Informal Institutions and Enforcement of Forest Rules

Forrest Fleischman
POLS Y673: Networks and Institutions
April 22, 2009

Informal Institutions and Enforcement of Forest Rules

by Forrest Fleischman

CONTENTS

1. Introduction

Research on the management of common-pool resources (CPR) has identified numerous conditions that may contribute to effective long-term management (Wade 1988; Ostrom 1990; Baland and Platteau 1996; Agrawal 2001; Dietz, Ostrom et al. 2003). Recent analyses of a large database on forest management have found that the existence of monitoring of resource use and sanctioning of rule violations has a strong correlation with improved forest condition (Gibson, Williams et al. 2005; Ostrom and Nagendra 2006; Coleman 2009), lending support to the proposition that monitoring and sanctioning, or as Gibson et al. refer to it, rule enforcement, plays a crucial role in the successful governance of CPRs such as forests. Little is known about why some forests have rules that are well enforced, and others do not. This paper attempts to increase our understanding of enforcement by examining the role of informal and formal institutions in monitoring and sanctioning. Although the focus is on forest management, this research has implications for a much broader array of social phenomena, as rule enforcement is fundamental to sustaining productive orders. At an analytic level, this paper forwards the agenda of studying linked social-ecological systems (SES) by explicitly analyzing forest rule enforcement as a relational phenomenon.

1.1 Formal Institutions and CPR management

Early theoretical models of CPR utilization (Gordon 1954; Hardin 1968) emphasized the role of property rules in the management of CPRs. Hardin predicted that unless resources were strict private property or were tightly controlled by the state they would inevitably be overexploited. Empirical work has shown, however, that many systems of common property ownership are successful at conserving common-pool resources (Feeny, Berkes et al. 1990; Ostrom 1990; Ostrom, Burger et al. 1999; Dietz, Ostrom et al. 2003), and more recent analyses of forest management data from the International Forestry Resources and Institutions (IFRI) program (Wollenberg, Merino et al. 2007) have found no correlation between resource conditions and formal designations, such as protected versus unprotected, or common versus state versus private (Gibson, Williams et al. 2005; Hayes 2006; Ostrom and Nagendra 2006; Coleman 2009). Ostrom (2007) suggests that there are no simple or reliable solutions for CPR governance that apply to all or even most situations.

Monitoring and sanctioning has been posited to play a crucial role in the successful management of CPRs in theoretical works (Wade 1988; Ostrom 1990; Baland and Platteau 1996; Agrawal 2001; Dietz, Ostrom et al. 2003), and Gibson et al. (2005) found the relationship between rule enforcement and forest condition to be so strong that they posited that monitoring and sanctioning may be a necessary (but not sufficient) condition for successful CPR management. Chhatre and Agrawal (2008)have found similar results using a more complex model that controlled for factors such as pre-existing forest condition. In spite of the apparent importance of monitoring and sanctioning in CPR management, there are relatively few theoretical or empirical investigations of why some groups are more capable of monitoring and sanctioning. Research in behavioral economics has shown a willingness on the part of humans to invest in costly sanctioning, leading Henrich, McElreath et al. (2006) to suggest that, "a willingness to engage in costly punishment, even in one-shot situations, may be part of human psychology and a key element in understanding our sociality." If this willingness exists, what factors might lead it to vary?

Gibson et al. suggested that rule enforcement was conducted by local user groups, however the data they rely on use a very broad definition of user group that includes any, "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, even though they may or may not be formally organized (Wertime, Ostrom et al. 2007)." Thus, a local user group that conducts the monitoring and sanctioning that Gibson et al. believe to be a necessary condition might be:

a) The local branch of the National Park authority which uses weapons to exclude other users from using the forest.
b) An organized village forest protection committee that makes rules about forest uses for all villagers, and hires some villagers to serve as guards.
c) Village women who gather firewood legally from a forest in exchange for paying a fee to the forest owner or governmental authority who monitors their use and sanctions violators, in cooperation with women who monitor each other's use and report violations to officials.
d) Village women who gather firewood illegally and monitor each other's use informally and verbally sanction those who take too much.

Although all of these groups are theoretically capable of enforcing rules, it should be obvious that their motivations and capabilities for rule enforcement may be quite different.

