

Collective Choice and Community Forestry Management in Mexico: An Empirical Analysis

CAMILLE ANTINORI & GORDON RAUSSER

University of California, Berkeley, USA

Final version received January 2006

ABSTRACT *Democratic participation has increasingly become a natural resource management policy approach for governments around the world. Yet, its effective application across stakeholder groups remains a challenge. With original survey data from Mexico, a country with extensive common property forestland, we assess the effect of incorporating both local representation and outside technical expertise on forest management. Descriptive statistics show how existing community governance accommodates local management decision-making. The empirical analysis constructs and compares multidimensional indices for rule conformance and forest conditions with measures of local and professional service providers' involvement in community forums. Regression results suggest that active use of these forums for disseminating information and seeking management plan approval improves rule conformance, which, in turn, leads to better forest conditions.*

I. Introduction

Development practitioners strongly support the role of participatory management; yet implementing this approach has met with mixed results (Knox and Meinzin-Dick, 2001). Critics note that, at one extreme, complete devolution leaves local stakeholders without the technical guidance necessary to implement or maintain development plans (Klooster, 2002; Brett, 2003). Neither does it eliminate the need for local accountability. Recent studies now suggest a multi-layered approach that balances state regulation and oversight, technical input, and local decision-making (Ribot, 1995; Klooster, 2002; Brett, 2003; Platteau and Abraham, 2003). However, practitioners continue to find it difficult to design institutional decision-making

Correspondence Address: Camille Antinori, Department of Agricultural and Resource Economics, 207 Giannini Hall, University of California, Berkeley, California 94720-3100, USA.
Email: antinori@are.berkeley.edu

strategies that allow for accountability, access to information, and adequate stakeholder representation.

The few empirical analyses of participatory management explore relationships among collective action mechanisms, physical resource attributes, population characteristics, and performance measures, where the collective action mechanisms describe characteristics of the decision-making process. Fujiie et al's (2002) regression analysis includes past experience in communal organisations to explain rule conformance. Bardhan (2000) measures whether the government makes all decisions or whether farmers perceive that the local elite make all decisions to explain cooperation in using Indian irrigation systems. Yet, although the representativeness of the decision-making process is a fundamental concept in participatory management, few studies capture this concept with a context-appropriate measure. Ribot (1995) explains that while recently created Rural Councils in Senegal have given local villagers more control over the forest, the Councils themselves are hardly representative bodies. Chiefs are not accountable to the local villagers, and they may work directly with charcoal producers to harvest communal forests or with merchants to sell products. This form of exclusion of the less wealthy or politically powerful from resource management decisions has been associated with skewed income distribution patterns (Sundar, 2001). Atkinson (1995) argues that institutional analysis should consider who participates in decision-making and how this participation is engendered. Bargaining theory applies only to those at the bargaining table; thus, bargaining outcomes may be inequitable and inefficient depending on who participates in decision-making processes.

However, effective organisations must economise on decision-making time, particularly as their activities become more varied and complex. To facilitate operations and activities, groups commonly delegate authority to specialised managers. This also applies to targets of participatory management projects. General fora for discussion may be more appropriate for decision-making than are 'elected' leaders who may perpetuate patterns of local favoritism. But, as Brett (2003) argues, a blanket referral to general fora is too simplistic and belies the importance of hierarchy, market competition, and representative democracy. We echo this point and assert that organisations require expertise, low-cost decision-making, and management control mechanisms, all of which may be generated from bottom-up or top-down.

This paper explores these issues from two perspectives. First, we utilise unique survey data to describe the decision-making processes within the community. We observe that the venues for key decisions vary among the General Assembly (GA), community management authorities, and technical service providers in a pattern that is consistent with Zusman's (1992) observations that decisions that have greater expected marginal impact on individuals are made in the general forum, while decisions with lower expected marginal impact are delegated away from the GA.

The second part of the paper consists of an econometric analysis that tests relationships between decision-making characteristics and forest conservation measures. We focus on the interaction of foresters with the community, drawing on interviews with community authorities and technical forestry services provider for each community sampled. We asked foresters how they interacted with the community when preparing the forest management plan. Possibilities included discussing

and exchanging information in the GA; conversing in smaller, specialised committees; and engaging in local hiring to carry out inventories. There are two reasons why we expect some level of discussion about the plan in the GA. First, extraction of benefits from common property forests directly affects all community members. One would expect community members to be apprised of the scope of planned extractions. Second, such presentation and discussion provides an opportunity for participants to arrive at a better-informed and mutually agreeable plan that meets technical, state, and local expectations. We therefore argue that the forester's participation in GA discussion indicates that the community's collective decision-making processes incorporate a level of accountability and that the STF is engaging in an active participatory approach. Case studies corroborate this interpretation (Merino and Alatorre, 1997; Klooster, 2000). Using data from a sample of 44 Mexican communities or work groups involved in timber production, we find a positive relationship between foresters' use of the GA and conformance to management practices and healthier forest conditions, although other stresses, such as income and proximity to markets, are present. We also find that the variables form a recursive system where governance characteristics explain rule conformance, which then directly relates to forest ecological conditions.

As such, this research complements work that emphasises the need to address both sociodemographic and physio-geographic characteristics when designing management practices (see Deininger and Minten, 2002). Additionally, by characterising local stakeholder governance, we refine the meaning of 'participation', based on institutional access to and power over information. The results can be directly applied to situations in which technical personnel interface with local communities in advancing adaptive, ecosystem management approaches which incorporate both professional expertise and local knowledge.

II. Mexican Community Forestry

The Setting

In Mexico, the term 'community' has a legal and historical meaning that connects individuals to specific land territories. It derives its legal basis from Article 27 of the 1917 Constitution, which was created subsequent to the Mexican Revolution. The constitution mandates the redistribution or repatriation of large landholdings, concentrated under the *hacienda* system, to peasant populations. Groups of individuals who apply for agrarian community status may incorporate as a community under two legal fictions. Indigenous communities, or *comunidades*, consist of individuals who can claim that their ancestors originally occupied the land. *Ejidos* consist of individuals who, regardless of historical connection to the territory, have, as a group, acquired land redistributed from the *haciendas*. All land becomes property of the community. Individuals are given usufructory rights to plots for agriculture, livestock, and dwellings; however, they do not hold title nor are they able to sell the land outside the community. This rule changes only when the community has voted to privatise all individual plots, as provided by the Agrarian Reform of 1992, an action which has been mainly limited to urban *ejidos* (Goldring, 1998). Governance structure and ownership rights are similar in *ejidos* and in indigenous *comunidades*;

therefore, we will use the term ‘communities’ to refer to both institutional forms. Distinctions are otherwise noted.

Internal governance is a mix of pre-colonial traditions and modern political systems. Many indigenous communities practice a system of rotating civic and religious responsibilities among registered community members, based on merit accumulated by service in a rising hierarchy of civic positions, called *cargos* (Segura, 1988). In states with strong indigenous populations, *Usos y Costumbres*, as this practice is called, remains widespread. Each *ejido* and *comunidad* has a General Assembly, which is the supreme governing body that decides on all principal issues within the community. In the GA, each registered member of the community has one vote. Voting is by consensus or majority rule, depending on community practices. Assemblies meet a minimum number of times per year as required by law.

The *Comisariado de Bienes Comunales/Ejidales* (CBC), is the first line of administration for forestry operations and acts on behalf of the community as a whole. Elections to civic offices are held approximately every three years, and because the CBC/CBE position is among them, it may be unsalaried and the individual in office may have limited forestry management skills.

