Property Rights and Forest Adaptation: Household Evidence from Bolivia, Kenya, Mexico, and Uganda

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1. Introduction

For some time scholars have studied how communities adapt to environmental change (IPCC, 2001; Adger, 2003; Pelling and High, 2005; Adger, 2006; Solomonet al., 2007; Agrawal, 2010). Recently, some scholars have advocated careful attention to the institutional and policy tools available to communities (Agrawal, 2010). In recent work I examine the role of common property rights and the ability of such rights to constrain or enhance possible adaptation strategies that communities use when responding to disturbance (Coleman, forthcoming).

Scholars of the commons have conducted much research on the determinants of successful commons management (Ostrom, 1990; Baland and Platteau, 1996; Gibson et al., 2000; Ostrom and Nagendra, 2006;Pagdee et al., 2006; Coleman, 2009). Much of this literature finds that there is not a panacea of policy choices that policymakers can implement to solve commons dilemmas (Ostrom, Jannsen, and Anderies, 2007). Part of the reason that it is difficult to provide such policy advise is the inherent complexity of different commons. A particularly difficult problem for those studying the commons is to assess how communities should guard and against and respond to environmental disturbances (Coleman, forthcoming). Such disturbances pose second-order collective action dilemmas on the commons. Not only must common pool resource users solve the first-order problem of overexploitation, but they also must solve the problem of building adaptive capacity to be more resilient to environmental disturbances (Yohe and Tol, 2002).

Scholars and policymakers have sought to implement policies that help local communities plan for and adapt to disturbances (IPCC, 201). While policymakers are often unable to manipulate many of the tools available to cope with collective action dilemmas on the

commons (such as group norms of trust and reciprocity) they do have the ability to change relevant institutions such as property rights. Decentralization, for example, can be thought of as a large scale attempt to change property rights structures and thus change the incentives resource users face (Agrawal and Ostrom, 2001). Thus, there is interest in examining if changes in property rights can help mitigate some of the first and second order problems involved in commons adaptation. For example, if one strengthens the property rights of resource users, does this enhance the likelihood that they respond favorably when faced with disturbances?

Coleman (forthcoming) examines the effects of common property rights on the likelihood that local users rank the condition of the forest highly after a disturbance. He finds that user groups with stronger property rights are more likely to respond favorably, but that property rights are most important when there are many rival users and when the organizational capacity of the users is small. When there are few rival users groups, strong property rights do not appear to have much of an effect on forest conditions after a disturbance. However, when there is high organizational capacity strong common property rights actually strongly decrease forest conditions after a disturbance. This may be because forest users can mobilize resources and exploit an opportunity to engage in large-scale harvesting.

This paper is in much the same vein as Coleman (forthcoming) except that I examine property rights not at the community level (i.e. rights held jointly by communities of forest users) but rather at private rights exercised by households within a community of users. Data is examined that assesses the likelihood that forest user households will rank forests as being more dense after a disturbance depending upon the property rights held by the household. I also examine the property rights each household has relative to three forest types: government-, community-, and privately-owned forests. The effects of household property rights at

engendering favorable response to disturbance are expected to vary depending on the type of forest (as outlined in the next section). Data come from a cross-country household survey of forest users in Boliva, Kenya, Mexico, and Uganda. These countries were selected to exploit the fact that each country has experienced widespread forest decentralization in recent years (See Coleman, Fleischman, and Bauer, 2009). In general, there is significant variation in the types of forest property rights held by different households both within (see Andersson and Gibson, 2007) and across (see Ribot, Agrawal, and Larson, 2005) countries. Since decentralization has been implemented in each country, there is significant variation in household property rights within and across the countries.

The paper is structured as follows. In the next section I review some of the literature on property rights theory and in Section 3 present a model and derive a number of hypotheses that will be tested in the paper. In Section 4 I present the empirical results and in Section 5 I conclude.

