plus hunt, fish, plant swidden gardens, raise livestock and collect Brazil nuts.

In the mid-1970s, the Acre state government (with federal support) paved the #317 road from Rio Branco to Assis Brasil and offered tax incentives and cheap credit to attract investors, mostly cattle ranchers from southern Brazil, who began buying up the old rubber estates. Yet the lands in question largely were occupied by rubber tappers. They lacked land titles, but had rights to occupied lands as “posseiros”. As a form of ‘land re-allocation’, the ranchers hired gunmen to intimidate the rubber tappers in order to get them off the land on the way to the clearing of forest. This was clearly a form of less financially empowered groups losing out in who gets to use land.

Some families resisted, despite this violence, with the support of the “liberation theology” wing of the Catholic Church. Leaders such as Chico Mendes and Wilson Pinheiro then organized demonstrations against deforestation and expulsions. Such “empates” often slowed deforestation. The Church helped organize Rural Workers’ Unions. It called on The National Confederation of Agricultural Workers (CONTAG) and National Institute for Colonization and Agrarian Reform (INCRA) to help resolve disputes given posseiros’ land rights. INCRA did intervene, by dividing disputed lands between ranchers and rubber tappers and then dividing up the rubber tappers’ land into 100 ha lots. Since rubber tappers’ land uses did not conform to a rectangular grid, however, the division rendered them unviable – with lost rubber trails, lost Brazil nuts, a lack of water – with the end result that the rubber tappers sold out to the ranchers and migrated to urban slums. Thus, while legally there was some support of poorer rights, effectively higher capital won out.

At this point, in the late 1970s, Mendes and Pinheiro devised a new strategy to oppose any negotiations and call for ongoing resistance in the forest and better living conditions there. Amidst ongoing conflicts, and empates, Pinheiro was assassinated. In 1985, at the 1st National Meeting of Rubber Tappers, Mendes learned of the international environmental movement and with a small group of rubber tappers as leaders and close advisors he proposed the concept of the extractive reserve. Such an action by the state was conceived as a means of securing (collective) land rights for the members of what was the underempowered group in this setting, as well state investments in health and education as well as economic alternatives. This was all very much in the spirit of a collaboration between low-capital and environmental objectives, in consideration of rubber tappers' commitment to use the forest on a sustainable basis and to prevent large-scale deforestation. With support and lobbying by anthropologist Mary Allegretti the new concept was taken up first by INCRA when it creates the "Projeto de Assentamento Extrativista", and the first PAE's are created in the Acre River Valley in 1987 (Seringal São Luis de Remanso and others).

After Mendes' assassination – linked to his success in pressuring the state government to expropriate Seringal Cachoeira to create a PAE -- IBAMA was lobbied to create the "Reserva Extrativista" category of land-use restrictions nonethless linked to smallholder production, which is put into practice in the Chico Mendes Extractive Reserve, Upper Juruá, one site in Rondonia and another in Amapá. The term "reserva extrativista" was invented by a rubber tapper explicitly seeking land rights for extractors (extractivistas) modeled on indigenous lands (Allegretti 20##), while the coalition to support those rights clearly also involved interests in forest conservation.

(b) Indonesia, Central Sulawesi Province, Lore Linda National Park

Lore Lindu National Park (LLNP) is a mountainous area of over 200,000 hectares that is dominated by primary and secondary forest, within the province of Central Sulawesi. The region is renowned for its unique biodiversity. For instance, the LLNP is one of the identified core areas for protection of the Wallacea biodiversity hotspot (Myers et al. 2000; Achard et al. 2002), with over 200 bird species observed of which 77 are endemic to Sulawesi (Waltert et al. 2004; 2005). Thus, this state land restriction clearly targets conservation objectives. While the interactions of the relevant groups in this area are complex, recent governance innovations support low capital.

Despite decentralization after the fall of Suharto in 1998, all National Parks are still run by the central government (Ministry of Forestry), which holds *de jure* property rights to all the natural resources. By combining three PAs established during 1973 to 1981, LLNP was officially founded in 1993 (Birner and Mappatoba 2003). Land customarily used by local communities was within the Park while a few communities moved out of the park to its borders (Mappotoba 2004). Strict rules prohibit forest use by communities within the Park. In contrast, land-use rights in the local communities tended to be based upon traditional *adat* rights or customary laws. There was evidence of variation in extraction by communities inside LLNP suggesting a mix of Paper Tiger − little protection − and Fences & Fines − strong protection – forest scenarios (Engel et al. 2013).

