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Analysis

Effects of a policy-induced income shock on forest-dependent households in the Peruvian Amazon

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ABSTRACT

This paper describes how forest-dependent communities in the Peruvian Amazon responded to forest policy changes meant to improve sustainability. These new laws emphasized block-based, collectivized extraction — a strategy incompatible with local communities' logging traditions and technical capacity. Field surveys before and after the policy change revealed a drastic reduction in local logging activities for households at all income levels. Non-Timber Forest Products (NTFPs) subsequently became more important to household cash incomes. However, only some households were able to shift to a more intensive and far-ranging pattern of NTFP harvest, particularly households with boats and motors. Others lost income from both logging and NTFP extraction because for many households, these income sources were interdependent. An increasing Gini coefficient signals potentially escalating household income inequality. Key lessons for biodiversity and forest–carbon interventions in tropical forests include 1) regulations designed to control large-scale extraction can lead to unnecessarily restricted access for small-scale extractors, and 2) potential shifts in extractive pressure should be taken into account when access to forest resources is curtailed.

1. Introduction

Conservationists often seek to improve forest management by modifying or clarifying rules of access. Schemes to pay for avoided deforestation, create new protected areas, or more tightly regulate extractive industries all involve altering forest access regimes at different scales. Optimal rules and incentives at one scale can lead to suboptimal outcomes at non-target scales, as often happens when the entities causing the primary threats to a resource are not the same as those who depend most heavily upon it (Coomes et al., 2004). Trade-offs are sometimes unavoidable, but careful consideration of a wider range of actors can limit unintended policy effects. In the case of forest conservation, good information about vulnerability and adaptability of target and non-target forest users can help inform whether trade-offs are acceptable, whether they are avoidable, and help to prevent unpredicted leakage and knock-on effects.

To better predict vulnerability and adaptability to changes in forest policy, we need to recognize the dynamic nature of forest dependency. There is a growing body of literature on the predictors of forest dependency (Adhikari et al., 2004; Lepetu et al., 2009; Timko et al., 2010; Vedeld et al., 2007), but we know less about how this dependency changes in response to external shocks. Studies of forest-dependent communities suffering natural disasters or resource depletion suggest that extraction patterns may shift dramatically and some households will be hit harder than others (Coomes, 1995; McSweeney, 2004; Takasaki et al., 2004). Policy changes can also resemble shocks, where forest resources may still be present but legal barriers alter local access. Enforcement may be uneven, some actors may be better able to adapt to the policy changes or work around them, and others may lose access altogether (Larson and Ribot, 2007). Here we present empirical evidence of loss of access and differentiated adaptation using a case study involving the onset of enforcement of logging restrictions in the Peruvian Amazon.

A wave of 'science-based' forestry reforms in South America during the past two decades has curtailed some of the most destructive industrial logging practices, but the impact on local forest-dependent communities has been variable and seemingly unpredictable (Ebeling and Yasué, 2009). New forestry laws helped consolidate forest territory claims for some communities (e.g. Dockry (2012)) and left others in worse poverty (Larson and Ribot, 2007). We examine outcomes of a recent logging reform in Peru with a case study concerning strongly forest-dependent communities in a biodiverse and carbon-heavy region. We first describe how the logging reform resulted in lost access despite intensive efforts by third-parties to facilitate local logging in compliance with the new rules. Next, we test whether households

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[1] Original conception of project and field work performed by J. L'Roe who also wrote majority of text and analyzed data. L. Naughton assisted with study design, analysis, literature review and writing.

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adapted to the income shock by shifting to other activities to compensate for lost logging income. Because they are often contrasted in forest-dependence literature (Angelsen and Wunder, 2003), we pay special attention to whether Non-Timber Forest Products (NTFPs) are able to substitute for timber products as primary generators of cash-income for households. Third, we identify characteristics of households that proved to be better able to adapt to logging losses by earning large incomes from NTFPs after the rule change. Finally, because the reforms aimed to improve sustainability, we consider conservation implications of extractive shifts in response to policy reforms.

2. Background and Study Site

2.1. Timber Sector Reforms

Touted as a radical turn away from previous 'cut and run' toward more sustainable logging practices, in 2000 Peru's Congress approved a new Managed Forest Law (*Act No. 27308*). The 2000 law required all logging concessions to conform to best-management practices — including feasibility studies, inventories, management plans, and annually authorized harvest areas. Under the previous system, smallholder contracts less than 1000 ha were exempt from many of these requirements. The subsequent abuse of this exemption by well-capitalized companies who circumvented the regulations by acquiring multiple small contracts was so widespread that the loophole was closed in the new law and smallholders were held to the same regulations (Melgarejo et al., 2006; Smith et al., 2006). Opponents claimed that the new law favored large-scale enterprises over smallholder loggers, and implementation was delayed due to intense and even violent civil protest. New logging concessions were auctioned throughout the 2000's but many sustainability requirements of the law were not initially enforced. This changed in 2008 when, in response to conditions of the Free Trade Agreement with the United States and its clause that all timber exported to the US must be "sustainable," the state government gave the law more teeth by criminalizing informal logging (Sears and Pinedo-Vasquez, 2011). Thus we begin our analysis in 2008, in the Region of Loreto.

The vast northeastern Region of Loreto has been heavily affected by the forestry reforms; half of rural jobs there are in the forestry sector (Fernández et al., 2004) and it contains half of Peru's lowland forests. Loreto also holds the world's highest species richness in several taxa (Gentry, 1988; Vriesendorp et al., 2007) and is home to many indigenous groups, including some that are still quite isolated (Dixon and Aikhenvald, 1999; Napolitano, 2007). In 2003, the national government opened bidding on 4,400,000 ha of new private forest concessions in Loreto (INRENA, 2003; Salo et al., 2011). The sale of large new logging concessions in this biodiverse indigenous homeland in turn spurred a rush to create new parks and reserves (see Fig. 1). Some of the land newly allocated for concessions and reserves was already being formally or informally used by local actors and so to avoid conflict in the region, concessions were granted not only to large or outsider corporations, but also to small local firms and villages with communal title to their land (Salo et al., 2011).