2. Property rights

Ostrom (1990) was perhaps the first to show that there was little reason to believe that government, community, and privately managed commons were unlikely to experience significant differences in outcomes. This finding is now empirically supported by a number of studies (Ostrom and Nagendra, 2006; Coleman, 2009). Some scholars have acknowledged that the labels "government," "community," and "private" hide many relevant differences in institutional forms that are not co-determinant with those labels (Coleman and Steed, 2009). Why should we expect two forests with identical institutions, but one is labeled "community" and one is labeled "government" to have any bearing on outcomes?

Schlager and Ostrom (1992) provide a careful theoretical framework to examine in more detail what is meant by property rights and McKean (2000) shows that such rights are not exclusive to any type of property owner—government, common, or private. The Schlager and Ostrom (1992) framework, then, sets out a blueprint for how to distinguish relevant institutional features that a scholars might consider when doing empirical work on the effectiveness of different property institutions. While this framework has been used to develop more complete theoretical concepts of property rights (e.g. Agarwal and Ostrom, 2001; Arnason, 2005; Scott, 2008) it has been limited in empirical application, especially in relation to large-n statistical analysis.

Schlager and Ostrom (1992) delineate property rights by conceptualizing "bundles" of property rights. Property rights for a resource may be divided into rights of access, withdrawal, management, exclusion, and alienation. In the case of forests, rights of access imply that the rights holder can enter into the forest and use the forest non-consumptively. Rights of withdrawal refer to a rights holder's ability to withdraw (harvest) some specified resources within the forest (such as timber and non-timber forest products). Rights of management imply that the rights holder has the ability to make rules about the forest use, while rights of exclusion refer to the ability of the rights holder to prevent other users from exercising rights of access, withdrawal, and management. Alienation rights refer to the ability to alienate, or divest, oneself from the resource (by lease or sale).Schalger and Ostrom (1992) carefully point out that full property rights, including all rights up to and including rights of alienation, is seen as the *sin qua non* of property rights. Rather than conceptualize property rights as a binary variable (users have full property rights or none) Schlager and Ostrom (1992) challenge scholars to think about the range of property rights a user might hold. Schlager and Ostrom (1992) posited that users with more

complete property rights (property rights including all the bundles including alienation rights) were likely to provide the greatest incentives for rights holders to invest in and sustainably manage the resource.

The empirical support for Ostrom and Schlager's (1992) theory is more limited. Ribot (2009), for example, argues that access rights (to government forests, at least) are denied to local groups and instead given to merchants and conjectures that granting access rights to local users might be sufficient to improve the sustainable management of forests. As mentioned, Coleman (forthcoming) finds that stronger property rights can improve forest conditions, but only under specific conditions. In general, there is much debate about whether forest decentralization, attendant with full property rights to local users, will improve forest sustainability (Ostrom and Agarwal, 2001; Ribot, Agarwal, and Larson, 2005), and it has been difficult to identify the conditions under which large scale decentralization of property rights will have positive effects (Treisman, 2007). Still, there has not been much large-n statistical analysis of property rights—at least there is little research that uses composite measures of property rights to reflect the theoretical constructs of property rights hypothesized by Schlager and Ostrom (1992)—and forest sustainability.

3. Theory

Consider a forest-dependent household that may access one of three types of forests, government, private, or community. This household has different bundles of rights in each forest and must decide how to allocate its resources (i.e. labor and time) across the three types of forests. Furthermore, each forest is vulnerable to environmental change and any investment made in any one type of forest is in danger of being destroyed by such change. How would the household allocate its resources in this situation?

First consider the decision the household makes in the government forest. If the household has no property rights in the government forest and the government holds all residual rights to the forest (see Coleman and Steed, 2009) then the household is likely to overharvest from the forest. If the household cannot expect that forgoing harvesting will be beneficial in the long term, then it has no incentive to stop harvesting today. When property rights are weak, it is less likely that the households will benefit from the decision to forgo harvesting. However, if the household has a complete bundle of property rights it will be more likely to forgo harvesting, because it has the potential to realize the benefits of foregone harvesting (i.e. harvesting continually over a longer time horizon). Because the government is the residual claimant of forest rights the household may be assured that those rights will be recognized into the future (at least compared to private forests where the residual rights are privately held and more easily changed). Finally, strong property rights in government forests will be especially important when a forest has experienced a disturbance. Forest disturbance brings a higher degree of uncertainty as to the benefits of foregone harvesting. This uncertainty is exacerbated by households with weak property rights and they will be more likely to overharvest after such a disturbance; however, those with strong property rights are more assured relative to those with weak property rights. Hypothesis 1 and 1a formally state the hypothesized relationship between property rights and forest conditions in government forests.

