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When is an Open-Access Forest Healthy? Dependence, Scarcity, and Collective Action in Eastern Guatemala

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Executive Summary

The residents of the settlement Moran, located along the border of the Sierra de las Minas Biosphere Reserve, have lived and farmed in the area for over a century. Despite a lack of community level rules about protecting their communal forest, a limited amount of arable land, and a strong birthrate, their forest is in no immediate danger of being cleared. This study seeks to explain the pattern of forest use, the lack of forest-conserving institutions, and the implications of this study for the development of theories regarding common-pool resources more widely. Using social and biological data, we argue that communities do not create institutions concerning a resource unless two conditions apply: first, those community members depend significantly on the resource; second, that there is a perceived scarcity of the resource. These two necessary conditions do not hold in Moran and, as a result, their communal forest is an open-access resource. Although an open-access resource, we also attempt to account for the fact that the communal forest is in good general condition.

The literature regarding institutions has provided a great deal of work about how communities have managed to protect their communally-held natural resources, in contradiction to what was perceived by some as their inevitable destruction. Design principles (Ostrom, 1990) and their various refinements have attempted to explain how a community can overcome this social dilemma, and construct institutions or rules to help manage their resource more successfully. What is stressed in this debate is the value of the resource to the local community: if the members of a community do not depend significantly on a resource, then they will not

construct rules to manage it (Ascher 1995). Less emphasized is how community members perceive the scarcity of the resource. In an economic approach to individual behavior, if a resource is valuable, but not perceived to be scarce or in danger of being scarce, then it may not make sense to individuals to incur the costs resulting from the construction and maintenance of an institution regarding that resource. This would be true no matter how much the community depended on the resource.

In Moran, we find the first condition met: members of the community depend on the forest for a number of products. They use their communal forest's timber for construction, limbs and trunks for fuel, resinous pieces for fire ignition, undergrowth for grazing, and wildlife for eating. Individuals assert that without the products of the forest, they would not be able to survive in the area. However, the second condition does not appear to be met: residents of Moran do not perceive the forest or its products to be scarce, nor do they believe that scarcity will characterize their forest in the near future. Residents resent having to travel a little further and longer to obtain some of the forest products on which they depend. They also resent some government restrictions aimed at forest conservation. But in general they see no great decline in the forest's bounty. In addition to the oral testimony of Moran's residents, biological data also show that residents follow a type of optimal foraging theory when using the forest.

To investigate community members' perceptions, we construct a regression model that evaluates the impact of biophysical and social causes for the number and distribution of pine stems. The biophysical factors do not emerge significant in the model. However, the areas closer to the settlement or to the major road are significantly more likely to have been exploited for their pine than areas further away from the settlement or road. Further, the average size of the pine is significantly smaller, indicating that larger stems have been cut. This patterns of use suggest that residents follow no rules in their use of pine (and, we will argue, other important species in the forest). Their communal forest is thus an open-access resource.

But the data also suggest that the forest is not in poor biological condition overall. And, the communal forest is not being cleared for new agricultural fields, despite a strong birth rate in the community and a limited supply of agricultural land. We explain this outcome by using demographic data collected in the settlement. While the birthrate is significantly positive, many people who are born into Moran migrate to other areas within Guatemala and to the United States. The lands that could be cleared of forest and used for farms are too steep and infertile to sustain agriculture. This constraint of suitable land impels many residents to seek their fortunes elsewhere.

Since land for agriculture is valuable and scarce in Moran, members have constructed elaborate rules about this resource as they have not about their forest. Despite their dubious *de jure* claims to the land - which is owned by either the municipality or absentee landlords, Moran's residents rent, trade, allocate, and defend their farms with vigor. The institutions the community members have constructed about land, therefore, provide support for the theory that two conditions are necessary for the construction of local level rules about natural resources: they must be considered valuable and scarce.

Introduction

The residents of the settlement Moran, living along the border of the Sierra de las Minas Biosphere Reserve in Eastern Guatemala, have farmed in the area for over a century. Despite a lack of community rules about protecting their communal forest, a limited amount of arable land, the central place of forest products in the local household economy, and a strong birthrate, their forest is in no immediate danger of being cleared. How can such an important open access forest not be over exploited? Why do the residents of Moran fail to construct their own institutions to manage the forest products upon which they rely so heavily?