2.2. Study Communities

This study describes the impact of new forestry laws on two remote timber-dependent communities who numbered 245 and 190 people. There are many familial ties between these adjacent communities and households sometimes move between them, thus we discuss them together as a single study site. The communities are located in the Nanay River watershed about 150 river-kilometers upstream from Iquitos, the capital of the region and home to a half-million people (Fig. 1). The two focal communities are equally remote and have no road access. Their territories are ~8000 ha each but they also use areas upstream beyond their formal territories including parts of the 970,000-ha Nanay

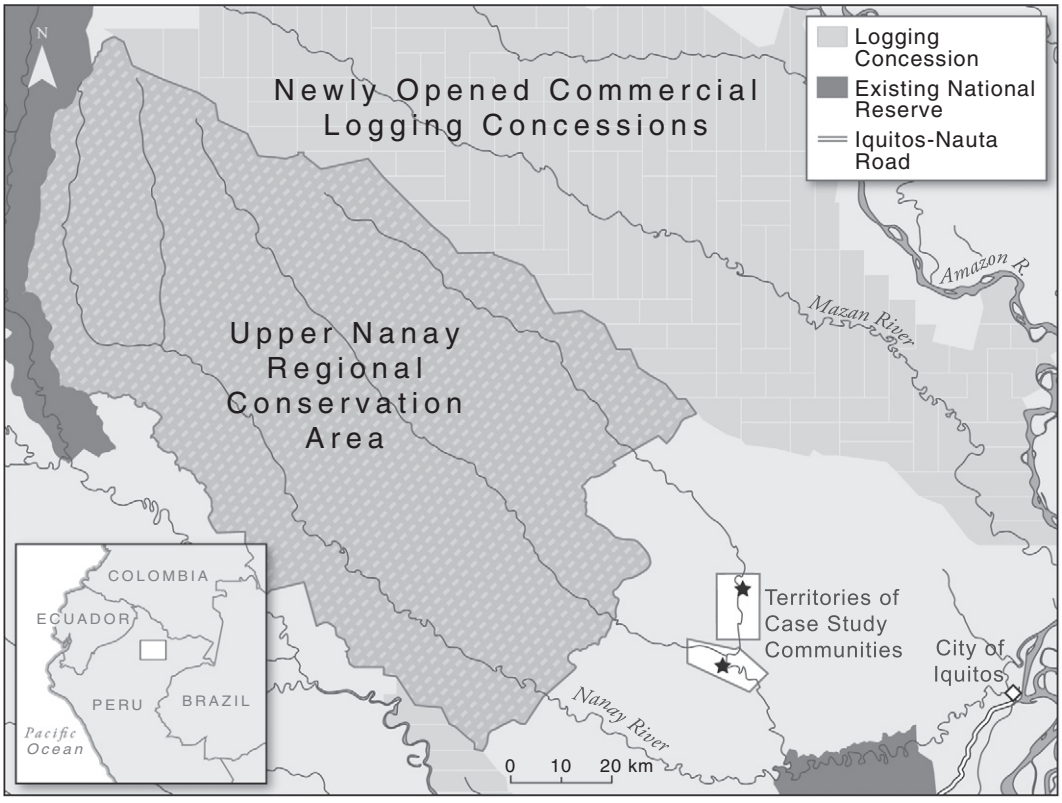

Fig. 1. Map of study area. Wider context of the study communities showing new commercial logging concessions in the neighboring watershed, a recently established conservation area upriver, and the large city of Iquitos downriver.

Regional Conservation Area gazetted in 2011. In this sense, they are representative of frontier communities in the Amazon and their relationship to the forest differs from settlements closer to the city who more commonly face land-constraints and limited timber stocks (Pyhala et al., 2006). (For notes on settlement history, see Long (2012) and Appendix A).

As in many riparian communities in the Amazon, residents practice swidden–fallow agriculture and gather forest products for subsistence and commercial use. Agricultural productivity is generally low in this region; most food comes from subsistence farm-gardens (*chacras*), fish, bushmeat, and forest fruits and nuts. Other important household goods, from soap to machetes, are brought from the city and purchased with cash or traded for commercializable forest products. Though many forest species are collected for subsistence use, few are commercialized (see Appendix A). Presently, the main commercialized forest products are timber (several species with the most common being *Virola sp.* or "cumala" and *Simarouba amara* or "marupa"), palm leaves for thatch (*Lepidocaryum sp.* or "irapay"), and small trees for polewood and construction (multiple species). The lower watershed is known for production of non-timber forest products (Peters et al., 1989a; Pyhala et al., 2006), but for the focal communities in the more remote upper watershed, timber has been the primary source of cash income for the past several decades.

2.3. Local Logging Practices

A key difference between customary informal logging in the area and logging under the new sustainability rules concerns where timber is harvested. Before the rule change, community members practiced traditional riparian forestry — felling trees with axes or chainsaws and rolling them by hand to waterways to be lashed into rafts and floated down to the city. Higher water-levels mean more areas can be logged as creeks extend further inland. Thus cutting often occurs in the dry season and logs are later transported to market when the water levels rise. Water-levels are not always predictable so many groups set up camps for weeks or months, waiting to transport their logs to market. During this time they often collect other forest resources from around the camp to take to market on the timber rafts. Traditionally, any household with voting rights in the community could log at their discretion within the community's territory with the provision that they give a small percentage (<1%) of earnings to the community treasury, and different households and small groups staked out camps in different parts of the river. The whole territory is held communally, but camps away from the village center customarily belong to certain families who may have secondary gardens nearby to provide food during extraction expeditions. Outside financing, or "habilitación," was not the norm in these communities prior to the rule change although it is common in smallholder logging elsewhere in Peru (Bedoya et al., 2007). Most households worked primarily with family labor and capital though some wealthier householders hired young men to help roll their trunks to the waterways.