While overall that may suggest relatively low community extraction from inside the park, at the time there was considerable pressure by resource users to allow increases in extraction, for both political and economic reasons (Palmer 2014). Cocoa cultivation was the main driver of the forest conversion inside the park, led by well-capitalized migrant groups who tended to open up a few hectares or more per household and claim land as private property. Migrants influenced a change in the local livelihood strategy from 'food first', based on irrigated rice, to 'cash crop first', with an increased use of intensified cocoa cultivation techniques (Steffan-Dewenter et al. 2007).

We believe these trends link well with our model, allowing for probabilities of multiple land scenarios and thus expectations as well as risk aversion. In sum, while it could be possible that without a recent governance innovation bringing together local groups with environmental authorities the state exclusion of private production would have continued, many actors thought it likely that forest conversion due to cocoa − more like ‘open access’ − would have come about. That would have increased rates of deforestation along with reallocations of land to newcomers.

The local response to conditions was ‘co-management’, negotiated between the state and user groups, in which the state holds *de facto* rights but the relevant local users enjoy greater use of park resources in exchange for taking on some of the park management responsibilities. The head of LLNP pioneered ‘Community Conservation Agreements’ (referred to simply as ‘KKMs’ for *Kesepakatan Konservasi Masyarakat* (Mappatoba 2004)) formally between communities and the park authority, with both promotion and facilitation by NGOs. The KKM in many cases led to a reinstatement of customary (common) property rights and also allowed for exclusion rights, which meant that the indigenous could keep out migrants if they so wished. For NGOs focused on forest conservation, whom it seems suspected Fences & Fines would end, KKM were a way to allow some extraction instead of more. For communities, at the cost of some effort to help in management of the park, this increased not only the ability to exclude but also rights to extract.

In terms of exclusion, for example, customary institutions were granted the authority to impose two-hectare limits on the forest conversion by migrants who were keen to expand cocoa cultivation (Acciaioli, 2010). Customary leaders also wanted to recast the certified, private land rights as temporary use rights, so they could not be sold. Empowering customary institutions with such authority helped for environmental objectives as well. Because migrants tended to clear more than 2 ha, sometimes 12 ha or more, the imposition of customary limits on forest conversion may have forestalled higher levels of forest conversion in and around the park.

(c) Colombian Amazon, Amazonas & Vaupes Districts, Yaigoje-Apaporis National Park

Yaigoje-Apaporis, in the Amazon, is now the second largest protected area in Colombia. With one million hectares, Yaigoje-Apaporis is the habitat of an important number of species of flora and fauna, as well as the home of an important number of Colombian indigenous groups: Macuna, Taminuca, Letuama, Tuyuca, Barasano, among others. Fitting the nature of our model, Yaigoje-Apaporis was declared a National Park in 2009 as a response of the indigenous groups, in agreement with the national environmental authorities, to the threat of mining concessions.

The Yaigoje-Apaporis area has been an indigenous reservation (*resguardo*) since 1988. However, land in indigenous reservations can be included in mining concessions. In Colombia, as in many other countries, the state owns the subsoil and makes all the decisions regarding the mineral resources. More specifically, even while any reservation grants collective property rights to the indigenous communities, the state keeps the subsoil property rights. A mining concession, though, requires a process of 'previous consultation', as recognized in the ILO Convention 169. Still, such a process does not guarantee the protection of the indigenous territories from mining.

In response to the mining threat, the indigenous people of Yaigoje-Apaporis approached the National Parks office of the Ministry of Environment to request that their collectively owned territory was declared as a National Park. It was officially declared under a special management regime regarding the indigenous groups' autonomy and traditional practices. Yaigoje-Apaporis is the first such park in Colombia created as express request of the indigenous communities and given the status as indigenous reservation, a process of previous consultation was required for it.

Yet two days after the creation of the park Cosigo Resources, a Canadian gold-mining company, was granted a license of 2000 hectares within the boundaries of the protected area. To make it effective, Cosigo is attempting to have protected-area status revoked by taking advantage of dissatisfaction expressed by some communities regarding the restrictions on economic activity implied by being within a national park. Advised and financed by Cosigo, a community member pursued a civil suit against the creation of the park, arguing that the consultation process was poorly done, in particular not involving all of the indigenous communities within the reservation.