The implications for Mexico’s forestry policy cannot be understated. Approximately 80 per cent of national forest resources are held by communities (Snook, 1997), meaning that, to achieve its goals, forest policy must take into account communal forms of governance. Bureaucratic reform and community activism eliminated a restrictive federal leasing program in 1982, after which communities were allowed to freely enter and exit the wood products market. Professional forestry services, once organised by the government, are now privatised. In this case, devolution refers to removing restrictions on property rights and to augmenting the property rights ‘bundle’ that communities hold. Communities acting as collective organisations or as subgroups within the community now participate in the market as collective, non-industrial private foresters. They negotiate stumpage contracts with outside logging operations or vertically integrate into extraction and processing activities. New evidence shows that about 2000 communities, or 25 per cent of forested communities, hold logging permits (Antinori et al., 2004).

Communities have placed these new economic roles within the CBC’s purview; however, the collective decision-making processes vary across communities. The CBC may be directly responsible for managing timber production, or the community may form a commercial corporation (for example, a *sociedad* or *unidad*). Each individual member of the community is a *socio* – the term for a part-owner, partner, or shareholder in a labor-managed firm – yet, shares are not defined nor traded. The CBC may, as needed, appoint additional personnel to manage these community forestry enterprises.

The harvest of timber for commercial purposes requires a management plan prepared by a qualified forester and approved by the Ministry of Environmental and Natural Resources, known by its Spanish acronym, SEMARNAT. Beyond basic services, the forester–community relationship varies widely. The forester may provide technical training or hire locally for marking trees, inventory assessment, or treatments. S/he may act as a liaison with the private sector to seek markets and financing for projects and may attend Assembly meetings where forestry matters are discussed. Much depends on the forester’s particular training, experience,

preferences, relationship with the community and the limits established by the community itself.

Government programs have responded to a need for technical capacity-building within Mexico's community forestry sector. The *Programa de Conservacion y Manejo Forestal* (PROCYMAF) began in 1995 as an initiative designed to reorient and enhance professional forestry services in the community sector. In recent years, the program has focused on technical and organisational capacity-building within communities, according to their specific needs. Policymakers and community representatives have described the current issue of forestry management in Mexico's agrarian sector as one of institution building, where traditional organisations, capable of accommodating civic duties, are now being 're-engineered' to act as collective commercial production operations.¹ The following sections explore the scope of this re-engineering effort in the specific context of Oaxaca's community forestry operations.

Implications for Democratic Governance

Debate continues over precisely how participatory management works, what adequate representation is, and what the relationships to democratic governance are.² Numerous scholars have considered why, in collective choice settings, the opening of communication channels enables cooperative outcomes (Ostrom et al., 1994; Kopelman et al., 2002). John Stuart Mill describes the process of meeting for collective decision-making as one of personal transformation in that it places individuals in the position of facing a set of interests broader than their own (as cited in Rodrik, 2000). In common property settings, communication often occurs in existing decision-making fora or in fora created to address specific management problems. Voting acts like a communication device even when no other communication is possible, since the voting process offers individuals an opportunity to learn (Kopelman et al., 2002). Sociologists have long noted that even where consensus building is the norm or voting is held in general assemblies, consensus has often been achieved with a significant amount of discussion that eventually yields a decision (Fox, 1992).

But as collective endeavors become more complicated, how do organisations evolve to represent widening stakeholder interests, and to develop skills to remain productive? Any organisational structure will influence the interaction of participants (Zusman and Rausser, 1994), but productive organisations frequently resort to hierarchy or delegation of authority to facilitate day-to-day decision-making as the organisation's activity grows, while stakeholders monitor managers. Variations in organisational oversight structures and decision-making processes yield variations in outcomes. At the same time, access to specialised skills also remains a major issue for growth. In the realm of devolution and participatory management, Brett (2003) states:

Neither the strong nor the weak understandings of participation in the current literature take full account of the fact that these problems can only be avoided by combining hierarchy and expertise with participation in management systems. Participation will only be successful in producing good organisational

performance when it is operationised through institutional arrangement which maximise the accountability of agencies to users. (Brett, 2003: 1)

In the context of Mexican community forestry operations, we argue that the GA acts as the appropriate representation mechanism and communication channel which can accommodate information exchange between 'science' and local communities (Klooster, 2002). This point is particularly relevant to the current study site. Oaxaca's self-governance system has less state intervention at the local level than do other Mexican states (Fox, 1996). After Chiapas, Oaxaca has the second largest indigenous population, and *Usos y Costumbres* holds strong among the Oaxacan *comunidades* which far outnumber the *ejidos*. In 1998, the State of Oaxaca formally accepted *Usos y Costumbres* as an official alternative to the national electoral process (EDUCA, 2001). After this point, 73 per cent of Oaxacan communities vote by *Usos y Costumbres* and 54 per cent vote by a show of hands (Rendon, 1998).

We characterise judicial use of the GA as a community-level indicator for the degree of stakeholder participation. Since all communities have General Assemblies, organisational variations rest with the governance *process*, where voice and exit options simultaneously work to affect the level of civic functioning. If we are to believe the participatory management literature, the characteristics of the governance process should affect resources and the way people behave vis a vis those resources. One study of a Oaxacan community found that forest benefits were channeled to local bosses because they maintained the power to allocate jobs, distribute revenue under the table, and manipulate the General Assembly (Klooster, 2000). Many sought the approval of timber contracts through threats, bribes, and violence, rather than open discussion. Individuals harvested pine without following management plan guidelines or obtaining community permission. These examples exist in contrast to 'successful' communities that were characterised by well-attended General Assembly meetings. The next section summarises governance data from a survey of Oaxacan forestry communities to explore the delegation of authority and develop indicators for governance functioning which we later use in our econometric analysis.

Empirical Aspects of Governance

The sample of Oaxacan forest communities was surveyed from 1997 to 1998. Each observation represents an agrarian community which, based on SEMARNAT's permit files, produced timber commercially during at least one of the three harvest seasons 1994–95, 1995–96 or 1996–97. Out of a total population of 95 communities that produced 80–95 per cent of the commercial timber harvest in Oaxaca during this time period (*SEMARNAP*, 1999), a random sample of 44 observations was selected.³ The sample includes seven of the eight regions of Oaxaca,⁴ which cross climatic zones and ecosystems. Pine represents the bulk of the total authorised volume (82 per cent in the 1996–97 season). Interviews were first conducted in the communities, where any community member was able to attend, although questions were directed at community authorities and managers. Additional interviews to collect technical forestry data were conducted separately with the professional foresters who administered the communities' forests. Demographic data were obtained from the

Instituto Nacional de Estadística, Geografía e Informática's Conteo 1990 and Conteo 2000.

Survey questions explored decision-making processes for three aspects of timber production: preparation of yearly harvest volumes, choice of buyers, and profit distributions. Responses are illustrated in Table 1. Data are organised by most processed end product sold to compare governance structures and scope of collective commercial activities. The decisions vary in terms of the technical expertise and knowledge required to make a decision and the direct impact of the decision on stakeholders. The data are consistent with organisational theory and the collective choice literature, which indicate that detailed issues are delegated to authorised, specialised fora to economise on time and expertise and that decisions with more direct impacts on a broad constituency are decided in open forums (Ostrom, 1990; Zusman, 1992). The General Assembly rarely acts as a forum to prepare yearly harvest volume proposals. Rather, community authorities perceive that professional foresters are responsible for this task. Follow-up questioning revealed that setting harvest rates is often considered to be a technical decision that the General Assembly

Table 1. Community decision-making in timber production

	Vertical integration level				χ^2_3	Pr. diff = 0
	Stumpage	Roundwood	Sawnwood	Secondary products		
Key management decisions						
<i>Prepares proposed harvest volumes (n = 41*)</i>						
Forester	11	10	7	5	0.83	0.84
Community authorities	4	5	2	2	0.90	0.83
General Assembly	4	4	1	0	3.21	0.36
Other	6	1	0	0	9.10	0.03
<i>Chooses buyer (n = 30)</i>						
Forester	0	2	0	0	4.27	0.23
Community authorities	4	7	5	3	2.63	0.45
General Assembly	5	3	1	1	3.20	0.36
Other	3	2	1	1	0.75	0.86
<i>Decides distribution of profits (n = 35)</i>						
Forester	0	0	0	0	–	–
Community authorities	2	1	1	2	2.28	0.52
General Assembly	11	9	5	4	0.57	0.90
Other	2	1	1	1	0.31	0.96
Forester-community information exchange						
GA meeting discussions	6	6	5	5	2.86	0.41
Small group discussions	0	2	1	2	4.33	0.23
Local hiring	14	10	7	4	3.15	0.37
Other	5	5	4	4	1.69	0.64
Totals	16	12	8	7		

Note: *Due to multiple responses or missing observations, columns do not add to group totals.