In contrast to the system of independent riparian family camps, under the 2000 Forestry Law's provisions the community's territory-level concession was divided into 20 socially undifferentiated blocks including riparian and upland forest. One block (called the PCA for *Parcela de Corta Anual*) is chosen each year and all timber extraction for the year for all residents must occur within it. Block-harvesting aims to allow time for harvested areas to regenerate by eventually rotating through the whole concession and thus avoid over-harvest near the waterways. Each PCA requires its own spatially referenced technical inventory specifying which trees will be cut and which will be left as seed-bearers. To help communities meet the new requirements, a regional non-governmental organization (NGO) contributed significant financial, legal, and technical assistance to create official timber management plans for several communities in the Nanay watershed. The associated community assemblies and inventory fieldwork began in the study area at the end of 2008.

3. Data Collection

3.1. Study design

Field work was carried out during two periods: 1) May–June of 2008, before the majority of the timber-management interventions in the area and 2) July 2010, a year after initial establishment of the management plan. In 2008 we did not anticipate we would be studying a resource shock; instead our 2008 surveys were intended to establish a general socio-economic baseline in the communities prior to the creation of a protected area upstream. The protected area was not approved until 2011 and thus far has had negligible impact on resource extraction in the communities. By contrast, interventions to help bring communities into compliance with the new logging rules prompted major changes. Thus we used the baseline data as a reference for examining changes in extractive patterns immediately before and after the new management plan. In Phase I, the first author and a team of 6 student interns from the University of Iquitos spent 3 months living in the communities conducting focus groups and household surveys using community assessment instruments developed by Campo and Wali (2007). Because the total number of households was not large, we tried to survey all households in both communities, but only half of all potential households volunteered to participate during community wide assemblies in 2008 (n = 46, 20/36 and 26/60). The sample contains households from many families across various income levels. We have no reason to suspect it is biased with respect to timber because logging in 2008 was proceeding along customary practice and new rules had yet to be announced. During Phase II (2010) we again sought to survey all households and since return visits allowed us to build more trust we reached a near universal sample of 84% (n = 76. 31/34 and 45/57). Thirty-four households were surveyed in both sample periods (henceforth called the "panel households").[2] Surveys in both phases lasted 1 to 2 h and were conducted in Spanish with the self-identified "head of the household" or other available adults. Resource extraction sites were identified for each household using a reference map made by focus groups. For additional interpretation and verification of the household surveys, the first author also interviewed local authorities, community leaders and conservationists.

3.2. Measuring Incomes

Surveys included questions about household characteristics, income sources, and patterns and volumes of forest resource use. Respondents were asked to rank their economic activities in order of importance (both subsistence and commercial). They then described the volumes of different agricultural and forest products that they harvested for household use or sale. For sold goods, respondents reported the amount of money made from each sale. If a household earned income by selling a forest resource like thatch to another household, and the other household earned an additional amount by transporting and selling the thatch in the city, the volume harvested was only counted for the first household and the respective incomes were registered for both households. We also counted associated wage labor in the income totals for each resource — e.g. getting paid to weave thatch leaves into panels was counted as thatch income. Wage labor by older teens might be under-reported if they were working on their own account rather than for the household's. We were unable to measure time costs and expenditures for each household, so income values should not be interpreted as profits per se, and different activities can only

[2] Of the twelve households we were unable to re-survey, half had left the communities permanently and half were temporarily away.

roughly be compared against each other since they require different investments.

Resource harvest and income data were based on the sum of recall estimates prompted month by month for the previous year. Recall error is a bigger problem for thatch extraction than timber extraction because it is harder to accurately remember many small sales than one or two large ones. While the precise volumes of thatch may not be accurate, there is no reason they should be systematically biased from one time period to the next. Our data relies on self-reported activities and incomes, though we used informal observations, key informants and group discussion to corroborate data whenever possible. Some households may have under-reported logging in 2010 for fear of reprisal. We reduced the risk of under-reporting by building trust over 8 visits by the first author since 2007 and several months of participatory observation while researchers lived in the communities. Throughout the study, individuals told us about other extraction activities that were officially illegal but locally accepted (e.g. commercial hunting) and also spoke readily about the activities of their neighbors, allowing for triangulation in suspicious cases. Though we recognize the limitations of self-reported recall estimates covering a 12-month period, comparing values produced with the same type of estimation in two time periods can still reveal broad trends in extraction.

Harvest for subsistence is critical in this site and a full accounting of forest-dependence would need to include subsistence income (Angelsen et al., 2011). Although we collected data on species and volumes harvested for subsistence in both years, commercialized forest products — timber, thatch, and polewood — were extracted in higher volumes. Our analysis thus focuses primarily on changes in cash income from these dominant, construction-oriented forest products. Unlike food products such as fish and fruit that can be sold or consumed, these construction-oriented resources are less interchangeable between subsistence and market uses. In both time periods, the amount households harvested for subsistence use (e.g. to repair their houses) was a small fraction of what was harvested for sale. Thus, when we discuss reliance and income, unless specifically noted, we are referring to proportion and magnitude of cash income from each sector.