One possible answer is provided by Coleman and Steed (2009), who find evidence in the same IFRI data that institutional factors played a role in explaining variation in monitoring and sanctioning. They find evidence that monitoring and sanctioning by local groups was associated with previous experience in monitoring and sanctioning, harvesting rights for members of the group, and residual claimancy on the resource by members of the group. They also found that monitoring and sanctioning by external groups was associated with the presence of NGOs in the local area. While the work of Coleman and Steed represents an interesting start to addressing the question of why some groups are more capable of monitoring and sanctioning, their work does not address the influence of organizational form on the likelihood of groups engaging in rule enforcement. There are strong theoretical reasons for predicting that organizational form will influence the likelihood of groups engaging in rule enforcement.

1.2 Relational analysis in social-ecological systems

The International Journal of the Commons recently devoted a special issue to the topic of CPRs in a "multi-level world." (Berkes 2008) The IFRI program was created to expand the analytic focus of the commons literature from its traditional focus on single case study or small-n comparative research. Today, thanks to the devotion of IFRI researchers, it is possible to analyze large numbers of case studies to test hypotheses about general relationships in local forest management. Berkes draws attention to the fact that commons are located in multi-level contexts. While some studies of irrigation systems have successfully integrated a multi-tier perspective (Ostrom 1990; Lansing 2006), less attention has been paid to networks and relationships in other types of commons (Carlsson and Sandström 2008). Furthermore, most CPR studies focus on attributes of resources and attributes of the human users and managers of those resources independently. The analytic premise of this paper is that it will be productive to explicitly analyze linkages between resources and users as relationships. In the terminology of social network analysis, most studies of social-ecological systems focus on the nodes, while this study takes as its unit of analysis the linkages between these nodes.

1.3 The approach of this paper

In the theory section of this paper, I will propose six hypotheses to explain the variation in monitoring and sanctioning. The application section will begin by describing the methods used for gathering IFRI data & the methods utilized in this paper for analyzing the data. It will proceed to preliminary tests of the hypotheses. The models presented here are illustrative, however they do not represent final results, as there are substantial improvements to be made as the author develops his statistical skills. Finally, I will discuss the substantive conclusions, as well as the challenges of conducting this type of relational analysis.

1. Theory

Although there is no coherent theory to predict monitoring and sanctioning, the literature on collective action and CPR management provides useful guideposts. A large number of variables have been posited to influence collective action in CPR situations (Agrawal 2001; Ostrom 2007). There are reasons to believe that at least some of these variables may be important not only because of their direct effect on resource management, but also because of their impact on the propensity of a community to engage in monitoring and sanctioning. In this paper, I focus on those variables likely to influence the propensity of user groups to engage in monitoring and sanctioning activities. Each of the six hypothesis outlined below will be operationalized using one or more variables as described below in section 3.1.4, and presented in table 2.

2.1 Hypothesis 1: Government Ownership

There are theoretical reasons for believing that differences in organizational form will influence monitoring and sanctioning. Hardin (1968) argued that the imposition of rules and enforcement by governmental actors would be necessary to protect common-pool resources from overexploitation. If the state is distinguished by its possession of a monopoly on coercive use of force, and if coercive force is necessary for rule enforcement in forests, then it follows that only state actors should be able to engage in enforcement. Although empirical studies have provided substantial evidence that coercive force provided by state involvement is not necessary for successful forest management (Gibson, McKean et al. 2000), it is still plausible that possession of coercive force may give government agencies an advantage over local organizations in enforcing rules. This leads to the first hypothesis:

H1: Rule enforcement is more likely in government owned forests.

2.2 Hypothesis 2: Formal Organization

Helmke & Levitsky (Helmke and Levitsky 2006) have highlighted the distinctive role played by informal institutions in many societies. The distinction between formal and informal institutions has not been deeply explored in CPR management. An alternate way of interpreting Hardin's (1968 p. 1427) theory of the importance of government is to emphasize his conception of "mutual coercion, mutually agreed upon." It may be that states are not the only institutions capable of enforcing mutual coercion. Instead, it may be that any user group that is formally organized, in the sense that it has "rules, policies, and/or guidelines about a forest (or forests), some of which the users have prescribed for themselves (Wertime, Ostrom et al. 2007)," will be more likely to engage in rule enforcement. This leads to hypothesis 2:

H2: Rule enforcement is more likely when user groups are formally organized.

2.3 Hypothesis 3: Rule-making

Ostrom (Ostrom 1990) identified the ability of users to organize and participate in collective choice processes as a "design principles illustrated by long-enduring CPR institutions." User groups who have the ability to organize and design their own rules may be more likely to engage in costly enforcement activities. This may be because they feel that rules they design are legitimate, or it may be because such rules are more accurate reflections of local conditions. In either case, this leads to a third hypothesis:

H3: Rule enforcement is more likely when user groups participate in rule making.

