

Adaptive Forest Governance in Northwestern Mato Grosso, Brazil: Pilot project outcomes across agrarian reform landscapes

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ABSTRACT

Recent research on deforestation in the Brazilian Amazon has rarely included empirical observation of how land managers perceive and respond to forest governance rules. In this case study, we consider how two decades of pilot projects for integrated conservation and sustainable development (ICDPs) variously influenced forest governance across three agrarian reform settlements in northwestern Mato Grosso state. The analysis combines: i) remote sensing of deforestation from 1997–2015; ii) land use and economic data for individual settler farms and cooperatives; iii) settlers' perceptions regarding legitimacy and relevance of state policies, including land use regulations under the Brazilian Forest Code. Deforestation across settlements varied in association with synergies – or lack thereof – between policy instruments and socially embedded rules organizing economic alternatives to the dominant regional pattern of cattle ranching. In two of the settlements deforestation surpassed or was approaching 80% of their total area. In the third settlement deforestation stabilized at 45%, corresponding with the initiation of ICDP support for a pilot project focused on Brazil nut extractivism to consolidate community management of the settlement's collective forest reserve. The latter process involved a 'policy mix' or sequence of overlapping components: technical assistance, cooperative organization, environmental licensing, infrastructure, equitable contracts with surrounding indigenous communities and market development. Comparing with the two counterfactual cases, we suggest a framework for analysis of systemic socio-ecological change in settlements in the Brazilian Amazon, and reconsider the role of ICDPs in landscape approaches to environmental governance in tropical forests. Copyright © 2017 John Wiley & Sons, Ltd and ERP Environment

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Introduction

FOR THE BRAZILIAN AMAZON, IDEAS REGARDING FOREST OR AGRICULTURAL FRONTIERS HAVE SHAPED THE DEBATE ON THE RELATIONSHIP between development and environmental change since the 1970s (Browder *et al.*, 2008). Essentially a set of hypotheses about how the region was being articulated – or not – within a capitalist system, researchers posited that land use, regional markets and rural and urban populations were conforming to characteristics of different ‘fronts’ typical of frontier expansion or retraction (e.g. Sawyer, 1984). Early research on frontiers in the Brazilian Amazon frequently emphasized institutional complexity. For example, studies on land value (Hecht, 1985) and on land tenure (Alston *et al.*, 1999) considered how deforestation helped to establish institutional rents and tenure in the eyes of government bureaucracies with contradictory mandates, situations that contributed to violent conflict. However, while underscoring the importance of institutions and state capacity in enforcing laws and regulations, recent research on ‘frontier’ forest governance has tended away from examining institutional complexity on site. Instead, it has moved towards sophisticated macro-scale geospatial models that assess policy effects on reducing deforestation, often for the entire national biome (e.g. Soares-Filho *et al.*, 2010; Cisneros *et al.*, 2015). At the other geographical extreme, researchers have analyzed micro-scale determinants of land use change for individual farms by developing models based on demographic and panel data (e.g. Walker, 2003; Guedes *et al.*, 2014).

Both macro-scale and micro-scale modeling approaches however present certain limitations for the empirical assessment of forest governance. Although they can statistically compare and aggregate municipal deforestation, macro-scale models lack field data on land managers’ interactions with specific instruments and cannot pinpoint how they make individual or group-based decisions. Micro-scale models on the other hand largely do not account for how local institutional arrangements and politics affect livelihoods and landscapes over time (Browder *et al.*, 2008). While persuasive proposals exist for organizing governance in terms of specific territories or jurisdictions (Nepstad *et al.*, 2014), there is little research for the Brazilian Amazon that attempts to empirically connect land managers with policies using an intermediate lens (Brondizio and Moran, 2012). Considering policy oriented research on sustainability – in contrast to frontiers – it is apparent that there is a need for research on the meso-scale in the region, considering a municipal or sub municipal scale of several hundred to several thousand square kilometers (Gardner *et al.*, 2013).

Our meso-scale case study considers the influence of pilot projects in connecting land managers with government policies and with technical interventions that support livelihoods in tandem with forest conservation. The study is based on the concept of a ‘policy mix’ – and addresses how the selection, implementation and integration of policy instruments and interventions may effect and consolidate systemic socio-ecological change (Ring and Schröter-Schlaack, 2011; Barton *et al.*, 2014). We analyze the impacts of pilot projects on the development of sustainable land management, and consequent rates and extent of forest loss, in and near three agrarian reform settlements (ARS),¹ each located in a different municipality in northwestern Mato Grosso (NW MT). Our case study thus attempts to contribute to an improved understanding of the relationships between state policy and collective action in support of sustainable landscapes in tropical forests.

We also revisit a debate about sustainable development and Integrated Conservation and Development Projects (ICDPs), understood as biodiversity conservation projects with rural development components (Hughes and Flintan, 2001). The literature indicates that there is little to no data supporting ICDP effectiveness (e.g. Ferraro and Kiss, 2002; Minang and van Noordwijk, 2013). For example, Bauch *et al.* (2014) and Weber *et al.* (2011) found no significant impact of ICDPs on forest conservation in the Tapajós National Forest in the Amazonian state of Pará.

¹Agrarian reform settlements (ARS) are federal territories under the authority of the Brazilian National Institute for Colonization and Agrarian Reform (INCRA), instituted in 1970.

However, this may be due to the fact that the latter is a remarkably well protected forest area, itself an enduring governance intervention (Fearnside 2003). In contrast to situations in protected areas in which ICDPs may have limited additional impact, we have focused on ICDPs in ARS territories associated with significant deforestation pressures and governance challenges (Schneider and Peres, 2015).

Below we track how a meso-level policy mix, applied by pilot ICDPs, corresponded with deforestation across entire settlements over time, viewed as the aggregate result of land use decisions motivated by institutional and economic factors. Rather than to conceive ICDPs as discrete or standalone interventions, we have attempted to analyze how ICDPs connected land managers with a combination of policy instruments and technical and institutional support, including the Brazilian Forest Code,² environmental regulations derived from the latter, technical assistance and rural extension, market development, and local institutions and governance capacity.

The case study is structured as follows. In the next section, we provide background information on development in NW MT, describing the conservation and development approaches adopted to preserve tropical forests and biodiversity and introduce our research questions. In the third section, we outline the data sets and methods used. In the fourth section, we set out the results, and delve into a particular pilot ICDP in one ARS observed to halt forest loss. In the fifth section, we compare and interpret results and the counterfactual cases in relation to ICDP applied policy mixes and interventions, and develop a framework for analysis in future studies. In the final section, we advocate for additional research on the local application of policy mixes, and on the relevance of ICDP approaches in long duration adaptive management for environmental governance in the Brazilian Amazon and in agrarian reform landscapes.

The Study Area and Policy Context

NW MT is a humid tropical forest (Submontane Open and Dense Ombrophilous Forest, IBGE, 2004) region about the size of Guatemala (107,622 km²). The region consists of seven municipalities: Aripuanã, Castanheira, Colniza, Cotriguaçu, Juína, Juruena, and Rondolândia. Its population of about 120,000 is now 62% urban.