3.3. Modeling NTFP Engagement Post-Logging

To better understand who would be most affected by a shift from a timber-dominated economy toward one based more on NTFPs, we used standard OLS regression techniques to explore household characteristics associated with high NTFP incomes and high reliance on NTFPs in 2010. NTFP reliance depends on amount of income from other sources, and the characteristics correlated with higher reliance may be different than those correlated with high incomes (Coomes et al., 2004). We used predictor and control variables common to resource dependency studies in this region: household size (number of adults); productive assets (ownership of a large boat and/or motor); the head of household's age, years of education, and residence time; and a binary variable indicating whether the head of household was born in the communities. We also tested for differences between the focal communities but these were not significant and so we do not use a community variable in our final models. We were unable to include some predictors of NTFP harvest deemed significant in other studies: landholding area (Coomes et al., 2004) was not used because the communities hold a communal title to 8000 ha and are not land-limited; distance-to-market and resource availability (Coomes, 1995; Takasaki et al., 2001) were too closely similar between households to use for predicting intra-community variation; and it was not feasible to measure ecological knowledge (Gavin and Anderson, 2007; McSweeney, 2005). Models were inspected for outliers and tested for heteroskedasticity and omitted variable bias. We excluded 3 households earning NTFP incomes of 0 from the log-transformed income model as they were outliers with undue influence, but see Long (2012) for a discussion of livelihood strategies of such outliers.

4. Findings

4.1. Dramatic Drop in Logging

By early 2009, an NGO had helped both communities prepare technical timber management plans and get official permits in compliance with the new logging law. However, rather than the continued or increased timber harvest expected after such an investment, there was actually a marked decrease in both the number of households logging and in total logging income.

In 2008, the majority of surveyed households reported extracting timber during the preceding year (41 of 46 or 89%). Households who logged reported earning on average 1000 USD[3] per year from timber (ranging from 105 to 2850 USD), roughly half of average total incomes for households in these communities. Two years later, far fewer households reported logging activities and those who did reported significantly lower profits. In fact, out of the 76 households surveyed in 2010, only 15 (20%) reported any income from logging within the past year. Based on ancillary knowledge and triangulation from information given by other households, we calculate that 2–5 households from the larger group of 76 may have under-reported logging, but the observed marked declines remain significant when these houses are dropped. Among the households that did report logging in 2010, average logging income dropped to 410 USD[4] because they were harvesting fewer trunks. To be sure these differences were not an artifact of variation in sampling in the two periods, we next examined only those households interviewed in both 2008 and 2010 ($n = 34$). The same pattern of declining logging activity persisted. The results of a paired *t*-test on the panel data show a ten-fold drop in average reported logging income across the panel of 34 households from 710 USD in 2008 to 70 USD in 2010 ($t = -5.27, \rho < 0.001$).

By far the predominant reason households mentioned for decreased logging activity was the restriction obliging them to log in a single officially designated forest block (PCA), rather than in customary family camps located along creek and river edges. The technical inventory revealed that there are plenty of commercially valuable trees in the 2010 PCA, but community members complained that these trees are too far from the streams. Respondents said that harvesting from interior forest is extremely difficult without mechanized equipment to get the trees to the river. This type of heavy machinery is prohibitively expensive and also illegal under their new official management plan. Many also expressed reluctance to register as members of the formally organized community-level logging groups called for by the new management plan; respondents said they preferred to work primarily with family and close neighbors, often near customary camps. Only the camps of a few families are located near the 2010 PCA, and most found it difficult to pay for food and long expeditions to the PCA where they themselves had no camp.

> "I don't dedicate my time to this activity because of the distance, and because I'm not used to working in a society, just with my family." — 76 year old patriarch of a larger household who reported logging in 2008 but not 2010. (7/21/10).

Among the 15 households who reported timber incomes in 2010, most were not logging according to the management plan. A handful of families ($n \sim 5$) were continuing to log openly as though nothing had changed despite warnings of legal consequences. Others became more clandestine. Clandestine methods often cost more, for example paying for higher value banned species to be taken out in small pieces by covered boat, or paying for the logs to be milled upstream and sold in the city as less traceable boards. Most households did not log at all during the first year of the management plan (2010).

[3] Dollar amounts are based on conversion rate of 1 PEN = 0.3568 USD from July 2008.
[4] 1 PEN = 0.3541 USD in July 2010.

Table 1
Changes in average household income from forest extraction activities.

Sources of market income		Mean annual incomes in USD			Mean proportion of annual incomes		
		2008	2010	Δ [ab]	2008	2010	Δ [ab]
Timber	Total	$768	$109	−$658***	43.2%	6.6%	−36.6%***
NTFPs	Total	$652	$909	+$258	35.2%	64.0%	+28.8%
	Hunting and fishing	$120	$53	−$68*	7.2%	5.8%	−1.4%
	Thatch and polewood	$531	$840	+$309†	27.9%	56.4%	+28.4%***
Other	Total	$625	$718	+$93	21.6%	30.6%	+9.0%†
	Agriculture and livestock	$63	$63	$0	5.1%	5.3%	+0.3%
	Transport and sale of city goods	$146	$282	+$136	5.6%	7.6%	+2.0%
	Reforestation and handicraft projects	$18	$177	+$159***	3.1%	14.9%	+11.8%***
	Salaried positions and remittances	$399	$196	−$203	7.9%	2.8%	−5.1%
Total		$2044	$1723	−$321			

[a] Significance determined with two-sided unpaired t-tests on full 2008/2010 samples.
[b] $\rho(t) < 0.1 = \dagger$, $\rho(t) < 0.05 = *$, $\rho(t) < 0.01 = **$, and $\rho(t) < 0.001 = ***$.