It is important to distinguish between formal organization and the ability to make rules. Using the definition of formal organization above, all groups that are formally organized should, by definition, have the right to make rules about forest use. However, members of groups that are not formally organized may still participate in rule-making. For example, a group of women who harvest firewood from a village-managed forest may include a woman who sits on the village council, and all of the women may have the right to vote in council elections.

2.4 Hypothesis 4 & 5: salience & prior organizational experience

Ostrom (2001) identified characteristics of users likely to contribute to successful management of common-pool resources (see also Gibson, Ostrom et al. 2000). Two of these characteristics seem particularly likely to contribute to increase the likelihood of monitoring and sanctioning. The first is salience: if resource users are highly dependent on the resource, they are more likely to invest in protecting the resource. The second is prior organizational experience: users who engage in monitoring and sanctioning outside of the forest are more likely to have the knowledge that enables them to monitor and sanction inside of the forest. Thus:

H4: Rule enforcement is more likely when user group members are highly dependent on forest products.

H5: Rule enforcement in forests is more likely when user groups are also engaged in rule enforcement outside of the forest.

2.5 Hypothesis 6: Group size

Theories of collective action have been heavily influenced by the work of Olson (1965), who argued that groups' ability to organize would be inversely proportional to size, due to the increasing difficulty of controlling free rider problems as group size increases. Since monitoring and sanctioning requires costly investment by group members, we might expect, with Olson, that larger groups would have greater difficulty monitoring and sanctioning. Agrawal & Goyal (2001), however, point out that monitoring is a lumpy collective good: a certain amount of monitoring is required before it can be even minimally effective. Thus, they argue that very small groups may be unable to engage in effective monitoring because they may not be able to hire enough guards to exclude outsiders from using the resource. They develop a model and evaluate empirical evidence from the Indian Himalaya which suggests that medium sized groups may be more effective than either small or large groups. For the purposes of forest management, the effect of groups size may also be mediated by forest size: larger forests likely require more monitoring than small forests, holding group size constant.

H6: Rule Enforcement is more likely in small user groups.

2. Application

3.1 Methods

3.1.1 IFRI Field Methods

This study uses data from the International Forestry Resources and Institutions (IFRI) program. The IFRI research program has been described extensively elsewhere (Gibson, McKean et al. 2000; Ostrom and Wertime 2000; Poteete and Ostrom 2004; Wertime, Ostrom et al. 2007; Wollenberg, Merino et al. 2007; Poteete and Ostrom 2008). IFRI is an international network of scholars who collect data on forest resources and institutions using identical research instruments. Interdisciplinary teams of researchers typically visit a site for a week to a month, depending on the complexity of the site, and study both biophysical and social aspects of the site. Biophysical measurements are performed using conventional forest mensuration techniques. Relationships between the forest and users, and between different groups of users are studied using techniques drawn from participatory rural appraisal (Chambers 1994), such as focus groups, participatory mapping, and semi-structured interviews. All the results of IFRI studies are stored in a relational database.[1]

3.1.2 IFRI Data

---

[1] Current copies of IFRI research instruments, as well as information on how to access and use the database, are available from the IFRI Administrative Center at the University of Michigan's School of Natural Resources and the Environment (http://sitemaker.umich.edu/ifri/home).

There are currently active IFRI centers in eleven countries (USA, Mexico, Colombia, Guatemala, Bolivia, Kenya, Tanzania, India, Nepal, Thailand). Scholars from these centers conduct studies in forested areas of their own countries, and several centers have also studied sites in neighboring countries. Thus, in addition to the eleven countries listed, as of the July 2008 compilation of the IFRI database used in this study, IFRI studies had been performed in Bhutan, Brazil, Ecuador, Honduras and Madagascar. This database compilation contained information on first visits to 294 forests, and 391 user groups.[2] The relationship between forests and user groups is potentially many to many: a forest may have multiple user groups, and a user group may use multiple forests. The unit of analysis for this study is the dyadic relationship between forests and user groups. There are 440 unique first observations of such relationships, however not all can be used in this study. For the purposes of this analysis, all observations from Brazil and Madagascar were dropped from the data, as there are reasons to believe that the data collection from these sites was not strictly comparable. Observations of leasehold forests in Nepal were also dropped from the data because these sites differ systematically from others in the database in ways likely to affect outcomes (Nagendra, Karna et al. 2005; Thoms, Karna et al. 2006). In addition, several dyads were missing data for the outcome variable or one or more explanatory variables. These dyads were not included in the analysis.