This study seeks to explain the Moran community's pattern of forest use, the lack of forest-conserving institutions, and the implications of this study for the development of theories regarding common-pool resources more widely. Using social and biological data, we argue that communities do not create institutions concerning a resource unless two conditions apply: first, those community members depend significantly on the resource; second, that there is a perceived scarcity of the resource. The second of these two necessary conditions does not hold in Moran and, as a result, their communal forest is an open-access resource. We test the implications of the forest's lack of rules by using biological and social measures of its use. In contrast, the two conditions do hold for farmland, however, and a great number of locally constructed institutions guide the management and exchange of these valuable plots.

Although an open-access resource and used daily, the communal forest is in relatively good overall condition. Every household uses forest products on a daily basis, and the population of the community has increased significantly over the past century. But the growth rate of Moran has been steady, and has benefitted from an important flow of out migrants which keeps the population in check. Consequently, the community's population does not over strain the significant amount of forest resources in the area. Another important constraint on local behavior is the Guatemalan government's rule that does not allow more lands to be cleared for agriculture in the Biosphere. While this is imperfectly enforced, local farmers have kept the extent of their fields roughly constant, resulting in a communal forest that is not under immediate threat of being cleared.

Theoretical Issues

When do members of a community construct institutions to manage their natural resources? This is a central question for those exploring common-pool resources, common property, and local-level natural resource management. The answer is, of course, far from straightforward. Scholars have presented many sets of conditions, and offered details from hundreds of cases, in their efforts to explain the success and failure of collective action regarding natural resources (e.g., Bromley, 1992; Gibson, McKean, and Ostrom, 1998; McKean, 1992, 1998; Wade, 1994; Schlager, 1990; E. Ostrom, 1990, 1992a, 1992b; Baland and Platteau, 1996; E. Ostrom, Gardner, and Walker, 1994; Arnold, 1998).

The conditions forwarded by researchers generally impact on the costs and benefits that accrue to individuals from group action, affecting their decision to act collectively or not. For

example, if a great deal of ethnic tensions exists between the members of a community, the costs of constructing an institution for the management of a natural resource are greater than in a community with more harmonious relations between members; or if the community does not have any effective means of enforcing its own rules, the benefits accruing to individuals from a collective agreement will not exist.

E. Ostrom, building on her own work regarding the management of common pool resources, has recently elaborated a model that explicitly incorporates many of the costs and benefits of collection action regarding forests. In this model, Ostrom constructs lists of the attributes of the natural resource and of the appropriators of that resource that might affect the likelihood of whether or not an individual will invest choose to invest their time in a collective solution (Ostrom 1998, see also Ostrom 1992: 298-99; Baland and Platteau 1996: 286-89). (See Table 1.)

Table 1.

Attributes of the Resource:

- R1. Feasible improvement: The forest is not at a point of deterioration such that it is useless to organize or so underutilized that little advantage results from organizing.
- R2. Indicators: The quality and quantity of rapidly growing forest products provide reliable and valid information about the general condition of the forest.
- R3. Predictability: The availability of forest products' units is relatively predictable.
- R4. Spatial extent: The forest is sufficiently small, given the transportation and communication technology in use, that users can develop accurate knowledge of external boundaries and internal microenvironments.

Attributes of the Users:

- A1. Salience: Users are dependant on the forest for a major portion of their livelihood or other variables of importance to them.
- A2. Common understanding: Users have a shared image of the forest (attributes R1, 2, 3, and 4 above) and how their actions affect each other and the forest.
- A3. Discount rate: Users have a sufficiently low discount rate in relation to future benefits to be achieved from the forest.
- A4. Distribution of interests: Users with higher economic and political assets are similarly affected by a current pattern of use.
- A5. Trust: Users trust one another to keep promises and relate to one another with reciprocity.
- A6. Autonomy: Users are able to determine access and harvesting rules without external authorities countermanding them.
- A7. Prior organizational experience: Users have learned at least minimal skills of organization through participation in other local associations or learning about ways that neighboring groups have organized.

From Ostrom 1998.

The implication of these lists is that different levels of these attributes increase or decrease the costs and benefits to individual users, and therefore affect the probability that collective action will emerge about forest resources.

These lists do not, however, state which attributes - or which levels of attribute - are necessary conditions for the emergence of collective action. This is of course in great part a matter for empirical study: such attributes will be present to varying degrees and interact in different ways over space and time. If enough cases employ concepts similar to Ostrom's useful list, comparisons can be made to determine which attributes (and at what levels) are more important than others to promote collective action (see Ostrom and Wertime, 1994).