NW MT was colonized in the 1970s by private land corporations that received public concessions in return for infrastructure development and technical support, enabling them to speculate on land sales to farmers from southern Brazil who hoped to exchange small parcels in the South for significantly larger holdings in the Amazon. By 2009, although deforestation had proceeded apace, over 80% of NW MT's original 104 thousand km² of primary forest cover remained. Forest remnants were located within 11 indigenous territories (37% of remaining forest cover) and in nine conservation units (5.5% of remaining forest cover) (Figure 1). The remaining 57.5% of forest cover was located on private properties ranging from large ranches to small farms, and in agrarian reform settlements. The state of Mato Grosso hosts the largest livestock population in Brazil (28.4 million head of cattle), and the municipality of Juína in NW MT has one of the largest herds among all Brazilian municipalities nationwide.

Recognizing the threat to remaining forests in NW MT, in the aftermath of the 1992 Rio Earth conference, international donors such as the G-7 and the Global Environment Facility (GEF) pledged support to a series of pilot projects in cooperation with Brazilian federal and state governments. Additional programs and projects emerged in NW MT after 2009, funded by the the Brazilian petroleum company Petrobras and the *Fundo Amazônia* (Amazon Fund) administered by the Brazilian Development Bank (BNDES) with initial funding from Norway. The municipality of Cotriguaçu also saw the emergence of a pilot Reduced Emissions from Deforestation and Forest Degradation (REDD+) readiness project *Cotriguaçu Sempre Verde* (Cotriguaçu Forever Green) (Duchelle et al., 2014). See Table 1 below for a timeline of projects in NW MT from 1992 to 2015.

The PPG-7 and GEF projects in particular were multi-faceted attempts to build governance capacity for sustainable development in NW MT. They were comprised of support for decentralization of environmental administration; consolidation and increase in the area and number of protected areas; public hearings to prepare information in support of constitutionally mandated social, economic and ecological zoning plans (ZSEE); and

²Federal Law 12.727, 17 October 2012; www.planalto.gov.br/ccivil_03/_Ato2011-2014/2012/Lei/L12727.htm.

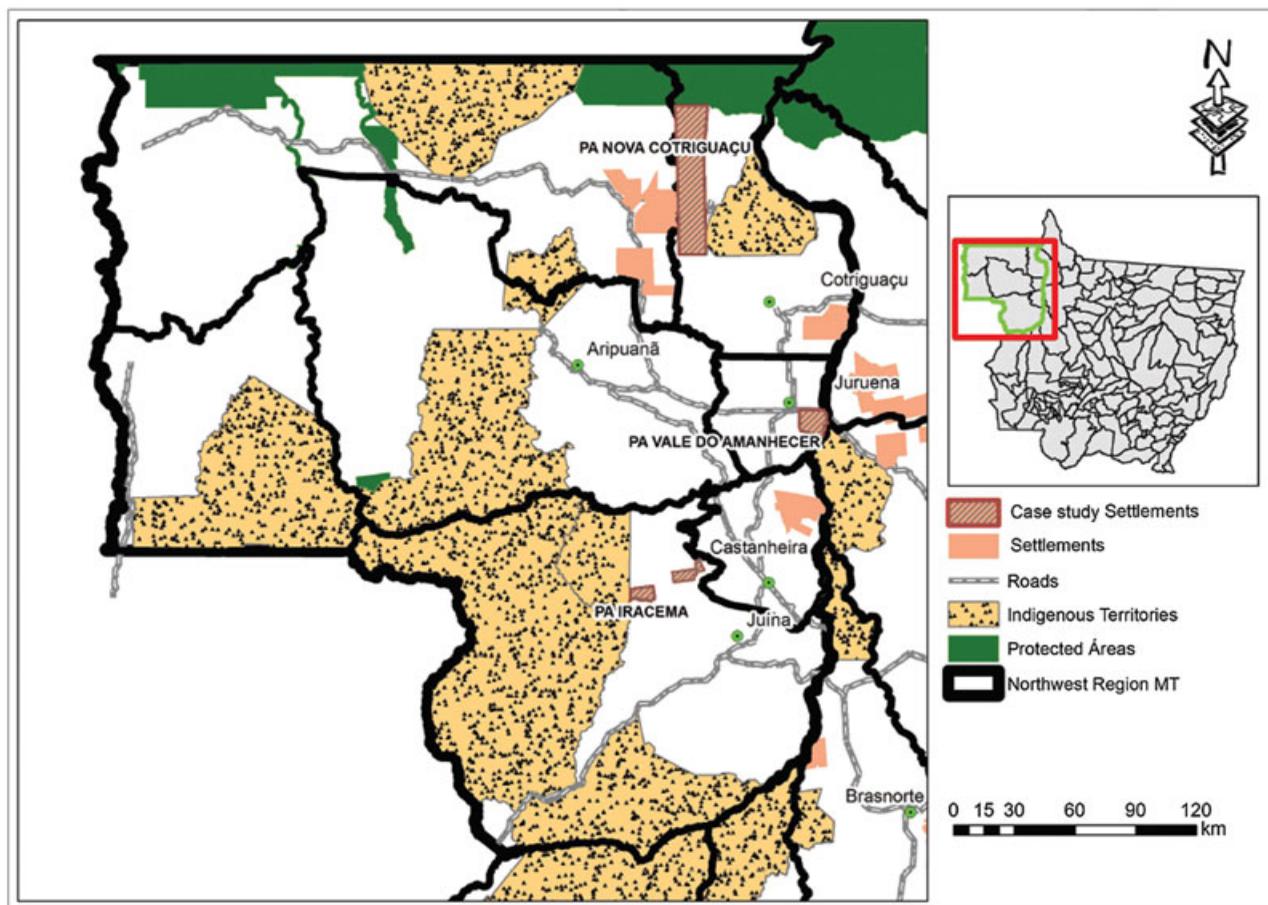


Figure 1. Map of northwest Mato Grosso, indicating agrarian reform settlements (ARS) included in the case study. [Colour figure can be viewed at wileyonlinelibrary.com]

agro-environmental measures. These agro-environmental measures were based on the ICDP model, and included technical assistance for soil and water conservation, restoration of degraded land, silviculture and agroforestry systems (AFS), non-timber forest products (NTFPs), and low impact forest management. Programs for subsidized credit, product certification and incentives for added-value processing of forest and agroforestry products were also involved. These projects sought to intervene in the institutional context by putting into practice a range of policy instruments, supporting local efforts for social organization, and providing technical assistance on various fronts.

However, this was not a simple task, as policy instruments and project interventions were sometimes co-opted or thwarted by vested political interests. Here we provide three examples. First, significant PPG-7 and GEF funds were allocated to support statewide environmental management plans and ZSEE from 1998 to 2008. However, since 2011 the statewide ZSEE has been paralyzed as a policy instrument due to aggressive lobbying by agribusiness. Sub-state planning in NW MT was able to move forward, but was seriously impeded by the lack of a statewide zoning framework.

Second, while Mato Grosso's state environmental secretariat developed innovative licensing instruments and land use monitoring systems during this period, studies by Rajão *et al.* (2012) and Azevedo (2009) have demonstrated that this system was subject to so-called institutional subversion. Rather than to curtail unregulated deforestation, participants in the regulatory system in fact deforested more land than non-participants. Azevedo (2009) hypothesized that the larger capitalized landowners who were prioritized used the system as a means to gain legitimacy while continuing with business as usual.