In January 2014, three members of the country's Constitutional Court made a trip to the indigenous reservation to hold a public audience and listen to the indigenous communities. It seems to be widely believed Cosigo was behind the suit and, further, that indeed there had been a significant process of consultation involving all the indigenous communities. In September 2015, the Constitutional Court made a final decision in favor of the creation of the National Park. The Court also ordered the immediate suspension of any mining activity within the Park's boundaries.

4. EVIDENCE ON FOREST IMPACTS OF CHICO MENDES EXTRACTIVE RESERVE

Protected areas generally have been assumed to lower deforestation, yet it is now solidly established that because the baseline deforestation rate that PAs might block varies greatly across the landscape, impacts of PAs also vary (Pfaff et al. 2009 for Costa Rica, Joppa and Pfaff 2010b globally, Pfaff et al. 2015a for all the Brazilian Amazon). Deforestation-related characteristics of PA locations are critical for impacts because a PA cannot block more than the pressure at its site.

That perspective on PA impacts leads immediately to asking what drives those locations. Surely, as in our model, it is a form of public process that in some way trades off the benefits of forest conservation and its costs. Such processes clearly evolve, for instance comparing the early days in protection in Acre (as in section 3a) with processes employed there in the early 2000s.[6] Within almost any such process, if PA types vary in terms of the local benefits that they permit, their locations may vary as well. There is growing evidence for that (see Joppa and Pfaff 2010b, Nelson and Chomitz 2011, Pfaff et al. 2015b). That government also determines the level of PA enforcement can confound this (Pfaff et al. 2015b) but, all else equal, we might expect that a PA which permits limited smallholder production can be implemented nearer to people and pressure, instead of pushed to isolated rural areas (Joppa and Pfaff 2009 document global PA isolation), as the PA's net local costs are lower. For instance, Pfaff et al. 2013 show that for the state of Acre, home to the Chico Mendes Extractive Reserve, PAs of the multiple-use or Sustainable Use type are located nearer to drivers of deforestation pressures than are PAs of the strict or Integral type.

As seen in Figures 6 and 7, the Chico Mendes Extractive Reserve is particularly close to an important deforestation driver, the InterOceanic Highway (see results in Delgado et al. 2008). While one might presume that at such close proximity this reserve would be completely overrun − and indeed Figure 7 indicates internal deforestation, which can be legal in an extractivist area − investments in the capacity to implement agreed protection levels have been significant in Acre. That includes a legal framework for PAs (Lei Estadual n° 1.426/2001), plus the State Economic and Ecological Zoning (Lei Estadual nº 1.904/2007), and Acre also was one of the first Amazon states with wall-to-wall, fine-scale monitoring which can detect a forest loss of just two hectares. Demonstrating dual public objectives, Acre has supported the extractive communities via several programs and policies, e.g., within supply chains for non-timber forest products and for timber.

(a) Data & Matching Approach

(i) Deforestation

We study deforestation in Acre during 1989-2000 and 2000-2007. We use ######## remotely sensed pixels of information on land cover in 1989, 2000 and 2007 from ?????? and calculate the deforestation during these two time periods. For one observation, the data indicate a single class of land cover. Deforestation is the change from forest land cover to a non-forest one. Thus, for each pixel in forest cover in 1989, our deforestation variable is binary, with value 1 if the parcel is covered with forest in 1989 but deforested in 2000 and value 0 if it is in forest in both years. Then, for each pixel in forest in 2000, our deforestation variable takes value 1 if the parcel is in forest in 2000 but deforested in 2007 and value 0 if it is in forest in both those years.

(ii) Protected Areas

The Brazilian Legal Amazon is a region of 521,742,300 hectares (about 5 million km^2). Acre makes up about 3%. About 44% of the Legal Amazon is protected, with 8% in Integral areas, 14% in Sustainable Use protection, and 22% in Indigenous lands. For the entire Legal Amazon, most Indigenous land was designated during 1990-1999, while most federal areas were created during either 1980-1989 or 2000-2008. For Acre, Figure 6 places our site into context.

(iii) Characteristics

Many factors affect both rates of deforestation and the chosen locations for protection and thus difference between deforestation in protected and unprotected locations could represent impacts of protection or instead influence of factors that vary between protected and unprotected areas and also affect deforestation. To correctly infer the impacts upon deforestation of protected areas such as the Chico Mendes Extractive Reserve, we need to control for influences of these site characteristics. Examples of important observed characteristics are distances to rivers, the nearest city and InterOceanic Highway. We also use altitutude, a relevant biophysical condition.

(iv) Units

We have a sample of ###### randomly selected pixels for the state of Acre. If our data do not clearly indicate that there is forest cover in 1989 for our first time period (or for 2000 for our second time period), then we drop the observation. This leaves ###### forest pixels to analyze.