But we can, in fact, go further in examining the necessary conditions for the collective management of natural resources.[1] We argue that two of Ostrom's attributes are more than just additional influences on individuals' cost-benefit calculations; indeed, we assert that these two conditions are necessary to motivate individuals to construct collective institutions regarding natural resources: 1) Individuals must depend on some forest resource, and 2) they must perceive it to be scarce (see Ostrom's attributes **AI** and **R1**). We discuss each of these conditions in turn..

Individuals must depend on a resource to create institutions to manage its use. The reasoning for this condition is straightforward. Unless a resource is important, individuals will not incur the costs entailed in constructing an institution to manage it, which can be quite high indeed since they must include decision making, monitoring, and enforcement structures at a minimum (Ascher 1995). Note that this use of the concept is not the same as economists' concept of value. Economics defines value by scarcity. Here we focus on something that is necessary to human lives. Hence in our conceptualization, breathable air is valuable while for economists, its plentitude obviates its value.

This condition causes conservationists great frustration as they seek to build projects with the help of local communities. The things that conservationists value are usually not the same things upon which local communities depend (Bailey 1996). Community members, therefore, must be induced with other benefits (more land, more resources, less erosion, cleaner water, wages, etc.) to participate in such schemes. This is also why such projects are fragile, since these other benefits may not last, which may cause a local community's commitment to the conservation project to flag quickly.

The second condition is also relatively well known to both academics and conservationists: people must perceive a resource to be scarce in order to want to contribute to a collective solution. If individuals view a resource as plentiful, they will not be willing to endure costs to manage it. Indeed, some anthropologists have claimed that without scarcity there are no reasons for people to interact at all (e.g., Harner, 1975: 125). Perception is key here. For example, if little land for extensive migration actually exists, but if people perceive that they can use up a forest's resources and move on, they will be less inclined to organize to manage their current actions and resources.

We claim that both of these conditions must be present before members of a community will engage in the construction of institutions to manage their natural resources. If individuals do not

depend on a resource, they will not organize to manage it whether or not it is scarce. If individuals do not perceive a resource as scarce, they will not organize to manage it whether or not it is valuable to them. Consequently, we consider these necessary conditions for collective action regarding resources.

Exploring Resource Value and Scarcity in Eastern Guatemala

To begin to test these conditions, we use data collected from a site located in the Sierra de las Minas Biosphere Reserve in eastern Guatemala.[2] The Reserve covers approximately 2,363 square kilometers, the entire extent of the Sierra de las Minas, a transverse range running east-west along the north bank of the Rio Motagua (see map 1). The Sierra de las Minas range is approximately 130 kilometers long and at its highest point reaches over 3,200 meters above sea level; it represents a large portion of Central America's biodiversity, containing 70% of species found within Guatemala and Belize. The north slope of the Sierra de las Minas range is covered by broad leaf tropical forest, largely as the result of high amounts of precipitation (2,000+ mm) caused by the interaction of Caribbean trade winds and mountainous topography. The south slope of the Sierra de las Minas is drier: at the lowest elevations in the Rio Motagua valley are found thorn forests; with increasing elevation, the forests on the southern slope transition to oak and pine.

The study site is located within the watershed of the Rio Santiago, a sub-watershed of the Rio Motagua (see map 2). The Rio Santiago watershed maintains a southward aspect and ranges in altitude from 150 to over 1,500 meters in elevation.

Community Attributes

We collected data in the communities of Moran and Naranjo, located at 1,200 meters above sea level. Moran is a community of 60 households; Naranjo a community of 9 households; together they share a population of 290 individuals. Since the communities are linked closely by kinship and share similar forest use patterns, they are treated as one community for this site study (hereafter we use the name Moran to refer to both). With regard to political territories, the research community is located within the department of Zacapa and the municipality of Rio Hondo.

Residents of Moran are ethnically ladino, that is, people of mixed Spanish and indigenous ancestry. They speak Spanish and identify themselves as Guatemalans, observing national holidays such as Independence Day (September 15). Historically their religious orientation has been Roman Catholicism, though now a majority of residents consider themselves Protestants: Moran maintains a full-time Evangelical pastor; Naranjo has a small Catholic chapel which is infrequently visited by an itinerant priest. The people of Moran say that a man named Moran settled on the Rio Santiago approximately one hundred years ago though he eventually left the area (according to local legend) because his wife was attacked and killed by a jaguar. The majority of residents trace their ancestry to migrants from villages in the neighboring watershed immediately to the west of the Rio Santiago watershed.