Source: Survey data.

is not sufficiently informed to undertake. The second decision, the decision to choose a particular buyer, usually lies with community authorities. The forester is a much less frequent response, indicating that communities tend to separate technical and marketing issues. Finally, the distribution of profits concerns the entire community and is mainly decided at the General Assembly level.⁵

The above delegation patterns generally hold across vertical integration levels. For all three decisions, the χ^2 statistics testing differences in decision-making forum across vertical integration levels are mainly insignificant at the 10 per cent level or better, meaning that by conventional statistical standards, there is no pattern of differences across vertical integration levels. This is true in all cases except that the 'other' category appears more frequently as a response for the stumpage group in the harvest volume decision. Stumpage communities more often noted that the buyer was involved in this decision-making process. The responses as a whole illustrate that division of decision-making exists even at low levels of vertical integration. Each decision has a varied set of decision-makers, where the degree of participation of each actor may weigh differently, ranging from direct formulation of the decision to advice, oversight and approval.

The final set of data in Table 1 summarises foresters' responses to questions about how they worked with communities to develop management plans. The CBC is a forester's primary link to the community. Beyond interaction with the CBC, there is considerable scope for variation in how the forester engages with the community. The most common means are the General Assembly, advisory councils, locally hired teams for management planning or silvicultural treatments or all of the above, although the General Assembly is the broadest forum for communicating information. As seen in the table, variations in use of the GA are not associated with product type; however, further consultation with foresters revealed that the nature of the information exchanged varies across product types. As one forester explained, the more vertically integrated communities discuss forestry issues extensively and in more detail (for example, they touch on budgets, production, management) among themselves with little input from foresters although foresters are present as advisors. In less vertically integrated communities, which are often characterised by more limited knowledge of forestry issues, foresters tend to explain general information, and discussion frequently focuses on boundary issues and internal problems.

Other discussion fora include smaller advisory councils. These may be comprised of *caracterizados*, or respected or older members of the community who have completed much of their community service work, or may include others regarded as having valued knowledge. Foresters may also form smaller teams made up of CBCs and other officers to develop management plans before presenting them to the General Assembly. Finally, almost all foresters hired locally. Local participants typically assisted with preparatory work, including taking inventories and marking trees for harvest.

A lack of significant variation in these governance characteristics with vertical integration suggests that many of the basic principles of organisation apply even as an organisation becomes more complex. Therefore, the next step is to explore whether deviations in these governance principles vary with performance indicators selected for these community organisations.

Measuring Performance

Describing governance processes allows us to compare variations against objective measures of performance. While the exercise is never perfect, especially in complex institutional settings, we focus on two performance measures suggested by the literature. The first is ‘rule conformance’, a term used to indicate how well local residents cooperate with management guidelines. The second is the condition of the forest stock, which we term ‘ecological condition’. We will use these measures to statistically test the impact of the governance characteristics described in the previous section.

Resource performance measures typically focus on one measure, such as agricultural productivity or deforestation rates. However, these measures gloss over different dimensions of agents’ efforts. In institutional settings based on common property and communal governance, a single measure may be even less appropriate. Using confirmatory factor analysis, Lam (1998) shows the superior model fit of multidimensional versus single measure performance indicators in irrigation systems in Nepal. Concomitantly, we take a multidimensional approach to construct performance indicators for community forestry in Mexico.

For purposes of this discussion, rule conformance refers to the degree to which individual community members follow community-accepted forest management rules. We also measure the physical condition of a forest that encompasses ecosystemic services and commercial timber production. The two measures are designed to differentiate between community members’ actions and the physical condition of a forest. This distinction allows us to entertain the possibility that management efforts may not correspond to current forest conditions – a possible function of historical harvesting practices.

Components of rule conformance. In developing the rule conformance measure, we considered that forest management rules have developed through government intervention and regulation as well as through community customs and agreements. Jodha (1992) explicitly defines management in terms of people’s rather than governments’ interventions, given that stakeholders in a common property resource may have their own approaches to management. Our set of measures represents a mix of both government supported rules or actions and community practices. We sought professional judgments as to appropriate measures of rule conformance and ecological soundness, similar to the methodology followed in other studies of common property forests (Tang, 1994; Bardhan, 2000; Varughese and Ostrom, 2001). Additionally, we integrated community interview data into our analysis.

Components of the measure are summarised in Table 2. We asked foresters to rate the community as a whole on three aspects of forest management: community readiness for preventing and combating fires, clandestine timber harvesting, and clearing forestland. *Community readiness for preventing and combating fires* refers to how well residents follow practices to prevent fires, as well as to their responsiveness and readiness for fire outbreaks. Answers are recorded on a four-point scale. Human-induced fires are a leading cause of forest cover loss, and individual farmers frequently prepare agricultural plots according to the *roza-tumba-quema* scheme that uses fire to clear fields. Coal kilns are also common. As these are fairly old customs in

Table 2. Components of performance indices

Variable	Mean	Standard error	Number of observations
<i>Rule conformance</i>			
Organisational preparedness for fire prevention	2.00	0.14	39
Very high (=1)			13
High (=2)			15
Low (=3)			9
Very low (=4)			2
Clandestine timber harvesting commonly occurs?*	0.26	0.07	43
Forest land clearing occurs?*	0.26**	0.07	43
Extent of clearing			
None (=0)			32
Low (=1)			5
Medium/Large (=2)			6
Rules exist for fuel wood collection*	0.54	0.08	43
Rules exist for collecting wood for domestic use*	0.77	0.07	43
<i>Ecological condition</i>			
Per cent ha. with 'good' or 'very good' commercial quality	57.74	4.25	43
Per cent ha. 30–60 cm DBH	50.40	3.94	41
Per cent ha. with 'good' or 'very good' soil maintenance	73.84	5.00	38
Per cent ha. with 'very good' biodiversity	15.58	4.60	43

Notes: *Variable with 0 or 1 value, with 1 indicating a positive response; **Equality with clandestine harvesting is coincidental. Values represent different communities.

Source: Survey data.

Mexico, farmers are generally aware of precautionary measures. The timeframe of the survey (1997–98) included a particularly bad year for fires in Oaxaca. SEMARNAT also makes efforts to inform communities about fire prevention. This includes conducting educational presentations at regional or community meetings about individual and collective practices, such as fire brigades. *Clandestine timber harvesting* is a dummy variable that takes a value of one if a forester indicated that unmanaged extraction of commercial size trees was 'frequent' or 'somewhat frequent'. A third measure accounts for *clearing forestland* for agriculture or pasture. Individual community members may request permission from the CBC to clear a parcel of forest to plant crops. In a well-managed forest, the CBC limits this activity. This measure is a dummy variable. A value of one indicates that forest clearing occurred in the three years prior to the survey. An additional variable scales the severity of the clearing.

For community-derived data, we constructed two dummy variables for *rules for regulating collection of fuel wood* and *rules for collection of wood for domestic use*. Individuals typically collect wood from forests to use as fuel wood or domestic construction. Rules for fuel wood collection typically support customary practices of

collecting dead and fallen wood, rather than felling live trees. Timber collection rules include size and quantity limitations and sometimes require collectors to pay a fee to the CBC office.