For our first time period, we consider a pixel as protected only if it was protected in 1989. For our second period, we use the same areas for comparison (one could analyze new 1989-2000 protection). Pixels in PAs created after the time period in question are included in the potential controls for that time period, since they were not protected during that period. Pixels in PAs that were created during the time period in question are not included within the analysis because we cannot tell how much of the deforestation was before or after the creation of the PA in question. That leaves ##### and ##### total observations for our two time periods, respectively, of which ##### and ##### are in our two control groups, while ##### and ##### are labeled as protected.

(b) Results

(i) Matching

If protection in the Brazilian Amazon and in Acre had been implemented randomly, then its deforestation impact would be easy to estimate. We would only need to look at the difference between the deforestation rate inside and outside of the protected areas. The deforestation rate outside would be an unbiased estimate of what would have been the deforestation rate inside the boundaries of protection, had there been no protection, since the other factors would cancel out. Yet Table 1 conveys that the deforestation relevant characteristics we measure are not identical within the Chico Mendes Extractive Reserve and the entire set of unprotected or untreated lands.

Looking across its columns, Table 1 also shows that protection types differ in terms of their site characteristics. While its first two columns showed that Mendes was perhaps closer to some deforestation drivers than average untreated land, the other PAs are considerably farther. In light of that, to isolate the impact of protection upon forests, here we apply 'matching' methods. The idea is to 'match' each protected point to the most similar unprotected point(s). Thus, the protected points will be compared not to all unprotected lands but only to the most similar land.

We use propensity-score matching, which defines 'similarity' as a similar probability of a pixel being protected. Thus, the protected pixels are compared to pixels that are not protected but that have similar enough site characteristics to yield a similar probability of being protected. The probabilities of protection are generated in a probit model to explain where protection occurred, using factors that may affect both protection and deforestation (Rosenbaum and Rubin 1983). This implies that more weight is given to variables that are important determinants of protection.

We also directly check whether the selected unprotected points are, in fact, more similar. Table 2 examines the 'balance' from matching, i.e., whether the average value of the covariates is distinguishable between the protected and selected subset of matched untreated observations. Ideally it should be the same. More generally, a significant reduction in the differences between groups indicates the potential for this 'apples-to-apples' exercise to reduce biases in estimation. Table 2 shows, without question, that we can compare each of Chico Mendes and the other PAs to observationally much more similar comparison untreated points through this explicit focus on the sites' characteristics. Further, to emphasize, those matched untreated sets differ greatly for the two sets of PAs, which explains why controlling for site characteristics affects impact estimates. We also emphasize, however, that such matching is not a fix for factors that we do not observe.

(ii) Impacts

Table 3 concisely presents two key points. First, even when protection is of a form which permits smallholder production, it can have a significant impact on the deforestation rate in PAs. Second, counter to the intuition that allowing deforestation must lower overall impact − intuition that could follow from the patches of deforestation within Chico Mendes seen within Figure 7 − multiple-use or smallholder-oriented protection actually can have greater impacts than other PAs.

Table 3's Mendes columns for each of the two time periods contrast with recent literature finding that correcting for the influence of PA isolation (using observable characteristics in OLS, Matching or both) tends to significantly reduce the estimated impacts of PAs upon deforestation. Looking down the Mendes columns, we see that the estimated impacts for Mendes hold up to the introduction of controls in OLS and an increase in similarity of control comparisons in matching. In light of Figure 7, actually that is not surprising, given proximity to the InterOceanic Highway. One must expect that locations so close to highways in the Amazon face deforestation pressures (see, e.g., Pfaff 1999 and Pfaff et al. 2007 among other such analyses). Since matching compares Mendes to other forest locations that are relatively close to that big highway (see Table 2), which tend to be relatively highly deforested, internal deforestation in Mendes (as apparent in Figure 7) easily could still be below rates in its apples-to-apples comparables (also suggested by Figure 7).

Comparing Mendes to the other PAs, starting with Table 3's inital top row, it is precisely the internal deforestation in Mendes that makes the initial estimates of impact lower for Mendes. Since the top-row estimates compare any protected point to the same set of all unprotected points the only basis for a difference in calculated impacts is a difference in the deforestation internally. Extractive reserves have more of that, naturally – and legally − so initially they look less strong.