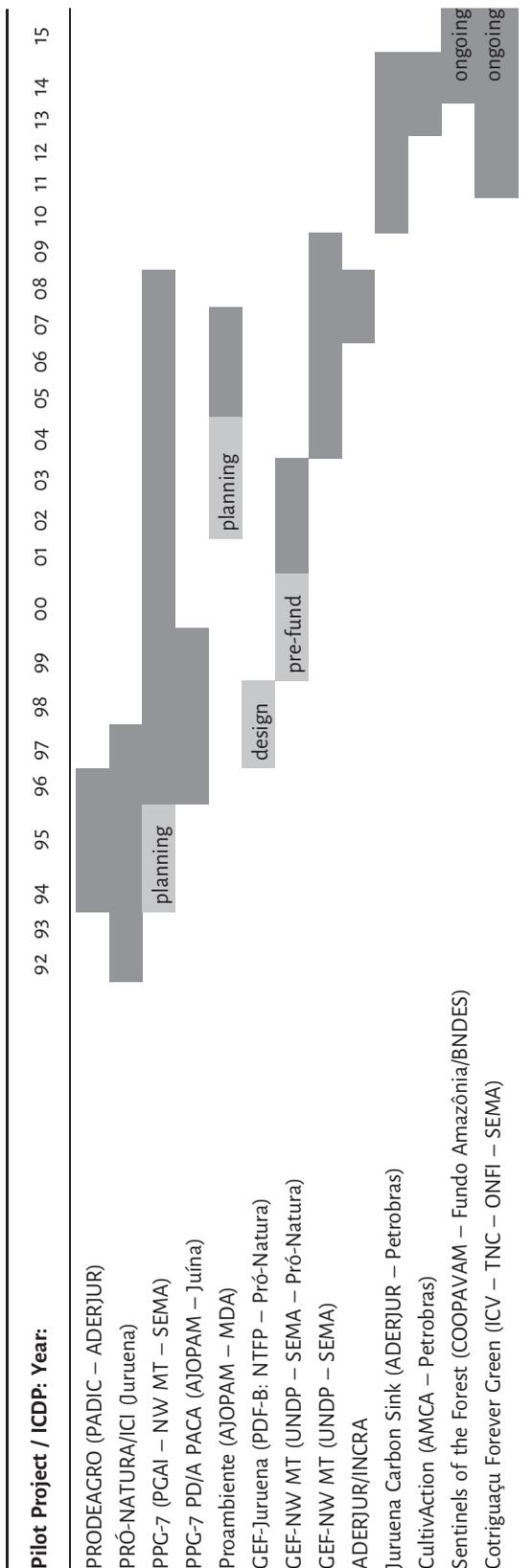


Table 1. Timeline of planning and execution of pilot projects in NW MT from 1992 to 2015

PADIC = Program for Integrated Community Development; ADERJUR = Juruena Rural Development Association; Pró-Natura = Franco-Brazilian NGO supported by ICI Agrochemicals; PGAI = Program for Integrated Environmental Management; SEMA = State Environmental Secretariat of Mato Grosso; PD/A = Demonstration Projects for Non-Governmental Organizations; PACA = Tree Density Enhancement Consortium Project; AJOPAM = Juiua Association for Agroforestry Development; MDA = Ministry of Agrarian Development; GEF = Global Environment Facility; UNDP = United Nations Development Programme; INCRA = National Institute for Colonization and Agrarian Reform; Petrobras = Brazilian Petroleum Company; AMCA = Corner of the Amazon Women's Association; COOPAVAM = Vale do Amanhecer Producers Cooperative; BNDES = Brazilian Development Bank; ICV = Instituto Centro de Vida; TNC = The Nature Conservancy; ONFI = French Forest Service Intl.

Third, the state rural extension and research service (EMPAER-MT), fundamental to the GEF project strategy for implementing AFS, was dismantled through budget cuts from 2003 to 2013. The Secretariat for the Environment for the state of Mato Grosso (SEMA-MT) was also severely de-funded, which created delays of up to several years in processing permits and licenses.

In the analysis below, we present the results of ICDP-applied policy instruments and interventions in order to appraise their relative influence on stemming deforestation and improving settler welfare. We examined the land use, economic and institutional impacts of the variety of ICDP-like interventions in the region, using the following questions to frame our analysis:

- 1 How have ICDP technical interventions and local application of policy instruments, influenced institutional arrangements and deforestation dynamics for entire ARS in NW MT?
- 2 How has the adoption of agroforestry affected land use and economic characteristics of small to medium sized farms in NW MT?

Considering the first question, we analyzed not only settlers' perceptions of the Brazilian Forest Code and associated environmental regulations, but the practical feasibility of institutions in managing resources at the settlement scale. We sought to understand how the local socio-ecological system (Ostrom, 2007) might be transformed by policy and practice interventions, considering landscape-scale outcomes in terms of deforestation.

Methodology and Data Sets

To appraise the roles and influences of such ICDP type interventions, our sources were primary and secondary data collected in the municipalities of Juína, Juruena and Cotriguaçu from 1996 through 2013, associated with monitoring and impact assessment during the PPG-7 and GEF projects. These data consisted of: i) remote sensing data on land use and deforestation; ii) economic data on AFS, non-timber forest products (NTFP) and the prevailing beef and dairy cattle practices; and iii) farmer perceptions and experience regarding land use policy and regulations and the factors affecting their decision making with respect to specific ICDP institutional and technical interventions. The different comparisons used to illuminate ICDP influences are illustrated in Table 2. It will become clear as we present these data, that our principal approach in this study is one of integration of various data sources and analytical perspectives rather than a formal evaluation of outcomes.

Individual Farm Land use

We focused on the introduction of AFS on individual farms in NW MT to review pilot projects that encouraged biodiversity-friendly farming practices. During the GEF project in NW MT from 2005 to 2010, more than 1,000 AFS trials were planted on farmers' fields averaging one ha per farm. Earlier interventions in the region showed their performance over a longer time period (Gonçalves, 2009; Nunes and Rognitz, 2011). Vivan (2010) collected data on 62 farms in Juína and Cotriguaçu and compiled them in data sheets and farm-level maps constructed through visual interpretation of land use, complemented with on-farm interviews and field notation of GPS coordinates. We identified 22 AFS adopters and 24 non-adopters, comparing for land use composition, chiefly forest cover and area dedicated to pasture.