Hypothesis 1	Households with strong property rights in government forests are more likely to rank the forest conditions favorably than households with weak property rights in government forests.
Hypothesis 1a	Households with strong property rights in government forests are more likely to rank forest conditions favorably *after a disturbance* than households with weak property rights.

Now consider the behavior of the household with respect to a community forest. Community forests have shared rights among a group of community members, although in practice some community members may have different rights than others. Still the existence of a community forest implies certain rights available to households that are members of the relevant community. Property rights in community forests are expected to have a much weaker effect than such rights in government forests. First, even if a household has strong formal property rights to engage in overharvesting in a community forest, there may be social norms prohibiting that household from engaging in such behavior.[1] Second, because property rights are available to the entire community of users, property rights may be over-allocated. This may make it difficult, in a practical sense, to harvest a forest product that some other user may also have a claim on. Finally, those with property rights in community forests may prefer to first harvest from government and private forests instead of using the community's forest resources. That is, the substitute their harvesting in community forest and instead harvest in other types of forests. These effects may be exacerbated by the presence of an environmental disturbance. If the forest conditions in the community forest decrease drastically for some reason, then forest users will be likely to substitute their harvesting to other types of forests in order to allow the community forest to regenerate and may face more strident social norms to change their harvesting activity. Hypothesis 2 and 2a formally state the hypotheses between property rights and forest conditions in community forests.

Hypothesis 2	Households with strong property rights in community forests are *no* more likely to rank the forest conditions favorably than households with weak property rights in community forests.

[1]These norms are more likely to exist in community forests, because the community, as a whole, is the residual claimant of the property rights in the forest and overharvesting directly impacts the wealth of many other community members. Overharvesting may indirectly impact other users of government or private forests, but this impact is not a direct or obvious in these other types of forets.

Hypothesis 2a	Households with strong property rights in community forests are *no* more likely to rank forest conditions favorably *after a disturbance* than households with weak property rights.

Finally, consider the case of private forests. If the household is the owner of the forest it may have strong incentives to not overharvest, deplete the forest, and loose its future value. Thus, we would expect that households with complete (alienation) property rights of private forests are more likely to rank the condition of the forest favorably. However, if the household is not the owner of the forest, but instead a lessee of some subset of rights from the forest owner, it may face quite different incentives. First, note that households which lease property rights have incentives to forgo harvesting to the extent to which their harvesting can be observed by the property owner. When there is not disturbance in the forest it is easier to observe what has been harvested by the lessees. Thus, when there is not disturbance, those with strong property rights are likely to rank forest conditions favorably (those with full ownership are the most likely to forgo harvesting) *ceteris paribus*. However, after a disturbance, it is more difficult to observe what the lessees have harvested; however, those with full ownership rights may still be likely to forgo harvesting. Thus, it is uncertain what the effect of property rights will be in the aggregate after a disturbance. Hypotheses 3 and 3a formally state the hypotheses between property rights and forest conditions in private forests

Hypothesis 2	Households with strong property rights in private forests are more likely to rank the forest conditions favorably than households with weak property rights in private forests.
Hypothesis 2a	Households with strong property rights in private forests are *no* more likely to rank forest conditions favorably *after a disturbance* than households with weak property rights.