The resulting dataset contains 252 unique dyads. These dyads are from 12 countries (See Table 1), and represent 173 distinct forests and 230 distinct user groups.

3.1.3 Outcome: Forest rule enforcement

The outcome, rule enforcement is operationalized in this study as a dichotomous variable indicating whether members of the user group engage in monitoring and sanctioning activities in the forest. This is the same measure that was found to have a large and statistically significant effect on forest condition by Gibson, Williams et al. (2005), but is not precisely the

---

[2] IFRI defines a forest as "an area of at least 0.5 hectares, containing woody vegetation (trees, bushes, shrubs, etc.) exploited by at least three separate households and governed overall by the same legal structure. A user group is defined as "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… users know the shared duties and rights that they hold in common for harvesting from the forest." User groups may be formally organized, but may also be nascent. "Nascent user groups do not regularly participate in an arena for discussing, presenting, and/or arranging for the enforcement of rules about a forest or forests." Since new user groups and new forests may be found in return visits to sites, there is not necessarily a one-to-one correspondence between a first visit to a forest and a first visit to a user group. For example, a new user group may be found using a forest on the second visit to the forest.

same measure as that used by Coleman and Steed (2009).[3] Researchers are asked to answer the following question: "When do individuals in the user group interact in monitoring and sanctioning tasks within the forest?" If researchers code that users never interact, the outcome is coded as zero. If researchers code that users interact year round, seasonally, or occasionally, the outcome is coded as one. 139 dyads (55%) have user groups that engage in at least some monitoring and sanctioning.

3.1.4 Explanatory Variables

Table 2 presents summary statistics for all variables used in the model

The first hypothesis, government ownership, is operationalized using a dichotomous variable that differentiates government-owned lands from lands owned by various non-governmental entities. A forest is classified as government-owned (1) if the legal (de jure) owner of the land is a national, regional, or local government. 189 dyads, Seventy five percent of the dyads in this analysis, are of forests owned by a national, local, or regional government.

The second hypothesis, formal organization, is operationalized using a dichotomous variable that differentiates formally organized from not formally organized user groups. A user group is formally organized if it is classified as a cooperative, a nonprofit organization, a for-profit organization, a family or clan, or as another form of formal organization. User groups that are classified as informal are specifically designated by the researcher as being without formal organization except in the case of one user group, which was marked as being an "other organization type," but which review of the organization type revealed to be an informal organization. 108 dyads (43%) contain user groups which are formally organized.

The third hypothesis, participation in rulemaking, is operationalized using another dichotomous variable. User groups which contain individuals who are "responsible for making rules about the forest" are marked as 1, while user groups which do not contain such individuals are marked as zero. It is not necessary that all members of the user group participate in rule-making, nor is it necessary that all rules are made by members of the user group – the group is marked as participating in rule making if some members are responsible for some rulemaking. 101 dyads (41%) have user groups whose members participate in making rules.

The fourth hypothesis, resource salience, is perhaps the most problematic to operationalize, as a resource may be salient in many different ways. As a general description, forests may serve as sources of a variety of subsistence and commercial products, any one of which may be particularly important to a particular community. Forests can also serve as sources as important

---

[3] Actually neither Gibson et al. nor Coleman & Steed clearly identify their unit of analysis, however it appears that both papers take the forest rather than the forest-user group relationship as their unit of analysis

sources of non-consumptive products. Sacred groves, for example, are widespread in South Asia, and are also present in many other parts of the world (Gadgil and Vartak 1976; Gadgil and Berkes 1991; Gadgil, Berkes et al. 1993; Berkes 1999; Ostrom 2005). For the purposes of this paper, analysis is limited to major consumptive products used for subsistence. These are likely to be the products with the highest salience as they are both highly valuable and highly necessary to many forest users who collect them. Researchers are asked to evaluate, based on conversations with a number of different individuals, the percent of the user group's need for fuelwood and housing timber met by a particular forest. For the purposes of this analysis, I use an average of the values for fuelwood and timber. The mean percent dependence is 50%, with a standard deviation of 35.46%.

The fifth hypothesis, outside experience with monitoring and sanctioning, is operationalized using a measure quite similar to the dependent variable: researchers are asked to answer the following question: "When do individuals in the user group interact in monitoring and sanctioning tasks outside the forest?" If researchers code that users never interact, the outcome is coded as zero. If researchers code that users interact year round, seasonally, or occasionally, the outcome is coded as one. Only 90 dyads, 36%, have user groups that engage in at least some monitoring and sanctioning outside of the forest.

