Common Property Rights, Adaptive Capacity, and Response to Forest Disturbance*

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Abstract

I analyze common property rights of forest user groups and assess how such rights interact with adaptive capacity to constrain or enhance the ability of communities to engender favorable outcomes. I delineate common property rights in terms of rights of access, withdrawal, management, exclusion, and alienation. Then, using statistical analysis of 326 forest user groups from 13 countries from the database of the International Forestry Resources and Institutions program, I show how forest users respond to disturbance based on the property rights they hold, their organizational capacity, and the presence of rival users. I find that the presence of rival groups significantly modifies the efficacy of particular bundles of property rights, while organizational capacity has a limited role in engendering desirable outcomes in response to disturbance.

Keywords: Property Rights, Adaptation, Forestry

1 Introduction

Forests play crucial roles both in the earth's climate system as well as in the rural livelihoods of many in less developed countries (Chhatre and Agrawal, 2009). Those who depend most heavily upon forest resources are likely to be the most vulnerable to the effects of climate change (Mendelsohn et al., 2007). There is still much uncertainty as to how the rural poor will adapt to the challenges of climate change in the future, although in the past many forest users have been able to adapt to disturbances and continue to manage long-enduring resource systems (Ostrom, 1990). It is impossible to investigate the effects of climate change which have not yet happened; however, examining past responses to major disturbances may provide insight into how forest users will respond to climate change induced disturbances in the future.

Groups of forest users are likely to alter their responses to disturbance depending on the institutions which constrain or enhance the set of possible decisions they can make. Thus, when considering local adaptation

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to disturbance one must carefully consider both ecological and institutional factors as well as their interplay (Young, 2002; Basurto and Coleman, Forthcoming). The nature and extent of the property rights which forest groups hold will provide incentives to adapt to disturbances in certain ways.

It is generally recognized that there are bundles of property rights associated with natural resources (Barzel, 1997; Schlager and Ostrom, 1992; McKean, 2000). These bundles of rights may be held in common, privately, by the state, or by nobody at all (open access) (McKean, 2000). In addition, different parties may hold different bundles of the property rights. For example, in many countries the residual claimant (the party to which all unspecified rights belong, see Coleman and Steed (2009)) of forest land is held by the state, while local communities may have property rights to appropriate timber or other forest products and outside tourists may hold rights of access to the forest. Thus, the property rights to the resource are dispersed over many different holders of those rights.

Despite the recognition that there are bundles of property rights associated with any given resource, there appears to still be a tendency for academics and policymakers to oversimplify resource ownership as wholly private, common, state, or open access (See McKean, 2000). Virulent debates have emerged to argue that one ownership type is superior to all others (See Ostrom, 1990; Ostrom et al., 2007), but little research has examined what stakeholders are best able to exercise which bundles of rights to achieve environmentally sustainable outcomes.[1]

Schlager and Ostrom (1992) identify and classify property rights and distinguish the diverse bundles of rights of natural resources. They classify property rights holders into four categories: authorized users who have rights of access and withdrawal; claimants who have rights to manage the resource; proprietors who have rights to exclude others from using the resource; and owners who have rights of alienation—they can divest themselves of the resource. The rights associated with the resource should not be confused with the type of rights holder. Individuals, national governments, or groups of forest users may be authorized users, claimants, proprietors, or owners. Schlager and Ostrom (1992) argue that if property rights holders have bundles of rights approaching full ownership rather than mere access, they will be more likely to invest in the resource. For example, owners of forest land will be more likely to invest in efforts to monitor the use of the forest than authorized users.

The investment decision of property rights holders with different bundles of rights has not been thoroughly investigated empirically. Some evidence suggests that full ownership is not necessary to achieve sustainable outcomes, but that some rights of access and withdrawal are important (Coleman, 2009). Other work shows

[1] Although recent research has examined the relative effectiveness of vesting full ownership rights to private individuals, user groups, or states (Hayes and Ostrom, 2005; Ostrom and Nagendra, 2006; Coleman, 2009; Chhatre and Agrawal, 2009). This literature largely concludes that no single owner is significantly more likely to sustainably manage forests, although Chhatre and Agrawal (2009) find that local users with ownership rights are more likely to have more forest biomass than national governments or private individuals.

that when groups of forest users are given rights to withdraw forest resources they are more likely to make investments to monitor and sanction other forest users, while government owners are less likely to do so (Coleman and Steed, 2009). This paper adds to this literature by investigating in finer detail the full range of property rights that might be given to local forest user groups and how forest users respond to ecological disturbances when they hold different bundles of property rights.