Components of ecological condition. Ecological condition of the forest, in this paper, refers to the commercial potential of a forest, its ability to retain soil and protect water quality, and its degree of biodiversity relative to forests with similar physical and geographic conditions. Using survey interviews with foresters and reviews of management plans, we developed a combined measure of forests' ecological condition that account for marketable and non-marketable benefits. Where possible, these measures were checked against management plan data, field observations, and informal discussions with informants.

Foresters used a five-point scale to estimate the percentage of hectares that presented viable *commercial potential*. We asked respondents to consider the existence of commercial-quality species, average diameter at breast height (DBH), and climate and soil conditions. Management plans generally specify the distribution of standing timber by age classes or by DBH.⁶ Thus, our review of the management plan assessed the percentage of forest in merchantable timber as determined by size class. Foresters indicated that size and age correlated fairly well for the pine forests under their management.⁷ If an inventory was not available, we asked the forester to use his/her best judgment to provide a general estimation. For pine, merchantable timber is 30–60 centimeters DBH, or 30 to 60-years-of-age. Therefore, these data act as a measure of current commercial value and applies only to communities with pine stands.

Soil quality assessments considered soil coverage and erosion problems. Some management plans classify forest stands according to degree of erosion, and this information provides a check against foresters' responses. During the survey process, the most difficult variable to assess was *biodiversity*, given that foresters may not have training in species diversity and ecosystems, and can differ in their assessment of biodiversity within a single forest. Therefore, responses should be viewed as best approximations. We asked foresters to judge biodiversity by comparing a community forest to the level of biodiversity possible for that type of forest, considering climatic conditions, elevation, geography, soil type and spatial extension. Since the biodiversity measure is less refined as an estimate, we report only the percentage of hectares classified as 'very good.'

Empirical measures. We apply factor analysis to inform our choice of measures for rule conformance and forest condition. This technique is appropriate for explorations of hard-to-define characteristics – such as general ability, attitudes, intelligence, or, in this case, rule conformance – of which the observed variables are expressions. Factor analysis categorises relationships among a set of variables, based on their covariances, into a smaller set of factors. The technique weights, or loads, each variable per factor. Then, 'scoring' the factor, which involves calculating the weighted sum of variables, provides a single index representing a specific inter-relationship among the set of variables (Mardia et al., 1979). For rule conformance, the principal factorisation using the maximum likelihood method and retaining one factor gives all the variables a positive weight, meaning that they vary positively with each other (Table 3). Increases in any of the six variables – contraband, readiness for

Table 3. Factor loadings

Variable	First factor	Uniqueness
	Rule conformance, $n = 39$	
Fire control	0.541	0.708
Contraband	0.590	0.657
Clearing	0.954	0.091
Severity cleared	0.980	0.040
No fuelwood rules	0.300	0.912
No wood for domestic use rules	0.245	0.940
	Ecological condition, $n = 36$	
Biodiversity	0.245	0.940
Soil erosion	0.687	0.528
Commercial quality	0.325	0.894
DBH 30–60 cm	0.531	0.718

fire control, occurrence of clearing forested areas, severity of clearing, and lack of rules for gathering fuel wood or wood for domestic use – indicate less rule conformance. Although all variables contribute to the factor, the clearing variables carry the greatest weight.⁸ Hypothesis tests indicate that one factor performs better than no factors in explaining the data. Furthermore, the first factor sufficiently describes the data (at the 10 per cent significance level). We score the factor to create a rule conformance index and multiply the results by (-1) ; thus, increasing values indicate greater degrees of rule conformance (RC).⁹

Of the four components of ecological condition, soil erosion and distribution of size class are the most closely related variables, while biodiversity is least collinear with the other components. This suggests that characteristics associated with biodiversity are less associated with assessments of commercial value or soil retention. While it would be useful to distinguish these relationships in future research, we score this factor with all four components to create the ecological condition indicator, ECO.

Effects on performance measures. We propose that interaction between the foresters and community members at the General Assembly level during the course of plan approval represents an effective participatory mechanism to exchange information, which is expected to increase rule conformance and result in better ecological conditions. Although a community may have formed basic norms about where it is illegal to harvest trees, the use of foresters as technical experts helps to codify that information and to link specific individual actions into quantifiable benefits, such as timber revenues and soil retention, that result from adhering to the rules that communities and foresters work together to develop. This level of involvement indicates a meaningful combination of technical expertise with local knowledge – a mix that development practitioners often seek. We argue that this specific mix translates into better cooperation in the form of individual adherence to rules that support long-term management.

This type of involvement also indicates important aspects of community functioning. While the GA may not develop the technical aspects of a management plan, it has a role in ratifying decisions that directly affect a community as a whole. This process allows the GA to remain informed about harvest plans and general management guidelines. This measure also reflects a degree to which local elites are held accountable through the community's collective choice mechanisms. The forester-GA interaction indicates a political dynamic that incorporates outside operators, who are crucial to forest use patterns, into accepted decision-making procedures. Foresters who do not utilise GAs, it is hypothesised, are less successful in obtaining group cooperation in regard to forest management rules. Indeed, several communities in which foresters did not engage with the GA were marked by weak leadership, internal problems, exclusion of women from meetings, and a minimalist approach by the STF.

In the analysis, we also test the impact of other governance characteristics summarised in Table 1 on the performance measures. We suggest that the GA is a critical forum for deciding distribution of profits. Profit distribution has potentially large impacts on poverty alleviation efforts, through investments in public infrastructure and long-term forestry operations and management, and through generating loans, new businesses, and direct payments to individuals. Therefore, we argue, a community-level forum such as the GA acts as an appropriate venue for this type of decision-making.

III. Econometric Analysis

Model

The econometric analysis consists of estimating the linear regression model:

$$y = \alpha + \beta_X X + \beta_Z Z + \varepsilon \quad (1)$$

where $y = \{RC, ECO\}$ is the dependent variable; α is a constant; X is a vector of collective decision-making characteristics; and Z is the vector of production and community characteristics that may also affect rule conformance and ecological conditions. β_i , $i = (X, Z)$ are the coefficient vectors to be estimated and ε is the error term. The expected signs of the independent variables in vector X and a selected set of variables in vector Z are illustrated in Table 4.

For the *collective decision-making characteristics*, forester-community interaction is a binary variable that takes the value of one if a forester attended GA meetings as a venue for interacting with the community to bring the management plan to completion. We expect GA involvement in profit distribution decisions to have a positive effect on RC and a positive, but weaker, effect on ECO. We construct a binary variable where a value of one corresponds to an indication that the General Assembly was the forum in which profit distribution was decided, thereby generating a positive influence on individual community member behavior and condition of the forest stock.

Production characteristics consist of kilometers of logging roads for both performance measures and, additionally, years of harvesting for the ecological condition measure. Logging roads may positively or negatively affect the indicators

Table 4. Expected signs

	RC	ECO
<i>Collective decision-making characteristics</i>		
Forester-GA interaction	+	+
Profit distribution decision in GA	+	+
<i>Production characteristics</i>		
Logging roads	—	—
Years of harvesting	0	—
Vertical integration	+	+
<i>Community characteristics</i>		
Income	+	+
Coffee production	—	0
Distance away from capital	+	+
Distance to population center	+	+
Parcelization	—	?
Forested ha. per capita	—	—

as defined. Roads can facilitate access and encourage forest exploitation; yet, better roads can enhance responsiveness to fires and may be integrated into an overall sustainable forestry management plan. The ecological condition of a forest, however, is a stock variable which may be tempered by historical use patterns. Years of harvesting may degrade and thin forests. This factor is expected to have a negative impact on ecological health. In the regression model for RC, the coefficient for years of harvesting is restricted to zero.

Vertical integration often provides more added value from forest management and may therefore provide individuals with an incentive to manage forests according to accepted practices. This variable also represents increasing market integration because larger amounts of capital and labor are required as an operation advances along the production chain. However, because this form of integration only encompasses one economic sector, it may exhibit weak effects.