4.2. A shift to other forest resources?

Table 1 summarizes the mean contributions of different sectors to cash incomes in the years preceding and following the logging rule change. Despite the dramatic decline in logging, forest-based income still accounted for >2/3 of average household cash incomes after the logging rule change and some extraction shifted toward NTFPs. The increase in NTFP income primarily reflects the increased extraction of palm leaves for roof-thatching and to a lesser extent polewood. By contrast, commercial hunting and fishing incomes remained the same or decreased. Non-forest incomes also rose, but the majority of the increase was related to a short-term payment-for-reforestation project taking place in the communities during 2008 and 2009 (CEDIA, 2009). These payments ended in 2009, and did not rival incomes from forest extraction. In both time periods, a small subset of households (10%) obtained sizable income from government salaries or from transport and resale of manufactured goods from the city of Iquitos. There was a decline in average salary income due to two households who stopped receiving large salaries from a project to make an Iquito language dictionary. Cash income from livestock and agriculture remained steady and small in both time periods; in this remote site these are primarily subsistence activities. A robustness check using the subsample with panel data yielded comparable results with the exception that the decrease in hunting income was not significant and the increase in the proportion of income made up by the category 'Other' was significant with $\rho(t) < .05$. To check for changes in the distribution of income from each sector and not just the means, we used the Kolmogorov–Smirnov test for equality of distributions (Massey, 1951) and found that the 2008 and 2010 income distributions were statistically equivalent for all of the sectors in Table 1 except timber ($\rho(D) < 0.001$), palm thatch ($\rho(D) = 0.029$), and incomes from the reforestation and handicraft projects ($\rho(D) < 0.001$). Total income distribution was also different after the rule change ($\rho(D) = 0.049$).

On the whole, NTFPs and especially thatch played a larger role in the community economy in the year immediately following the logging rule change. In 2008, 1/46 households (2%) depend solely on NTFPs for cash income. In 2010, this increased to 13/76 households (17%). Overall, the share of income from thatch and polewood jumped from a quarter in 2008 to over half in 2010 (Table 1). The 34 households in the panel sample harvested almost half again as much Irapay palm following the rule change, from 66,500 palm leaves in 2008 to 100,000 palm leaves in 2010 (two-sided paired *t*-test; $t = 2.38$, $\rho = 0.02$, $n = 34$). In the panel households' self-appraisal of their most important economic activities (including *both* subsistence and commercial activities), harvesting thatch received an average rank of 3.15 in 2008 while in 2010 it moved up to 2.16, usurping timber harvesting as the second place to agriculture[5] (two-sided paired *t*-test; $t = 2.45$, $\rho = 0.01$, $n = 34$). Polewood was also extracted more heavily; in 2008, households harvested polewood mainly for constructing their own houses while in 2010, about 40% of households reported harvesting polewood to sell,[6] though polewood income was still dwarfed by income from thatch.[7]

Though several signals suggest a shift toward higher intensity extraction of NTFPs, the shift appears to be unequal and incomplete. Much of the proportional change in NTFPs' share of average total income in the communities is accounted for by falling timber incomes as opposed to rising real incomes from NTFPs. Furthermore, though the increase in *volume* of NTFPs harvested is significant, the increase in NTFP *income* is not significant in the panel data and only marginally so in the larger sample (see Table 1) because the variation in individual responses was quite high.

4.3. Differentiated Adaptation

In 2010 almost all households had lost timber income, but only some households were able to earn significant cash incomes from NTFPs in the absence of logging. Fig. 2 shows changes in individual cash income portfolios for the subsample of 34 households with panel data over the 2-year period encompassing the rule-change.[8] The near universal trend of decreasing timber is evident in the panel across the whole spectrum of cash-earners. In contrast, there is a lot of variation among households in their change in total income and the extent to which NTFPs replaced logging. Those with the biggest timber losses were not necessarily those with the biggest NTFP gains. Some households lost NTFP incomes on top of lost timber incomes, and others showed little change thus far. Fig. 2 also reveals that this was not simply a case where, with the decline in logging income, poor households from 2008 made even less in 2010 while high income earners maintained or increased earnings. Nevertheless, there are signals of growing inequality. The Gini coefficient indicating inequality of income distribution increased from 0.469 to 0.513 for the panel subsample of households, and from 0.422 to 0.544 in the larger samples of households surveyed in 2008 and 2010. Households do not appear equally able to profit from NTFPs.

Palm thatch is the most profitable of the NTFPs harvested in the study site and also the NTFP that showed the largest change in mean and distribution of income after the rule change. Thus we focus on understanding differentiation in the thatch sector to better understand factors that contribute to intra-village differences in adaptability to a

[5] Agriculture was almost always ranked the highest because of its importance for providing food to the household, but it does not usually generate appreciable cash income in this site.

[6] It is not possible to directly quantify changes in the volume of polewood harvested because it was not specifically addressed in the 2008 survey.

[7] Average of 720 USD from thatch vs. 100 USD from polewood.

[8] The panel may be biased toward more resilient or diversified households since some of the heavily timber-dependent households we surveyed in 2008 did not make it into the panel set because they left the communities when they could no longer log the way they had done prior to the rule-change ($n = 5$).

