Vertical Integration in Mexican Common Property Forests

by

Camille Marie Antinori

B.A. (University of Pennsylvania) 1984
M.S. (London School of Economics and Political Science) 1985
M.S. (University of California, Berkeley) 1993

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Committee in charge:

Professor Gordon C. Rausser, Chair
Professor Irma Adelman
Professor Louise Fortmann
Professor Brian Wright

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The dissertation of Camille Marie Antinori is approved:

Chair *Date*

Date

Date

Date

University of California, Berkeley

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Abstract

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One of the missing links in common property research is investigation of the interaction between common property resource users and the market. The present research fills that gap with a study of communities, Mexico's *ejidos* and *comunidades*, which coordinate timber production within commonly-owned forest land. The key research questions are: under what conditions does a local community overcome obstacles to cooperation among its members to conduct downstream timber products businesses as opposed to selling raw material, and does the pattern of industrial organization reveal complementarities in investments between timber and nontimber production? The focus on community-level production rather than individual production under a common property resource regime also distinguishes this paper from much of the common property literature.

The dissertation adapts contract theory to Mexican local community control over timber production from communally-held forests to explain a choice of contracts, given community-level characteristics. The research methodology consists of model formulation, development of a survey instrument and empirical estimation of the model based on data gathered through the survey and secondary sources.

A basic argument is that community forward integration into downstream timber processing activities is observed for two reasons. First, it reduces the transaction costs of guiding development according to community objectives, which demands decision-making over time in response to changing environments. Second, community forward integration reduces transaction costs of managing forest ecosystem services which inherently require adaptive management approaches. This argument is formally presented as propositions then empirically tested. A corollary states that communities exploit complementarities between timber and nontimber production more efficiently than private, single product firms, leading to more nontimber production under community forward integration.

A survey was administered to a random stratified sample of 42 communities in Oaxaca, a state in southern Mexico. The communities fall into four main categories of vertical integration according to the most processed product sold – stumpage, roundwood, lumber or finished wood products. A summary of the survey data describes the transition of community governance structures into timber production units. Results of the econometric analysis are consistent with the theoretical predictions. Communities opt to integrate forward when able to overcome start-up costs of human capital expertise and organization to guide development within the community. In turn, vertical integration in communities leads to further nontimber production, indicating that economies of scope exist between timber and nontimber production. Conclusions suggest implications for policy makers and common property theory and areas for future research.

Gordon C. Rausser, Chair *Date*

To my parents

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Chapter 1

Introduction

A vast amount of natural resources are held as common property - where a specific group of people own and manage resources in common. Yet, only in the last 20 years has research recognized the role of common property in production, risk diversification, poverty alleviation, natural resource management system and cultural heritage (Jodha 1992, Ostrom 1990). Research has sought to explain how people overcome obstacles to collective action which sustain common property resource management systems, avoiding the predicted tragedy of the commons, in which overexploitation occurs.

Less research has explored how resilient common property institutions are to changing market opportunities. A challenge is to describe common property within a larger market structure. Privatization programs, often a centerpiece of economic development programs (DeWalt et al. 1994, Cousins 1996, Scott 1998), can change fundamental relationships between land and people. A rich case study literature focuses on the characteristics of long-lasting common property management (Ostrom 1990, Hess 1999, McCay and Acheson 1987). Game theory models seek to explain evolution of common property (Sethi and Somanathan 1996). What has been missing from the literature, however, is a systematic focus on stakeholders in a common property resource responding to larger market opportunities as an alternative source of benefits provided by the common property asset. Little research exists on the "economic context of successful arrangements" (McKean 1997) and the commercialization of extracted resources. Observing community choice among a set of management and control options could identify how people value common property and if alternative management systems can provide those benefits.

Posing the question in this way focuses on why ownership matters. Coase (1937) argued that with zero transaction costs, property rights should not matter to the outcome, although there are distributional consequences. But rural communities often exhibit missing markets for labor, credit and public infrastructure, introducing substantial transaction costs (Morduch 1995). Ownership guarantees access to a stream of benefits over time even when those benefits cannot be completely defined in advance. The literature on incomplete contracting refers to this concept as the residual rights of control of the owner (Grossman and Hart 1986, Hart 1995). This assured discretion over the asset can be important when other opportunities are scarce. A key argument is that property rights are the result of uncertainty and unforeseen contingencies. Given a set of parameters, one property allocation may be more efficient than another property allocation.

Much theory has been written about the efficiency properties of separating ownership from control. The principal-agent and mechanism design models optimize over a set of strategies where delegating responsibilities is efficient (Holmstrom 1982, Holmstrom and Milgrom 1994). Hiring a manager to carry out a task is more efficient than doing the task oneself because of different expertise levels between the owner and manager, provided that moral hazards are addressed in the contract. These models assume that all strategies and contingencies can be defined. Who owns which assets is not explained. Given a variety of contracting arrangements, a question is when would a group of stakeholders in a common property resource find it important to manage and control the resource as well as own it.

With this set of issues in mind, fieldwork in Oaxaca, Mexico was conducted to provide data for such a study. Oaxaca has one of the largest concentrations of communal forests and community forestry - almost 90% of forests in Oaxaca are held as common property, typically by indigenous communities that have maintained a historical political structure. From the 1940's to 1982, the Mexican government leased much of its forests to semi-public, semi-private pulp manufacturers. After years of conflict with local communities, the governmental did not renew their leases in 1982, when leases expired. The timber industry shifted from the parastatal firms to community-based timber production. In 1986, laws formally recognized communities' legal right to exploit their own timber resources. A community today which owns a forest and sells timber commercially can choose to integrate forward by extracting and processing the timber with its own capital equipment and labor, or it can contract with outside private harvesting firms and simply sell the timber at stumpage value. The transition from communities being unable to commercialize their timber resources to a political environment in which they could provides a unique opportunity to test theories of collective action and property rights. Rather than privatization imposed through government policy, the extent of management control is left as choice by the local community population, given their status quo position of communal forest land holdings.

This thesis advances a property rights model of bargaining between outside private firms and local communities with communal forest land holdings to explain vertical integration in the timber industry. The modeling framework based on the contract literature reflects the choices facing communities with forest resources today. The central question is the "sell-or-make" decision: when does a local community invest as a group in downstream harvesting operations and when does it contract with outside firms for the extraction and processing? The silvicultural techniques for managing a forest for industrial activity and the actual extraction process both require specific investments in physical and human capital. If the community integrates, it can avoid the bargaining problem of dividing up total revenue whenever the contract is renegotiated. This promotes community investments in both stages of production. However, the community may lack expertise, reducing its efficiency of investing. Communities balance comparative advantage in skills and resources with costs of bargaining.

The main argument is that control over common property assets provide both economic development and natural resource management benefits. Many communities with common property resources face uncertainty in production income, food sources and job security. In addition, resources for public goods may be unavailable. Control over the common property management is important because of the complexity of directing resources in the local economy. Second, viewing the forest as an ecosystem, timber production has potential impact on nontimber benefits such as soil maintenance, water quality and food sources. Multiple-use strategies of local populations vis a vis the forest pose opportunities to capitalize on complementarities between timber production and other forest ecosystem services. The common property resource acts as a buffer to shocks and a public reserve of goods and services.

Since common property is used to balance risk and uncertainty, the application of the incomplete contract literature and contract theory in general is particularly appropriate. Contract theory directly addresses problems of uncertainty and complexity of production cycles (Hart and Moore 1990, Grossman and Hart 1986, Hart and Moore 1999, Maskin and Tirole 1999b). A main assumption is that complete, comprehensive contracts are infinitely costly to write. Each party's awareness that haggling will occur distorts the level of investments away from first-best outcomes. While first-best outcomes may not be feasible, properly assigning ownership rights depending on the characteristics of the market, production processes, weights on noncontractible elements of a trade and the investments achieves at least second-best points (Hart 1995). Subcontracting by its nature requires renegotiation during the period of the contract. Haggling reduces the incentives to invest under certain conditions. The analysis here focuses on how to allocate property rights when 1) nontimber benefits are important, 2) scale economies and labor/capital complementarities exist, 3) parties to a contract have different abilities and 4) specific physical investments have already been made. By observing the pattern of ownership over the industry, inferences are made on how property rights allocation is important to managing uncertainty.

An empirical analysis using ordered logit tests the model of vertical integration. Data on management efficiency, investments characteristics and resource characteristics allow testing of the relationship between these variables and the sell-versus-make choice. Variables to compare alternative interpretations are included in the analysis.

Further, common property management inherently implies multiple-use strategy towards the commons. Rather than separate tasks, timber production may be only the beginning of an entire management plan for the forest as a whole. This paper argues that communities capitalize on economies of scope once they have integrated forward. Vertical integration leads to greater investments in nontimber benefits because of knowledge spillovers in timber and nontimber production. Using data on investments in nontimber activities, ordinary least squares and instrumental variables regressions statistically assess the impact of vertical integration on nontimber investments. It is shown that vertically integrated communities are more likely to invest in nontimber benefits due to scope economies between timber and nontimber production.

To the author's knowledge, no one has applied these recent advances in the theory of the firm to common property resource problems that emerge. In many ways, the community utilization of the resource is an industrial organizational problem. Placing the community's decision over management control within a vertical integration scenario and changing parameters of the model can identify basic economic rationale and where further research is needed. The research contributes to the economic literature since few empirical applications of incomplete contracts theory have been attempted.

The broader application of studying forest management in Mexico is the growing interest in how local communities participate in public resources management. Even when private property systems predominate, changing attitudes and new scientific evidence concerning natural resources can expand the scope of decision-making to external stakeholders. This research can tell us the extent to which activities are separable in both an ecosystem management and economic sense so that adequate management systems, either market or institutional, can be developed. Studying the response of forest communities in Mexico provides information on the impact of land tenure reforms. The research also sheds light on the prospects for community forestry activities across communities that currently do not manage or have minimal participation in timber production.

The paper is organized as follows. Chapter 2 reviews the property rights literature as developed in economics, sociology and political science. Specific sections discuss ecosystem management, cooperatives and vertical integration as they relate to the present study. Chapter 3 presents background information critical to an understanding of community forestry in Mexico, followed by a description of the sample and survey design and a summary of the survey data according to its relation to property rights theory. With this background understanding, Chapter 4 links the theory with the empirical study and presents a model and hypotheses based on the transaction cost and incomplete contracts literature. Chapter 5 discusses the empirical approach, econometric models and econometric results. The final chapter draws conclusions from the analysis.

Chapter 2

Literature Review

This review bridges the property rights literature found in the anthropology, sociology and political science fields on the one hand, and economics on the other. These approaches to property rights theory share themes of risk, uncertainty and transaction costs, but overlaps are rarely synthesized. Doing so provides a rationale for the theoretical adaptation of the incomplete contracts model in Chapter 4.

This chapter features six sections. The first reviews common property theory, from Garrett Hardin's *Science* (Hardin 1968) article on the "tragedy of the commons" to theories of cooperation. The next section reviews ecosystem management approaches in relation to institutional design.

An extensive literature on industrial organization seeks to explain patterns of asset ownership and is the focus of the remaining sections. The third section reviews the economic theory of the firm, information and transaction cost economics and their implications for property rights. The recent literature on incomplete contracts, in particular, builds on the notion of residual rights of control – rights not specified in contracts concerning the property. This section motivates the model in Chapter 4, where it is argued that a premium for control over assets leads communities to integrate into timber production. The fourth section draws attention to related empirical research. The final two sections review theories of cooperatives and the impact of vertical integration on economic behavior, respectively.

2.1 Common Property Theory

The tendency to dissipate rents in open access resources has long been recognized, perhaps earliest by Aristotle in *Politics* (Aristotle 1943). More recently, it received particular attention as the "tragedy of the commons" in Hardin (1968). While the article confuses open access with common property resource management regimes, it serves as a convenient introduction into common property and property rights research in general.

Hardin's powerful metaphor for ecological disaster centers on the free-riding problem which inhibits collective action over resources with free and open access tenure regimes. A goatherder puts her flock on common land but does not consider the crowding costs of an extra goat to the other goatherders. Furthermore, if this goatherder does not put the goat on the common land, someone else will. There is no incentive for the goatherder to employ restraint. The inability to exclude people from enjoying benefits of others' cooperation diminishes any one person's incentive to cooperate by restraining themselves from adding an extra goat. Because anyone can cheat undeterred, collective action falls apart. The result is an exhaustion of the open access resource, the grazing field.

Despite Hardin's prognosis, many groups of people have persistent self-governing common property management regimes and research in the past twenty years cites numerous examples (Hess 1999). In many cases, local stakeholders in a common pool resource (CPR) have successfully established rules to manage the CPR without exhausting it. This seeming paradox partially rests on confusion between open access resources (*res nullius*) with common property (*res communus*). Open access means that no one can claim exclusive rights to a resource and anyone can exploit it. The resource has no owners and, therefore, cannot be "property." On the other hand, the present thesis uses the term "common property systems" to refer to regimes in which rights are assigned to a distinct group of people who decide on the rules of access (Ciriacy-Wantrup and Bishop 1975, McCay and Acheson 1987). A taxonomy of common property management regimes is a complex and nuanced undertaking. "Communal management" refers to "user-governance and local-level systems of common pool resource management (McCay and Acheson 1987) (p. 115), and "co-management" to a mixture of local and state governance over a publically-owned resource.

Policy responses to resource management problems typically include government action or market-based innovations. With government intervention, the public policy maker takes externalities into account in setting policy to maximize social welfare. However, the policy tools of government intervention and privatization may not be appropriate in all circumstances. The disadvantage of government control is that informational needs are rarely fulfilled (Farrell 1987, Ostrom 1990).

Privatization is not successful in many cases because of transaction costs posed by culture and history. As a measure to reduce deforestation, privatization may actually have the opposite effect, depending on intensive and extensive production effects of increasing labor productivity that can reduce or augment deforestation (Scott 1998, Angelsen 1999). Culture and history can preclude effectiveness of privatization programs in advancing economic growth and reducing conflicts, and can have adverse welfare consequences. For example, Palsson (1999) writes that "[c]ommon rights in fish are deeply embedded in Icelandic history and national identity, underlining the traditional notion that fish can only be transformed into commodities through the act of catching." The current attempt to adopt individual transferable quota systems to Icelandic waters has led to a recent Icelandic Supreme Court decision that favored this traditional notion. In Zimbabwe, land appropriation by whites sabotaged new privatization efforts after Independence in 1980 because neighboring people saw the land as their traditional lands (Goebel 1999).

A large body of theory exists describing the pattern of tenure systems (Johnson and Libecap 1982, Barzel 1989, Baland and Platteau 1996, Eggertsson 2000, Libecap 2000). Common property resources often exist in relatively high-risk, low-productivity areas, where few factors favor privatization or where there are concerns for collective sustenance and ecological fragility. Examples of common property include forest lands, irrigation systems, watersheds and fisheries. Its functions include food supply and income generation, risk diversification and contributions to employment (Jodha 1992, Bardhan 1993, Wilson and Thompson 1993, Nugent and Sanchez 1998). For example, in a study of Indian villages, Jodha (1992) found that the poor spent more hours in activities involving common property resources than on their own farms. Including income generated from common property lowered the Gini coefficient, a measure of income inequality. He concludes that economic development which ignores the management systems operating within communities may lead to ecological and environmental damage (Jodha 1992). Rural and developing economies frequently have missing markets in finance, employment or public resources for risk diversification (Morduch 1995). Common property's role in risk diversification raises the question of how people balance their decisions over the resources.

In addition to resource characteristics, social interaction, norms, culture, historical events affect the evolution of institutional regimes (Greif 1995). Although the hypothesis that property rights change as a person's valuation of the good changes may hold truth, legal systems have treated property not as a relation between "men [sic] and things" but as "sanctioned behavioral relations among men" (Furubotn and Pejovich 1972, McCay and Acheson 1987). For example, the legal system in the United States has been increasingly challenged by the shift in attitudes from what Sax (1993) calls the transformative economy to the economy of nature. The growing recognition of the ecosystem value of nature raises questions as to how far private property owners need be compensated for changes in the law that seek to protect ecosystem value of land, whose benefits exceed that of the private owner's. Zoning laws are another example which date back in the United States to at least the previous century (Nelson 1995). Therefore, the predictions on tenure type according to person's valuation of a good ignore other factors that determine property rights.

Game theory models frequently explain the existence of common property regimes in terms of recurring interaction among players. The tragedy of the commons metaphor is similar to a prisoners' dilemma game in which non-cooperation is the (sub-optimal) Nash equilibrium (Dasgupta and Heal 1979). A *repeated* game builds trust and reciprocity to overcome the free-riding problem and may yield Pareto optimality (Axelrod 1984, Ostrom 1990). Seabright (1994) found that past incidences of cooperation led to further cooperative actions, thus having a "habit-forming" effect. A drawback to repeated prisoners' dilemma games is multiple equilibria, substantially limiting its predictive power. Based on evolutionary theory, Sethi and Somanathan (1996) depicts players who persistently cooperate or defect over time, depending on initial conditions. This result is consistent with general observations that common property regimes are long-lasting once established. The model leads to a path dependency interpretation of cooperation, where historical events are critical to future cooperation over the commons.

Leadership abilities are a focal point in other studies of collective action (Buchanan and Tullock 1962). Leaders may provide public goods in seeking a leadership surplus, the resources the leader collects in excess of costs (Frohlich, Oppenheimer and Young 1971). Rausser and Zusman (1992) constructs a governance function in which special interest groups are the unit of analysis yet the central government exercises a degree of autonomy. Constitutional rules can be chosen to minimize the adverse impact of corrupt leaders or increase the internalization of group goals. Such models suggest transition paths for countries, and communities, in deciding which collective choice rules to adopt given their characteristics (Rausser and Simon 1992).

The social capital literature suggests another source of collective action. In this dissertation, social capital refers to Putnam's and other authors' conceptualization of social capital as the obligations, expectations, information channels, social norms and trust relationships that facilitate exchange among people (Coleman 1988, Putnam 1995, Knack and Keefer 1997). Social capital is an asset, investments in which enhance social cohesiveness, the bonding effect of shared experiences or visions among individuals in a society. The development literature claims that such characteristics enhance growth and income and facilitates collective action to create public goods.[1] Referring to grassroots political organizations in Mexico, Fox (1996) calls the ability of local organizations to create links regionally or nationally a "scaling-up" process. He identifies pathways that the scaling-up of social capital has taken: local independent movements, the intervention of local outsider organizations such as churches and non-governmental organizations and the intervention of motivated state reformers. External actors in particular serve the function of protecting local populations from retribution from authoritarian leaders.

The importance of understanding property rights lies not only in efficiency aspects for society but also equity issues. Given any property rights allocation,

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[1]For a review of the literature from an economics perspective, see Dayton-Johnson (2000). See Birner and Wittmer (2000) for a discussion on the relationship between social capital and political capital.

the prescription which maximizes total social welfare results in an efficient level of demand, production mix and income distribution while another allocation results in a different level, mix and distribution which is also efficient. The problem is one of creating a property rights regime that leads to the highest level of social welfare among the possibilities. The Coase Theorem says that property rights do not matter to the outcome, provided transaction costs are zero, but initial allocation of property rights matters considerably for the payoffs to individual members of society (Coase 1960). Cohen and Weitzman (1975) showed the distributional consequences of market integration where common property became privatized. Their proposition is that a change in norms, not an increase in demand for wool, led to the English Enclosure Movement. As landlords' objectives shifted from valuing the number of men under their protection to profit maximization, the authors argue, landlords chose a lower labor level so that depopulation occurred. Remaining workers received lower wages and less overall returns from the gross national product than under the common land holding system.

A recent trend in management policy promotes participatory management. Local participation in development projects encourages local populations to contribute and sustain the project, which is especially important if they will eventually own and manage assets produced through the project (Isham, Narayan and Pritchett 1994, IBRD 1996). From within a capitalist firm, worker participation in management has efficiency and social equity benefits, and can reduce feelings of alienation in the workplace (Greenberg 1986, Levine 1995).

Local empowerment also encourages decision-making that takes account of local people and builds the capacity to address local problems and respond to external threats (Kusel and Fortmann 1991, Olsen 1999), but the mechanisms through which local control and well-being are linked are not always clear. In a study of the

Pacific Northwest, (Kusel 1991) sets out compelling examples. It is claimed that decision-making by non-local actors are made without regard for community well-being (p. 120). He describes how mill closures, modernization, restructuring and lower wages reduced "community capacity," described as the capacity to maintain and improve local opportunities, the ability to persist and the energy devoted to communal issues (pp. 121,151). The narrative mentions at least seven ways that the industry changes adversely affected community capacity (pp. 121-153). First, layoffs required that wives work for an income. This dried up the volunteer labor pool that provided time and effort for public services, as well as time with families, and put increased pressure on women. The economic shifts meant that less income was available for consuming in the local area, adversely affecting local businesses. Psychological stress increased significantly. Social networks declined with the loss of jobs. Local schools, a focal point of the community, lost their connection with the older generation as the younger generation moved away. Newer residents and long-time residents experience a form of cultural gap so that long-time residents felt alienated from the community. Finally, local poverty intensified as cheap housing caused by the layoffs attracted an unemployed population influx, exacerbating poverty in the community. In observing resident's anger at the layoffs, he notes that "part of the frustration was having no control over what was happening and not knowing if they would be able to hold their jobs" (p. 123). Community action can counteract these effects. Local involvement in a sediment removal project proposed by Pacific Gas and Electric Company for its hydroelectric dams led to creative solutions that trained and hired among the local population at greater rates with longer-lasting impacts than had the company proceeded with the original plan to grant the entire project to an outside construction firm. These examples illustrate how managers in non-local private firms, even if well-intentioned, make decisions different from locally-organized community groups and the consequences of those diversions.

Serious questions about the effectiveness of local decision-making remain. The disadvantages of local community management include cooptation by local elites of the resource, lack of technical expertise, and ineffective institutions (Land Tenure Center 1995, Ostrom 1990, Wade 1994). Fox (1992) examines the history of an *ejido* union, focusing on how leadership accountability varied with members' ability to exercise "voice" or "exit" options in the organization, drawing on Hirschman (1970). Indicators of governance to judge accountability include mechanisms of representation, channels for participation, the degree to which "exit" is an option which strengthens "voice" and the interactive effect of the holding the local leader responsible and autonomy from state intervention.

The common property literature should be distinguished from the present study. First, common property literature has far to go in modeling the interaction of local populations with common property resources. Ostrom deliberately avoids a specific model because of the complexity of common property institutions. In this study, the collective action decision is to integrate forward into timber production activities or to transact through the marketplace for selling timber resources. Each progressive step of forward integration requires more organization by the community. Community-level characteristics affect the community's propensity to integrate production activities at the community level. Characteristics at the community level describe initial conditions of human and physical capital, social capital, resource characteristics and use patterns of the resource, as suggested by the literature reviewed. However, these characteristics are aggregated into a representative individual who makes investments. This paper presents an innovative application of the theory of the firm. The theory of the firm paradigm is one in which an individual entrepreneur invests effort and money, makes rules to manage assets, receives the residual income, and contracts with agents for services. The modeling framework in Chapter 4 puts two principals in a bargaining mode rather than in a principal-agent relationship. The set of principals in this study is the community on the one hand and the outside buyers on the other. In other words, the community has solved the collective action problem in their choice to integrate or not integrate. The characteristics of the community are parameters in the modeling framework which affect the resulting collective action decision of vertical integration. The actual bargaining process among the n-individuals in the community is assumed to occur in the background and is affected by these parameters in a way to be explained in the following chapters.

Second, trade between the common property stakeholders and outside firms over the common property resource is rarely considered. Whether a developing region that experiences growing market integration or a developed region with high degrees of market integration, the choice to act collectively can be placed within a larger choice set, given opportunities available to the individuals involved. This study clarifies community-level choices given broader options in production than is considered in literature.

Third, the Mexican agrarian communities are formal institutions that are adapting to a new role in resource production, whereas much of the common property literature assesses informal institutions not recognized by the state apparatus, even though these institutions can represent long-existing stable rules. Therefore, the focus is on how they manage control over their common property forests as well as other asserts used in timber production

2.2 Ecosystem Management and Institutions

Emerging ecosystem management research takes as a premise the uncertainty involved in natural resource management. Part of the uncertainty is due to the interdependencies among different biological levels and species (Cortner 1996, Amaranthus 1998, Hosford, Pilz, Molina and Amaranthus 1997, Pilz and Molina 1996, Sedjo 1995). Forest management increasingly sets more than one goal in forest planning, such as managing for both biodiversity and commercial ends. With adaptive management approaches, feedback from past management practices informs and updates current management plans (Mather 1999, Michie, Chandrasekharan and Wardle 1999, Gordon 1994, Romm 1994).

A concurrent trend in environmental and development policy of devolving property rights over natural resources to local community management systems has important links to ecosystem management approaches. Among the advantages of devolution are reduced conflict, promotion of biodiversity (Getz, Fortmann et al. 1999) and maintenance of important food supplies, sources of employment and cultural traditions (Breckenridge 1992, McCay and Acheson 1987, Breckenridge 1998). Policy makers have begun to link the environmental standard of "sustainability" to empowerment of local communities and the formulation of rights for marginalized peoples. Local community rights support the environmental agenda of preserving biological diversity because of local knowledge of the ecosystem, human practices which promote biodiversity, community organizations which have developed systems of resource management, and values which place greater weight on the preservation of resources. Further, local community property rights may be necessary insofar as the land resource is integral to community identity and survival.

Community management or co-management departs philosophically from private ownership or government management. These approaches emphasize cognitive, normative and regulatory solutions. To paraphrase Jentoft (1989), they are more about process and the way process is organized. These approaches empower and legitimize users of resources and involve them in the decision-making. If users get more "functional managerial responsibility" they will behave more responsibly, it is argued. Where the new institutional economics is overly legalistic, organizations rather than market or legal mechanisms provide a third way to avoid the tragedy of the commons (Hanna and Jentoft 1996). The institutional arrangements required by ecosystem management are consistent with devolution. Local community decision-making is seen as a way to include local knowledge into ecosystem management. It may also allow conflicting interests in the resource to reach agreement (Kemmis 1989).

The actual means and results of local participation in forest planning are anything but clear (Gericke, Sullivan and Wellman 1992, Duane 1997). There are considerable questions as to how to mix regulation, property rights and local participation in resource management (Yost 1998, Milstein 2000). Consequently, strong resistance exists to devolution of resource management to the local level. Some in the U.S. claim that devolution is unlawful and that the government needs to beef up the current system of governance and laws and improve information flows (Coggins 1998). External groups such as citizens at large and remote populations that nevertheless depend on the resource for soil, water, or air quality should also have a say in resource management (McCloskey 1998).

2.3 When Ownership Matters in Economic Theory

Walras (1898) recognized that property rights were a vector of rights, including the right to sell the services of the asset, allocate the asset as the owner likes, and receive the returns from the asset. Where branches of the economics literature define ownership as having the claims to the residual *income streams*, a bundle of rights implies that ownership has claims to the residual *rights of control* which the owner exercises when unforeseen contingencies arise. Ownership would not matter in a world where all contingencies could be accounted for. In that case, people could write contracts for every contingency – a situation called complete contracts – and ownership would be meaningless. The dichotomy of residual streams or losses and complete contracts on one hand, and residual rights of control and incomplete contracts on the other, distinguishes the property rights approach.

Traditional economics envisions the firm as a production set. Resources like labor and capital are allocated according to market prices. If property rights are not efficient, then market forces would mold them into optimality. The theory, however, does not explain the boundaries of the firm (Salanié 1997).

Coase's view of the firm as a contractual authority relationship has been a benchmark in the theory of the firm literature to explain the ultimate size and scope of a firm (Coase 1937). A disgruntled customer, for example, can walk away from a supplier and not transact again, without any consequences, but the employer does not transact with an employee on this same basis. Coase sees the boundaries of the firm as the point where the transactions are as easily negotiated within the firm as in the open market, Williamson (1985) identifies four types of these costs: costs of writing contracts, costs of negotiating contracts, costs of enforcing contracts, and costs of breaches of contract. These costs are largely unobservable or nonverifiable, and their size and magnitude are affected by other factors, making it more likely that transactions will be carried out within a community rather than between communities and an outside service provider. These factors are: uncertainty or complexity; the presence of durable, transaction-specific, sunk investments; dedicated assets; diseconomies of scale; informational asymmetries; and the costs of bearing risks (Joskow 1985). For example, a production process (e.g. automobile design, apparel fashion) that involves complex processes, uncertainty over the time period for production, or hard-to-define quality characteristics, tends to encourage in-house production so that the buyers avoid costs renegotiating contracts with outside producers.

Detractors of transaction costs economics criticize this interpretation of a firm because they note that the employer can fire the employee (Alchian and Demsetz 1972). The employee/employer relationship, just as with the grocer/shopper, are not long-term contracts but spot market contracts that are renegotiated continuously. Alchian and Demsetz (1972) claim that the firm is defined as a nexus of contracts rather than as a hierarchical, authoritative scheme. The firm represents an "institutional set-up" (Foss 1994) where the monitor gets the residual claims and has the incentive to monitor a team of workers. Alchian and Demsetz see the boundary as the point where monitoring is as efficient within the firm as in the marketplace.

Since ownership by stockholders and control by managers who make the decisions is often separated, Manne (1965) argues that mergers protect shareholders from incompetent managers. Few measures of managerial efficiency other than share price are available. Falling share prices may signal that costs of managerial inefficiency are rising, making the firm more susceptible to a merger. But stock ownership signifies access to potential capital gains inherent in the stock. In this market for corporate control, takeovers - by proxy, tender offer, or merger - pay shareholders a premium for this control. Mergers may be the most effective way to takeover a company because management, which has veto power over the merger, can receive new stock equal to or exceeding the value to existing management shareholdings and offered new positions. Valuable industry information is also acquired by mergers.

Separating ownership and control leads to the phenomenon known as moral hazard - the inability to observe or verify a person's action or characteristics and the person's ability to change the outcome of a production decision depending on the action. The conditions for moral hazard to exist are: hidden action; hidden actions do not map one-to-one with outcomes; players have different objectives; and at least one party is risk averse (Kreps 1990). The asymmetry in information between two parties to a contract is the basis of the principal-agent literature, which includes adverse selection and signalling models.

The separation of ownership and control is key to the defining the boundaries of the firm. The benefits of separating the roles of risk bearing (bearing the wealth effects of decisions taken), decision management (initiating proposals and implementing decisions), and decision control (ratifying and monitoring decisions) are 1) the value of specialized decision-making among people with information to make sound decisions, and 2) the benefits of unrestricted risk-sharing, which can raise large amounts of capital. In cases of many residual claimants, the costs of involving them in decisions is high, so delegation occurs. The cost of separating these roles is the agency problem, where persons making decisions do not bear the full wealth effect of their decisions. As a result, their incentives may diverge from the risk bearers'. The fact that firms are ubiquitous and that people freely invest their money in forms to be managed by strangers requires explanation. The answer suggested is that organizations combine ownership and control (owner-operated firms) when the benefits of specialization and unrestricted risk bearing are less than the benefits of controlling agency problems (Fama and Jensen 1983).

Share tenancy arrangements balance moral hazard problems with risk-bearing ability (Otsuko and Hayami 1988, Eswaran and Kotwal 1985, Schultz 1964). The idea that a person who bears the risk of managing an asset should own the asset has strong support. The presence of production risk explains sharecropping contracts in which the landlord shares part of the output with the tenant farmer, rather than charging a fixed rent, as economic theory would predict (Bell 1989, Stiglitz 1989, Binswanger and Rosenzweig 1986). In contrast, Gilson and Mnookin (1985) claim that large law firms with a seniority-based sharing of profits do as well or even better than those with productivity-based sharing. Productivity-based sharing, economists argue, should dominate because it addresses the agency problems of leaving, grabbing, and shirking. However, the seniority-based systems remain competitive, the authors claim, because they diversify the lawyers' income risk.

Transaction costs can be considered production costs that must be included in the choice of contracts. While perhaps not their intention, Eswaran and Kotwal (1985) is a good example. Their paper models contract choice between a landlord and tenant where the choices are fixed rent, fixed wage, or sharecropping contracts. They view different forms of human capital, such as managerial ability, as unmarketable resources. Transaction costs are enforcing quality standards among workers. The relative efficiencies of a landlord's managerial ability and the tenant's supervisory advantages partly determine which contracts will emerge. Landlords are better at making general management decisions because of better information on markets, while tenants have better ability at daily supervisions and monitoring, an idea that contrasts somewhat with other literature (Schultz 1964, Roumassett 1995) that claims, for example, that non-resident owners are generally less efficient than resident owners at making production decisions

(Schultz 1964). Share tenancy contracts provide the tenant with incentives to monitor more effectively. Changes in parameters caused by knowledge diffusion and changing relative abilities and input importance, also shifts optimal contract choice in favor of fixed rental contracts. In this way, transaction costs increase or decrease, thus determining the ultimate choice of contract.

The "hold-up" (Williamson 1985, Edlin and Reichelstein 1996) problem illustrates the trade-offs created by moral hazard. Relationship-specific investments, often necessary before production can occur, lowers the value of the end product for those outside the intended trading relationship. This places the investing party at risk of being "held-up" by the other party. One side can threaten to cancel the contract after the investment has been made. The most efficient course of action is to renegotiate, splitting the gains to trade, with the split a function of each side's bargaining power. In doing so, the investing party loses the investment's value on the margin, depending on each side's bargaining power. Since contracts cannot be written on the nonverifiable investment levels, underinvestment results. One theoretical solution calls for the description of the end-product in advance and a fixed trading price *ex post* with stiff penalties for breach of contract (Williamson 1985). Where this is not possible, the transaction cost literature states that integration is the proposed course of action to reduce hold-up risk (Williamson 1985). Renegotiation *ex post* limits the power of complete contracts. When a new opportunity arises which increase the value of trade, the owner of the asset has the option to refuse to renegotiate. The other party must split the gains from trade to induce the owner to agree to the proposal. This ultimatum-type game creates suboptimal outcomes because of the distortion effect on investments. Edlin and Reichelstein (1996) show how raising the status quo payoffs under certain conditions and applying specific performance criteria also allows efficient results. However, this result may not encourage specific investments that increase the value of trade (Che and Hausch 1998).

Mechanism design and principal-agent theories have opened the "black box" of the firm to examine the incentives among the managers and employees. The focus is designing optimal contracts in the presence of moral hazard and asymmetric information (Holmstrom and Milgrom 1991, Holmstrom and Milgrom 1994, Hart and Moore 1990, Hart and Moore 1995, Aghion and Bolton 1992). The principal-agent literature assumes that hidden actions are nonverifiable while states of nature and the good can be described *ex ante*. In an important paper in this literature, Holmstrom and Milgrom (1994) models an optimal contract with a fixed wage where the agents have multiple tasks. The question is which tasks to perform in-house and which to contract. The answer depends on the measurability of the tasks which benefit the firm. The tasks include asset enhancement or output production. In a linear principal agent model with a risk-neutral principal and a risk-averse agent, they find that hard-to-measure tasks should be brought inside the firm. Examples are where measuring is difficult or there is a long-term or long-selling cycle. Tasks which are easier to measure can be performance-based.

The incomplete contracts literature takes issue with principal-agent and transaction cost analysis. Principal-agent theory supposes that contracts are costless to write and assume perfect foresight. In contrast, the incomplete contract argument states that it is nearly impossible to write or negotiate a complete contract which anticipates every contingency (Hart 1995). In other words, the action sets are not known in advance and the payoff functions are not verifiable *ex post* (Hart and Holmstrom 1987). In addition, the transaction cost tradition does not explain why managers become less opportunistic or how the information structure changes if a firm merges (Hart 1995) (p. 27). Grossman and Hart (1986) and Hart and Moore (1990) emphasize ownership as the residual rights of decision-making over an asset. Since contracts are inherently incomplete, the owner decides how to allocate the asset in unforeseen circumstances. The exact nature of the good is uncertain in advance: more precisely, it depends on a state of nature which is yet to be realized. Investment must be made before the state of nature is known. It is impossible to contract on the optimal value of one party's cost of investment before the state of nature is known because the cost is too complicated to describe in an enforceable way. Further, investments, actions or information are observable to both contracting parties but nonverifiable to a third party. Contracts therefore cannot be made contingent on these observable but nonverifiable factors. Fixing prices does not resolve the agency problems when parties can always renegotiate the fixed price.

Further, the information structure does not automatically change when the firms are integrated. In fact, symmetric information between the manager and an employee or two managers in the same firm does not solve the agency problem because that information is still nonverifiable to a third party who could enforce a contract. "Observable but nonverifiable," means that investments are observable by the two parties but nonverifiable to a third party, rendering unenforceable any contract contingent on these effort levels. As in bounded rationality arguments, the parties know that there are unforeseeable events and contingencies that may arise but are limited in their ability to predict and address every contingency. Even if two risk neutral firms contract for production, the nonverifiability of certain actions and the bounded rationality constraints lead to inefficiencies in production.

A typical incomplete contract story goes as follows. In the first time period (see Figure 2.1), two risk neutral firms agree that one will supply the other with a widget at a specified date in the future. Let us say this basic good is B_0 supplied

Figure 2.1: Contract Timeline

at a cost of C_0, both of which can be verified. But they want to contract on a superior good $B = B_0 + b$ that can be supplied at a cost of $C = C_0 + c$, where b and c are observable but nonverifiable aspects of the good. Therefore, revenue and cost-sharing agreements are not feasible. The superior good is too complex to describe in advance. The two parties negotiate over applying b and c during the contract cycle. If specific investments are involved, each party can threaten to trade elsewhere to capture the additional gains of trade created by the investments. The more specific the investment, the more the investing party stands to lose by not trading. Assuming that each party has equal bargaining power, they agree to split the gains from trade 50/50 and they exchange the superior good in the last period. For each dollar that one manager invests, she gains only 50% of the returns from the investment at the margin, which leads to inefficient levels of investment compared to a first-best scenario. Hart, Shleifer and Vishny (1997) applied this framework to the decision for the government to own and operate prisons or to contract with private prisons as an issue of quality control. Segal (1996) shows that when the future is sufficiently complex, the optimal complete contract is no contract at all. Aghion and Tirole (1994) have used this approach to explore the market for innovation. New discoveries are hard to describe in advance so that contracts cannot be written on specific performance or end products. Schmidt (1996) takes an incomplete contracts approach to public policy. Whether a government or an absentee private owner owns a company changes who has the residual rights of access to cost information. Market conditions determine which ownership structure leads to the greatest social welfare level.

In their model of vertical integration, Grossman and Hart (1986) contend that in the presence of nonverifiable and noncontractible activities, a first-best, efficient outcome is not attainable. Moreover, transaction costs do not disappear if a firm integrates because owner and managers can still renegotiate. The possibility of renegotiation unavoidably increases transaction costs. In forward integration by a seller, backward integration by a buyer, or nonintegration, the optimal outcomes are second-best efficient and differ only by the *distribution* of investments and benefits. The noncontractible nature of investments or products *ex ante* limits the size of the firm.

So who should own the asset? To reach a conclusion, more information concerning the nature of investments or the interaction between people and assets must be known. A basic finding is that in a buyer-seller relationship in which the parties invest in human capital, complementary assets should always be owned by a single party (Hart 1995, Hart and Moore 1990). Complementary investments are such that the production function has increasing marginal products, e.g. for a production function $f(z_1, \ldots, z_n), \partial^2 f(z)/\partial z_h \partial z_k \geq 0 \ \forall \ z, h, k$ (Mas-Colell, Whinston and Green 1995) (p. 683). Such positive externalities in production encourage forward integration. Common ownership is suboptimal because the two parties will either underinvest or overinvest in human capital compared to the first-best level of investment. A second prediction of the model is that the party with "important," defined as essential or productive, investment decisions more likely will own the asset. Third, increasing returns to scale should lead to the formation of large firms, and fourth, independent assets should be owned separately. The implication of the property rights literature is that control over nonhuman assets can lead to control or authority over human assets, and could explain why people do not leave in a merger (Hart and Moore 1990, Hart 1995).

Grossman and Hart's findings do not hold if investment becomes embodied in the physical capital. The asset owner would get all the benefits from the asset's increased value, since human capital is no longer needed to enjoy the benefits of the asset's increased value. In the case of specific physical capital investment, joint ownership is optimal. Each party has veto power over the use and allocation of the asset and both are able to realize gains from increases in value of the asset through a resale.

The hold-up problem is not necessary to the property rights approach. The crucial ingredients of the property rights approach is that there are incomplete contracts and residual rights of control over non-human assets. The other ways to make the property rights approach useful and applicable are asymmetric information, a positive probability that the two sides will not get along, and different views as to the value or returns from various asset usages. All one needs is an inefficiency in the economic relationship that asset ownership can influence. Under this condition, bargaining can breakdown and the default payoffs matter (Hart 1995).

Caputo and Lueck (1994) and Lueck (1994) outline a model that seeks to explain when individuals will choose among the property rights systems of private property, common property with equally-shared access rights or common property with equally-shared output rights. Unlike the incomplete contracts models, their model does not consider investments, indescribability of end products before the state of nature is known or bargaining to realize trade, but tackles the same problem of predicting governance structure. The papers use comparative statics to identify general tendencies to choose a system as costs and benefits change. The costs are costs of exclusion, marginal effort costs, marginal output effort, marginal pricing and output division costs. For example, they use a shift parameter to consider the marginal productivity differences among individuals. Pairwise comparisons are possible but no general results are given.

The property rights model here differs from mechanism design and principal agent models in a number of key points. One is that risk aversion by one party to a contract is not necessary to create inefficiencies. In the property rights model, the players are two risk-neutral firms or managers. Also, the end product is not completely describable in advance, and unforeseen contingencies arise. The renegotiation that inevitably ensues during the course of a contract cause the inefficiencies. Any contract can involve specifiable or measurable aspects. The point is that there are always some non-specifiable aspects of the contracting relationship. This is the "partial incompleteness" argument (Hart and Moore 1999).

Recent work questions the incomplete contracts literature because it lacks a formal, accepted paradigm (Maskin and Tirole 1999b, Maskin and Tirole 1999a, Tirole 1999). On the one hand, it assumes unbounded rationality through the dynamic programming employed to solve the model. On the other hand, it assumes transaction costs of describing *ex ante* the state of nature. A logical question is whether these two firms can make binding agreements that each will make investments as planned. In the conceptual framework of incomplete contracts, however, performance bonds do not work because one cannot verify the performance. Even if an investment is simply money, the money could have been spent in the wrong way (Hart 1995). Can they each pay the other a certain amount in advance to induce the optimal level of investment? This tactic, according to Hart, still poses a problem because between the time of this payment and actual production, the supplier could hold out for a better payoff and capture more of the gains from trade. The firms anticipate this maneuver and change levels of initial investments accordingly. Neither can contracts be made renegotiation-proof. In a renegotiation-proof contract, a punishment clause makes it undesirable or impossible for either party to breach the contract. Yet the spirit of an incomplete contracting environment implies that renegotiation can take place. The inability to commit not to renegotiation undermines schemes (e.g. Chung (1991)) that depend on that commitment.

Maskin and Tirole (1999b) devised an option-to-sell contract to avoid underinvestment. With joint ownership of an asset, each party can challenge the other's underinvestment through the option to sell her share of the asset. Tirole (1999) proposes that with certain assumptions, transaction costs are irrelevant: there exists a mechanism that assures the same payoffs with unforeseen contingencies as with foreseen contingencies. This does not necessarily render obsolete the incomplete contract literature. Complete contracts may be very complex and are not widely observed in the real world. "Simple" institutions like property rights while possibly inefficient may be the best option given constraints on knowledge. Rather we need to understand how far complete contracts can go and to advance the theory of bounded rationality.

The incomplete contract theory is similar to the multi-task model (Holmstrom and Milgrom 1991) because both agree that not all tasks are verifiable or measurable to the same extent. Some tasks are less measurable than others, especially those tasks involving investments in quality. This is an important point but the incomplete contracts story argues that describability of the end product matters as well (Maskin and Tirole 1999b, Hart and Moore 1999). Uncertainty, it is argued, is prevalent, and no contract can describe all states of nature that arise. Whenever two managers in an upstream-downstream production relationship renegotiate, the renegotiation creates inefficiencies that lead to less-than-first-best outcomes for society as a whole. Under certain conditions, the two parties can do no better than signing no contract at all (Segal 1996, Hart and Moore 1999). This approach is not inconsistent with empirical studies of transaction costs, which Holmstrom and Milgrom (1991) interpret with the multi-task approach. But in a property rights approach, there is no monotonic relationship between transaction costs and integration (Hart 1995) (p. 54). Property rights cannot be defined according to the measurability of a task. Other parameters, such as those mentioned above, must inform the model.

Up to this point, the contract literature considers shocks that would arise in any contracting situation due to the nature of transactions. Depending on parameters of the model, ownership rights are allocated to economize on these costs. Overall risk management strategies could also have an impact (Dixit 1993). Feeney (1999) shows that a lack of financial markets to insure against risk, risk averse agents and uncertainty leads a country to allocate less labor in the industry in which it has a comparative advantage than it would have with complete risk markets. The risk of specialization is balanced against comparative advantage when risk markets are incomplete, and countries under-allocate labor in an industry even though it has the human capital skills available. This rationale could extend to community-level decision-making, especially if the community is remote or has other factors that restrict risk insurance.

2.4 Empirical Studies

A number of empirical studies uphold transaction cost predictions while few studies have been conducted for the incomplete contracts literature (Klein and Shelanski 1994). Hold-up risk offers an explanation of why General Motors integrated backward when it bought Fisher Body, which made its car bodies. Joskow (1985) applies the transaction cost of specific asset investments to understand vertical integration between power generating utility companies and mine-mouth coal plants. Distance between an electricity generating plant and a coal mine predicts the duration of contracts between the two operations, showing empirically that greater distance has a negative effect on the duration of the contracts. Chesbrough and Teece (1996) apply transaction cost theory to the trend towards virtual organizations. They argue companies should eschew virtuality and remain integrated when new standards are being set or when innovations are systemic rather than autonomous from other operations within the company. This finding relates to the idea of "core competencies" noted in the business literature. The advice is that businesses should not subcontract their core, comparative advantages. When decisions are systemic, integration is the recommended ownership structure.

Complexity and quality considerations also encourage integration. For example, the design of an automobile evolves as a team of engineers work together and may take five years in advance of a finished model (Monteverde and Teece 1982). It is difficult to contract for specific automotive parts that require more engineering effort. The empirical evidence showed that automobile companies integrate production of those automotive parts that require more engineering effort, based on the theory that integration avoids the hold-up problem. Masten, Meehan Jr. and Snyder (1991) found that the variables representing importance of input in terms of total production cost to the buyer, production risk, industry concentration and intensity of research and development investments on the buying side were significant in explaining vertical integration across industries which supplied intermediate goods. Pennings, Hambrick and Macmillan (1984) finds that customer dependence motivates forward integration.