2 Forest Property Rights

2.1 Incentives of Property Rights

Common property rights in forests are given to user groups. "A user group is a group of people who harvest from, use, and/or maintain one or more forests and who share the same rights and duties to products from the forest(s), even though they may or may not be formally organized (International Forestry Resources and Institutions, 2008, p.III.A.5-1)." User groups hold common property rights; a group of people jointly hold some subset of the bundle of rights. Such arrangements are quite common in many parts of the world (Agrawal et al., 2008) and are often effective institutional arrangements for the sustainable management of forests (Chhatre and Agrawal, 2009).

Schlager and Ostrom (1992) provide a typology of property rights which is presented in Table 1. Table 1 lists four types of property rights associated with forests and the relative strength of incentives each right provides in the investment decisions of the rights holders. It is important to note that investments here are broadly termed; an investment is any action which delays consumption of forest products. Examples of investments include the following: time spent creating, implementing, or enforcing rules (Coleman and Steed, 2009); physical investments in the forest such as fencing, planting seedlings, or other maintenance activities (Coleman et al., 2009); and delaying harvesting so that greater harvests might be made in the future (Tietenberg, 2000).

The most prevalent property rights in forestry relate to rights of access (the right to enter a defined

Table 1: Bundles of Rights and Property Rights Holder Designation

Property Right	Property Right Holder	Incentives to Invest
Access and Withdrawal	Authorized User	Weak
Management	Claimant	Somewhat Weak
Exclusion	Proprietor	Somewhat Strong
Alienation	Owner	Strong

Source: Adapted from Schlager and Ostrom (1992).

physical property) and withdrawal (the right to obtain forest products). Those who hold only rights of access and withdrawal are termed "authorized users" by Schlager and Ostrom, and are hypothesized to have weak incentives to invest in the forest or limit harvesting effort. They have no rights to make rules about forest use; authorized users who make forest investments are dependent on the rights that others may exercise to expropriate their investments.

Forest users with rights of management (to regulate internal forest use and choose priorities over uses) are termed claimants. Claimants have somewhat weak incentives to invest in the resource because without rights of exclusion they are not guaranteed to benefit from such investments. On the other hand claimants may still invest in the resource if no other groups are interested in these resources or if the resource is physically isolated from others.

Those with rights to exclude others from the forest (i.e. to decide who will have access and withdrawal rights) can realize the benefits of the investments they make in the forest. Such users are termed proprieties. Proprieties are hypothesized to have somewhat strong incentives to invest in the forest as they can realize the direct benefits from their investments and exclude others from them.

Many authors have argued that the right to alienation (the right to sell or lease any of the aforementioned rights) is the crucial characteristic of property rights (Schlager and Ostrom, 1992; Arnason, 2005; Scott, 2008). When owners are allowed to sell their rights and realize the benefits of long-term investments they can potentially realize the full benefits from those investments. While proprietors have the right to realize the direct investment themselves, owners have rights to sell those benefits to those that value them the most and receive the largest possible benefits from investment. Thus, full ownership is hypothesized to give the largest incentive to invest in the resource.[2]

2.2 Adaptive Capacity

Climate change models suggest that the rural poor and those most dependent on forest resources are likely those to become extremely vulnerable to the adverse effects of climate change (Agrawal, 2010). Climate change is expected to increase the volatility of weather patterns and engender more frequent extreme weather events such as fires and floods (Stern, 2007). Forest dependent people that live just above subsistence are sensitive to such disturbances. This increased vulnerability to disturbance in turn raises the uncertainty of realizing the future gains from investment decisions. For example, if fires frequently destroy forest assets then risk averse forest users may be much less likely to make investments in those assets.

Most research on climate change adaptation stresses the role of technology (such as providing information

[2] It is important to note that if the rate of returns from investments are not sufficient or if owners have particularly high discount rates then even those with full ownership rights still may not invest in the resource.

on weather forecasts or early warning systems, (see Stern, 2007, ch.18)) to respond to such disturbances and largely ignores the role of social institutions such as property rights (Agrawal, 2010). While technological interventions may benefit those producing and providing such technology, creating robust institutional conditions may simultaneously improve adaptive capacity as well as benefit the forest-dependent poor. Other policy advise focuses on national-level policies such as integrating climate change impact models into national policymaking and the creation of national climate change ministries for coordination and planning (Stern, 2007, ch.20). What little policy advise there is that focuses on local social institutions is largely confined to variables that are not easily influenced by direct policy intervention, such as increasing the resilience of livelihoods and infrastructure, improved governance, and community empowerment (Stern, 2007, ch.20). Unfortunately, less emphasis has been placed on analyzing local property rights which are more directly amenable to policy change (Agrawal, 2010).

A user groups' property rights bundle endowment modifies their ability to respond to disturbance. There is a relative paucity of research on such intuitions, which is alarming given the central role of local institutions in adapting to climate change (Agrawal, 2010). This paper seeks to fill this gap by providing a comparative empirical analysis of different property rights bundle endowments on the ability of forest user groups to adapt to external disturbance through changes in investment activities.