There are two possible ways to operationalize the 6^{th} hypothesis. If, as Olson (1965) suggests, the chief problem is group coordination, then group size is the relevant variable. The mean group size in the sample is 900, with a standard deviation of 2153. If, as suggested by Agrawal & Goyal (2001), the problem relates more to the lumpiness of monitoring, forest size may also matter. The mean forest size is 1675 HA, with standard deviation of 3345. Both of these variables have distributions that are highly skewed towards the lower end. For these reasons, these variables were logged for most analyses.

3.2 Results

All data analysis was performed using Stata version 10.1, using the SPost package (Long and Freese 2005), and tables were generated using estout (Jann 2005; Jann 2007).

3.2.1 Correlations

One concern is that there may be a high degree of collinearity between some of the explanatory variables. As can be seen in the correlation matrix (table 3), collinearity between most explanatory variables is not a very serious concern. The right to make rules has a fairly strong positive correlation with the existence of a formal group, and a fairly strong negative correlation with government ownership, however the right to make rules has an even strong correlation with the outcome variable. Because of concern that these two variables may be collinear, the second and third models presented in table 4 omit user rulemaking and formal group status respectively. Forest dependence appears to have a very weak correlation with the outcome variable.

3.2.2 logit models

Results from logistic regression are presented in table 4. In the base model, government ownership, resource dependence, forest size, and user group size do not have significant effects on user group monitoring and sanctioning when controls are in place for the existence of formal user groups, user rulemaking, and external monitoring and sanctioning, and standard errors are clustered by country.

The effects on rule enforcement of formal organization, user involvement in rule-making, and non-forest monitoring and sanctioning are all significant and strongly positive. In the base model, the coefficient for formal user groups is 2.60 ($p<0.001$), indicating that formal user groups are 13.52 times more likely to engage in monitoring and sanctioning than informal user groups. In the same model, the coefficient for user rulemaking is 2.04 ($p<0.01$). User groups which contain individuals who are involved in rule-making are 7.69 times more likely to engage in monitoring and enforcement. Finally, the coefficient for external monitoring and sanctioning is 2.88 ($p<0.001$), indicating that user groups which engage in monitoring and sanctioning outside of the forest are 17.87 times more likely to engage in monitoring and enforcement.

The second and third models presented in table 4 omit user rulemaking and formal group status respectively, in an attempt to examine what the effects of collinearity in the model might be. Omitting either of these variables increases the effect of the other, however the models with these variables omitted fit the data somewhat poorly compared to the base model. In the model with formal user group dropped, user group size becomes significant, with increases in the natural log of user group size associated with a small increase in the likelihood of rule enforcement.

Several functional forms of user group size were tested in an attempt to capture the hypothesized positive relationship between intermediate group size and rule enforcement (Agrawal and Goyal 2001). These include using a log of user group density (i.e. user group size/forest size), standardized rather than logged group size, a quadratic functional form, and a series of dichotomous variables representing small (<100), medium (100-500) and large (>500) groups. Of these, only a model containing the dummy variable for large group size (presented as the fourth model in table 4) yielded a significant effect, with large group size associated with a small increase in the likelihood of rule enforcement.

3.3 Discussion

The models presented here provide strong support for three of the initial hypotheses: User groups that are formally organized (H2), that have users that are involved in making rules (H3), and that engage in monitoring and sanctioning outside of the forest (H5) are more likely to engage in rule-enforcement. Two hypotheses find no support: there is no observed relationship between government ownership and user group rule enforcement, nor is there a relationship between the percent of fuelwood and timber dependence of a user group and enforcement. Finally, there is weak support for a relationship between user group size and rule enforcement, but in a direction not hypothesized either by the primary hypothesis that small groups would be more likely to engage in enforcement, nor by the secondary hypothesis that intermediate size groups would engage in more enforcement.

Although government ownership of forests and other CPRs has been widely advocated as a solution to overharvesting, the data presented here are consistent with an increasing literature that has failed to find clear relationships between forest ownership and other variables of interest. It is perhaps more surprising that resource dependence is not associated with monitoring and sanctioning. Two explanations are possible. First, the theory may be incorrect. Those who are strongly dependent on local resources may be so dependent because they lack capacity to access other resources. A lack of capacity may also result in an inability to monitor and sanction. Second, the operationalization may be insufficient. There are many other resources that may be harvested from forests, and forests may be highly salient because of their spiritual or cultural meaning, not only because of their economic value. Unfortunately, there is no easy way to capture this complexity in a single or even a small number of variables. Future work might include constructing an index which might capture a greater percent of potential monitoring and sanctioning activity.