Empirical studies on the forestry sector to test transaction costs theories are few although the industry lends itself to this research. Globerman and Schwindt (1986) take an inductive approach in describing how the forest industry in Canada conforms to transaction cost predictions. They categorize the industry into its multiple stages from forest management, logging, transport, lumber, finished products, pulp and newsprint manufacturing. Sawmills are essentially dedicated assets bounded by transportation costs to a specific forest stand. So sawmill companies have backward integrated into ownership of timber lands. Standing timber on the other hand is not specialized. Primary processors do not find it necessary to integrate forward, although some do to monitor the transportation phase which they primarily subcontract. Much like the parastatal era in Mexico described in the next section, Canadian private firms historically assumed the responsibility of forest management on public land, despite the costs and scope of this production phase, to maintain assured access to fiber. The lack of natural reasons for primary processors to forward integrate makes forward integration by local communities in Mexico particularly puzzling.

In the only empirical application found of the incomplete contracts approach, Hanson (1995) employed tobit regression methods to estimate Mexican apparel manufacturers' share of payments to subcontractors who assemble the clothing. He argues that fashion designers balance natural risk with hold-up risk through the decision to integrate production activities. The paper describes the natural variability in women's fashions during and between fashion seasons as an example of unforeseen contingencies. The greater variability in women's fashions as compared to men's reduces the share of subcontracting of women's apparel manufacturing.

2.5 Community as Owner-Managed Firm

A question about the Mexican agrarian corporate community structure is whether it has advantages over private corporations where members are stakeholders in the corporation. A private corporation has efficiency advantages, such as the avoidance of free-riding and less cumbersome decision-making mechanisms. Further, since stakes in the cooperative are nontransferable, cooperatives have a tendency to underinvest. This tendency leads to lower capital-to-labor and capital-to-output ratios in cooperatives as compared to conventional firms (Furubotn and Pejovich 1972, Furubotn 1976, Bonin and Putterman 1993, Bonin and Putterman 1987, Carter 1984). However, the dynamics of cooperatives may not describe forest communities in Mexico. The forestry communities have interests other than producing timber, such as producing nontimber goods and services. More employment security (Pencavel and Craig 1994, Jones and Svejnar, eds 1982) could be a possible similarity.

Miyazaki (1984) suggests a modeling approach to determine the willingness of people to form, join or stay in a cooperative. In a model of a labor-managed firm in a mixed economy (labor and privately managed firms), he shows that the labor allocation in the labor-managed firm becomes Pareto optimal, unlike Ward (1958), where the cooperative has too few members. The risk of a worker joining is the person's share of the debt burden of the enterprise, which can either be dependent on the state of nature or fixed. In the life-cycle hypothesis, if a rationality condition is satisfied, workers take over an ailing firm facing bankruptcy and reorganize it as a cooperative rather than face the spot labor market. With the debt burden fixed, either better rents in the case of procyclicality or risk reduction in the case of countercyclicality leads to workers joining the cooperative as opposed to staying in the spot labor market.

While the community-run timber operations resemble a cooperative, there are important distinctions. First, members of the communities have limited ability in restricting the size of the membership. Those who are borne in the community and fulfill community responsibilities have a legitimate right to enjoy membership privileges. Members cannot easily enter the enterprise within the rules of the enterprise. Therefore, membership size is not necessarily endogenous. A second clear difference between community operations and private firms or cooperatives is that the shares of ownership in the community enterprises are not clearly defined. Although *comuneros* are owner-managers, rights to profit streams and use of the land are not tradeable in the formal sense. This raises the question of the nature of risk-sharing among *comuneros*. While it is beyond the scope of this dissertation, future research would identify how their responses to changes in prices or other market forces would differ from a private firm or cooperative.

In the cooperative literature, Zusman's study of Israeli moshavim comes the closest to describing community forestry in Mexico (Zusman 1997). A key point that allows comparison is that the study conceptualizes the moshav not only as a marketing cooperative but also a municipality. His model of individual and collective choice captures the idea that rules must be "within the ethos and political culture" of the moshav, with the goal of explaining when moshavim are "successful" and when they "differentiate", meaning the members link themselves more outside the moshav. A survey of eight communities records indicators of better management which make Ostrom's notion of accountability more concrete: 1) pattern of voting behavior by independent action rather than bloc formations, 2) adequate notice and preparation for decision-making and reporting to members, 3) active committees, 4) high participation rates, and 5) frequent meetings. While this study is one of the few that models the multiple aspects of community life, it has a limited discussion of why moshavim choose to provide services collectively rather than through third parties. Explanations are similar to those posed in this thesis, and include economies of scale and scope, complementarities in certain investments, externalities (p. 127), as well as agency costs (p. 125). Other characteristics, some which appear to be endogenous, are also listed (p. 143). Zusman does not systematically relate these factors with the choice of "vertical integration" by the moshav into service or production activities. The value of the analysis extends to describing the overall structure of a local community with productive capacity and public responsibilities, operating within a specific cultural context.

2.6 Vertical Integration, Investment and Diversification

The preceding section focused on literature that predicts the level of vertical integration. This section discusses literature on the impact of vertical integration on other economic decisions. Vertical integration is theorized in turn to have an impact on investments, profitability, and technical innovations. In a study of the effect of labor unions on profitability and investment levels, Cavanaugh (1998) used vertical integration measured as value-added adjusted for total assets to explain investment levels. His reasoning is that insofar as asset specificity causes firms to integrate forward because of the hold-up problem, vertical integration is a proxy for asset specificity.

The literature on diversification points to assets that a firm owns and the transaction costs associated with exchanging information. Teece (1980) reasoned that assets have a life cycle. If all inputs are fully employed, then a firm has a choice of whether to repurchase stock with its profits or to diversify. Therefore, he suggests measures of cash flow and petroleum reserves to explain diversification. As cash flows increase and reserves decrease, diversification should increase. Teece emphasizes the multiproduct nature of technical know-how to explain diversification within an industry. The contractual difficulties in sharing information are a disincentive for firms to exchange knowledge in the marketplace (Arrow 1962, Arrow 1974). Therefore, Teece builds a *prima facie* case for explaining diversification in the petroleum industry by comparing the types of technology shared among the different activities. Research and development normalized by sales would explain diversification in the industry. As research and development spills into other areas, the opportunities open for diversification rather than a sale of this knowledge.

Economic theory suggests that vertical integration leads to greater technological innovation in lines of businesses related to a firm's primary line of business. In one paper, Armour and Teece (1980) note that firms can internally exploit technical complementarities between different but related production processes, and all the departments of an integrated firm can assist in formulating goals. An integrated firm's sharing of technological information common to various stages of production facilitates innovations. Their empirical analysis provides evidence that vertically integrated and diversified firms have more productive research and development.

The multiproduct nature of ecosystems invites studies of scope economies within forestry management systems (Gottfried, Wear and Lee 1996). Multiproduct production functions, in particular, demonstrate economies of scope between production lines (Panzar and Willig 1981, Bailey and Friedlaender 1982). A consequence is that integrated firms can benefit from joint production. Yet this link with natural resource policy has been little explored in the economics literature. One issue is that it difficult to measure nontimber benefits. Exchange of nontimber benefits are often non-cash in nature. Consider for example the benefits of habitat, biodiversity, carbon sequestration, soil maintenance and aesthetic value. Alternative ways of measuring nontimber value have been developed, such as contingent valuation and revealed preference approaches, and it has been found that nontimber benefits affect harvest decisions (Scarpa et al. 2000).

Chapter 3

Background and Survey Data

In the past ten years, communities have evolved into production units that compete in national and international forest products markets. Today, Mexican community forestry production units face Coase's classic question of which transactions to manage with the firm and which to address via the market. This chapter describes this transformation and summarizes the survey data relating to vertical integration.

Mexico's land tenure and community governance systems have a distinct history, dating back to pre-Columbian times, transformed under Spanish rule and adapted further after the revolution in 1917. Management of community forestry operations surveyed for this study and communal forest land fall within this governance structure. It is essential to the analysis to have a contextual description of broader community life. Therefore, this chapter not only summarizes data for the empirical analysis of Chapter 5, but also offers a political, sociological and cultural perspective in which a large part of the Mexican timber industry operates. Given the nature of the data required for this study, it was not possible to collect systematic ethnographic data. The text draws on secondary sources, informants and the survey data itself to describe the institutions in which the forestry operations and forest ecosystem are embedded, while a full ethnographic study is left to future research.

A rich literature exists on the political, social and cultural aspects of Oaxacan community life (Spores 1984, Goldring 1998, Stephen 1997, Kearney 1972, Montes 1992, Fox 1996, Cohen 1999, Klooster 2000). Here only basic points as they relate to this research are noted. This chapter is organized as follows. A background section describes the political organization of Mexico's agrarian communities and the cultural aspects that make Oaxaca, Mexico, the field study site, particularly complex regarding property relationships. A review of timber production in Oaxaca follows. Section 3.2 details the sampling process and survey design. Section 3.3 and onwards summarizes survey data according to topics suggested by a theory of property rights – stock of human, physical and social capital, uncertainty in the contracting horizon, decision-making processes, contract clauses, specificity of factor inputs, quality concerns in forest management, production levels and general community-level characteristics. Summary statistics, a list of variables and their definitions, and sample surveys in Spanish and English are in the Appendices. Throughout the text, capital letters refer to variable names. Occasionally, the code number for qualitative responses are shown with the variable name, e.g. CVW=2. Any data not listed in the appendix may be obtained from the author.

3.1 Common Property and Forestry in Oaxaca

Governance

The term "community" in this study refers to the agrarian communities - *comunidades, ejidos* or *colonias* - codified in Article 27 of the *Ley Agraria* and the Mexican Constitution.[1] These three types of communities are similar in political organizational and structure. The main differences are a person's historical relationship to land. The *comunidad* refers to a community of indigenous culture who can claim that Spanish colonialists or the Catholic Church usurped their ancestral lands. If the groups can legally substantiate when and how land had been taken,

[1]For a discussion of "community" in general, see Agrawal and Gibson (1999).

the constitution allows these populations to reclaim their land. Communities have title to the land upon incorporation.

The *ejido* was established as a land tenure arrangement to entitle landless peasants giving them the legal right to petition for expropriation of private estates above a given size. *Ejidos* can be formed by groups of people who have joined to reclaim land appropriated by Spaniards but who do not necessarily come from that area. Since the Spanish hacienda system never took hold in Oaxaca (Spores 1984), *comunidades* rather than *ejidos* predominate in Oaxaca. Oaxaca has 674 *comunidades agrarias*, almost half of all *comunidades agrarias* found in Mexico.

The *colonia* system was created in 1950 by decree to encourage ranching and new settlements in Mexico in humid tropical areas.[2] It was thought that these areas would be productive ranch lands once cleared of the forest. Many people who came to establish *colonias* came from areas where they did not hold land. In order to lay claim to land and maintain title, colonists were encouraged to clear forests (J.M. Barrera Terán, pers. com., 1997).

The size of Oaxaca's indigenous population is second only to Chiapas. However, the differences in indigenous groups do not correspond to differences in community organization or governance structure, which agrarian law determines. Sixteen different recognized languages are spoken in Oaxaca and include Zapotec, Mixtec, Mixe, Triqui, Mazatec, Chinantec, Cuicatec and Zoque, with regional variations within each language group. While supra-community political organizing in Oaxaca occurs along ethnic lines (Stephen 1997), organizational form and decision-making processes at the community level do not exhibit systematic differences across ethnicities. In an ethnographic study in Oaxaca, Cohen (1999)

[2] Refer to *Titulo Tercero: De los Ejidos y Comunidades* of the agrarian law as published 27 April 1992.

contends that a person's sense of identity is not necessarily linked to the ethnic group, defined as the language spoken, but to the community itself. The term "Zapotec" may connote one's ancestors rather than one's own identity. Neither did one ethnicity appear to have greater inherent "forest culture" than another during the course of fieldwork. Therefore, cross-ethnic patterns in forest use, if they exist, are not a focus of this study. Variations in forest-use patterns will be captured with indicators other than ethnicity.

Each community is located within a municipality, much like counties in the United States. The municipality has a "county seat" *(cabecera de municipio)*, the community where the municipal offices are located. Aside from the municipal town population, municipal territory is usually dotted with satellite populations called *agencias* which may even be separate *ejidos* and *comunidades*, especially if the municipality covers a large territory. Of Mexico's 2378 municipalities, Oaxaca has 570, or 25% of the total municipalities and more than any other state in Mexico (Meixueiro 1996). The president of the municipality and other offices are elected from within the borders of the municipality, including the *agencias*.

The communities hold the land title in common while individuals have usufructory rights over their land plots for homes and agricultural crops. A quote from an ethnographic study makes clear the levels of usufructory and ownership rights in *comunidades* which affect the dynamics of community forestry (Kearney 1972):

> Of the three general systems of land tenure in Mexico – a pre-Columbian communal system, individual private ownership introduced by the Spanish, and the ejido system of post-Revolutionary land reforms – only the first is formerly recognized in Ixtepeji [the community of study]. As in pre-Columbian times title to all land is legally vested in the community and is administered by elected officials. There is, however, individual

> tenure by right of use. Any *comunero* (adult member of the community) is free to utilize any unoccupied land. It is treated as his alone for as long as he cares to exploit it. Therefore, land can neither be sold nor inherited, except for house plots which, as with houses, are treated in practice as private property held in fee simple. All comuneros also have the right to hunt on municipal land and cut wood for firewood and charcoal. The right to use land in the *municipio* is attainable virtually only by birth or marriage into the community. In the past there have been a number of bitter land disputes between towns of the Sierra and Ixtepejanos today zealously maintain their municipal boundary by regularly repairing land markers and clearing the boundary line of all plain growth – a formidable task considering the length and width of the swath. (p. 5; brackets added)

While it is true that the sale of land to persons outside of the community is prohibited, it is misleading to say that no land trades occur (Goldring 1998). DeWalt et al. (1994) reports that people borrow and lease land within the community population and that sharecropping is common (p. 35).

However, the economic, social and political role community membership offers through property rights limits the commodification of land in these communities (Goldring 1998). The Agrarian Reform of 1992 (*Ley Agraria* 1992) allows privatization of agrarian land, but the majority of the land remains communally-held and managed (Stephen 1997). Indian communities retain their right to recover and title land (Moros and Solano 1995) while the 1992 reform eliminated that right for new *ejido* claimants. The 1992 agrarian reform could have a profound impact on the economy, but to date few communities in Oaxaca have opted to sell communal land. Even in urban *ejidos*, privatization efforts have proceeded more slowly than expected (Goldring 1998). As will be detailed further in this chapter, common property timber production is a source of dividends, jobs and revenue for public resources for the community members as a group and could even be viewed as a chance for political gain by managers in the community. Contracts with outsiders for timber production may be difficult if the community seeks to balance various benefits through timber operations.

Further, legal ambiguity remains over whether forest land can be sold at all. The laws allowing privatization generally do not apply to forests (Snook 1997). Historically, land classified as communal forest land is considered common property and cannot be bought or sold. Parcelization in a community has legally occurred but without the right to sell to entities outside the community. The changes in the agrarian and forestry laws in 1992 permit community members to parcel or divide forest lands. Community members could become forest "smallholders" (*pequeno propriedades forestales*) and individually own up to 800 hectares. However, another clause in the law forbids parcelization of forests or rainforests and reverts communal forest land to the government if an *ejido* privatizes (Bray and Wexler 1996). If forest land was completely deforested and reclassified as pasture or agricultural land, then it could be sold under the new laws.

The community is comprised of official community members (*comuneros*) and non-members who live in the community. At the community level, the General Assembly is the supreme governance body comprised of all registered *comuneros*. Each person has one vote. By law, the assembly should meet regularly and by specially-called sessions during the year, as needed. The benefits of *comunero*-status include the right to vote in the General Assembly and the right of access to communal land and water, and a household plot. Members of the community cannot transfer their rights over land to others outside the community and usually pass on the rights to a member of the family. Rights cannot be divided among more than one individual. Official *comuneros* are usually male heads of household, with women winning the right to vote most frequently as widows.

Each community maintains a list of registered membership, be it *comunero, ejidatario* or *colono*. To be a current member on the list, one must render time to the community, which involves voluntary labor contributions, called *tequios*, and holding civic offices within the *cargo* system. The *cargo* system provides for the public needs of the community. This system is more strongly rooted in the agrarian communities than in the *ejido* systems. Integration into the economy and the advent of religious groups to communities have challenged the cargo system in a number of communities recently, but this system is still much in effect among the communities surveyed. Members of the community rotate public responsibilities, such as president of the municipality, oversight officer, common property officer, police duty, health clinic representative, transportation services and religious festivities (Nader 1990, Cancian 1992, Kearney 1972). The cargo system is obligatory. Failure to serve could lead to a suspension of a person's rights to services within the community, the right to vote and social ostracism. The offices of president, oversight and common property carry more responsibility, and one holds these offices usually after accumulating merit by holding lower offices first. Elections for these positions take place in the General Assembly. Often, appointment to office is seen as a yoke, a burden to be borne, as it removes the person from the income-earning stream for up to three years when the cargos carry more responsibility. Women rarely participate in the cargo system since they are not heads of households. Occasionally, when proposed to bear a cargo, a woman's male relatives may argue her case or represent her in the General Assembly (Kearney 1972).

The agrarian community structure has historically been a political organization rather than an economic unit (Fox 1996). Until recently, it was necessary that a representative from the Procuraduria Agraria be present for all General Assembly meetings and votes. Voting was along the party system. However, Fox (1992) notes that Oaxaca's self-governance system is somewhat unique in Mexico because it has much less state intervention at the local level. The state government of Oaxaca is gradually recognizing traditional indigenous customs of voting according to the cargo system. The Oaxacan government in 1998 officially accepted this practice, although it has probably long been the implicit norm. Of its 570 municipalities, 417 voted by *Usos y Costumbres* (Rendon 1998) in 1998.

Anthropological studies further our understanding of a local population's governance methods with respect to the larger political arena. Harmony-compromise models depict how groups protect themselves against superordinates and colonizers defend against subordinates by creating the illusion of harmony. Nader (1990) hypothesizes that harmony ideology is part of a social transformation through law and a key to counter-hegemonic movements in Zapotec communities in Mexico. She claims that harmony ideology is evident in local participation in dispute resolution which disperses power and reinforces community solidarity. Village courts encourage decision-making which is accountable to the townspeople, thereby competing successfully with district courts as places to resolve disputes. A division between state and local decision-making upholds the community's desire for separation. Nader highlights the importance and currency people place on the decision-making process within the General Assembly.

Migration rates in Oaxaca have historically been high but travel away from the community does not exclude the person from contributing to the community or fulfilling cargos. Indeed, a person living outside the community who returns for service or sends financial support may be held in higher regard and enjoy more membership rights than a person living in the community but does not fulfill obligations (Cohen 1999, Kearney 1972).

The cargo position of *Comisariado de Bienes Comunales* (CBC) administers the communal property of the community, which includes forests. It consists of three elected representatives - the President of the CBC, Secretary and Treasurer. During elections, the candidates for CBC are often slated with candidates for other offices. Its responsibilities are to represent the community in agrarian conflicts and other activities related to the territory of the community. Management of the forestry operations in this study falls to the CBC, who act as an advisory board or executive officers in charge of administering to forest activities and making reports to the General Assembly. The CBC were the key contacts during the survey interviews. All visits and surveys were accomplished with the permission of the CBC. Except in rare instances, the CBC was present for the community interviews. The survey process is more fully described below.

Common property forestry in Mexico differs from many case studies in the common property literature because community forestry institutions are an extension of already-existing local institutions, which are formally recognized both internally and externally. Challenges to traditional forms of governance and community homogeneity or cohesiveness exist, such as migration and new religious affiliations. Yet the General Assembly remains an active organ in decision-making processes over economic functions of the community. Decision-making at the General Assembly level in forestry matters includes determination of lines of work which the enterprise will engage in, distribution of profits, election of cargos, authorization of contracts between the forest enterprise and outside agents or government and approval of the forestry management plan. Therefore, common property theory remains relevant to a study of community forestry in Mexico.

A notable aspect of Mexico's indigenous communities today is that they must balance traditional demands of maintaining community integrity or structure while adopting the outward vision necessary to compete in the industrial forest sector. A fundamental issue is how this social and economic role will evolve over the next ten years (Aquilar 1991, Arzola and Gerez 1993, Hernandez 1998). The management of the forestry operations is an outgrowth of the system of *cargos*. A person may be elected, not on his ability to manage a forestry operation, but because it is his "turn." The *Comisariados*' ability to manage forestry operations therefore varies greatly, and each CBC often learns from scratch. While some communities are adapting their governance structure to operate more like a capitalist firm, the agrarian system is often seen as a stumbling block to successful community forestry. At the same time, the concept holds strong among community members that the forest is common property. Recognizing that members of the community are co-owners of community public goods, the CBC in particular is expected to ensure that benefits from communal resources flow to community members. The General Assembly is one forum in which community members communicate their preferences to the CBC in allocating resources. The forest enterprise as a whole is expected by the community to give back to the community in the form of social benefits. The communities will be continually challenged by the question of degree to which they will open up to new governance forms, such as hiring non-community member employees or managers, delegating more decision to the CBC, special CBC training sessions, restructuring the management schemes, permanent employment, and investments in long-term forestry operations.

Timber Production

Mexico today has 55 million hectares of forest land, of which Oaxaca has 7,059,653 hectares, or about 13% (IBRD 1995b). Forests are the largest soil classification group in Oaxaca, covering 74% of the state territory (SARH 1994). Deforestation, discussed in the following sections is a major problem, and the reforestation rate is only 0.3% of hectares per year in 1993 and 1994 (IBRD 1995b). The annual increment in forest is estimated to be 1,855,484 cubic meters (SARH 1994).

Mexico's forest resources have been exploited since at least the last century. Referring to pine harvests in the 1940's, de la Peña (1950) laments the destructive logging practices of locally-based sawmill companies in Tlaxiaco, the commercial center of the Mixteca region in Oaxaca. At that time, the timber companies contracted with local communities to harvest trees, but left land deforested or degraded.

Aside from industrial forestry, individuals traveled into the forests to collect wood for domestic uses, for consumption or sale in the vibrant regional markets (de la Peña 1950). The method of extraction was by handheld saws, with logs carried out by the individuals or donkeys. People also accessed the forest to collect palm and maguey products and hunt.

Until recently, the Mexican state interpreted agrarian law as granting ownership of forestland to communities but allowing the state to retain the right to lease land and to sell trees on the land. While the pre-revolutionary governments granted timber concessions to foreign capital, laws passed in 1926 after the Mexican revolution prohibited access to forestland by outsiders, albeit with varying success (Bray and Wexler 1996). The Mexican government reversed this policy when it implemented an import substitution program during World War II because it was concerned with ensuring a constant supply of pulp for newsprint during the war.

One informant suggested that the government did not have the capital to build roads or buy equipment necessary for timber production, but it did have the power to grant concessions to land. A law passed in 1943 created the *Unidad Industrial para Explotacion Forestal* (UIEFs), or Forest Exploitation Industrial Units. In 1945, the president of Mexico began granting concessions by presidential decree to private companies registered as UIEFs to develop forestry. Private companies classified as UIEFs had access to large blocks of forest. Mexican government ministers were on the executive board of these companies and participated in decision making. Local communities maintained the official rights to the land but under a concession agreement were permitted to sell only to the concession-holder and they could not transform the wood themselves (Snook 1986, Bray and Wexler 1996).

To some extent the concession came with a social mandate. The government expected the companies' investments of capital in return. Not only did the government direct the companies to provide social benefits such as public infrastructure to the communities, but also the presidential decree stated that the parastatals must pay the communities the fair market value of the trees extracted, the *derecho de monte*, which the parastatal would deposit with the *Fidecomiso del Fondo Nacional de Fomento Ejidal* (FIFONAFE), a type of trust fund to be set aside for the community.

The President granted the leases to usually one parastatal company and several private companies per state. The first lease was in Jalisco state, with 12 others following in the next years. The president granted a lease in Oaxaca in 1956 (*Diario Oficial* 1956), one of the last states to be leased. Table 3.1 shows companies operating in Oaxaca in 1976. In Oaxaca, the parastatal companies were Fabrica de Papel Tuxtepec, known as FAPATUX, and Compania Forestal de Oaxaca (CFO). FAPATUX management were employees of the government. The Board of Direc-

Table 3.1: Oaxaca's Parastatal and Private Companies and Location

Concession	Community Land	Ejidal Land	Private Land	Exploitable Forest Area Held (ha)
Unidad Industrial Fabrica de Papel Tuxtepec	43			281,859
Unidad Industrial Compania Forestal de Oaxaca	11			63,579
CIA Maderera la Mixteca	3	2		39,915
CIA Forestal Jamiltepec		3		5700
CIA Maderera La Soledad			1	27,000
CIA Industrial y Beneficadora de Bosques	2			27,525
CIA Maderas de Oaxaca	1			8000
CIA Forestal Lachixonase	2			5475
Empresa Comunal	1			9000

Source: Autorización de Aprovechamiento Actualemente en Vigor 1976, Comisión Forestal del Estado de Oaxaca, Situacion de la Actividad Silvícola en la Entidad, Conclusiones y Recomendaciones, 1976.

tors included the government ministries of agriculture and commerce. Property of the company belonged to the state. Logging concessions from the government lasted for 25 years (Bray and Wexler 1996). CFO remained a private company but held a concession. The others in the table are private companies that negotiated one-on-one with the communities without a federal lease. The only community-run organization was in San Andres Cabecera Nueva, the first community to organize for forest production, accomplished by convincing the company Maderera la Mixteca to sell its equipment to the community (F. Maldonado, pers. com. 1998). This occurred despite formal laws that prohibited communities from formally organizing for commercial production.

The companies sought leases in forests that would minimize costs and risks. According to the chief forester of FAPATUX at this time, concessions were usually sought in the best quality forest with the easiest access to the market and no internal community conflicts (J. Escarpita, pers. com. 1998). The final community-UIEF relationship had to be negotiated. The communities and "concessionaires" renegotiated contracts yearly. The communities had bargaining power in that they held the right to accept or refuse the contract, but, except for a few communities, usually accepted the proposed contract. At times, communities exercised their bargaining power more rigorously when the companies renegotiated terms each year. Sometimes the community refused, so there was a suspension of work for a few years. Others did not permit the total volume to be cut. Others said that the company could only hire locally.[3]

Over the years, political confrontations began against the concessions. Communities complained of the monopoly power of the lease-holding companies. The communities had an informational disadvantage because a "fair market value" for the timber was not well-established. They claimed that the *derecho de monte* payments were below fair market value and that the parastatals underreported extracted wood. FIFONAFE escrow funds were reputedly hard to access, as financial officers may have slowed access to the funds to draw profits from them. The parastatals did not hire locally but brought experienced loggers from the state of Michoacan. In Oaxaca, social protests against the FAPATUX and CFO began in the 1960's (Arzola and Gerez 1993, Moros and Solano 1995). Salaries deteriorated while the parastatals ignored demands for pay increases. The communities used as a point of leverage, the ability to refuse to accept the contract which companies were required to negotiate with them to set the stumpage fees.

The incidents closely parallel the "hold-up" risk interpretation of transaction

[3]Clearcutting is not allowed in Mexico, so this was not an issue. The section on Forestry Resource further elaborates the silvicultural methods.

cost and contract theory. Descriptions of the strikes reflect the difficulties of contracting between the local communities and the parastatal firms in terms of costly bargaining, renegotiation and enforcement (Moros and Solano 1995):

> Disputes began in 1978, when San Pedro demanded that CFO improve its harvesting practices and leave less cut timber in the forest. The company agreed to pay for all cut timber, but renewed the following year. The community held up the next contract until the timber bill was paid. In 1980, CFO again refused to honor the accord and began firing San Pedro workers as a way to pressure the community to renew the annual contract. Tired of waiting for payment and indignant over the firings, the comunero assembly removed all CFO vehicles (trucks, cranes, etc.) from one of its sawmills and held them in the churchyard as ransom until the timber contracts were settled. The workers were finally reinstated and the timber bill paid. Only two years remained on the 25-year concession, and San Pedro signed no further contracts with CFO. During that time, the community's transport company hauled timber in other parents of the region, at better rates. (p. 108)

> In 1978, the community, with the assistance of *comuneros* who had studied outside the community, initiated a project to process oak timber in which FAPATUX had no interest. Only after overcoming strong opposition from the community and ultimately threatening to suspend the timber contract could the community install a workshop to manufacture tool handles. (p. 108)

A direct quote from a community representative speaking at a meeting of 13 communities to discuss the leases expresses the frustration of contracting with the parastatals, a frustration that has parallels with the forest communities in the Pacific Northwest (see Chapter 2):

> We want this situation cleared up. The Company [CFO] has always concealed its proposal to the government. They always do everything behind the communities' backs. They have always violated the contract in their operations and payments. We must protest this decree to be free and, if possible, to organize ourselves to establish our own sawmill. If we can't do this, the most important thing is the free market, that every village be free to sell. It's possible to contract with the Company, but we must demand our rights. (p. 109; brackets added)

In 1974, the new forestry secretary in the *Secretaria de Recursos Hydraulicos* (SARH), the agriculture ministry, adopted a reformist stance promoting community forestry and supported the end of the concessions. In 1982 the leases came up for renewal. The forces opposing renewal coalesced. Although the outgoing president renewed the leases in a misguided action, the incoming president quickly rescinded them (Moros and Solano 1995). Several communities had already begun to harvest themselves before 1986 under the agrarian laws, but the Forestry Law of 1986 (*Ley Forestal* 1986) recognized the communities' right to form organizations to exploit the forest commercially and acquire their own technical forestry services (Zabin 1992, Snook 1986).

The literature on Mexican forest communities cites varied reasons why forest management shifted towards the communities. First, formal education and industry training developed management skills and outside contacts. Over the time period of the concessions, some community members sought higher levels of education. In certain cases, these people provided leadership and management expertise for the transition to community forestry (Pego 1995, Klooster 2000). Second, logging companies and eventually parastatal companies hired from the communities, which led to an accumulation of technical experience and training in forestry practices (Moros and Solano 1995). Third, among the inefficient businesses that the government subsidized were parastatal timber companies (F. Chapela, pers. com. 1996). This made them susceptible to a withdrawal of government support. The conflict over the contract renewals may have provided a convenient breaking point. Fourth, bureaucratic and grassroots reformers favorable to community control were a driving force for the 1986 law and transition to more environmentally-friendly forest policy and community involvement (Wexler and Bray 1996, Klooster 2000). The governmental and nongovernmental support ensured the end of the concession era.

Of the three pathways of building social capital noted by Fox (1996) – local movements, local outsider organizations, and state reformers – Oaxaca has ingredients of all three in the transition towards greater community control of timber exploitation. As a local movement, communities themselves formed a consensus regionally that the parastatals were not hiring locally to the extent they could be. However, the presence of external, non-governmental actors (local outside organizers) in the Sierra Norte and progressive reformers within the government's state offices (state reformers) contributed to the change. The pathways to greater community control matter if the pathways are correlated with successful governance systems in the community, an important line of inquiry left to future research.

An explanation of patterns of vertical integration and its impact requires an assessment of the parastatals' impact on community's propensity to integrate into production activities. The analysis must therefore distinguish between the parastatals' impact *per se* and other various confounding factors which could explain vertical integration. The parastatal experience may have affected present-day ownership patterns for several reasons. First, the parastatals invested in infrastructure and the human capital related to timber production operations, which gave communities initial capital start-up requirements. Second, any positive effect on vertical integration in communities could be confounded with higher quality forests since parastatals may have sought higher quality forest land. Third, exposure to the timber industry as a business over the long term could have transformed the communities' vision of the economic potential of forests. Finally, solidarity among communities who sought removal of the parastatals from their communities could have motivated organization in the community around common property forest land. The single entity represented by the leases, the government, allowed politicization around the leases, which led to regional alliances and social capital formation, an awareness of the value of the forest, and the impetus to organize. The econometric analysis in Chapter 5 will account for the interaction of these components in explaining ownership and investment in forestry.

Provision of Forestry Services

For commercial harvest to occur, a forest management plan must be prepared by a registered professional forester (*servicios tecnicos forestales*) and submitted to the Ministry of Environment, Natural Resources and Fisheries (SEMARNAP) for review and approval. Over the past 50 years, the management plans have evolved from basic plan for commercialization to silvicultural management plans that account for nontimber ecological benefits (Snook 1993), and economic and social objectives of the local community. Permits for regular harvests are granted on an annual basis. Permits can also be given for salvage harvests when fire, pests or disease cause mortality. No research was done to determine the extent that the review process is a “rubber stamp” or leads to renegotiation of the plan.

The management plan is a key part of the production process. No commercial harvesting legally occurs without such a plan. Plans vary widely in their coverage and comprehensiveness. The main objective is to elaborate a program for the production of timber, which requires an inventory of the forest resource and a schedule of rotation over a given time period. Management plans frequently categorize the forest resource according to it commercial productivity, and areas for restoration, reforestation or conservation. The forestry management plans required to harvest in Mexico are integrated management plans, meaning that they address not only the commercial production of the forest and a forest inventory, but also the forest ecosystem as a whole, including its ecological services. In this latter purpose, the plans are required to specify that logging does not occur a certain distance from water courses or in critical areas (roads, sloped terrain, etc.), that area is set-aside for protection of species, and that restoration in critical areas will be carried out (Snook 1993). Maps typically delineate the forest into these separate areas. Some plans specify non-forest land uses for the entire community: urban areas; permanent and migratory agriculture; grazing; and road and water networks.

Prior to 1982, either the government or commercial sector provided technical services necessary to plan harvests. The parastatal companies employed foresters who prepared the plans for areas intensively exploited by the companies. In areas less intensively exploited by the parastatals, government forestry engineers developed management plans, as necessary. The private companies without governmental leases worked independently with the communities and employed their own foresters to prepare management plans in these communities (J. M. Barrera Terán, pers. com. 1997).

The end of the government leasing system in 1982 meant that the communities had to hire technical services. Government foresters assumed responsibility for management plans. Each forester had a particular area of responsibility, and the communities paid for the service. The 1986 forestry law changed the name of the technical concessions to *Unidad de Conservacion y Desarrollo Forestal* (UCODEFO). The state of Oaxaca was broken up into UCODEFOs with a separate forester responsible for each. Table 3.2 lists typical services. The technique applied to forestry management in Mexico historically is the *Método Mexicano de Ordenación de Montes* (MMOM) but now the *Método de Desarrollo Silvícola* (MDS) or *Sistema de Coordinación y Desarrollo Silvícola* (SICODESI) are the norm. MMOM is a low-intensity, selective cutting system. It often led to high-grading, leaving genetically impoverished forests, and it created conditions that favored non-commercial oak to regenerate at the expense of commercial pine. MDS, introduced in the late seventies, is based on even-aged seed-tree system of management that includes thinnings, seed-tree regeneration cuts, and a liberation cut. This approach attempts to mimic the effects of a fire to encourage the regeneration of pines (Snook and Negreros C. 1986, Snook 1997, Rosales, Olaya et al. 1982). SICODESI is a slightly modified version of MDS.

The UCODEFOs were to provide a comprehensive management plan that allowed for integrated forest management, watershed and soil conservation, fire protection, and pest management, in addition to marking trees for felling. Despite the changes, the communities found that the engineers often only marked trees for felling. The communities argued that they should be able to hire their own technical services instead of paying for an engineer appointed to the community by the government.

The 1992 forestry law privatized the technical services, but specific engineering firms remained responsible for each geographic region, as under the UCODEFO

Table 3.2: Examples of Technical Forestry Services under MDS/SICODESI

Forest Protection: e.g. fire roads
Fomento Forestal
Forest Management (*Manejo Forestal*)
Treatments (*Tratamientos*)

- clearing
- selection
- regeneration
- liberation
- mark trees for harvest (*marqueos*)

Ancillary treatments (*Tratamientos complementarios*)

- clearing shrubs (*limpias arbustos*)
- clearing debris from harvest (*limpias chaponea*)
- clearing oak to allow light for young pines
- clearing broad leaf species (*hojosas*)

Source: M. P. Lopez, pers. com., March 1995.

system. A law passed in 1993 further loosened government control over technical services so that communities can hire whomever they want, as long as the engineer is qualified by the government and authorized to provide services. In some cases, members of the community have become forestry engineers (Wexler and Bray 1996, Snook and Negreros C. 1986).

Only qualified and registered foresters have the authority to mark trees for felling, which is done with a *martillo*, a hammer with the forester's registered stamp mark. Unauthorized duplication of *martillos* is illegal. The head forester frequently delegates authority to subordinates who carry out the work within the forests. Extra labor is most often hired locally to assist with marking or other silvicultural treatments. As of 1995, there were 18 registered foresters or technical services offices in the state of Oaxaca (SARH 1994). In 2000, a management plan cost about 62 pesos per hectare. Fixed costs of creating a management would mean that this rate would have a minimum size forest (E. Chavez, pers. com., 2000).

Government programs and international aid continue to fortify the shift to local community control. The World Bank has funded a $15 million project *Proyecto de Conservación y Manejo Sustenable de Recursos Forestales en Mexico* (PROCYMAF) for three years to fund technical training to the communities and foresters, management plans, and courses for nontimber production. The project targets communities at all levels of production, including those with potentially commercial forests but no production. For communities with management plans, the government-sponsored *Program de Desarrollo Forestal* (PRODEFOR) subsidizes studies, workshops, silvicultural treatments, temporary labor, logging roads and fire roads. Envisioned to cover the years 1998-2000, PRODEFOR has spent a much smaller amount, largely due to delays at the state level government in releasing its co-payment for the projects. The United Nations Global Environment Fund has also begun to consider a pilot project in Oaxaca to promote biodiversity and conservation. The Fund would consider projects to write management plans, provide seed money for nontimber forest production projects, and money for conservation swaps. If implemented, these projects could continue the impetus towards integrated forest management at the community level.

While the encouragement for communities to manage their own resources is much less intense than before, when the threat of labor strikes and confiscating equipment loomed large, these programs have at their core the idea that communities should manage their forests. The reasons for this ideological push could be that the land tenure structure forces the hand of the government to address communities directly in any policy towards land management. Even if future agrarian laws clearly permit communities to trade forest land, a persistent suspicion towards selling land could remain. Second, the forest as an "engine for growth" allows communities to more fully control development within their community and provides a source of funds for infrastructure and social benefits. Why this development role cannot be undertaken as efficiently through the private sector is a question this thesis seeks to answer. Third, community cooperation is necessary to restore degraded forest land, and these projects specifically envision as their goal the reforestation and restoration of forest land.

3.2 Survey and Sample Design

The population is the set of community-based governance organizations in which commercial harvests have occurred in at least one of the three harvest seasons 94/95, 95/96, or 96/97 according to the permit files of the SEMARNAP. The sample population therefore includes communities or subgroups within the communities that are authorized to make decisions concerning common property. Communities were categorized according to the number of production stages realized by the forestry operations. Communities under the "stumpage" heading sell stumpage to outside private firms who coordinate the extraction process. "Roundwood" means that the community harvests the timber and sells timber in the form of roundwood or *tablones*, or logs that have been squared off by a chainsaw (this is done for cedar and mahogany logs). "Lumber" communities have a sawmill and sell lumber, while "finished products" communities sell lumber as well as more finished products such

Table 3.3: Population and Sample

Product sold	Population	Stratified Sample	Sample	Final Sample with work groups
Stumpage	27 (28%)	17 (28%)	15	16 (36%)
Roundwood	42 (44%)	26 (43%)	12	13 (30%)
Lumber (or finished)	26 (27%)	17 (28%)	15	15 (18%)
Finished products	?	?	?	7 (16%)
Total	95 (100%)	60 (100%)	42	44 (100%)

as tool handles, doors or furniture. Enumerators verified the categorization to the extent possible prior to administering the survey. The number of communities that processed their timber into finished products was not known prior to the survey so that their number is included with communities that sell lumber. A random sample of 60 communities stratified by type replicated the same distribution of types as in the sample population in column one of Table 3.3. From the communities in column one, 17 communities which sell stumpage, 26 communities that sell roundwood, and 17 communities which sell lumber and/or finished wood products were chosen at random. The survey instrument was pretested on each of the four types of communities. Corrections in classification were necessary during the course of fieldwork. Seven of the communities originally recorded as roundwood or lumber sellers were actually stumpage sellers and so were reclassified. The final sample includes forty community level observations and four work group level observations (in two communities) for a total sample of forty-four observations. Originally, all 95 communities were to be interviewed. Due to budget constraints, the sample of 60 was taken. However, several communities had been surveyed. Since the percentage of the population sampled is large, this should not substantially bias the results. Of the stumpage communities surveyed, two were not randomly selected. Of the roundwood communities that were surveyed, two were not random. Of the lumber/finished products communities, four were not random.

The survey had three parts, which can be found in English and Spanish in the Appendix. Part One focused on the history of forestry activity in the community, labor and capital data, management structure, production, and contract and client characteristics. Part Two addressed questions of nontimber benefits of the forest, general community characteristics such as non-forest sources of income. Parts One and Two were directed to the community authorities responsible for forest administration and conducted with one or more of the community authorities present. Part Three of the survey collected information on the characteristics of the forest resource, classification of land use as listed in the management plan, location of forest in relation to populations, silvicultural management, timber inventories and technical services in general. Enumerators conducted this part of the survey solely with the professional forester responsible for the community's forest.

3.3 Human, Physical and Social Capital

Timber harvesting in Oaxaca has built human, physical and social capital within the communities that could lower the fixed costs of collective action to manage production at the community level. This section reviews how the community groups compare in terms of past training and employment in the timber industry, asset infrastructure such as logging roads networks and sawmill acquisition. It also introduces the "social capital hypothesis" where it is argued that the parastatal leasing experience had its primary impact as a consolidating force among communities that facilitated collective action to invest in the industry.

Parastatal and Private Company History

The experience of stumpage communities with industrial forestry is very different from that of the more integrated communities. The number of communities with parastatal history before 1986 strongly increases by type of community (CONC), with a χ^2 squared statistic (18.52) significant at the 1% level. Across groups, the parastatal companies were in nineteen of the sample of 44 observations. In the years 1956-1982, the lumber and finished product communities sold little to no timber as stumpage to private firms. Further, the parastatal harvested for more years on average in the communities which are more integrated today (CONC2). At times, the parastatal held leases in a community but never harvested in the community. This is the case in one of the two stumpage communities where concessions were held. So just the existence of parastatal harvesting is not sufficient to explain present day levels of integration among communities. In contrast, most stumpage communities have a harvesting history with private companies rather than parastatal firms prior to 1986. Furthermore, the average number of years in which private companies operated prior to 1986 (PRIV1) is shorter than the parastatals. Private companies, where they were present, tended to operate longer in the roundwood communities than in the stumpage communities, perhaps because of other factors favoring timber production, such as larger forests. Private companies also have a shorter history as well, starting on average in 1973 in stumpage communities as compared to 1966 and 1954 for lumber and finished products communities (PRIV2), respectively.

To separate the organizational, infrastructure, and quality of forest effects, an indicator was needed of the quality of the forest in 1940, since commercial logging in Oaxaca began in earnest in the mid-forties. Very little photographic or written data exists on Mexican forests in 1940. In addition, where they do exist, interpreting the data would be difficult. To create an indicator, three forestry engineers with extensive knowledge of Oaxacan forests and timber history ranked the quality of the forest in terms of soil and climate conditions that would be favorable to tree growth, and the presence of harvestable, commercial timber, including trees of large diameter. Commercial timber is mostly pine, but cedar, mahogany and common tropical species grow in more tropical zones. The range was a 1-5 scale, with 5 meaning "excellent," and 1 "very low." The three estimates were averaged together and rounded to get a measure from 1 to 5. Initial quality of the forest increases with community type, with the stumpage group having an average of 3.6 and the finished products category having 4.57. The correlation between past quality of forest and parastatal existence is surprisingly weak ($\rho = 0.29$). Nor does past forest quality explain parastatal existence in a logit regression as a single explanatory variable. Therefore, initial quality of the forest can be eliminated as a confounding factor for any explanatory value that parastatal history has on the level of vertical integration of the communities today.

Human Capital

The survey collected data on levels, sources and types of historical training or employment experience held by members of the communities. Stumpage communities reported their employment or training experience prior to 1986 while the other groups reported their experience before beginning to harvest timber on their own. A variable for each of nine possible tasks in timber production takes a value of zero to five for the approximate number of people in the community who received this experience, according to the forestry authorities. The five categories are zero persons, less than 10, 11 to 20, 21 to 50, and greater than 50 persons. The tasks divide the training into mechanical and technical aspects of the timber industry operations, where mechanical experience is work with chainsaws (EMPCO1), handheld saws (EMPCO2), cranes (EMPCO4), trucks (EMPCO3) and sawmills (EMPCO9), and technical means documentation (EMPCO5), administration (EMPCO8), silvicultural treatments (EMPCO6) and reforestation (EMPCO7). When the variables are averaged according to whether the source of experience was a private company or a parastatal, private companies provided more employment opportunities than parastatals for all tasks except for sawmill work. Parastatals had centrally located sawmills where local community members worked while private companies hauled logs to destinations further from the communities.

The level of past experience increases by community type for the mechanical tasks, except that the lumber communities often show a slight dip in the average while technical tasks have a flat pattern. The results mean that firms hired community members for manual labor rather than for the management of timber operations. Alternatively, technical operations represent tasks that call for a few persons regardless of the scale of operations. For example, one documenter, accountant or trained forester could be sufficient in larger or smaller forests depending on the flow of operations. In this case, the number of persons would not correlate with the extent of community hiring.

A potential source of bias is that the negative experience of communities with parastatal firms leads community authorities to underestimate systematically the historical hiring by parastatals. To reduce biases due to differences in tasks, the employment experience variables are changed from a scale of zero to five to a binary variable which takes the value one if any member of the community received this experience. As with the original variables, more integrated communities have higher rates of experience working with chainsaws. In the other mechanical tasks, the tendency is still towards higher communities except for the lumber communities. Percentage of communities with technical experience reveal a flat pattern across production types once again. Only a few people with experience are needed to teach others the skill, so that even a low number could hypothetically have a large marginal impact on the ability to manage extraction and transformation processes.

Prior to 1986 or prior to a community's integration into harvesting, very few sources of training existed besides employment with harvesting companies. Communities usually referred to learning by observation of other workers or from members of other forestry communities who offered to train them, as other sources reported. For prior mechanical training, only one roundwood community noted that a forester provided training to handle chainsaws (ENT1B, ENT2B). Responding to the transition from private to community-run timber operations, the SARH sent out persons to train communities in mechanical and technical skills during the period 1984-1985 (J.M. Barrera Teran, pers. com., Feb. 2000). However, they tended to go to communities that were already beginning to harvest themselves, and training focused on technical aspects of timber production. Out of 176 possibilities, government programs accounted for five instances of technical training broken down by task. Three communities (two roundwood and one finished products) in the sample noted technical training from the government prior to beginning harvest operations themselves. This training was in documentation, reforestation, or administration (ENT3B, ENT4B, ENT5B, ENT6B).

The data were further checked with communities that had integrated into higher levels of integration, then switched back to a lower level. This occurred in four stumpage observations. However, in each case, the community members received the training *after* their community had integrated forward *and* in the early nineties. Therefore, this training is not included in measures for *past* training.