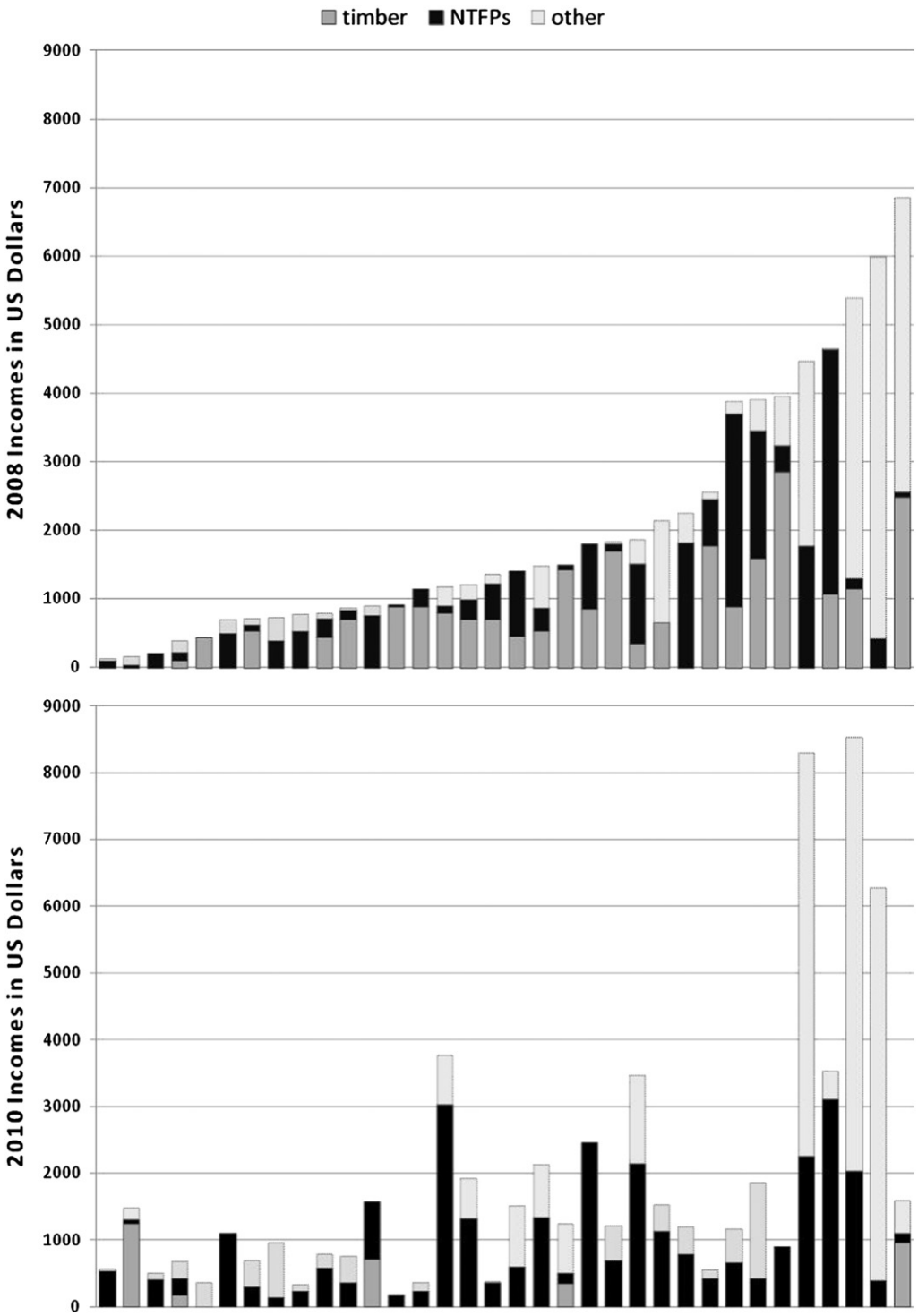

Fig. 2. Income in panel households. Change in income portfolios for the same 34 households, before and after the local implementation of the logging rule-change. Households are arranged by total income in 2008.

more NTFP-dominated economy. Table 2 shows two multivariate regression models summarizing the household characteristics that are correlated with the magnitude (column 1) and proportion (column 2) of income from thatch in 2010. Among the households with any engagement in the thatch sector (n = 73 of 76), younger heads of household who were not born in the community but were also not brand new to the community and owned large boats or motors tended to earn more from thatch. None of the characteristics predicting the magnitude of thatch income were significant predictors of the proportion of households' total income from thatch. Instead, years of education were significantly associated with lower reliance, indicating that education has more bearing on opportunities for cash income from other activities.

The significance of owning large boats and boat motors suggests that earning higher thatch incomes depends on having the right types of assets for transportation. To harvest thatch on a scale that compensates for lost timber incomes, the manner and location of extraction must change dramatically. Though it grows in small patches around the communities, the large, dense stands of Irapay palm are one to two days journey up river in remote headwaters. Thatch harvesters now travel farther than they did for logging- up to 80 river-kilometers upstream, beyond

Table 2
Household characteristics associated with high thatch palm use in 2010.

	Thatch income (log-scale)	Thatch reliance (% of total income)
# of adults	0.096 (0.084)	−0.022 (0.019)
Age of head of household	−0.040** (0.015)	−0.006 (0.004)
Yrs of education of head of household	−0.038 (0.040)	−0.025* (0.010)
Head of household born in community? (Binary)	−1.310** (0.395)	−0.161 (0.106)
Residence time of head of household in community	0.031* (0.012)	−0.000 (0.004)
Household owns large boat and/or motor (Binary)	0.586* (0.252)	−0.085 (0.069)
(Constant)	7.098 (0.657)**	0.928 (0.160)**
Model	n = 73[a]	n = 76
	F(5, 67) = 4.11	F(5,70) = 5.01
	R^2_{adj} = 0.202	R^2_{adj} = 0.214

Cells contain the coefficient and robust std. errors from OLS regression. ρ(t) < 0.05 = *, ρ(t) < 0.01 = **.

[a] Log-transformed income model excludes the 3 households who earned zero thatch income in 2010.

the communities' official territories into areas where tenure is particularly unclear. Thus large-scale thatch extraction requires motorized river transportation and capacity to spend weeks away from homes and farm plots or hire others to do so. Intra-community *habilitación* is more common for thatch expeditions. Large thatch incomes also require the ability to store and transport thatch to the city when the price is high (it varies seasonally). Some respondents complained they had lost the ability to afford higher-profitability kinds of thatch extraction without cash from timber sales to buy thatch from others to resell at the higher city price. For other respondents, timber rafts had been the physical mechanism for cheaply carrying non-timber products like thatch and bushmeat to higher-paying urban markets downriver.