Moran provides an interesting case study in human-forest interactions. This population has

lived for over one hundred years with its local forests - forests still extant although modified by human use. Population growth appears to have been slow and steady over the last hundred years; the oldest residents remembered about five houses being present in early Moran; now there are sixty. In the last twenty years however, out-migration seems to have become an important population valve in the context of poor and scarce agricultural lands: many adult children of the older couples have moved to the Caribbean coast of Guatemala, the PetJn frontier region, or to Providence, Rhode Island.

The people of Moran are campesinos, or peasant-like farmers, practicing milpa agriculture traditional to most Central America. The most important crops are maize and black beans. Other tropical crops (e.g., coffee, plantains, manioc, yams) and fruit trees (e.g., oranges, mangoes) are grown, but are secondary in importance to maize and beans. Agriculture is almost entirely for subsistence and direct consumption by households, though small amounts of excess harvests are sold in the regional market. Cattle are also important as a form of wealth and financial security. Fields and pastures are found mostly on steep slopes within the Rio Santiago watershed. There is little flat land within the watershed (forest plots sampled ranged from 17 to 45 degrees in slope gradient). Soils are generally shallow and rocky and poor for agriculture; milpa farmers in Moran now use commercial chemical fertilizers, herbicides, and pesticides to increase their yields.

Land Tenure Issues

The history of land tenure which shapes use of agricultural land and local forests is complex, involving several layers of legal demarcations, usufruct rules, and Reserve management policies (see map 2). According to the national cadastral survey of Guatemala, the majority of the area now utilized by Moran for agriculture, cattle pasture, and extraction of forest resources is municipal land locally called "El Sitio" or The Site. Within El Sitio are located trabajadero agricultural lands worked and fenced together by community members. Also smaller usufruct plots, known as tierras "con dueZos" are found in El Sitio. Rights to work in these plots, though not legal, are recognized by the community members and can be inherited, sold, and rented. Apart from the municipal lands, mostly in the northern extent of the Rio Santiago watershed, are found tierras privadas, lands legally demarcated as privately owned by the national cadastral survey. However, just as in the municipal lands, individual or family usufruct plots "con dueZo" are scattered across the land demarcated as private. As delimited by the Master Plan of the Sierra de las Minas Biosphere Reserve, Moran and the majority of lands economically important to its residents, falls within the buffer zone of the Reserve; within the buffer zone is allowed the "sustainable use of resources to better the quality of life of its inhabitants."

El Sitio Forests and Their Use

Two kinds of biological forests are found within the municipal lands of El Sitio: oak forest and pine forest (see map 3). These forests are used for three main purposes: (1) extraction of ocote, or resinous pine, for kindling; (2) extraction of firewood, oak varieties being preferred because they create less smoke (though pine is sometimes used); and (3) pasture areas for cattle

which browse freely through the understory.

Each of the three economic activities has its own technologies and practices. Ocote is most often cut by men with an ax.. An entire pine may be felled, then cut into short lengths and split; a burro or mule is used to carry the split wood home in a bundle called a carga, the amount a mule can carry on its back. Sometimes ocote is cut from live standing trees simply by slashing through the bark of the pine trunk and prying the quantity of desired kindling from the resinous interior wood. Firewood may be collected by men and women; the preferred pattern is for men to cut firewood with an ax and carry it home with the aid of a beast of burden. However, if men are away or unable to cut firewood, women and children will go out to collect it, most often cutting wood with a machete and carrying it home in a bundle on their heads. Almost all households collect ocote and firewood. Cattle, however, are owned by less than half of the households in Moran, at an estimated total of 225 heads. All cattle, at various times during the year, range throughout the forested lands of El Sitio, though other pastures (e.g., privately owned pastures or usufruct pastures) are also important for maintenance of cattle. Campesinos typically burn the ground cover of these common access forests at least once a year to foster new growth of pasture grasses in the forest.

Factors shaping forest use in Moran

Four significant factors shape the pattern of forest use by members of the Moran community: the difficulty of traveling to nearby markets, the laws governing forest use in Guatemala, individuals' perception of the quantity of forest products, and how forest products fit into the pattern of local agricultural production. Together, these factors have led to a situation in which use is not greatly constrained in the forested parts of El Sitio land: rules-in-use for the forest are few.

Given this lack of local institutions governing the use of the El Sitio forest, we hypothesized that the pattern of community members' use would follow optimal foraging theory, i.e. humans maximize their net rate of return of energy per unit of foraging time. That is, without rules to constrain behavior in the forest, people take what is easiest first. Biological data taken from forest plots support this hypothesis.