Going down the columns for Other PAs, however, we see results more typical of many in the recent literature correcting for PA isolation: those estimated impacts fall greatly with control. That is also not surprising, if many of these Other PAs are in relatively isolated locations. In that case, correcting for the isolation with OLS or finding matches that are equally relatively isolated will lead to comparing the low deforestation within the PAs to low deforestation in comparables. A canonical if not always representative image could be a pristine PA around which the forest is also pristine, such that one cannot distinguish visually where the PA ends and unprotected starts. In that setting, even if internal deforestation is zero, impact also is zero if controls are uncleared. The lack of any significant estimate in the lower two rows for Other PAs is consistent with that.

5. DISCUSSION

We provided a new theoretical model for one way that multiple-use PAs might help those less able to generate profit based on land use, in a land-allocation process driven by profitability. When PA restrictions constrained more the more profitable actors, less profitable actors viewed PAs as 'the enemy of my enemy' and so they welcomed regulations that led others to cede lands. Next we provided qualitative evidence of relevance in Brazil, Indonesia and Colombia as well as empirical evidence that, within the Brazilian case, such a multiple-use PA reduced deforestation.

While as described our model is perhaps more civilized (or at least well organized by the state) than some actual settings of competition among groups for land allocations, we believe the basic idea carries through to other settings. For instance, instead of state allocation, land markets would yield similar initial allocations and results for PAs. Also, we must be cognizant that some land allocations are "negotiated" using guns. Even for that background process, sometimes state interventions in land allocation may improve outcomes relative to the 'private process' defaults.

We also must be cognizant that surely there could be reactions, to reverse these impacts, from those whom they harm. In the Colombia story we provided, for instance, the higher capital group quickly tried to use processes that were set up to avoid unfair allocation in order to contest, through some locals, a process that other locals supported (though in this case they lost in court). In one story we heard, for one South American country, to capture the gains to low-capital actors some high-capital actors used human capital (in the form of lawyers) to get deeds to land altered, then violence by going to the field to burn down the homes of those “now on land others owned". Further improvement in our understanding of dual outcomes generated by PAs that engage local actors requires careful consideration of when and how challenges to the processes we described, or to analogs, change the final outcome. Both further modeling and further empirics should add.

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Appendix A When Capital Substitutes For Land Quality In Production By "High" Type

Here we consider how the results would change if capital were not a complement to land quality in H's production function but, rather, a substitute. We assume S production remains unaltered, as it does not use capital. H's profit function changes, of course, as do rankings of relative profit on some parcels, since now H will be more profitable than S on all types of land. Its profits are higher for the best land. Now, in addition, capital negates the effects of falling land quality so, instead of falling more quickly as L increases, H profits fall less quickly than S profits with L.

A.1 Case (a): If the protected area is not binding on S, i.e., $\bar{E} \in (\alpha, \gamma)$, the regulation decreases the profits of H but has no effect on S. For influencing voting, the difference between H profits given a protected area and unregulated H profits is an upper bound on transfer that H is willing to give to L in order for L to vote against the protected area with probability one. In this case, then, H will make sure PAs are not introduced on any land parcels where H might eventually produce. That leaves the potential for a PA to be set up only in the most unproductive parcels of land.

A.2 Case (b): If both actors are strictly regulated, meaning that $\bar{E} \leq \gamma$,then the new regulation is going to affect both actors' profits. Still H will be more profitable than S on all of those lands that are used to produce. Thus, once again, S is going to be indifferent about a protected area, since S was going to lose out in this land-allocation process anyway. H will strictly prefer to vote against the PA. Again, H has an incentive to bribe S an amount between zero and the H loss due to the PA to vote against the PA. Again, no PA is set up upon any productive parcels of land. However, since in this case the regulation is more stringent, the upper bound for this transfer is greater than in case (a), though of course the actual transfer is the result of a bargaining game.

A.3 Case (c): If $\bar{E} \leq \gamma$ but this time we can assume that the regulation only applies to the H type, then H profits decrease while S is helped, as long as some profit is permited in the protected area. In this case, H votes against the regulation, while S votes in favor. In a setting of dueling bribes, what occurs depends on the characteristics of the two profit functions. However, even if the H bribe prevails, we note that the lower bound on that transfer to S from H is not zero, as above, but instead the expected value of S profit under the regulation, which is strictly positive. Thus even a credible proposal to create such a PA that would be limiting only on H could support S.