Table 3.4: Source of Training in Past* (Counts and Percentages)

	Para-statal	Private company	Other communities	Observation	Forester	Government program
Mechanical	17 (41%)	17 (41%)	3 (7%)	3 (7%)	1 (2%)	0 (0%)
Technical	6 (21%)	17 (61%)	0 (0%)	0 (0%)	0 (0%)	5 (18%)

* Prior to 1986 for stumpage communities; prior to forward integration into extraction activities for roundwood, lumber and finished products communities. Type of training is grouped as mechanical or technical. Numbers in table represent number of times each source was cited for either the mechanical or technical training.

Physical Capital

The preexisting road infrastructure and training could have two effects on the pattern of integration across communities. First, a larger initial infrastructure lowers the fixed costs of production in the start-up phase. Second, the immobility of capital places the community in a position to be held up by outside harvesters. In the first case, lowering start-up costs still begs the question of vertical integration patterns, since both communities and contractors can make investments to begin logging. The second reason implies that communities integrate to avoid renegotiating a contract once harvest has begun. Distinguishing between these possibilities is empirically difficult except for considering the immobility of capital and anecdotal evidence.

Logging roads represent one of the largest capital investments required before production can occur. Since roads are immobile, they become specific investment to the community, laying the conditions for hold-up risk for the party making the investment. For example, one stumpage community in the sample was lured mid-season by a harvester offering higher prices than what it was receiving from its current harvester. It switched to the new buyer, after the first had made investments, until the first buyer matched the new price. Forests are often remote from the community. While roads increase access to the forest, they rarely access other communities or act as communication routes other than for timber operations. Joint ownership of physical assets recommended by Grossman and Hart (1986) when one party makes human capital specific investments in the asset, would be problematical in the context of Mexico's land tenure history and culture. Land rights are closely tied to agrarian communities' political and social organization so that joint ownership of natural resources may not be a ready solution.

BRE20, BRE10, BRE5 and BRE1 indicate the average number of kilometers of logging roads (*brechas*) existing in the forest as of 20, 10, 5, and one year ago, respectively. The average number of logging roads in existence starting twenty years ago increases unambiguously by type. The stumpage and roundwood communities have almost the same average number of kilometers of roads 20 years ago, but the roundwood communities gained a greater number on average since then.

The more integrated communities had more kilometers of logging roads (BRE1). Because of the substantial timber production in Oaxaca, many of these roads were built by parastatals or private companies. The percent of roads built by the parastatals is 7, 28, 61 and 60% (BRECO) as integration increases among groups, and 82, 45, 11 and 3% (BREPRIV) by private firms for increasing levels of integration by group. This means that more than half the road network in the communal forests was built by the private or semi-private sector. Further, stumpage communities only funded 6% of the logging roads built. The lumber and finished products groups built 26 and 37%, respectively, on average of their current logging road infrastructure (BREPU), while outside private firms built 82% on average in the stumpage communities and 40% in the roundwood communities. In absolute terms, communities have funded the construction of 2, 15, 13 and 33 kilometers of logging roads on average, in order of increasing levels of integration.

Formation of Community Enterprises

BEGANH indicates the year that the roundwood and sawmill communities began to harvest under their own organization. Lumber and finished product communities started to harvest timber on their own on average earlier than the roundwood communities. YRH1 notes the first year since 1986 that harvest has occurred. Again, the sawmill communities predate the other types, then roundwoods, and lastly, stumpage types. YRH2 indicates the total number of years of harvest since 1986. The average is the lowest for the stumpage group. These indicators suggest that the more integrated communities have more constant, continuous operations and a greater harvesting history, while those less integrated have a more sporadic pattern and have started later.

Community funds financed the majority of the sawmills. Otherwise, lumber and finished product communities are distinguished in their access to funding in three ways: the lumber group more often received government funds to purchase and install sawmills, the finished products group more often received credit, and the finished products group negotiated deals between private companies or parastatals in the transition period between outside and community control of sawmill operations. Whereas 13% of the lumber communities reported receiving government funding to help acquire a sawmill (ASDIN2), zero of the finished product communities received government funds. Rather they had relied on the agreements with the outside companies (ASDIN5) or bank credit (ASDIN3). Five of the 15 sawmill communities had sawmills installed by 1986 (ANOAS1). At least two of these sawmills were installed originally by the parastatal which left the

Table 3.5: Sawmill Acquisition Strategy (% Responses by Group)

	Lumber	Finished Wood Products
Community funds	75	86
Government funds	13	0
Private credit	13	43
Public credit	13	14
Private agreement	0	14
Other	25	0

Note: Numbers do not add to 100 because multiple sources of funding could have been tapped for one sawmill purchase.

community to take over its operations (Snook and Negreros C. 1986). Another community funded the purchase of its sawmill through a sale of logs left by a company with which it had a disagreement. Some sawmills were acquired with a mix of both community and non-community funds. The average number of years that the sawmills have operated since 1986 (YRA2) has been 5 years for the lumber communities where the average year of installation is 1993, and ten years for the finished product communities where the average installation year is 1988. Only two communities have two sawmills. The rate of installations per year has been more constant, with one or two a year (ANOAS1).

The communities were asked if a sawmill had operated in their community or at a main entrance route to their community in the past and then was dismantled (ASCO). Of those responding affirmatively, the stumpage communities had the highest number (6), followed by the the two groups of sawmill communities (3 each), then the roundwood communities (2). Private companies, which operated primarily in the stumpage communities had private sawmills near the communities but dismantled them as contracts expired, perhaps to avoid appropriation by the communities when the community forestry movement gathered speed. Without a government mandate to negotiate with communities, they relocated their operations off of communal land.

A possible scenario is that communities acted on the momentum to organize and overinvested (Aquilar 1991), for example, vertically integrating forward even though it was not economically feasible in the long run. Two stumpage observations reported that they formerly had a sawmill. These two observations were actually from one community which had two work groups, hence two separate observations. However, the sawmill was a government donation given during a period of government promotion of community forestry after the concession period ended. A representative of one work group said that the sawmill was of poor quality and never functioned correctly. In addition, conflicts over party politics not necessarily related to the sawmill arose after this sawmill was installed, leading to the division into two separate work groups. Since this time, the forest has been managed in two halves with considerable effort by the forester in charge to maintain equity in volume allocated to each group. The area of harvest is literally split in half with the one logging road as the axis. Two other currently stumpage communities said that they had formerly sold roundwood. In one interview, the common property officer said that coordination to find truckers and organize the harvest in general was excessive. This was a particularly remote community with steep terrain, and he said that it was easier for the community to let an outside firm conduct timber operations. All of these communities had little infrastructure and former training so on the one hand they were not vulnerable to hold-up risk but on the other they did not have the capital nor expertise to manage operations on their own.

Inter-Community Conflict

In some cases, titles to land still remain unclear and give rise to conflicts (DeWalt et al. 1994, Russell 1996), but these conflicts existed relatively evenly across types. External territorial conflicts existed in 56, 54, 38 and 57 percent of the communities, by increasing level of integration. Such territorial conflicts do not necessarily impede production activities because the areas vary between forested and non-forested land, hence the lack of correlation with level of vertical integration.

General Characteristics

Measures collected from census data indicate that quality of life increases with each higher level of integration, with some measures exhibiting marked gaps between groups. The literacy rate, as measured by percent of population 15 and older who can read and write (PP15A), for the lowest two groups are 76 and 77%, and 82 and 83% for the highest two groups respectively. The finished product category are markedly better off in the extent of drainage (PPD) and water (PPA) services to households, while the stumpage communities have much less access to electricity (PPE).

Most of the residents of the each community in the sample belong to families of registered members of the community. The number of non-registered heads of households is relatively lower for the communities with sawmills, at about 1.5% for the lumber and finished product communities and about 9% in stumpage and roundwood. But the between group differences are not individually significant at the 10% level.

3.4 Community as Entrepreneurial Firm

This section discusses how timber production in communal forest land extends the local governance structure beyond its original mandate in Mexico. It summarizes the data on organization, management incentives, decision-making and conflicts related to the forestry operations. The purpose is twofold. First, the aim is to detail the parallels between the management of community forestry activities and a capitalist firm, facilitating application of the theory of the firm. Second is to note distinctions that require adaptations of the theory in the next chapter.

The community forestry operations can assume various legal forms. The value one for UNID indicates that the community has formed a *unidad comunitaria forestal*, a management team especially responsible for administering to forestry matters. All of the roundwood and sawmill communities are *unidades* except for one roundwood and one lumber community which have "other" forms of organizations. "Other" most often indicates a *sociedad* allowed by agrarian law (*Ley Agraria 1992).* A *sociedad* can be constituted by the community as a whole or by subgroups, for example, when production is organized by work groups, or among a number of different communities (Zabin and Taylor 1997b). A zero value indicates the community does not have a separate forestry management team, but that the forest production activities fall within the responsibilities of the existing managers for communal property. Half of the stumpage communities manage forests as an extension of regularly existing *cargos*. Most communities with an organization or "society" to sell timber commercially incorporated around that time: twelve of the 15 sawmill communities built sawmills and incorporated in 1988 or before and the average foundation date is 1984. The average for the roundwood group is 1988, and nine of the 12 formed before 1989. The stumpage communities are more recently organized (average 1994). The *sociedades* are the most recent because they have existed only since 1992 when the agrarian law created them. The oldest values for FUND, the year that the community organization recorded in UNID, refer to communities without a separate forestry organization and indicate the year the *communidad* or *ejido* itself was founded.

Figure 3.1, 3.2, 3.3 and 3.4 depict examples of organizational structure from the four types of communities studied. The *Comisariado de Bienes Comunales* (CBC) is the elected three-person group charged with the responsibility of overseeing common property and agrarian issues in the community. It consists of the *Presidente del Comisariado*, the secretary and treasurer. Almost all communities have a three-year period for the *Comisariado*. One community changed this time period to 1.5 years because three years was "too onerous" with no compensation. Three of the stumpage observations do not have a Comisariado because they represent community subgroups or a community with territory in conflict so that the election of a *Comisariado* is not yet possible. The *Comisariado* is "on call" to problems in the community 365 days a year. On average, the finished product group reported that the *Comisariado* works the greatest number of days a year (CBCD) and the roundwood group the smallest. Compensation is not necessarily given, in conformance with the idea that the cargos are duties to the community. Some of the forestry management jobs are seen as public service duty, so are compensated little or not at all, depending on the community. Pay ranges from a minimum of zero to a maximum of 125 pesos per day in the finished product category. The Comisariado is almost always paid from the communities' coffers, except in two cases, for stumpage communities, where the outside harvester paid the Comisariado.

A separately elected three-person committee, the *Consejo de Vigilancia*, monitors the *Comisariado* and acts a vigilance group for protecting the communal lands. The *Consejo de Vigilancia* works in conjunction with the *Comisariado* as a management and administrative council for operations in the community concerning common land. The Comisariado together with the Consejo de Vigilancia is the head of a *unidad*, while the rest of the management team can include managers, sales chiefs, logging foremen, manager of the sawmill and supply, etc. The *Consejo* also works about 365 days per year, with the averages increasing by type (CVD). The pay (CVP) ranges from zero to 125 pesos, with the highest average pay of 61 pesos per days in the finished products group. In all communities, the *Consejo* is paid directly by the community except in three stumpage communities, where they are paid by the private harvester (CVW=2).

Figure 3.1: Stumpage Community Organization

Figure 3.2: Roundwood Community Organization

In some cases, the community elects a general manager to oversee operations. The *Gerente General* (GG), or *Coordinador*, makes decisions on a day-to-day basis for the forestry enterprise. Otherwise, the *Comisariado* and *Consejo* couple their duties to fulfill this responsibility. All except five of the more integrated communities have a designated slot for a general manager, while only four stumpage communities incorporate this position into their governance structure. However, the GG does not necessarily have a regular three year term, not being a traditional *cargo*, but holds the position from one to three years or for an indeterminate amount of time (GG).

Most logging operations have a *Jefe de Monte* (JM), or foreman, in charge of overseeing the extraction process. This job also falls under the cargo system but can range from one to three years. In some cases, the term is indefinite and may change from season to season. The JM works on average less days (JMD) than the Comisariado or Consejo, as his duties focus specifically on harvesting rather than the community in general. The average compensation (JMP) increases with type, although the foremen in stumpage communities are more often paid by the outside harvester. The foreman is paid by an outside firm for 11 of the 13 stumpage types.

The sawmill manager, called the *Jefe de Industria* or *Jefe de Patio*, in the sawmill communities have terms from 1 to 3 years, although three communities have indefinite time periods. The manager's average pay is 224 pesos and 273 pesos per day in the lumber and finished products communities, respectively, while the

Figure 3.3: Lumber Community Organization

days of work per year (JID) are 52 and 70 days per year. Except for one case, the source of payment is the community.

The roundwood and sawmill types had occasionally a Chief of Sales (*Jefe de Ventas*) (JS), whose average pay and number of days per year working also increased by type, most likely due to the greater volume to manage in the more integrated communities. Pay increases with type (JSP). Again, the community pays the sales chief's salary except for a lone exception. In communities that are integrated, the sales chief would devote effort to acquiring and keeping clients. Otherwise, the harvest manager in nonintegrated communities seeks buyers for the wood products. The outside harvesters are often owners of sawmills or directly hired by sawmills to seek raw material sources. So the community relies on the harvester to find end-product buyers. Vertical integration could give the community authorities more control over marketing the product from the community and over clientele. They could consider the competitive position of all community products in their efforts, whereas a private manager seeks sources of raw material depending on his end needs.

The *Jefe de Finanzas* (JF) administers the accounts. Only five of the stumpage communities had a finance officer, while the majority of the other types of communities had this position. However, the term is most often for one year or is indefinite, depending on the flow of material, harvest season and Comisariado.

Figure 3.4: Finished Product Community Organization

While not necessarily *cargos*, documenters are required in every forestry operation. Their duty is to measure the volume of timber extracted from the forest and hauled away. On the basis of the volume, the salaries, purchases and taxes are paid. Many documenters have only a one year term, and rotate out for a new documenter. Nine communities have no specially designated documenter, meaning that another person within the forestry administration fulfills this responsibility as well. The average days a year that the documenters work (DOCD) are directly correlated with level of integration. The average pay (DOCP) is larger for the finished product group, followed by the stumpage and lumber groups. The stumpage documenters may receive a larger pay because their salary is paid mostly by outside harvesters (DOCW=2).

Small group discussions among community leaders who have fulfilled most of their cargos, called *Caracterizados*, play a role. This group is based on a traditional form of communal, indigenous governance and not all communities have such a group. Of 42 observations, 18 of the communities have a *Consejo de Caracterizados* (CRZ), a group of well-respected persons in the community that meet to address general problems in the community. There is no distinct pattern. In communities with a *Consejo de Caracterizados*, only two report that the *Consejo* participates in decision making for forestry issues (CC).

Communities become more complex as they adapt to market competition. With the creation of the community forestry *empresas*, the CBC begins to resemble a corporate executive in part, overseeing commercialization activities. Permanency of positions also increases. The more integrated communities have more permanent employment positions ($\chi^2_3 = 17.64$, Pr. $= 0.001$) in administration, documentation, accounting and technical services. Four of the finished product communities, but none of the lumber communities, had a documenter as a permanent position (PERM1-2). A majority of the sawmill communities had a permanent employee as a receptionist. One community that has been very successful has altered their structure over time to smooth management operations. Instead of a CBC, an accountant that acts as general manager conducts the daily operations, such as sales and accounting. A long line of paperwork accounts for payments, costs, sales and income in triplicate. Another finished product community has allowed their *empresa forestal* more autonomy since 1988, where the CBC and CV act as an administrative council and separate day-to-day operations are left to managers.

Political Hierarchy

In the sample, the percentage of observations where forest operations are coordinated at the municipal level increased by level of integration. Thirty-one percent of the stumpage communities were *municipios* while 50, 63 and 57% of the more advanced communities were *municipios*. This relationship could be correlated with size of the forest, since a *municipio* is likely to control a larger common property resource than an *agencia* or community within its borders. Alternatively, the positive correlation between municipality status and vertical integration could signify greater access to capital resources or organizational ability.

The state has followed a trend towards decentralization of duties to the municipality (*Acuerdo No. 15* 2000). The state provides funds to municipalities on a yearly basis, with which it attends to health, education, roads, and other infrastructure. As another source of income, the *agencias* within municipalities sometimes must give a portion of money generated at the local level to the community. However, this is not a significant source of income for the municipalities.

Only on one occasion did the community authorities mention that the municipality obligated them to pay a fee for timber production. A check of the sources of municipal income revealed that by far the major sources of income are federal funds and household taxes paid to the municipality.

Decision-Making

The communities are designed along "democratic" lines in that votes on major decisions affecting the community are taken in the General Assembly where each head of household with *comunero* status has one vote. The process of decision-making is seeking consensus. However, decision making does not necessarily begin in the General Assembly. An example of how the decision to install a sawmill in one community was described as a gradual process that led to a final General Assembly vote. A general desire and need for work was present in the community leading to a general consensus to purchase a sawmill. Finally, the formal decision was taken in the General Assembly.

However, policy makers and interviewees themselves have raised a concern that community-based decision making is not efficient. General policy decisions are usually made at the General Assembly level while more technical decisions are delegated to the community authorities. Data shows a tendency where the General Assembly decides profits distribution, the forestry authorities choose buyers, and foresters seek financing and clients. More often than not (13 of 36) respondents said that the Assembly did not meet to discuss volumes (AGJUNO). Reasons given were that harvest rates are a technical decision depending on silvicultural management of the forest, and the General Assembly is a general body not sufficiently informed to make this decision. While the χ_2 statistic is weak ($\chi^2_3 = 1.11$, Pr. $=$ 0.77), the lumber and finished products communities met in the general Assembly more often, in percentage terms, to discuss volumes. This group discussion could suggest more oversight in the two most integrated communities as compared to the stumpage and roundwood groups. The more integrated communities may have members with more requisite knowledge or control of forest management, given their longer history of harvests. Communities whose General Assemblies meet to discuss volumes usually meet before the harvest takes place (AGJUN1). Three communities stated that the Assembly meets after the harvest, in which case they are only being informed of the volume harvested (AGJUN2). Two communities said that the General Assembly meets during the harvest to discuss volumes to be cut (AGJUN3). This could be because they are being advised of the harvest plan only or because they can still influence the harvest even after it has begun. When the groups do meet, there is not much difference between the number of persons who attend, participation rates and number of days necessary to reach a decision across groups.

For taking a decision on volume, all except one community reported attendance at General Assembly meetings of one-half (AGAS=3) or greater (=4) of the community's voting population present at the meetings, suggesting a fair degree of participation of the community in forestry matters. The number of people that speak up or discuss the issues in these meetings drops, which seems reasonable as the entire group of individuals usually does not talk at the meetings. Ten communities, distributed more or less evenly, say that less than one-quarter speak up (AGHAB=1), six said that one-quarter to one-half speak (=2), two said that one-half to three quarters speak (=3), and 3 said that more than three-quarters speak up (=4). Most communities need two days of meetings to come to a vote to approve the management plan each year (AGDIAS). The lack of correlation across types suggests that once the basic structure of the community is established, the

Table 3.6: Who Chooses the Buyer (Count)

	Stumpage (9)	Roundwood (10)	Lumber (11)	Forest Products (5)
Forester	0	2	0	0
Community managers	4	7	5	3
General Assembly	5	3	1	1
Other	3	2	1	1

Note: Columns do not add to total because of multiple responses by individual communities.

differences in the regular civic functioning are small.

As Table 3.6 shows, communities prefer to maintain control over the sales contracts rather than relying on the professional forester (ELGC1). The roundwood communities may have more limited networks of contacts, so that they rely on the forester to help make business connections. Nineteen of 30 responses said that the community administration itself elects buyers (ELGC2). Most observations (20 of 30) reported that the decision to choose a buyer is not taken in the General Assembly, showing a tendency to delegate this decision to the community authorities (ELGC3).

The third key decision discussed with the community authorities was how to distribute profits generated by sales (Table 3.7). Few communities said that the decision was taken solely by the community forestry authorities. Most communities said that the General Assembly decides on the distribution of profits. A few communities noted "other" forms of deciding the distribution of profits.

Case studies have extensively documented the manipulation by local elites of the community governance structure. This topic is raised in more detail in a following section on conflicts.

Table 3.7: Who Decides Distribution of Profits (Count)

	Stump-age (14)	Round-wood (10)	Lumber (11)	Forest Products (5)
Forestry Authorities	2	1	1	2
General Assembly	11	9	5	4
Other	2	1	1	1

Note: Columns do not add to total because of multiple responses by individual communities.

Variations in Governance

Timber production communities exhibit additional variations in their governance structures that could affect their production efficiency and forest quality. The following subsections review three management variations found in the field - association of communities, work groups, and parceled forests - and possible governance regimes stated in forestry law that did not appear in our sample.

Associations The importance of the variety of association lies in the freedom communities have to organize in more efficient ways, for example, to achieve economies of scale in size or discounts for technical services. In Oaxaca, about 26 communities belong to an association of communities that originally grew from their associated status under the older forestry laws that assigned geographical regions of responsibility to technical forestry engineers. Government forestry engineers were allocated "concessions," for which they provided technical services. In the transition phase to privatized technical services in 1992, many of these communities maintained their group identity to form an association. In some cases, they retained the services of the same forester and same name as under the technical concession.[4]

The sample included at least one community from each of the six associations existing in Oaxaca. These associations are *Union Zapoteca-Chinanteca* (UZACHI), IXETO, *Union de Comunidades y Ejidos Forestales* (UCEFO), MIXTZA and Yucutaco. Communities in an association are more integrated vertically. The main impetus for forming associations was in 1989, foreshadowing the privatization of services in 1992. One association dating 1984 formed under different circumstances than the creation of UCODEFOs. With one exception, communities individually harvested commercially before they joined the association.

The communities maintain their associated status to share costs of technical services (ARAZ1=1). ACOM shows costs shared by the communities in associations. All except for a community where the association is defunct said that they share technical services costs. Special training and courses seemed to be extra, paid by individual communities where the training took place. All the harvest takes place independently in each of the communities. One association has recently invested in a sawmill as a joint project among its members. The sawmill was to absorb excess production by the communities whose own sawmills could not handle all the wood they produced. The communities in this association are paid for the logs they bring to the sawmill. Volume is not yet rationed, since the sawmill is new and volumes low. They do not share production or joint marketing activities.

On average, communities in associations pay a slightly greater fee per cubic meter – 13 pesos versus 12 pesos per cubic meter (28 observations) – so that seeking lesser costs is 1) illusion, 2) not the real reason why the communities are in an association, or 3) to receive better, more reliable or a broader range of services

[4]These concessions refer to the UCODEFOs, explained further in Section 3.5

than non-association communities. Communities in an association are on average slightly further from Oaxaca. In general, communities pay the foresters by cubic meters marked (AGAST). In at least one case, the rate per cubic meter varies for each community in the association depending on the effort provided by the forester in each community. One community pays 3.20 pesos per cubic meter, while others pay 8-10 pesos, because this community has a "better appropriation" of the work, since they have a technical person from their own community who does much of the work, and the community takes on tasks (e.g. financial reporting, the silvicultural treatments, disease control, and reforestation). The forester noted that he performs all these tasks for the other communities and must rely on persons from outside the community, making coordination harder. While the cross-type patterns are not statistically significant, more integrated types divided costs equally among themselves regardless of timber volume authorized, marked or produced by that individual community (AGAST=4).

Could associations solve problems of economies of scale and facilitate investment in the communities? At least two of the five associations in the sample had not met in over one year, and the community authorities were not influenced by being in an association. One association that had originally received its impetus from a government effort and even received a sawmill from the government had had major organizational, internal problems that ultimately led to a breakdown in that association. While the organization exists on paper and there are efforts to revive it, it still is not functioning as a group, and the sawmill is rented out to private operators.

An imbalance in the size of forest land represented by each community may be a destabilizing factor among associations, recalling Ostrom's statement on heterogeneity in stakeholders. Over the years, some larger, more successful communities broke away from the associations to seek customized technical services. These communities tended to be "more capacitated." A lumber community left because, in one outside observer's opinion, the community wanted more attention, had different objectives, and sought a technical forester to live in the community for these purposes. This community wanted to expand into ecotourism or nontimber forest products. In another example, one large, successful community ceased production due to internal conflicts. When it resolved these conflicts, it decided to proceed independently from the association. Perhaps the smaller communities have different types and levels of needs and are not willing to share certain costs that favor larger communities.

It is not impossible to pursue diverse, new goals for an association. Although it, too, experienced organizational problems, one association has invested in nontimber forest products ventures including carbon sequestration possibilities with the hopes of diversifying the sources of money value from the forest, particularly since the forests for these communities are smaller.[5]

Parcels Five of the sample observations have parceled forests, meaning that the *comuneros* within the community have claims to particular parcels of forest. *Comuneros* do not hold title to the parcels, but knowledge of the parcels is commonly held and recognized. These rights are limited in that the person could not sell his parcel to an outsider, but they are able to buy or rent parcels from each other. Among the five communities are a lumber and a roundwood work group located in the same community. The other three observations are stumpage communities operating at the community level. Parcelization originated at incorporation of the communities for the sample observations. One community was formed by a 1950's

[5]For a review of the carbon sequestration possibilities of Mexico's forests, see Klooster and Masera (2000).

legal edict establishing colonies (*colonias*), in which each person in a *colonia* was initially allotted 50 hectares. Another community explained that the forest had been divided among the original 20 or so founders of community in 1925, and then divided and allotted among their heirs.

In the five communities with parceled forest (COLL), harvest takes place either collectively or by individual proprietors of the parcel, but in both cases, the person who "owns" the parcel receives a share of the harvest sale (COLL). The parcels sizes range from 0.5 to 5 hectares (PMIN, PMAX), with an average of 3 hectares (PAVG).

Boundaries transgressions are not tolerated, according to the interviewees. Boundaries are not specifically marked, but using natural markers, each parcel-holder is able to define the limits of his/her holding. Sometimes the parcel had been held in the family for generations, so boundary lines are familiar. Where activity is more frequent such as in coffee *fincas*, the boundaries are particularly well-defined.

The method of exchange between outside buyers and parcelholders with timber was usually between community-level representatives and the outside buyer (PHOW). The harvest plan is maintained at the level of the community and the buyer negotiates with community representatives. Parcelholders receive 70 and 75% (PPER) of the sale price in some communities. Parcelholders can also receive a fixed payment (PFIX) if harvest occurs in their parcel.

In the *colonia* divided into two work groups, individuals organize the extraction of timber from their parcels and sell the timber to their work group which in turn sells to outside buyers or processes it in the work group's sawmill. Individuals contribute a percentage of the sales revenue to the work group (PMAN=3).

Not everyone in a community lays claim to a parcel, which leads to divergence of opinion on timber production goals. In the five communities with parcels, the percentages of registered *comuneros* with parcels in forested areas are 44, 44, 50, 16 and 42%. In one stumpage community, *comuneros* with parcels wanted to continue production with harvest contracts. Those without parcels felt that the forest was overharvested and that too few benefits flowed to the community. As the harvest contracts are approved by consensus in the General Assembly, a near stalemate arose before a harvest season. Nevertheless, the parceled communities did not have significantly higher rates of reporting negative impacts due to differences of opinion ($\chi^2_{(1)} = 0.27$, Prob. = 60%).

An important issue for parceled versus collective systems concerns the quality of the forest and the effectiveness of management. The communities with parceled forests are harder to organize for harvest and management, in the opinion of one forester. *Campesinos* in the organizations with more completely communal forests have a longer planning horizon, the informant thought, which could be due to economies of scale and smoothing production. One parcelholder must wait years for a sale if he has a small forest and if he wants to cut "sustainably," but a group with a large forest can space out harvests over time. It is not known the extent to which parcelholders trade among themselves over time to smooth income. Parcelholders may also be afraid to lose rights to their parcel if they attenuate their rights in any way.

Work Groups In a work group, community members create partnerships among themselves for the purposes of production. Work groups are legal but controversial because of their potential detrimental impact on a forest. In one extreme case, a Chinatu Indian community in the state of Chihuahua formed 59 associations among 1218 *ejidatarios* which ranged from 2-94 *ejidatarios*. They have not divided the land but have divided the authorized volume, which has led to uneven delivery at the sawmill, diseconomies of scale, and fragmentation of the forest (Wexler and Bray 1996).

The survey sample contains four work groups. Two work groups of 50 and 37 people sell stumpage from one community forest. In the other community, one work group of 102 sells roundwood while the other work group of 42 maintains a sawmill and sells lumber (GT1, GT2). In the stumpage work groups, the groups have the same technical forester who is charged with dividing the authorized yearly volume between the two groups, allocating volumes per group member, with each group paying the forester accordingly. The harvest area likewise must be planned each year to accommodate the two group's harvest. This community had originally harvested as a single community, but internal political conflicts broke down the organization. Now the groups have their own JM, documenters, and other personnel, but communicate with the community's single CBC who acts as the interface for the forester. Almost all the profits were distributed among the group members (REPQ).

In the second community with work groups, the evolution was less conflict-ridden. An original group of around 45 persons in a community with parceled forest, decided to form a group for selling timber in 1990. They also have installed a sawmill and sell sawn wood. The forest is parceled into 50 hectares each for each official member of the community. Harvests are controlled by a management plan, but each individual coordinates harvest in his own parcel. A second group of community members decided in 1994 to form a work group, which they did apart from the original group. It is a slightly larger, but self-admittedly less organized, group, that sells logs only. Each of these groups has a different forester, whom they pay directly. Potential new members for the first work group must pay 6000 pesos to join and current members share part of their profits to the group.[6] At the time of the survey, the work groups were decreasing in size over time as individuals exhausted harvesting possibilities in their parcel and, therefore, dropped out of the organization. Each of these groups also had their own personnel separate from the community-level organizations. Monetary contributions to the community as a whole were minimal to nil.

Other Today, recent laws promote private sector investment in timber communities. The Forestry Law of 1992 provides for new forms of community-private sector association to encourage production, mainly plantation-style forest production and joint ventures with foreign companies. The Forestry Law passed on April 24, 1997 subsidizes foreign investment to establish forest plantations on either community or private land which has already been cleared or degraded. Foreign firms are allowed to own up to 40% of the joint ventures (Bray and Wexler 1996).

The law further allows joint ventures called participatory associations (*asociaciones en participacion*) with outside private firms. The community is recognized as the resource owners, while the outside firm contributes capital, training, technology, and marketing contacts. The partnership has to be approved by a “core” population of the recognized *ejidatarios*. Under this law, the paper company Boise Cascade of the United States formed a highly-publicized joint venture with an association of communities in Guerrero. It planned to export logs to United States mills while delivering higher prices to the community than the community received in the national market, building roads and providing training in timber operations. The long-standing and violent conflicts over timber harvesting in Guerrero has led Boise Cascade to withdraw from this project, particularly since Boise was accused

[6] There were some conflicting answers in financial obligations of new and current members.

of exacerbating the problem of corruption and land alienation from community members. Otherwise, this form of association has been little used.

In theory, communities can form a shareholding corporation for the purposes of timber production through a unique form of share contributions. Under this system, each community member has a share of the common area of forest land, called a T share.[7] *Ejidos* and *comunidades* can transfer control over common lands to corporate partnerships in the form of the T shares. If the corporation is dissolved, only the original holders have the rights to the land, a clause serving as a form of protection. The law places tenure limits on the shareholding corporation of 30 years, and limits to foreign ownership of 49%.

This form of shareholding corporations was to open the possibility of "free-market" trading and to promote plantation-style forestry, where a single species is planted on land which has already been cleared. This law could serve as a way to overcome the lack of a market for forest land and create incentives of private firms to invest in the forestry sector. However, this form was not observed in the sample, nor did anyone seem to know about it. Generally, this form of association has been little used, perhaps due to vagueness in the law and the possible risk of alienating land. In addition, the spread of shareholding corporations is perhaps hampered by the difficulty of setting market prices on forest land which has not been traded before, and in many cases, had been rented to timber companies at below market prices.

Community Micropolitics

The community management literature has been sensitive to the local social and political rivalries that could impede collective action. Many of the community

[7]See Articles 125-133 of the agrarian law, as of 12 April 1992.

forest management studies in Latin America and Mexico in particular cite dominance by local elites as a major drawback to sound forest management and economic development (Chandrasekharan 1996, Snook 1993, Merino and Alatorre 1997, Klooster 2000). The impact of conflicts can be serious, leading to three years or more suspension of operations, contraband harvesting, a split from a community-level production into work group levels, and a forester shot on one of his visits.[8] In their review of agrarian reform, DeWalt et al. (1994) found evidence to suggest that conflict seems to have been more debilitating in collective *ejidos* while the *comunidades* which comprise the majority of the sample population have worked reasonably well because of the demands of the cargo system (pp. 31-35). This section analyzes the presence of conflict in the communities studied and claims that internal conflict is not an overriding factor explaining vertical integration across communities in that communities with less vertical integration do not have higher incidences of conflict than integrated communities.

The term "conflict" is ambiguous as is. Conflicts occur in any organization, communal or private or public and at times are healthy for the continuing success of the organization. Many decision-making scenarios could be described as conflictive but part of a necessary process of reconciling legitimate differences, which is different than lack of accountability of political leaders.[9] The question is distinguishing micropolitics from other organizational difficulties in a community.

Examples from fieldwork and case studies illustrate the nature of actual conflicts in forest communities. Disputes occasionally arise between *agencias* and the head municipality over rights to profits from timber production, particularly when the forest lies nearer one *agencia* than to the rest of the populations within

[8]We dropped this community from the list to visit.
[9]Thanks to Reneé Molina for pointing out this distinction.

the municipality. A lumber community had had a major conflict in the early 90's (Martinez and Ramirez 1997). The conflict resulted from two political factions disagreeing on how to divide the revenue of timber production among the main town in the municipality and its *agencias*. One faction argued that the agencias should secede from the main community or receive more revenue, since it is situated closer to the forest, while the other faction argued to maintain unified operation. Outside protagonists may have had an influence as well. The conflict led to a three-year work stoppage, in a community that had just prior received a national award for excellence in production and management. They have since resolved the conflict, "closing out" the outside protagonists and resuming work as a unified community. A similar conflict occurred in another community, leading to work stoppages for a number of years, and the sawmill was boarded up. In both communities, the conflicts and work stoppages led to major contraband logging (Klooster 2000). The fact that one was able to resolve the conflict while the other remained divided could be that political factionalism and *caciquismo* goes beyond forestry to other aspects of community governance. In one stumpage community, the forester has worked extensively to avoid conflicts by locating volumes cut annually according to population. As this was a large community with many *agencias*, the management plan provides for greater volumes harvested in *agencias* with greater populations. Note that communities at all level of integration have experienced conflict.

To open the discussion as wide as possible in gathering information on conflicts within communities that may have impeded investment in forestry, the following approach was taken. We asked whether differences of opinion existed in the community regarding forestry development, what was the nature of those differences of opinion, and whether those differences led to work stoppages or delays. This approach recognizes that conflict could exist in any organization, but focuses on the nature and impact of those differences. We expected the answer to the first question almost always to be "yes." For each affirmative response to whether differences of opinion existed in the community concerning forestry operations, the interviewer followed up with an open-ended question as to the impact of the differences on the community and its forestry operations. Responses were coded after all interviews were held. The responses would indicate internal problems are: reluctance to allocate authorities more power, the administration does not get along among themselves, criticism of management, and a division over whether to invest in maintenance.

Interviews with informed outside observers crosschecked the existence of major conflicts when possible. Because community forestry requires interaction with the public and private sector, persons outside the community occasionally have first-hand experience with the community politics. Occasionally, enumerators spoke with non-authority residents of community visited. People were asked what they thought of the forestry enterprise, what were examples of positive and negative actions taken by the current management and previous management, and how specific decisions were taken. These alternative sources of information were used to verify and inform coding of the responses.

The summary tables show the results. Although the data may not be used in an econometric analysis, it is informative from a contextual viewpoint. Eleven observations which were less reliable due to inconsistencies during the interview process are dropped.

Of the remaining 33, almost all (29) said that there were differences of opinion in the community regarding forestry operations, as expected. With the follow-up question of the the nature of different points of view, the most common point of contention was that the community was split over whether to emphasize conservation or production (Table 3.8). Less integrated communities tended to resist forward integration because of concern that harvest would damage the resource. In informal conservations, people raised the issue that people realized that the forest protects watersheds and did not want it cut. This view contrasted with those who felt that production and conservation could occur simultaneously. The high number of stumpage communities reporting "other" types of differences is due to the varied, unique nature of those differences. Issues include differences over price that buyers offered, political factionalism, concern over damage to coffee crops in particular, and mixed feelings among parcelholders and non-parcelholders in two parceled stumpage communities. Criticism of management and division over investing occurred across all types of communities, although mainly in the more integrated. The least integrated slightly more often reported that their administration did not get along among themselves. Of all groups, the stumpage group had the broadest range of responses, as reflected in the high number of "other" responses.

Most which said that there were differences, said that the differences caused a negative impact on forestry operations (Table 3.9). The most common negative impacts were no investment in developing the forestry operations or to integrate forward, and a suspension of harvest operations. During the course of the survey period, one community had shut down their sawmill operations until they could account for flows of funds. Both the least and the most had experienced suspension of harvest operations due to conflicts. None of the χ^2 statistics were significant at less than or equal to a 10% level of significance across types of communities. Nor was any correlation coefficient greater than 0.4 absolute value between a negative impact and type of community. Therefore, existence (PVIMP) and type of negative impact shows no correlation with level of vertical integration.

Table 3.8: Nature of Differences (Number of Responses)

	Stump-age	Round-wood	Lumber	Forest Products	Total
Differences of opinion exist?	14	8	5	6	33
Yes	13	5	4	6	29
No	1	2	1	0	4
A fraction prefers to conserve and not cut the forest	5	1	0	2	8
Resistance to employ people from outside	0	0	0	1	1
Resistance to give authorities more power	2	0	0	0	2
Criticism of the forestry management authorities	1	1	2	0	4
No agreement in the application of profits	0	0	1	3	4
Some prefer more integration, others the status quo	1	3	1	1	6
The administration does not get along among themselves	3	0	0	1	4
Other	8	2	1	2	13

Table 3.9: Impact of Differences (Number of Responses)

	Stump-age	Round-wood	Lumber	Forest Products	Total
Negative impact occurred?					
Yes	7	4	4	4	19
No	4	1	1	2	8
Forest and harvest is badly managed	0	1	0	1	2
No investment for maintenance	0	1	0	0	1
Harvest operations suspended	3	0	2	1	6
Sawmill operations suspended	0	0	2	1	3
Delay in obtaining permit from SEMARNAP	1	0	0	0	1
Contraband harvesting	0	1	1	0	2
Do not cut full authorization	2	0	0	0	2
No investment to diversify or develop forestry operations	0	2	2	1	5
Authorities not named	0	1	0	0	1
Delay in the harvest	1	0	0	0	1
Other	2	1	0	3	6

Another approach is to look at management incentives. As described earlier, the formal governance structure of the community encases the community forestry enterprises and operations and does not arise from capitalist roots. The formal institutions are products of cultural, social and political systems rather than economic contractual relationships, as firms are typically viewed. Therefore, incentive structures familiar in conventional firms may not be effective in the present setting. Having stated this caveat, the survey questions asked how the community members sanction "bad" behavior and reward "good" behavior of managers, with the terms "good" and "bad" left for interviewees to interpret.[10] Most communities reported that they had some form of sanctioning "bad" performances by persons in the administration. By far, sanctions most often took the form of asking the person to renounce his post (ESTMAL1). Other forms were the community denouncing the person (ESTMAL2), fines imposed on the perpetrators (ESTMAL3), and "other" (ESTMALO). Criticism by a local community can be extremely harsh and should not be underestimated. Sawmill groups preferred that the person renounce his post. Stumpage communities prefer fines and "other" although the patterns are not significant according to χ^2 statistics. Informal conversations revealed that they were used on occasion. The survey asked whether incentives were offered if the

[10] An experience in one community demonstrates the complexity with which community members respond to managers who operate in bad faith. One survey was conducted with a man later discovered to have embezzled funds to the point that the community had to shut down its operations when it discovered the loss. After several months, the community still was not yet sure what sanctions to impose. A major problem was regaining the money lost. This would be difficult, since the man denies that he still holds the money and lacks means of paying it back. Community leaders seemed upset by the situation and perhaps blamed themselves to an extent, since they had given this person a wide range of responsibilities with little oversight. The principal authorities had side jobs that took them out of the community, so they had delegated work to him. The question remains whether they will seek specific forms of justice against the individual, fire him, or solely try to recoup their losses without calling attention to (what they perceive as) an embarrassing fiasco. Nader (1990), in her study of dispute resolution in a Oaxacan community, states that internal enforcement by local judicial processes allows communities to avoid external intervention, which could partly explain this community's reaction.

community forestry management performed unusually well during a term. The general answer was no (ESTIMAD). One general manager interviewed facetiously answered that all the compensation they receive is "*gracias*."

To summarize, conflicts in the less integrated communities are about perception and impact of harvesting which may prevent them from reaching a consensus on whether to integrate. Also, the less integrated tended to have parcelized forests. This suggests other factors than political infighting and *caciquismo* are at work. Individual incentives affecting personal gains and losses of community-level vertical integration are at stake. Both the less and more integrated communities have suspended operations due to conflict.

Open format survey questions about the community authorities' perceptions of future plans for forestry operations (FUT) to understand the communities' commitment to developing forestry operations and technical progressiveness. While communities across the board had a variety of long term plans, the least integrated more often had just "holding pattern" plans. The more integrated groups were clearly interested in diversifying their wood product lines away from only lumber, and improving the harvest process. They also stated more often than the other types that credit or training would be the means to achieve these goals. A frequent response across all types was reforestation.

Gender Dynamics

How does gender affect the ownership decision? Although this study does not focus on gender issues, it is important to note that very few women participate in General Assembly meetings where the key decisions are discussed and brought to a vote. Women appear to have a small voice in decision-making. To participate in General Assembly meetings, one must be a registered member of the community, a *comunero, ejidatario,* or *colono* depending on the legal status of the community. Women become registered members most often when their husbands die. Women with *comunera* status have the right to vote but rarely do even though all communities show a typical pattern of developing regions in that the population is comprised of more females than males, as males migrate away from the region to find work. The percentage of women registered as *comuneras* is 8% for the stumpage, 6% for roundwoods, 6% for the lumber, and 13% for the finished products groups. The higher rate of women registered as *comuneras* in the more integrated community may correlate with their actual participation in community politics. This could be particularly true because this data was collected by responses from community authorities without consulting written documents. Although the community authorities are well aware of details of community, their response could reflect not only the actual list number but also a perception of women's role in community politics.

Neither do women have much employment in the forestry sector. Gender of workers or comparisons of salaries was not recorded in the survey. By general observation, of the 42 communities surveyed, the presence of women was mostly in the administrative staff of seven sawmill communities who had permanent support staff (PERM1-1). In one case, a woman who had received her training from the forestry school in Oaxaca was the documenter for a finished products community. Women were employed in the lighter jobs in the sawmills and as cooks for work crews during harvest.

The gender division would have an effect on investments in the community given that decisions such as the division of profits and the destination of investment funds are taken in the General Assembly. A community organizer said women would likely vote for different application of funds, such as medicine and health care. In this sense, incorporating women into the voting process could make a difference in ownership issues.

While not a scientific coverage, informal interviews with women revealed that in general they considered the forest harvests from similar points of view as the men. Some noted that harvesting the forest provides jobs and income for the community. Both men and women expressed the concern for controlling uses of the overexploitation of the forest. One woman's reaction to not participating directly in General Assembly meetings was that, even though women did not vote, "one needed to cooperate" in general. So any differences that they may have could be tempered by a pull to cooperate with the community as a whole. Some ill feelings towards the authorities in the community, from conversations with women, reflected personal antagonisms based on conflicts between community managers and individual families. For example, a woman complained about the authorities because they denied her husband an advance on his wages. In another community, the lack of voting rights was a distinct point of contention between men and women. The antagonisms existed along gender lines, where the men fined a group of women who attempted to enter a General Assembly meeting to vote.

Gender divisions were less pronounced in nontimber uses of the forest. While we did not ask specifically about gender divisions in non-timber use, formal interviews and informal conversations with women would state that women collect medicinal plants or mushrooms from the forest. For example, in some communities, the sale of mushrooms is a large enterprise. Women in addition to men collect mushrooms for sale during the season. Both men and women and to a lesser extent children collect firewood. One study reported that in the case study communities, 80-100% of the men, 63-85% of the women, and 34-43% of children collected fuelwood (Arzola 1997). In informal interviews, women said that their husband or father would collect the firewood. Buying firewood is also an option in some cases.

Women may benefit from forest activities though loans given to women-run enterprises in the community. Communities occasionally give small loans to entrepreneurial endeavors to provide initial start-up capital. In some cases, all-female groups start these activities, as in the case of a chicken farm and a chocolate milling factory in two survey communities.

3.5 Forest Resource Characteristics and Management

The survey covered questions about the technical production process to determine the nature of contracting relationship among those who invest in upstream silvicultural stages of forestry, those who invest in extraction and processing and the owners of the forest land and machinery required for production. Data describes aspects of production which would be difficult to monitor or specify in a contract, for example, the types of quality standards present in forestry, the scope for changes and unforeseen events that would require renegotiation among those involved in production, and the impact of industrial forestry on nontimber forest products and ecosystem benefits. Forestry management often depends on hard-to-define effort and quality levels. Characteristics of the forest resource itself would also affect management decisions. This section discusses forestry management and the resource with an eye towards these issues.

Technical Forestry Services

Technical services in forestry are an integral step in the production process. During the course of this research it became evident that the foresters not only offered the basic technical knowledge necessary to plan a harvest and long-term management of the resource but also could act as a point of interface among the government, private sector and the communities. Further, they can help foster a "forest culture" in the communities that combines production with conservation.

The government, World Bank project and the service providers themselves recognize this potential role. A newly formed technical services trade organization, *Centro de Estudios para el Manejo Sustenable de los Recursos Naturales S.C.* (CESREM), seeks to set standards among the technical foresters and promote these potential roles, with linkages between the government, private sector, academic researchers, and the communities. However, CESREM also recognizes that the technical services need government and financial support to fulfill these responsibilities.

Today, most communities hire technical services, meaning that they contract a private forester to provide technical services (PM). The communities that belong to an association share the overhead costs of these services. Twenty-nine percent of the finished products communities employed their own full-time forester.

The lumber communities have the highest average number of years that they have been working with their technical forestry engineers (YSTF), perhaps because these communities organized earlier than the other groups. An alternative reason is that the technical engineer develops human capital-specific skills related to the community which would increase the transaction costs for the community to switch to another forestry engineer. Usually, one head forester is responsible for the overall work in the community (STF) but is assisted by technical staff. The number of technical personnel (STFTEC), mostly from the local community, to combat plagues and clear fire trails, was the highest for the finished product category on average. The finished product category paid for technical services and the management plan from their own funds, while the buyers or the government paid for these services in the stumpage communities.