Difficulty of Transport

While members of the Moran community live relatively close to local markets (10-20 kilometers), the steep slopes, and the poor road found in this part of the Sierra de las Minas make the trip to markets very difficult. No one in the community owns a motor vehicle, and so traveling to markets must be done by foot or on horseback. The majority of community members walk, which can take anywhere from 4-5 hours round-trip for a young man, and up to 8 hours for those less fit.

Such difficulties reduce the return to any marketing of forest products by local community members: firewood is never sold outside the community, timber has not been sold by community members in local markets, and only one member of the community regularly sold ocote. The difficult access has also prevented many outsiders from taking a great deal of Moran

forest products as well. With the exception of a municipality-sanctioned timber company that cut thousands of trees 20 years ago, community members believe that outsiders have little effect on the condition of their forest. The costs of transport have reduced the effect of external market demand for forest products from this watershed.

National laws

The multiple laws and policies that govern forest are ambiguous, overlapping, and difficult to enforce in the Rio Santiago watershed. Nevertheless, these laws have affected the pattern of forest use in Moran. The most significant laws and policies are found in: Laws of Protected Areas (Decree 4-89), the Forest Law (Articles 98 and 99), and the Master Plan for the Sierra de as Minas Biosphere Reserve. In general, these laws and policies allow for the subsistence use of forests, but set certain limits on the amounts of products taken.

Community members do not always know exactly what these limits are. In Moran a community member has been hired as an extension agent for Defensores de la Naturaleza (DN), a non-governmental organization that has been given executive authority by the government to manage the Biosphere Reserve, in which the community is found. The extension agent has discussed one particular policy with his fellow community members, i.e. that land cannot be cleared for agriculture. This policy is based on DN's policy of preventing any change in land use, so as to stabilize forest exploitation. Local individuals know about this general policy. Additionally, because government personnel have investigated forest exploitation in the community in the past, individuals fear government intervention. Thus, in practice, community members rarely violate the government laws, so that their de facto activities generally reflect the *de jure* rules, and they rarely clear additional forested lands for new agricultural plots.

Forest Products and Local Livelihoods

Subsistence use dominates the manner in which the forested lands of El Sitio fit into the locals' livelihoods. The forest products taken from El Sitio (pine and oak) predominantly relate to fuel use. The forested lands themselves are also used for cattle grazing.

Community Perceptions of Forest Product Abundance

Members of Moran generally perceive firewood, ocote, and pasture land to be abundant in the El Sitio forest. While most acknowledge that it takes more time to walk to gather firewood than in years past, most also find the increased time to be insignificant. Also, while some members understand that the amount of pasture land is limited, they also perceive that it is satisfactory for the amount of cattle owned by individuals.

Testing the importance of natural and social factors

Although community members depend on the products of their forest, their belief in the abundance of these products leads us to hypothesize that local institutions would not have been created to manage these products or the forest. Qualitative evidence supports this hypothesis: in the dozens of interviews that our team undertook, we could find no formal or informal rules

guiding use of forest products. Community members repeatedly said that if a community member wanted firewood or timber, that all they had to do was cut it. This behavior was constrained somewhat by the formal rules of the Reserve - that no additional lands could be cleared. But other than clearing, forest products appeared to be for the taking by locals.

Quantitative evidence also supports this explanation. If community rules exist about the use of the forest, we would expect that certain patterns of use could be discovered in various parameters regarding forest condition. For example, if a community had a prohibition on the cutting of large oak trees, we would expect to find more large oaks than if the community did not have such a rule. If no rules exist about a forest, on the other hand, we would expect that the pattern of use would resemble optimal foraging theory (Stephens and Krebs 1986, Hayden 1981, Smith 1983). Without local institutions to constrain subsistence behavior, individuals use the forest trying to maximize their returns to individual effort.

Such a view fits generally the theories emerging from the common property literature that people construct institutions under the condition that expected value of creating an institution to manage the resource is positive (Ostrom 1990, Bromley et al. 1992). In this case, because locals are not concerned about the supply of the products offered by the forest, there is little attempt to construct management institutions. This may change if the conservation agency in charge of the area decides to stiffen its rules and/or enforce them. If this puts limits on access to forest products, we may see local level responses that may include the creation of management institutions.