Economic Characteristics of Production Systems

Our economic assessment relied on data provided by Vivan (2010) and Gonçalves (2009); the federal family farm loan program PRONAF; internal project reports from GEF and Petrobras (Juruena Carbon Sink Project); published studies (Vivan 2008); and reports from technical assistance and support organizations. We compared economic data for beef and dairy cattle production, with configurations of AFS and in NTFP extraction and processing, the latter focused on Brazil nuts. Data were based on surveys conducted with managers of 55 farms ranging from 4

Indicators	Pilot Project / ICDP	Cases compared	Data Sets	Sources
<i>Land use and land use change</i>				
Land use composition compared between AFS adopters vs. non-adopters	GEF	AFS adopters vs. AFS non-adopters	Individual farms in Juína and Cotriguaçu: 22 AFS adopters and 24 “controls” without AFS	Vivan, 2010
Deforestation dynamics in ARS	PPG-7; Pró-Natura; Proambiente; GEF; ADERJUR/INCRA; Juruena Carbon Sink	Accumulated deforestation compared for three ARS with distinct exposure to ICDP interventions, from 1997 through 2015	Remote sensing data for 3 ARS in NW MT, 1997 through 2015	PRODES (INPE, 2015)
<i>Socio economic conditions</i>				
Economic characteristics of small to medium size farms	PPG-7; GEF	Cattle and dairy farming, various typologies of AFS, Brazil nut extractivism and added-value processing	55 farms ranging from 4 to 250 hectares in size; 2 cooperatives	Vivan, 2010; Vivan, 2008; Gonçalves, 2009; Nunes and Ruginitz, 2011; PRONAF; internal project reports
<i>Institutional change</i>				
Perceptions toward Forest Code and historical experience with government agencies and ICDPs	PPG-7; Pró-Natura; Proambiente; GEF; ADERJUR/INCRA; Juruena Carbon Sink	Individual settlers' experience with state, municipal and pilot project programs from 1996 to 2012; Municipality specific political and institutional factors	29 individual farmers within 3 ARS	Davenport, 2013
Perception of factors affecting land use change in ARS; evolution of institutional arrangements	GEF; ADERJUR/INCRA; Juruena Carbon Sink	Specific project interventions, policy instruments and institutional arrangements for each year from 1998 through 2012	10 farmers within one ARS in Juruena (PA Vale do Amanhecer)	Davenport, 2013; May et al. 2016

Table 2. Indicators used in the case study, pilot project / ICDP indicator context, cases compared, data sets and data sources

GEF = Global Environment Facility, World Bank; PPG-7 = Pilot Program for the Protection of Brazilian Rainforests; ADERJUR = Juruena Rural Development Association; INCRA = National Institute for Colonization and Agrarian Reform; PRODES = Project to Monitor Deforestation of the Legal Amazon; INPE = National Institute for Space Research; PRONAF = National Family Farm Strengthening Program.

to 250 ha in size in Juína and Cotriguaçu (Vivan 2010). Nunes and Rognitz (2011) also developed a set of economic indicators for PA Vale in the context of the Juruena Carbon Sink Project.

Institutional Arrangements and Perceptions

The institutional analysis was carried out during 2012 and 2013 using questionnaires and semi-structured interviews with 29 farmers on lots of between 50 and 100 ha, equally balanced between the three selected INCRA settlements. All three ARS were *Projetos de Assentamento* (PA), or settlements designed for general social distribution of land. Some, but not many, PAs also include collective forest reserve areas, although with little social recognition of collective management value (May *et al.*, 2016). PAs are distinct from other INCRA settlements specifically designed around collective management and forest-based economic activities, such as *Projetos Agroextrativistas* (PAE), which have emerged since the late 1990s, but mostly not in Mato Grosso. The following are characteristics of the three PAs in this case study:

- 1 PA Nova Cotriguaçu. Municipality of Cotriguaçu. 99,989 ha. 1,234 households. Settled in 1995;
- 2 PA Iracema. Municipality of Juína. 18,120 ha. 343 households. Settled in 1996;
- 3 PA Vale do Amanhecer. Municipality of Juruena. 14,400 ha. 243 households. Settled in 1998. PA Vale contains a collective forest reserve area of 7,200 ha.

This sample included 16 participants in ICDP programs, 7 occasional participants, and 6 non-participants, based on recording status of participation for each year from 1996 to 2011. The questionnaires documented current legal status regarding land tenure and environmental regulatory compliance. Semi-structured interviews with individual farmers took three approaches: i), interviews elicited how farmers' perceived the relative influence along four broad criteria – legal, economic, community, ecological – when making land use decisions; ii) interviews were used to draw out farmers' experiences of their communication with various municipal, state and federal government agencies, each with distinct if interrelated mandates in terms of land use; and iii) interviews prompted responses in terms of perceived fairness and legitimacy of the Brazilian Forest Code.

Researchers then held a group workshop with farmers from PA Vale do Amanhecer (PA Vale). Interview responses were collated and compared with group workshop data in order to understand the historical evolution of land use decision making processes and institutional arrangements. This group workshop entailed settlers working to identify community events, land use trajectories and the perceived practical relevance of specific program and project components (both rural development and ICDP) in each year from 1998 – year of the founding of the settlement – until 2012.

Settlement Deforestation Dynamics

To analyze deforestation dynamics, we used a time-series approach to compare *Projeto de Monitoramento do Desflorestamento na Amazônia Legal* (Project to Monitor Deforestation of the Legal Amazon, or PRODES) composite remote sensing data between 1997 and 2015 for the 3 settlements above (INPE, 2015). We evaluated year to year deforested areas in each settlement, and measured, for each year, the percentage of forest cover remaining in each ARS relative to total area.

Results

Individual Farm Land use

Considering our sample of 46 small to medium size farms' land use, AFS adopters exhibited 13% more on-farm forest cover than non-adopters (Table 3). Seventy-two percent of the AFS adopting group had deforested over 10%

³http://www.debit.com.br/consulta30.php?indice=salario_minimo

⁴*Associação de Mulheres Cantinho da Amazônia*, (Corner of the Amazon Women's Association) formed by a group of 120 women from PA Vale

⁵*Cooperativa dos Agricultores do Vale do Amanhecer* (Vale do Amanhecer Producers Cooperative)

Sample (n) and average area (ha)	FA (ha)	AFS (ha)	FC (ha)	FC (%)
Controls $n = 24$; 96 ha	2,298	0	774	34
AFS Adopters $n = 22$; 85 ha	1,859	63	869	47
Difference for AFS adopting group	-439	+63	+95	+13
Difference (average per farm)	-10	+2.9	+4.3	--

Table 3. Forest cover for 46 farmers in Juína and Cotriguaçu (between 30 ha and 400 ha)

FA = total farm area; AFS = total agroforestry area; FC = forest cover in hectares; FC (%) = percentage of forest cover in relation to total area of the farm.

in excess of the 80% legal reserve benchmark stipulated by the Forest Code, whereas 95% had done so in the control, non-AFS group.

Economic Characteristics of Production Systems

Table 4 presents the economic characteristics of agricultural and forest land use systems surveyed in NW MT, including: i) gross revenues obtained per unit of area managed (in US\$/ha); ii) gross revenues obtained per 8 hours of labor for the particular land use (in US\$/day); iii) area in hectares that could be managed per unit of human labor in a year, based on 260 days of 8 hours per year (in ha/person). Among AFS adopters in all three settlements, a

Farm or forest productive activity	US\$/ha (gross revenue)	US\$/PD	ha/PYL	Costs (%)
Shaded extensive	377	49	32	0
Cocoa AFS				
Shaded Cocoa	4000	110	5	7
AFS intensive mgmt				
Shaded Coffee AFS	1552	33	7	7
Coffee and Pupunha AFS	1268	99	5	3
Intensive irrigated AFS	7176	341	8	3
Cupuaçu extensive AFS	1119	142	42	7
Silvipastoral Dairy cattle	504	71	42	16
NTFP (Brazil nut, Raw)	13	150	880	0
NTFP (Brazil nut, subproduct Dry nut)	63	ni	ni	60
NTFP (Brazil nut, subproduct Oil)	43	ni	ni	10
NTFP (Brazil nut, subproduct Flour)	28	ni	ni	10
NTFP (Brazil nut, Flour + Oil)	71	ni	ni	10
Control group				
Cattle (beef)	114	43	97	35
Cattle (mixed beef and dairy)	212	209	39	45
Open sun coffee monocrop	1117	35	6	35

Table 4. Synthesis of economic indicators for 55 farms ranging between 4 and 250 ha in the municipalities of Juína and Cotriguaçu, Mato Grosso, Brazil

US\$/PD = return in US\$ person/day (PD); ha/PYL = area in hectares of the system manageable by one year of labor per person (PYL).

ni = no indicator. Labor is not included in costs as these farmers do not habitually hire external labor.

range of different options were possible, as specified in Table 4, including intensive tree crop systems involving cocoa, cupuaçu, coffee, peach palm and other products, combined with timber species for shade and fencing (Nunes and Rognitz, 2011). Most AFS adopters also kept cattle on their properties, so that the farm enterprise typically consisted of a combination of livestock and tree crop production.