Much social scientific research has examined the concept of adaptive capacity and has tried to measure the different components of such capacity (Eakin and Lemos, 2006; Engle and Lemos, 2010). So far, however, research focused on empirically estimating the effects of adaptive capacity, with special emphasis on the local institutional components of adaptive capacity, remains largely unexamined.

Engle and Lemos (2010, p.7) review the literature on adaptive capacity and argue that the the concept has 7 basic underlying determinants: human capital, information, material resources, organizational/social capital, political capital, wealth/financial capital, and institutions. The authors acknowledge the tradeoffs among various determinants, especially given the limited resources that local users have to invest in the portfolio of possible capacities. However, beyond the simple tradeoffs of investment in each determinant of adaptive capacity, there may be real tradeoffs in terms of each determinant's ability to modify the effectiveness of other determinants. For example, strong knowledge without material resources to act upon that knowledge may not produce a desirable result. In other words, it is not only important to consider how the overall level of each determinant is effected by a limited budget, but to also consider that different configurations of adaptive capacity may be more effective at engendering resilient responses to disturbance than other configurations.

It is also important to consider that while adaptive capacity is not entirely determined by exposure to disturbance and other biophysical factors (Ribot, 2010), such factors are nonetheless a key component of any environmental decision (Ostrom, 2005). In other words, both social factors as well as biophysical factors are important for determining environmental outcomes (Young, 2002; Basurto and Coleman, Forthcoming) and adaptive capacity. Thus, measures of adaptive capacity should consider both types of factors. The relative importance of biophysical or social determinants of adaptive capacity remains an empirical question.

2.3 Property Rights, Rival Users, and Organizational Capacity

The purpose of this paper is not to give a complete profile of adaptive capacity of forest user groups. Rather, the purpose is to examine a subset of social factors that have been linked to adaptive capacity and to assess how such factors modify the effects of an important policy variable, property rights. I examine one of the determinants of adaptive capacity from Engle and Lemos (2010): organizational/social capital. Social capital has long been linked to successful resource governance (Ostrom, 1999). I am particularly interested in organizational capacity within activities undertaken in the forest. If a user group has cooperated in the past to collectively monitor each other, for example, it might be much more likely to respond to disturbance collectively.

To examine the effects of biophysical factors I examine the presence of rival users in the forest. If there are multiple user groups that compete for forest products it will probably be difficult for any one user group to successfully act collectively and respond favorably to disturbance, given that other user groups can disregard this behavior and still respond unfavorably. The presence of rival users is a biophysical and social factor because it directly emphasizes the isolation of a user groups to other users which depends both on the spatial distribution of users as well as patterns of human activity.

My primary interest is to examine the role of property rights and to assess how organizational capacity and the presence of rival users change the incentives to respond to a disturbance. The hypothesized relationships between rival users, organizational capacity, and different property rights are presented in Table 2. The signs in the table represent hypothesized relationships of each variable on forest conditions after a disturbance. For example, the $-$ in the upper-left cell between management rights and rival users implies the following hypothesis: as the number of rival users increase for groups with management rights, forest conditions will worsen.

First consider the effects of different property rights bundles as the number of rival users increase. Those with management rights may create rules that limit harvesting in the absence of rival groups, but as the number of rival groups increases the rules which they create can only be enforced on their group, and not on rival groups, so they will be less effective. The rights of exclusion, on the other hand, will be most effective in situations where there are rival user groups to exclude. The effects of exclusion rights will be the most pronounced in forests where there are many rival groups. Alienation rights are expected to have a negative impact on forest conditions when there are rivals. User groups may find it more profitable not to reinvest in a forest that has just experienced a disturbance, or may have no immediate political obligations to do so. User groups with exclusion rights may be required by law to meet forest management objectives, while groups with alienation rights can make decisions that leave the forest in a poor condition without accountability to others.

Table 2: Hypothesized effects on forest conditions in response to disturbance

	Rival Users	Organizational Capacity
Management Rights	−	+
Exclusion Rights	+	−
Alienation Rights	−	−

Next consider the effects of different property rights bundles as the organizational capacity of the user group increases. User groups with management rights and high organizational capacity are better able to design and implement rules for the forest than groups with low organizational capacity. On the other hand, if such groups have the ability to exclude others from the benefits to be gained from organization, then they may be more likely to mobilize the organizational capacity to harvest the forest. If user groups possess alienation rights, they may be effectively able to mobilize and find buyers or renters for forest products and thus continue harvests after a disturbance.