The community authorities were asked what training they had received since 1986 or since they had integrated, in what years, from whom, source of funding of the training, and the number of persons who received that type of training, given as a range. The questions were broken down by type of training. Mechanical training included chainsaws, trucks and cranes and sawmill experience. The more integrated communities had greater instances of training with trucks and cranes since their integration, but the stumpage communities are also receiving training in sawmilling and in handling chainsaws. This is probably because at least two of the stumpage observations formerly had sawmills but then switched to selling stumpage. The forester is most often the source of training for chainsaw handling but communities have learned about truck and crane handling mainly by observation of others. The roundwood group has very little exposure to working in sawmills. Only 13% of the stumpage observations have persons with experience with tractors or cranes. People in the more integrated communities also received training as work exchange or exchange of "goodwill" from other forest communities, many from Michoacan, while the less integrated community populations relied on outside buyers and technical forestry services.

On the technical side of forestry, again the foresters play a large role. While various sources of training were cited, the foresters were most frequently the source of training across groups of communities for documentation (ENT3) and silvicultural treatments (ENT4) although less than half of the communities in each category have persons who received training in silvicultural treatments except for the finished products group. When it came to administrative counseling (ENT6), the foresters again were the most frequent source of training for all groups on average except for the finished products group that most frequently cited corroborations with technical schools or agricultural universities extension programs. The government was most frequently the source of assistance in reforestation programs (ENT5). For measuring logs, relatively more of the higher integrated communities have people who have learned from other sources such as government officials. Finally, community forestry authorities ranked administrative skills and documentation as the most important training they received for developing their forestry enterprises (IMPT).

In sum, more vertically integrated communities have more linkages with other communities regionally and across state lines, which could be an important factor in their organizational and informational capabilities, and the government has more often financed reforestation efforts, while other types of training fall mainly to the technical foresters. Most training efforts have been paid for by the communities.

The forester for the community assessed the level of involvement of the community in forest management. These questions were intended to capture the level and significance of community participation. Forms of local involvement were employment in taking inventories, information gathering in General Assembly meetings or in groups of "respected" community members (Table 3.10). The χ^2 statistics correlating "type" of community with the various forms of involvement are not significant. Almost all foresters, regardless of vertical integration of the community, hired locally for projects such as clearing trails and combating plagues. This tends to be labor intensive work that requires less training and preparation. Only one forester in a wood products community said that the community was apathetic and was not involved in forestry management. In contrast, a forester in another wood products community described the *comuneros* as very involved in the plan design. Assemblies met every two months to discuss the management plan. The forester explained that this is because the people do not like to see a lot of cutting. So the forester discusses the plan with the local community before or during the elaboration, not after the harvest, or else friction occurs. In addition, if the forester needs to modify the plan, he brings up those changes in a meeting with community members.

Table 3.10: Local Participation in Technical Management (Number of Responses)

	Stumpage (16)	Roundwood (13)	Lumber (8)	F. Products (7)
No involvement	0	0	0	1
Exchange of information in GA meetings	6	6	5	5
Small group discussions	0	2	1	2
Employment	14	10	7	4
Other forms	5	5	4	4

These data should be used with caution. Many or all communities have assembly meetings or send people to help the technical forestry services. But the interest shared by the community in managing the forest varies greatly and affects participation. The other difficulty is that these questions do not gauge the degree of effort the forester makes to involve the community.

The questions in the technical survey also sought to understand how the foresters interacted with the community governance and management. Foresters were asked if their responsibilities included finding clients for the community, making suggestions for improvement of operations, or seeking project funds. Overall, their responses were consistent with the community authorities' responses. It seems that the foresters are the least involved in the communities which sell logs and most involved in the communities with sawmills. Foresters were least involved in finding clients. From the foresters' responses, they seemed to have the most arm's-length attitude with the roundwood communities. In those communities, the foresters were least involved in finding clients, making production and development suggestions, and looking for financing (STFINVOL). Roundwood communities seem to be defining their path of development so that they seek more autonomy from technical forester input beyond technical issues. However, the chi-squared statistics were not significant for these indicators. Rather, the responses display a tendency, perhaps a longer-term relationships with the sawmill communities that have built trust on the one hand, and the overall needs for the stumpage communities on the other.

A key area is their potential in helping communities seek financing. They can train a community in management and administrative practices, although this has to be done with each new group of cargos. With increased administrative organization in the community, the foresters can more easily seek financing for projects.

There is concern among policy-makers that the foresters could guide communities for personal gain, especially since the number of qualified foresters is relatively small. While this is definitely a possibility and undoubtedly happens, it did not jump out as a pronounced problem in this investigation. All foresters interviewed distinguished which decisions they take in concert with the community's approval and input and which the foresters control. Likewise, the communities seemed aware of their vulnerability to the foresters' potential influence. In several instances the communities had switched foresters during the past two years because of dissatisfaction with their services. A few foresters noted that communities were particularly "jealous" of their operations, not wanting the foresters involved in market and strategic decision making.

Four communities retained their own foresters as paid staff. In one extreme example, a forester who was hired by the community and required to live in the community for much of the year, expressed frustration with his job. He said that he could not easily make suggestions to the community on how to improve their forest management because the community was so concerned that he was seeking personal gain. Living literally within the center of town next to the town square, he described the evolution of his relationship with the community as going from friendliness to contempt. While this forester worked within the political dynamics of a well-established, vertically integrated community that had itself a strong central family, this example shows the range of power-balancing tactics between foresters and communities.

There is debate concerning the changes in quality over time of the plans, given the different forms in which it was provided. Some claim that the quality has deteriorated because privatization allows communities to seek the cheapest, but poorer quality, services (Segura 1995, Zabin and Taylor 1997a). A registered forester and on average three technical assistants (*tecnicos*) carry out the silvicultural treatments. They usually hire *comuneros* to help with tasks, such as marking, clearing, and taking inventories. The forester or *tecnico* records the diameter at breast height of each tree marked and is paid a fee per cubic meter marked. The inclusion of *comuneros* to help with this task acts as monitoring device. From the survey results, the amount paid per cubic meter was 12 pesos on average, ranging from three to 27 pesos, with the group averages being 11, 10, 13 and 18 for communities that sell stumpage, logs, lumber, and finished products, respectively (STFSIN). Therefore, the roundwood communities pay the least per cubic foot to the foresters, reflecting their lack of capital in comparison to outside buyers, who usually pay for technical services in stumpage communities, and the sawmill communities. More comprehensive and detailed management plans in the finished products communities could explain their high average fee.

Quality of the Resource

According to property rights theory, if the observed pattern of ownership is optimal across communities, then quality of the forest and management effort should not vary significantly across community type. Even stumpage communities can be managed well. It is not necessary for community to manage to achieve sound management practices.

The choice of indicators to measure quality of management and quality of the resource can differ according to goals of management. This research sought measures of quality of the forest for commercial and ecological ends and quality of management to avoid forest deforestation and degradation. To determine what data would be needed, forestry experts in both the United States and Mexico were interviewed. The idea was to develop a multidimensional approach to avoid overreliance on a single measure, which is risky without a non-controversial, universally-accepted indicator for quality. This multidimensional method employs various characteristics to build indices for quality, both of the resource and the management practices of the community.

For quality measures of the forest for commercial and ecological ends, substantial data were already available in the management plans. Management plans have a minimum basic format required by law (*Ley General* 1997). The only cross-plan differences noted here is the manner of conducting inventories and the extent of classifying use of the soil. For example, some management plans had very little data for inventories and land use classifications did not extend beyond forested areas.

The approach to inventories varied widely across plans, with some plans not even including an inventory. Most management plans stated a fire exclusion policy. Fire roads are mentioned in the plan but road planning is not necessarily spelled out in detail.

The plans do not address the nontimber production or conservation of biodiversity. Their primary purpose is to plan the commercial harvest. At most, territory is delineated by land use. If the community has areas of recreation for ecotourism, religious sites, or areas where nontimber forest products are harvested, the plan can identify these areas cartographically to separate them from the harvest rotations. Ecosystem protection provisions can be general and did not exist in all plans, except that the rules about prohibiting harvest in buffer areas, hydrologic zones, and watershed ares was carefully specified. Impacts on the local community could be stated generally or in detail. Any studies of nontimber products and collection is done apart from the management plan.

However, the plan is often updated as new information is gathered on the nature of the forest and as events such as fires or diseases change the location, sequence and timing of harvests. Also, if communities change foresters, the new forester often revises the plan. In the survey, the duration of the plans was 5, 11, 12, and 7 years for communities at each increasing level of integration. The management plans are the shortest for the stumpage communities, reflecting more intermittent and short-term horizons of timber production in these communities. Buyers in 31% of the stumpage communities pay for the management plan (PAGOPM4), so the plan is much shorter in length as communities may change buyers from year to year. In response to the question of whether the management plan was changed over the last five years, 94% of the stumpage communities responded affirmatively in contrast to 54-63% of the more integrated communities. The major difference in reasons for the change between communities was that the harvester was not able to extract the full authorization level (WHYMOD1) so that the plans were altered accordingly ($\chi^2_3 = 12.16$, Pr. $= 0.007$). Harvest rotation cycles were also on average longer as communities became more integrated. The stumpage communities had an average rotation period (CICLO) of four years as compared to between 6.3 and 9 for the communities that extracted timber themselves.

Indicators for forest stand quality for commercial harvest and long-term health of the forest are:

- Silvicultural method used currently, how long that method has been applied, the number of the last harvest rotation, and what silvicultural method was used before.

- The stated goals of the forestry management plan, e.g. producing pine for sawn wood, managing for ecological or social benefits. For purposes of the survey, ecological objectives meant that the plan included more detailed information on non-commercial, silvicultural approaches to managing the forest rather than boiler-plate language.

- Actual age or size distribution. Having an available and current inventory of the age or size distributions of trees in the forest stand is an important element for forecasting growth. Most forest management plans had such an inventory. We first looked for a distribution for the area of harvest (area of production) as a whole. Clearcuts are prohibited, so we asked for the age or diameter at breast height (DAP) distribution of the forest, i.e. what percent of the trees are in each age/size class. If information for the forest stand was not aggregated, we asked for average ages/diameters for each rotation area or subdivisions (*rodales* and *subrodales*) within the stand and then averaged to obtain a distribution. Finally, if an inventory was not available in this manner, we asked the forestry engineer for a general estimation using his best judgment ("*ojo de buen cuvero*").

- How the actual distribution compares to an ideal distribution, given the stated goals of the management plan. All management plans have the primary goal of producing timber for commercial production. The question of comparing distributions, however, only works for pine, since ideal distributions for tropical species are not well-defined. In the case of pine, we can determine what percentage of the forest is in the 30 to 60 year old range, which is where the foresters wish to have the greatest concentration of trees.

- Since no objectively defined criteria exists for combining the above indices, we augmented the management plan data with the forestry engineer's general assessment of the quality of the forest for quality of the forest for commercial production, soil conservation, and biodiversity. Foresters responded to the questions of what percentage of the forest was very high, high, medium, low or very low quality for each of these "services." Soil quality assessments considered soil coverage and erosion problems. Commercial quality focused on species, average DAP, climate and soil conditions. Biodiversity was the most difficult to assess. Without training in species diversity and ecosystems, foresters can differ widely in their assessment of biodiversity in the same forest (F. Schurr, pers. com., Jan. 2000). The subjective measures of biodiversity as gathered in this survey should be treated with caution. The foresters were not given specific criteria to judge biodiversity, only to compare biodiversity to the whole range possible in any forest, including tropical and dry forests.

From foresters' responses, the purpose of the management plan is primarily for planning commercial harvests (OBJ). Foresters for the more integrated communities most often stated that the plan had distinguished ecological objectives.

The more vertically integrated communities have a longer and more consistent history of forest management. The particular silvicultural technique currently applied to manage the forest, usually SICODESI or MDS, has been applied continuously for a longer period of time in the roundwood and lumber communities (DUR). This may be because the the stumpage communities have had management plans for shorter periods of time. The low average for the finished products group may be because at least a few finished products communities had continued with the parastatal plan written under the MMOM system in the transition to community control.

For those communities whose management plan has inventories of the entire forest tract, DIST indicates whether the following distribution is in age classes (EDAD) or centimeters of diameter at breast height (CM). The stumpage and roundwood types included in DIST have a higher percentage of their forests in the critical range of 30 to 40, either DAP or years. Forest practices in Mexico aim to have an even-aged forest stand with equal percentages of hectares in each of the age classes. Size and age does not necessarily correlate, because of varying light and soil conditions across communities. However, the foresters interviewed indicated that size and age correlated fairly well for the pine forests under their management. Therefore, some comparisons of size and age will be made depending on the data available in the management plan. Inventories covered entire forests or subdivisions of the forest. The method of recording inventories is noted in NOD. Stumpage communities tended to inventories recorded for a subset of their forest in the plans. Those recorded in age classes range from 25-35 to 65 and up. Those grouped by DAP have a slightly different range from 20-30 to 70 plus. Distinct distribution differences between types of communities does not appear.

For the five levels of commercial quality (QCOM1 to QCOM5), the difference in averages do not appear large, but closer observation suggests some patterns. The stumpage group has the lowest average percentage of hectares considered excellent commercial quality, followed by the wood products group. The latter category could be experiencing effects of a long history of logging that has begun to take a toll on forests. The middle two groups appear to have a larger percentage of their forests as high commercial quality.

The finished products group has more hectares on average ranked as high in biodiversity (QBIO1). The stumpage group has a larger average percentage than the roundwood and lumber groups perhaps because they have less harvesting to disturb biodiversity. Foresters classified zero percentage of hectares as high in biodiversity, except for one lumber community with 20%, leading to the low average in this group.

For severity of soil erosion in the forested areas (QSUE1 to QSUE5), the stumpage and roundwood groups had greater percentages of their soil suffering from erosion problems than the sawmill communities.

To explore the effect of parcelization on the state of the forest, the averages for parceled communities only were compared with the averages for the whole sample. The five communities with parceled forests (COLL) together show a higher average level of quality of the forest than the non-parceled forests for commercial, biodiversity and soil maintenance services. This may be because at least one of the parceled forest had not experienced much commercial harvest, so that its commercial potential remained high.

Pairwise correlations show that commercial potential, soil and biodiversity indicators often vary together at the lower levels of quality. Forest that is ranked poorly in one aspect often is ranked poorly for other characteristics, for example low commercial potential and biodiversity ($\rho = 0.52$), high soil erosion and low biodiversity ($\rho = 0.63$) and low commercial quality and high soil erosion ($\rho = 0.75$). At the high quality end of the scale, only high soil quality (QSUE1) varied positively with high biodiversity (QBIO1) ($\rho = 0.56$) above a 0.50 ρ-value.

To sharpen the measures, indicators for level of biodiversity, soil maintenance capacity and commercial quality were combined in the following way. QSUE and QCOM are the addition of percentages of total hectares of forest rated very good or excellent for soil maintenance and commercial quality, respectively. Since biodiversity measures are less refined as an estimate, only the number of hectares classified as excellent are used. Noting that foresters frequently seek to have the largest percentage of their timber volume in the 30-60 year-old age group (DIST3060), a variable captures the percentage of forest hectares covered by trees in this age group. This applies only to pine stands, so a measure for all communities is not possible. The measures were averaged together to arrive at a measure of forest quality (SILVAVG2). The average by group is 44, 50, 49 and 60%, showing a relatively increasing level of forest quality with integration level. However, the correlation coefficient is weak (0.28) and differences in means are not significant according to a t-test, except for the difference between the stumpage and finished products categories, which is significant at the 10% level. The lack of correlation is consistent with the theory that optimal ownership patterns are chosen given exogenous conditions and should lead to optimal investment levels under those conditions. This points to the result that communities need not integrate forward to achieve these forest quality standards.

Most of the management plans classified land use for the entire community. The roundwood communities have the largest average area (SUP), forested land

(SUPA), forest land designated as commercially viable (APROV), and areas under protection for flora and fauna (PTTN), mainly because of one outlier that covers 460,000 hectares, driving the average for this group up. Not all management plans denoted urban and agricultural areas, but of those that do, stumpage communities have the smallest average urban area, followed by the lumber communities, then roundwood and finished products groups (ZU). The stumpage communities are more agriculturally oriented, with a larger average agricultural land area despite smaller overall size of territory (ZA). The finished products have more land dedicated to reforestation efforts (REF) and tourist purposes (TURIS) than the other communities, while the lumber group have the largest average number of hectares under natural regeneration and below productive potential (BAJA).

Local Management Effectiveness

A separate set of survey questions explores community responsiveness to management goals and land use rules. Questions to rank the quality of community management practices were:

- Level of community's organization and readiness for combating fires. This refers to how prepared or trained community members are for attending to fires, how quickly they respond to fires and general fire awareness. Answers were given on a coded basis for degree of organization. This measure should technically also be a function for the forester's planning effort, which is not included here.

- Number of hectares that suffered in forest in the past five years and the cause of the fires.

- Existence, degree and purpose of clandestine harvesting of commercial trees

- Existence and severity in the last 3-5 years of clearing forests (*aperaturas*) for agriculture or pasture. Clearing is usually for a practice of *roza, tumba, quema*, or swidden agriculture. PROCAMPO, introduced 3 years ago, encourages otherwise infeasible clearing because it subsidizes fertilizer for corn and bean crops. Oaxaca's predominantly mountainous terrain is not conducive to such harvest practices. This question could establish a measure for opportunity costs of land. An example of overharvesting and degradation is if high quality trees were cut to clear land for a low return activity.

- Existence of illegal collection of nontimber products, firewood or hunting.

- Stability of harvest history in past 10 years (both community and technical services practices) and reason for variations in year-to-year harvest levels. Consistent levels of harvests over the years indicate better management.

- Whether they have an inventory of the forest as a whole, by rodale or by subrodale. Several forestry engineers stated that an inventory at the level of the entire forest as well as by subrodale/rodale for cutting purposes indicates a better forestry management policy.

- Rules for managing access to the forest. The data includes rules regarding collecting timber and non-timber resources from the forest, permits, length of time the rules have existed, sanctions, and enforcement of the sanctions.

- Distance of population centers from the forest resource. This measure can have both positive and negative effects on responsiveness. Closer control can mean greater monitoring opportunities to protect the forest. Distance can make response to fire difficult. If a forest is geographically far from the community, the need for rules may be lessened because of collection costs.

The stumpage group ranked lower in their organizational readiness to combat fires (EVITA), with readiness increasing by group. The roundwood group lost the largest average number of hectares to fire in the year before the survey, partly because of a devastating fire that consumed 12,000 hectares in one roundwood community in 1998. Taken by percentage of total hectares, about 10% of the forest in both stumpage and lumber communities suffered a fire in 97-98. The lumber communities have a larger percentage of their reforested plants grow to maturity (CRECE). Of the communities that clear forest for agriculture or pasture, the stumpage group has higher degrees of clearing (SEVER) even though they are on average farther from the forest resource (ACERCA).

The indicators for contraband logging reveals that contraband logging is more common in the parceled communities (ILLEG) ($\chi^2_3 = 17.5$, Pr. $= 0.001$). But the degree of transgression (QILLEG) is similar to other communities that have contraband logging.

The four variables, EVITA, CONTRA, CLEAR, and CLEAR2, were factored with principal factors techniques, the first factor scored and then saved as the dependent variable. The factor loadings on all variables together are greater than 0.5, suggesting that they vary together to a reasonable degree allowing a believable index for forest management responsiveness. Score averages (FMQ) across groups are -0.44, 0.21, 0.05, and 0.60. Lower numbers indicate less responsiveness to management rules. The roundwood group has the lowest group average. As with the forest quality indicator, the indicator for management responsiveness is correlated weakly (0.39) with vertical integration, and mean differences across groups are not significant according to a t-test, except between stumpage and finished wood products at the 5% level and stumpage and roundwood at the 10% level.

Table 3.11: Factor Loadings: Forest Management Responsiveness

Principal Factors, 3 factors retained, Observations=39				
Factor	Eigenvalue	Difference	Proportion	Cumulative
1	2.51722	2.40915	0.9786	0.9786
2	0.10807	0.05647	0.0420	1.0206
3	0.05161	0.15613	0.0201	1.0406
4	-0.10452	.	-0.0406	1.0000
Factor Loadings				
Variable	1	2	3	Uniqueness
EVITA	0.55729	0.26100	-0.05034	0.61877
CONTRA	0.63379	0.09308	0.16975	0.56083
CLEAR	0.94811	-0.17127	0.04992	0.06926
CLEAR2	0.95187	-0.04419	-0.13328	0.07424

3.6 Patterns of Nontimber Benefits

Communities have historically used their forests for a wide variety of nontimber resources at the subsistence level. Nontimber production often does not represent large sources of revenues in comparison to industrial timber operations, but are important culturally and for income substitution and smoothing strategies, even when the broader uses and market potential are not known to the users. Because timber production potentially affects the availability of these benefits, this study seeks to determine the ownership response of community organizations when nontimber benefits exist to differing levels of volume and value. This section discusses the source of nontimber benefits of forests in the communities surveyed and the degree to which the production of timber can be separated from nontimber production through contractual arrangements. The inability to separate the two flows of benefits hypothetically raises the costs of transacting in the marketplace, a hypothesis which will be tested in the empirical section of this study. The nonseparability of timber and nontimber production arises in one of several ways, each of which could alter how members of a community decide about the way to approach forest management.

- Timber and nontimber production may be ecologically nonseparable (Pilz and Molina 1996, Hosford et al. 1997, Valencia Herrera 1996). With sizeable nontimber production, a breach of contract by an outside firm would be more costly because of forest damage. In informal conversations, one community authority said that the community members work more carefully than non-owners. Another commented that they cannot control private firms that enter the forest to harvest, so they prefer to harvest themselves.

- Bounded rationality arguments could also apply here. Communities may place importance on the quality of production services in their forest stands because of future nontimber benefits. The future benefits of the forest ecosystem is unknown. One can hypothesize that as communities learn more about the forest, their perceptions of its value change as well. Uncertainty over future valuation of the forest could encourage them to control production to a greater degree.

- Nontimber and timber production likely draw on the same investments in patrolling, establishing a management plan, and improving forest quality. Cost complementarities would make community control more efficient. A community which has invested in forest management institutions for reasons other than timber may also have a human capital or institutional base for addressing timber management. The degree of separability of forests can be very low so that plans must be coordinated. For example, a management plan not only must identify water sources but separate these areas to account for flora and fauna habitat, to protect them from damage caused by harvesting.

Table 3.12: Prevent Damage to Forest During Harvest

	Stumpage (15)	Roundwood (10)	Lumber (8)	Fd. Pdts. (7)
Very easy	6	3	3	5
Easy	4	5	2	0
Difficult	3	1	3	2
Very difficult	2	1	0	0

$\chi^2_{(9)} = 9.1427, Pr. = 0.42$

The quality of wood operations can vary considerably, for example, in the quality of the road built to extract timber (Kusel 1991) or the amount of debris left in the forest. Community authorities assessed the level of difficulty in preventing damage during the harvest, using a scale of one to four with one the most difficult. The χ^2 statistic for cross-group patterns is not significant at the 5% level. All communities had incidences of training loggers to follow practices that would prevent damage to the forest and surrounding trees, but this training could be part of standard practice. All communities also had incidences of supervisions to verify that they were following these practices (PRVSUP=1).

Fuelwood Collection

Most families use firewood for cooking even when the household has gas stoves (Table 3.14). In percentage terms, the stumpage group families on average more often consume firewood perhaps because of their lower access to electricity (PPE). However, only in the most integrated communities is there a significant drop in the percentage of families that use firewood for own consumption. Likewise, the percentage of families that consume charcoal for their own use increase by category of production.

The dynamics of fuelwood collection is complex, depending on household income, village size, cultural connotations, scarcity of fuelwood resources and reliability of fuelwood supply, according to recent studies (Masera 1995, Amacher, Hyde and Kanel 1999). An important point for forest conservation practices is that the impact of fuelwood collection on land and forest resources depends highly on the method of collection, e.g. dead or live branches, spatial patterns of collection (Masera 1995). A report on firewood and charcoal consumption and sales notes that in their case studies, a family that cooks with only fuelwood uses 11.9 kilograms per family per day of fuelwood (Arzola 1997). The adoption of gas furthermore does not mean that a family relinquishes use of fuelwood. Even when they have a gas stove, cooking may still occur with firewood (Masera 1995). Therefore, families included in the percentage that use charcoal may be included in the percentage that consumes firewood. Sales of firewood are usually organized by individuals and their families (VENGRUPL).

Most sample communities have customary rules regarding collection of fuelwood. Persons are allowed to collect fuelwood for their own use without permission but only in certain parts of the common property, such as parts further away from the population, and only dead branches and trees. Rules include areas specified for collection, type of wood which can be collected for fuelwood, and permits and payments for collection. Increasing vertical integration in the sample is correlated with stricter rules and enforcement for collecting firewood. For example, the tariff table for collecting wood for commercial ends is shown in Table 3.13 for one finished product community. The most integrated communities have the highest average for existence of "credible" rules regarding forest use, in terms of the number of times that rules were enforced over the last two years. Although more vertical integration increases the number of rules, all communities that have rules have had them in place for similar lengths of time because of the widespread customary nature of fuelwood collection.

Table 3.13: Table of Prices (pesos), for Commercial Ends Only for *Comuneros*

Derecho de monte for a branch of pine, per m^2	25.00
Oak for firewood, load of a 3-ton truck	75.00
Morillo of pine, per meter in length	1.70
Pilote of oak, per m^2	50.00
Horcon of oak, per meter in length	2.50
Load of sand and gravel, 8-ton truck	100.00
Load of sand and gravel, 3-ton truck	50.00
Costal of soil from forest	10.00
Load of rocks, per m^2	20.00
Costal of *musgo* or *pasle*	15.00
Rental of 3-ton truck, sawmill to town	75.00
Rental of 3-ton truck, Forest to town	370.00
Rental of 3-ton truck for moving, town to Oaxaca	450.00
Rental of 3-ton truck for moving, town to Oaxaca, per day (not including gas and driver)	500.00

Note: Payment of above items will be made in advance. This price table is in effect as of August 16, 1999. Signed by the *Comisariado de Bienes Comunales*.
Source: Internal document of community forestry enterprise.

From the survey data, marketing charcoal more commonly occurs in the sawmill communities and has existed for more than 21 years in these communities. An export market developed for charcoal in about 1988. At this time, parts of Europe, specifically Germany, were seeking sources of charcoal. The SARH informed communities that a market existed. One union of timber producing communities in Oaxaca particularly took the initiative and formed a charcoal collection business. Some of them had had members involved in charcoal production, while others built new stoves for this production. Both large and small stoves were built in communities. Building on the structure of communities in the association, the charcoal export business funded two assistants to collect the charcoal and trucks to transport the product. Individuals made the charcoal and then supplied the charcoal to a central collection point. The market ended in about 1988.

Wood for Domestic Use

All community populations use the forest to collect wood for domestic use (UD), often to build homes (Table 3.15). The stumpage and the finished products communities have the highest percentage of families that collect wood for domestic use. The roundwood and finished products groups more often had rules to regulate collection, possibly facilitating collection. The volume collected in the finished products community is considerably higher than other groups on average. However, enforcement increases by integration. Likewise, the finished products group had the highest incidence of sales of wood for domestic use (SELLUD). Only 10 communities said that they allowed persons to sell wood for domestic use commercially, but of those that do, the roundwood by far sell the most average quantity per community.

Fungi

Mushroom collecting has a long and important cultural history in Oaxaca (Wasson 1980, Estrada 1981). Most communities said that people have collected mushrooms for consumption for hundreds of years. Mushrooms are used in rituals for religious and spiritual purposes. Aside from ritualistic practice, however, almost no rules existed at the community level for collecting mushrooms for own consumption. Interviewees indicated that this was because of the relatively small amount collected. An alternative reason could be that harvesting practices have become so ingrained that people do not realize that community norms exist for collection.

The commercial market for mushrooms is in complete contrast. The sale of

Table 3.14: Fuelwood Use

	Firewood				Charcoal			
	Stpge	Rdwd	Lmbr	F. pdts	Stpge	Rdwd	Lmbr	F. pdts
Families which consume	96%	93%	95%	76%	0%	1%	29%	17%
Communities which sell (count)	4	4	3	4	2	1	3	2
Number of years sold								
Less than one year	0	0	0	0	0	0	0	0
Between one and two years	0	0	0	0	0	0	0	0
Between three and five years	1	0	0	1	0	0	0	0
Between six and ten years	1	0	1	1	0	0	0	0
Between eleven and 20 years	1	2	0	1	1	0	0	0
Between 21 and 50 years	0	0	0	1	0	0	1	1
More than fifty years	1	0	1	0	1	0	2	1
Frequency of rules in place*	25%	62%	71%	86%				
Number of years that rule existed*								
Less than one year	0	1	0	0				
Between one and two years	0	0	0	0				
Between three and five years	0	2	0	2				
Between six and ten years	0	0	3	0				
Between eleven and 20 years	0	4	2	2				
Between 21 and 50 years	2	1	0	1				
More than fifty years	2	0	0	1				
Existence of sanctions (percent)*	75%	38%	60%	80%				
Times rules enforced in last two years (avg.)*	0.33	0.33	0.50	1.25				

Note: “*” indicates that data refers to both firewood and charcoal.

mushrooms to a national or international market has exploded in the last eight years, largely due to market opportunities in Japan. In the eighties, Japanese importers visited communities in Oaxaca to seek sources of the local version of the *shitake* and *matsutake* varieties. When the market was finally established, communities began to sell mushrooms to exporters at up to 500 pesos per kilogram for the local variety, which grows in the roots of dead pine trees. Since then, the export market has become a regulated market that provides income to a number of communities. Individual persons or persons organized into work groups (VGRHON) collect the mushrooms according to specific guidelines for harvesting and packaging. Exporters have funded courses in the proper handling of the mushrooms and have provided containers and raincoats for collectors. On a regular basis during the harvest season, buyers visit the community to collect the harvest. One stumpage community authority claimed that mushroom collection employed up to 100 persons. Averages for other communities were between seven and 25 individuals for the roundwood and lumber communities, respectively, and two work groups for the finished products communities.

The percentages of communities that exported fungi were 7, 8, 38 and 57% according to each group of increasing level of integration. Most are located in the Sierra Norte region. The average prices per group were 420 pesos per kilogram for both the stumpage and roundwood groups and 533 and 483, respectively, for the lumber and finished products groups. Mushrooms have to be protected from timber harvests, as their growth is sensitive to trampling, soil conditions and light (Pilz and Molina 1996, Hosford et al. 1997, Amaranthus 1998). Although an exact number is not available, some communities had separated areas for mushroom growing or experimentation. The mushroom season is exactly the opposite as the harvest season, as the rains prevent harvesting but encourage mushroom

Table 3.15: Collection of Wood for Domestic Use and Mushrooms

	Wood for Domestic Use				Mushrooms			
	Stpg	Rdwd	Lmbr	F. pdts	Stpg	Rdwd	Lmbr	F. pdts
Communities that collect	100%	92%	88%	100%	88%	92%	88%	100%
Families that consume	11%	6%	8%	14%	63%	23%	46%	48%
Volume consumed (average)	42 m^2	50 m^2	22 m^2	342 m^2	164 kg	116 kg	167 kg	260 kg
Communities that sell product	6%	8%	0%	29%	13%	6%	50%	57%
Volume sold (average)	0.23 m^2	286 m^2	0 m^2	140 m^2	400 kg	20 kg	448 kg	451 kg
Number of years sold								
Less than one year	0	0	0	0	0	0	0	0
Between one and two years	0	0	0	0	0	1	1	0
Between three and five years	1	0	0	0	0	0	2	4
Between six and ten years	1	1	1	0	1	0	1	0
Between eleven and 20 years	1	0	0	1	0	0	0	0
Between 21 and 50 years	0	0	0	0	0	0	0	0
More than fifty years	1	0	0	1	0	0	0	0
Frequency of rules*	10	12	5	6	1	1	3	5
Number of years that rule existed								
Less than one year	0	0	0	0	0	0	0	0
Between one and two years	0	1	0	0	0	0	0	0
Between three and five years	1	0	3	4	2	1	0	0
Between six and ten years	0	0	0	0	1	3	1	4
Between eleven and 20 years	0	0	0	0	4	5	2	2
Between 21 and 50 years	0	0	0	0	3	3	1	0
More than fifty years	0	0	0	0	0	0	1	0
Communities with sanctions	100%	100%	67%	100%	100%	64%	80%	100%
Times enforced in last two years (avg)	0.17	0.29	0.50	2.6	0	1	0	2.5

Note: "*" Frequency of rules for mushrooms refers to commercial mushrooms.

growth. During this time, groups of *comuneros* devote themselves to collecting the mushrooms for sale.

There are numerous projects to promote the cultivation of mushrooms. The *Instituto Nacional de Investigaciónes Forestales y Agropecuarios* (INIFAP) runs a project and collects a small fee per kilogram of mushroom sold from the communities to fund the project. An association has an active mushroom collection and research project underway, led by researchers in U.S. universities. PROCYMAF has funded courses to teach persons to identify, cultivate, cook and market mushrooms. Much of the efforts in promoting mushroom production is not only for export but also as a source of food (PROCYMAF meeting, Feb. 2000 Oaxaca).

Other Nontimber Products

Interviewees noted between two to three different products on average which were collected from the forest (NTRANGE) that included ornamental flowers, resin, game, medicinal plants, soil, butterflies, *palma camedor*, *pita*, *barbasco*, and the "other" category. Oaxaca is the number one producer in Mexico of *barbasco*, a root which pharmaceutical companies use for producing hormonal drugs. However, it grows in tropical areas that tended to have less timber production and so did not appear in the survey sample often. The most popular response for "other" products collected from the forest was medicinal plants used in the home or traded casually among the families, most frequently in stumpage communities (NU1). A possibility is that all communities had people collecting medicinal plants, but that it is so common as to be overlooked by authorities, especially since mainly women collect plants. Medicinal plants was also a safe answer in situations where communities were not completely confident in the interview process. The percentage of communities by increasing level of integration that mentioned a product other than medicinal plants as their most important product was 31, 54, 50 and 43%, so that the roundwood category had the highest average.

The second most common answer were flowers which grew in the forest. People collected flowers on a long-standing basis for seasons such as Christmas and Easter holidays when certain flowers were popular. During Christmas season a green moss (*musgo*) is collected to decorate Christmas mangers. Aside from these activities, one lumber community has developed an orchid research project which investigates the relationship between the flowers and the trees in which they grow. This project began about three years ago with international funding.

Community authorities were asked to name their most important product of the nontimber products they collected and then answered questions about their management. For these products, very few rules applied to the collection of these products, and the markets were local or regional. Only three lumber and one finished product community had rules regarding collection of "other" products (REGOT). The three lumber communities had had rules in place for more than six years. The average number of years collecting the product was between 21 and 50 years for the more integrated communities and more than 50 years for the stumpage communities, since stumpage communities most often reported their most important product as medicinal plants, which has a long history of collection. Of those communities whose members sold the product, the communities had an even average by group for years selling the product.

Grazing

The survey questions asked about whether persons allowed their livestock to graze in the forest. This is not necessarily a destructive activity for the forest. Grazing could promote timber growth and be viewed as a complementary activity. Both foresters and a community member noted that animals eat oak trees which compete with commercial pine, leaving the pine trees to grow. Secondly, grazing in the forest appears to be a marginal activity. When asked the percentage of forest area over which livestock roamed to graze, the average percentage was estimated 35% for stumpage communities, with the other groups having an average of 19% or less. The stumpage group had the second largest average after the lumber group for persons receiving income from livestock activities, which may explain this higher figure. Overall, communities most often (31 of 44) said that no rules exited to regulate animal grazing inn the forest, and no rules, where they existed, had been enforced in the last two years. Most rules about grazing animals were designed to keep animals from destroying agricultural crops.

Other Access Rules

An important motivator for community integration would be assuring access to the forest. Rules for collecting forest products existed prior to 1986, usually increasing in frequency by type, but they were not common. Where they existed, community authorities themselves usually imposed and enforced the rules without outside influence. Narratives in informal conversations from other sources suggested otherwise. During a community meeting held with PROCYMAF a member noted that the parastatals prohibited people collecting wood for domestic use from the forest. This point was also raised in discussions with NGOs. Further research would be necessary to determine the level of restrictions imposed by outside firms harvesting in the Oaxacan communities in the past.

Complementarities

Patrolling, developing the management plan, harvesting and decision-making can affect different aspects of forest exploitation at once. Complementarities can take the form of building a stock of knowledge in one area that is applicable to another area. For example, knowing where the mushrooms grow is an important piece of information and can be used to plan out timber and mushroom production areas. Another opportunity for complementarities are the coordination of harvest and sharing of fixed costs.

Overlaps can occur through the design of the management plan, supervision during harvesting and forest management in general, and the scope of the community enterprise activities. Community authorities were asked a series of questions that targeted potential investments to protect or promote nontimber products, endangered species, wildlife or the forest in general. Interviewees were asked whether 1) the management plan delimits an area of conservation in the managed forest area, 2) foresters are paid to carry out projects or training on conservation, 3) the community forestry organization pays patrols to monitor non-commercial timber products and services, 4) the community members participate in projects for the protection of flora and fauna, and 5) the community participates in projects for the production of nontimber projects. The indicators do not capture the knowledge gained in timber activities but research in areas of nontimber forest products for commercial and scientific ends. Table 3.16 shows that as communities become more vertically integrated, they are more likely to have management plans or systems that integrate both timber and nontimber uses of the forest with χ^2 statistics significant at the 5% level for all indicators except for one which is significant at the 10% level. Comparing this result with the land use classifications from the management plan, the roundwood communities by far have the highest percentage of their forests classified for protection or conservation, followed by the finished product communities. The finished products communities have the highest reforestation rate compared to the size of their forests, as well as the most area dedicated to recreational uses (PPTTN, PPREF, PPREC). Fourteen communities have management plans which delimit an area for conservation (CMP11). Thirteen communities in the sample pay their foresters to carry out conservation programs in the community (CMP12). Twelve communities paid their vigilance officers to protect specifically nontimber benefits (CMP13). With less clear cross-type patterns emerging, 18 of 43 respondents said that projects to *protect* the flora and fauna existed in the community (CMP14). This included mushroom research projects, horticultural projects, and rules on hunting. The reason for a weakly significant χ^2 statistic on this variable is that the Mexican government recently introduced a law prohibiting deer hunting. While less than half the communities interviewed mentioned the moratorium, this law would affect all groups equally. Four communities have projects targeted toward the *production* of nontimber products from the forest (CMP15). These include mushroom production. A few lumber and finished products communities had some "other" form of promoting or protecting nontimber benefits from the forest (CMP1O). Eleven communities distributed across all three types reported no particular investment in non-timber benefits from the forest (CMPNO).

Complementarities were sought in the use of inputs in timber and their possible use in nontimber production (COMP2). Community authorities were asked whether equipment or persons dedicated to the timber operations were also involved in nontimber operations such as those described above. While affirmative responses followed a nonlinear pattern (47, 50, 25, and 71%, respectively according to increasing levels of integration), the communities with sawmills most often use

Table 3.16: Production of Nontimber Benefits (% Responses)

	Stumpage	Roundwood	Lumber	Fd. Pdts.
Delimit area of conservation ($\chi^2_{(3)} = 13.90, Pr. = .003$)	12	18	50	86
Pay forester to conduct conservation programs ($\chi^2_{(3)} = 14.62, Pr. = .002$)	6	27	38	86
Pay patrols to monitor nontimber products ($\chi^2_{(3)} = 9.21, Pr. = .027$)	13	18	38	71
Projects for protection of flora and fauna ($\chi^2_{(3)} = 6.33, Pr. = .097$)	19	45	50	71
Projects for production of nontimber goods $\chi^2_{(3)} = 11.55, Pr. = .009$	0	9	0	43

their logging trucks in nontimber activities when not occupied in the timber operations (CMP31) while the stumpage communities used workers in other activities (CMP33). Of those that responded affirmatively, 14, 0, 5 and 20% in each category used their timber workers for nontimber activities. This is because the workers have no work during the off-season, so are employed to keep them active. Communities allocate equipment for timber operations in nontimber forest operations as well, usually trucks which can transport goods from the forest to population centers (CAMNF). Communities in which the forestry enterprise or individual *comuneros* owned their trucks were more often the communities of increasing levels of integration. The communities can utilize the trucks for nontimber activities when the trucks are not occupied in timber operations, thus introducing complementarities in production of different services within the community. This variable indicates a degree of synergy between nontimber and timber activities when the community controls timber operations.

Finally, government programs and nongovernmental programs are promote the production of nontimber forest products. PROCYMAF and the United Nations Global Environment Fund mentioned above are a few of the initiatives, along with those of nongovernmental groups and SEMARNAP.

3.7 Contract Relationships

The ability to describe a contracting relationship through contract clauses can reduce transaction costs of a trade and therefore favor market transactions. The inability to write such clauses can discourage market transactions depending on the nature of investments. This section summarizes the survey data on contracts for the sale of roundwood sold by cubic meter across all community types, and, to some extent, the sale of lumber.

Location and Transportation

With transportation costs a major factor in production, location specificity could have strategic importance. The sample contains communities from seven of the eight regions of Oaxaca so that it is a highly representative cross-sample. Because of the concentration of forestry activity in the Sierra Norte and the Sierra Sur, most of the sample is based in these regions. The next largest category is the Valles Centrales, which include regions on the valley side of the Sierra Norte and Sierra Sur mountains and have easy access to the sawmills and transportation routes in the Valley. The variable DOAX is driving hours in an automobile from the community to the capital city of Oaxaca. The distance from the capital city of Oaxaca (DOAX) decreases by type, although the stumpage communities are closer to a major population center other than Oaxaca city (DCITY), measured in driving hours from the village center.

Mexico's agrarian laws present a caveat to the application of the contract literature. The institutional restriction that communities will not or cannot sell forestland, the upstream asset, introduces a twist in the analysis, both for reaching economies of scale in production and for writing contracts. Sawmills on community land near communal forests are owned by the community, while sawmills in the larger cities range in ownership over community and private companies. In the present study, the owners of sawmills in rural areas would be subject to hold-up risk because they are largely committed to the particular areas where they are situated, relying on a specific source of timber supply and labor pool. Spanish colonialists, for example, built sawmills in the main city of Oaxaca to avoid reliance on a single supply source. In an open land market, a site located next to a community forest would most likely lead to integration, either upstream or downstream (Joskow 1985). Because no land market exists for common land, private sawmills cannot backward integrate into timber rights.

There are about 70 sawmills in Oaxaca, the majority of which are in rural areas, with the balance in the main city of Oaxaca (Zabin 1992). Transportation costs are a key factor determining efficiency and profits in the forestry sector. This suggests production efficiencies between harvesting and sawmill operations. Most of the sawmills were in the community (UBIAS1=2) rather than in a city (UBIAS1=1). The second sawmills, where they existed, were also located in the community, usually next to the principal sawmill, perhaps built as a replacement. These sawmills were most often an hour from the logging roads where harvest takes place, although locations varied from 1 to 12 hours away.

Almost all the communities that harvested their own timber delivered timber to the receiving area of the client (UBIDEL3). Only one roundwood community left the logs at the site of the cut for the buyer to fetch (UBIDEL1). One roundwood and one lumber community left timber in the logging road for the client to haul away (UBIDEL2). The buyers in the stumpage communities were responsible for hauling the logs away. Sawmill communities sell lumber at the site of their own sawmill.

If the communities are optimizing according to comparative advantage, prices should vary positively with skill of the community and negatively with distance to client. As communities get further from the capital of Oaxaca, they have fewer clients, as expected, and more from other Mexican states. Hours needed to transport the logs to the buyer lengthens. Remoteness could possibly encourage the community to own the production processes themselves. Instead, just the opposite effect occurs. The reasons to be explored are that the legal limitations on the sale of land prevents buyers to backward integrate into forest land and production, and that the risks of investing in a sawmill closer to the capital are less while opportunity costs for community members are greater. If greater distance reduces the range of income-earning opportunities, then specialized investments may not be attractive to community members. Specialized investment in a community with few options may not be a good risk management strategy. Distance from Oaxaca was negatively correlated at a significant level (-0.5) with less clients based in Oaxaca.

Most clients are sawmills or intermediaries acting on behalf of sawmills (HRR1). The finished product category had the most business with pulpmill factories (HRR2) than other groups of communities, usually with FAPATUX which maintains a pulp factory in Tuxtepec. This could be because of the historical relationship between these entities, the accessibility between many of these communities which are located in the Sierra Norte and Tuxtepec, or because the trees in these communities tend to be smaller after a their long period of exploitation.

The hours necessary to haul logs from the logging road to the client are similar across communities (HRR). The averages are 8.8, 9.5, 6.7 and 8.8 hours for the four groups in order of integration level, so that the lumber communities on average are closer to their clients.

Uncertainty and Unenforceability

A series of questions explored the level of uncertainty and strategies to cope with unforeseen events during the contract period. Uncertainty in timber production takes the form of damage to trees, changes in prices and other events that force renegotiation of the contract. Across all integration types, 20% of the communities said that a change in price occurred during the contract period, and all renegotiated the contract based on that change (RIESP, RIESP1). Five communities, all roundwood or lumber communities, had a fire that damaged trees and led to renegotiation of the contract (RIESD, RIESD1). Seven, or 16%, of the communities renegotiated due to some other event, but no cross-group pattern existed. As mentioned in an earlier section, the management plans are frequently modified, not necessarily during the course of a contract period but during the term of the management plan or at the beginning of a new contract relationship. Seventy percent of the communities had had their management plans modified (MOD), with the stumpage group reporting the greatest frequency of modification. Ninety-three of the percent of the stumpage communities had changed their management plans in the last five years mainly because the harvester could not extract the total volume specified in the contract, forcing modifications in harvest rotations (WHYMOD1).

Information on breaches of contract where the buyer failed to fulfill contractual obligations over the last five years occurred in all communities, although the stumpage group reported a slightly higher average of 1.13 times, with the lumber communities reporting the least average of 0.75 times in the last five years (NOCUM). Breaches of contract involved harvesters which cut beyond volume specified in the initial contract and went undetected, a harvester in a then-stumpage community which promised to train and employ people from the community to harvest timber but did not fulfill his salary obligations, and a harvester in a stumpage community which did not repair a road, claiming that the rain and equipment failure. If they had experienced disputes with contractors, the communities most often said that their primary course of action was to try to talk with the buyer to resolve the issue (MEDID, PROBME). The finished products communities as a group more often responded that they would seek public denunciation if the demand was not met, reflecting perhaps a greater sophistication in dealing in the marketplace.

Clients

Stumpage communities usually had only one client, since that client must commit to setting up extraction operations in the community throughout the harvest season. The other groups of communities had averages of 2.2, 2.4, and 2.3 clients in a harvest season, respectively.

While many sawmill communities supply their sawmills with timber, well more than half of them also sell timber because their sawmill does not have the capacity to consume the entire harvest, a lack of labor or expertise limits sawmill capacity, or because of policy decisions by the community. For example, during the year of the survey, one sawmill community sold their entire harvest as roundwood. The forest had suffered a fire, and the community was concerned with moving affected timber out quickly. Six of the lumber and six of the finished product communities sold roundwood in addition to their end products. The following data pertains to the contracts between the community and an outside roundwood buyer.