We can see some evidence of the Moran's optimal foraging patterns of use when we compare the El Sitio forest, which is located close to the community, with a forested area called Palmar that is located a 2.5 hour walk away. While only three plots were sampled in the Palmar forest, the results are indicative.[3] Both forests are pine forests of approximately the same elevation. Yet, the average number of trees in each forest is quite different: plots in El Sitio have an average of 11.6 trees per plot, while the Palmar forest boasts about 12.7 trees per plot. Comparing the percent ground cover produces another distinct difference between the two forests: Plots in the El Sitio forest average approximately 50% ground cover, while those in Palmar average over 75%. This difference in ground cover is in part attributable to the lack of cattle grazing in the more distant Palmar forest.

The pattern of disturbance in the El Sitio forest also indicates that human activity is intense (see graph 1). Evidence of cutting was found in nearly half the plots sampled; evidence of fire in more than half of the plots. The most significant disturbance discovered was that caused by livestock: every plot sampled showed evidence of cattle. Finally, in the El Sitio forest, considered by the member of the Moran community to be an open access resource, plots reveal that human-induced disturbances far out number the natural disturbances of insects and erosion.

We construct two regression models to provide a better test of the hypothesis that members of the Moran community use the El Sitio forest in a pattern resembling optimal foraging theory. Both models attempt to separate the natural and human factors that may affect the forest.

Model 1:

Pine DBH = Stem count + Elevation + Steepness + Erosion + Insects + Distance to Settlement + Distance to Road

The first model uses the average diameter at breast height of pine trees per plot as a dependent variable. We hypothesize that since pine is an important species in this biome as well as a major product used by locals - for firewood, ocote, and timber - the impact of human use of pine would be captured by the size of trees remaining in each plot.

The first five independent variables attempt to control for the most important natural factors that may affect the size of pine trees. The independent variable **Stem count** is the number of pine stems found in a plot. Our hypothesis is that the more stems of pine that live in a plot, the smaller the dbh of the trees should be due to crowding effects. .The independent variable **Elevation** is the elevation of the forest plot, measured as meters above sea level. We hypothesize that the size of pine trees per plot decreases with elevation, since this does occur naturally in this region according to local forest ecologists. **Steepness** is the steepness of the forest plot, measured as the plot's slope in degrees. In some cases the size of trees will decrease with increases in slope since trees have a more difficult time establishing and maintaining themselves. But this variable might also capture human intervention, as it may be more difficult to access trees on steeper slopes. Higher levels of **Erosion** and **Insect** damage may also affect the dbh of pine.

The last two independent variables attempt to capture social effects on the size of pine trees in the El Sitio forest. **Distance to Settlement** is the independent variable representing the distance, measured in meters, between forest plots and the closest house located in the Moran community. This independent variable seeks to capture the effect of distance on the size of pine trees. If community members are trying to maximize their return to effort, then plots closer to settlements should contain smaller pine stems than plots located farther away. **Distance to Road** on the other hand captures the distance, also measured in meters, from to road to forest plot. The one road to the Moran community both traverses and follows the edge of El Sitio forest. Because it would be easier for an individual to transport pine products by road, we hypothesize that the larger pine trees would be taken from plots closer to the road. Thus, as distance from road increases, we expect to see an increase in the dbh of pine stems per forest plot.

Table 2. Results of Pine DBH Model

	Intercept	Stem Count	Elevation	Steepness	Erosion	Insects	Distance to Settlement	Distance to Road
Coefficient	48	-1.204	-0.034	-0.174	10.992	-4.178	.0389	.184
std. Error	12.146	.269	.01	.17	3.12	2.629	.0374	.1017
t-statistic	4.016	-4.469	-3.416	-1.02	3.52	-1.59	1.03	1.812
P-value	.0004**	.0001**	.002**	.31	.002**	.125	.312	.082*

N = 33
R squared = .7749
Adjusted R squared = .7199
F statistic = 12.30063
Significance F = 1.03E-06

* = significant at the .10 level
** = significant at the .01 level

The results of the model provide some evidence that Moran residents do indeed use the forest in an economic way unconstrained by local institutions. The overall fit of the model is relatively strong, with an adjusted R squared of .77. The F statistic of 112.3 exhibits a very high degree of significance.

The independent variables yield interesting and important results as well. First, stem count, elevation, and erosion are all significant "natural" variables (at the .01 level) that impact on pine dbh. All but erosion are in the hypothesized direction: as stem count and elevation increase, the dbh of pine decreases in this forest. One of the weaknesses of both the erosion and insects variables are their categorical nature: for erosion only three choices are possible (high, low, and none), and for the damage caused by insects only two (yes or no).