Thus, the relationship between different types of adaptive capacity, and their interaction, may theoretically constrain or enhance the ability of property rights to achieve sustainable forest outcomes. Again, in this paper I do not consider the full range of adaptive capacities, but instead show that even among a subset of those capacities, policies implementing different bundles of property rights might be expected to have vastly different outcomes depending upon different levels of adaptive capacity.

3 Data Analysis

To investigate the hypotheses outline in Table 2, I analyze data from 326 user groups from forests in 13 countries around the world. Table 3 presents the distribution of user groups across countries for the data used in this analysis.[3] The data is collected from the International Forestry Resources and Institutions

[3]These data do not represent a random sample of all forests in the world or even in the given countries; it is difficult to imagine a process for such sampling. However, none of the sampled user groups were chosen on the basis of the outcomes analyzed in this paper, so the inferences here can be generalized to user groups with similar ranges of the independent variables (See Coleman, 2009)

Table 3: Distribution of User Groups by Country

	Frequency	Percent	Cumulative Percent
BHU	2	0.61	0.61
BOL	18	5.52	6.13
BRA	4	1.23	7.36
GUA	12	3.68	11.04
HON	5	1.53	12.58
IND	59	18.10	30.67
KEN	37	11.35	42.02
MAD	23	7.06	49.08
MEX	18	5.52	54.60
NEP	66	20.25	74.85
TAN	12	3.68	78.53
THA	1	0.31	78.83
UGA	69	21.17	100.00
Total	326	100.00	

Notes: Data from (International Forestry Resources and Institutions, 2008).

(IFRI) program (see Section 5 for details on the dataset and coded variables).[4]

The IFRI program is an effort by a worldwide network of colleagues to analyze forestry and the local user groups which access the forests. IFRI researchers use a standard instrument to collect data; this data is then compiled into a worldwide dataset. Data is collected both on forest biophysical characteristics (through forest mensuration techniques) and on the institutional and socioeconomic characteristics of forest users (through ethnographic techniques). Thus, the data represent a consistent way to analyze forest users management practices as well as the biophysical outcomes which result from such practices (Coleman, 2009). IFRI presents a unique opportunity to analyze forest commons with cross national data (Ostrom and Nagendra, 2006; Chhatre and Agrawal, 2009; Coleman, 2009; Coleman and Steed, 2009).

3.1 Description of Data

A subset of the data collected through IFRI is used in this paper.[5] Table 4 reports the data, divided into four categories of variables: the dependent variable which measures forest outcomes, variables which measure the bundle of property rights with which a particular forest user groups has been endowed, measures of adaptive capacity, and and a set of control variables including a variable indicating disturbance.

The outcome variable is a subjective measure of forest conditions as assessed by the user group. It is

[4]See International Forestry Resources and Institutions (2008) for a discussion of the data collection process and Gibson et al. (2000) for an introduction to IFRI analysis.

[5]Data for most user groups were included, but observations for which there was missing variables was eliminated. Approximately 75 observations were eliminated by listwise deletion because of missingness. Data from U.S. sites were not included, nor were data from leasehold forests in Nepal, for which there are serious reverse causality problems because property right were given to local communities in leasehold forest precisely because they had historically been mismanaged and were had poor ecological conditions.

Table 4: Summary Statistics

	N	Mean	Std.Dev.	Min	Max
Outcome					
Forest Conditions	326	0.36	0.48	0.00	1.00
Property Rights					
Management Rights	326	0.41	0.49	0.00	1.00
Exclusion Rights	326	0.29	0.46	0.00	1.00
Alienation Rights	326	0.06	0.23	0.00	1.00
Adaptive Capacity					
Organizational Capacity	326	3.00	1.44	1.00	5.00
Number of Other User Groups	326	1.30	1.53	0.00	5.00
ln(Distance)	326	0.77	0.56	0.00	2.83
Control Variables					
Tree Density Decrease	326	0.53	0.50	0.00	1.00
ln(Scarcity)	326	−1.65	2.32	−7.20	4.22
ln(Forest Size)	326	5.88	1.94	−0.11	10.03
Forest Subsistence	326	0.76	0.37	0.00	1.00
Conservation/Aesthetic Objectives	326	0.05	0.22	0.00	1.00

Notes: Data from (International Forestry Resources and Institutions, 2008).

dichotomized to indicate if forest conditions are better for ecologically similar forests in the region (=1); or if they are worse (=0).

Also included in Table 4 are various measures of the bundle of property rights which the user group enjoys. Rights of access and withdrawal are not included as all user groups coded in the IFRI database have such rights. As part of the coding process for IFRI forms, user groups must be able to at least access the forest. Rights of management indicate that the user group has relative autonomy to make and enforce rules within the forest, and 41% of user groups have such rights. Exclusion rights indicate that only one user group can make rules and thus exclude others and about 29% of user groups have these rights. Alienation rights refer to rights to sell or lease the aforementioned rights. Only 6% of user groups possess alienation rights; these are private forest owners or indigenous groups that have exclusive rights to a forest. As in Schlager and Ostrom (1992) these rights are nested; that is, those with alienation rights possess exclusion and management rights. The variables in this analysis are coded as such. The effects of alienation rights, for example, should be interpreted as the effects of having rights to alienation in addition to the rights of management and exclusion.