Appendix B When The Regulated Quantities Themselves Vary With Land Quality

Above we assumed profit functions of the form $\Pi_i = p\ Q_i - c_i L$, where p is the price of a unit of the final product (which is the same for each of these actors), Q_i are the quantities produced that varies across the actors because of the technology investment that the high capital type H makes, and c_i is the cost of production for each land parcel. We considered a fixed amount of output for each actor generated from each land parcel, no matter its quality. What varied with land quality was the cost of producing that quantity, with costs rising at different rates due to the different technologies of production. An alternative could be fixed costs but production varying with L.

Whether cost varies with L for a given quantity or quantity varies for a given cost matters within our model since the PAs' land-use restrictions are reasonably formalized as limits upon quantity. In the figures so far, since quantity does not vary with L the PAs shift only the profit intercepts, not profit slopes. However, if quantity falls with L for a given cost, instead of generating parallel profit lines, as above, then PA restrictions would make the profit functions horizontal in L until the land quality that yields the regulated quantity, where they rejoin unregulated profit function (currently we have not provided even more figures for this but they are available upon request).

Clearly, this kind of shift in profit function from a regulation could different impacts from those parallel shifts above. For instance, when the quantity limit is not binding on S because it is above the highest quantity producible by S on the best land (its quantity intercept within such figures), clearly nothing changes due to the regulation in terms of land allocations. However, the transfer offered from H to S to vote against a protected area for low L is lower than it would have been.

If the maximum quantity regulation is strict enough to affect both actors, this formulation of the profit function yields slightly different results but only in terms of the magnitudes of transfers. The basic logic holds for this situation, as the weaker S benefits from PAs that constrain it less.

Generally this version of our model generates the same key points (again the second is our core):

- PAs are more likely to be put in place in areas where they are not binding on local activity
- weaker actors are willing to be regulated when it restricts more one's competitors for lands
- the threat of a PA, even if not enacted, can create redistribution through a political process