Within PA Vale, in 2005, over half of the income of 70% of settler households came from working outside of the settlement. Only 12% had farm-based incomes equal to the Brazilian minimum wage (US\$ 150 in 2005).³ The majority were below the poverty line (Vargas, 2006). By 2013, however this scenario had changed, as two cooperatives, AMCA⁴ and COOPAVAM,⁵ were operating inside the settlement, organized with support from the GEF project and two additional ICDPs (ADERJUR/INCRA and Juruena Carbon Sink). The cooperatives, comprised mostly of women, were processing Brazil nuts harvested from the settlement's collective forest reserve, and purchased from indigenous territories and from smallholders. With approximately 70 direct participants in the cooperatives, and assuming 10% costs, we calculated approximately US\$ 6,573 user/yr⁻¹ net income per cooperative member, based on production of flour and oil from Brazil nuts harvested out of the settlement's collective forest reserve (7,200 ha). This income is higher than that of a well-managed mixture of beef and dairy cattle on smallholder farms: approximately US\$ 5,374, after costs, for 39 ha of pasture (area manageable by one person's year of labor, see Table 4).

Institutional Arrangements and Perceptions

All farmers in our sample for the institutional analysis had been living in their respective settlements for between 10 and 18 years. Nevertheless, none of the 29 farmers in the sample had managed to secure private land title, or *Título Definitivo* (TD). Private title is distinguished from INCRA usufruct, in the form of *Concessão de Uso* (CCU), which authorizes land use but without alienation rights. While 23 farmers in the sample were officially recognized by INCRA, only 15 of these households actually possessed the CCU, meaning that roughly half of our sample lacked land tenure documents. Tenure irregularity was a factor in all three settlements, but it was more prevalent in PA Nova Cotriguaçu.

Concerning perception of the legitimacy or fairness of the Brazilian Forest Code, settlers unanimously considered the legal reserve (LR) rule that stipulates that 80% of privately managed land be maintained as forest in the Amazon biome, to be inappropriate, unreasonable, and unfair. Among reasons for the illegitimacy of the 80% LR rule, settlers cited that: i) prior to 2000, land managers in the Amazon biome deforested 50% of their land or more, as the rules were in dispute; ii) INCRA originally directed settlers to deforest their lots to establish and secure their rights and thus demonstrate that they were using the land productively; iii) It would be difficult under current market conditions, to secure a livelihood, especially with cattle, on only 20% of the farm's land. In contrast, riparian protection areas (*Áreas de Proteção Permanente*) rules, also part of the Brazilian Forest Code, were unanimously considered to be appropriate, reasonable and fair.

Surveys and interviews indicated that from 1996 to 2011 ICDPs were more active in PA Vale than in PA Iracema or in PA Nova Cotriguaçu. In PA Vale, four of ten interviewed settlers registered consistent participation in the GEF project and in Juruena Carbon Sink from 2002 through 2011. In PA Iracema, settlers recalled participating in the PPG-7 PACA (Tree Density Enhancement Consortium) project in 1997, and then later in Proambiente from roughly 2004 to 2007, with ICDPs absent in the settlement after 2007. In PA Nova Cotriguaçu, only one out of nine interviewed settlers recorded consistent participation in ICDPs.

Table 5 indicates simple averages of value responses from individual farmer interviews, organized by municipality, and by participation *vs.* non-participation in ICDPs. Across the entire sample, whether grouped by municipality or by participation, legal factors were perceived to be less important for settlers' land use decisions than were economic, community or ecological factors. However, ICDP participants valued legal factors more heavily than did non-participants.

Settlers' perception of policy instruments and of government agencies varied by municipality. In Juína settlers in PA Iracema were more positive about the relevance of a land use registration instrument, the *Cadastro Ambiental Rural* (CAR), understanding the latter as a pathway toward regulatory compliance and enabling access to credit. Juína's mayor in 2012 was committed to supporting small farmers, and technical staff in the municipal secretariat of agriculture and environment had assisted 7 out of the 10 farmers in our sample, all of which

	Legal	Economic	Community	Ecological
By municipality / settlement				
Cotriguaçu / PA Nova Cotriguaçu	4.3	7.9	7.2	8.3
Juruena / PA Vale do Amanhecer	6.6	7.1	7.7	9.0
Juína / PA Iracema	4.8	8.4	8.0	7.1
By participation in ICDPs				
Consistent participation in ICDPs	5.9	7.0	7.5	8.4
Controls (occasional to no participation in ICDPs)	4.4	9.0	7.8	7.8

Table 5. Simple average values (1–10) attributed to factors or criteria affecting farmers' land use decisions. 1 = minimum influence, 10 = maximum influence. $n = 29$ interviews

had a CCU, to begin processing a CAR. The municipal administration had designed a process such that farmers would need to make only two visits to the municipality to obtain the CAR, and pay a fee of approximately US\$ 60. Both the Juína mayor and municipal technical staff in 2012 previously had been involved with the Proambiente⁶ project.

Settlers appraised ICDP instruments and interventions in PA Vale in terms of perceived practical relevance, on a scale of 1 to 10, presented in Table 6. Many of the specific program components offered in 2001 by PRONAF, a national rural development program focused on small farm agriculture, were not considered practical by settlers. In contrast, settlers gave value of '10' for the following ICDP project components: courses & training, managed by the GEF project in 2006; portable saw mill services for the legal recuperation of timber from already fallen trees, managed by the GEF project in 2006 and by Juruena Carbon Sink in 2010; cooperative organization, managed by ADERJUR/INCRA in 2008 and by Carbon Sink Project in 2010; and market development, managed by Carbon Sink Project in 2010. Interestingly, the provision of tree seedlings for agroforestry and silviculture on individual farms was valued less than interventions related to the cooperative Brazil nut supply chain itself.

Settlement Deforestation Dynamics as a Socio-Ecological Systemic Outcome

In terms of deforestation dynamics for ARS, Figure 2 indicates percentage of original forest cover remaining in the three settlements from 1997 through 2015, whereas Figure 3 is a map illustrating the location of year by year deforestation and remaining forest cover. In 2015, PA Iracema and PA Nova Cotriguaçu had 18% and 33% of original forest cover remaining, respectively, whereas PA Vale still retained 55% of the original forest area. Deforestation in PA Vale and PA Nova Cotriguaçu demonstrated similar deforestation rates until 2005, at which time the dynamics split – PA Nova Cotriguaçu deforested 33% in the decade between 2005 and 2015, whereas PA Vale deforested 13%. Deforestation rates continued to decrease in PA Vale, arriving at 0.2% in 2015. In PA Nova Cotriguaçu deforestation began to increase in 2011, rising to 3.2% in 2015.