User involvement in rule-making and prior experience have been widely posited to be positively associated with possibilities for self-organization and improved resource conditions. Coleman and Steed (2009) found similar results with regards to external monitoring and sanctioning, but did not include involvement in rule-making in their analysis. Formal organizational structure has not previously been considered as a causal factor for rule enforcement: in fact, much commons literature emphasizes the role of informal mechanisms in protecting natural resources. My results, however, do not necessarily contradict these previous findings. Many associate formal organization with notions of governmental organization or formal private corporations, however as understood in this model, formal includes these groups as well as self-organized groups that may or may not have sanction for their organization from higher authorities (Wertime, Ostrom et al. 2007). Formal organization and involvement in rule-making appear to be fairly strongly correlated, raising concerns of collinearity in the model structure. Removing either of these variables from the model makes the effect of the remaining variable substantially stronger, so collinearity, if it is a problem, is masking the strength of these effects.

The group size effect is the most difficult to interpret. In a simple model, with errors clustered by country, it is not significant, however depending on the exact specification of the model, there does appear to be a marginally significant effect in the opposite direction that Olson (1965) predicted. It is not clear what group size should be focused on for intermediate group size. Agrawal & Goyal (2001) found improved monitoring and sanctioning in intermediate size groups of between 30 and 100 households, however this analysis indicates that groups larger than 500 individuals may be more likely to engage in rule enforcement.

Attempting to model relations between forests and user groups, rather than focusing on one or the other, creates problems in data analysis. First of all, there is a threat to the independence of observations. Some user groups use multiple forests, and some forests have multiple user groups. While each relationship is separate, it seems highly plausible that a user group that engages in monitoring and sanctioning in one forest is more likely to engage in monitoring and sanctioning in another forest it uses. Similarly, several user groups using the same forest may be subjected to similar conditions, and thus may be more likely to share common patterns of monitoring and sanctioning.

A more serious problem arises from the possibility of a seventh hypothesis, which was not explored in this analysis: users may be more likely to enforce rules in forests which are more valuable to them. Indeed, Ostrom (2001) identified good resource condition as likely to contribute to the development of successful CPR regimes. Severely degraded forests may not have resources that are worth monitoring. Alternatively, very abundant resources may also not be worth monitoring. Few studies of collective action have controlled for resource condition (Chhatre and Agrawal 2008). The problem here is that monitoring and sanctioning is of interest precisely because it is believed to have a causal relationship with forest condition, but it may itself be caused by forest condition. Such complicated relationships are amenable to modeling, but require more advanced techniques that I have not learned yet.

Finally, there is a challenge with regards to modeling social-ecological systems as relationships. While I have shown that it is possible to analyze relationships between forests and user groups, actual socio-ecological systems are much more complicated. While I can demonstrate that certain factors increase the probability of monitoring by a given user group in a given forest, a given forest may have other users who may engage in the requisite monitoring. Furthermore, monitoring and sanctioning activities may be related to aspects of larger governance processes, such as the enabling environment for local organizations, which are difficult to integrate into relatively simple regression models. Ostrom's (2007) diagnostic ontology permits a classification of these variables, however any reasonable classification reveals very complex structures of networks between organizations, individuals, and various aspects of the natural environment. Developing a relational perspective that goes beyond the dyads analyzed in this paper is a big challenge.

3. Conclusion

In this paper I have shown how a relational perspective can be used to understand the relationship between forest users and forests. I have also shown that forest rule enforcement has a strong positive relationship with formal user organization, the ability of users to make rules, and their experience of monitoring and sanctioning outside of the forest, while it does not have a clear relationship with government ownership, resource dependence, or group size. This paper represents a first attempt to develop these ideas. I hope to continue to develop this model over the next year, and would appreciate suggestions.

References

Agrawal, A. (2001). "Common Property Institutions and Sustainable Governance of Resources." World Development **29**(10): 1649-1672.

Agrawal, A. and S. Goyal (2001). "Group Size and Collective Action: Third-party Monitoring in Common-pool Resources." Comparative Political Studies **34**(1): 63-93.

Baland, J. M. and J. P. Platteau (1996). Halting Degradation of Natural Resources: Is There a Role for Rural Communities. Oxford, Clarendon Press.

Berkes, F. (1999). Sacred Ecology: Traditional Ecological Knowledge and Resource Management. Philadelphia, Taylor & Francis.

Berkes, F. (2008). "Commons in a Multi-Level World." International Journal of the Commons **2**(1): 1-6.