As hypothesized in Table 2, the affects of property rights are attenuated by the number of potential rival claimants to those rights and the organizational capacity of the user group. The maximum number of rival groups is 5 in any given forest and for some forests there are no other rival groups.[6] Another variable is also included to measure the potential impacts of rivalry and that is the (natural logarithm of) distance to the

[6] Table 6 in the Appendix shows the distribution of other user groups. The most frequent number of other user groups is 0 (about 41% of user groups in the sample are the sole user group in the forest). However, for more than 50% of the user groups there is at least one other user group in the forest.

closest market (in kilometers). Even if user groups are not currently using the forest, the distance to market is a proxy variable indicating the possibility that latent groups could challenge the property rights of the user group. I analyze this variable to confirm the results of the effects of groups which are already formed.

The organizational capacity of the user group is taken from an index of activities that the user group engages in. Four measures are used to assess organizational capacity: the frequency with which the group cooperates to harvest forest products, to monitor and sanction forest users, and to engage in forest maintenance activities. Each of these variable is on a scale of $1 - 4$, where 1 indicates the group never cooperates on such activities; 2 indicates they cooperate "occasionally"; 3 indicates they cooperate "seasonally"; and 4 indicates they cooperate "year round." The fourth variable is a binary indicator of whether the group has had a disruptive conflict in the last two years which disrupted normal activities. I examined two methods to construct the index, ultimately choosing the second method. First a simple additive index was examined, but there is some concern that such an index does not adequately weight different aspects of organizational capacity. Instead, I use an index based upon a principle components analysis of the four indicators. The scores from the first principle component are used as the index (the first principle component explains 49% of the variation among the four variables). The principle component scores were then divided into quintiles to facilitate interpretation—the first qunitile is composed of those user groups that have the lowest 20% of organizational capacity, while the fifth quintile is composed of those user groups that have the highest 20% of organizational capacity.[7]

The measure of disturbance is an indicator if there was a significant decrease in tree density in the past 5 years. The reasons for such a decrease ranged from exogenous natural disturbances (such as fire, flooding, or wind damage), to exogenous institutional change (encroachment on the forest from other groups, roads, or market access for forest products), to endogenous user group behavior (over-harvesting) or some combination of all three. In the majority (56%) of cases tree density decreases are attributed solely by exogenous change. While it would be helpful to separate purely exogenous change from endogenous change this is difficult because both processes often act simultaneously; thus for this analysis I look at all disturbances that decrease tree density.

A number of other control variables are also included in the analysis. Scarcity is measured by (the natural logarithm of) the number of households per forest hectare. If there is much pressure on the forest then forest users may be less able to act collectively to respond to disturbance (See Coleman et al., 2009). Forest size is measured by the (natural logarithm of) forested hectares and presents a scale effect. Those in large forests may have more valuable assets and thus more incentive to adapt to changes (Chhatre and Agrawal, 2009). Forest subsistence is measured by the proportion of households in the user group that rely on the forest for

[7]More detail on the principal components analysis is available from the author upon request.

subsistence and ranges 0 to 1. This is an especially important control because it severely limits how much user groups can restrain from harvesting if the costs of doing so are extremely high for a large proportion of the group. High subsistence user groups may not be able to limit harvesting in the forest if doing so would endanger many of its households from subsisting. On the other hand low subsistence groups may be able to delay harvesting while the forest recovers from the disturbance event. A control variable is also included to indicate the type of forest. If the forest is a nature preserve or sacred forest there may be more of a norm to restrain from harvesting after a disturbance and such a designation may provoke proactive measures to ensure good forest conditions, such as more careful monitoring of the forest to ensure that sacred elements of the forest are not removed. (Coleman and Steed, 2009).[8]

3.2 Estimation and Inference

To investigate the effects of property rights institutions on adaptation strategies, logit regressions were run where the dependent variable is a binary variable indicating the conditions of the forest as ranked by the user group, either above (=1) or below (=0) average for similar forests. This outcome was regressed on the property rights, adaptive capacity, and control variables described in Table 4. These results are reported in the first column of Table 5. Estimated logit coefficients and robust standard errors are reported.