What Made PA Vale Different?

PA Vale, unlike the other two settlements, had experienced a series of ICDP institutional and technical interventions to integrate forest conservation, livelihood development and regulatory compliance. A series of ICDPs from roughly 2005 to 2012 had applied an ongoing policy mix, resulting in the legal authorization for Brazil nut harvesting and processing in a collective forest reserve of 7,200 hectares, in the form of an environmental license or *Licença*

⁶Proambiente is sometimes viewed as an early payments for ecosystem services (PES) program, however the program involved significant rural extension and participatory farm planning.

Timeline	2001	2006	2008	2011
Project Activity	PRONAF	GEF	ADERJUR/ INCRA	Juruena Carbon Sink
Capacity building				
<i>Courses/training</i>		10	8	8.5
<i>Visits and exchanges</i>		6	8	5.5
<i>Workshops</i>		7		7.5
<i>Services</i>				
<i>Deforestation 10 h bulldozer</i>	4			
<i>Portable saw mill service</i>		10		10
<i>Technical assistance</i>				9
Social organization				
<i>Cooperative formation (COOPAVAM)</i>			10	
<i>Cooperative formation (AMCA)</i>				10
Institutional supporting services				
<i>Community management of NTFP</i>		8		
<i>CONAB: financial support</i>				8
<i>Brazil nut factory; purchase of machinery</i>			9	
<i>Credit application</i>	9			
<i>Elaboration of contracts with indigenous groups</i>				8
<i>Environmental license (LAU)</i>		9		
<i>Mapping NTFP trees and production study</i>		8		
<i>Market development</i>				10
<i>Soil analysis</i>	8			
Procurement				
<i>Chick starter kit</i>	1			
<i>Chicken wire</i>	1			
<i>Coconut seedlings</i>	0			
<i>Fruit trees</i>	7			
<i>Horse drawn cart</i>	3			
<i>Manual seed planter</i>	1			
<i>Coffee seedlings</i>	6			
<i>Dairy cattle</i>	8			
<i>Fencing wire</i>	9			
<i>Fertilizer</i>	5			
<i>Line trimmers</i>				7
<i>Tree seedlings</i>		6	6	7
<i>Water reservoir</i>	2			

Table 6. Value of specific applied instruments and interventions in terms of perceived practical relevance (1 = low practical relevance to 10 = high practical relevance)

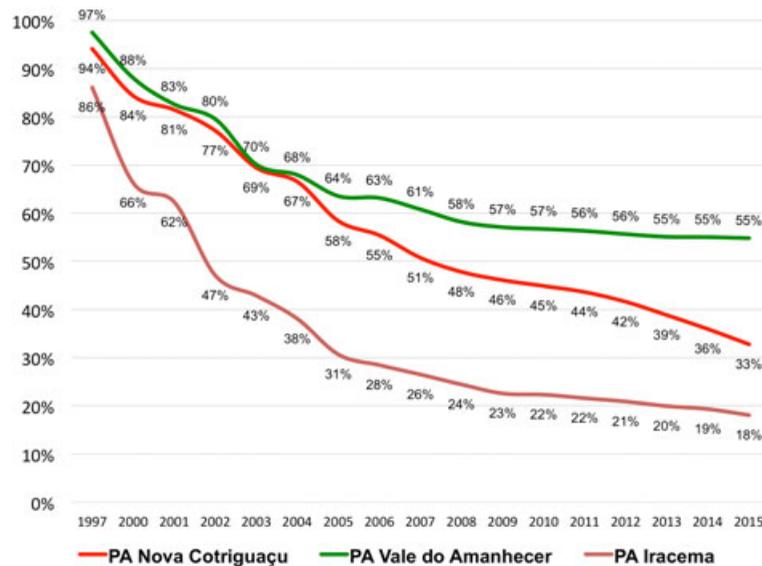


Figure 2. Percentage of primary forest cover remaining from 1997 to 2015 in three settlements in Northwestern Mato Grosso. Source: PRODES/INPE. [Colour figure can be viewed at wileyonlinelibrary.com]

Ambiental Única (LAU).⁷ Its LAU was formally authorized by SEMA-MT in May of 2012, after six years of bureaucratic negotiation. The LAU is designed as successor instrument to the CAR in that it goes beyond registering land use to legalizing and certifying sustainable forest and NTFP management. This collective legal license for Brazil nut extraction and processing is effective regardless of formal INCRA documentation of land tenure on individual lots. The rights and responsibilities regarding the collective forest reserve are fully documented by the state of Mato Grosso. To our knowledge no other ARS has attained a settlement-wide LAU in the state.

ICDPs in PA Vale served as an administrative and communicative link between federal and MT agencies and the settlement, whereas the LAU instrument in PA Vale functions in conjunction with several other instruments and interventions in a locally implemented policy mix. The LAU required mapping of the forest reserve, including the geo-referencing of 800 Brazil nut trees (*Bertholletia excelsa*), as well as technical training on sustainable forest management. The LAU is therefore dependent on mapping and on ecological maintenance plans, along with community monitoring against illegal human occupation of the area. With the LAU licensing process in place, ADERJUR was able to broker financial support from INCRA, beyond the resources provided by the GEF project, in order to build and outfit a Brazil nut processing plant, including buildings and equipment, for approximately US \$300,000. The latter was in addition to the in kind value of milled lumber from the portable saw mill intervention above.

With ICDP support, the AMCA and COOPAVAM cooperatives, mentioned above, entered into contracts with the National School Food Program (PNAE) and the Anticipated Acquisition Program (PAA) – programs managed by the federal Supply Company (CONAB) within the Ministry of Agriculture. CONAB provided US\$ 580,000 in financial credit to these cooperatives to procure organic Brazil nut derived foods in 2013, including pasta and cookies; these foods were distributed to 33,000 persons in seven local municipalities. ICDPs brokered market contracts with the cosmetics company Natura, based in São Paulo, for the sale of Brazil nut oil, delivering on an average 9 metric tons of oil per year. ICDPs served to coordinate logistics, and secured tax relief on production. To satisfy demand for Brazil nut products, the cooperatives, with support from ICDPs, elaborated equitable contracts with four indigenous groups in NW MT (Munduruku, Apiaká, Cayabi, Cinta Larga) to harvest and deliver raw nuts from their respective territories.