Figure 6: Location Of The Chico Mendes Extractive Reserve

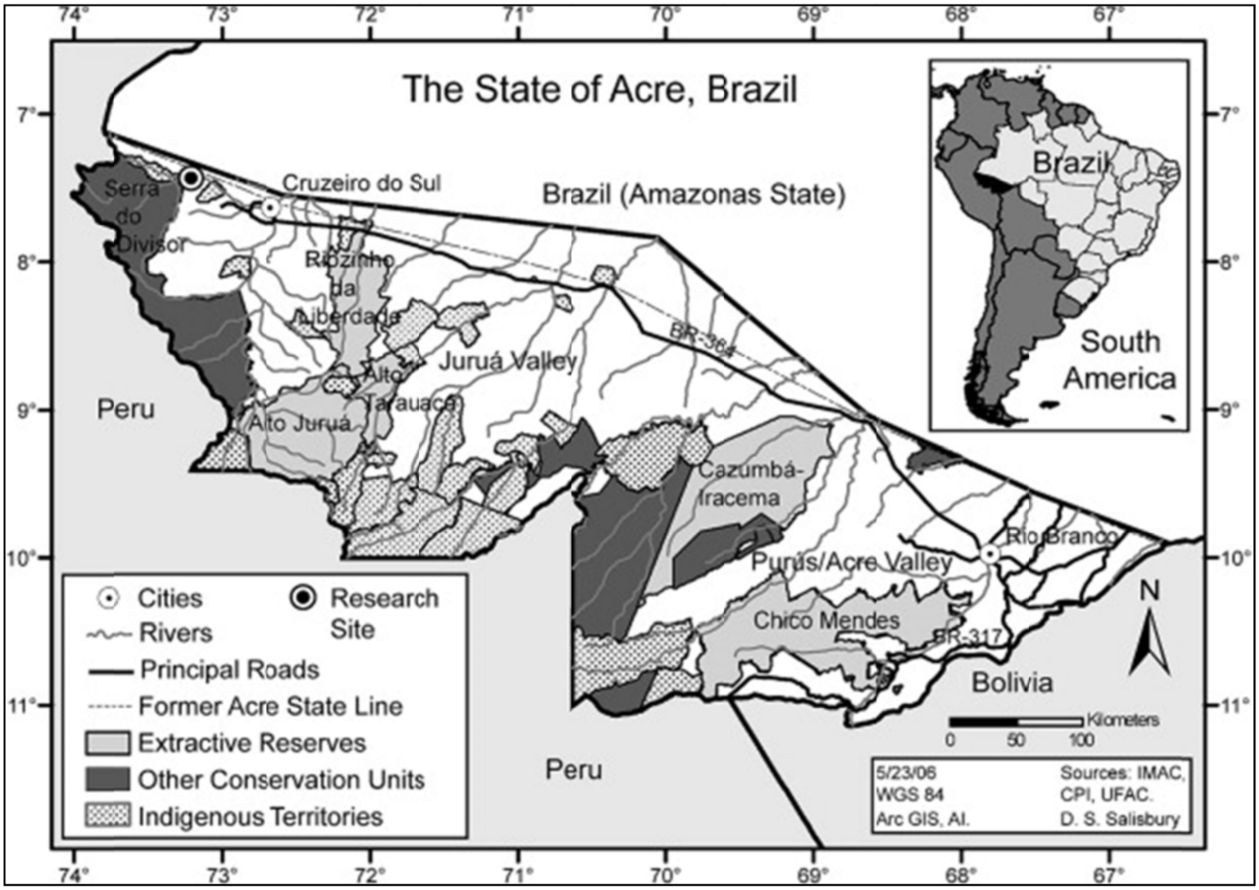

Figure 7: Deforestation Inside & Outside The Chico Mendes Extractive Reserve

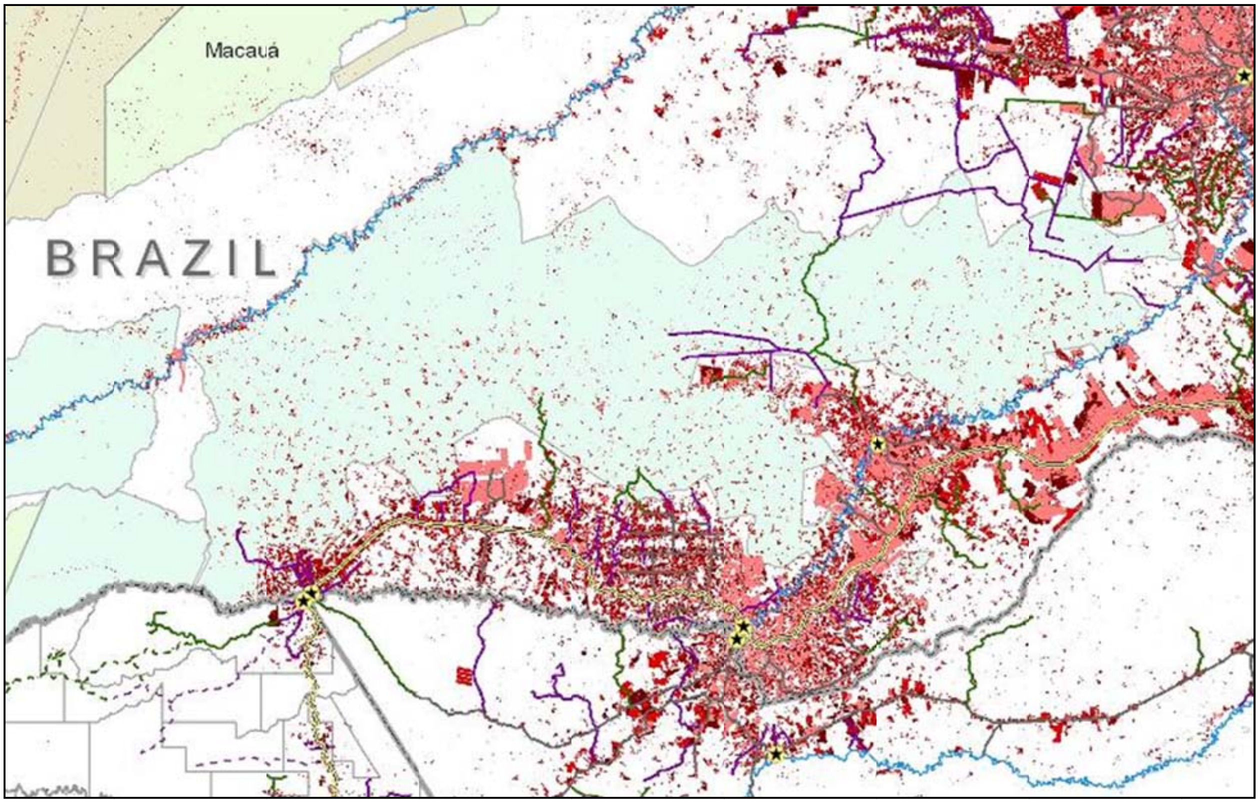

Table 1 Descriptive Statistics

	Chico Mendes Extractive Reserve		Other Protected Areas	
	Treated	*All Untreated*	*Treated*	*All Untreated*
Distance to Highway	36	50	120	50
Distance to City	45	55	125	55
Distance to River	22	18	15	18
Altitude	254	218	262	218