The only "social" variable that is significant (at the .1 level) in this model is distance to road. This variable is also in the hypothesized direction: as the distance from the plot to the road increases, so too does the average size of pine trees. By using the beta from this variable we find that for every 18.4 centimeters a plot lies away from the road, we can expect its pine trees to have another centimeter in diameter; or, for every meter a plot is located off the road, its trees will be 5.43 centimeters greater in diameter.

The insignificance of the distance to settlement variable is not surprising. Given the extreme slopes that surround the community, any direct line to a plot is difficult to travel (up and down ravines, through agricultural fields, etc.). Thus, it makes sense that an economic forager would use the road rather than the distance as the crow flies.

The second model attempts to use another biological indicator - stem count - as the dependent variable. The independent variables are the same (except for stem count) as in the first model, as are our hypotheses.

Model 2.

Stem count = Elevation + Steepness + Erosion + Insects + Distance to Settlement + Distance to Road

The results of the model can be found in Table 3. The fit of this model is also strong, with an F statistic of 6.19 significant at the .001 level, although not quite as strong as the first (it has one less independent variable). The results indicate that none of the "natural" independent variables in this model captures the variation of number of pine stems per plot. The only independent variable that turns out to be significant (at the .01 level) in this model is a "social" variable, viz. distance to road. Using the beta coefficient, this model predicts an increase of one pine stem on average per plot for every 18.74 centimeters a plot is located away from the main road; or for every meter a plot is away from the road, a plot contains 5.33 more stems of pine.

Table 3. Results of Pine Stem Count Model

	Intercept	Elevation	Steepness	Erosion	Insects	Distance to Settlement	Distance to Road
Coefficient	-6.019	.0018	-.0182	2.668	-.8529	.0091	.18736
std. Error	8.759	.0073	.124116	2.2093	1.9906	.0272	.0642
t-statistic	-.6872	.2467	-.1466	1.2078	-.4475	.3357	2.918
P-value	.498	.807	.8845	.238	.6582	.7398	.0072**

N = 33
R squared = .5885
Adjusted R squared = .4935
F statistic = 6.197224
Significance F = .00039

* = significant at the .10 level
** = significant at the .01 level

The only variable that is significant in both models is the distance to road. This result provides

evidence that members of Moran are using their communal forest in an economic way, i.e. in a manner that minimizes their efforts to obtain goods. The variance in both the number and size of pine was found to be negatively impacted by the nearness of the plot to the road near the community.

Conclusion

Given the incentives generated by their socio-bio-economic environment, it is not surprising that community members from Moran have not created institutions to manage their forest resources. Community members perceive their most valued forest products as relatively abundant, easily accessible, and under no threat from either insiders or outsiders. The community members' behavior matches what many observers would predict: with no incentive to manage the forest, they do not make efforts to do so. Qualitative data demonstrated that few local rules exist about accessing forest products. Quantitative evidence demonstrated that the pattern of use in the area conformed with optimal foraging theory, which omits all institutional influences on behavior: resources are sought only in an economically efficient manner.

This community is not incapable of constructing institutions: on the contrary, we found a bundle of rules regarding agricultural land and agricultural practices. Good agricultural land is in short supply and is highly valued. This is especially true given Defensores de la Naturaleza's policy that land use may not change, which has the effect of locking in the total amount of arable land in the community. We discovered - among other things - that community members hold yearly meetings to decide on the allocation of arable land within El Sitio, members negotiate among themselves to establish rental and sharecropping contracts, and members share an understanding about the rules regarding the burning of arable lands. The ubiquitous barbed-wire fences around land also indicate that community members take individual as well as collective action to protect those things they consider valuable and scarce.

But at this time, however, forest products are not thought to be scarce, and thus remain open-access resources for community members. This does not necessarily doom the forest: after all, the community has live there for a hundred years and a great deal of forested land remains. In fact, since the settlement's population is not growing quickly, the increase in forest use due to population pressure has been only slightly increasing. Consequently, while community members value agriculture more than the forest, the area for each is somewhat static in size and locals feel no great urgency to protect their forest resources.

This case helps provide evidence for the argument that two conditions are necessary for individuals to create institutions: dependence and scarcity. Certainly these are not sufficient conditions: the many additional conditions forwarded by researchers to account for successful collective action are surely important at different levels and combinations across different settings. But this paper has at least taken two of the many conditions often asserted and elevated their theoretical if not practical importance.