The various policy instruments and interventions in PA Vale were applied in a particular sequence over 6 years: 1) mapping the productive potential of the collective forest reserve; 2) training and technical assistance; 3) support for social organization of cooperatives; 4) formalizing the LAU; 5) material investments in buildings and equipment;

⁷The equivalent instrument in the state of Pará is the *Licença de Atividade Rural* (LAR)

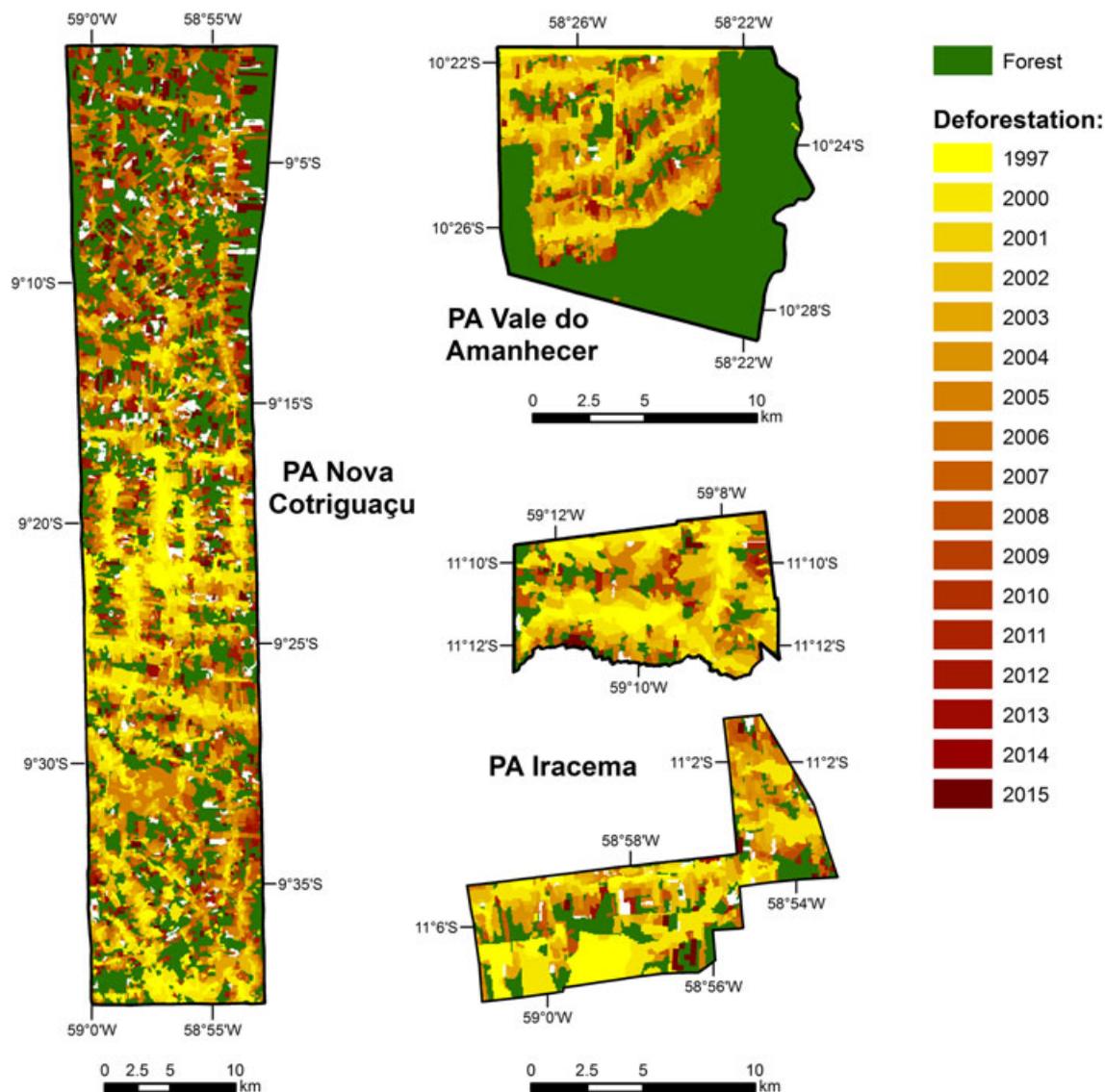


Figure 3. Location of annual deforestation and remaining primary forest cover from 1997 to 2015 for three settlements in Northwestern Mato Grosso. Source: PRODES/INPE. [Colour figure can be viewed at wileyonlinelibrary.com]

6) market development, credit financing and the elaboration of contracts with surrounding indigenous groups; 7) contracts with private companies (Natura) and CONAB; 8) support to increase Brazil nut production.

PA Vale settlers attested to a complex set of factors influencing land use change since the late 1990s. Unlike PA Iracema and PA Nova Cotriguaçu, PA Vale was designed with a collective forest reserve, and intended by INCRA as a 'model' settlement, but under the INCRA designation of general land distribution and not for forest extractivism. Its socio-environmental history involved political alliances, extensive slash and burn methods to clear forest and additional burning to manage pasture, road construction, federal agricultural credit programs (PRONAF), a violent occupation of the settlement by gold miners in 2004, the formation of local cooperatives, and fluctuating prices for agricultural commodities, among others. The federal rural development program PRONAF, in this case providing credit for obtaining beef cattle, was perceived by interviewees as one of the strongest incentives to clear forest, and coincides with peak deforestation intensity in PA Vale between 2000 and 2003. The settlement's relationship with the municipality was not consistent in time but changed every 4 years as each new mayor effected a complete turnover of administrative staff.

Although cooperative processing and marketing of Brazil nut products in PAVAM involves approximately 70 households, just under a third of the total in the settlement, we observed a broader social legitimacy for the legal institution of the forest reserve as commonly held property, requiring collective responsibilities in turn. This was reflected in a dramatic shift in local production practices, to the extent that during 2012 settlers in the participatory workshop had not observed farmers using fire to manage pasture. The latter occurred through ICDP technical assistance to raise awareness about the long term agro-ecological disadvantages of managing extensive pasture with fire in the Amazon.

Discussion

Emergence of a Forest Commons amongst Agrarian Reform Beneficiaries

Our results suggest that ICDPs in PA Vale integrated livelihood development with forest conservation. Systemic change started to emerge in PA Vale began in 2005, when deforestation rates began to decrease, and when ICDPs initiated technical training and assistance, increasing social buy in and legitimacy for the LAU and associated institutional arrangements. Our results also suggest that the social recognition of a shared forest resource was not limited to ICDP participants, as all settlers interviewed in PA Vale, whether participants or not, perceived that the institution of the collective forest reserve was legitimate.

While PA Vale was designed as a 'model' settlement, we suggest that the existence of the collective forest reserve on INCRA's maps did little on its own to ensure forest conservation matched with sustainable development. Its deforestation was similar to that of PA Iracema and PA Nova Cotriguaçu until 2005, at which point ICDPs started to intervene in the collective action problem of instituting a forest commons amongst families from southern Brazil with no experience with community forest management or with NTFPs. All three PAs contained significant numbers, if not a majority, of families who had migrated from southern Brazil. In May et al. (2016), we have compared PA Vale with another ARS in NW MT with a collective forest reserve (PA Juruena in the municipality of Cotriguaçu), in which deforestation is most prevalent in the collective areas, precisely due to the lack of social recognition of common property.