General *community characteristics* include economic, population, and land tenure indicators. The average income level proxy is the percentage of persons who receive income from owner-operated stores in the community, assuming that the shops represent an availability of wealth to generate a demand for goods. Communities in the sample are significantly distant from each other; thus, the presence of a store offers real convenience for local residents. This proxy is expected to have positive impacts on both performance indicators because of individuals' reduced reliance on marginal activities that degrade the forest.

Coffee, a significant source of non-timber forest income and another community descriptor, grows in the warmer regions of Oaxaca and correlates positively with lower altitudes. Under the shade-tree method practiced in these regions, coffee plots compete with timber production because they require shade and mulch provided by broad-leaved trees that have low commercial value.¹⁰ The variable for coffee production takes the value one if coffee production occurs in the community. Coffee production is expected to have a negative but weak effect on RC because individuals may be tempted to change the species mix to undermine the pine-oak structure.

Additionally, coffee plots may provide individuals with incentives to respond efficiently to fires. In addition, during the nineties, coffee prices decreased. This may have placed increased pressure on farmers to diverge from group rules.¹¹ Effects on ecological conditions are more difficult to predict. While shade-tree coffee plots support soil retention and biodiversity, their cultivation may erode pine species' timber values without loss of tree cover (Blackman et al., 2002).

Continuing with the list of community characteristics to be included in the empirical analysis, geographic proximity to major population centers acts as a measure of market integration and therefore exit opportunities, which we predict will have a negative effect on performance. A binary variable represents whether the forest is parceled among individuals. While forests technically remain common property and are managed under a single management plan, five communities in the sample maintain a form of parcelisation in which individuals have usufructory rights over particular plots in the forest, for use as woodlots, hunting grounds or coffee plots. In some cases, this type of parcelisation dates back to the community's founding. Parcelisation is expected to have a negative effect on rule conformance and ecological conditions because not all community members may necessarily have access to parcels, a system that creates unequal access to and additional pressure on the commons. For example, contraband harvesting of timber or non-timber goods was reported in all five communities that maintain parceled forests. Finally, the number of forested hectares per community resident acts as a measure of land scarcity. This variable is expected to have a negative effect on both rule conformance and ecological conditions.

Summary statistics for these and other community characteristics are given in Table 5. While the ecological condition variable is distributed as a roughly normal curve, about half of the observations for rule conformance are distributed evenly up to the 0.58 median value, with the other half clustering around the median. This pattern suggests a synergistic effect among the variables that form the rule conformance index. When a community as a whole scores high on one variable, it tends to score high for other aspects of cooperation with forest management practices. A low score for one variable, on the other hand, indicates a more random adoption of management practices that increases the variability of cooperation. For example, none of the high-scoring communities (that is, ≥ 0.58) ranked in the lowest two categories for fire responsiveness, none had problems with contraband logging or clearing of forest land, and a higher percentage of these communities maintained operating rules for collecting firewood or wood for domestic use. The separate components appear to capture similar effects; this supports the decision to combine them into a single index.

However, our distribution poses problems for the usual fit for an ordinary least squares (OLS) regression model because the process that generates the error terms is most likely different across the sample, thus violating the assumption of constant variance. The variance is also correlated with the GA-forester involvement variable, as many of the communities scoring higher in the rule conformance index also have a one for the involvement variable. We apply two econometric techniques to address this pattern in the data. First, we split the sample between high and low scoring observations at the median value of RC and estimate the model as a probit regression. Second, we use the generalised least squares (GLS) with weights applied

Table 5. Timber production and community characteristics: sample statistics

Variable	Mean	Standard error	Number of observations
Rule conformance	0*	0.16	39
Ecological condition	0*	0.13	36
Kilometers of logging roads	61.65	9.88	43
Years harvested since 1986	8.58	0.58	43
Frequency of coffee production	0.37	0.08	43
Meters above sea level	1549.26	97.05	43
Per cent pop. receiving income from retail shops	5.01	1.00	42
Population	815.18	91.76	38
Forested hectares	5455.33	858.59	43
Forested ha. per capita	0.50	0.15	38
Hours driving to capital	5.26	0.57	43
Share of non- <i>comunero</i> households	0.06	0.03	42
Village distance to forest (Values equal 1, 2 or 3)			
<3 kilometers			15
3–12 kilometers			15
≥12 kilometers			13
Vertical integration level			
Stumpage			16
Roundwood			12
Lumber			8
Secondary products			7

Note: *By construction, the principal factor has a zero mean.

Source: Survey data and *Instituto Nacional de Estadística, Geografía e Informática, Censo 1990*.

to each variable in the regression model. The weights are proportional to the amount of variance in the error term explained by the independent variable, GA-forester involvement. We do this by regressing the squared errors of the OLS model on the involvement variable and using the results to generate the weight.

Results for Rule Conformance

Columns 1–3 in Table 6 report results for rule conformance for the OLS, probit, and GLS models. All three columns indicate that the forester–GA involvement variable has positive and significant explanatory power for RC and is robust to various model specifications. This supports our hypothesis that the GA is an appropriate forum for technical information exchange. The weights in the GLS model (Column 3) tend to reduce the standard errors for the forester–GA involvement variable, so that the *t*-statistic is slightly larger, but coefficients, signs and significance are similar to the OLS model.

The regression results across model specifications are also similar with respect to the sign and significance of the other independent variables. Across equations, coffee is negative and significant, which is consistent with the prediction that competition with timber production discourages conformance with overall forest management rules. To check whether the coffee dummy masked differences due to elevation, we substituted it with meters above sea level, a variable that is negatively correlated with coffee

Table 6. Estimation results

	Rule conformance				Ecological condition	
	1	2	3	4	5	6
	OLS	Probit 1 = RC > median	GLS	IV	OLS	OLS
Forester-GA involvement	1.56** (7.37)	2.44** (2.79)	1.48** (7.68)	1.46** (3.36)	0.77** (2.45)	–
Coffee production	–1.08** (–4.82)	–2.28** (–2.25)	–0.76** (–3.86)	–0.75** (–4.10)	–0.11 (–0.33)	0.30 (0.88)
Ln(km logging roads)	–0.35** (–3.69)	–0.63* (–1.90)	–0.23** (–2.97)	–0.23** (–2.78)	0.07 (0.50)	0.22 (1.60)
Income	0.15** (4.66)	0.22* (1.83)	0.12** (3.86)	0.12** (2.78)	0.02 (1.55)	–0.01 (–0.15)
Distance to capital	0.08** (2.87)	0.28** (2.19)	0.06** (2.70)	0.06** (2.98)	–0.06 (–1.52)	–0.09** (–2.23)
Distance to population center	0.10** (2.05)	0.24 (1.65)	0.07** (2.01)	0.07** (2.20)	0.02 (0.24)	–0.04 (–0.49)
Years of harvesting RC					–0.08* (–1.85)	–0.08* (–1.97)
					–	0.43** (2.46)
Constant	–0.63 (–1.34)	–1.41 (–1.04)	–0.72* (–1.99)	–0.71* (–1.66)	–0.01 (–0.01)	–0.44 (0.62)
Number of observations	38	38	38	38	35	35
R ²	0.73	.46	0.70	0.70	0.28	0.28
Mean VIF	1.35	–	1.72	–	1.54	1.50
Ramsey OV test <i>p</i> -value	0.00	–	0.00	–	0.66	0.27

Notes: Numbers in parentheses are *t*-statistics. *** denotes statistical significance at the 5 per cent level and ** at the 10 per cent level. The null hypothesis for the Ramsey omitted variable test is that there are no omitted variables.

($\rho = -0.54$). However, the coffee dummy has more explanatory power. The altitude measure is strongly collinear with distance to the capital and has no significant explanatory power when this distance measure is dropped from the regression.