To focus the discussion, each community was asked a series of questions about their largest contract in terms of volume for that year. Most communities described this client as a lumber mill or plywood factory. Only two observations in the finished product group identified a pulpmill as their most important client for roundwood that year, most likely referring to the FAPATUX plant in Tuxtepec. The volume sold to the most important buyer is 4071, 3578, 1348 and 4864 cubic meters for the communities by increasing level of integration. Although the communities which specialize in selling lumber have on average more clients, the volume traded to each client is smaller.

The more integrated communities had significantly longer ($\chi^2_9 = 20.82$, Pr.

= 0.01) working relationships with their "currently most important" customer (ANO). Level of integration is also positively correlated (ρ = 0.5) with number of years working with the client. Most communities have contracted with their current roundwood buyer between two and five years, but the communities with longer-term clients (more than five years) tended to be closer to their client (HRR) as well as being closer to Oaxaca city (DOAX) or another major population center (DCITY). So proximity to the client encourages long-term relationships yet is associated with community integration. While proximity lowers transportation costs for both private firms and community enterprises, it remains unclear why the institutional pattern of community integration is observed. Proximity to clients and city centers also presumably raises opportunity costs, so communities are integrating despite the other opportunities available in the city. Therefore, the data favors an interpretation based on lower risks of diversification, where communities integrate when more opportunities are available.

FORM refers to whether the contract was written (FORM=1), verbal (=2) or a mix of both (=9). All the stumpage types had written contracts, while three of the sawmill communities had verbal contracts, and one roundwood community reported using a combination of written and variable agreements. This mixed form agreement could be referring to a series of verbal requests made under an overall formal written agreement. Contracts could be arranged in various ways, from rolling request contracts throughout the harvest season to 3-year contracts. For example, stumpage communities most often had a contract that allowed the buyer the total volume of authorized timber for the harvest season (COMO=1). Roundwood communities frequently had a series of contracts throughout the harvest season (COMO=2), a principle contract plus a series of contracts (COMO=3) and contracts for longer than one year (COMO=4). Under a principle and series of smaller contracts, a general contract was signed, but the buyer could request fractions of the total agreed volume through smaller, and usually simpler, contracts throughout the year. The stumpage communities differ from other groups by the duration of the contracts. Almost all stumpage and three roundwood communities signed contracts for one harvest season (DCON=4), while the sawmill communities used 1-3 month contracts (=1) and a 7-12 month contract (=3). The stumpage communities have longer-term contracts, since the buyer needs more lead time for reaching the community and to begin harvesting. Investments may be necessary, as well, if the community has little infrastructure in place.

Among the stumpage and roundwood communities, authorities gave best prices as the most frequent reason why they chose a particular client. A client's reputation came in as a distant second most frequent answer. The stumpage group gave a wider variety of reasons, such as financing and knowledge of the area (RAZ).

The contract for standing timber and roundwood is usually signed before the harvest period. Harvesting takes place within a window of opportunity to avoid the rainy season. Investments must be made before the harvest can be realized and the sales transacted. Communities only sold logs through prior contracts (ROLYA=2) except for one roundwood community that sold both through contract and spot sales. DEL is the coded responses for length of delivery times from the signing of the contract to the actual delivery of the product. Most communities needed 1-2 weeks to deliver logs (2). The stumpage communities had slightly higher averages of about one month for first delivery.

In the stumpage communities which have less infrastructure, the buyer more often built public works as part of the agreement to harvest in the community (OBRA), such as electricity systems or churches. To begin timber operations, buyers often had to construct logging roads and general transportation roads before

Figure 3.5: Pre-Investments by Buyer for Last Harvest

Figure 3.6: Pre-Investments by Community for Last Harvest

harvest occurred (INVE). See Figure 3.5. These investment are specific to the community and expose the buyer to hold-up risk. Figure 3.6 shows the pattern of the community investing to begin harvests. A point worth examining is that what is being traded is not so much timber for pesos, but access to the forest for development. Two communities had churches under construction and were waiting to harvest more to finish it. Almost all the funds had gone to build these churches.

Data distinguishes whether investment in social services in the community before 1986 were made by a parastatal (INVCO=1), by a private company (=2), or by both (=3). Private companies more often invested in public services (schools, roads in the village, etc.) and infrastructure prior to 1986 than the parastatals. This could be because the parastatals had more bargaining power with the government lease and breached the contract more often. Another explanation could be a bias in interviewees' recall against the parastatals.

The tendency to ask for advance payments increases by type. Zero means that the community does not stipulate advance payments in its trade agreements with buyers. Those that extracted their own timber did so more often (ANT=1) while two finished product communities used advance payments depending on the buyer (ANT=2). Roundwood and stumpage communities reported getting the entire amount of the sale paid in advance (ANT1=1). The stumpage types tend to get a fixed payment, like a deposit, at the signing of the contract (ANT2=5), but that deposit is less than the total price of the sale (ANT1=3). The responses that take a value greater than three represent the deposit as percentage of total sale. For those who did not get a percentage, their answer is recorded with a value two. Roundwood and lumber types receive 50% in advance. The roundwoods receive the payments two to three weeks in advance (ANT2=2) while the sawmill communities, who know their buyer longer, require only one week in advance, generally. Roundwood and stumpage types had the longest history of accepting advances, perhaps because of the greater specificity required between buyer and seller in these contracts (ANT3=4, meaning more than five years).

The contract clauses in written contracts specify more upfront investment by buyers in the less integrated communities (see Figure 3.7). Stumpage community contracts more often detailed who would pay for labor (CLEM1), provisions for hiring within the community (CLEM2) and training of community employees/members (CLENT). All timber sales contracts specified prices, but the roundwood and sawmill communities relatively more often had clauses that allowed for the changes in price and volume ($\chi^2_3 = 7.85, Pr. = 0.05$) of the timber during the term of the contract.

A source of hold-up risk is the presence of relationship-specific investments. Product specificity in the context of timber production refers to whether logs are harvested specifically for a particular sawmill and would have a lower value if sold to another sawmill. Log specifications can differ according to size, type of cut, delivery point, and time of delivery. The sawmill could be sensitive to changes in the quality of the logs, in size or quality of wood, because of equipment that is adapted to types of logs. Pulpwood mills can generally handle wood of less quality, while lumber mills need a higher grade of wood. One community said that a pulpmill stopped buying from the community because the wood was not to specifications.

Most contracts specified size and quality characteristics in the contracts, but these clauses were almost always the same for each contract. There appears to be a standard type of quality and size of log required when buyers contract for first-class wood. Clauses describing the product were focused on the dimensions, number of knots allowed, and type of wood. The contracts did not often go beyond describing dimension and number of knots. Other quality measures tended to be negotiated outside of the contract. CLDIM refers to whether the contract specifies dimensions and type of logs to be delivered. Most communities do have these clauses in their contract. Beyond these clauses, contracts referred to the need to adhere to the management plan which is a form of setting a quality standard.

Five of the sawmill communities said that they bought logs from other forests (FUEN). While the logs came from forests in their region and so were probably similar in type, no information suggested that it would be difficult for these sawmills to utilize logs from forests other than their own, provided the logs met general standards. Of the sawmill communities that said they bought wood from outside their community, most said that this occurred periodically (FUEN1=3), while one said it was a one time occurrence (FUEN1=1), and one said it occurred each year (FUEN1=2). In ranking the level of difficulty they think the buyer would have in finding another source of raw material should their community refuse to sell to them, most communities said that it would be easy (PROV=2). A few community authorities noted that the client may not get as high a quality product but alternative sources of supply would be available. Therefore, the difference in levels of integration between selling would not appear to turn on differences in types of logs, as it appears that logs of similar quality are readily available. Once basic specifications are met, there is little variation needed in the design of the sawmills.

Some contracts anticipated changes in volume or prices. Communities in each category had variable price clauses or provisions specifying action in case the market price of timber changed (CLCPB). This approach was found in all groups without significant differences. However, in percentage terms, the stumpage communities most often had fixed price contracts. In contrast, the communities which harvested their own logs more often had clauses for volume (CLCVB) changes during the course of the contract ($\chi^2_3 = 7.85$, Pr. $= 0.05$). This clause reduces renegotiation costs between the community and buyer, but buyers in stumpage communities have little need for the clause since the buyer controls volume and investments necessary to begin operations. In the first case, the community has hold-up risk because of specific investments made to realize trade with the buyer who has made less specific investment. Private harvesters have less incentive to change volume midway through the harvest period because they risk losing specific investments made in the community to begin harvests.

All community groups reported having clauses for breach of contract or clauses for arbitration (CLCONF) in their contracts. Many of the arbitration clauses were standard language and did not vary. In stumpage communities who were contracting with a private harvester, the contracts noted that the harvester should follow guidelines put forth in the management plan. The management plan limits the areas and methods and timing of harvests.

Figure 3.7: Contract Clauses

For the roundwood, lumber and finished products categories, their plans were to renegotiate the contract with their current buyer the following year while the stumpage group most often said that they would seek new proposals (POST). Also, more stumpage types said that they did not know what they would do next year, i.e. whether they would have a harvest, seek new bids or renegotiate with the same buyer. Only one roundwood community said that the contract would automatically renew.

In the survey communities, written contracts were usually signed for log sales but not for sawn wood sales. Variation exists among board sales by contract (TABYA=2), spot buying (TABYA=1), and both methods (TABYA=3), but spot was the norm. Information on the one sawn wood contract in the sample says that the contract was for a period of 1-3 months. Other contracts were using sales orders and standard invoices that supports these sales. For lumber communities that had a contract with a buyer for sawn wood sales, the contracts were almost always a series of contracts throughout the year (COMOCT=2), while finished product communities also had "other" forms of contracts. Most said their sawn wood buyers could easily find other sources of supply (PROVT). The agreements for board sales were simpler and had less variation among the clauses. All had clauses for price, type and dimension of wood, and volume. A little more than half had clauses specifying actions to be taken in cases where one of the parties did not comply with the contract, conflicts, or a change in price or date of delivery. A little less than half had clauses to change the volume contracted for and an advance payment. The sawmill communities most often had a 2-5 year relationship (ANOCT=2) with their currently most important customer for sawn wood. Both lumber and finished products groups usually required one week or less to deliver once receiving an order (DELT = 1). Most said that they used advance payments for their boards sales (ANTTA=1).

3.8 Production and Factor Inputs

Extraction

Pine is the main commercial species of Oaxaca, comprising over 90% of volume produced. The bulk of production is destined for sawmills (about 80%) with most of the remainder going for pulp (SARH 1994). One of the main consumers of pulp is the FAPATUX plant in Tuxtepec. It closed in 1993, causing the drop in production in 1994. The large increase in 1997-98 during the time of the survey could possibly be due to the extensive fires in Oaxaca during that year and the subsequent increase in emergency sales.

Table 3.17: Production, Oaxaca (m^3 *rollo*)

1989	573920
1990	432159
1991	559311
1992	582635
1993	516993
1994	430060
1995	405324
1996	463510
1997	478426
1998	667321

Source: Subsecretary of Forest and Selva-Wildlife, 1994; *Anuario Estadístico del Estado de Oaxaca*, 1996, 1997; *Estadísticas del Sector Forestal*, SEMARNAP, August 1999.

In the sample, total volume authorized for pine harvest was 350,345 cubic meters (*total arbol*) in 1997. The average volumes of pine produced in the last harvest season before the survey are 2817, 4849, 4521 and 15,889 cubic meters according to level of integration, showing a large jump in the finished products category. While pine is by the far the bulk of the harvest, one roundwood community produced cedar (AUT5>0) while one roundwood and one lumber community produced common tropical species (AUT9>0).

Of the communities that sell pine, the average percentage of the authorized volume actually cut is the lowest for the roundwood communities (AUT1). Where actual harvest fell short of the authorization level, the maximum cut was 88%, so that communities either cut the full amount allowable under the law of fell short by a percentage greater than 10%. Both the private companies in the stumpage communities and the communities with sawmills have more organized extraction processes, while the roundwood communities may be beginning to capitalize and organize.

Table 3.18: Percentage of Authorized Volume Extracted

Type	Range	Average
Stumpage, n=16	28-100	73%
Roundwood, n=11	35-100	67%
Lumber, n=8	23-100	70%
Finished Wood Products, n=7	61-100	88%

The responses as to why harvest was less than 100% inform the nature of unforeseeable contingencies during the course of a timber contract. The communities that said they usually harvested 100% (GENAUT=1) were a little less than one half of the sample, with no strong pattern across types emerging. Overall, the main culprit was the onset of the rainy season, but this may mask a lack of organization to complete the harvest in time (Table 3.19). Authorities in only one stumpage community said that equipment malfunctioned, so that less than 100% of the authorized harvest was harvested. Level of integration was positively correlated ($\rho = 0.65$) with stating the reason as decayed, diseased, or damaged trees. One forester suggested that this was because these communities are reaching the limits of their harvest capacity. The second most frequent response, lack of roads, did not correlate strongly with level of integration ($\rho = -0.32$) despite the increasing frequency of this response among less integrated communities. However, less integration was correlated with the disorganization of the buyer hampering harvest efforts ($\rho = -0.65$). Only one stumpage community authority said that the community's own disorganization caused a less than 100% harvest. Two stumpage communities said that a disagreement between themselves and the buyer led them to underharvest. Internal conflicts caused two finished product communities to harvest less than the allowable amount, so that internal conflicts plagued even the more sophisticated operations. Two finished products communities and one roundwood community said that they agreed by General Assembly to harvest less than the authorization level in order to take a more conservative approach to harvests. One roundwood community blamed both a lack of labor and a lack of market for their product. External territorial conflicts prevented full harvests in only one stumpage community. Six communities reported "other" causes. Therefore, across the board, shocks occurred that prevented harvesters from obtaining the full authorized volume.

Factor Inputs

The following paragraphs summarize the factor input statistics. The basic mechanical equipment necessary for timber harvesting are chainsaws and specially adapted trucks with winches called *gruas*, or cranes, to haul the logs to the logging road

Table 3.19: Harvesting Less Than Authorized Levels (Number of Responses)

	Stump-age	Round-wood	Lumber	Fd. Wood Products	Total
Cut all?					
yes	8	5	5	3	21
no	8	8	3	4	23
If no, why not?					
Rain	1	5	2	1	9
Equipment malfunction	1	0	0	0	1
Damaged trees	0	0	0	3	3
Lack of roads	4	3	1	0	8
Buyer misplanning	6	0	0	0	6
Community misplanning	1	0	0	0	1
Contract disagreement	2	0	0	0	2
Internal issues	0	0	0	2	2
Desire to cut less	0	1	0	2	3
Labor shortage	0	1	1	0	2
Low demand	0	1	0	0	1
Territorial conflict	1	0	0	0	1
Other	2	1	2	1	6

and load them onto transport trucks. The levels of communities employed six, 17, 16 and 19 chainsaws on average in their timber operations for the past year. The use of cranes is flat and even dips for the lumber communities, while the number of trucks increases only for lumber and finished products groups.

The data on equipment ownership indicate various sources of ownership among the entire fleet of trucks, cranes and chainsaws. Table 3.20 shows ownership patterns for trucks and cranes. Consistent with the levels of integration, ownership of equipment is more common with increasing levels of integration for trucks and cranes. Chainsaws (data not shown) on the other hand tended to be individually owned by persons hired to operate them. In many communities, trucks were individually owned by persons in the community. Buyers provided trucks and cranes in all but the finished products communities. However, even the finished products

Table 3.20: Capital

	Trucks				Cranes			
	Stump-page	Round-wood	Lumber	Forest products	Stump-page	Round-wood	Lumber	Forest products
Average number used	10	10	13	14	1.75	1.7	1.5	2.9
Average year first bought, if own	1993	1991	1989	1980	1994	1995	1991	1986
Ownership patterns (CAMDUE, GRDUE)								
Community-owned	1	8	6	7	0	6	7	7
Individually-owned, *comuneros*	4	7	7	4	1	3	0	0
Individually-owned, non-*comuneros*	11	9	2	4	0	0	0	1
Buyer-owned	7	1	1	0	14	4	1	0
Communities responding*	(15)	(13)	(8)	(7)	(15)	(11)	(7)	(7)
How bought first truck/crane if community- or *comunero*-owned (CAM1DIN, GR1DIN)								
Community funds	1	7	5	4	1	4	5	6
Government assistance	0	0	0	1	0	0	0	2
Bank credit	0	1	1	0	0	0	0	1
Agreement with private company	0	0	0	2	1	4	1	1

* Numbers do not always add due to multiple responses per community or response in another category not shown.

communities relied on outside operators for both transport and crane operation. After chainsaws, trucks are most often privately-owned.

For those communities that own trucks and cranes, the table also shows how the community acquired the equipment. Many communities used their own funds, often raised by timber sales. All except the stumpage communities borrowed on credit to acquire either trucks or cranes. Individuals relying on various credit arrangements were often the conduit through which communities accessed trucking services. In at least one community, the community forestry enterprise negotiated with a bank to finance the truck purchase, but allowed the trucks to become property of individual *comuneros* who paid the community over time with salary earnings. This example shows the scope of possibilities in acquiring capital. A quote from an ethnographic study (Kearney 1972) describes how one currently lumber community built up its trucking fleet:

> In early 1968, a man in the town was able to acquire a truck on credit, which he used for hauling passengers and cargo to and from Oaxaca. In this way he was able to make his payments and clear a small profit. After a short time, he sold it to buy a larger truck, which he used mainly for hauling men to logging camps in the mountains and also for hauling wood for the paper company. Upon seeing his success, four other men decided to form an association to buy another truck, which they did, using it for the same purpose . . . By now, many more people were beginning to see advantages of the trucks. Potential business thus appeared great enough that the [then] three associates invested in a second one, bringing the total for the town up to six. Thus, in less than two years the coming and going of the trucks in the town has become a regular event . . . (p. 132; bracket added).

The buyer can act as a source of credit. This occurred in all communities for cranes and in the finished products group for trucks. The buyer lends equipment or funds to the community rather than to individuals. Since cranes tend to be owned by the communities rather than individuals, more cranes are funded in this way than trucks, which tend to be individually owned.

Data on equipment prices was not always available because purchase occurred years before under a different administration or because the community authorities did not own the equipment. Therefore the following price data summarizes data from surveys as well as secondary sources. Chainsaw prices were very consistent, at 6000 pesos per chainsaw. Trucks bought between 1970 and 1992 cost 25,000 to 30,000 pesos according to survey data. From 1992, trucks costs between 100,500 to 400,000 pesos from survey data. This jump in costs could reflect the devaluation in 1994. Many of these trucks may have been bought used. In 1998, the time of the survey, a local truck dealer quoted 399,850 pesos as the price of a new 12-ton truck. Estimates on cranes vary widely because the cranes are sometimes makeshift trucks that have been outfitted with a winch for dragging logs up from a downslope onto the logging road. Estimates from survey data ranged from 40,000 to 80,000 pesos for cranes acquired before 1993. For acquisitions after 1993, the costs ranged from 150,000 to 250,000 pesos. Calls to local dealers revealed that a new crane could cost 3,560,000 to 3,895,000 pesos in 1998. Renting a crane, without driver or gasoline, would cost 8000-10,000 pesos per month. The lumber communities tended to have newer cranes (GR1, GR2, GR3), since they integrated forward more recently and are more likely to be gearing up their operations.

Some communities had opened an office in Oaxaca and acquired computers to facilitate their business. By increasing level of integration, there were zero, two, four and three offices (OFI) among the sample by group, and 0, 1, 2, and 5 observations by group used computers to manage operations (CMP).

Sawmills costs between 220,000 pesos to 3.5 million pesos to buy and install, depending on the age of equipment at installation date and capacity. Of the two sawmill groups, the finished products communities operated their sawmills more efficiently, at least in terms of percent capacity utilized. Lumber communities operated at 47% capacity versus 60% capacity for finished product communities, according to survey data. This is consistent with reports of several communities in the sample (Fuge 1999).

As mentioned earlier, a strong bias exists towards hiring internally. Several communities who are expanding operations are struggling with the issue of hiring outside workers as their needs expand. Many are reluctant to offer jobs to outsiders when those outsiders would not contribute to the community in the form of *tequios* or taxes, since they would not be registered members of the community and may take jobs from *comuneros*. Inefficiencies are recognized within the communities themselves. As one community member noted, "lack of competition for jobs generates inefficiencies. The forestry operations are seen as a source of jobs for the local population. A *comunero* can work here, but it is much harder for someone without *comunero* status. However, those that do work, work as they can and according to their own schedule." For this reason, he thinks that his community's sawmill is about half as efficient as a private sawmill.[11]

[11] A story from one community highlights the passions that surround the issue of hiring from the outside. This community pays their workers by day, since the worker-*comuneros* said that they preferred to be paid in this way. The reason given was that trees were sometimes plagued or crooked, and they did not think they would get a fair share if they were paid by cubic meter. The assistant manager felt these were largely pretexts. He decided to search for workers from a nearby community and hired workers who had been recommended to them. The assistant manager made an agreement with them to work for a certain amount of days. When the local *comuneros* found out, they demanded that he fire these workers. In the end, these workers worked for 20 days. In this time, 4 persons with 2 chainsaws cut more in one day than 7 workers from the local community in a comparable amount of time. They reportedly made 3 truckloads per day. They worked in sequence, with each person in a team having a specific task

The summary tables show the average number of outside workers by type of community and category of work. Of the loggers, the stumpage group has the largest percentage of outside workers, perhaps because of the resident lack of experience. The finished product group looks elsewhere for workers perhaps because of the larger scale of operations that absorb the labor availability within the community. Level of vertical integration, though, is inversely correlated with the average number of truck drivers (CHOAFN) from outside the community. Of all the activities in which local members are involved, the stumpage communities had more people hired as loggers.

LTRASO shows the number of tractor operators from outside, LSECSO the number of secretarial or administrative help from outside, LGRUSO the number of non-community crane operators, and LOTROSO the number of non-community workers in the "other" category. The wood product group relies least on outside help in these areas. Regarding sawmill operations, 63% of the wood products communities hire outside workers compared to 11% of the lumber communities (LASAF).

Both community enterprises and private firms paid loggers mainly on a per cubic meter basis (LOGSA). A few paid loggers per day, some as the only form of payment and others as a base pay in addition to the per unit fee. Sawmill communities paid higher salaries on a per unit basis.

Truck drivers were paid either per trip, per day or per cubic meter. In each case, however, the pay is linked to the distance that the trucker travels. Some-

in getting the tree cut and loaded. The manager said that they cut cleanly and without damage to surrounding trees, a problem which the local workers had. He paid them 40 pesos/m3 which ended up being 4500/week for the 4 person-team, earning and producing more with piece-rate wages than a greater number of local workers in a week with daily wages. The manager said that the *comuneros* felt somewhat "pained" about this. The outside workers left, but he thinks it had a positive impact because the local workers could see "what the competition was like."

Table 3.21: Labor

	Loggers				Drivers			
	Stump-page	Round-wood	Lumber	F. Wood Products	Stump-page	Round-wood	Lumber	F. Wood Products
Average number hired (LOG, CHOF)	6	16	17	18	10	9	13	14
Percent of workers from community (LOGAF, CHOFAF)	76%	100%	100%	95%	7%	46%	69%	91%
Average pay per day (LOG, CHOF)	80 (2)	50 (1)	40 (1)	45 (1)	–	–	–	–
Average pay per trip (CHOFSA)					151 (6)	153 (5)	140 (3)	135 (2)
Average pay per cubic meter (LOGSA, CHOFSA)	16 (13)	19 (9)	30 (6)	30 (6)	10 (1)	73 (3)	32 (4)	30 (3)

Note: Number of observations are in parentheses.

times a trucker makes one trip per day. Since the trucks usually hold about 11 cubic meters, the amount and distance does not vary greatly per day, so these forms of payment are possible. Most of the data on trucker salaries reflect a per trip basis of pay, with the finished products group paying the least, either because they are closest to their client destination or because private truckers hired by outside private firms gain more in the market. For the few observations on instances where truckers are paid per cubic meter only, the salary is the lowest for the one observation on a stumpage community, followed by the finished products group. Salaries paid across the board to community member workers usually did not differ from non-community member workers. When communities were responsible for the transport of the timber to the client, the truckers were most often employees of the community and could be paid by trip. If the truckers were paid by the buyer, they were paid per m^2. Usually, the logs were transported directly to the clients for all except the stumpage communities. Almost all communities in the three most integrated communities use people from their own community to transport logs, while private harvesters in stumpage communities provide this service and rarely hired people from the community (TRAN11, TRAN21, TRAN31, TRAN12, TRAN32). The roundwood communities more often employed truckers from outside the community (TRAN13).

Very few communities have work incentives, bonuses or disincentives beyond a fixed salary per unit processed. Two of the eight lumber communities and four of the seven finished products communities used bonus schemes to motivate production (ESTIM). In one finished products community, the enterprise paid workers a higher per unit fee for boards produced above a daily quota.

Rotation schemes exist in some communities to generate employment across a broader range of the population. The lumber communities reported most often that they had some form of rotation system (ROT). The finished products group had the least incidence of rotation schemes, perhaps because they have more permanent employment positions.

The interaction between the traditional civic aspects of community life and the more recent forestry operations arises again through the *tequio* duties. *Tequios* are groups of people who convene for one day or more, usually on weekends to accomplish tasks in the community, such as painting a school, repairing a road, or clearing brush from paths. The *tequios* are a source of labor for supporting forestry activities. All community members must put in a certain number of hours per year in *tequios* to stay current with his membership rights. Forestry operations make use of this system for projects other than the daily production process. The use of *tequios* in general is waning across Mexico in some places but remains stable in other places. Almost all observations held *tequios* throughout the year for forestry activities. The *tequio* lasts on average three days (TEQDI). Most communities have between one and five forestry *tequios* per year (TEQNU). The least integrated groups record the most per year, possibly indicating a greater reliance of stumpage communities on traditional forms of work to maintain the forest, while more integrated communities rely on paid timber workers.

The opportunity costs of working in forestry was considered in terms of non-forest income-generating activities in the community and the percentage of registered *comuneros* who received the income on a regular basis. The community forest authorities estimated the number of persons receiving income on a regular basis from a list of activities. The figures should be thought of in terms of relative magnitude rather than precise estimates, due to the community authorities informed but rough estimation.

Oaxaca has a mainly subsistence-based agriculture due to it mountainous terrain that precludes large scale ranching and agriculture. Employment in the community's forestry operations increases with type (FOR=15, 17, 19 and 26%, respectively). This figure includes both male and female employees. A broader range of activities in the finished product communities demonstrates greater employment opportunities in these communities. The roundwood populations have the highest percentage of people receiving income from nontimber forest products (NOM), such as mushrooms and flowers, and resin (RES). All communities have subsistence level agriculture. The percentage refers only to persons who receive agricultural income annually to avoid counting those who sell crops or produce sporadically. The highest percentages of persons receiving agricultural income annually (AGRI), livestock (GND) and fruit (FRU) are lumber communities. The finished products communities have the highest average percentages of persons receiving income from forestry, employment in Oaxaca city (OAX), fish (PES), and employment outside of Oaxaca state such as the federal district and the United States (TRAF). This percentage captures the interviewee's estimates. It is not calculated as a percentage of registered *comuneros* unless we were told with certainty that those who emigrated were registered. Therefore, in some cases it is percentage of persons registered, and in other cases it is a general estimate of persons from the community working outside of Oaxaca, regardless of registration. Finally, the stumpage group has the highest percentage for income sources from owner-operated stores in the community (TIE).

A variable, OTHERYO, sums all the percentages from non-forest income-generating activities, including jobs outside Oaxaca. The averages across groups are 99, 79, 94 and 66. Note that income categories are not mutually exclusive, so sums can exceed 100, indicating cases where persons are involved in more than one type of income-generating activity. None of the adjusted Wald tests for differences in averages were significant at the 10% level.

An important source of non-forestry income is coffee, a significant crop in some regions of Oaxaca. This cash crop is exported internationally. The number of persons receiving income from coffee decreases by type. Coffee is an alternative use of the forest, as it requires shade to grow. Interviewees in communities in coffee plants expressed that they desired, within the limits of the law, to change the species mix from pine to broad-leaf and oak tree species because pine needles were not a good soil substance for the coffee plants. Therefore, the species mix may change over time where coffee *fincas* exists.

Agricultural work and emigration pose important opportunity costs of time. Twenty-nine communities reported that they have a sufficient source of labor within the community to fill forestry jobs (AVAIL). Seventy-five percent of the lumber communities said that an availability problem exists, more than any other group, but the differences in means are not statistically significant. Most communities said that agricultural work was not an obstacle to filling forestry jobs or developing the forestry industry in their community (CAMPO1). Those that did say that fieldwork was an obstacle said that this problem has existed for years and was not a particularly recent problem (CAMPO2).

Oaxaca has one of the largest emigration rates in Mexico, due mainly to poor economic conditions (DeWalt et al. 1994) (p. 14). Other explanations are a culture of mobility where many people in the past gained their income as traveling traders (Snook 1986, Stephen 1997) and the U.S. *bracero* program which drew from the Oaxacan population. In the Sierra Norte of Oaxaca, the traditional occupation was traders or muleteers who traveled among the system of trails linking mountain towns (Kearney 1972, Stephen 1997) and the two coasts. In about 1993-1994, Oaxaca experienced a negative population growth in 302 of its 570 municipalities

(IBRD 1995b). Even remote villages have linkages to cities in the United States where they claim pockets of neighborhoods solely from their village. Emigration therefore would be a function of education and the existence of family members in the destination cities rather than geographic remoteness from population centers (Taylor et al. 1994, de Janvry et al. 1997). However, most communities said that emigration was not an obstacle to developing forestry (EMIG1). Those that did say it was a problem, said that the problem is recent (EMIG2). Consistent with their response for sources of income and greater labor demands, the wood products group by far reported more often that emigration was a problem in recruiting labor. The stumpage group had the next highest emigration "problem." The stumpage populations may have less experience in forestry and seek employment elsewhere while the finished products group may have a problem if their operations are larger. Comparing these responses with the percent of registered *comuneros* working outside of Oaxaca state (TRAF), the average for communities that said that emigration was a problem (EMIG1) is 37% and for those that said it was not a problem, only 17%.

When community forestry authorities said that they had more persons in the community who would like to work than available jobs, they were asked how they selected workers. Most selection processes were by individual agreements with a worker (SELEC5). This usually meant that an announcement was made and the first person to respond had the job, or that individuals made their own agreements with the timber management team. The second most frequent response was a system of rotation of workers (SELEC2), followed by "other" (SELECO), and by agreement in the General Assembly (SELEC4).

Revenues and Costs

Data includes for most observations an estimate of total revenues and costs. Where possible, enumerators recorded data directly from financial reports kept as accounting information or as periodical reports presented to the General Assembly. Where it was not possible to review these documents, authorities provided estimates from recall. Finally, if even this was not possible, numbers were estimated by the author based on sales volume and price data. Therefore, the data on overall profits and costs should be considered as general estimates rather than exact figures.

The finished products group has the largest average profits, reflecting the value added from sawmill operations. The roundwood group pays the largest percentage of their costs for salaries, followed by the lumber group. The stumpage group pay on average the least in salaries, since the buyers usually coordinate and pay labor.

Table 3.22: Revenue and Cost Data (pesos)

	Stumpage (13)	Round-wood (9)	Lumber (5)	F. Wood Products (5)
Sales revenue	573549	1688274	3020021	9578861
Salary payments	1410	406718	306388	774227
Total costs	304125	1010740	1462620	1462620
Profit	311,386	870498	1,557,401	3,056,819
Percent paid to salary	10%	44%	29%	28%

The possible official destinations of revenues are reinvestment in forestry operations, public services and disbursements to individual members of the community. The more vertically integrated communities invested in new equipment more often than those selling standing timber only (REIN). The finished products group invested in maintenance more regularly than the other types while the roundwood group tended to invest in logging roads.

All communities channel funds to social services (SSOC), with few exceptions. SSOQ distinguishes the level in absolute terms of money spent on social services, coded from 1-5. The degree of social giving does not follow a clear pattern across types, reflecting the general civic role of forestry production.

Communities decide on a year-to-year basis whether they will disburse profits to individuals. When they do, it is by equal shares among the community or work group members. Among those that disbursed profits (*repartos*) to individuals, the stumpage communities have the largest average (REPQ), due to one stumpage community with two work groups which divided almost all of their profits among their group members. After stumpage types, the wood products group distributes the largest amount of dividends per *comunero*. In the opinion of one community member interviewed from a lumber community, the *repartos* do not need to be large to induce the desired effect of a community cooperating with rules of forestry. The *repartos* signal that the *comuneros* "count for something to the community." In turn, the community receives their cooperation. In two communities, the funds were distributed in kind (*dispensas*) – beans, rice, oil and other basic goods – rather than in cash. One community member justified this approach because he said it avoided spending money on getting drunk. The *dispensas* are not reflected in the summary statistics. The roundwood communities disbursed the least, supporting the contention that the roundwood communities are in a process of capitalization.

Access to Credit

The national bank lends funds to banks at rates depending on the destination of those funds. The branches of the central Bank of Mexico - *Fideicomisos Instituidos en Relación con la Agricultura* (FIRA), *Banco Nacional de Comercio Exterior*

(BANCOMEXT), Nacional Financiero (NAFIN) - are the funding sources which channel social sector funds to the intermediaries. For lending to the social sector, in which agrarian communities are classified, the central bank will lend to intermediary commercial banks at a rate less than the *certificados tresorias* (CETES) rates. The intermediaries then lend to the social sector at CETES rates. Thus, some incentive exists to lend to the social sector, although this sector competes with the private sector where commercial banks can potentially make more profits by lending at higher rates.

The forest sector as a whole is not a large recipient of direct bank credit. From 1987 to 1993, about 15 communities received about 39,388,000 pesos from banks to fund investments or working capital in the state of Oaxaca. In 1997, the community sector received zero in new loans while 6 million pesos were given to the private sector for either working capital or investments in the forest industry (*FIRA* 1998).

A reason for the drop in lending to the communities could be that when wood products demand is high, buyers pay advances which fund working capital. The data on contract clauses stipulating advance payments and policies showed that the incidence of paying advances increases by type. This explanation does not answer the question of finding investments beyond working capital.

In addition, money illusion may discourage communities from assuming debt. Rates of inflation were greater than the rate of interest at the time of the survey. Psychologically, communities could have difficulty overcoming the idea that borrowing is cheaper. Culturally, community members may shun the use of debt. Certainly during the interviews community authorities seemed to consider own funds as a superior way to finance a project and a source of pride. However, Mexico's financial crises in the eighties validates a note of caution. During this period, many persons holding loans saw their debt substantially increase above what was expected and went bankrupt. Despite money illusion, however, lending institutions historically have favored agriculture rather than forestry. Another stumbling block may be that the land cannot be used as collateral, since it is held in common by the community (IBRD 1995a, IBRD 1995b). Finally, banks seek to lend to communities which have the level of managerial and production organization and community support to pay back the loan. For whatever reason, little attention has been paid to the value of forest resources through conservation, timber production or nontimber production

From the sample, only the sawmill groups said that they currently held credit. All types said that buyers had helped with capital needs in the past, but this happened more often in the stumpage types (CUBR). The form of assistance was generally lending equipment or construction, with construction more common in the stumpage communities. All types said uniformly that their revenues from timber sales covered working capital needs, but when asked if the revenues allowed for commercial development of timber operations as they would like, the affirmative answers increased by type in frequency (CRDES).

Communities may face substantial transaction costs in obtaining a loan, since the sawmill groups, which had most often received a loan before, were also the group who most often said that they could attain a loan if they desired. The roundwood were the least confident that they could ask for a loan (CRPRES). Communities mainly gave high interest rates as the reason preventing them for asking for a loan (CRRAZ). The responses can be taken at face value, or they could mask a larger problem for the social sector in accessing loans or authorities' own assessments of their community's ability to pay back a loan. Also, the sawmill communities were more often the ones who had first obtained loans before the

Table 3.23: Credit

	Stumpage (16)	Roundwood (13)	Lumber (8)	F. Wood Products (7)	Total (44)
Credit arrangements with buyers	6	5	4	4	19
Borrow Equipment	4	4	2	1	11
Construction	6	3	2	0	11
Hold credit now	0	0	2	1	3
Used credit in past	0	1	1	6	8
Income covers working capital	11	11	8	7	37
Income supports industrial development	5	6	7	7	25
Could get a loan?	7	5	5	5	22
If not, why not: prerequisites	2	0	0	0	2
If not, why not: interest rates	3	3	1	1	8

drying up of funds in 1993.

Other forms of financial assistance comes directly from government programs (APOG) and nongovernmental organizations (APONG). The projects target both timber and nontimber production and conservation goals. Communities in the roundwood and finished products categories had the highest frequency for receiving government assistance in the last five years (69 and 71%, respectively, compared to 31 and 38% for stumpage and lumber groups, respectively). Projects in sawmill communities centered on reforestation, nurseries, and temporary employment (APOGF), while stumpage and roundwood communities received assistance directed towards investment in equipment and management plans to aid their start-up phase. The government program, PRODEFOR, and national government offices (see survey for list) supplied much of this assistance (APOGP). From 1998-

1999, PROCYMAF funded 148 technical assistance initiatives and 173 courses in timber and nontimber production topics across all community types, but had only assisted a few roundwood communities as of the survey.

Table 3.24: Government Assistance in Last Five Years

	Stump-age	Round-wood	Lumber	F. Wood Products
Received funds (%)	31%	69%	38%	71%
Activity (Count)				
Reforestation	0	1	1	4
Tree nurseries	0	4	2	2
Temporary employment	0	3	1	2
Mushrooms	0	0	1	1
Plantations	0	0	0	0
Fauna	0	0	0	0
Equipment investment	2	2	0	1
Forest plans	1	3	0	0
Other	2	5	0	0

Overall, nongovernmental organizations have targeted mainly the finished product communities over the last five years. NGO assistance addressed reforestation, forest plans and mushroom research (APONGF). The source of funds came from a diffuse set of NGOs, some of which have had long working relationships with communities that included assisting them in the transition from parastatal control to independent operations. This assistance could be a determining factor in aiding communities to diversify production away from timber products, since many NGOs focus on conservation.

Table 3.25: Nongovernmental Assistance in Last Five Years

	Stumpage	Roundwood	Lumber	F. Wood Products
Received funds (%)	6%	15%	25%	71%
Activity (Count)				
Reforestation	0	2	1	5
Tree nurseries	0	0	0	1
Temporary employment	0	0	0	0
Mushrooms	0	0	1	1
Plantations	0	0	0	0
Fauna	0	0	0	1
Equipment investment	0	0	0	0
Forest plans	0	2	0	2
Other	1	1	1	2

3.9 Diversification

As mentioned above, members of the communities in Oaxaca traditionally perceive the common property resources as a source of benefit to the community as a whole. The development of industrial forestry is therefore seen as a potential source of funds and opportunities for economic development and enhancement of social well-being in the communities. The flow of benefits from the forest, in the opinion of many communities, should be towards public benefits to be shared by the local community. Government programs support this concept by emphasizing the nontimber market potential to reduce forest degradation and deforestation and provide new economic opportunities in the communities.

Diversification of forest activity is one avenue to achieve these goals. Diversification relieves pressure on the capital resource (the forest) and provides an outlet for profits which may be more productive than reinvesting in the asset itself (Teece 1980). Although communities view the forest as a common good with the potential to be an "engine for growth" whose benefits include local employment, timber extraction and processing generates a limited amount of jobs. According to informal conversations, communities diversify their activities to reduce the harvest pressure on the forest and to generate employment in the community. With a fixed, forest stock, continuous harvesting can reduce the average age and diameter of the commercial species if harvest rotations are too short. More vertically integrated communities have had on average more continuous harvesting histories and greater average number of years of harvesting in the last 13 years. Along the lines of the Teece's life-cycle hypothesis, harvesting is like drawing on a resource reserves. As reserves decrease, firms seek to invest their profits in other areas. YRH2, or the number of years that a community has harvested, is positively correlated with level of integration ($\rho = 0.65$). Expanding production activities opens employment opportunities for broader ranges of skills. For example, a water bottling plant in one finished products communities employed almost solely women, who tend not to be employed in timber extraction and transportation.

The frequency of community level diversification into nontimber production activities is the largest for finished products communities, followed by the roundwood group, and the stumpage and lumber groups (DIV). Among the five categories of ecotourism, public nurseries, water purification, mining and an "other" category, the finished products group had the widest range of activities on average. The relationship is nonlinear in that the lumber group had a lower range than the roundwood group. Further research is warranted to determine if this is a general pattern of transition where roundwood communities have greater economic forest activity than the stumpage groups and lumber groups.

Communities can allocate timber resources to promote community-level production activities, work group-level activities and individual-level activities. More sales revenue leads to more funds allocated to diverse activities within the community population. Six, 16, zero, and 71% of communities by type (DIVAS1) allocated funds to other community-level forest activities, such as nurseries, ecotourism, and purified water. Six, zero, 13, and 28% of communities by type contributed funds for work-group level activities (ORGAS1), such as carpentry shops, firewood and charcoal cooperatives and grazing cooperatives. Tests for differences in allocating funds to individuals to encourage entrepreneurial ventures (INDIV), such as a chicken farm in one community, showed that more integrated communities gave to individuals more often (χ^2 Pr. $= 0.02$).

Chapter 4

A Property Rights Model

4.1 Application to a Timber Industry with Communal Forest Land

The forest industry in Mexico has characteristics which lend themselves to the analytical tools of contract theory. While a contract can assign certain flows of benefits and separate rights from ownership, other benefits which may be critical to community members are harder to specify and left as residual ownership rights.

One example is economic opportunity. Timber production can fit into a larger development strategy. An argument supporting noncontractibility of economic opportunity would note that local community members claim that they seek control over forestland and downstream production to provide jobs, improve job skills, seek higher profits through value-added activities, and have a source of funds for social services. This argument is consistent with the observation that missing markets for economic opportunities, personal enhancement and public infrastructure capital frequently exist in developing areas. The previous chapter discussed the social and economic linkages between community members and forest land. The numerous management decisions in the course of production pose continuing opportunities where the goals of the community residents and an outside private firm diverge, leading to bargaining costs as new decisions are negotiated. Residual control rights related to timber production cover rights to decide how the business is conducted, whether it expands or is kept small, number and allocation of jobs in the short and long term and actions which affect the physical stock of the timber resource.

In scenarios akin to the communities' history, the outside firm can skimp on the quality of training of the local population. For example, it can claim that a change in the market occurred, so that it is no longer able to provide the same level of training, or hire people locally. The community may be able to renegotiate the contract but it faces switching costs in doing so. Different objectives between two parties to a contract leaves open the possibility of renegotiation costs as the production cycle evolves. Asset ownership leaves the owner with the final say over how to allocate these assets. Had the community owned the harvest equipment, they would have made different management choices. A factor to be balanced is the parastatals possibly greater access to capital and expertise. The parastatal had a long-term lease which allowed it to make specific investments in roads and silvicultural management, while private firms with short-term contracts made less specific investments. Yet, at some point management differences between the community and the parastatal became important to communities so that communities fought to end the leases.

Considering the forest as an ecosystem, ecological linkages could exists as well. The likelihood that the forest can be neatly parceled to accommodate different "production lines" is low. Export-quality wild mushrooms that grow in one area one year may appear in another area the following year. Therefore, while perhaps not specialized, the forest has a degree of indivisibility for the purposes of joint production. Therefore, contracting decisions may depend on timber and nontimber economic activity.

Institutional capital at the community-level related to the forest could provide basic organizational infrastructure and skills to encourage expansion into larger timber operations. For example, in San Juan Nuevo, a forest community in Michoacan, a state west of Mexico City, members supplemented their agricultural income by resin-tapping. To reduce conflict and manage these operations, each community member was assigned a section of the forest for the purpose of resin-tapping. At specific time intervals, the members would rotate the areas. As logging opportunities opened, the need arose to monitor and enforce rules against illegal logging and to develop a system for sharing profits. The community decided on a payment scheme where members would be paid for trees cut in the areas assigned to them for resin tapping. In this way, the rules for resin-tapping were adapted to accommodate logging operations.

Once vertically integrated, revenues may provide the local community with the capital to enhance nontimber benefits. As profits increase, diversification could help to maintain a higher return on investment in the forest stock. This can result if the community members seek to maximize the productive capacity of the local population and the forest. With a fixed forest size, diversification could increase returns from forest production activity.

4.2 Bargaining Model of the Vertical Integration Decision

The bargaining model in this paper is an adaptation of that presented by Grossman and Hart (1986) and Hart (1995). It depicts a buyer-seller relationship between a local community, C, that owns forest land, $F = F(T, NT)$, where T is the timber stock and NT is the nontimber stock, and a harvesting manager, M, operates the harvesting equipment, H. The production of the assets is not modeled. The stock parameters T, NT and H represent physical size, such as hectares, biomass or equipment inventory, as well as the value which the community and manager places in the timber and nontimber stock for consumption, production, cultural and aesthetic use, and quality of the resource for commercial purposes. The owner of an asset has the residual control rights over the asset. The parties are risk neutral and each has initial wealth large enough to purchase any asset which is efficient to own. The community and the harvest manager are in a vertical production relationship. They negotiate a transfer of timber to the harvest manager who will then use the timber as an input for other wood products.

$B_C(\cdot)$ and $B_M(\cdot)$ are functions that represent the monetary value of production and trade of forest products if the two parties decide to trade. Since the model focuses on vertical integration relationships, the benefit function of the upstream community, $B_C(\cdot)$, can be negative to represent a cost of production which will be recouped through the sales price. Assume that the community forest authorities – the *Comisariado, Consejo de Vigilancia* and the General Manager (if the post exists) – act on behalf of the community members at large in all decisions made as managers of the community forestry enterprise. The General Assembly meetings could be thought of as the means by which the authorities and other community members coordinate their preferences. Future research would model this bargaining process in the community with an n–person bargaining game. The function $B_M(\cdot)$ includes revenues from selling timber products. The functions B_C, B_M include non-pecuniary private benefits which accrue to the owner of an asset such as the ability to make decisions over the allocation of the asset, feelings of pride of ownership, or ability to divert benefits to themselves.

There are two dates in the model. At Date 1, the investments i_F and i_H are made, where i_F is an investment in the forest or forest management process and i_H is an investment in the harvesting equipment or process. Assume the forest and the harvesting equipment already exist and in place. The investments are to improve productivity, meaning that they enhance the efficiency or lower the costs of production, thereby increasing the value of *ex post* payoffs. It is assumed that the investments i_F and i_H involve temporal or human capital specific investments. For example, i_F could be adapting the management plan to accommodate the harvester's needs, or specific training to apply treatments that aid the harvester. Examples of i_H are improving the timber harvesting practices for this community's forest, learning about the forest to plan a harvest or consulting the management plan. It can also include constructing a road where it is assumed that some human capital specific investments become embodied in the investing party so that the investment is specific to trading with the community. The investments are made independently, noncooperatively and simultaneously by C and M. Each observes the other's choice of investment after it has been made, so they have symmetric information on investments and costs. B_C and B_M are functions of i_F and i_H, respectively, so that $B_C(\cdot) = B_C(i_F)$ and $B_M(\cdot) = B_M(i_H)$. The function $B_C(i_F)$ captures the costs and benefits of trade where i_F can be thought of as reducing costs of trade. Both investments i_F and i_H affect the final payoffs to C and M through bargaining. Finally, it is assumed that i_F and i_H are the costs as well as the levels of investing.