Column 1 indicates that differences in common property rights do not significantly explain forest conditions. This finding is contrary to the hypothesized relationships in Schlager and Ostrom (1992) and outlined in Table 1.[9] That is, the bundles of specific property rights do not explain forest conditions in response to disturbance unconditional on other factors. A more nuanced theory of property rights as hypothesized in Table 2 is needed to explain these results. The first column of Table 5 does show that user groups are less likely to rank their forest as having above average conditions when there has been a disturbance in the past 5 years. As for adaptive capacity, organizational capacity is not a significant predictor of outcomes, although user groups are less likely to rank forests as above average as the number of rival groups increases.

Columns 2, 3, and 4 in Table 5 are used to test the hypotheses of Table 2. The second column interacts the variable indicating the number of other user groups with the property rights bundles. After conditioning on the number of rival groups, property rights become a significant predictor of the user group's ranking of forest conditions. The first thing to note is that the coefficient next to the specific property rights bundle indicates the effect of property rights when there are no rival user groups. When there are no rivals, user

[8]A number of other control variables were included at various stages of the analysis such as: the commercial value of the forest and ease of monitoring. These controls were generally insignificant and the results reported here are robust to their inclusion. These results are available from the author upon request.

[9]In fact, the sign of the effects of alienation rights is opposite than expected, implying groups with alienation rights are less likely to rank forest conditions as above average (although not significant).

Table 5: Logit Estimates of Forest Conditions

	Types of Interactions			
	(1) None	(2) Property Rights	(3) Organizational Capacity	(4) Distance
Management Rights	0.376	2.257**	−0.718	−1.250*
	(0.39)	(0.96)	(1.20)	(0.69)
Exclusion Rights	0.114	−2.044**	2.084	0.606
	(0.47)	(0.97)	(1.49)	(0.76)
Alienation Rights	−0.254	−0.127	0.362	1.498
	(0.59)	(0.79)	(1.42)	(1.04)
Management Rights X Number of Other User Groups		−0.826**		
		(0.41)		
Exclusion Rights X Number of Other User Groups		1.815***		
		(0.63)		
Alienation Rights X Number of Other User Groups		−0.687		
		(0.71)		
Management Rights X Organizational Capacity			0.304	
			(0.35)	
Exclusion Rights X Organizational Capacity			−0.544	
			(0.40)	
Alienation Rights X Organizational Capacity			−0.200	
			(0.38)	
Management Rights X ln(Distance)				1.767***
				(0.60)
Exclusion Rights X ln(Distance)				−0.051
				(0.61)
Alienation Rights X ln(Distance)				−2.924**
				(1.35)
Tree Density Decrease	−0.667**	−0.851***	−0.689**	−0.672**
	(0.27)	(0.28)	(0.28)	(0.27)
Organizational Capacity	−0.047	−0.065	0.010	−0.038
	(0.10)	(0.10)	(0.12)	(0.10)
Number of Other User Groups	−0.208*	−0.172	−0.188*	−0.152
	(0.11)	(0.12)	(0.11)	(0.11)
ln(Distance)	−0.096	−0.293	−0.087	−0.954**
	(0.25)	(0.28)	(0.25)	(0.40)
ln(Scarcity)	−0.173*	−0.138	−0.173*	−0.150
	(0.09)	(0.10)	(0.10)	(0.10)
ln(Forest Size)	−0.137	−0.138	−0.143	−0.109
	(0.11)	(0.12)	(0.11)	(0.12)
Forest Subsistence	0.501	0.718*	0.483	0.663*
	(0.36)	(0.38)	(0.37)	(0.39)
Conservation/Aesthetic Objectives	0.435	0.406	0.419	0.511
	(0.52)	(0.52)	(0.53)	(0.54)
Constant	0.152	0.281	0.041	0.402
	(0.67)	(0.73)	(0.71)	(0.70)
Log-Likelihood	−201.090	−194.748	−199.344	−193.447
AIC	426.180	419.495	428.689	416.894
BIC	471.623	476.299	485.492	473.698
χ^2	23.216**	29.921***	27.243**	37.953***
N	326	326	326	326

Notes: Robust standard errors in parentheses. Two-tailed hypothesis tests: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

groups with management rights are more likely to rank the quality of the forest as above average, holding all else constant (significant at the 0.05 level), while user groups with exclusion rights are less likely to rank the forest as above average, holding all else constant (significant at the 0.05 level). However, as the number of rivals increase, the effects of management rights decreases (significant at the 0.05 level) , while the effects of exclusion rights increase (significant at the 0.01 level) holding all else constant. The effects of alienation rights are not significantly moderated by the number of other user groups, but the anticipated effects of management rights and exclusion rights in Table 2 are confirmed by the analysis.

The third column in Table 5 examines the interaction of property rights with organizational capacity. These hypotheses are rejected by the data analysis; there does not appear to be a significant relationship between organizational capacity and forest conditions, despite the types of property rights which the user group has.