Bibliography

Arnold, J.E.M. 1998. Devolution of control of common pool resources to local communities: Experiences in forestry. Paper presented at the meeting of the UNU/WIDER Project on Santiago, Chile, April 26-28.

Ascher, W. 1995. *Communities and Sustainable Forestry in Developing Countries.* San Francisco, CA: ICS Press.

Robert C. Bailey, 1996. Promoting Biodiversity and Empowering Local People in Central African Forests. In *Tropical Deforestation: The Human Dimension,* ed. Sponsel, Bailey, and Headlund, pp. 316-337.

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

Bromley, D.W. 1992. Making the Commons Work. San Francisco: Institute for Contemporary Studies Press.

Gibson, C., McKean, M., and Ostrom, E. (eds.) 1998. Forests, Trees and People Programme. *Forest Resources and Institutions.* Working Paper no. 3. Rome, Italy: Food and Agriculture Organization of the United Nations.

Michael J. Harner. 1975. Scarcity, the Factors of Production, and Social Evolution. In *Population, Ecology, and Social Evolution,* ed. Steven Polgar, Paris: Mouton Publishers, pp. 123-138

Hayden, B. 1981. Subsistence and Ecological Adaptations of Modern Hunter-Gatherers. In *Omnivorous Primates,* ed. R.S.O. Harding and G.Teleki, New York: Columbia University Press, pp. 344-421.

International Forestry Resources and Institutions. 1996. *Field Manual*. Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington. Version 8.0.

McKean, M.A. 1992. Management of traditional common lands (*Iriaichi*) in Japan. In *Making the Commons Work: Theory, Practice, and Policy,* ed. D.W. Bromley et al., San Francisco, CA: ICS Press.

McKean, M.A. 1998. Common property: What is it, what is it good for, and what makes it work? In *Forest Resources and Institutions,* ed. C. Gibson, M. McKean, and E. Ostrom. Forests, Trees and People Programme, Working Paper no. 3, Rome, Italy:

Food and Agriculture Organization of the United Nations.

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action.* New York: Cambridge University Press.

Ostrom, E. 1992a. *Crafting Institutions for Self-Governing Irrigation Systems.* San Francisco, CA: ICS Press.

Ostrom, E. 1992b. The rudiments of a theory of the origins, survival, and performance of common-property institutions. In *Making the Commons Work: Theory, Practice, and Policy*, ed. D.W. Bromley et al., San Francisco, CA: ICS Press.

Ostrom, E. 1998. The international forestry resources and institutions research program: A methodology for relating human incentives and actions on forest cover and biodiversity. In *Forest Biodiversity in North, Central and South America, and the Caribbean: Research and Monitoring*, Man and the Biosphere Series, vol. 22, ed. F. Dallmeier and J.A. Comiskey, Carnforth, Lancashire, UK: Unesco and The Parthenon Publishing Group.

Ostrom, E., Gardner, R., and Walker, J.M. 1994. *Rules, Games, and Common-Pool Resources.* Ann Arbor: University of Michigan Press.

Ostrom, E. and Wertime, M.B. 1994. International forestry resources and institutions (IFRI) research strategy. Working Paper, Indiana University, Workshop in Political Theory and Policy Analysis, Bloomington, IN.

Schlager, E. 1990. Model specification and policy analysis: The governance of coastal fisheries. Ph.D. diss., Indiana University, Bloomington, IN.

Smith, E.A. 1983. "Anthropological Applications of Optimal Foraging Theory: A Critical Review." *Current Anthropology 24* (5):625-52.

Stephens, D.W. and J. R. Krebs. 1986. *Foraging Theory.* Princeton: Princeton University Press, 1986.

Wade, R. 1994. *Village Republics: Economic Conditions for Collective Action in South India*. San Francisco, CA: ICS Press.

Notes

1... This follows Ostrom's own call for further work in this area. See Ostrom 1990, pp.90-91.
2... The Reserve was created in 1990 by act of the Guatemalan Congress. Pre-existing legislation in 1989 had defin the Law of Protected Areas and served as the basis for the Reserve's legal definition.
3... Research teams collected data from randomly selected, 10-meter radius, circular plots at each study site. Withir each plot, mature trees (at least 10 cm in diameter at breast height) were examined to determine species, diameter, ar height. Sapling data are collected from 3 meter diameter concentric circles, and ground cover information from 1 m circles (IFRI 1996).