There is uncertainty at this point as to the exact nature of the product, since a harvest season is long enough where events could change the volume and form of the good traded. The uncertainty makes a long-term contract impossible to write, i.e. it is too costly to specify uses of the assets in a Date 1 contract. The uncertainty is removed at Date 2 when the C and M must renegotiate before trading to resolve unforeseen events and realize *ex post* gains from trade. This is the potential source of hold-up because if investments are specific, C or M can hold out for better terms or refuse to trade. As an example from the field, one community could not finish their harvest season because the contractor's equipment broke down beyond repair, and the community could not find another contractor before the rainy season ended the harvest season. In another example where the community "held-up" the firm, the community found another buyer willing to pay a higher price, forcing the current harvester to match the higher price.

The transfer price, p, at which the two parties trade is a function of their bargaining power, benefits and reservation payoffs. They negotiate the transfer price in the second period for the timber produced. The price allocates the total surplus between the two players.

The two "firms," the community enterprise and the harvesting company, receive benefits depending on which assets they own, which differs under each ownership scenario. Neither the harvesting entity nor the forest community can acquire the human capital investments of the other party, only physical assets, F and H. Since Mexican laws currently prevent sales of communal forest land, only nonintegration and forward integration by the community are considered here.

Now, notation is introduced to express the default payoffs. In a default situation, bargaining breaks down and the two parties search for other trading partners. The reservation payoff if the two "firms" do not trade at Date 2 are the functions $b_C(\cdot)$ and $b_M(\cdot)$. C and M no longer have access to each other's physical assets, only to the assets which they own individually. The function $b_C(i_F; X_C)$ indicates the general default benefit function for the community when it owns assets X_C, so that $X_C = \{F, H\}$ under community forward integration, and $X_C = \{F\}$ under nonintegration. Similarly, let $b_M(i_H; X_M)$ indicate the default benefit function for the harvest manager, so that $X_M = \{H\}$ under nonintegration. Under integration, however, the manager is a member of the community so that the manager cannot be fired. This default position contrasts with nonintegration, where the manager is a private harvester who is fired and seeks alternative trading partners if bargaining with the community breaks down. Such a modification to the typical incomplete contracts story is consistent with the observation that no communities in the sample hired managers from outside the community when they integrated forward. With this switching of managers, the community manager under integration maintains access to the assets F and H even if bargaining breaks down. Therefore, $X_M = \{F, H\}$ for a community harvesting manager in the integration scenario. Before defining the default benefits of a manager in this position, a few more assumptions are necessary.

The default price, $\bar{p}$, is the price that C can get on the spot market if renegotiation between C and M fail and C finds another harvest manager to harvest. When the two parties trade, they have access to each other's human capital specific investments and physical assets, so $B_C(\cdot) = B_C(i_F; F(T, NT), H)$ and $B_M(\cdot) = B_M(i_H; F(T, NT), H)$. The *ex post* surplus with trade is $B_C(\cdot) + B_M(\cdot)$. Without trade, the *ex post* surplus is $b_C(\cdot) + b_M(\cdot)$. Assume that *ex post* gains from trade strictly exist so that the following holds:

$$B_C(i_F; F, H) + B_M(i_H; F, H) > b_C(i_F; X_C) + b_M(i_H; X_M) \geq 0 \qquad (4.1)$$

Therefore, the investments i_F and i_H are more productive in a trading relationship between the firm and the community. This captures the idea that the investments are human capital specific and have less value outside the trade agreement.

It is further assumed that relationship-specificity holds in a marginal sense. The marginal productivity of investments is strictly greatest when C and M trade because the human capital investments i_F and i_H are partly specific to the trade

Figure 4.2: Marginal Assumptions

relationship but not to the physical assets. If C and M do not trade, the marginal productivity of investments increases the more assets C or M controls, but not as much as when the two parties trade. The weak inequalities allow for those cases:

$$B'_C(i_F; F, H) > b'_C(i_F; F) \quad \forall \;\; 0 < i_F < \infty \tag{4.2}$$

$$B'_M(i_H; F, H) > b'_M(i_H; H) \quad \forall \;\; 0 < i_H < \infty \tag{4.3}$$

This relationship shows that a person's investment produces more the more assets the person has to work with. The functions B_C and B_M are assumed to be strictly concave: $B'_C(\cdot) > 0, B''_C(\cdot) < 0$ for F, T, NT, H, and i_F, and $B'_M(\cdot) > 0, B''_M(\cdot) < 0$ for F, T, NT, H, and i_H. The default benefit functions $b_{C,M}$ are weakly concave: $b'_C(\cdot) \geq 0, b''_C(\cdot) \leq 0$ for F, T, NT, H, and i_F, and $b'_M(\cdot) \geq 0, b''_M(\cdot) \leq 0$ for F, T, NT, H, and i_H.

Since the exact nature of the product is not completely describable until at Date 2, the community and the harvest manager must negotiate at Date 2 to realize the *ex post* gains from trade, $(B_C + B_M) - (b_C + b_M)$. Either can hold-out for better terms of trade or refuse to trade otherwise. Assume the gains are realized through Nash bargaining and are split 50:50. This assumption of an equal split is not necessary for the results to hold (Hart 1995). Through bargaining, they reach the optimal outcome and trade because of the gains to be realized. The *ex post* payoffs with the arguments suppressed for clarity are:

$$\pi_C = B_C + p = b_C + \bar{p} + \frac{1}{2}[(B_C + B_M) - (b_C + b_M)] \tag{4.4}$$

$$\pi_M = B_M - p = b_M - \bar{p} + \frac{1}{2}[(B_C + B_M) - (b_C + b_M)] \tag{4.5}$$

The first terms on the right hand sides are the reservation payoffs. The two parties will trade at a transfer price. From the above set of equations:

$$p = \bar{p} + \frac{1}{2}[(b_C - B_C) + (B_M - b_M)]$$

Note that an increase in the benefits to B_C of 1 will decrease the transfer price by one-half, so that the net increase is one-half. Likewise, an increase in b_C by 1 will increase p by one-half with net increases to C by one-half again.

The model does not solve for production level as in the optimal path of resource depletion but assumes that the community and harvest manager understand the future flows of benefits from these stocks. They are assumed able to perform backwards induction. The separability of the production and integration decision is consistent with contract theory and transaction cost approaches to the extent that quantity produced does not affect specificity of investments or contracting relationships. The characteristics of F and H stock levels are exogenous. Their size, volume, capacity, quality and other characteristics are given. The investments i_F and i_H improve the quality, efficiency or productivity of the trade relationship and do not contribute to production levels. It is assumed in this model that harvest, price per unit, and location of the harvest are specified prior to Date 1. Therefore, the integration decision is independent of production.

An argument to be explored is that communities have high costs of organization, are less able to insure against risk, and are less technically effective at timber and wood products industrialization. Because of the bias towards hiring internally, communities are thought of as having a fixed labor endowment, unlike a private firm which hires from the open market. From interviews and survey data, communities hire from outside, especially when people with the available skills are not to be found in the community. But most communities hire for manual work, while the managerial work in harvesting is by community members. Similar to the Eswaran and Kotwal (1985) approach, weights indicating the relative efficiency of community investments compared to outside private firms are applied to the investments i_F and i_H when the community makes those investments. Investments made by the community in forest management, $i_F^c = \alpha_F i_F^m$, and that $i_H^c = \alpha_H i_H^m$, where $0 < \alpha_F \leq 1$, $0 < \alpha_H \leq 0$ and the superscripts indicate who is making the investments, a community member or a manager of an outside private firm. Parameters α_F and α_H range between zero and one for cases where community investment is less than or just as efficient than an outside private harvester. More job skills, for example, in forestry management and production could lower costs of training and expertise and contribute to the stock of knowledge specific to a forest. This will be represented by a increase in the parameter values, α_F and α_H.

First best case

In a completely open and integrated economy, the social planner solves the problem of maximizing social welfare by choosing investments cooperatively without regard to relative efficiencies, since there are no restrictions on who makes each investment. Therefore, the social planner maximizes Date 1 net present value W where:

$$W(i_F, i_H) = B_C(i_F; F, H) - i_F + B_M(i_H; F, H) - i_H$$

In the social planner's problem, B_C, B_M are contractible and i_F, i_H are chosen cooperatively. In the first-best scenario, the maximum is attained at i^*. The first-order conditions (FOC) are:

$$i_F^*: \quad W_1'(i_F, i_H) = B_C'(i_F; F, H) = 1$$
$$i_H^*: \quad W_2'(i_F, i_H) = B_M'(i_H; F, H) = 1$$

Second-best cases

In contrast to the first best case, i and B are no longer contractible.

Nonintegration of forest management and harvesting stages

In this case, the community owns the forest, and an outside private harvesting firm owns the harvesting equipment. In this case, the net payoffs realized through bargaining are:

$$\text{Community, C:} \quad \pi_C - i_F = \bar{p} + \frac{1}{2}\Big[B_C(\alpha_F i_F) + B_M(i_H)) + (b_C(\alpha_F i_F; F) - b_M(i_H; H))\Big] - i_F$$
$$\text{Outside harvester, M:} \quad \pi_M - i_H = -\bar{p} + \frac{1}{2}\Big[B_C(\alpha_F i_F) + B_M(i_H)) + (b_M(i_H; H) - b_C(\alpha_F i_F; F))\Big] - i_H$$

Investments i_j, where $j = F, H$, are no longer chosen efficiently. To see the inefficiency, note that the first order conditions (FOC) are:

$$i_F: \quad \alpha_F \frac{1}{2}[B_C' + b_C'] = 1 \tag{4.6}$$
$$i_H: \quad \frac{1}{2}[B_M' + b_M'] = 1 \tag{4.7}$$

That is, in choosing i_j, C and M place one-half the full weight on the default payoffs of b_C and b_M even though the no-trade option does not occur. B_C and B_M are the Pareto optimal outcomes with trade, but the *ex post* distribution of trade surplus has led to suboptimal *ex ante* investments. The comparative efficiency weight α_F in the FOC further removes silvicultural investment levels away from first best.

Integration of forest management and harvesting stages

In this first approximation of a modeling approach, assume that if the community is integrated, the community members make the investments in the forest management stage as in the nonintegrated scenario. However, the manager making investments in the harvesting stage at Date 1 is a member of the community and may not have the specialized skills of an outside private company. Further, if this member-manager does not agree with the community during the contract period, he still has access, as a member of the community, to the assets F and H in a default situation. Likewise, the community still has access to his human capital specific investments. One can assume a fixed cost, c, that the manager (and perhaps the community) must pay for negotiating differences with the community authorities.[1] The costs could be large or small, positive or even negative. The point is to capture, however crudely, the generalized skill levels of *comunero* managers as opposed to the specialized skills of a private harvesting company. A further assumption is that the managers in each scenario have the same preference structure so that the functions differ only with respect to the weight α_H.

[1] This cost is similar to division costs (d) in Lueck's model of contracting over common property (Lueck 1994).

Therefore, if the community integrated forward, its payoffs are:

$$\pi_C - i_F = \bar{p} + \frac{1}{2}\Big[\big(B_C(\alpha_F i_F) + B_M(\alpha_H i_H)\big) + \big(B_C(\alpha_F i_F; F, H) - B_M(\alpha_H i_H; F, H)\big)\Big] - i_F$$

or,

$$\pi_C - i_F = \bar{p} + B_C(\alpha_F i_F) - i_F \tag{4.8}$$

The harvest manager's payoffs are:

$$\pi_M - i_H - c = -\bar{p} + \frac{1}{2}\Big[\big(B_C(\alpha_F i_F) + B_M(\alpha_H i_H)\big) + \big(B_M(\alpha_H i_H; F, H) - B_C(\alpha_F i_F; F, H)\big)\Big] - i_H - c$$

or,

$$\pi_M - i_H - c = -\bar{p} + B_M(\alpha i_H) - i_H - c \tag{4.9}$$

The FOCs are:

$$i_F: \quad \alpha_F B_C' = 1 \tag{4.10}$$

$$i_H: \quad \alpha_H B_M' = 1 \tag{4.11}$$

Proposition 1 *If $0 < \alpha_F < 1$ and $0 < \alpha_H < 1$, then i_F and i_H under nonintegration and integration by the community are less than first-best i_F^* and i_H^*.*

Proof of Proposition 1: Suppose i_F and i_H satisfy 4.2 and 4.3. Then, $i_F^* > i_F$ and $i_H^* > i_H$ under nonintegration because B_C and B_M are strictly concave. Under integration by the community, $B_C' = \frac{1}{\alpha_F} > 1$ and $B_M' = \frac{1}{\alpha_H} > 1$. Therefore, $i_F^* > i_F$ and $i_H^* > i_H$, since B_C and B_M are strictly concave. QED.

Table 4.1: Ownership Cases

Nonintegration	Integration
• Community owns F • Outside harvester owns H • Community members invest i_F^c • Outside harvester invests i_H^m	• Community owns F and H • Harvesting manager is community member • Community members invest i_F^c • Community members invest i_H^c

Proposition 1 says that where skills are exogenously given and local skills are less efficient than outside firms, then investment levels are less than the first-best Pareto optimal outcome under integration by the community. Bargaining costs with nonintegration also lead to less than first-best investment levels. The parameter α measures how less efficient community members collectively are than private firms, but a trade-off of higher transaction costs occurs for hiring-in outside managers.

Which case is best?

If neither integration nor nonintegration is Pareto efficient, the problem is to choose the property allocation yielding the highest social welfare. The solution method first observes the optimal level of investments, i_F and i_H, in each ownership scenario and compares the "size of the pie" under each scenario, given the exogenous characteristics of the problem. Say there are two possible ownership options as outlined above. The problem becomes $\max\{V_0, V_1\}$, where V_0 is the total social surplus of nonintegration and V_1 is total social surplus from forward integration by the community, so that:

$$V^0 = B_C(\alpha_F i_F; F, H) - i_F + B_M(i_H; F, H) - i_H$$
$$V^1 = B_C(\alpha_F i_F; F, H) - i_F + B_M(\alpha_H i_H; F, H) - i_H - c$$

Given the value of each ownership structure, society "chooses" the ownership option with the greatest social surplus. By the assumption of wealth maximization, it is assumed that someone will propose a new ownership scenario if the prevailing one is not optimal.

Proposition 1 claimed that if community members are not as efficient at investing as a privately operated firm, then the first-best solution is not obtainable. The next proposition considers the case where community members are just as efficient. In this case, integration by the community is socially preferable. As community members have greater initial stock of skills, the more efficient are their investments. Integration then avoids renegotiation costs.

Proposition 2 *If $\alpha_F = 1$ and $\alpha_H = 1$, forward integration by the community is more efficient than nonintegration.*

Proof of Proposition 2: If α_F and $\alpha_H = 1$ then B'_C and $B'_M = 1$ under forward integration by the community. By the concavity assumptions for B_k where $k = C, M$, then $i_F = i_F^*$ and $i_H = i_H^*$ under integration. By conditions 4.2 and 4.3, i_F and i_H under integration are greater than i_F and i_H under nonintegration. QED.

The next proposition considers characteristics of the forest asset, F, in terms of timber (T) and nontimber (NT) resources. In this proposition, increases in the timber resources, T, shift out the productivity of the investments, i_F, due to scale economies or complementarities between the resource and labor. Complementarities between the community labor force and the stock levels may exist so that the community labor force becomes more productive with greater stock levels. They may be able to allocate the stock among different uses more efficiently, for example. The fact that timber production occurs in large forests is not surprising. However, the allocation of property rights remains to be explained. A simple interpretation of scale economies begs the question of why multiple firms or larger private firms do not enter to harvest. In reality, the forest is specific to a community and size is exogenously given, whereas private firms may not be large enough to provide the services, and additional investment to meet production requirements would be too specific to the community.

Similar to conditions 4.2 and 4.3, assume that the same pattern of marginal products holds as the stock increases in value. Say that the stock of timber in one community, T_1, is greater than the stock of timber in another community, T_2, so that $T_1 > T_2$ for $T_1 > 0$ and $T_2 > 0$. Then, holding all else equal, assume:

$$\begin{aligned}
B'_C(i_F; F(T_1, NT), H) &> B'_C(i_F; F(T_2, NT), H), \\
b'_C(i_F; F(T_1, NT)) &> b'_C(i_F; F(T_2, NT)), \\
B'_M(i_H; F(T_1, NT), H) &> B'_M(i_H; F(T_2, NT), H), \\
b'_M(i_H; H) &= b'_M(i_H; H), \\
\forall \;\; 0 < i_F < \infty, \;\; \forall \;\; 0 < i_H < \infty
\end{aligned}$$

Both the benefit function under trade and the default option increase with increases in the timber stock. But, of course, the outside harvest manager, in the case of nonintegration, loses access to the forest in a default situation, so default payoffs remain the same for an outside harvest manager.

Proposition 3 *For any given α, NT, H, there exists a timber stock, T, large enough so that forward integration by the community is socially preferable to non-integration.*

Proof of Proposition 3: Comparing the FOCs for i_F under nonintegration and forward integration by the community, the community's investment i_F is greater under forward integration for any given α_F because of the weight placed on the default payoff $b_C(\cdot)$. By 4.2 and 4.3, i_F under integration is greater than i_F under nonintegration.

Comparing the FOCs for i_H under nonintegration and integration, note that the default payoff under nonintegration for a harvest manager stays the same even as the timber stock increases, although the benefit function in the trade situation, $B_M(\cdot)$ increases. Since the function $B_M(\cdot)$ is strictly concave, then by the Archimedean property of real-numbers [2] as T increases, T will reach a point where $\alpha B'_M(i_H) > \frac{1}{2}(B'_M(i_H) + b'_M(i_M; H))$ for any given i_M. So for the FOCs to hold and by conditions 4.2 and 4.3, i_M under integration is greater than under nonintegration. QED.

A similar relationship is assumed to hold for increases in the nontimber stock, NT with the other assets, T and H, held equal. Increasing nontimber stock also may increase local labor productivity for the reasons given above, but interaction effects between timber and nontimber production raise monitoring issues. Depending on the community's perception, more nontimber resources may require greater coordination of timber harvests. The separation of timber and nontimber production may be difficult to define, in terms of monitoring and quality control,

[2] If $x > 0$ and if y is an arbitrary real number, there exists a positive integer n such that $nx > y$ (Apostol 1967) (p. 26).

therefore becoming a noncontractible element of the production process. Nontimber and timber investments can be complementary on a broader scale given the inadequate knowledge we have of an ecosystem's true value. As knowledge about forest ecology evolves, a change in management plans may be appropriate to enhance the flow of resource benefits. Also, with larger nontimber stock levels, the more likely are community members to harvest nontimber resources. Uncertainties in providing these nontimber products are more important to control.

Nontimber resources are not traded in the model. The model assumes that timber sales do not include nontimber sales, as is usually the case in the community forestry sector. This model assumes that timber and harvest equipment remain the same as nontimber values increase so that only direct effects of nontimber stock size on contracting decision are considered. Allowing nontimber trades in the model would introduce further layers of complexity and is left to future research.

Finally, investments in nontimber benefits can be an *outcome* of vertical integration. Joint production of timber and nontimber products can exhibit economies of scope. Examples include coordinating management plans, exploiting the knowledge gained from the forest resource as a whole, and better incentives to harvest according to practices that minimize damage to the ecosystem and its ability to produce market and nonmarket goods. The harvest of timber and nontimber products is coordinated in some communities, wherein the harvest management plan accounts for the presence of nontimber products (flora, fauna, mushrooms, area of high biodiversity) in delineating commercial forest stands. Planning for timber and nontimber production can occur simultaneously and with better knowledge of the other production activity. Further, as timber production brings community members into the forest, their knowledge of the location and biological habits of nontimber goods increases, creating a complementarity between timber and nontimber efforts. The know-how for nontimber production is unlikely to be static, but requires updating as the forest ecosystem experiences shocks or changes temporally and spatially. Vertical integration may provide the local community with the capital to enhance nontimber benefits.

Therefore, from the above propositions, a corollary follows:

Corollary 1 *Investment in the forest, i_F is greater under community integration than nonintegration.*

The model differs from other property rights models in three ways. First, the identity of managers switches from community to non-community member status between the integration and nonintegration scenarios. The default payoff for a harvest manager under community integration, who carries out the duties of the logging foreman and sales chief, differs from the default payoffs under nonintegration where the private company manager must find other sources of raw material. In the former case, the community manager cannot be alienated from access to the forest resource, and the community has the manager's skills at their service. The community and manager under the integration scenario work out their differences at some fixed cost (c). This adaptation is appropriate to describe the status quo of the communities. Common property holdings are exogenous to the community, while the community decides on acquiring harvest equipment. Second, the efficiency parameters, α_F and α_H, are added. This facilitates comparisons of human capital expertise across communities. However, it is implicit that there is a division of labor among the community members according to skills, that is, the marginal costs are lower for one person than another in each job task. Third, the model breaks the asset F into two components T and NT to explore scale and scope effects across communities with different endowments of forest land.

The present model differs from Lueck (1994) for reasons discussed in the literature review, but also because of the "political institution" which determines common property in Mexico. Lueck's model envisions individual extraction from a common pool resource. In this study, the community forestry enterprise or work group coordinates production on behalf of individual members. In this way, community operations resemble a labor-managed firm. The present model does not solve for membership size because of historical events which created and defined the community territory and membership.

The model is helpful to identifying relationships between a common property resource and a local community. The shift parameter, α, describes both the range and level of skills among the community rather than of a single individual. The representative individual of the model can be seen as an "average" member of the community in terms of this indicator.

Multiple uses expand with a diverse set of individuals. It is assumed that the *Comisariado* is a mechanism to coordinate these uses. Of course, individual owners of forest land often use the forest for both timber and nontimber purposes, but is is argued that multiple use strategies are more likely with a local population.

Finally, the literature claims a positive causal relationship of economies of scale to common property tenure. This paper argues that scale and complementarities between community labor and the forest encourage common property resource management in the form of community forestry enterprises. Proposition 3 expresses this relationship formally.

4.3 Hypotheses

The following hypotheses link the propositions in the theoretical section with the empirical analysis. The first three hypotheses present a way to measure the expertise parameter, α, in terms of physical, human and social capital. From Proposition 2, as the measure increases, the greater the expectation of vertical integration. Greater initial stock in human and social capital is expected to lower the fixed costs of starting timber operations within a community and therefore encourage vertical integration to avoid costs of renegotiation.

The first interpretation of the α parameter is the level of human capital expertise relevant to timber operations.

Hypothesis 1 *As the extent of job or training experience in timber production increases among the local population, the greater is the likelihood of community integration into timber production.*

Next, it is maintained that communities' political resistance to parastatal leasing created social capital within and among communities, and that exposure to long-term industrial forestry changed the relationship between people and forests from subsistence use to large-scale market production. The hypothesis to be tested is that exposure to the timber industry as a business over the long term and solidarity among communities who sought removal of the parastatals from their communities motivated organization in the community around common property forest land. Once fixed costs of organization decrease, local populations integrate into forestry operations to transaction costs.

Hypothesis 2 *Past history of parastatal leasing and harvesting increases the probability of community integration due to the reduced cost of organization in the face of opportunistic behavior in the marketplace.*

Since the previous chapter showed that mechanical training was acquired through work with both private and parastatal firms, it is not implied that the parastatal presence changed training levels any more than a private firm's would. Therefore, a variable for both parastatal leasing and training will be added independently to the regression.

To the degree that the existing physical capital inputs such as logging roads are substitutes for new capital investment to produce timber, a measure for existing specific physical capital tests the transaction cost economics prediction that whoever makes specific investments should own the asset. In this approach, greater initial stock of logging roads reduces the need for new investments and therefore increases the likelihood that an outside harvester contracts with the community. Once the logging roads are built, they become specific to the community, discouraging investment by outside harvesters due to hold-up risk. However, more roads lower the start-up costs for the communities, encouraging them to integrate forward to avoid renegotiation costs with contractors. In this way, the measure may be interpreted as raising the α_F parameter because it makes i_F more productive. Therefore, the initial level of logging roads has an ambiguous effect. A positive value is consistent with the incomplete contracts adaptation, while a negative value is consistent with transaction cost economics.

Hypothesis 3 *As the extent of initial stock of logging road infrastructure increases, the more likely is community integration into timber production.*

Another explanation is also consistent with a positive sign on initial stock of logging road infrastructure. The community may integrate to reduce its hold up risk, which increases with higher levels of sunk, immobile investments. A community with fixed capital stock has a very low or zero opportunity cost of capital because the investments are sunk. A harvester who claims he cannot finish the roads in time, for example, costs the community valuable time. In this case, the community's threat point is lower than a community's without this capital. As the threat point decreases, risk of holdup becomes greater. So initial capital stock has both favorable and unfavorable implications for the community because it simultaneously lowers start-up costs and increases the community's vulnerability to hold-up, due to sunk costs. Both interpretations argue for community integration into timber production. These alternative explanations will be compared in the empirical analysis.

The next three hypotheses are empirical applications of Proposition 3, which says that as timber and nontimber stock increases, the community is more likely to vertically integrate. The first hypothesis interprets stock as the number of forested hectares.

Hypothesis 4 *As the size of the commercial forest increases, the more community ownership of the forest and harvesting equipment is observed, all else equal.*

The initial level of forest stock can be measured in terms of quality as well as physical size. The next hypothesis interprets stock as including value of its commercial potential.

Hypothesis 5 *As the quality of the forest for commercial purposes increases, the more community ownership of the forest and harvesting equipment is observed, all else equal.*

The next hypothesis considers the implication of greater nontimber stock and nontimber interactions with timber harvesting. Uncertainties in nontimber production and the difficulty of monitoring harvest management practices can make complete contracting infeasible. In addition, greater non-commercial timber activity may increase the risk of damage to non-commercial timber products caused by timber harvesting. To the degree that nontimber production is separable from timber production, we should not observe any relationship between timber and nontimber production. So a positive impact of nontimber marketization would suggest that the two processes are not separable. Note that this hypothesis refers to exogenous nontimber production.

Hypothesis 6 *As the stock of nontimber resources increases, the more community ownership of the forest and harvesting equipment is observed, all else equal.*

Finally, investments in forest resources and management can be such that community integration leads to scope economies between timber and nontimber investment goals, as expressed in the corollary. Therefore, vertical integration is the independent variable in the next hypothesis.

Hypothesis 7 *Greater vertical integration leads to greater incidence of nontimber forest production.*

While investment levels in effort and quality generally are not observable, the existence of investments which contribute to both timber and nontimber production may be identified. Unlike the previous hypotheses, Hypothesis 7 examines the relationship between two possibly endogenous variables. To verify results, additional econometric methods such as instrumental variables will be applied.

Chapter 5

Empirical Approach and Results

The empirical analysis tests the theoretical model in two basic regressions. The first regression tests Hypotheses 1 through 6 to predict vertical integration. The second tests Hypothesis 7, the impact of vertical integration on nontimber investments. The following two sections discuss the form of the regression models, variables in the regressions, results and tests of the regression results.

5.1 Vertical Integration

The first regression estimates a choice model of vertical integration across sample communities. The dependent variable is the level of vertical integration, which takes a value of one to four according to the end product which the observation unit sells, i.e. stumpage, roundwood, lumber or finished wood products.

The independent variables include theory and control variables. Based on the hypotheses developed in the theoretical chapter, the causal relationship with the expected sign of each theory variable is hypothesized to be as follows:

Vertical integration = f(initial kilometers of logging roads (+), initial training (+), parastatal leasing history (+), historical nontimber markets (+), forested hectares (+), initial quality of forest (+))

The control variables for assessing alternative theories are: distance to the capital city; distance to the main client; road density; coffee production and parcelization of the forest. Construction of each variable is as follows.

Initial human capital As with the initial physical capital measure, the initial human capital indicators represent either job experience prior to 1986 or prior to any extraction activities conducted by the community itself. Creating this measure required several steps.

The empirical approach first factored mechanical and technical training variables discussed in Chapter 3 to create one index. Principal factors is a method of capturing relationships among a group of variables. Statistically, the technique identifies the most important variables and maximizes variance in a multivariate data matrix. It has been used as an exploratory data analysis tool to elucidate possible theoretical relationships (Adelman and Morris 1967) and to create rating indices for consumer information (StataCorp 1997).

The principal factors of the training variables shows a separation between mechanical and technical training. Mechanical training refers to experience with chainsaws, handsaws, cranes, trucks for transporting logs and sawmilling. Technical tasks include administration, documentation, silvicultural treatments and reforestation. When these job experience variables were factored together (Table 5.1), all the training variables had high factor loadings in the first factor except for handsaws (EMPCO2) and crane operation (EMPCO3). This is because handsaws are an old method of logging not in commercial use today, and crane operation experience is relatively sparse. The second factor loading exhibits a pattern in which the mechanical training variables (EMPCO1-4, EMPCO9) vary together, except for handsaws, and in an opposite direction than the technical training variables (EMPCO5-7), except for administration (EMPCO5) which is close to zero. This pattern together with the consideration that sources of technical and mechanical

Table 5.1: Factor Loadings: Past Mechanical and Technical Training

Principal Factors, 5 factors retained, Observations=39						
Factor	Eigenvalue	Difference	Proportion	Cumulative		
1	2.9895	1.4503	0.5604	0.5604		
2	1.5392	0.7089	0.2885	0.8489		
3	0.8302	0.3289	0.1556	1.0045		
4	0.5013	0.4575	0.0940	1.0985		
5	0.0438	0.0657	0.0082	1.1067		
6	-0.0219	0.1179	-0.0041	1.1026		
7	-0.1398	0.0584	-0.0262	1.0764		
8	-0.1982	0.0112	-0.0372	1.0393		
9	-0.2094	.	-0.0393	1.0000		
Factor Loadings						
Variable	1	2	3	4	5	Uniqueness
empco1	0.6434	0.2022	-0.2745	0.0153	0.0873	0.4619
empco2	0.3660	-0.3725	0.6131	-0.0268	-0.0029	0.3507
empco3	0.3927	0.7668	0.1017	-0.0647	0.0797	0.2369
empco4	0.4758	0.5502	0.4216	0.2621	-0.0326	0.2234
empco5	0.7007	0.0493	-0.4189	0.1160	-0.0623	0.3139
empco6	0.6036	-0.3422	0.0007	0.3725	-0.0291	0.3790
empco7	0.6554	-0.4633	-0.0676	0.0786	0.0553	0.3420
empco8	0.6898	-0.2931	0.0986	-0.4110	0.0433	0.2578
empco9	0.5481	0.2209	-0.0344	-0.3165	-0.1383	0.5303

training differ (see Chapter 3) suggest that the analysis should distinguish between technical and mechanical training.

A dummy variable was then created for each task and recorded a value one if interviewees claimed anyone had received training in the community in the past. "In the past" means before 1986 for stumpage communities or before vertical integration into extraction activities for all other types of communities. Within each mechanical and technical task group, the dummies were summed and divided by the number of tasks in that group so that the resulting measure indicates a percentage of the possible activities in which the community population participated. Therefore, the job experience variables capture the range of skills community members acquired. The reasons for this are twofold. First, this avoids bias in recalling the number of persons hired, especially in formerly-concessioned communities who had negative experiences with parastatals. Second, the existence of people in the community with that skill should be sufficient to build a base of knowledge accessible to other community members. Training represents a base of knowledge about industrial forestry that can be passed on to others in the community. Survey data revealed that many people learned skills by observing other community members.

History of parastatal leasing A binary variable takes the value one if a parastatal held a lease or harvested regularly in the community by arrangement, zero otherwise. The strong effect of the parastatals is evident in the transition graph where the more integrated communities had more parastatal experience. Parastatal history is expected to positively effect vertical integration tendencies because of the educational exposure to industrial forestry and unifying effect of the communities' political resistance to the leasing programs. Statistical tests for selection bias and multicollinearity are conducted to isolate these effects.

Initial physical capital The number of kilometers of logging roads measures the level of asset-specific stock available in the community. A positive sign is consistent with the interpretation that lower start-up costs encourage community integration, and raise its exposure to hold-up risk. A negative sign would indicate that outside harvesters find it easier to contract with the community because of lower specific physical capital investment needs. The survey recorded kilometers of logging roads 20 years ago and 10 years ago. For stumpage communities, the measure of initial physical capital is kilometers of logging roads as of ten years ago, when the transition to community forestry began in earnest. For roundwood, lumber and finished product communities, the measure is either ten years ago, as with the stumpage communities, or twenty years ago if integration into extraction activities had already taken place by 1986.

It is assumed that by the time of the survey in 1997, a sufficient amount of time had passed for communities to transition into timber production if they desired. The chart shows the transition profile of communities in the past 11 years. The numbers one through four refer to the levels of vertical integration. No finished products communities existed in 1986. In three communities, the direction of integration had gone forward then backward - twice with two formerly sawmill-owning observations which are now stumpage work groups, and once with a current stumpage community that extracted timber one year prior to the survey. The chart also shows that many of the current lumber and finished products communities participated in the parastatal lease program.

Nontimber markets in past Hypothesis 6 claims that as nontimber stock increases, the propensity for communities to integrate forward increases. The proxy for the stock of nontimber benefits is the presence of markets in nontimber goods. Such a proxy assumes that markets are more likely to exist where more nontimber products are available. It can also be interpreted as a weight people place on nontimber benefits of the forest, assuming that people value these resources more when they harvest them for sale. The measure does not capture non-market benefits.

The survey supplies information on the range of forest products sold and number of years community members have sold each product. To avoid endogeneity, nontimber markets are considered only if the market has existed for more than ten years so that the market predates or is concurrent with the vertical integration decision. The mushroom export market began in the last eight years and so postdates much vertical integration.[1] The remaining non-commercial timber forest products are fuelwood, wood for domestic use and the "other" category. A dummy variable takes the value one if a market in these products existed for more than ten years, zero otherwise.

Quality of forest, 1940 A proxy for the quality of the forest is used to test Hypothesis 5. Because parastatal firms may have selected better quality forests, an indicator was needed of forest quality before the parastatal era. To prevent selection bias, the measure ranks quality of forest in 1940 from one to five, as explained in Chapter 3.

Forested hectares The size of the forest is measured by hectares of forested land in the community. Technology was similar across communities for harvesting, so size of the forest should affect each community similarly in relation to economies of scale. The logarithmic scale of this variable is used in the regression. The logarithmic scale of forested hectares squared controls for nonlinear effects of size.

Distance Distance, here measured as the number of hours of driving time in a car from the village center to the capital city of Oaxaca (DOAX), has an expected ambiguous effect. Greater distance could increase the propensity to integrate forward because local investments in the forest industry have less competition. Conversely, distance could decrease the propensity to integrate because of increased transportation costs and risks of specialization. A second distance measure represents the distance between the client served by the community and the community (HRR). The measure is number of hours required to drive a truck loaded with logs

[1] Only two communities, a stumpage community and a lumber community, sold mushrooms in non-export markets. The former had been selling for 50 years while the latter only had sold for three years.

to the main client's yard.

Road density Density of the logging road network offers another way of measuring physical infrastructure relative to the size of the forest. The variable for road density (RDDENS) divides the kilometers of logging roads ten years ago, or 20 years ago if the community integrated forward before 1986, by the number of forested hectares.

Coffee As an alternative use of the forest, the production of coffee could conflict with efforts to develop a timber production industry where pine would be the commercial species. A binary variable takes a value one if community members have income from coffee production on a regular basis, zero otherwise (COFFEE).

Parcelization Several communities were parcelized at the time of their founding. To test whether parcelization decreases the probability of vertical integration due to increased internal conflicts, a binary variable takes the value one if the forest is parcelized, zero otherwise (COLL).

5.1.1 Summary Statistics

Summary statistics for theory and control variables are shown in Table 5.7. Wald tests were applied to test whether significant differences exist among group averages. Both pairwise comparisons and joint tests that all averages are equal were conducted (see Appendix). Initial road infrastructure jumps significantly (at the 10% level or above) between the stumpage group and each sawmill group. Otherwise, only roundwood and lumber groups have significant differences. The joint test statistics are significant at the 6% level. Differences in initial mechanical training are significant at the 10% level or above between each group except the roundwood/lumber and lumber/wood products categories, suggesting that mechanical training has the largest effect at the early stages of integration. Independent and joint tests of differences in past technical training were not significant at 10% confidence levels. Parastatal experience differs significantly between the sawmill groups and the other categories, as was expected from the transition graph. Independent tests are significant at the 5% level between stumpage and sawmill communities and between roundwood and sawmill communities. The joint test that all averages are equal across groups is rejected at the 1% level. Independently, the difference in average forest hectares is significant between the stumpage group and each other category at a level of 6% or more and between the roundwood and wood products groups at the 5% level. The joint test rejects the null at the 1% level mainly due to the difference in the stumpage group vis a vis the other groups. The Wald test rejects the null hypothesis at the 10% level that averages for past nontimber sales are equal across all groups, where the stumpage and wood products groups have significant differences in averages only at the 11% level whereas the difference is significant between the roundwood and wood products groups at the 1% level, suggesting a nonlinear pattern in past nontimber marketization. For quality of the forest in 1940, the stumpage group has a significantly different average (at the 5% level) from all other categories. The transition from roundwood to lumber categories does not have significant changes in average forest quality, but a significant gap (at the 5% level) exists between the roundwood and wood products group. The joint test rejects the null at the 1% level.

Within the correlation matrix in Table 5.3, the only strong bivariate correlations are: forested hectares (base and squared) and initial physical infrastructure; technical and mechanical training; and the base and squared terms for forested hectares.

Table 5.2: Summary Statistics, $n = 43$

Variable by group	Mean	Standard Error	Number of observations
Initial mechanical training			
Stumpage	0.20	.0506	16
Roundwood	0.48	.0842	12
Lumber	0.38	.0754	8
Finished wood products	0.57	.1037	7
Initial technical training			
Stumpage	0.26	.0723	16
Roundwood	0.44	.1197	12
Lumber	0.25	.1183	8
Finished wood products	0.32	.1673	7
Past nontimber marketization			
Stumpage	0.25	.1095	16
Roundwood	0.33	.1377	12
Lumber	0.50	.1789	8
Finished wood products	0.57	.1893	7
Parastatal existence			
Stumpage	0.19	.0987	16
Roundwood	0.33	.1377	12
Lumber	0.88	.1183	8
Finished wood products	0.86	.1338	7
Forested hectares, logarithmic			
Stumpage	7.42	.2318	16
Roundwood	8.09	.2868	12
Lumber	8.33	.4579	8
Finished wood products	8.90	.4236	7
Quality of forest in 1940			
Stumpage	3.61	.1433	16
Roundwood	4.06	.1448	12
Lumber	4.30	.1806	8
Finished wood products	4.57	.1644	7
Initial kilometers of logging roads, logarithmic			
Stumpage	2.25	.3372	16
Roundwood	2.43	.4483	12
Lumber	3.45	.3735	8
Finished wood products	3.69	.6320	7

Table 5.3: Correlation Table

	1	2	3	4	5	6	7	8	9
Initial logging roads (logarithmic)	1.0000								
Initial mechanical training	0.3298	1.0000							
Initial technical training	0.2830	0.6605	1.0000						
Parastatal leasing	0.2255	0.0882	-0.2649	1.0000					
Past non-commercial timber markets	-0.2516	0.0763	0.0503	-0.0068	1.0000				
Forested hectares (logarithmic)	0.6270	0.2252	0.1023	0.1745	-0.1374	1.0000			
Forested hectares (logarithmic), sqd.	0.6163	0.2225	0.1026	0.1917	-0.1241	0.9976	1.0000		
Distance to capital of Oaxaca	-0.0751	-0.2732	-0.0159	-0.4606	-0.2466	-0.2628	-0.2810	1.0000	
Quality of forest, 1940	0.3307	0.3190	0.2418	0.2871	0.2532	0.2929	0.3050	-0.3565	1.0000

Approaches to address multicollinearity include dropping variables, formalizing relationships, finding suitable instruments and doing nothing (Kennedy 1992). Multicollinearity among independent variables increases variances and standard errors, leading to spurious results, although the estimators remain best, linear and unbiased (BLUE) and the R^2 is unaffected (Kennedy 1992). Correlation matrices are not sufficient to detect multicollinearity among more than two variables (Belsley, Kuh and Welsch 1980, Kennedy 1992). Mechanical training and technical training explain each other at highly significant levels in ordinary least squares regressions of one variable on the other. Due to close correlation and causality, technical training is dropped from the regression equation for vertical integration. However, forested hectares and initial physical infrastructure are retained for the base model despite their correlation since the aim of the empirical exercise is to control for these varying effects.

Separating effects of the parastatal encounter Distance from the capital city and initial quality of the forest could explain why a parastatal chose a particular community, introducing selection bias. In addition, presence of a parastatal could explain the stock of physical infrastructure and human capital, contributing to multicollinearity in the model. Regressions of the independent variables on each other sought to identify selection bias. The negative correlation between distance from the capital city and the past existence of parastatal leasing is weak ($\rho = -0.46$). Regressing parastatal leasing on distance from Oaxaca city and quality of the forest in 1940 demonstrates that distance has positive and significant explanatory power at the 5% level but that prior forest quality is not significant at the 28% level. It remains possible that the parastatal effect is strong because of its positive correlation to distance from the capital city of Oaxaca. Additional regressions with distance as an explanatory variable will be run to assess this interpretation.

The possibility that the parastatal contributed to initial stock in human and physical capital was tested statistically. Separate ordinary least squares (OLS) regressions of initial logging road stock and mechanical training, with parastatal history as the single explanatory variable show that parastatal history has no explanatory power at more than the 10% level for logging roads or mechanical training.

The condition index offers another tool for checking multicollinearity among more than two variables (Belsley et al. 1980). The singular value decomposition of the matrix of independent variables was performed to calculate the condition index. Each vector of the independent variables are scaled, meaning that the length of each vector is equal to one. The variables are parastatal existence, initial mechanical training, initial physical infrastructure, quality of forest in 1940, forested hectares and past nontimber marketization. The condition index is the maximum singular value (2.13) divided by the minimum singular value (0.11) (Belsley et al. 1980) so that the condition index equals 19. See Table 5.4. A value between 30 and 100 is taken to mean moderate to high collinearity (Belsley et al. 1980), so this test indicates relatively low collinearity among the regressors.

Table 5.4: Matrix of Singular Values

2.1282975
0.81075465
0.67902511
0.49053655
0.31348705
0.11424258

5.1.2 Ordered Logit Model

The estimation technique is the ordered logit model developed by McKelvey and Zavoina (1975). In this case, the increasing levels of vertical integration from selling timber to selling finished wood products has a step-by-step characteristic. While it is possible that communities could own a sawmill and yet contract outside companies for the harvest stage, this has not occurred. Ordered logit is the appropriate model for choice options greater than two when the choices have an ordinal nature. In this case, the increasing levels of vertical integration from selling timber to selling finished wood products has a progressive characteristic. The multinomial logit would lose this information, making it an inferior choice of models.

The regression model is based on a linear probability model:

$$y_i^* = \beta' x_i + \epsilon_i$$

where y_i^* is an unobserved latent random variable, x_i is the vector of explanatory factors, β is a vector of parameters and ϵ_i is the residual error. It is assumed y_i^* lies along a continuum and indicates the propensity of the ith community to be least, middle, upper middle or most integrated into the production chain. In this study, the dependent variable takes the value 1, 2, 3, or 4 for level of integration. The dependent variable is thought to be such that $\mu_{j-1} < y^* < \mu_j$, where $j = 1, 2, 3, 4$ and $-\infty = \mu_0 < \mu_1 < \mu_2 < \mu_3 < \mu_4 = +\infty$ where the parameters, μ_i, are cut points to be estimated. The cut points serve to divide the distribution of y^* into the four categories, so that the response variable y is a discrete realization of y^* and is assumed to be generated in the following manner:

$$y = \begin{cases} 1 & \text{if} \qquad y* \leq \mu_1, \\ 2 & \text{if } \mu_1 < y* \leq \mu_2, \\ 3 & \text{if } \mu_2 < y* \leq \mu_3, \\ 4 & \text{if } \mu_3 \leq y*. \end{cases}$$

Therefore, the probability that an observation falls in each of the four categories is modeled by four probability distributions:

$$\begin{aligned}
Pr(y = 1) \quad &= Pr(\beta' x + \epsilon < \mu_1) & &= Pr(\epsilon < \mu_1 - \beta' x) \\
& & &= F(\mu_1 - \beta' x) \\
Pr(y = 2) \quad &= Pr(\mu_1 < \beta' x + \epsilon \leq \mu_2) & &= Pr(\mu_1 - \beta' x < \epsilon \leq \mu_2 - \beta' x) \\
& & &= F(\mu_2 - \beta' x) - F(\mu_1 - \beta' x) \\
Pr(y = 3) \quad &= Pr(\mu_2 < \beta' x + \epsilon \leq \mu_3) & &= Pr(\mu_2 - \beta' x < \epsilon \leq \mu_3 - \beta' x) \\
& & &= F(\mu_3 - \beta' x) - F(\mu_2 - \beta' x) \\
Pr(y = 4) \quad &= Pr(\mu_3 < \beta' x + \epsilon) & &= Pr(\mu_3 - \beta' x < \epsilon) \\
& & &= 1 - F(\mu_3 - \beta' x)
\end{aligned}$$

where $F(\cdot)$ is the cumulative distribution function (CDF). In this case, the CDF is the logistic distribution. For any value Z, the CDF is:

$$F(Z) = \frac{exp(Z)}{1 + exp(Z)}$$

The ordered logit regression can be conducted with different techniques, such as the proportional odds version and the stereotype version (StataCorp 1997). The version used here is the proportional odds model (POM), which includes an assumption that the slope coefficients are equal across groups (McCullagh 1980). To see this formulation, suppose the propensity that a community is a given level of integration, then $P_i = P(y = i|x)$. The POM fits a set of equations for the cumulative distribution probabilities and estimates the probability that a community is at each level of vertical integration, given a set of characteristics (Lu 1999):

$$\frac{P(y \leq i|x)}{P(y > i|x)} = exp(\mu_i - \beta' x)$$

where μ_i are the parameters representing the $J - 1$ cut points when there are J groups, in this case four. Taking logs of these equations,

$$log\frac{P(y \leq j|x)}{P(y > j|x)} = \mu_j - \beta' x$$

The result is that three cut points will be estimated but the coefficient parameters in β will be the same. This implicit assumption is tested below.

5.1.3 Regression Results

The regression results are displayed in Table B.1. The first regression is the model with only the base term for forested hectares. The second regression adds the squared term but drops quality of the forest variable to determine the effects on past timber marketization, while the third regression is the full model.

In all three regressions, initial physical infrastructure is not significant. The lack of significance in the models could be due to opposing effects. More logging roads in place reduce the need for new specific investments by outside firms, encouraging subcontracting. Competing forces are that the initial infrastructure lowers start-up costs for the community or expose it to hold-up risk. The lack of significance could also indicate that contracts adequately address investments in roads so that the existing infrastructure characteristics do not affect ownership patterns.