To ensure that the analysis of column 2 is robust a different measure of rival groups was also employed. The distance to market is a proxy for any latent groups that could potentially challenge property rights holders in the forest. Given the hypotheses of Table 2 I expect that as the distance to the nearest market increases the potential for rival groups decreases. Thus, as distance increases management rights should become more important, but exclusion rights should become less important, while alienation rights should also become more important. The results in Column 3 suggest that if the distance to the nearest market is 1 kilometer (ln(0)=1), then management rights negatively effect the propensity of the user group to rank the forest as above average. However, as the distance to markets grows, management rights are associated with a high probability of ranking the forest in above average conditions, holding all else constant (significant at the 0.01 level). On the other hand, exclusion rights are more important when the user group is close to a market, but less so the farther away the group is from the market. User groups with exclusion rights are less likely to rank the forest as being above average, the farther they are located from a market, holding all else constant (significant at the 0.05 level).

3.3 Analysis

The specific research question of this paper relates to how user groups rank forest conditions after a disturbance, conditional on their property rights, organizational capacity, and the number of rival groups. Inferences should be made conditional on there being a disturbance in the forest. The estimation results outlined in the previous section are analyzed in this section conditional on a disturbance and given the interactions previously discussed. This can be best done by a visual inspection of the predicted probabilities from the interaction models estimated and reported in Table 5.

Figure 1 reports the estimated effects of property rights conditioning on there being a disturbance in the past five year (Tree Density Decrease=1). Predicted probabilities are examined based upon the estimated effects of property rights, the number of other user groups, organizational capacity, and the distance to market as well as each variable's interaction with property rights. The plots are derived from the estimates given in Columns 2, 3, and 4 of Table 5.

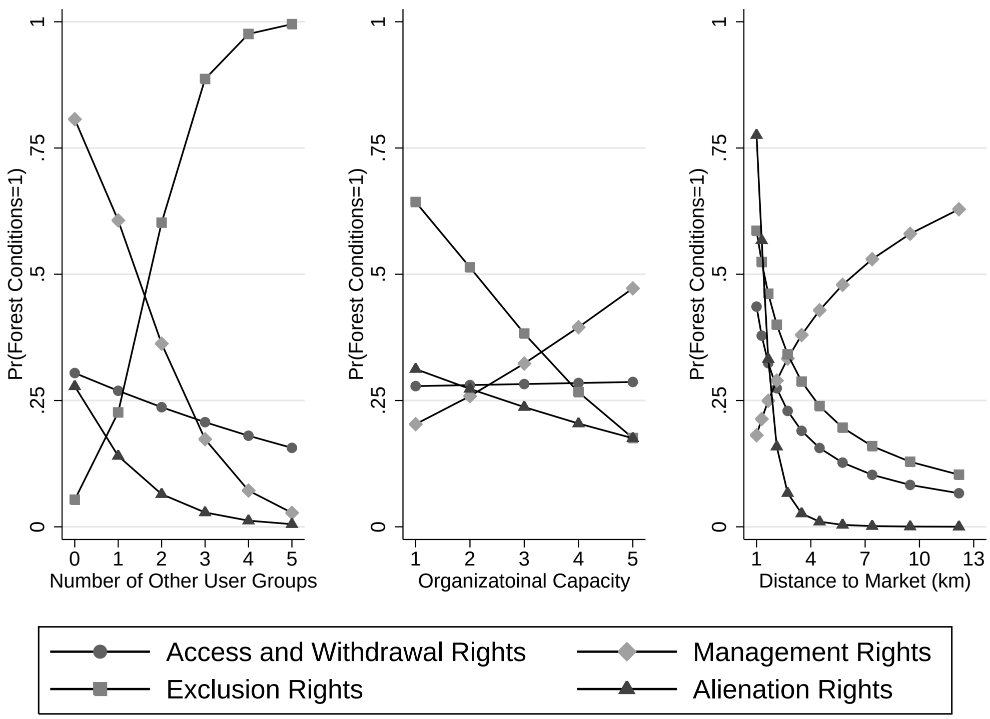

Figure 1: Predicted Probabilities of the user group ranking the forest as above average for different bundles of property rights. The three panels show the predicted probability that the use group ranks the forest as above average depending on the property rights when interacting property rights with the number of rival groups (left panel), organizational capacity (middle panel), and the distance to market (right panel). Predicted probabilities are calculated from the estimates of Columns 2, 3, and 4 of table 5 and after conditioning on a disturbance (Tree Density Decrease=1) and holding all other variables at their median.