Carlsson, L. and A. Sandström (2008). "Network governance of the commons." International Journal of the Commons **2**(1): 33-54.

Chambers, R. (1994). "The origins and practice of participatory rural appraisal." World Development **22**(7): 953-969.

Chhatre, A. and A. Agrawal (2008). "Forest commons and local enforcement." Proceedings of the National Academy of Sciences **105**(36): 13286-13291.

Coleman, E. A. (2009). "Institutional factors affecting biophysical outcomes in forest management." Journal of Policy Analysis and Management **28**(1): 122-146.

Coleman, E. A. and B. C. Steed (2009). "Monitoring and sanctioning in the commons: An application to forestry." Ecological Economics **forthcoming**.

Dietz, T., E. Ostrom, et al. (2003). "The Struggle to Govern the Commons." Science **302**(5652): 1907-1912.

Feeny, D., F. Berkes, et al. (1990). "The Tragedy of the Commons: Twenty-two years later." Human ecology **18**(1): 1-19.

Gadgil, M. and F. Berkes (1991). "Traditional Resource Management Systems." Resource Management and Optimization **8**: 127-41.

Gadgil, M., F. Berkes, et al. (1993). "Indigenous Knowledge for Biodiversity Conservation." Ambio **22**(2/3): 151-156.

Gadgil, M. and V. Vartak (1976). "The sacred groves of Western Ghats in India." Economic Botany **30**(2): 152-160.

Gibson, C. C., M. A. McKean, et al. (2000). People and Forests: Communities, Institutions, and Governance. Cambridge, MA, The MIT Press.

Gibson, C. C., E. Ostrom, et al. (2000). Forests, People, and Governance: Some Initial Theoretical Lessons. People and Forests. C. C. Gibson, M. A. McKean and E. Ostrom. Cambridge, MA, The MIT Press.

Gibson, C. C., J. T. Williams, et al. (2005). "Local Enforcement and Better Forests." World Development **33**(2): 273-284.

Gordon, H. S. (1954). "The Economic Theory of a Common-Property Resource: The Fishery." The Journal of Political Economy **62**(2): 124-142.

Hardin, G. (1968). "The Tragedy of the Commons." Science **162**(3859): 1243-1248.

Hayes, T. M. (2006). "Parks, People, and Forest Protection: An Institutional Assessment of the Effectiveness of Protected Areas." World Development **34**(12): 2064-2075.

Helmke, G. and S. Levitsky (2006). Informal Institutions & Democracy: Lessons from Latin America. Baltimore, MD, Johns Hopkins University Press.

Henrich, J., R. McElreath, et al. (2006). "Costly Punishment Across Human Societies." Science **312**(5781): 1767-1770.

Jann, B. (2005). "Making regression tables from stored estimates." The Stata Journal **5**(3): 288-308.

Jann, B. (2007). "Making regression tables simplified." The Stata Journal **7**(2): 227-244.

Lansing, S. J. (2006). Perfect Order: Recognizing Complexity in Bali. Princeton, NJ, Princeton University Press.
Long, J. S. and J. Freese (2005). Regression Models for Categorical Outcomes Using Stata. College Station, TX, Stata Press.
Nagendra, H., B. Karna, et al. (2005). "Examining Institutional Change: Social Conflict in Nepal's Leasehold Forestry Programme." Conservation and Society **3**(1): 72.
Olson, M. (1965). The logic of collective action: public goods and the theory of groups. Cambridge, MA, Harvard University Press.
Ostrom, E. (1990). Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge, UK, Cambridge University Press.
Ostrom, E. (2001). Reformulating the Commons. Protecting the Commons: A Framework for Resource Management in the Americas. J. Burger, E. Ostrom, R. B. Norgaard, D. Policansky and B. D. Goldstein. Washington, DC, Island Press.
Ostrom, E. (2005). Understanding institutional diversity. Princeton, Princeton University Press.
Ostrom, E. (2007). "Going Beyond Panaceas Special Feature: A diagnostic approach for going beyond panaceas." Proceedings of the National Academy of Sciences **104**(39): 15181-15187.
Ostrom, E., J. Burger, et al. (1999). "Revisiting the Commons: Local Lessons, Global Challenges." Science **284**(5412): 278-282.
Ostrom, E. and H. Nagendra (2006). "Inaugural Article: Insights on linking forests, trees, and people from the air, on the ground, and in the laboratory." Proceedings of the National Academy of Sciences **103**(51): 19224-19231.
Ostrom, E. and M. B. Wertime (2000). Appendix: International Forestry Resources and Institutions Research Strategy. People and Forests: Communities, Institutions, and Governance. C. C. Gibson, M. A. McKean and E. Ostrom. Cambridge, MA, The MIT Press**:** 243-68.
Poteete, A. R. and E. Ostrom (2004). "In pursuit of comparable concepts and data about collective action." Agricultural Systems **82**(3): 215-232.
Poteete, A. R. and E. Ostrom (2008). "Fifteen Years of Empirical Research on Collective Action in Natural Resource Management: Struggling to Build Large-N Databases Based on Qualitative Research." World Development **36**(1): 176-195.
Thoms, C. A., B. K. Karna, et al. (2006). "Limitations of Leasehold Forestry for Poverty Alleviation in Nepal." Society & Natural Resources **19**(10): 931-938.
Wade, R. (1988). Village Republics: Economic Conditions for Collective Action in South India. Cambridge, Cambridge University Press.
Wertime, M. B., E. Ostrom, et al. (2007). International Forestry Resources and Institutions Research Program Field Manual: Version 13. Bloomington, IN, Center for the Study of Institutions, Populations, and Environmental Change, Indiana University.
Wollenberg, E., L. Merino, et al. (2007). "Fourteen years of monitoring community-managed forests: learning from IFRI's experience." International Forestry Review **9**(2): 670-684.