Across all regressions, mechanical training is positive and significant above the 5% level, supporting the hypothesis that integration increases as human capital skills increase in the community. Mechanical training is the most basic and fundamental job skill for timber operations. As more people acquire mechanical ability, the more likely are community members to choose forward integration.

Past nontimber marketization does not have strong explanatory power in the first and third regression, but is positive and significant at the 5% level in the second regression where quality of the forest is dropped. The positive coefficient supports the hypothesis that nonseparability between timber and nontimber production encourages local communities to control production. Its weak explanatory power in the other two regressions may be because nontimber market activity substitutes for timber activity in the less integrated communities while it complements community forest investments or poses interaction costs in integrated communities. Its increased significance when quality of the forest is dropped indicates that these two variables are picking up a similar effect, perhaps related to available markets and value associated with higher quality forests. Although the measure for past forest quality refers to commercial timber, some quality factors, like soil and climate conditions, favorable to industrial forestry may overlap with conditions favorable to nontimber products.

The historical effect of parastatal leasing is positive and significant at the 5% level across all three regressions. Given these findings, the analysis points towards the social capital hypothesis, the claim that the historical experience of forests leased to parastatal firms bonded communities against a common enemy. The experience also led to a cultural shift regarding forestry, from one that accessed the forest for subsistence needs to long-term industrial operations.

The number of forested hectares has a significant (at the 5% level) and positive effect with only the base term in the model. Hart (1995) (p. 37) notes that on the margin, more assets, here represented as more stock in the same good and across goods, shifts a person's productivity outward to the point where integration becomes more efficient than nonintegration. Positive externalities of stock size could also be that community organizations economize on supervision costs with larger forests or that larger forests provide greater risk diversification opportunities and, therefore, are more important to control.

Another implication of larger forests is that it poses the opportunity to harvest over longer time horizons. With this in mind, local community members may foresee the need to renegotiate with outside private firms if they choose to subcontract production activities. Cumulative bargaining costs over time could rise to where forward integration is feasible.

Fixed costs of timber processing is yet another interpretation consistent with the data. Many of the stumpage communities have a shorter timber history and have not logged every year since beginning timber operations (YRH3). A large jump in average forest size occurs between the lumber and finished products categories. About a third of the finished products communities buy additional timber from other communities, some on a regular basis (FUEN, FUEN1), indicating a high demand for raw material. Integration beyond a certain point may require a discontinuous jump in minimum forest size required to maintain operations. One crane and a small fleet of trucks may be sufficient to cover timber operations from roundwood to lumber sales, but moving to finished products may require additional machinery. These "lumpy" investments can represent a discrete jump in production costs despite scale economies.

The empirical analysis does not distinguish between economies of scale and returns to scale, but survey data sheds light on the distinction. Economies of scale would mean that costs less than double when production doubles. Increasing returns to scale would mean that production more than doubles when all inputs are doubled. The concepts are related in that increasing returns to scale implies economies of scale. Labor intensity in logging operations, defined as number of loggers and truckers divided by volume (LABORIN), is lowest in the finished products category (0.003) but highest in the lumber category (0.009), so a nonlinear pattern emerges. Integration into finished wood products may allow longer-term planning and more efficient use of labor. Communities have rotation schemes among their workers who can shift between forest and non-forest work. The most likely conclusion is that integrated communities are operating at points where they experience returns to scale.

Adding the squared term reverses the sign of the base term. The squared term is positive, suggesting that additional hectares of forested land have increasingly larger positive effects on the propensity to integrate. However, the terms are not significant at the 10% level. Looking at the average number of hectares by group, there is an even rise of about 2400 hectares between the stumpage and roundwood and the roundwood and lumber communities. A large increase occurs between the lumber and the finished product communities after this gradual rise. The communities in the roundwood and lumber categories have approximately 5000 and 7500 average hectares of forest, respectively. Finished product communities have 11,000 forested hectares on average. The distinction in timber operations is also clear in the sawmill capacity. The sawmills of the lumber communities had capacities that ranged from 2.5 to 11 thousand board feet per day[2] with an average of seven compared to a range of four to 20 thousand board feet per day with an average of ten for the finished wood products communities (ACAPP). Therefore, communities with forests in the five to seven thousand hectares range are candidates for vertical integration, although for smaller capacity sawmills.

Quality of the forest in 1940 has a positive and significant effect in all three base models. Initial quality has the effect of reducing the significance of the nontimber marketization variable. This is because quality of the forest is most likely associated with greater product value which leads to market opportunities, providing additional reasons to integrate vertically.

5.1.4 Tests

Likelihood ratio tests of the regressions in Table B.1 against a model with only a constant reject the null hypothesis at a very significant ratio. Each of the χ^2 test statistics has significance at greater than the 1% level. For Regression (3), the χ^2 statistics for testing singly whether the coefficients are significantly different from zero are also significant at the 5% level for mechanical training, parastatal leasing, and quality of the forest. Past nontimber marketization is significant at the 11% level. The coefficients for forested hectares are not significantly different from zero at the 20% level. The hypothesis that each of the three cut points are equal to zero cannot be rejected. Each cut point is significantly different from the others at the 1% level. Tested jointly, the hypothesis that all coefficients, including those of the cut points, are zero is rejected at the 1% level (see Appendix).

With the ordered logit regression model, marginal effects refer to changes in

[2]The unit of measurement for lumber is actually *millares*, where one *millar* equals 1,200 pieces of 24" x $\frac{1}{4}$" x 4" boards.

probability of being in each category as a variable changes by one unit. This change can be calculated by taking the partial derivative of the probabilities with respect to that independent variable. Table B.2 displays the marginal effects calculated in this manner for the two continuous variables, kilometers of logging roads as a measure of initial physical infrastructure and number of forested hectares. The marginal effects for forested hectares account for both base and squared terms in Regression 3 in Table B.1. All marginal effects are averages of the marginal effects for individual observations.

Consistent with the regression results, the marginal effects for logging roads are small. In addition, logging roads has a surprisingly perverse effect on forward integration, as it increases the chances of selling stumpage and decreases the chances of processing the raw material.

An increase in number of forested hectares tends towards further integration despite the low explanatory power in Regression (3). Accounting for the logarithmic scale, a one percent change in forested hectares decreases the chances of being a stumpage community by over 7%, whereas the chances of being a finished products community increases by 7%.

Marginal effects for binary variables are calculated with different methods (Greene 2000). The same calculations as above are done twice, once with the explanatory variable set to zero, then with the variable set to one, all else constant. The difference between the two probabilities is the marginal effect. The binary variables are existence of a parastatal and past nontimber marketization. Since past mechanical training and forest quality have limited ranges (zero to one for mechanical training and one to five for forest quality), this method is also applied to calculate the marginal effects of these variables.

The two largest marginal effects are for mechanical training and parastatal experience. A value of one for either of these variables decreases a community's chance of selling stumpage by over 30 percentage points, and increases the chances of selling finished products by 20 percentage points or more. In addition, both variables show increasing positive tendencies for each progressive phase in the wood products transformation process, and each have their strongest effects at the two extremes of the spectrum included in this sample. Therefore, these variables have the most significant impacts on predicting level of integration. A χ^2 statistic of mechanical training and vertical integration is significant at the 5% level. None of the stumpage communities had a score as high as the more integrated communities. However, four roundwood communities had scores as high as the lumber and finished products groups. Therefore, other factors explain why they have not integrated into sawmilling despite their range of mechanical skills. The next strongest impact is that of initial forest quality, showing that having forests with higher initial commercial potential increased the probability of vertical integration among communities.

Past nontimber product marketization encourages forward integration, albeit at lower rates. The negative percentage change on the probability of being a stumpage community, and the positive change in the sawmill categories suggest that this variable encourages diversification and investment into industrial forestry.

The small marginal effect and lack of explanatory power for the physical infrastructure indicator is somewhat puzzling. In addition, a χ^2 test of initial physical capital and vertical integration is significant at only the 12% level, and its correlation with vertical integration is weak ($\rho = 0.37$). One finished products community had had no initial network of logging roads, while some of the stumpage and roundwood communities have just as much initial infrastructure as the sawmill communities. Therefore, the stumpage and roundwood communities choose not to fully integrate forward for other reasons. In adding independent variables one at a time, initial logging roads loses substantial significance when parastatal existence and forested hectares are added. However, the stumpage contract frequently calls for the private harvester to make investments in the community. Such investments may act as a "hostage." The firm makes specific investments that raise its risks of hold-up while the community risks breaches of contract as the firm extracts its timber. Mutual "hostage-taking" could be a form of protection against hold-up. The "access for development" hypothesis, where communities and firms reach agreements to trade raw material for investment, does not have support in this particular regression model. If development were equated with investments in timber operations, having less roads would lead to more subcontracting. Yet the measure is insignificant. Consensus over public goods investments may be easier to reach than new timber investments which require more community-level commitment to timber production. Also, development interpreted as the well-being indicators are not correlated strongly with vertical integration. With this first attempt at understanding the relationship between harvester and community, future research is needed to determine the impact on development, however it is defined.

Whether mutual-hostage taking is an efficient or wise strategy can be considered in terms of trade. For example, the prices which the communities receive on average for roundwood, by increasing levels of vertical integration, are 148, 350, 438 and 448 pesos per cubic meter. The contractors with stumpage communities invest more physical capital in stumpage and roundwood communities, perhaps rationalizing lower payments. However, the range of prices among the stumpage group is the widest, with a minimum of 45 pesos per cubic meter to a maximum of 275 pesos per cubic meter. The roundwood and lumber groups each have one community receiving a low price for roundwood (less than 50 pesos per cubic meter) compared to the four stumpage communities receiving less than 100 pesos per cubic meter. Whether these communities are receiving a "fair deal" could be further explored.

McFadden et al. (1977), as cited by Maddala (1983) (p. 76), recommends a table comparing predicted versus observed choices as a goodness of fit measure for grouped data models. Table 5.5 displays the observed versus predicted choices in each category. The model correctly predicts stumpage, roundwood and finished wood products relatively more often than lumber status. The suggested overall prediction success index is:

$$\sigma = \sum_{i=1}^{4} \left[\frac{N_{ii}}{N_{..}} - (\frac{N_{\cdot i}}{N_{..}})^2 \right]$$

which takes a maximum value of:

$$1 - \sum_{i=1}^{4} \left(\frac{N_{\cdot i}}{N_{..}} \right)^2$$

where N_{ij} refers to the number of observations which choose alternative i but were predicted to chose alternative j, and $N_{..}$ refers to the number of correct predictions for alternative i. Taking the value of σ which is 0.39, and dividing by its maximum value which is 0.71, the index performs at 55% of its maximum value. A second measure is the number of correctly predicted observations divided by the sample size. This measure gives the model a 67% success rate (Maddala 1983).

Table 5.5: Prediction Table

Observed Choice	Predicted Choice Stumpage	Roundwood	Lumber	Wood Products	Observed Count
Stumpage	13	3	0	0	16
Roundwood	2	8	2	0	12
Lumber	0	3	3	2	8
Wood Products	0	1	1	5	7
Predicted Count	15	15	6	7	43

5.1.5 Generalized Ordered Logit Comparisons

The proportional odds model assumption of equal slopes across groups is compared with the generalized ordered model that allows slope coefficients to vary and then tested. The small cell sizes in the lumber and finished wood products categories pose somewhat of a problem, and results may not be robust. However, the comparison and tests provide information on the degree to which the POM assumption holds in this model.

The generalized logit model produces $J-1$ equations. Since the dependent variable has four groups, the regression model produces three equations, with the stumpage category as the base comparison group. The program encountered a non-concave function when the squared term for forested hectares is included. Therefore, results are reported for a regression without the squared term. Results are shown in Table B.4. The first equation is the previously reported ordered logit model. The last three columns are the simultaneously estimated equations of the generalized ordered logit model. The results exhibit a large variation across the three equations of the generalized model. It appears that the first equation estimating the probability that a community is integrated into roundwood or higher has coefficients similar to the POM model, suggesting that the largest transition among the categories is in integrating beyond selling stumpage. Consistent with the large marginal effects for mechanical training in stumpage communities, the mechanical training coefficient is large and positive in the first equation. The coefficients for past nontimber marketization are larger in the lumber (Equation 2) and finished products (Equation 3) comparisons but are not significant at the 10% level. Parastatal leasing has the strongest explanatory value in Equation 2 distinguishing lumber and finished products communities, but has virtually no explanatory power for predicting integration into finished products (Equation 3). Size of forest holdings and past forest quality also have their largest effects in comparing stumpage with other categories (Equation 1), suggesting that stumpage communities are more likely to integrate with increases in these variables.

Despite the wide variation, the confidence intervals around all coefficients of the generalized model include coefficient values of the restricted model, except for the parastatal coefficient in Equation 3 which differs from the POM model with a 8% probability. A joint test that all coefficients are the same across equations cannot be rejected at more than the 10% level.

Further, the log-likelihood ratio test statistic for the difference between the POM and generalized ordered logit model is 13.74 with 12 degrees of freedom (18 parameters in the generalized model and six in the POM model) so that the χ^2 is not significant (Pr. = 33%), meaning that the two models are not significantly different.

A standard statistical package program also calculated an approximate likelihood-ratio test of proportionality of odds across response categories. [3] This technique

[3] The omodel command in the Stata statistical package

accommodated the squared term for forested hectares. In the full model of Regression (3), Table B.1, the likelihood ratio test for differences in the restricted and unrestricted models does not reject the null hypothesis that the slope coefficients are equal ($\chi^2_{14} = 17.75$, Pr.=0.22). In conclusion, it is reasonable to assume that the slope coefficients are equal across categories.

Table B.5 presents the same regression models as in Table B.1 but combines the lumber and wood products categories into one "sawmill" category. Therefore, the dependent variable, vertical integration, has three instead of four levels. The coefficient estimates and t-values are similar to the model with four levels. The only differences are that the forested hectares variables are significant at the 10% level in the second regression, and that forested hectares squared and past non-commercial timber marketization are significant at the 10% level in the third regression which includes all variables in the model. Therefore, the results are consistent across alternative groupings except that non-commercial timber markets and size of the forest have stronger effects when comparing sawmill versus other groups.

Alternative Explanations Table B.6 considers alternative explanations for the observed pattern of ownership. In the first regression, distance to the capital of Oaxaca is positive but not significant. Distance to the client is also positive but not significant. It does, however, reduce the significance of quality of forest in the past to the 10% level and drastically increases the coefficient value and significance level of forested hectares. It is interesting that the lumber communities have the closest proximity to clients on average. The more remote stumpage and roundwood communities may not fully integrate because of risks of specialization. The finished products communities may be able to compete in terms of economies of scale, reputation and quality to compensate for transportation disadvantages. Coffee production, while associated with smaller forests ($\rho = -0.53$) and greater distance from Oaxaca ($\rho = 0.51$), does not have explanatory power nor significantly alter the regression results.

Neither does road density have explanatory value because vertical integration depends on the level of capital stock. One kilometer of road costs the same to build no matter if it was built in a large forest or a small one. Finally, a regression including parcelization has an insignificant statistic. Neither does it significantly change parameter values of the model.

5.2 Investment in Nontimber Benefits

Complementary investments between timber and nontimber activities were discussed in Chapter 3. Exogeneity of vertical integration to these complementarities is based on chronology, theory and econometric analysis. First, the measures of nontimber investments refer mostly to recent investments which occurred in 1992-7, while most integration decisions were taken between 1978 and 1994. Two sample communities that began timber production since 1994 mentioned only the general moratorium law on hunting deer applicable since 1995 in Mexico as the complementarity between timber and nontimber planning. This factor is given less weight in the econometric analysis that follows.

Second, vertical integration in one activity provides incentives to invest in other production activities under certain conditions. Logically speaking, while the ability to invest in nontimber activities makes vertical integration more attractive to a community, the community would probably not vertically integrate for these gains absent other motivating factors. The new nontimber activities included in the indicators require overhead, like roads, management plans, and technical assistance which communities would not be able to afford without timber income. Larger cash flow can be directed towards new but related investments. Diversification employs underutilized productive capacity of the local population which has fixed, nontransferable forest stock and a distribution of education and skills.

To substantiate these claims, econometric techniques are employed. A common method to correct for endogeneity includes the instrumental variables technique where alternative variables supposedly uncorrelated with the dependent variable but correlated with the independent variable in question proxy for the independent variable. Complementary nontimber investments are factored using the principal factor method and scored to create the dependent variable for investment in nontimber benefits. Factor loadings are shown in Table 5.6. Complementary nontimber investments has explanatory power at the 5% level when added to Regression (3) in Table B.1 as an independent variable. If vertical integration is endogenous to the model, vertical integration would be correlated with the error term. This results in a bias in the coefficient estimates and an asymptotic bias as well.

In the regression model of complementary investments, the independent theory variable is vertical integration. Vertical integration is correlated with sales revenue ($\rho = 0.65$) in the sample and bicausal in that regressions of one variable on the other both return coefficients with significant explanatory power. Since vertical integration and sales revenue are correlated, sales revenue as an explanatory variable is omitted. The control variables are firm size and high ratings of biodiversity. The regression model to be estimated is:

$$\text{Complementary investments in nontimber activities} = f(\text{vertical integration level } (+), \text{ firm size } (+), \text{ high biodiversity } (+))$$

Table 5.6: Factor Loadings: Nontimber Investments

Principal Factors, 3 factors retained, Observations=42				
Factor	Eigenvalue	Difference	Proportion	Cumulative
1	2.16302	2.04803	1.0778	1.0778
2	0.11499	0.09630	0.0573	1.1351
3	0.01870	0.09011	0.0093	1.1444
4	-0.07142	0.14705	-0.0356	1.1089
5	-0.21846	.	-0.1089	1.0000
Loadings				
Variable	1	2	3	Uniqueness
Conservation	0.79895	-0.19502	0.00960	0.32356
Programs	0.84234	0.05033	0.03367	0.28680
Patrols	0.61856	-0.06401	-0.08817	0.60551
Protection	0.43028	0.05595	0.08978	0.80367
Production	0.49741	0.25922	-0.04046	0.68375

Firm Size Models of technical innovation, investment or applied research include a firm size variable, such as number of employees, total asset value or total sales revenue (Armour and Teece 1980, Cavanaugh 1998, Chen 1996). Each should theoretically be a substitute for the other. Vertical integration of the sample communities in this study is correlated with sales revenue ($\rho = 0.65$). In addition, vertical integration and sales revenue explain each other in a regression of one on the other. However, the number of persons employed by the extraction and transformation processes is the measure for firm size (LABOR). Firm size should positively affect investments in nontimber benefits because of greater possibilities for organizational and informational scope economies.

Biodiversity Higher levels of biodiversity within a forest are expected to expand the range of investment in nontimber benefits. Biological diversity is likely to increase the range of forest products harvested. Chapter 3 discussed the biodiversity indicators collected in the field study. The definition and understanding of biodiversity can vary widely. To reduce ambiguity, only the percentage of hectares categorized in the highest level of biodiversity is used as a proxy (QBIO1).

5.2.1 Summary Statistics

Summary statistics are listed in Table 5.7 and in the Appendix. For firm size, the stumpage communities have a distinctly smaller average number of workers. The average is significantly different than the averages in all three other categories at the 6% level or above. Smaller operations may be due to smaller forests found in the stumpage group. However, despite differences in number of forested hectares, firm size was not significantly different among the top three integrated community groups due to the large spread of firm sizes within each category. For the biodiversity measure, the lumber group stands out as the overall lowest average. In seven out of the eight lumber communities, the forester ranked zero hectares as high biodiversity areas. The two extreme groups, stumpage and finished wood products, have the highest average, supporting the interpretation that nontimber forest benefits are substitutes for the stumpage communities but complementary activities for the finished wood products category. The averages for the stumpage and finished wood products groups are significantly different from the lumber group at the 10% and 1% level, respectively, while the roundwood group has an average significantly different from the finished wood products group at the 11% level.

5.2.2 OLS Regression Results

The first column in Table B.7. is the ordinary least squares (OLS) regression of nontimber investments. Vertical integration and biodiversity are positive and significant at the 5% levels, supporting the hypothesis of complementarities in

Table 5.7: Summary Statistics I

Variable by group	Mean	Standard Error	Number of observations
Nontimber investments			
Stumpage	-0.50	.1122	16
Roundwood	-0.17	.1912	11
Lumber	0.19	.3232	8
Finished wood products	1.21	.3208	7
Enterprise size			
Stumpage	30.81	3.79	16
Roundwood	70.08	20.19	12
Lumber	73.13	18.53	8
Finished wood products	111.14	26.31	7
High biodiversity (% forested ha)			
Stumpage	16.88	8.08	16
Roundwood	10.83	8.04	12
Lumber	2.50	2.37	8
Finished wood products	35.71	12.90	7
Historical nontimber markets			
Stumpage	0.25	.1095	16
Roundwood	0.33	.1377	12
Lumber	0.50	.1789	8
Finished wood products	0.57	.1893	7
Deviation from predicted level			
Stumpage	0.25	0.11	16
Roundwood	0.50	0.15	12
Lumber	0.63	0.17	8
Finished Wood Products	0.29	0.17	7
Years harvesting			
Stumpage	5.69	0.88	16
Roundwood	8.92	0.67	13
Lumber	10.38	0.93	8
Finished Wood Products	12.43	0.54	7

production. Firm size has no explanatory value at the 10% level.

5.2.3 Instrumental Variables Regression Results

Regression (2) of Table B.7 is the instrumental variables version, where the instruments are past mechanical training, history of parastatal leasing, forested hectares (logarithmic), past nontimber marketization, quality of the forest in 1940, firm size and percent of forest rated as having high biodiversity levels. The instrumental variables (IV) version returns coefficient estimates, signs, standard errors and R^2 statistic similar to the OLS regression, supporting the hypothesis of exogeneity of vertical integration.

5.2.4 Tests

Several statistics indicate that vertical integration is exogenous to complementary nontimber investments, leading to consistent estimates. First, the t-statistic for vertical integration decreases only slightly in magnitude and remains significant at the 5% level. The statistic for the Hausman test (Greene 2000) (p.385) is 0.21 with 1 degree of freedom, meaning that the null hypothesis that the OLS and the IV estimators are both consistent cannot be rejected.

Further, the correlation between vertical integration and the error terms is zero. Also, the predicted score for vertical integration, calculated from the ordered logit regression, has a correlation of less than 0.1 with the residuals. In conclusion, vertical integration appears exogenous to complementary investments in nontimber production and explains an increase in new nontimber investments.

Chapter 6

Conclusion

This study adapts economic theory to explain vertical integration in the Mexican industrial forestry sector where forests are common property and decision-makers are community members and outside private firms. Recent events in Mexico's history raised a unique opportunity to examine the role of common property in development and resource management. Once communities received formal recognition to exploit their forests, management for overseeing timber production became the responsibility of local community decision-makers. The local governance structure, historically oriented to civic and political activities, incorporated its new economic activity of commercializing timber products. The investigation casts the question in terms of a vertical integration decision. The central question is why do Mexico's agrarian communities integrate into industrial forestry, when hiring-in private contractors should be a perfectly substitutable choice? Greater endowments of human and physical capital for timber production does not explain why communities rather than private firms should extract and process timber because the private firm could always hire local labor and contract to use local resources.

An incomplete contracts approach was adapted to develop a framework of analysis. The value of this approach is its conceptualization of residual control rights of ownership. In a world characterized by missing markets and high transaction costs, these rights are likely to become more important in economic decision-making. A basic argument is that communities seek control over local economic development and ecosystem benefits, the noncontractibles in the production process. Such control is inherently difficult to define in contracts with outside private firms. Under circumstances described in the propositions, communities prefer to manage downstream production activities rather than contract in the marketplace. Key factors of analysis are physical, human and social capital as fixed costs of production in the timber industry in Mexico, nontimber activities indicating the ecosystem's potential, and forest resource characteristics. Given comparable efficiency levels, the interpretation of community integration offered in this paper is that when able to overcome fixed costs, communities integrate forward to avoid contractual hazards. Integration forward is a way for the community to access capital gains from owning downstream timber operations. Asset ownership assures these investment goals when markets are not complete. At a certain point, the benefits of control exceed the costs of organizing the community forestry enterprise.

The empirical section introduces two models, one of vertical integration and one of investments in nontimber activities. For the first model, the empirical findings were:

- *Fixed costs in human capital expertise* Communities gained from having prior job experience, and an increase of one in the indicators for mechanical training increased a community's propensity to forward integrate by about 40%. The positive effect of human capital skills and parastatal leasing on forward integration suggests a complementarity between community workers and the forest resource. This suggests in the past, the logging firms operating in Oaxaca prior to 1986 created a positive externality for the community by raising the level of skills. The firms did not necessarily gain from creating this externality, so this is a possible area for government programs.

- *Fixed costs of social capital* Historical events of leasing to parastatal firms lowered the fixed costs of organization for two reasons – motivating the communities to form alliances between communities as well as among themselves against a perceived common enemy and exposing local populations to industrial forestry as a consistent, long-term economic venture. Today, the technical foresters are one source of building social cohesiveness around the idea of managing the forest, either for timber production or nontimber benefits. Through training programs and appropriate outreach activities, they can facilitate communities in overcoming the fixed costs of organization.

- *Physical infrastructure* Transaction costs are not necessarily lowered by capital infrastructure investment. The contradictory effects of less required specific investments to start production, sunk costs and the communities' own ability to start production most likely led to the insignificant impact of logging road infrastructure on the propensity to integrate. Alternatively, parties may find satisfactory ways to contract on the physical investment. However, whether communities are trading access to raw material for development funds should be explored further. Stumpage communities may be giving up "too much" for access to scarce funds. Firms may have an unfair bargaining advantage given their capacity to raise capital. Data on the nature of credit constraints, greater details on contracting arrangements and investment characteristics and evolution of community development over time would shed light on the implications for social welfare.

- *Uncertainty and scale of non-commercial timber benefits* The hypothesis that a history of non-commercial timber market activity raises the community's value of controlling access to the forest resource had mixed support. Non-commercial timber sales in the past has explanatory value at the 5% level in one model, suggesting causality. However, this effect drops in significance when forest quality is added to the model, possibly because commercial forest quality captures similar effects.

- *Economies of scale and labor-capital complementarities* Forest quality and size, both considered as stock variables, exhibit scale economies that favor community integration. But to explain why community integration rather than continual contracting between a community and a private harvesting firm is favored, it is argued that complementarities between the asset and community labor and management exist, perhaps through monitoring and supervision advantages. The communities' default benefits increase with increases in quality and size of forest as they exploit these complementarities. The result is less likelihood of subcontracting. A policy question is why communities with smaller forests do not pool production activities with other communities more than is observed. Local decision-makers' preferences for autonomy and avoid bargaining costs, even from other agrarian communities, may be a reason.

- *Alternative explanations* The empirical analysis provided evidence that selection bias does not exist between the parastatal leasing history and distance to the capital city or quality of the forest. Integration occurs despite differences in distance and coffee production, which have no explanatory value as control variables for opportunity costs and comparative advantage. Neither did the parastatal contribute significantly to mechanical training more than private firms. A tendency towards internal conflicts as proxied by parcelized forests does not explain vertical integration.

- *Transition into timber extraction* Stumpage communities are qualitatively and quantitatively different that other categories of communities. The largest marginal effect and explanatory power of the independent variables were in calculations distinguishing the stumpage group. This should be taken into account in forestry policy initiatives. Members of stumpage communities may not have the incentive to invest in timber production without substantial investments in human capital skills, organizational and social capital and commercial quality of the forest. To do this, communities could build partnerships with outside private firms, but disincentives for outside firms would need to be addressed. One possibility are multiyear contracts that reduce hold-up risk. Government intervention is another option.

The second model sought to explain recent investments in nontimber activities. The basic argument is that integrated communities diversify their uses of the forest in timber and nontimber production because they can benefit from economies of scope. Conservation of a forest ecosystem may not be a sole reason to integrate forward because the returns are relatively small, but once integrated, the costs of providing nontimber benefits are smaller for a community engaged in timber production.

To test the the hypothesis, an ordinary least squares and instrumental variables regression analysis were used. The findings support the prediction:

- *Economies of scope* Vertical integration positively and significantly explains recent investments in nontimber activities which include the protection, conservation and production of nontimber goods and services. The reasoning is that communities can exploit economies of scope between timber and nontimber production better than outside private firms. Synergies between the two production processes, possibly through monitoring, management plan and administrative overlaps as well as knowledge of the forest gained through integrating forward, provide the scope opportunities. Private firms were not observed to engage in nontimber production. If they did, they would compete with the scope economies available to communities, assuming that forests remain community property.

- *Exogeneity of vertical integration* For investments in nontimber production and ecosystem services, the main relationship is in the direction of vertical integration to nontimber investments. The instrumental variable regression results, Hausman tests and near-zero correlation of residuals with vertical integration, point towards the consistency of the ordinary least squares and instrumental variables estimators, meaning that vertical integration is exogenous to recent nontimber investments.

The positive impact of vertical integration on recent nontimber investment and production bodes well for adopting ecosystem management approaches in self-governing systems. Several government programs are focusing on nontimber benefits of forest resources. The impetus in this direction may make it more likely that communities will forward integrate contemplating not just the production of timber but also nontimber production. As programs diffuse information and finance projects concerning forest projects, we may begin to see greater use of the complementarities between timber and nontimber production by community forestry enterprises and innovative approaches to industrial community organization.

The contribution to the common property literature is in defining under what conditions individual community members coordinate investments to undertake a sometimes sophisticated production process using common property forests. The economic role of common property management is always affected by the social and cultural context in which it is embedded. For example, *comunidades* and *ejidos* emphasize the contribution of common forest land to community development. The question is how will communities maintain their control, a question which incomplete contracts and transaction cost analysis can help to solve. In thinking about property rights as a bundle of rights, we should consider which benefits the market is able to provide and which it cannot. This distinction has implications for land reform policies that change the access to resources for local populations. The desire to control production to manage ecosystem uncertainties partly explains forward integration of forest communities. The degree to which nontimber production is nonseparable from timber production and complete contracts are infeasible matters to the optimal ownership pattern. For community forestry, this approach has potential to expand and transform the idea of property, from a commodity which is assumed to be tradeable in the marketplace to an asset whose use is constantly renegotiated over time.

A second contribution to common property research is the application of theoretical advances in the economic theory of the firm to common property research. Contract theory bears directly on property rights, yet has not been applied in the field. It places community-level decision-making in the context of a larger set of options available in the market.

The study contributes to the theory of the firm literature in several ways. It is one of the few empirical applications of the incomplete contracts literature. More empirical studies are needed to operationalize the abstract notions of uncertainty, unforeseeability and residual control rights. The adaptations of the "typical" incomplete contract story show how this can be done. The model and empirical analysis combines comparative efficiency parameters with agency costs, an aspect that contract theory frequently overlooks. Another adaptation allows multiple sources of benefits from the forest stock. Changes in stock levels of timber and nontimber resources affects the community's investment under different ownership scenarios. The model then links the vertical integration level with new investments, based on economies of scope in production.

This paper suggested numerous avenues for future research. One extension would be to allow forest land to be traded to facilitate comparisons in other parts of the world. However, it is unclear how land markets would change the results. The factors under which a community was shown to integrate forward with higher probability may also apply with land markets, i.e. stumpage communities face substantial fixed costs of integration and may choose to sell land whereas communities with other characteristics would hold the land and make investments. The status quo is important in that communities with small forests do not necessarily have capital to acquire more forest land.

Further research could consider the role of credit markets. However, credit was a limited source of investment funds among communities, so new credit lines may not change the investment pattern. The risk of specialization could discourage timber investments even without capital constraints for timber activities. Data on opportunity costs and credit markets is needed to determine the effect.

The research leaves open the question of management performance. While parcelization which is associated with internal conflicts, it does not explain vertical integration as an independent variable in the empirical analysis. Local governance could be further explored in terms of why conflicts arise and how they are solved. Multi-person bargaining games could provide insights, although the broader community characteristics as identified in this paper should not be ignored. Performance indicators such as profitability, forest management effectiveness and integrity of the ecosystem could be developed. A recurring theme in discussions with community authorities is if community forestry is a third way, beyond private or public ownership. The evolution of many forestry communities, from receiving only a stumpage fee dictated to them, to productive organizations has been a spectacular transformation. Yet, community members themselves grapple with how to maintain competitiveness in the marketplace and maintain community structure. The answer may lie in novel approaches to management and interaction with community members. The forests in these communities are an important source of income and well-being, so assured access may remain a priority for the foreseeable future.

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Appendix A

Summary Statistics

SURVEY DATA

Note: Variables for coded multi-response questions not shown. Data available from author.

Mean Subpop.	Estimate	Std. Err.	Obs
conc			
trees	.1875	.0987062	16
roundwoo	.3076923	.1294876	13
lumber	.875	.1182786	8
woodpdts	.8571429	.1337891	7
conc3			
trees	57.33333	13.07051	3
roundwoo	66	5.971423	4
lumber	61.28571	3.947639	7
woodpdts	62.66667	3.39992	6
bre20			
trees	14.5	7.070759	16
roundwoo	15.69231	5.985371	13
lumber	37.9375	11.55242	8
woodpdts	80.14286	27.26235	7
bre10			
trees	21.5	7.404872	16
roundwoo	29.61538	11.28711	13
lumber	56.5625	17.92657	8
woodpdts	97.85714	28.19174	7
bre5			
trees	29	6.85841	16
roundwoo	41.88462	13.39731	13
lumber	68.4375	20.11222	8
woodpdts	114.4286	31.59217	7
bre1			
trees	34.375	6.877543	16
roundwoo	52.73077	13.28003	13
lumber	69.3125	20.34725	8
woodpdts	128.7143	36.80278	7
roadd10			
trees	.00938	.0028464	16
roundwoo	.0061905	.0022485	13
lumber	.0121709	.003547	8
woodpdts	.0100417	.0016568	7
rddens			
trees	.3051543	.0471184	12
roundwoo	.2937547	.0509596	12
lumber	.4105641	.0361159	8
woodpdts	.3957909	.0656272	7
supa			
trees	2402.813	481.6606	16
roundwoo	12207.92	7167.46	13
lumber	7466.75	2125.573	8
woodpdts	11047.43	2827.26	7
sup			
trees	7952.067	1554.469	15
roundwoo	48916.08	33603.83	13
lumber	15262.63	4745.486	8
woodpdts	16713.17	4265.685	6
lsupa			
trees	7.415106	.2317195	16
roundwoo	8.351995	.3680469	13
lumber	8.327244	.4578007	8
woodpdts	8.896582	.423436	7
breco			
trees	8.625	6.401968	16
roundwoo	27.84615	10.15912	13
lumber	60.75	11.74613	8
woodpdts	60.28571	8.996093	7
brepriv			
trees	82.375	8.57447	16
roundwoo	40.53846	12.01269	13
lumber	11.25	10.64507	8
woodpdts	2.571429	2.408203	7
brepu			
trees	5.8125	3.932239	16
roundwoo	27.84615	7.969483	13
lumber	26.75	9.143916	8
woodpdts	37.14286	9.580021	7
coll			
trees	.8125	.0987062	16
roundwoo	.9230769	.0747597	13
lumber	.875	.1182786	8
woodpdts	1	0	7
fund			
trees	79.0625	5.521375	16
roundwoo	87.61538	.9372338	13
lumber	86	1.419343	8
woodpdts	83.71429	1.483793	7
priv1			
trees	9.230769	1.698974	13
roundwoo	15.125	5.350469	8
lumber	5.5	3.247595	2
woodpdts	11.5	3.247595	2
priv2			
trees	73.61538	2.555329	13
roundwoo	70.25	4.731213	8
lumber	66.33333	11.09181	3
woodpdts	54.5	10.4561	2
beganh			
trees	83.5	2.468111	16
roundwoo	88.84615	.6210009	13
lumber	85.75	1.298758	8
woodpdts	82.85714	1.331185	7
yrh1			
trees	90.0625	1.125535	16
roundwoo	89	.6224991	13
lumber	87.25	.941995	8
woodpdts	86.42857	.4013672	7
yrh2			
trees	5.6875	.8793109	16
roundwoo	8.923077	.6735294	13
lumber	10.375	.9281021	8
woodpdts	12.42857	.5351563	7
yra1			
trees	(no observations)		
roundwoo	(no observations)		
lumber	93.375	1.280052	8
woodpdts	88.57143	1.431484	7
yra2			
trees	(no observations)		
roundwoo	(no observations)		
lumber	4.75	1.078659	8
woodpdts	9.857143	1.767399	7
q40			
trees	3.60625	.1431872	16
roundwoo	4.130769	.1510381	13
lumber	4.3	.1805998	8
woodpdts	4.571429	.1644028	7
empco1			
trees	.6875	.2486168	16
roundwoo	1	.4527693	10
lumber	1.625	.3551381	8
woodpdts	1.857143	.5938214	7
empco2			
trees	0	0	16
roundwoo	1.2	.586856	10
lumber	.375	.2491195	8
woodpdts	1.428571	.6739639	7
empco3			
trees	.0625	.0612671	16
roundwoo	.7	.321753	10
lumber	.5	.3579455	8
woodpdts	1	.3542742	7

empco4			
trees	.1875	.0987903	16
roundwoo	.7	.321753	10
lumber	.625	.3551381	8
woodpdts	1.285714	.3941999	7
empco5			
trees	.5625	.1255603	16
roundwoo	.3	.146714	10
lumber	.5	.2531057	8
woodpdts	.5714286	.2787414	7
empco6			
trees	.5	.219196	16
roundwoo	.7	.4062327	10
lumber	.375	.3551381	8
woodpdts	.4285714	.2787414	7
empco7			
trees	.3125	.2486168	16
roundwoo	.6	.41	10
lumber	.5	.3579455	8
woodpdts	.5714286	.3457362	7
empco8			
trees	0	0	15
roundwoo	.3	.2882307	10
lumber	0	0	8
woodpdts	.4285714	.2788286	7
empco9			
trees	.6666667	.3119454	15
roundwoo	.7	.454191	10
lumber	.375	.3553659	8
woodpdts	1	.4135851	6
venle			
trees	.5	.2528903	16
roundwoo	.4615385	.1779637	13
lumber	1.125	.4537073	8
woodpdts	1.142857	.4761588	7
precg			
trees	11.25	2.153002	4
roundwoo	12.5	3.608974	3
lumber	30	0	1
woodpdts	25.5	7.080882	2
carven			
trees	3.333333	3.259341	15
roundwoo	0	0	13
lumber	13.57143	10.56163	7
woodpdts	8	6.606933	7
precca			
trees	20	0	1
roundwoo	(no observations)		
lumber	24.33333	3.112698	3
woodpdts	21	3.098387	2
venud			
trees	.25	.1095047	16
roundwoo	.1538462	.1012251	13
lumber	.125	.1182786	8
woodpdts	.4285714	.1892063	7
udven			
trees	.1538462	.1502539	13
roundwoo	9.090909	8.811122	11
lumber	0	0	5
woodpdts	0	0	2
udvenq			
trees	.2307692	.2250502	13
roundwoo	285.7273	276.5272	11
lumber	0	0	5
woodpdts	140	88.95351	5
honven			
trees	.125	.0836356	16
roundwoo	.0769231	.0747597	13
lumber	.5	.1788204	8
woodpdts	.5714286	.1892063	7
honp1			
trees	212.5	154.6614	2
roundwoo	420	0	1
lumber	410	114.625	4
woodpdts	483.3333	14.34438	3
honp2			
trees	(no observations)		
roundwoo	(no observations)		
lumber	10	0	1
woodpdts	187.5	10.82532	2
honmer11			
trees	.5	.3708099	2
roundwoo	1	0	1
lumber	.75	.2270738	4
woodpdts	1	0	4
hexport			
trees	.0625	.061215	16
roundwoo	.0769231	.0747597	13
lumber	.375	.1731421	8
woodpdts	.5714286	.1892063	7
honmer12			
trees	0	0	2
roundwoo	0	0	1
lumber	.25	.2270738	4
woodpdts	0	0	4
honmer13			
trees	.5	.3708099	2
roundwoo	0	0	1
lumber	.25	.2270738	4
woodpdts	0	0	4
honmer21			
trees	0	0	1
roundwoo	(no observations)		
lumber	0	0	1
woodpdts	.3333333	.3042903	3
honmer22			
trees	0	0	1
roundwoo	(no observations)		
lumber	1	0	1
woodpdts	.3333333	.3042903	3
honmer23			
trees	1	0	1
roundwoo	(no observations)		
lumber	1	0	1
woodpdts	.3333333	.3042903	3
merotno			
trees	.8461538	.1015731	13
roundwoo	.6	.1572491	10
lumber	.6	.2223838	5
woodpdts	.5	.2071939	6
merot_1			
trees	.1538462	.1015731	13
roundwoo	.4	.1572491	10
lumber	.4	.2223838	5
woodpdts	.5	.2071939	6
merot_2			
trees	.1538462	.1015731	13
roundwoo	.1	.096295	10
lumber	.2	.1815756	5
woodpdts	.1666667	.1544332	6
merot_3			
trees	0	0	13
roundwoo	.1	.096295	10
lumber	.2	.1815756	5
woodpdts	.1666667	.1544332	6
merot_4			
trees	0	0	13
roundwoo	0	0	10
lumber	0	0	5
woodpdts	.1666667	.1544332	6
emplen_1			

trees	.375	.12243	16
roundwoo	.6923077	.1294876	13
lumber	.75	.154863	8
woodpdts	.7142857	.172721	7
emplen_2			
trees	.0625	.061215	16
roundwoo	.0769231	.0747597	13
lumber	0	0	8
woodpdts	0	0	7
emplen_o			
trees	0	0	16
roundwoo	.1538462	.1012251	13
lumber	.125	.1182786	8
woodpdts	.1428571	.1337891	7
emplenno			
trees	.625	.12243	16
roundwoo	.2307692	.1182055	13
lumber	.25	.154863	8
woodpdts	.2857143	.172721	7
carcon			
trees	0	0	15
roundwoo	1	.7628251	13
lumber	87	65.79379	7
woodpdts	72.14286	44.23398	7
empcar			
trees	0	0	13
roundwoo	.8333333	.7248451	12
lumber	1.285714	1.206319	7
woodpdts	.1666667	.1541875	6
vgrhq			
trees	100	0	1
roundwoo	7	0	1
lumber	25.25	9.451946	4
woodpdts	2	.7559289	2
ud			
trees	1	0	16
roundwoo	.9230769	.0747597	13
lumber	.875	.1182786	8
woodpdts	1	0	7
empud			
trees	.5	.2683032	16
roundwoo	.75	.7265685	12
lumber	1.125	1.064795	8
woodpdts	3.857143	1.703318	7
udcon			
trees	15.14286	5.673455	14
roundwoo	18.63636	8.368248	11
lumber	35.25	19.3153	4
woodpdts	60.66667	28.60216	3
udconq			
trees	42.16667	17.52615	12
roundwoo	50.31818	20.26813	11
lumber	22	4.500896	4
woodpdts	342.2	168.6729	5
honcon			
trees	.875	.0836356	16
roundwoo	.9230769	.0747597	13
lumber	.875	.1182786	8
woodpdts	1	0	7
famhoc			
trees	86.07143	11.17356	14
roundwoo	103.5833	43.5234	12
lumber	214.1667	107.1728	6
woodpdts	75.6	31.40287	5
ntfp			
trees	.8125	.0987062	16
roundwoo	.7692308	.1182055	13
lumber	.625	.1731421	8
woodpdts	1	0	7
ntfpne2			
trees	.3125	.1172178	16
roundwoo	.5384615	.1398626	13
lumber	.5	.1788204	8
woodpdts	.4285714	.1892063	7
ntrange			
trees	3	.4193711	16
roundwoo	2.153846	.4777219	13
lumber	2.5	.6447462	8
woodpdts	3	.8426234	7
famotro			
trees	135.4167	41.31121	12
roundwoo	341.5	285.5957	10
lumber	84	22.37049	5
woodpdts	72.6	31.8287	5
volhoc			
trees	164.5	52.7088	13
roundwoo	116.0909	85.93901	11
lumber	167.4167	78.52686	6
woodpdts	260	168.5335	5
yrvlen			
trees	4.75	.772393	4
roundwoo	5	0	2
lumber	5.5	1.107823	2
woodpdts	4.5	.5838742	4
yrvcar			
trees	6	.7637626	2
roundwoo	(no observations)		
lumber	6.666667	.2939724	3
woodpdts	6.5	.3818813	2
yrvud			
trees	4.75	.7843688	4
roundwoo	4	0	1
lumber	4	0	1
woodpdts	4.666667	1.258306	3
hony1			
trees	29	15.57402	2
roundwoo	2	0	1
lumber	4	1.229837	4
woodpdts	5	0	4
hony2			
trees	100	0	1
roundwoo	(no observations)		
lumber	6	0	1
woodpdts	4.5	.4082483	2
honyco			
trees	5	0	14
roundwoo	4.833333	.1089892	12
lumber	4.833333	.1541341	6
woodpdts	5	0	7
otroy			
trees	6.666667	.249382	12
roundwoo	5.625	.5062757	8
lumber	6.2	.5301572	5
woodpdts	6.166667	.6069301	6
ymer1			
trees	87.5	9.547033	2
roundwoo	8	0	1
lumber	44	27.49545	2
woodpdts	6.5	2.673169	2
ymer2			
trees	75	0	1
roundwoo	8	0	1
lumber	8	0	1
woodpdts	5	0	1
ymer3			
trees	(no observations)		
roundwoo	8	0	1
lumber	8	0	1
woodpdts	5	0	1
reglc1			
trees	6.5	.2556187	4
roundwoo	4.125	.5552724	8

```
       lumber |       4.4     .224013           5
     woodpdts |  4.833333    .6104795           6
--------------+-----------------------------------
reglc2        |
        trees |         5           0           1
     roundwoo |         4    .4150996           5
       lumber |  4.333333    .2824395           3
     woodpdts |       3.8    .3472973           5
--------------+-----------------------------------
reglc3        |
        trees | (no observations)
     roundwoo |  4.333333    1.163829           3
       lumber |  4.333333    .2909572           3
     woodpdts |         6    .7559289           2
--------------+-----------------------------------
regud1        |
        trees |       4.8    .3458685          10
     roundwoo |  4.833333    .2631111          12
       lumber |       5.4    .4631414           5
     woodpdts |  4.333333     .195434           6
--------------+-----------------------------------
regud2        |
        trees |  3.833333     .511594           6
     roundwoo |       4.8    .3456395           5
       lumber |         7           0           1
     woodpdts |      4.25    .2236068           4
--------------+-----------------------------------
regud3        |
        trees |         3           0           1
     roundwoo |         4           0           1
       lumber | (no observations)
     woodpdts |  5.333333    .3042903           3
--------------+-----------------------------------
reghv1        |
        trees |         3           0           1
     roundwoo |         2           0           1
       lumber |         3           0           3
     woodpdts |         3           0           4
--------------+-----------------------------------
reghv2        |
        trees |         3           0           1
     roundwoo |         2           0           1
       lumber |         3           0           2
     woodpdts |      2.75     .231455           4
--------------+-----------------------------------
reghv3        |
        trees | (no observations)
     roundwoo | (no observations)
       lumber |         3           0           2
     woodpdts |         3           0           2
--------------+-----------------------------------
reghc         |
        trees |         0           0          14
     roundwoo |         0           0          12
       lumber |         0           0           7
     woodpdts |  .4285714    .4018348           7
--------------+-----------------------------------
regot1        |
        trees | (no observations)
     roundwoo | (no observations)
       lumber |  4.666667    .3142697           3
     woodpdts |         3           0           1
--------------+-----------------------------------
regot2        |
        trees | (stratum with 1 PSU detected)
     roundwoo | (stratum with 1 PSU detected)
       lumber | (stratum with 1 PSU detected)
     woodpdts | (stratum with 1 PSU detected)
--------------+-----------------------------------
regga1        |
        trees |  3.142857    .7108762           7
     roundwoo |       3.5      .36799           2
       lumber |       3.5     1.10397           2
     woodpdts |         4           0           2
--------------+-----------------------------------
regga2        |
        trees | (stratum with 1 PSU detected)
     roundwoo | (stratum with 1 PSU detected)
       lumber | (stratum with 1 PSU detected)
     woodpdts | (stratum with 1 PSU detected)
--------------+-----------------------------------
involno       |
        trees |         0           0          16
     roundwoo |         0           0          13
       lumber |         0           0           8
```