4. Model

In order to test Hypotheses 1—3 we estimate a model of the effects of household property rights in government, community, and private forests and the effects of an environmental disturbance on the household's ranking of forest conditions. We operationalize forest conditions on a binary scale—whether the household perceives forest vegetation as dense (=1) or sparse (=0) "compared to other forests in the region (<20 km distance from your village)." This will be the dependent variable in the analysis. To estimate the effects of property rights and disturbance a logit model is estimated of the form:

$$\Pr(Forest\ Conditions_{ij} = 1) = \Lambda(\alpha_j + \gamma_j Property\ Rights_{ij} + \delta_j Disturbance_{ij} + \beta_j x_{ij}) \quad (1)$$

That is, the probability of having forest conditions as modeled as the logit (Λ) of property rights, disturbance, and a set of control variables *x*. Here the *i* subscript indexes the household (*i=1,…,n*) and *j* indexes the type of forest (*j=government, community, private*). Thus, the forest conditions in forest type *j*for household *i*is a function of the property rights the household has for that forest type, the disturbance in that forest type perceived by the household, and a set of control variables for that household in that forest type. Equation 1 is simply represents a set of three separate logit models: one model for government forests, one model for community forests, and one model for private forests. Equation 1 can be estimated from maximum likelihood (Long, 1997).

To make Hypotheses 1—3 concrete in terms of Equation (1) we set out the conditions under which we reject or fail to reject these hypothesis from the data and model. Hypothesis 1 implies that $\gamma_{government} > 0$, Hypothesis 2 implies $\gamma_{community} = 0$, and Hypothesis 3 implies $\gamma_{private} > 0$.

4.1 Data

As explained in the introduction, data are taken from a household survey conducted in Bolivia, Kenya, Mexico, and Uganda. Data was gathered at the household level and respondents (household heads) were asked to indicate the level of property rights they had for government, community, and private forests, if there was such a forest nearby. Respondents were also asked to indicate how far the forest was, whether there had been a disturbance in the past 10 years, and whether they thought the rules for the forest were fair. Additional information was collected at the household level in terms of asset holding, dependence on forests for subsistence, age, education, and other background variables. Table 1 reports the summary statistics for each type of forest; the top panel reports summary statistics for government forests, the middle panel reports summary statistics for community forests, and the bottom panel reports summary statistics for private forests.

Property rights are measured on a 21 point scale. Each household was asked whether they were allowed to 1) enter the forest, 2) harvest products from the forest, 3) contribute to managing the forest, 4) make decisions about managing the forest, 5) decide who can and can't enter the forest, and 6) make decision about selling or leasing forest land. Each type of property right is assumed to be more substantial than the previous right; thus, an index that weights each type of property right by the order of importance was used. For example, a household that had each type of property right had a property rights value of 21 (=1+2+3+4+5+6). A household with only rights to enter the forest had a property rights value of 1. Table 1 shows that in government forests the average property rights held by all households is 4.02, with a minimum of 0 an a maximum of 21. In community forests, the average property rights is 7.42, while in private forests the average property rights is 6.72.

Table 1. Summary Statistics

	Obs.	Mean	Std.Dev.	Min.	Max.
Government Forests					
Property Rights in Government Forest	874	4.02	3.60	0.00	21.00
Property Rights in Other Forests	885	1.16	4.68	0.00	42.00
Vegetation Government Forest	885	0.30	0.46	0.00	1.00
Govt Forest Subsistence	872	2.15	0.83	1.00	3.00
Time to Government Forest	884	21.18	31.28	0.00	600.00
Rules Fair?	885	0.31	0.46	0.00	1.00
Distance to Center (km)	878	3.23	34.34	0.00	800.00
You would Reduce Consumption?	882	2.68	0.60	1.00	3.00
Crisis	885	0.33	0.47	0.00	1.00
Raw FPs Subsistence	884	19.50	13.93	0.00	180.00
Socioeconomic Conditions	885	0.13	1.80	-3.94	5.96
Bolivia	885	0.03	0.18	0.00	1.00
Kenya	885	0.27	0.44	0.00	1.00
Mexico	885	0.00	0.00	0.00	0.00
Uganda	885	0.70	0.46	0.00	1.00
Community Forests					
Property Rights in Community Forest	506	7.42	5.48	0.00	21.00
Property Rights in Other Forests	519	2.19	5.38	0.00	42.00
Vegetation Community Forest	519	0.50	0.50	0.00	1.00
Comm Forest Subsistence	505	2.42	0.72	1.00	3.00
Time to Community Forest	515	43.18	36.59	0.00	300.00
Rules Fair?	519	0.52	0.50	0.00	1.00
Distance to Center (km)	519	8.76	47.29	0.00	500.00
You would Reduce Consumption?	516	2.51	0.72	1.00	3.00
Crisis	519	0.39	0.49	0.00	1.00
Raw FPs Subsistence	512	15.49	13.48	0.00	110.00
Socioeconomic Conditions	519	-0.37	1.57	-9.55	6.26
Bolivia	519	0.19	0.39	0.00	1.00
Kenya	519	0.20	0.40	0.00	1.00
Mexico	519	0.35	0.48	0.00	1.00
Uganda	519	0.27	0.44	0.00	1.00
Private Forests					
Property Rights in Private Forest	498	6.72	5.85	0.00	21.00
Property Rights in Other Forests	506	2.20	5.28	0.00	42.00
Vegetation Private Forest	506	0.17	0.37	0.00	1.00
Priv Forest Subsistence	500	2.29	0.70	1.00	3.00
Time to Private Forest	500	16.02	21.37	0.00	150.00
Rules Fair?	506	0.29	0.45	0.00	1.00
Distance to Center (km)	506	6.99	42.26	0.00	500.00
You would Reduce Consumption?	503	2.50	0.68	1.00	3.00
Crisis	506	0.36	0.48	0.00	1.00
Raw FPs Subsistence	501	20.39	14.64	0.00	180.00
Socioeconomic Conditions	506	-0.03	1.75	-3.94	6.11
Bolivia	506	0.22	0.42	0.00	1.00
Kenya	506	0.06	0.23	0.00	1.00
Mexico	506	0.02	0.15	0.00	1.00
Uganda	506	0.70	0.46	0.00	1.00