Table 1: Distribution of dyads by country

Country	Frequency	Percent
India	61	24.21
Uganda	54	21.43
Nepal	41	16.27
Kenya	33	13.1
Bolivia	21	8.33
Tanzania	11	4.37
Guatemala	10	3.97
Mexico	9	3.57
USA	5	1.98
Honduras	4	1.59
Bhutan	2	0.79
Thailand	1	0.4
Total	252	100

Table 2: list of variables (n=252)

Hypothesis	Variable	Mean	Std. dev	Range
Outcome	Forest Rule enforcement	0.55	0.50	0-1
H1	Government ownership	0.75	0.43	0-1
H2	Is the group a formal user group?	0.43	0.50	0-1
H3	User rulemaking	0.40	0.49	0-1
H4	Percent of firewood and timber from forest	49.53	35.46	0-100
H5	External monitoring & sanctioning	0.36	0.48	0-1
H6	Forest size (HA)	1674.70	3345.40	0.9-22700
H6	Number of individuals in user group	900.17	2153.30	1-27000

Table 3: Correlation matrix

	Forest Rule enforcement	Government ownership	Formal user group	User rulemaking	Percent of firewood and timber from forest	External monitoring & sanctioning	Forest size (natural log) (HA)	Number of individuals (natural log)
Forest Rule enforcement	1							
Government ownership	-0.1704	1						
Formal user group	0.5874	-0.1481	1					
User rulemaking	0.5095	-0.3693	0.4862	1				
Percent of firewood and timber from forest	-0.0601	0.0867	-0.0207	-0.0433	1			
External monitoring & sanctioning	0.4389	-0.2008	0.1745	0.2016	0.1237	1		
Forest size (natural log) (HA)	-0.1838	0.2935	-0.2813	-0.1492	0.2836	-0.0164	1	
Number of individuals (natural log)	-0.1838	0.2605	0.2	0.0337	0.0258	-0.0816	-0.0727	1

Table 4: logit estimates of forest rule enforcement(N=252).

	Base Model	User rulemaking dropped	Formal group dropped	Large group dummy
Government ownership	0.11 (0.68)	-0.63 (0.62)	0.36 (0.67)	0.29 (0.72)
Formal user group	2.60*** (0.55)	3.10*** (0.57)		2.59*** (0.54)
User rulemaking	2.04** (0.70)		2.70*** (0.57)	2.07** (0.66)
Percent of firewood & timber from forest	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
external monitoring & sanctioning	2.88*** (0.21)	2.71*** (0.30)	2.61*** (0.22)	2.97*** (0.21)
Natural log forest size	-0.04 (0.18)	0.02 (0.18)	-0.19 (0.20)	-0.06 (0.20)
Natural log number of individuals	0.25 (0.18)	0.23 (0.12)	0.31* (0.15)	
Group size > 500				0.86* (0.40)
Intercept	-3.02* (1.38)	-2.20 (1.43)	-2.00 (1.39)	-2.02 (1.09)
AIC	190.08	209.08	227.95	190.73
BIC	218.31	233.79	252.66	218.97

Standard errors in parentheses
Data Source: IFRI database, July 2008
Standard errors clustered by country
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$