The figures reinforce the interpretation of Table 5 from the previous section. I here focus specifically on management and exclusion rights and their interactions with the factors which measure adaptive capacity. The left panel in Figure 1 shows that when there are few rivals user groups with management rights are likely to rank the condition of the forest as above average, while the additional benefit of having exclusion rights does not significantly increase the probability of ranking the forest conditions as above average. However, as there are more rival user groups, exclusion rights become more important than management rights, so that by the point when there are 5 rival groups those with exclusion rights are very likely to rank the value of the forest as above average.

The middle panel reinforces that there is not a consistent story on the interrelationship between organizational capacity and property rights. There is no clear evidence that those with high organizational capacity are more likely to rank the forest as above average, nor that this relationship is somehow modified by the user group's bundle of property rights.

The right panel shows the relationship between distance to market, property rights, and the probability of ranking forest conditions above average. More isolated user groups (those further from markets and latent user groups) are more likely to experience the benefits of management rights, while less isolated user groups are more likely to experience the additional benefits of exclusion rights. Management rights for user groups near markets are not sufficient to prevent the user group from ranking the forest as below average.

Their is surprisingly weak evidence for the effects of alienation rights. User groups with alienation rights appear no more or less likely to rank the forest as above average than those with simply access and withdrawal rights, regardless of organizational capacity or the potential of rival groups to threaten those rights. The strong effects of exclusion may be because absent alienation rights the user group is "tied to the forest." With no prospects of divesting itself from the resource the group is forced to adapt to the disturbance rather than let another entity do so. After disturbance a user group with alienation rights, however can decide it is better off selling the asset to provide short-term income rather than reinvest.

Another reason for the strong effects of exclusion rights rather than pure alienation rights is the role of liability. Suppose that the state or a private entity is the owner of the forest and leases exclusion rights to the user group. They may be liable for any damages done to the forest and thus have an incentive to invest resources in the face of disturbance. However, if the user group is the owner of the forest (i.e. it holds alienation rights) then it may be disinclined to make investments in the face of disturbance if the group has other priorities.

Exclusion rights are the most powerful when there are more rival user groups. If there are multiple user groups in a forest and one of the user groups has rights of alienation, then other groups may decide to risk harvesting resources (perhaps contrary to established rules) before the asset is sold. If the user groups with rights of alienation anticipates this they will be hesitant to invest in the resource. However, if the user group only has exclusion rights there is no prospect to divest itself of the resource; thus, other user groups do not have an incentive for risky harvesting because the asset cannot be sold.

4 Discussion

Following the theoretical framework of (Schlager and Ostrom, 1992), I have explored the effects of different property rights bundles on the propensity of forest user groups to make investments when faced with disturbance. A number of important findings emerged. First, it appears that full ownership rights need not be given to user groups in order to increase the probability that users will rank the condition of the forest as above normal after a disturbance. Second, exclusion rights appear to be strongly associated with the user group's ranking of the forest when there are rival groups, but when there are no such groups that management rights can lead to a greater propensity to rank the forest above average. Third, the effects of property rights are the most pronounced in situations where there are rival users who might challenge those property rights, but do not seem to depend on the organizational capacity of the users.

These findings have implications for the way scholars treat the concepts of adaptation. This research strongly suggests that social measures of adaptive capacity may not capture important interactions between policy and adaptive capacity. If the analysis would have been confined to only organizational capacity as a potential mediating factor for property rights one might conclude that property rights are unimportant in determining outcomes after a disturbance. In this paper I have not addressed a comprehensive measure of adaptive capacity, but I have shown that biophysical determinants of adaptive capacity have an important role to play in our understanding of policy interventions that promote adaptation to disturbance.

These results also suggest that forest conditions are likely to deteriorate with an external disturbance. This finding suggests a positive feedback loop between deforestation and disturbance. Once a disturbance is felt local forest users may fail to adapt to these circumstances by harvesting less; this in turn will increase carbon emissions and increase the probability of future disturbances from climate change. This should be particularly troubling to climate change modelers and policy analysts of climate change. However, a potential tool has been identified for addressing this problem: giving exclusion rights to forest users when there are other rival groups and giving management rights when there are no rivals can engender adaptation in the face of disturbance. However, giving full alienation rights to user groups is not shown to affect the group's subjective rankings of the forest. This may imply that alienation rights will not prevent deforestation and that they may actually exacerbate the positive feedback loop.

5 Materials and Methods

The data for the analysis is taken from the IFRI training manual (International Forestry Resources and Institutions, 2008). Statistical analysis was conducted in Stata 11. Data files and Stata do file code is available from the author upon request.

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Appendix

Table 6: Distribution of Other User Groups

	Frequency	Percent	Cumulative Percent
0	150	46.01	46.01
1	58	17.79	63.80
2	41	12.58	76.38
3	35	10.74	87.12
4	30	9.20	96.32
5	12	3.68	100.00
Total	326	100.00	

Notes: Data from (International Forestry Resources and Institutions, 2008).