A separate variable was constructed using the property rights that the household has in all other types of forests. In principal if a household has full property rights in community and private forests they could have a value of 42 of other property rights (21 in each of the other two forest types). Indeed, three households claimed to have full property rights in each type of forest. The average property rights in other forests tend to be lower than the property rights for the forest in question (not all households have access to each type of forest).

The vegetation of the forest is the dependent, binary variable discussed before. On average, households tended to rate community forests more favorably then government or private forests. About 50 percent of household ranked community forests as dense, while only 30 percent of households ranked government forests as dense and only 17 percent of households ranked private forests as dense.

Forest-type subsistence is a ranking of the forest-type to the subsistence needs of the household as 1-not important, 2-somewhat important, or 3-very important. Time to the forest is an indicator of how long (in minutes) it takes the household to access the forest. Rule fairness relates to how the household perceives the rules, in general across all forest types, in terms of fairness. Rule fairness takes a value of 1 if the household respondent indicates that the rules are completely or more-or-less fair (as opposed to not fair). Distance to center is the distance, in kilometers to a central reference point in the nearest village (calculated from GPS coordinates). The variable for crisis binary and indicates if the household has experienced a severe crop failure, illness, death (and did not have the means to cope financially), land loss, or major livestock loss.

The variable for raw forest product subsistence is taken from an in-depth process of identifying various sources of household income (in-forest and out-of-forest). A household was

asked to rank their income from 11 different sources (e.g. raw forest products, processed products, fishing, wage income, agriculture). Once the household had ranked the importance of various sources of income, they were told to weight the sources of income by dividing 50 tokens on a chart indicating the various sources of income. The combination of tokens and rankings forms the basis of the ranking of forest subsistence. The maximum value that forest subsistence could take is 11×50=550 and the minimum is 1×0=0. The maximum in the sample however is 180. The higher the value of this variable, the larger the proportion of the individuals income is dependent on the forest.

The variable for socioeconomic conditions is an index of asset holdings of the household. A survey of 21 asset holdings was taken for each household and a composite index was formed by using principal components analysis (see Coleman and Andersson, 2010). This variable positively correlates with wealth.

5. Analysis

Table 2 reports the results from estimating Equation 1. Three models are reported in Table 2, one each for government, community, and private forests. Each logit model is estimated using probability sampling weights from the design of the household survey. First, forests communities were identified in each country and then the number of households was chosen from each community. The probability sampling weights take into account the fact that some communities were sampled at a greater intensity than others. Overall model significance results (Chi squared statistics) indicate the explanatory variables are jointly significantly distinguishable from zero at the 0.01 level.