Both the logging road network and income variables have the expected signs and significance across equations. A more extensive network of logging roads has a negative and significant coefficient, which is consistent with the deforestation literature. The income proxy has a positive and significant impact on rule conformance. We compared results with other proxies for income and well-being (obtained from INEGI), such as the percentage of households that rely on fuel wood or gas for cooking. We alternately substituted these for our income proxy and generated qualitatively similar results.

The market proximity variables have a relatively consistent influence across regression models. We observed a conventional level of statistical significance for the

variable for the distance to the capital, meaning that communities further away from the capital city are more likely to enjoy greater rule conformance. This supports predictions that exit opportunities generally challenge collective action efforts (de Janvry et al., 2001; Platteau and Abraham, 2003). In the present context, we observed that the increased demand for fuel wood and wood for domestic use near population centers encouraged contraband harvesting. The variable for distance to nearest population center is positive and significant, except in the probit model where it falls slightly below the 10 per cent threshold of significance.

We report statistics that indicate the degree of multicollinearity and note the omitted variables for the RC model. The variance inflation factor (VIF) technique, which is applicable for the OLS and GLS models, checks for multicollinearity by calculating the multiple correlation coefficients of the explanatory variables (Chatterjee and Price, 1991). All mean VIFs for the RC regressions are far less than the rule-of-thumb standard of 10; thus, evidence of multicollinearity is weak. We also tested for omitted variables using the Ramsey method. For the GLS model in Column 3, we reject the hypothesis that there are no omitted variables; therefore, there may be additional effects that the model does not capture. This also fits with our finding that the weights applied to the GLS model did not significantly remove heteroscedasticity present in the model. This finding is often associated with the possibility that the model omits variables unknown to the researcher.

We alternately added the other variables in Table 4 to the base GLS model specification.¹² The analysis reveals that taking the profit distribution decision in the GA is positively associated with rule conformance, while taking the decision by the CBC is negatively associated with rule conformance. However, in the regression results, these variables are not statistically significant. The result may be due to lack of enough variability in these factors or to a more nuanced relationship with cooperative group behavior. Future research will explore further this decision making process, such as which accountability mechanisms or de facto consensus-building activities may be in place.

Vertical integration into the wood products market is also not significant, indicating that a range of production possibilities are consistent with forest conservation and management goals within the community governance framework. Any added market access that vertical integration represents does not affect RC.¹³ Therefore, forests remain vulnerable to individual exploitation or neglect at all levels of vertical integration into the timber industry. The measure may also lack significance because all communities in the sample receive a basic level of added value from forests. While it is interesting that increased added value above this basic level, represented by increasing vertical integration, does not affect RC, future research could look at communities where no organised timber production is occurring.

We also included the parcelisation dummy and forested hectares per capita and dropped the distance variables to reduce multicollinearity evident among these variables. Neither had significance in this regression model (not shown). Thus, while parcelisation has potentially a divisive effect on cooperation, it is possible that the historical context of parcelisation along with other variables may mitigate tensions. These results support Geist and Lambin's (2002) conclusion that public and individual decisions regarding deforestation respond to local institutional factors.

A vast literature on deforestation indicates that several micro- and macroeconomic factors predict human behavior and forestry impacts. However, across studies, few variables provide consistently similar results. Angelsen and Kaimowitz (1999) find that road infrastructure, increases in agricultural prices, lower wages, and lack of off-farm employment generally increase deforestation rates. Institutional factors have received less attention; however, tenure security and reliable enforcement of contracts have been associated with lower deforestation rates. On the other hand, Deininger and Minten (2002) found that *ejido/comunidad* tenure did not affect deforestation rates in Mexico. Because of Mexico's particular agrarian system, we do not frame the current problem as one of tenure security, but as one of governance. Although scholars do not agree about relationships, we believe it is prudent to control for other variables that have been suggested in the deforestation literature.

To preserve degrees of freedom for a relatively small sample size, we alternately add to the base GLS model additional variables associated with cooperation and with the condition of forest commons. None of the following variables returned statistically significant results: size of forested holdings, proximity of the village center to the forest, percentage of non-*comunero* households (as a measure of heterogeneity),¹⁴ existence and level of CBC payment, and dummies for mountainous regions (Sierra Sur or Sierra Norte).

Instrumental Variables

In Column 4 we test the exogeneity of the forester–GA interaction variable by applying the instrumental variables (IV) technique. This technique entails identifying variables that correlate with the independent variable in question, that is, forester–GA interaction in the management plan decision, but do not correlate with the error term (Deaton, 1997). The instruments, as a set, should explain variations in forester–GA interaction without significantly affecting the dependent variable we are seeking to explain, that is, rule conformance. As instruments, we found that vertical integration and years working with the current forester are positively correlated (ρ equals approximately 0.30) with the forester–GA interaction variable, significantly explain (singly or as a set) the forester–GA interaction variable in first stage results and pass the test of excluded instruments at the 4 per cent level or better. Neither do they significantly explain rule conformance when added to the models shown in Columns 1–3, thereby supporting our choice of base model specification. We maintain weights applied to the GLS model for the IV version. Column 4 presents IV estimates with vertical integration as a single instrument. Results are very similar to the non-instrumented GLS estimates, and the model passes the standard Wu-Hausman test for endogeneity ($F=0.002$, $Prob.=0.96$). While the t -statistic for forester–GA interaction drops from the GLS model, it maintains statistical significance at conventional levels and R^2 values are essentially the same. The evidence suggests that the base GLS model is fundamentally sound.

Results for Ecological Condition

Next, we examine the OLS estimation for ECO. Column 5 in Table 6 shows that the GA-forester interaction variable explains a higher measure of ecological

condition. Coffee production is non-significant, perhaps due to a positive impact of shade-tree production methods which may support biodiversity. To check the possible interpretations for the coffee dummy, we again substituted altitude for the coffee dummy in the regression. Altitude did not provide significant explanatory power, thus supporting the biodiversity hypothesis. The logging road variable falls below conventional standards of statistical significance in the ECO model, giving a result at odds with other studies that use road density as an explanation for deforestation rates. The difference in primary use of roads may explain this discrepancy. In our sample, the variable refers to roads that are used for movement of timber under a collective management system; but many studies measure road networks according to individual access to forests. Our results coincide with observations by Bray et al. (2004), which suggests that this variable may be affected by other factors, such as location and the distribution of road networks.

Longer history of harvesting contributes to forest degradation (at the 10 per cent level). A question arises of whether these effects are caused by prior eras of forest policy, during which communities had less control over production, or if they relate to continued forest management practices, under greater community supervision, that degrade forests. We substituted a binary variable to represent pre-1986 harvest activity. This analysis generated a negative, but statistically insignificant, coefficient estimate. Combined with the more significant result for the duration of harvesting activity, this suggests that the effect is cumulative over time.

Unlike in the rule conformance regression, the income proxy and distance variables, surprisingly, have no measurable effects. These results tend to be inconsistent with other deforestation literature, where greater distance between a community and an urban center has a positive impact, presumably due to lower opportunity costs. We interpret the results as due to, first, the fact that ECO is a multi-dimensional stock rather than a flow variable, and, second, to institutional factors which exhibit mitigating influences.

Overall, the ECO model performed rather poorly as compared to the RC model, according to the R^2 statistic, although there is little evidence of multicollinearity or omitted variables. The model fit improves somewhat by adding the total size of forest, which has a positive influence on the ecological measure, as a greater forest size would increase the scope of biodiversity and commercial potential.

Checking the other variables from Table 4, the vertical integration, parcelisation and forest hectares per capita variables do not have statistical significance nor do they change the other results when added to the model. Also, literacy rates and the variables often associated with deforestation provide little explanatory power in the ECO equation.