5. Discussion

5.1. Unintended Loss of Access to Logging

Peru's 2000 National Forest Policy was chiefly designed to promote more sustainable timber harvest. Despite concerted efforts to facilitate local sustainable logging, both quantitative and qualitative evidence point to a large decline in timber income after the new rules came into force in the study area. We found no evidence supporting possible alternative hypotheses explaining the decline in local logging, e.g. price shocks, a drop in available financing, increasing scarcity of timber resources, or weather problems. Respondents reported that they sold thatch at an average price of 0.20 USD per panel (when selling within the community) in both 2008 and 2010. Respondents also reported fairly stable timber prices; selling the most common species (*Virola spp.*) at 0.20 USD per board foot in both 2008 and 2010 and the second most frequently commercialized species (*Simarouba amara*) at 0.10 USD in 2008 and 0.20 USD in 2010. On a larger scale, the ITTO Annual Review Statistics Database shows roughly stable or increasing average nationwide export values for sawnwood in Peru between 2008 and 2010. We heard from households about price crashes related to ornamental fish and scarcity problems related to bushmeat, but these were not the reasons that households gave for harvesting less timber. As for financing (habilitación), it was uncommon in 2008 when most households extracted with family labor at their own camps. Under the new system financing has more importance because loggers need more provisions to stay longer in places where they aren't with family or near their gardens. In fact, the NGO helping with the sustainable management plan offered financing for any compliant expeditions and NGO staff became exasperated when still no one wanted to log. Our estimates potentially understate the impact of the rule change in the communities given that some very timber-dependent households simply left after the rule change and the remaining panel does not include their losses. Longer term data would aid our interpretation, especially given high variability in local extraction (McSweeney, 2002), yet all the study households varied in the same direction (less timber), pointing to a broad external driver. The fact that it was concurrent with the rule change and that many households explicitly blamed the new system builds a strong case that the decline was policy induced.

The communities' quick and dramatic response to the policy change is somewhat surprising since logging reform research in Peru and elsewhere in S. America often describes limited enforcement of new laws and a failure to curb illegal logging practices (Sears and Pinedo-Vasquez, 2011; Smith et al., 2006). It is plausible that, though they had no enforcement authority, the presence of the NGO promoting the new management plan and potentially the field research team itself may have discouraged non-compliant logging in 2010. The NGO's main goal was to help communities transition to the new forestry system, and staff members were dismayed by the abrupt drop in logging, yet perhaps local residents otherwise might have continued logging as usual 'under the radar' despite the new law. It is difficult to predict how things would have played out in the absence of the NGO. In 2007 the president of a community in an NGO-free part of the same watershed was jailed for 7 years for failing to comply with logging rules. We did not ask respondents about enforcement due to the sensitivity of this issue; it remains an interesting puzzle. The Nanay case shows that, at least with the presence of external organizations, policy reform can produce rapid change in forest use, although not necessarily among target actors. In other parts of Amazonian Peru, Smith et al. (2006) found that logging practices did improve among some of the capitalized producers particularly if they were working closely with NGOs, but also that the far more numerous producers who had fewer resources faced difficulties adopting many of the law's stipulations. Regardless of the source of enforcement pressure that led to implementation, this case study provides an example of smallholder impacts when a policy is truly implemented across both companies and communities.

Peru's 2000 Managed Forest Law set sustainability standards for large-scale extraction — an urgent task especially given that Peru simultaneously began opening large new areas to commercial concessions. The reforms were not intended to exclude small-scale loggers, in fact forest concessions in Loreto were disproportionately awarded to small and local actors (Salo et al., 2011). However, being awarded a contract is not the same as being able to follow it, and some of the provisions of the new law were ill-suited for forest-dependent communities. The prescription to log in large blocks in formally organized groups using technical management plans runs counter to the local tradition of opportunistic, riparian extraction by family work groups (De la Rosa Tincopa, 2009). Similar commercially-oriented forestry reforms in Bolivia, Ecuador, and Brazil compelled communities to shift from diversified forest-based livelihood strategies to an enterprise model, or to rely on external support to meet the technical, financial, and administrative requirements (Medina et al., 2009; Pokorny and Johnson, 2008). Though timber extraction is generally considered an income source available to the relatively rich due to the often capital intensive nature of extraction (Angelsen and Wunder, 2003), in these communities and elsewhere in the Peruvian Amazon even the poorest households are involved (De la Rosa Tincopa, 2009). Although our respondents would likely all be considered "poor" by outsiders, there is a 10-fold difference in annual income within the community. The logging decline was felt by both the wealthier and poorer households in the study as loss of large quantities or large proportions of cash income. Law-makers must be doubly careful when creating or reforming regulations for a sector in which actors are involved at all scales, from international corporations to young indigenous households with no savings or capital. It is difficult to close loopholes allowing 'cut and run' logging by large enterprises while maintaining flexibility to accommodate non-capitalized extractors. Yet it is important to keep sight of this second

group if policies are not to disenfranchise indigenous groups or further marginalize the rural poor (Bluffstone and Robinson, 2012; Coomes, 1996).

Follow-up conversations in 2013 with professionals still working in the communities indicate that timber harvest has remained low and thatch harvest high. Long-term outcomes are not yet known, particularly because national logging laws continue to be revised (e.g. *Act No. 29763*) and may eventually include certain exemptions for smallholders. As such, this study is less useful for drawing conclusions about the fate of community forestry in Peru's Nanay watershed, let alone sustainable forestry reforms in Peru. It does provide important lessons about unintended consequences of sustainability reforms and suggest intra-community differences in adaptability to resources restrictions.

5.2. Shifts and Uneven Adaptation

After the logging shock, NTFPs became more important sources of income — they were ranked more highly by householders with respect to their other economic activities and a larger volume of NTFPs was extracted at the community level. The trend toward greater volume suggests some degree of interchangeability between timber and non-timber forest products as sources of cash income, but they are only partial substitutes, or they are substitutes for some households but complements for others. Only some community members were able to increase their income from NFTPs while others lost earning potential.