Table 2.Logit Estimates for Forest Vegetative Conditions

	(1) Government	(2) Community	(3) Private
Property Rights in Government Forest	0.103***		
	(0.03)		
Property Rights in Other Forests	-0.011		
	(0.03)		
Disturbance in Govt Forest	-2.512***		
	(0.25)		
Govt Forest Subsistence	0.011		
	(0.12)		
Time to Government Forest	0.007**		
	(0.00)		
Property Rights in Community Forest		0.010	
		(0.02)	
Property Rights in Other Forests		-0.091**	
		(0.04)	
Disturbance in Comm Forest		-1.162***	
		(0.36)	
Comm Forest Subsistence		0.355*	
		(0.19)	
Time to Community Forest		-0.004	
		(0.00)	
Property Rights in Private Forest			-0.013
			(0.03)
Property Rights in Other Forests			0.005
			(0.03)
Disturbance in Priv Forest			-1.503***
			(0.51)
Priv Forest Subsistence			0.242
			(0.30)
Time to Private Forest			-0.015
			(0.01)
Rules Fair?	1.269***	0.817***	0.228
	(0.25)	(0.25)	(0.34)
Distance to Center (km)	-0.014	0.012*	0.004
	(0.02)	(0.01)	(0.00)
You would Reduce Consumption?	-0.080	0.125	0.406
	(0.21)	(0.16)	(0.28)
Crisis	0.315	0.548**	0.201
	(0.22)	(0.25)	(0.35)
Raw FPs Subsistence	-0.018**	-0.003	-0.012
	(0.01)	(0.01)	(0.01)
Socioeconomic Conditions	-0.005	-0.052	-0.023
	(0.06)	(0.07)	(0.11)
Bolivia	1.222*	0.120	2.657***
	(0.73)	(0.50)	(0.50)
Kenya	0.474	-0.785*	-1.423
	(0.30)	(0.42)	(0.99)
Mexico		0.144	1.248
		(0.42)	(1.58)
Constant	-0.154	-0.247	-2.528**
	(0.70)	(0.71)	(1.19)
Log-Likelihood	-42377.660	-28290.713	-13721.005
Chi 2	225.262***	38.358***	71.110***
McFadden R2	0.301	0.116	0.206
N	846	472	470

Notes: coefficients with standard errors in parentheses. Estimation utilized sampling weights in estimation. Two-tailed hypothesis tests: *p<0.10, **p<0.05, ***p<0.01.

To test Hypothesis 1 note that the effect of government property rights is positive and significantly different from 0 at the 0.01 level, holding all else constant. Hypothesis 2 implies that the effect of property rights in community forests is zero and the results indicate that we fail to reject this hypothesis. The effects of property rights in other forests negatively, and significantly (at the 0.05 level)affects the household's ranking of community forests. That is, if households have strong property rights in other forests they are less likely to rank community forests favorably. Contrary to expectations, however the effects of property rights in private forests are also zero.

The effect of having a disturbance in the past 10 years is significantly and negatively correlated with households' rankings of forest conditions, holding all else constant, for each forest type. This result is significant in each type of forest at the 0.01 level.

Rule fairness also appears to be an important determinant of forest conditions, at least in government forests. The remaining control variables do not have consistently significant results across the three models.

In order to more clearly examine the effects of property rights and disturbance on forest conditions, Figure 1 plots the predicted probability of having dense forest conditions as a function of both property rights and a disturbance. The upper-left panel of Figure 1 shows the predicted probability of having a dense forest depending on property rights and disturbance. When there is a disturbance, government forests are expected to have a very low probability (near 0) of having dense forest conditions, especially when there are very weak property rights. As property rights increase, however, the predicted probability of having dense forest conditions increases. At the point of full property rights the forest is expected to have about .25 probability

of having dense forest conditions. Thus, when there is a disturbance, property rights appear to significantly increase the likelihood of attaining dense forest conditions. A similar pattern holds for forests where there has been no disturbance, but in such forests the probability is relatively much higher at each level of property rights. The largely insignificant role of property rights as described in Table 2 is confirms in the remaining panels of Figure 1.