The sample size became too small to reliably report the effects of other governance characteristics like the profit distribution variable. However, we re-evaluate the path relationships between the governance characteristics and ecological conditions. We hypothesise that rule conformance (RC) works directly on ecological condition of the forest through the behavior of individual community members, as expressed in the rule conformance index. This is a reasonable scenario because the rule conformance index accounts for individual actions regarding forest management which would affect the forest ecology over time. This postulation implies that we can

determine the endogenous variables sequentially and that there is unidirectional relationship where the endogenous variables earlier in the sequence affect those later in the sequence, but not vice versa. In this approach, we set up a recursive model. A recursive system assumes that the correlation between error terms across equations is zero and that the endogenous variables in lower equations do not explain those in higher equations. We found that the correlation between the error terms in the RC and ECO regressions are sufficiently low ($\rho = -0.14$) and ECO does not explain RC when added to the GLS model of Column 3, Table 6. These conditions suggest that the two equations, ordered first as RC and second as ECO, represent a recursive system where OLS applied to each equation is the optimal estimating technique.

Column 6 of Table 6 presents the results of this exercise. On the whole, the results are remarkably similar to Column 5. The RC variable positively and significantly contributes to higher measures of ecological condition, as would be expected. Further, RC accounts for a similar amount a variation in the ECO model as did the forester–GA involvement variable, as seen by comparing the *t*-statistics in each equation. The variables which were significant in Column 5 remain significant with the same signs in Column 6. Most of the insignificant variables also remain insignificant, except for distance to the capital city, which now has a significant negative influence on ECO, amplifying its tendency from the equation in Column 5. The R^2 values as a good-of-fit measure round off to the same number, showing no predominance of one model over the other. The evidence suggests that both models conform to the data. However, we posit that the recursive system represented by the RC equation (Column 3) and the ECO equation (Column 6) is a more useful tool for guiding future research. The system explains the performance measures as sequential, where governance characteristics affect choices which later translate into impacts on the forest.

Together, the regressions exhibit interesting contrasts between the rule conformance and ecological condition models. The performance measures represent different aspects of forestry which are affected differently by the same set of variables. Although a community may collectively invest in its resource base, the process may be slow to register discernible improvements in resource stocks. The regressions indicate that, except for forester–General Assembly interactions, variables that influence RC are distinct from those that explain ECO. The ECO model is more limited in its explanatory power, but it shows that broad dissemination of information through General Assemblies is correlated if not determinant of both rule conformance and forest attribute quality, while historical logging practices also affect current forest condition. The income proxy exhibits a significant, positive effect in rule conformance and a positive but insignificant effect on ecological condition. We find that while proximity to population centers, as one proxy for exit opportunities, does decrease rule conformance, it has a more ambiguous effect on ecological conditions. Thus, it is unclear whether economic opportunities necessarily erode ecological conditions, particularly if institutional processes counteract the negative tendencies. Finally, the processes generating rule conformance and forest ecological condition are sufficiently independent that they can be presented as a system of relationships in which rule conformance contributes positively to the ecological performance measure.

IV. Conclusion

This paper has presented the transition of Mexico's communities into forest management as an initial study in institution building. The recent entrance of Mexican communities into the wood production market has introduced a new economic role for traditional rural institutions. Which governance structures and decision-making processes will achieve community-accepted forestry management goals which require both individual and group level choices? Ribot (1999) states that '[Participatory approaches] must use or construct local representation if they are to proceed' (p. 1). In this case, the choice is to do both. Broad-based participation between foresters and community members via the General Assembly is closely related to positive outcomes in forest management practices and forest ecological conditions. Even where technical decisions are delegated to specialised community subgroups, government officials and professional service providers may be more effective in achieving management goals if they incorporate broadly inclusive forums for presenting technical information at some point in the decision-making process. The evidence presented here suggests that such fora, in this case, the General Assemblies in Mexico, are appropriate for technical information exchange to improve cooperation in management and forest conditions.

Our research suggests several avenues for further study. First, the approach used in this paper could be generalised to community resource management efforts elsewhere in the world, where technical expertise is used in combination with community governance systems and local knowledge. Devolutionary policies struggle to find a balance between a need for specialised committees and broad, inclusive decision-making. The organisational and decision-making principles discussed here could be extended further to 'unpack' local versus state governance in natural resource management. Second, the difference in statistical findings between the rule conformance and ecological condition measures indicates that institutional factors have varying impacts on these performance measures. Much work remains to be done to capture various socio-political-cultural nuances through empirical analysis and to link measures to a theoretical framework for collective action.

Acknowledgements

We wish to thank the participants of the Center for the Study of Institutions, Population, and the Environment Colloquium; Environmental Resources and the Spatial Economics Seminars at the Agriculture and Resource Economics Department, University of California-Berkeley; and the 2002 World Congress of Environmental Economics. Thanks are also due to Allen Blackman, Gary Casterline, Daniel Klooster, Maureen Lahiff and two anonymous referees for invaluable comments on earlier drafts. We gratefully acknowledge the financial support of UC MEXUS and the Ford Foundation.

Notes

1. Thank you to Pedro Vidal for elucidating this point.
2. See proceedings from the biennial conference of the International Association for Common Property Research, 2004, Oaxaca, Mexico for an array of case studies and theoretical work addressing these

- questions. See proceedings of the 2000 annual meeting of the American Economics Association, *American Economic Review*, 90(2), for other theoretical perspectives.
3. This fieldwork was conducted as part of a larger project on vertical integration of communities in the timber industry. See Antinori (2000) for a complete description of the data.
 4. Number of observations per region is as follows: Cañada – 1, Costa – 5, Istmus – 3, Mixteca – 4, Sierra Norte – 14, Sierra Sur – 11, Valles Centrales – 6.
 5. We also collected information on attendance rates in the General Assembly to discuss harvest proposals. Of those groups that said they meet for this purpose, meeting attendance rates generally exceed 50 per cent, with little variation across type of end product sold. Considering that a quorum of 50 per cent is required to convene, the critical variations are between half and three-quarters of the community population. In our sample, all except one community reported that greater than 50 per cent of the community voting population was present at General Assembly meetings, suggesting a fair degree of community participation in forestry matters at each level of vertical integration. Due to lack of variation among a small sample, we do not test the impact of attendance rate.
 6. Many management plans today apply the *Metodo de Desarrollo Silvicola*, which establishes a system of even-aged stands with seed-tree regeneration. This system is favored over the older method of *Metodo Mexicano de Ordenación de Montes* that permitted less intensive cuts but tended to impoverish the genetic strength and composition of Oaxaca's pine-oak forests (Snook, 1997).
 7. If information for the forest stand was not aggregated, we asked for average ages/DBH for each rotation area or subdivision (*rodales* and *subrodales*) and averaged these to obtain an age/DBH class distribution.
 8. The principal component scoring, which drops the assumption of normality, results in weights comparable to the factor loadings.
 9. See Lam (1998) and Fujiie et al. (2002) for other examples that use principal components or factors as measures of performance for common pool resources.
 10. Individuals in communities that engage coffee cultivation indicated a desire to change the species mix from pine to broad-leaf and oak tree species, stating that pine needles were not a good mulch (*abono*) for the coffee plants.
 11. Thank you to Allen Blackman for suggesting this point.
 12. Further details are available from the authors.
 13. This is consistent with previous research that found evidence that the form of contractual arrangement affects investments specific to the production process (Antinori, 2000). The vertical integration variable is exogenous, as integration decisions were made several years prior to 1998, the year for which the ecological indicators apply. Most stumpage communities had been harvesting in this manner for several years.
 14. These persons are generally classified as *posesionarios* or *avecindados* under Mexican agrarian law. Non-registered status means that an individual cannot attend General Assemblies nor can s/he have access to common pool benefits, such as revenues generated from collective timber operations.