Comparing against Counterfactual Cases

Project interventions in PA Iracema and PA Nova Cotriguaçu were either too short or not designed to integrate policies and investments to develop sustainable livelihood alternatives, foment institutional transformation, and reduce deforestation. The Proambiente project in PA Iracema, while perhaps having an influence on the relationship between Juína's municipal government and settlers, did not serve to conserve forests or shift land use away from the dominant trend toward pasture. In PA Nova Cotriguaçu, ICDPs were much less active, notwithstanding the presence of the pilot REDD+ project *Cotriguaçu Sempre Verde* managed by the NGOs Instituto Centro de Vida (ICV) and The Nature Conservancy (Duchelle et al., 2014). At the start of this REDD+ pilot in 2011, PA Nova Cotriguaçu retained 44% of its original forest cover. While incorporating outreach and organizational activities in the settlement, including technical assistance to dairy farmers and an emphasis on registering in the CAR, we did not assess these activities because they were still being developed at the time of our field work and settlers had not yet formed an opinion about their practical relevance to land use decisions. However, our deforestation analysis indicates an uptick in annual deforestation in PA Nova Cotriguaçu, from 1.3% in 2011 to 3.2% in 2015, despite the presence of these interventions. If it holds at the 2015 rate, PA Nova Cotriguaçu's forest cover will dip below 20% by the year 2020, which suggests that the implementing NGOs have not yet succeeded in implementing a policy mix approach to collective action in support of forest conservation. These results are in line with findings by Azevedo et al. (2014) that suggest that the CAR is likely insufficient to reduce deforestation as a standalone instrument.

Constraints on Alternative Land use and Livelihoods

Taking the adoption of AFS technology as a proxy for pilot ICDP 'effects', given self-selection bias, did not allow us to analyze farmers' decisions to adopt as a dependent result of ICDP instruments and interventions. We did

however observe land use differences for farms with AFS, all of which with *some* interaction with ICDPs. In spite of the substantial economic returns, however, what was remarkable was that AFS was not more commonly adopted across the landscape. According to our interviews beef and dairy cattle ranching remain the dominant livelihood in NW MT due to various financial, land tenure and logistical advantages of holding livestock, but also due to various constraining or risk factors affecting alternatives: lack of land title or usufruct documents, lack of technical assistance and rural extension, lack of access to credit, inadequate or undeveloped markets for alternatives, delays of nearly 5 years to reach productive capacity in AFS, significant bureaucratic delays and inter-agency dysfunction, and logistical and transportation challenges. For example, in PA Nova Cotriguaçu, we observed that one cocoa producing settler was leaving his product to rot, rather than to transport it hundreds of kilometers to points of sale. The reality of institutional constraints is supported by the overall lower value given to legal considerations in land use decisions across the sample. Our findings concur with studies that have argued that promotion of AFS technology is not as effective as attention to institutional arrangements (Richards 1997).

Developing a Framework for Analyzing Socio-Ecological Systemic Change in Settlements

Institutional arrangements and collective action processes were relevant to constraints and risks affecting extractivism and land use on individual farms. While the institutional literature has often examined collective management of natural resources (e.g. Ostrom, 1990), individual land managers are also subject to group conditions, for example in terms of land tenure security (Duchelle *et al.*, 2014), relationships with the state (Colfer, 2011) and trust or 'social capital' (Ostrom and Walker, 2003). Land use decisions are embedded in local systems that operate in tandem with or in tension with rules at other levels (Andersson and Ostrom, 2008).

Settlements are distinct from community forests in institutional terms, and require tailored analysis. Settlement forests are located on privately managed lots and sometimes in collective reserves, and institutional arrangements are simultaneously local, municipal, state and federal in character. Settlements are not politically autonomous; they are subject to multiple bureaucratic agencies and to political instability within the Brazilian municipalities in which they are situated. If and when settlements contain collective forest reserves, settlers may perceive such lands as lacking attached rights or responsibilities (May *et al.*, 2016). Finally, settlers are not longstanding residents of these forested regions and tend to have little knowledge of the local ecology upon arrival. Effective forest governance is never easy, but we recall the words of Elinor Ostrom regarding socio-ecological systems: "it is not the general type of forest governance that is crucial in explaining forest conditions; rather, it is how a particular governance arrangement fits the local ecology, how specific rules are developed and adapted over time, and whether managers consider the system to be legitimate and equitable." (Ostrom, 2009). The competence with which governance interventions are implemented and the time scale of execution are also relevant.

Adaptive forest governance in the PA Vale case consisted of embedding policy instruments in the landscape by connecting land managers with local institutions and technical support over time. Barton *et al.* (2014) convincingly argue that a 'policyscape' is a geographical space in which diverse policy instruments are tailored to different land uses and their associated opportunity costs, however in the case of PA Vale, ICDP policy instruments and interventions were arranged in time to give them traction in a changing socio-ecological system. ICDPs seem to have required *at least* six years to foment a collective action alternative to the dominant pattern of cattle ranching. In addition to the temporal scale of change, socio-ecological system analysis should include data on land managers' attitudes and outlooks on state policies and institutional arrangements. This allows for gauging which rules, and whose rules, are directly relevant to land use decisions, and for measuring how changes in the 'rules in use' link with economic and environmental outcomes over time. These are especially important considerations in the Brazilian Amazon given institutional subversion (Rajão *et al.*, 2012), perceived irrelevance of state policies, and the current political climate.

Concluding Remarks

Given a lack of data on policy mixes for environmental governance in tropical regions (Lambin *et al.*, 2014), we conclude that additional research is needed to map how policy mixes and interventions match with livelihood and environmental

outcomes, especially considering how the duration of these relationships matter (Estrada-Carmona et al., 2014). For example, recent research has demonstrated how specific credit programs correlate with types of smallholder land use in the Brazilian Amazon (Mattos et al., 2010), but there is limited understanding of how instruments and interventions interact in influencing these landscapes over time. Porro et al. (2015) have suggested that a decade is the appropriate scale for analyzing socio-ecological change in settlement landscapes.

Returning to debates regarding ICDPs, Bauch et al. (2014) and Weber et al. (2011) determined that ICDP efforts to commercialize NTFPs had no statistical effect on forest conservation for households living in the Tapajós National Forest. However, this result is perhaps not surprising considering that federal and local institutional arrangements were already present in these landscapes securing these riverine communities' longstanding tenure within a protected forest area. In contrast, our case study involved bureaucratic dysfunction and a lack of social legitimacy for maintaining standing forests. The latter situation reflects governance challenges in many contexts in which REDD+ projects are located; in Brazil and other forested regions in the tropics, others have noted parallels with ICDP experience (Minang and van Noordwijk, 2013). As such we suggest a reconceptualization of ICDPs as 'portals' that can absorb transaction costs in implementing policy mixes supporting systemic socio-ecological change. As ICDPs are often administered within or near the landscapes in question, they may be better suited for adaptive management and the practical application of institutional arrangements in land managers' daily lives.

The systemic socio-ecological outcomes observed in PA Vale involved engagement with institutional and economic complexity, in contrast to conceptualizations of Amazon frontiers that have posited the exhaustion of natural resources as the organic condition of 'boom and bust' patterns of development (Rodrigues et al., 2009). The systemic complexity underlying this case leads us to join others in questioning reductionist models for development and environmental change, either within settlements or across the region (Weinhold et al., 2015; Caviglia-Harris et al., 2016). We plead for a focus on institutional and policy mix enablers and pathways toward sustainable landscapes in the Brazilian Amazon. Deforestation is essentially a governance problem in agrarian reform settlements (Schneider and Peres 2015), but long duration interventions focused on local policy integration and relevance to livelihoods can enable alternative economic relationships with the environment to emerge.⁸

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⁸Ongoing governance instability threatens the sustainability of livelihoods and forest conservation observed in this case study. At the time that our article was going to press, the administration of President Michel Temer had made significant cuts to federal PNAE and PAA food programs under CONAB, ending livelihood support for approximately half of the families involved in the PA Vale Brazil nut industries.

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