Previous studies in this region have also shown high variability within communities in the types of resources that households extract and pointed to the key role of household assets in determining livelihood portfolios (Pyhala et al., 2006; Takasaki et al., 2001). This longitudinal study of an income shock adds that movement between diverse income sources is also constrained by assets, and that options within a portfolio can be interrelated. Our findings suggest that logging may have helped households obtain assets that allow for commercial-scale extraction of NTFPs (i.e. large boats and motors) or made them less necessary (i.e. through providing transport via timber rafts). Thus, while some households have been able to switch from timber to non-timber forest incomes, for others timber and thatch incomes were more interdependent than interchangeable.

NTFPs have been described as both 'pro-poor' resources and as 'poverty traps' in the literature on forest-based livelihoods (Angelsen and Wunder, 2003; Sunderlin et al., 2005). This contradiction stems partly from the very broad array of the resources included in the NTFP category (Belcher et al., 2005). Our study highlights a different difficulty with generalizing the relationship between forest products and the poor — in Nanay a single type of NTFP (palm thatch) yielded large incomes for some community members and little for others. Small-scale thatch harvest, with a low barrier to entry conventional to pro-poor NTFPs, continued to serve the traditional maintenance, subsidy, and gap-filling functions in household economies (Sunderlin et al., 2005). However, only the more capitalized method of thatch extraction generated income near the same magnitude as logging. Small-scale harvesters could not ramp up their low-profit extraction to higher profit extraction without expensive productive assets like large boats and motors. The complex role of boat transportation and middlemen in commercialization of NTFPs has been documented by several studies in this region (Cardozo, 2013; Padoch, 1992). Here, the absence of log rafts contributes to the uneven distribution of thatch profits since those with boats facilitating sale of thatch in the city act as middlemen and capture some of the NTFP income from those who cannot. This could increase local inequality since in this case logging was a potential source of capital for both rich and poor, whereas NTFPs are a source of modest income for all but a source of capital only for well-positioned households.

Besides productive assets, other factors that appear to be important for post-logging NTFP extraction include the age of the head of household and whether he was from the community (householders born elsewhere were not of Iquito ethnicity). These may be signals related to market orientation if these households are more aggressively pursuing cash incomes and prefer to shift between resources rather than shift from market to subsistence orientation. Or, they may signal fewer other options available to the household, corroborated by the correlation between more education and lower reliance. The fact that shorter residence times are correlated with lower NTFP incomes may be related to access rights; for example there is a community rule prohibiting new households from commercial harvest on community lands during a several-year waiting period. Explanations related to market-orientation and those related to access and opportunity both may be valid in the study site. Studies of income shocks in other areas have shown that the young and the poor within a community are most likely to turn toward forest products as a form of insurance (McSweeney, 2004; Takasaki et al., 2004). In this site where opportunities for wage-labor or commercial agriculture are limited, both the relatively rich and poor households shift toward intensified extraction of other forest resources when there is a shock to income from one profitable resource.

The manner and extent to which local citizens were able to shift their livelihood strategies post-logging offers key lessons about the potential impact of conservation interventions in other remote regions where large areas of carbon-heavy, biodiverse forests still exist. Further studies about the ease of shifting between the two oft juxtaposed categories of timber and NTFPs would be illuminating, and timely in light of widespread efforts to design REDD and PES programs that may limit timber harvest but permit harvest of NTFPs (Capella and Sandoval, 2010).

5.3. Concerns for Conservation

Though a conventional assumption holds that harvest of NTFPs is more sustainable than logging (Peters et al., 1989b), many have questioned the premise that NTFP harvest is automatically sustainable, especially under pressures to commercialize products (Arnold and Pérez, 2001; Coomes, 1995; Pinard and Barker, 2000). If thatch palm is harvested leaving a few leaves on the plant or if polewood is taken from fallows or secondary growth, regeneration time is relatively short (~1 to 5 years). Carefully gathering small quantities is a more viable option if palm leaves (or other NTFPs) are primarily used for subsistence or gap-filling purposes. However, because the commercial value of thatch and polewood is much less than that of timber, there is incentive to harvest large quantities quickly to make comparable amounts of income. The fact that households have to go increasingly far from the community to collect thatch indicates that they are not harvesting it 'sustainably'. Increased harvesting with long-distance expeditions could also increase other extractive pressures on areas previously unaffected. This could especially raise conservation concern if it means increased hunting in the remote headwaters conservation area (Peres and Lake, 2003). Additionally, in the case of polewood, many of the community members specified in 2010 that they extract it from *varillales*, a rare forest type with stunted pole-like trees that hosts several endemic species (Alvarez Alonso and Whitney, 2003; Fine et al., 2010; Rodriguez et al., 2003). Since this is an uncommon ecosystem in Peru that is locally abundant in patches throughout the Nanay watershed, it would be highly incompatible with conservation goals if community members shifted to applying more intense pressure directly on these patches.

6. Conclusion

The 2000 Managed Forest Law was designed to reduce environmentally degrading logging practices and represents a progressive step in Peru's national forestry agenda. However, such sweeping reforms can have unintended side effects in forest dependent communities who are unable to meet provisions more appropriate for a capitalized enterprise, even with heavy assistance from NGOs. In this case study, rule changes from the new law resulted in a dramatic decline in logging

participation, and though it is early to draw conclusions about long run effects, reports from the field in 2013 indicate that logging is still down. The implications of a subsequent shift to heavier reliance on NTFPs are still unknown but this study raises concerns about the potential for widening intra-community inequalities or increased pressure on more remote or threatened forest types.

The question of what happens to local economies when a high-value resource is restricted (intentionally or not) deserves attention by anyone trying to limit logging, whether to protect biodiversity or store forest carbon. Attention to differences in adaptability within communities is critical from both a social justice and a conservation perspective. If wealthier residents are losing relatively large amounts of income due to restricted access, then it is important to know what these more capitalized households will turn to in order to make up the difference, particularly in remote areas where there are few options other than forest extraction. Policy makers and practitioners ought also to guard against creating additional hardship for poorer members of a community, and be aware of the potential for compounded loss of access if a resource plays a facilitating role for other types of income.

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