Table 2 Matching Balance

	Chico Mendes Extractive Reserve		Other Protected Areas	
	Treated	*Matched Untreated*	*Treated*	*Matched Untreated*
Distance to Highway	36	36	120	102
Distance to City	45	46	125	104
Distance to River	22	20	15	17
Altitude	254	255	262	290

Table 3

Deforestation Impacts of Chico Mendes Extractive Reserve & Other Protected Areas

	Deforestation 1989 - 2000		*Deforestation 2000 - 2007*	
	Mendes	**Other PAs**	**Mendes**	**Other PAs**
Initial "Estimate" (compare means)	-0.069*** [.007]	-0.076*** [.005]	-0.077*** [.0084]	-0.101*** [.006]
Regression (all untreated data)	-0.059*** [.008]	0.008 [.008]	-0.075*** [.0094]	-0.015 [.010]
Matching (compare means)	-0.067*** [.009]	-0.002 [.007]	-0.073*** [.0107]	0.002 [.010]

Standard errors in parentheses (matching's do not reflect that propensity score is estimated) and *** = significant at 1%.

[1] Colombia's 2nd national communication to the UNFCCC includes: "In whole numbers, the sectors which caused most GHGs in 2004 were agriculture 38%, energy 37%; land-use, land-use change and forestry - LULUCF - 42%."

[2] See, for instance, Robalino 2007's modeling of protection's impacts on the local demand for labor in agriculture. That is without considering tourism, however, which can have local benefits. Empirical analyses of economic gain from PAs − often with links to tourism − appears in, e.g., Robalino and Villalobos 201# and Ferraro et al. 201#.

[3] Andam et al. 2008 apply the same method to average PA impacts in Costa Rica, while Joppa and Pfaff (2010b) show that such corrections are important globally. Pfaff et al. 2009 demonstrate the significant heterogeneity of such improved estimates across space, along observable dimensions relevant for the baseline threat of deforestation. Pfaff et al. 2015a and 2015b apply to the Brazilian Amazon the heterogeneous impact approach taken in Pfaff et al. 2009.

[4] Joppa and Pfaff (2010a) review a rich evaluation literature — see also Naughton-Treves 2005, Nagendra 2008 and Campbell et al.2008. They emphasize hurdles for solid inference about protection's impacts upon forests. Protected areas' impacts have been evaluated frequently but methods used have varied a lot. Some evaluations do not compare but only observe that forest is standing. They lack a comparison to what would have happened had a protected area not been protected. Others compare protected areas to all unprotected areas. Many compare protection to the areas immediately surrounding protection. All these have not tried to control explicitly for differences in characteristics.

[5] Examples highlighting discussion of heterogeneity in PA impacts over space are Cropper et al. 2001, Sims 2010 and Ferrao, Hanauer and Sims 2011. Such heterogeneity in impact is not surprising in light of longstanding theory about variation in land use across a landscape, such as nicely laid out in Hyde 2012's perspectives upon forestry. Arriagada et al. 201#, Alix-Garcia et al. 201# and Robalino and Pfaff 201# highlight variation in PES impacts.

[6] According to the Law (n° 4.340/2002), creating an area should be based on both technical studies and public consultations − regardless of the degree of protection. Technical studies cover topics including forest cover, biodiversity, the presence of indigenous and/or traditional communities, land rights and human pressure. This helps to inform agencies concerning tradeoffs involved in creating protection (and, after creation, involved again in decisions about levels of enforcement). Differences in where Sustainable Use and Integral protection are sited appear quite conscious. For instance, if the prior presence of people living in or more generally using a forest site is seen to dictate Sustainable Use instead of Integral protection, PA types' sites will differ. Public consultations are just that: consultations to both receive and provide information. Communities do not possess the power to veto proposed protection, but their feedback is to be taken into account. All of the information gathered should be presented by the environmental agency to the local populations as well as all other interested stakeholders, and in an easy-to-understand fashion. Critical issues include: (i) defining the type of protection to be created (Sustainable Use vs. Integral); and (ii) the extent and boundaries of protection. If Integral locations are located only where there is little local resistance, for example, again that leads to differences in spatial distribution by protection type, including with respect to clearing pressure. After all studies and consultations, a government (federal, state, municipal) decree creates the PA. After that, the agency in charge should in five years elaborate and approve these management plans.