References

- Angelsen, A. and Kaimowitz, D. (1999) Rethinking the causes of deforestation: lessons from economic models, *World Bank Research Observer*, 14(1), pp. 73–98.
- Antinori, C. (2000) Vertical integration in Mexican common property forests. Doctoral dissertation, University of California, Berkeley.
- Antinori, C., Magana, O., Torres Rojo, J., Bray, D. and Segura, G. (2004) New evidence of Mexican community forestry. Paper presented at the International Association for the Study of Common Property, Oaxaca, Mexico.
- Atkinson, G. (1995) Efficiency vs. Equity: a false dichotomy, in C. M. Clarke (ed.) *Institutional Economics and the Theory of Social Value: Essays in Honor of Mark R. Tool* (New York: Kluwer Academic Publishers).
- Bardhan, P. (2000) Irrigation and cooperation: an empirical analysis of 48 irrigation communities in South India, *Economic Development and Cultural Change*, 48(4), pp. 847–66.
- Blackman, A., Albers, H., Avalos, B. and Crooks, L. (2002) The determinants of land use in a managed forest ecosystem: Mexican shade coffee. Unpublished draft.

- Bray, D., Ellis, E., Armijo-Canto, N. and Beck, C. T. (2004) The institutional drivers of sustainable landscapes: a case study of the 'Mayan zone' in Quintana Roo, Mexico, *Land Use Policy*, 21(4), pp. 333–46.
- Brett, E. A. (2003) Participation and accountability in development management, *Journal of Development Studies*, 40(2), pp. 1–29.
- Chatterjee, S. and Price, B. (1991) *Regression Analysis by Example* (New York: John Wiley and Sons).
- de Janvry, A., Dutilly, C., Muñoz-Piña, C. and Sadoulet, E. (2001) Liberal reforms and community responses in Mexico, in M. Aoki and Y. Hayami (eds) *Communities and Markets in Economic Development* (Oxford: Oxford University Press).
- Deaton, A. S. (1997) *The Analysis of Household Surveys: A Microeconomic Approach to Development Policy* (Baltimore: Johns Hopkins University Press).
- Deininger, K. and Minten, B. (2002), Determinants of deforestation and the economics of protection: an application to Mexico, *American Journal of Agricultural Economics*, 84(4), pp. 943–60.
- EDUCA (2001) La eleccion en municipios de usos y costumbres, Technical report, Servicios para una Educacion Alternativa (Educa A.C.) and Comision Diocesana de Pastoral Social de Oaxaca, Oaxaca.
- Fox, J. (1992) Democratic rural development: leadership accountability in regional peasant organizations, *Development and Change*, 23(2), pp. 1–36.
- Fox, J. (1996) How does civil society thicken? The political construction of social capital in rural Mexico. *World Development*, 24(6), pp. 1089–103.
- Fujiie, M., Hayami, Y. and Kikuchi, M. (2002) The conditions of collective action for local commons management: the case of irrigation in the Philippines. Technical Report 2002–002, Foundation for Advancement on International Development (FASID), Tokyo.
- Geist, H. J. and Lambin, E. (2002) Proximate causes and underlying driving forces of tropical deforestation. *Bioscience*, 52(2), pp. 143–50.
- Goldring, L. (1998) Having your cake and eating it too: selective appropriation of *ejido* reform in Michoacan, in W. A. Cornelius and D. Myhre (eds) *The Transformation of Rural Mexico* (San Diego, CA: Center for US-Mexican Studies, University of California).
- Jodha, N. (1992) Common property resources: a missing dimension of development strategies. World Bank Discussion Papers, No. 168, World Bank, Washington, DC.
- Klooster, D. (2000) Institutional choice, community, and struggle: a case study of forest co-management in Mexico, *World Development*, 28(1), pp. 1–20.
- Klooster, D. (2002) Towards adaptive community forest management, *Economic Geography*, 78(1), pp. 43–70.
- Knox, A. and Meinzin-Dick, R. (2001) Collective action, property rights and devolution of natural resource management: exchange of knowledge and implications for policy. Technical Report CAPRI, Working Paper, No. 11, International Food Policy Research Institute, Washington, DC.
- Kopelman, S., Weber, J. and Messick, D. (2002) Factors influencing cooperation in commons dilemmas: a review of experimental psychological research, in E. Ostrom, T. Dietz, N. Dolsak, P. C. Stern, S. Stonich and E. U. Weber (eds) *The Drama of the Commons* (Washington, DC: National Academy Press).
- Lam, W. F. (1998) *Governing Irrigation Systems in Nepal: Institutions, Infrastructure, and Collective Action* (Oakland, CA: Institute for Contemporary Studies).
- Mardia, K. V., Kent, J. and Bibby, J. (1979) *Multivariate Analysis* (London: Harcourt Brace Jovanovich).
- Merino, L. and Alatorre, G. (1997) *El Manejo Forestal Comunitario En Mexico y sus Perspectivas de Sustentabilidad*. Universidad Nacional Autonoma de Mexico, Centro Regional de Investigaciones Multidisciplinarias; Secretaria de Medio Ambiente, Recursos Naturales y Pesca, Centro de Educacion y Capacitacion para el Desarrollo Sustentable; Consejo Mexicano para la Silvicultura Sostenible, World Resources Institute, Cuernavaca, Morelos.
- Ostrom, E. (1990) *Governing the Commons: The Evolution of Institutions for Collective Action* (Cambridge: Cambridge University Press).
- Ostrom, E., Gardner, R. and Walker, J. (1994) *Rules, Games and Common-Pool Resources* (Ann Arbor: University of Michigan Press).
- Platteau, J. and Abraham, A. (2003) Participatory development in the presence of endogenous community imperfections, *Journal of Development Studies*, 39(2), pp. 104–36.
- Rendon, I. (1998) La otra eleccion Oaxaqueña, *La Reforma*, 28 September, p. A1.
- Ribot, J. (1995) From exclusion to participation: turning Senegal's forest policy around?, *World Development*, 23(9), pp. 1587–99.

- Ribot, J. (1999) Decentralization, participation, and accountability in Sahelian forestry, *Africa*, 69(1), pp. 23–65.
- Rodrik, D. (2000) Participatory politics, social cooperation, and economic stability, *American Economic Review*, 90(2), pp. 140–4.
- Segura, J. (1988) Los indigenas y los programas de desarrollo agrario 1940–1964, in J. Pablos (ed.) *Historia de la Cuestion Agraria Mexicana: Estado de Oaxaca* (Mexico City: Centro de Estudios Historicos del Agrarismo en Mexico).
- SEMARNAP (1999) Estadísticas del sector forestal. Internal document.
- Snook, L. (1997) Uso, manejo y conservacion forestal en Mexico, in J. B. Luisa Pare, D. B. Bray and S. Martinez (eds) *Semillas para el Cambio en el Campo: Medio Ambiente, Mercados y Organización Campesina* (Mexico City: Universidad Nacional Autonoma de Mexico).
- Sundar, N. (2001) Is devolution democratization?, *World Development*, 29(12), pp. 2007–23.
- Tang, S. Y. (1994) Institutions and performance in irrigation systems, in E. Ostrom, R. Gardner and J. Walker (eds) *Rules, Games and Common-Pool Resources* (Ann Arbor: University of Michigan Press).
- Varughese, G. and Ostrom, E. (2001) The contested role of heterogeneity in collective action: some evidence from community forestry in Nepal, *World Development*, 29(5), pp. 747–65.
- Zusman, P. (1988) *Individual Behavior and Social Choice in a Cooperative Settlement: The Theory and Practice of the Israeli Moshav* (Jerusalem: Magnes Press, Hebrew University).
- Zusman, P. (1992) Constitutional selection of collective choice rules in a cooperative enterprise, *Journal of Economic Behavior and Organization*, 17, pp. 353–62.
- Zusman, P. and Rausser, G. C. (1994) Intraorganizational influence relations and the optimality of collective action, *Journal of Economic Behavior and Organization*, 24(1), pp. 1–17.