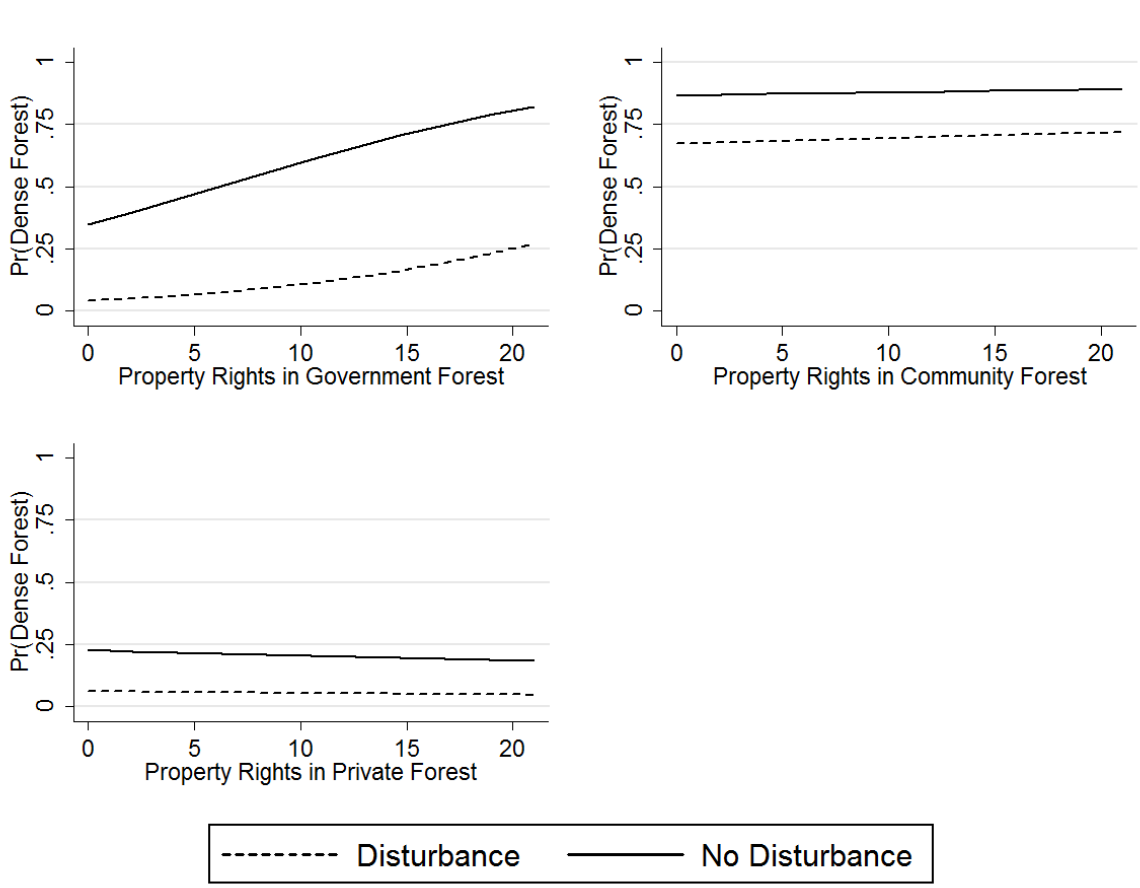

Figure 1.The probability of having a dense forest in government, community, and private forests, depending on property rights and the existence of a disturbance within last 10 years. Predicted probabilities estimated from the results reported in Table 2.

6. Conclusion

This paper has presented evidence that household property rights are important to increase the likelihood that household rank government forests as dense. The more complete property rights that a household has, the more likely they are to rank government forest favorably. The analysis did not find a similar result for community and private forests; that is, household property rights do not appear to significantly affect the household's ranking of forest conditions in these types of forests.

We also found that disturbances significantly reduce that probability that a household will rank any forest type favorably. However, at least in government forests, households with stronger property rights are more likely to rank forests favorably after a disturbance. These results add to the important, yet small, literature on property rights and adaptation to disturbance.

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