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     woodpdts |  .1428571    .1337891           7
--------------+-----------------------------------
invol_1       |
        trees |      .375      .12243          16
     roundwoo |  .4615385    .1398626          13
       lumber |      .625    .1731421           8
     woodpdts |  .7142857     .172721           7
--------------+-----------------------------------
invol_2       |
        trees |         0           0          16
     roundwoo |  .1538462    .1012251          13
       lumber |      .125    .1182786           8
     woodpdts |  .2857143     .172721           7
--------------+-----------------------------------
invol_3       |
        trees |      .875    .0836356          16
     roundwoo |  .7692308    .1182055          13
       lumber |      .875    .1182786           8
     woodpdts |  .5714286    .1892063           7
--------------+-----------------------------------
invol_o       |
        trees |     .3125    .1172178          16
     roundwoo |  .3846154     .136492          13
       lumber |        .5    .1788204           8
     woodpdts |  .5714286    .1892063           7
--------------+-----------------------------------
sellfuel      |
        trees |       .25    .1095047          16
     roundwoo |  .3846154     .136492          13
       lumber |        .5    .1788204           8
     woodpdts |  .5714286    .1892063           7
--------------+-----------------------------------
comp2         |
        trees |  .4666667    .1303367          15
     roundwoo |  .5384615    .1399005          13
       lumber |       .25    .1549049           8
     woodpdts |  .7142857    .1727677           7
--------------+-----------------------------------
coffee        |
        trees |     .5625    .1254534          16
     roundwoo |  .4615385    .1398626          13
       lumber |       .25     .154863           8
     woodpdts |         0           0           7
--------------+-----------------------------------
rules2        |
        trees |    4.9375     .700994          16
     roundwoo |  4.076923     1.10297          13
       lumber |         7    2.872281           8
     woodpdts |  8.571429    1.871454           7
--------------+-----------------------------------
ent1          |
        trees |     .4375    .1254534          16
     roundwoo |  .7692308    .1182055          13
       lumber |      .375    .1731421           8
     woodpdts |  .8571429    .1337891           7
--------------+-----------------------------------
ent2          |
        trees |      .125    .0836356          16
     roundwoo |  .3076923    .1294876          13
       lumber |      .375    .1731421           8
     woodpdts |  .5714286    .1892063           7
--------------+-----------------------------------
ent3          |
        trees |     .8125    .0987062          16
     roundwoo |         1           0          13
       lumber |      .875    .1182786           8
     woodpdts |  .8571429    .1337891           7
--------------+-----------------------------------
ent4          |
        trees |     .4375    .1254534          16
     roundwoo |  .4615385    .1398626          13
       lumber |       .25     .154863           8
     woodpdts |  .7142857     .172721           7
--------------+-----------------------------------
ent5          |
        trees |     .4375    .1254534          16
     roundwoo |  .7692308    .1182055          13
       lumber |      .875    .1182786           8
     woodpdts |         1           0           7
--------------+-----------------------------------
ent6          |
        trees |       .25    .1095047          16
     roundwoo |  .6153846     .136492          13
       lumber |       .25     .154863           8
     woodpdts |  .7142857     .172721           7
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ent3c			
trees	7.692308	.8052305	13
roundwoo	14.69231	6.879281	13
lumber	21.71429	12.09246	7
woodpdts	6.666667	1.385493	6
ent9b			
trees	4	.7905694	2
roundwoo	1	0	1
lumber	99	0	1
woodpdts	3	0	1
ent9c			
trees	5.5	1.976424	2
roundwoo	10	0	1
lumber	10	0	1
woodpdts	3	0	1
ent1d			
trees	1.285714	.1745844	7
roundwoo	2.142857	.2468997	7
lumber	1	0	3
woodpdts	1.666667	.3935507	6
ent3d			
trees	1.230769	.1618559	13
roundwoo	1	0	11
lumber	1.285714	.1731022	7
woodpdts	1.166667	.1542438	6
ent5d			
trees	2.857143	.5216405	7
roundwoo	1.428571	.2803734	7
lumber	1.285714	.1738802	7
woodpdts	1.285714	.269374	7
clien			
trees	.3571429	.1297792	14
roundwoo	.2727273	.1360841	11
lumber	1	0	6
woodpdts	.2857143	.173039	7
sug			
trees	.6428571	.1297792	14
roundwoo	.6363636	.1469877	11
lumber	.8333333	.1541875	6
woodpdts	1	0	7
fi			
trees	.7857143	.1111363	14
roundwoo	.6363636	.1469877	11
lumber	1	0	6
woodpdts	.7142857	.173039	7
impt			
trees	22.33333	12.45272	9
roundwoo	15.125	10.3309	8
lumber	17.14286	11.61746	7
woodpdts	19.16667	13.17743	6
ent1aa			
trees	91.42857	1.567156	7
roundwoo	87.4	1.155578	10
lumber	86.66667	1.545363	3
woodpdts	83.33333	1.169362	6
ent2aa			
trees	95	0	2
roundwoo	87	2.268443	4
lumber	87.33333	1.857584	3
woodpdts	83.75	2.998046	4
ent3aa			
trees	92.07692	1.115559	13
roundwoo	88.15385	1.14979	13
lumber	87	1.418006	7
woodpdts	84.66667	1.541341	6
ent4aa			
trees	91.85714	1.379885	7
roundwoo	90.66667	1.632142	6
lumber	55.66667	23.28829	3
woodpdts	85.8	2.016333	5

ent5aa			
trees	91.71429	1.34222	7
roundwoo	91.6	1.18721	10
lumber	89	1.377664	7
woodpdts	87.42857	1.978996	7
ent6aa			
trees	91.5	1.334635	4
roundwoo	89.875	1.302583	8
lumber	89	3.632416	2
woodpdts	85.8	2.258416	5
ent1d			
trees	1.285714	.1745844	7
roundwoo	2.142857	.2468997	7
lumber	1	0	3
woodpdts	1.666667	.3935507	6
ent2d			
trees	1	0	2
roundwoo	1	0	3
lumber	1.333333	.2854496	3
woodpdts	1.333333	.2854496	3
ent3d			
trees	1.230769	.1618559	13
roundwoo	1	0	11
lumber	1.285714	.1731022	7
woodpdts	1.166667	.1542438	6
ent4d			
trees	1.571429	.2833032	7
roundwoo	2.25	.5606588	4
lumber	2.5	.3638034	2
woodpdts	1.8	.3443664	5
ent5d			
trees	2.857143	.5216405	7
roundwoo	1.428571	.2803734	7
lumber	1.285714	.1738802	7
woodpdts	1.285714	.269374	7
ent6d			
trees	1.8	.4508815	5
roundwoo	2.166667	.2886751	6
lumber	2	.7276069	2
woodpdts	1.2	.1840716	5
ent7d			
trees	1	0	4
roundwoo	1	0	1
lumber	1.5	.3220306	6
woodpdts	2	.4131182	5
ent9d			
trees	1.5	.3952847	2
roundwoo	1	0	1
lumber	1	0	1
woodpdts	1	0	1
stf			
trees	1.125	.0836356	16
roundwoo	.9230769	.0747597	13
lumber	1.125	.1182786	8
woodpdts	1.285714	.172721	7
stftec			
trees	1.375	.2663614	16
roundwoo	1.076923	.3005924	13
lumber	.625	.2489075	8
woodpdts	3.142857	1.479766	7
stfot			
trees	32	24.76379	16
roundwoo	1.272727	.4136044	11
lumber	4.5	1.485926	6
woodpdts	8.142857	3.09912	7
ystf			
trees	1.8125	.1604097	16
roundwoo	2.076923	.0747597	13
lumber	2.875	.2143982	8
woodpdts	2.714286	.172721	7
stfpay_1			

trees	.3125	.1172178	16
roundwoo	.8461538	.1012251	13
lumber	.75	.154863	8
woodpdts	1	0	7
stfpay_3			
trees	0	0	16
roundwoo	0	0	13
lumber	.375	.1731421	8
woodpdts	.2857143	.172721	7
stfpay_4			
trees	.8125	.0987062	16
roundwoo	.0769231	.0747597	13
lumber	0	0	8
woodpdts	0	0	7
stfpay_5			
trees	.0625	.061215	16
roundwoo	0	0	13
lumber	0	0	8
woodpdts	0	0	7
stfpay_o			
trees	.0625	.061215	16
roundwoo	.1538462	.1012251	13
lumber	.125	.1182786	8
woodpdts	0	0	7
pagopm_1			
trees	.3125	.1172178	16
roundwoo	.8461538	.1012251	13
lumber	.875	.1182786	8
woodpdts	1	0	7
pagopm_4			
trees	.6875	.1172178	16
roundwoo	.0769231	.0747597	13
lumber	0	0	8
woodpdts	0	0	7
pagopm_o			
trees	0	0	16
roundwoo	.1538462	.1012251	13
lumber	.125	.1182786	8
woodpdts	.1428571	.1337891	7
pm_1			
trees	.9375	.061215	16
roundwoo	.6923077	.1294876	13
lumber	.375	.1731421	8
woodpdts	.4285714	.1892063	7
pm_2			
trees	0	0	16
roundwoo	0	0	13
lumber	0	0	8
woodpdts	.2857143	.172721	7
pm_3			
trees	0	0	16
roundwoo	.1538462	.1012251	13
lumber	.625	.1731421	8
woodpdts	.4285714	.1892063	7
pm_o			
trees	.0625	.061215	16
roundwoo	.1538462	.1012251	13
lumber	0	0	8
woodpdts	0	0	7
obj_1			
trees	1	0	16
roundwoo	.8461538	.1012251	13
lumber	.875	.1182786	8
woodpdts	1	0	7
obj_2			
trees	.125	.0836356	16
roundwoo	.2307692	.1182055	13
lumber	.25	.154863	8
woodpdts	.1428571	.1337891	7
obj_3			
trees	.0625	.061215	16
roundwoo	.3076923	.1294876	13
lumber	.125	.1182786	8
woodpdts	.2857143	.172721	7
obj_o			
trees	.4375	.1254534	16
roundwoo	.3846154	.136492	13
lumber	.125	.1182786	8
woodpdts	.5714286	.1892063	7
qcom1			
trees	14.0625	6.21415	16
roundwoo	19.23077	8.485586	13
lumber	17.5	10.98691	8
woodpdts	17.14286	8.540523	7
qcom2			
trees	35.8125	7.180268	16
roundwoo	43.07692	7.713607	13
lumber	53.75	10.26272	8
woodpdts	33.57143	7.695296	7
qcom3			
trees	29.1875	5.773172	16
roundwoo	23.46154	4.41494	13
lumber	25	4.731144	8
woodpdts	30.71429	7.256336	7
qcom4			
trees	12.1875	5.600976	16
roundwoo	14.23077	7.191779	13
lumber	3.75	2.489075	8
woodpdts	17.14286	5.39321	7
qcom5			
trees	8.75	5.628229	16
roundwoo	0	0	13
lumber	0	0	8
woodpdts	1.428571	1.337891	7
qsue1			
trees	26.2	9.382799	15
roundwoo	5	3.383878	11
lumber	25	12.11694	6
woodpdts	65.42857	11.28269	7
qsue2			
trees	37.6	8.557275	15
roundwoo	72.72727	10.56844	11
lumber	45.83333	8.134132	6
woodpdts	27.28571	8.742888	7
qsue3			
trees	15.66667	6.682297	15
roundwoo	14.09091	7.419943	11
lumber	20.83333	6.797644	6
woodpdts	5.857143	2.933512	7
qsue4			
trees	20.38333	7.240569	15
roundwoo	6.363636	2.068702	11
lumber	5	3.158808	6
woodpdts	1.142857	.7215527	7
qsue5			
trees	.1333333	.0889181	15
roundwoo	1.818182	1.75623	11
lumber	3.333333	3.082681	6
woodpdts	0	0	7
qbio1			
trees	16.875	8.082542	16
roundwoo	13.07692	7.733206	13
lumber	2.5	2.365572	8
woodpdts	35.71429	12.90215	7
qbio2			
trees	23.125	6.909434	16
roundwoo	47.69231	10.56381	13
lumber	55	11.3096	8
woodpdts	42.85714	13.35659	7
qbio3			
trees	34.0625	7.6812	16
roundwoo	21.15385	6.651795	13

lumber	35	11.3096	8
woodpdts	14.28571	4.013672	7
qbio4			
trees	22.1875	8.034103	16
roundwoo	15	7.257857	13
lumber	5	3.097261	8
woodpdts	5.714286	4.013672	7
qbio5			
trees	2.5	1.4137	16
roundwoo	3.076923	2.024503	13
lumber	2.5	2.365572	8
woodpdts	1.428571	1.337891	7
evita			
trees	2.6	.2091905	15
roundwoo	1.727273	.2289091	11
lumber	1.714286	.2678898	7
woodpdts	1.571429	.2788286	7
incen			
trees	286.7031	183.7264	16
roundwoo	1114.917	1003.428	12
lumber	126.8125	58.55802	8
woodpdts	225.4286	199.0782	7
ppincen			
trees	.0948815	.0422418	16
roundwoo	.0282113	.0112458	12
lumber	.084711	.0674988	8
woodpdts	.0123569	.0105288	7
crece			
trees	67.91667	5.255678	12
roundwoo	76.5	3.519732	12
lumber	83.75	2.796973	8
woodpdts	81.66667	4.727298	6
illeg			
trees	2.8125	.240225	16
roundwoo	3.076923	.2571706	13
lumber	3.25	.3462843	8
woodpdts	3.571429	.2785042	7
qilleg			
trees	3	0	11
roundwoo	2.875	.1193379	8
lumber	3	0	4
woodpdts	3	0	2
oilleg			
trees	2.9375	1.036807	16
roundwoo	2.230769	1.044855	13
lumber	2.25	1.393767	8
woodpdts	4	1.660279	7
sever			
trees	.9375	.3027925	16
roundwoo	.6153846	.3215537	13
lumber	.625	.3973477	8
woodpdts	0	0	7
acerca			
trees	2.1875	.183645	16
roundwoo	1.923077	.2324374	13
lumber	1.625	.3064828	8
woodpdts	1.714286	.2675782	7
dens			
trees	228	23.57661	16
roundwoo	254.8333	23.38461	12
lumber	270.625	26.89638	8
woodpdts	361.4286	85.17727	7
densb			
trees	61.5	5.898084	14
roundwoo	49.29167	5.833865	12
lumber	41	7.728892	7
woodpdts	62.71667	21.37653	6
dur			
trees	4.875	.7990842	16
roundwoo	10.69231	3.612012	13
lumber	11.625	3.173433	8
woodpdts	6.857143	2.11821	7
ciclo			
trees	3.9375	.6416178	16
roundwoo	6.25	1.285009	12
lumber	8.875	2.342003	8
woodpdts	6.571429	2.142598	7
pre5			
trees	1.9375	.2274651	16
roundwoo	1.833333	.2621602	12
lumber	2	.3098098	8
woodpdts	1.714286	.2676506	7
mor1			
trees	5.428571	.7726705	7
roundwoo	4.666667	.3126286	6
lumber	4.333333	.2796235	3
woodpdts	7	.9686442	3
les1			
trees	8.666667	.2868877	3
roundwoo	8	.745356	2
lumber	8	.745356	2
woodpdts	7.333333	.7590334	3
contra			
trees	.4375	.1254534	16
roundwoo	.2307692	.1182055	13
lumber	.125	.1182786	8
woodpdts	.1428571	.1337891	7
clear2			
trees	.6875	.2138148	16
roundwoo	.3076923	.1699311	13
lumber	.375	.2489075	8
woodpdts	0	0	7
qcom1			
trees	14.0625	6.21415	16
roundwoo	19.23077	8.485586	13
lumber	17.5	10.98691	8
woodpdts	17.14286	8.540523	7
qcom2			
trees	35.8125	7.180268	16
roundwoo	43.07692	7.713607	13
lumber	53.75	10.26272	8
woodpdts	33.57143	7.695296	7
qcom3			
trees	29.1875	5.773172	16
roundwoo	23.46154	4.41494	13
lumber	25	4.731144	8
woodpdts	30.71429	7.256336	7
qcom4			
trees	12.1875	5.600976	16
roundwoo	14.23077	7.191779	13
lumber	3.75	2.489075	8
woodpdts	17.14286	5.39321	7
qcom5			
trees	8.75	5.628229	16
roundwoo	0	0	13
lumber	0	0	8
woodpdts	1.428571	1.337891	7
qsue1			
trees	26.2	9.382799	15
roundwoo	5	3.383878	11
lumber	25	12.11694	6
woodpdts	65.42857	11.28269	7
qsue2			
trees	37.6	8.557275	15
roundwoo	72.72727	10.56844	11
lumber	45.83333	8.134132	6
woodpdts	27.28571	8.742888	7
qsue3			
trees	15.66667	6.682297	15
roundwoo	14.09091	7.419943	11
lumber	20.83333	6.797644	6
woodpdts	5.857143	2.933512	7

qsue4			
trees	20.38333	7.240569	15
roundwoo	6.363636	2.068702	11
lumber	5	3.158808	6
woodpdts	1.142857	.7215527	7
qsue5			
trees	.1333333	.0889181	15
roundwoo	1.818182	1.75623	11
lumber	3.333333	3.082681	6
woodpdts	0	0	7
qbio1			
trees	16.875	8.082542	16
roundwoo	13.07692	7.733206	13
lumber	2.5	2.365572	8
woodpdts	35.71429	12.90215	7
qbio2			
trees	23.125	6.909434	16
roundwoo	47.69231	10.56381	13
lumber	55	11.3096	8
woodpdts	42.85714	13.35659	7
qbio3			
trees	34.0625	7.6812	16
roundwoo	21.15385	6.651795	13
lumber	35	11.3096	8
woodpdts	14.28571	4.013672	7
qbio4			
trees	22.1875	8.034103	16
roundwoo	15	7.257857	13
lumber	5	3.097261	8
woodpdts	5.714286	4.013672	7
qbio5			
trees	2.5	1.4137	16
roundwoo	3.076923	2.024503	13
lumber	2.5	2.365572	8
woodpdts	1.428571	1.337891	7
sup			
trees	7952.067	1554.469	15
roundwoo	48916.08	33603.83	13
lumber	15262.63	4745.486	8
woodpdts	16713.17	4265.685	6
supa			
trees	2402.813	481.6606	16
roundwoo	12207.92	7167.46	13
lumber	7466.75	2125.573	8
woodpdts	11047.43	2827.26	7
aprov			
trees	1181.933	262.6958	15
roundwoo	7667.231	5527.915	13
lumber	4195.25	1062.003	8
woodpdts	6137.714	1713.634	7
baja			
trees	288.1875	73.81916	16
roundwoo	1587.75	723.5211	12
lumber	2148	1047.229	8
woodpdts	1458.286	661.753	7
pttn			
trees	626.8	314.3494	15
roundwoo	3671.769	2102.761	13
lumber	1247.125	649.5217	8
woodpdts	3073.714	1878.61	7
ref			
trees	1.875	1.83645	16
roundwoo	17.84615	6.571206	13
lumber	18.375	5.78875	8
woodpdts	92.57143	54.92011	7
regn			
trees	261	249.0021	16
roundwoo	208.6923	134.8111	13
lumber	581.75	529.7862	8
woodpdts	270.7143	196.9431	7
turis			
trees	0	0	16
roundwoo	7.923077	7.460631	13
lumber	4.875	4.612865	8
woodpdts	16.14286	13.76468	7
fmq			
trees	-.4407538	.272073	15
roundwoo	.2093738	.2791707	10
lumber	.2066617	.3813752	6
woodpdts	.5951408	.0277982	7
silvavg2			
trees	44.42483	5.630495	15
roundwoo	49.925	4.455858	10
lumber	48.95	5.052599	6
woodpdts	60.30464	5.982587	7
aut1			
trees	73.0625	7.679407	16
roundwoo	78	7.091142	11
lumber	79.57143	10.43327	7
woodpdts	88.42857	5.835163	7
aut5			
trees	(stratum with 1 PSU detected)		
roundwoo	(stratum with 1 PSU detected)		
lumber	(stratum with 1 PSU detected)		
woodpdts	(stratum with 1 PSU detected)		
aut6			
trees	(no observations)		
roundwoo	(no observations)		
lumber	(no observations)		
woodpdts	(no observations)		
aut9			
trees	(no observations)		
roundwoo	49	0	1
lumber	37	0	1
woodpdts	(no observations)		
mes			
trees	6.4	.6999187	15
roundwoo	9.25	.7169195	12
lumber	9.375	.8186912	8
woodpdts	11.57143	.4015897	7
genaut			
trees	.5	.1264451	16
roundwoo	.3846154	.136492	13
lumber	.625	.1731421	8
woodpdts	.4285714	.1892063	7
whyno_1			
trees	.1111111	.1070096	9
roundwoo	.7142857	.1744193	7
lumber	.5	.255377	4
woodpdts	.25	.2211629	4
whyno_2			
trees	.1111111	.1070096	9
roundwoo	0	0	7
lumber	0	0	4
woodpdts	0	0	4
whyno_3			
trees	0	0	9
roundwoo	0	0	7
lumber	0	0	4
woodpdts	.75	.2211629	4
whyno_4			
trees	.4444444	.1691971	9
roundwoo	.4285714	.1910668	7
lumber	.25	.2211629	4
woodpdts	0	0	4
whyno_5			
trees	.6666667	.1605145	9
roundwoo	0	0	7
lumber	0	0	4
woodpdts	0	0	4
whyno_6			

```
         trees |   .1111111    .1070096           9
      roundwoo |          0           0           7
        lumber |          0           0           4
      woodpdts |          0           0           4
---------------+-----------------------------------
whyno_7        |
         trees |   .2222222    .1415605           9
      roundwoo |          0           0           7
        lumber |          0           0           4
      woodpdts |          0           0           4
---------------+-----------------------------------
whyno_8        |
         trees |          0           0           9
      roundwoo |          0           0           7
        lumber |          0           0           4
      woodpdts |         .5     .255377           4
---------------+-----------------------------------
whyno_9        |
         trees |          0           0           9
      roundwoo |   .1428571    .1351046           7
        lumber |          0           0           4
      woodpdts |         .5     .255377           4
---------------+-----------------------------------
whyno_10       |
         trees |          0           0           9
      roundwoo |   .1428571    .1351046           7
        lumber |        .25    .2211629           4
      woodpdts |          0           0           4
---------------+-----------------------------------
whyno_11       |
         trees |          0           0           9
      roundwoo |   .1428571    .1351046           7
        lumber |          0           0           4
      woodpdts |          0           0           4
---------------+-----------------------------------
whyno_12       |
         trees |   .1111111    .1070096           9
      roundwoo |          0           0           7
        lumber |          0           0           4
      woodpdts |          0           0           4
---------------+-----------------------------------
whyno_o        |
         trees |   .2222222    .1415605           9
      roundwoo |   .1428571    .1351046           7
        lumber |         .5     .255377           4
      woodpdts |        .25    .2211629           4
---------------+-----------------------------------
doax           |
         trees |    7.59375    1.026485          16
      roundwoo |   4.788462    .8707717          13
        lumber |     3.7075    .6805891           8
      woodpdts |   2.951429    .6691095           7
---------------+-----------------------------------
dcity          |
         trees |   3.609375    .3719996          16
      roundwoo |   4.192308     .668323          13
        lumber |       4.25    .6064096           8
      woodpdts |   5.738571    .5154018           7
---------------+-----------------------------------
breco          |
         trees |      8.625    6.401968          16
      roundwoo |   27.84615    10.15912          13
        lumber |      60.75    11.74613           8
      woodpdts |   60.28571    8.996093           7
---------------+-----------------------------------
breg           |
         trees |          0           0          16
      roundwoo |   2.923077     2.84087          13
        lumber |          0           0           8
      woodpdts |          0           0           7
---------------+-----------------------------------
brepu          |
         trees |     5.8125    3.932239          16
      roundwoo |   27.84615    7.969483          13
        lumber |      26.75    9.143916           8
      woodpdts |   37.14286    9.580021           7
---------------+-----------------------------------
brepriv        |
         trees |     82.375     8.57447          16
      roundwoo |   40.53846    12.01269          13
        lumber |      11.25    10.64507           8
      woodpdts |   2.571429    2.408203           7
---------------+-----------------------------------
breot          |
         trees |     2.9375    2.877104          16
      roundwoo |   .8461538    .7451011          13
        lumber |       1.25    1.182786           8
      woodpdts |          0           0           7
---------------+-----------------------------------
hrr1           |
         trees |   8.863636    2.399761          11
      roundwoo |     6.1875    .5843884          12
        lumber |          7    1.285151           5
      woodpdts |        8.5    1.107161           4
---------------+-----------------------------------
hrr2           |
         trees | (no observations)
      roundwoo |          5    1.145644           2
        lumber |       10.5           0           1
      woodpdts |       8.75    1.037073           4
---------------+-----------------------------------
hrr3           |
         trees |          6     3.72678           2
      roundwoo |       14.5    7.969386           5
        lumber |          5           0           1
      woodpdts |          8           0           2
---------------+-----------------------------------
hrr5           |
         trees |   12.66667    5.364492           3
      roundwoo | (no observations)
        lumber | (no observations)
      woodpdts | (no observations)
---------------+-----------------------------------
hrrn           |
         trees | (no observations)
      roundwoo | (no observations)
        lumber | (no observations)
      woodpdts | (no observations)
---------------+-----------------------------------
hrr            |
         trees |   8.863636    2.395472          11
      roundwoo |   9.480769    3.180033          13
        lumber |   6.666667    1.112697           6
      woodpdts |   8.833333    .9685532           6
---------------+-----------------------------------
ubide1_1       |
         trees |          0           0           1
      roundwoo |   .0833333    .0815788          12
        lumber |          0           0           6
      woodpdts |          0           0           4
---------------+-----------------------------------
ubide1_2       |
         trees |          1           0           1
      roundwoo |   .1666667    .1100008          12
        lumber |   .1666667    .1555646           6
      woodpdts |          0           0           4
---------------+-----------------------------------
ubide1_3       |
         trees |          0           0           1
      roundwoo |        .75    .1278093          12
        lumber |   .8333333    .1555646           6
      woodpdts |          1           0           4
---------------+-----------------------------------
tranp1         |
         trees |          2           0           1
      roundwoo |   1.916667    .6428225          12
        lumber |   1.166667    .1555646           6
      woodpdts |          1           0           4
---------------+-----------------------------------
volclr         |
         trees |     1755.5    531.7182           6
      roundwoo |       3578    544.0918          11
        lumber |     1348.5    522.8856           4
      woodpdts |     4864.6    2013.015           5
---------------+-----------------------------------
volcap         |
         trees |   4071.538    909.7599          13
      roundwoo | (no observations)
        lumber | (no observations)
      woodpdts | (no observations)
---------------+-----------------------------------
voltot         |
         trees |   2817.475    701.4655          16
      roundwoo |   4848.923    730.6387          13
        lumber |   4521.143     1612.12           7
      woodpdts |   15888.71    6339.377           7
---------------+-----------------------------------
volasc         |
         trees | (no observations)
      roundwoo | (no observations)
```

	lumber	1815.625	427.2733	8
	woodpdts	8575.857	3449.772	7
volpt				
	trees	(no observations)		
	roundwoo	(no observations)		
	lumber	282034.5	148442.5	4
	woodpdts	1563432	600745.4	6
volrollo				
	trees	4260.8	1951.199	5
	roundwoo	4848.923	733.2888	13
	lumber	2577.875	1192.635	8
	woodpdts	7312.857	3665.617	7
vol5				
	trees	4203.5	776.0619	16
	roundwoo	6342.385	1069.234	13
	lumber	7118.625	2230.318	8
	woodpdts	15635.57	5009.58	7
qas				
	trees	(no observations)		
	roundwoo	(no observations)		
	lumber	1	0	8
	woodpdts	1.285714	.1767399	7
prol1				
	trees	60	14.57738	2
	roundwoo	419.2857	44.21818	7
	lumber	497.5	27.11917	4
	woodpdts	522.5	11.73852	4
prol2				
	trees	44	12.09486	2
	roundwoo	250	22.67787	2
	lumber	300	0	1
	woodpdts	293.3333	5.819144	3
prolpro				
	trees	90	30	2
	roundwoo	254.8	61.85779	5
	lumber	320.5	209.625	2
	woodpdts	(no observations)		
pap11				
	trees	176.5	21.08251	10
	roundwoo	(no observations)		
	lumber	(no observations)		
	woodpdts	(no observations)		
pap12				
	trees	98.57143	23.31754	7
	roundwoo	(no observations)		
	lumber	(no observations)		
	woodpdts	(no observations)		
pap51				
	trees	230	20	3
	roundwoo	(no observations)		
	lumber	(no observations)		
	woodpdts	(no observations)		
pap52				
	trees	186.6667	12.0185	3
	roundwoo	(no observations)		
	lumber	(no observations)		
	woodpdts	(no observations)		
pt1				
	trees	(no observations)		
	roundwoo	(no observations)		
	lumber	4.56	.4194542	5
	woodpdts	4.842857	.2930415	7
pt3				
	trees	(no observations)		
	roundwoo	(no observations)		
	lumber	3.24	.1586442	5
	woodpdts	3.425	.2690325	6
pt4				
	trees	(no observations)		
	roundwoo	(no observations)		
	lumber	2.46	.1604369	5
	woodpdts	3.0375	.2337178	4
pto				
	trees	(no observations)		
	roundwoo	(no observations)		
	lumber	2.05	1.169134	2
	woodpdts	2.6	0	1
labor				
	trees	30.8125	3.792531	16
	roundwoo	74.38462	19.09927	13
	lumber	73.125	18.52103	8
	woodpdts	111.1429	26.30093	7
las				
	trees	(no observations)		
	roundwoo	(no observations)		
	lumber	17.875	3.145136	8
	woodpdts	27.85714	5.077082	7
lasaf				
	trees	(no observations)		
	roundwoo	(no observations)		
	lumber	.625	.1771708	8
	woodpdts	.2857143	.1767399	7
lasafn				
	trees	(no observations)		
	roundwoo	(no observations)		
	lumber	1.8	.3614784	5
	woodpdts	17	6.110101	2
log				
	trees	5.8125	1.008469	16
	roundwoo	22.76923	7.521809	13
	lumber	16.625	6.604111	8
	woodpdts	18.14286	5.542163	7
logaf				
	trees	.2666667	.1155311	15
	roundwoo	0	0	13
	lumber	0	0	8
	woodpdts	.1428571	.1338253	7
logafn				
	trees	3.5	.8385255	4
	roundwoo	(no observations)		
	lumber	(no observations)		
	woodpdts	2	0	1
chof				
	trees	9.6875	1.108538	16
	roundwoo	10.30769	1.75513	13
	lumber	13.25	3.38226	8
	woodpdts	14	7.029128	7
choaf				
	trees	1	0	15
	roundwoo	.7692308	.1182375	13
	lumber	.5	.1788688	8
	woodpdts	.2857143	.1727677	7
choafn				
	trees	9.733333	1.031032	15
	roundwoo	7.222222	1.793471	9
	lumber	6.333333	1.542176	3
	woodpdts	3	.7196229	2
lotr				
	trees	5.625	3.477672	16
	roundwoo	.1538462	.1012251	13
	lumber	2	1.057916	8
	woodpdts	1.857143	.8027345	7
lotrso				
	trees	.75	.7219001	8
	roundwoo	0	0	2
	lumber	.3333333	.280056	3
	woodpdts	.6	.3681432	5
ltrac				
	trees	.8	.1706992	15
	roundwoo	1.076923	.3007589	13
	lumber	.625	.3066526	8
	woodpdts	1.666667	.3895658	6

ltraso			
trees	1.1	.0967471	10
roundwoo	1.125	.4203793	8
lumber	1	.4807402	3
woodpdts	.8	.3412917	5
lsec			
trees	0	0	16
roundwoo	.0769231	.07478	13
lumber	.4285714	.1892575	7
woodpdts	4.857143	2.068889	7
lsecso			
trees	(no observations)		
roundwoo	0	0	1
lumber	.25	.2296397	4
woodpdts	0	0	4
lgru			
trees	1.6875	.2318189	16
roundwoo	2	.5719566	13
lumber	1.375	.3974552	8
woodpdts	3.5	.7054681	6
lgruso			
trees	1.571429	.1975237	14
roundwoo	2.333333	.7810389	9
lumber	.1666667	.1543664	6
woodpdts	.3333333	.3087327	6
labor			
trees	30.8125	3.792531	16
roundwoo	74.38462	19.09927	13
lumber	73.125	18.52103	8
woodpdts	111.1429	26.30093	7
trac			
trees	.75	.1896677	16
roundwoo	.7692308	.2943293	13
lumber	.625	.3064828	8
woodpdts	1.285714	.3366951	7
ltrac			
trees	.8	.1706992	15
roundwoo	1.076923	.3007589	13
lumber	.625	.3066526	8
woodpdts	1.666667	.3895658	6
ltracp			
trees	4	0	10
roundwoo	1.5	.3605551	8
lumber	1	0	3
woodpdts	1	0	5
stftec			
trees	1.375	.2663614	16
roundwoo	1.076923	.3005924	13
lumber	.625	.2489075	8
woodpdts	3.142857	1.479766	7
stfot			
trees	32	24.76379	16
roundwoo	1.272727	.4136044	11
lumber	4.5	1.485926	6
woodpdts	8.142857	3.09912	7
stfiva			
trees	10.25	2.026388	4
roundwoo	10.5	2.711088	2
lumber	(no observations)		
woodpdts	(no observations)		
stfsin			
trees	11.125	.7936744	8
roundwoo	10.125	.9429625	8
lumber	12.9125	2.140765	8
woodpdts	17.75	2.933286	4
log			
trees	5.8125	1.008469	16
roundwoo	22.76923	7.521809	13
lumber	16.625	6.604111	8
woodpdts	18.14286	5.542163	7
loga			
trees	1.090909	.2055759	11
roundwoo	1.55	.5345418	6
lumber	1.6	.3651484	5
woodpdts	1.5	.4166667	3
logsa			
trees	14.26667	2.361841	15
roundwoo	17	3.752473	10
lumber	25.64286	6.605783	7
woodpdts	25.35714	6.419247	7
logsab			
trees	10.66667	7.360757	15
roundwoo	4.545455	4.38776	11
lumber	5	4.735174	8
woodpdts	6.428571	6.025638	7
logasa			
trees	7.4	5.450578	5
roundwoo	21.5	15.94483	2
lumber	3.75	2.781074	2
woodpdts	5.25	3.893504	2
logasab			
trees	31.42857	9.648452	7
roundwoo	13.33333	11.29758	3
lumber	13.33333	11.29758	3
woodpdts	35	0	1
chof			
trees	9.6875	1.108538	16
roundwoo	10.30769	1.75513	13
lumber	13.25	3.38226	8
woodpdts	14	7.029128	7
chofa			
trees	.0769231	.0750879	13
roundwoo	0	0	8
lumber	0	0	6
woodpdts	.2	.1817478	5
chofasa			
trees	25	0	1
roundwoo	(no observations)		
lumber	(no observations)		
woodpdts	25	0	1
chofsa			
trees	125.875	22.02058	8
roundwoo	109.3333	20.30611	9
lumber	78.54286	21.05738	7
woodpdts	60.71429	19.52174	7
chofsab			
trees	(no observations)		
roundwoo	800	0	1
lumber	(no observations)		
woodpdts	45	0	1
choft			
trees	0	0	1
roundwoo	0	0	1
lumber	5.285714	2.466333	7
woodpdts	2.571429	1.600777	7
choftsa			
trees	(stratum with 1 PSU detected)		
roundwoo	(stratum with 1 PSU detected)		
lumber	(stratum with 1 PSU detected)		
woodpdts	(stratum with 1 PSU detected)		
las			
trees	(no observations)		
roundwoo	(no observations)		
lumber	17.875	3.145136	8
woodpdts	27.85714	5.077082	7
lasm			
trees	(no observations)		
roundwoo	(no observations)		
lumber	1.375	.3136141	8
woodpdts	.2857143	.1767399	7
lasmsa			

trees	(no observations)		
roundwoo	(no observations)		
lumber	121.9943	21.93926	7
woodpdts	102	36	2
laspay			
trees	(no observations)		
roundwoo	(no observations)		
lumber	2	.9682458	8
woodpdts	1	0	7
lassa			
trees	(no observations)		
roundwoo	(no observations)		
lumber	.00025	.0002427	8
woodpdts	.15	.1420996	6
lassab			
trees	(no observations)		
roundwoo	(no observations)		
lumber	59.96375	17.63982	8
woodpdts	32.16667	7.195628	6
lgru			
trees	1.6875	.2318189	16
roundwoo	2	.5719566	13
lumber	1.375	.3974552	8
woodpdts	3.5	.7054681	6
lgrup			
trees	4	0	14
roundwoo	2.181818	.428539	11
lumber	1	0	7
woodpdts	1	0	6
lsec			
trees	0	0	16
roundwoo	.0769231	.07478	13
lumber	.4285714	.1892575	7
woodpdts	4.857143	2.068889	7
lotr			
trees	5.625	3.477672	16
roundwoo	.1538462	.1012251	13
lumber	2	1.057916	8
woodpdts	1.857143	.8027345	7
lotrp			
trees	4	0	8
roundwoo	1	0	2
lumber	1	0	4
woodpdts	1	0	5
lsecp			
trees	(no observations)		
roundwoo	1	0	1
lumber	3	1.837117	4
woodpdts	1	0	4
lsecsam			
trees	(no observations)		
roundwoo	800	0	1
lumber	1286.75	447.2028	4
woodpdts	2375	455.2429	4
cbcd			
trees	259.5625	30.23104	16
roundwoo	251.4167	24.59027	12
lumber	269.7143	27.72542	7
woodpdts	341.4286	22.08743	7
cbcp			
trees	8.666667	4.561784	15
roundwoo	19.53846	6.117347	13
lumber	42.375	6.639714	8
woodpdts	61.71429	16.5401	7
jvd			
trees	234.8667	35.49052	15
roundwoo	269.8333	24.21027	12
lumber	283.6667	28.54163	6
woodpdts	341.4286	22.10091	7
jvp			
trees	12.86667	4.868357	15
roundwoo	19.53846	6.119082	13
lumber	39.85714	7.084641	7
woodpdts	61.71429	16.54479	7
jmd			
trees	142.1538	25.8626	13
roundwoo	216.8	17.44622	10
lumber	234.4286	30.11618	7
woodpdts	288.3333	32.76903	6
jmp			
trees	44.41667	6.954158	12
roundwoo	43.23	2.15602	10
lumber	51.57143	5.702193	7
woodpdts	79.16667	12.67554	6
jid			
trees	(no observations)		
roundwoo	(no observations)		
lumber	223.8571	34.41341	7
woodpdts	273.2857	32.17173	7
jip			
trees	0	0	1
roundwoo	25	0	1
lumber	52.625	5.169762	8
woodpdts	70.71429	12.02571	7
jsd			
trees	(no observations)		
roundwoo	227.5	41.47151	4
lumber	268.3333	42.37876	3
woodpdts	332	30.82856	5
jsp			
trees	(no observations)		
roundwoo	37.2	8.67449	5
lumber	44.75	4.573387	4
woodpdts	97	25.57162	5
docd			
trees	140.5	22.88562	16
roundwoo	200	24.11757	10
lumber	207.5	36.52299	6
woodpdts	278.25	44.09574	4
docp			
trees	45.625	5.785643	16
roundwoo	35.39091	5.460724	11
lumber	51.28571	5.624698	7
woodpdts	73.75	14.3739	4
otd			
trees	129.3333	28.4184	12
roundwoo	201	29.60025	8
lumber	205.6667	37.4984	6
woodpdts	336.25	25.32387	4
otp			
trees	42.57273	7.104702	11
roundwoo	38.625	5.351817	8
lumber	53.16667	6.257073	6
woodpdts	143.325	70.07492	4
vigano			
trees	17.125	4.457172	16
roundwoo	19.95455	4.805629	11
lumber	22.28571	5.013175	7
woodpdts	25.57143	5.906425	7
vigq			
trees	6.4375	.9814738	16
roundwoo	9.555556	1.918989	9
lumber	4	.9385906	7
woodpdts	3.6	.5440588	5
vigrev			
trees	12.35438	3.091615	16
roundwoo	8.227273	3.182563	11
lumber	4	1.002039	7
woodpdts	14	5.314113	7
vigrtot			
trees	.62	.2134955	13
roundwoo	1.013333	.2143431	6

lumber	1.4	.2234278	5
woodpdts	.29	.1514332	2
grnum			
trees	1.75	.2096855	16
roundwoo	1.538462	.3036754	13
lumber	1.5	.3998546	8
woodpdts	2.857143	.7204763	7
gr1			
trees	94	0	2
roundwoo	94.5	1.270858	6
lumber	91.28571	1.443267	7
woodpdts	85.85714	1.698012	7
gr2			
trees	(no observations)		
roundwoo	93	0	1
lumber	89.66667	2.775555	3
woodpdts	84	1.253566	4
gr3			
trees	(no observations)		
roundwoo	(no observations)		
lumber	(no observations)		
woodpdts	91.25	3.614208	4
camnu			
trees	9.6875	1.328332	16
roundwoo	10.76923	1.851719	13
lumber	12.625	3.383146	8
woodpdts	13.71429	6.207871	7
cam1			
trees	92.66667	1.112077	3
roundwoo	90.57143	.7682375	7
lumber	89.42857	1.749418	7
woodpdts	80	2.822146	7
cam2			
trees	94	0	1
roundwoo	92	1.309307	5
lumber	88.5	.5786376	4
woodpdts	84.8	1.221241	5
cam3			
trees	(no observations)		
roundwoo	94	.7637626	2
lumber	94.5	2.673169	2
woodpdts	92.66667	2.612884	3
siernu			
trees	5.8125	.9924886	16
roundwoo	22.92308	7.48979	13
lumber	15.5	6.435051	8
woodpdts	19.42857	6.194882	7
sie1			
trees	92	2.0367	3
roundwoo	97	0	2
lumber	(no observations)		
woodpdts	90.5	4.200694	2
sie2			
trees	96	.8164966	2
roundwoo	(no observations)		
lumber	(no observations)		
woodpdts	97.5	.4082483	2
cmpaa			
trees	(no observations)		
roundwoo	95	0	1
lumber	97	.7559289	2
woodpdts	91.4	1.405296	5
ctsaa			
trees	90.08333	1.98217	12
roundwoo	92.71429	.6065889	7
lumber	86.71429	2.420133	7
woodpdts	88.5	1.165229	4
rot			
trees	.25	.1095654	16
roundwoo	.3636364	.1467989	11
lumber	.625	.1732381	8
woodpdts	.1428571	.1338632	7
consegno			
trees	0	0	12
roundwoo	.2222222	.1405457	9
lumber	.125	.1185854	8
woodpdts	.1428571	.1341361	7
conseg_1			
trees	.0833333	.0809174	12
roundwoo	0	0	9
lumber	.125	.1185854	8
woodpdts	.1428571	.1341361	7
conseg_2			
trees	.8333333	.1091089	12
roundwoo	.5555556	.1679842	9
lumber	.25	.1552648	8
woodpdts	.1428571	.1341361	7
conseg_3			
trees	.0833333	.0809174	12
roundwoo	0	0	9
lumber	0	0	8
woodpdts	0	0	7
conseg_4			
trees	0	0	12
roundwoo	.1111111	.1062425	9
lumber	.25	.1552648	8
woodpdts	.2857143	.173169	7
crfue			
trees	(no observations)		
roundwoo	(no observations)		
lumber	1.5	.5	2
woodpdts	(no observations)		
crq			
trees	(no observations)		
roundwoo	(no observations)		
lumber	1.5	.5	2
woodpdts	(no observations)		
crultno			
trees	1	0	16
roundwoo	.9230769	.07478	13
lumber	.8571429	.1338253	7
woodpdts	.2857143	.1727677	7
crult_1			
trees	0	0	16
roundwoo	0	0	13
lumber	.1428571	.1338253	7
woodpdts	0	0	7
crult_2			
trees	0	0	16
roundwoo	0	0	13
lumber	0	0	7
woodpdts	.1428571	.1338253	7
crult_3			
trees	0	0	16
roundwoo	.0769231	.07478	13
lumber	0	0	7
woodpdts	.1428571	.1338253	7
crult_4			
trees	0	0	16
roundwoo	0	0	13
lumber	0	0	7
woodpdts	.4285714	.1892575	7
crult_5			
trees	0	0	16
roundwoo	0	0	13
lumber	0	0	7
woodpdts	.1428571	.1338253	7
teq			
trees	.9375	.061215	16
roundwoo	1	0	13
lumber	1	0	8
woodpdts	1	0	7

```
---------------+----------------------------------
teqnu          |
         trees |  1.642857    .2421696          14
      roundwoo |      1.75    .2109214          12
        lumber |      1.25     .154995           8
      woodpdts |  1.285714    .2678061           7
---------------+----------------------------------
reinno         |
         trees |      .625    .1224631          16
      roundwoo |  .1666667    .1088561          12
        lumber |      .125    .1183106           8
      woodpdts |         0           0           7
---------------+----------------------------------
rein_1         |
         trees |     .0625    .0612315          16
      roundwoo |       .25    .1264793          12
        lumber |      .125    .1183106           8
      woodpdts |  .2857143    .1727677           7
---------------+----------------------------------
rein_2         |
         trees |     .0625    .0612315          16
      roundwoo |  .3333333    .1376933          12
        lumber |      .625     .173189           8
      woodpdts |  .8571429    .1338253           7
---------------+----------------------------------
ssoc           |
         trees |      .875    .0837068          16
      roundwoo |  .8181818     .117736          11
        lumber |      .875    .1183794           8
      woodpdts |         1           0           6
---------------+----------------------------------
ssocq          |
         trees |  2.769231    .2252636          13
      roundwoo |  2.285714    .5701104           7
        lumber |       2.5    .6666667           6
      woodpdts |  3.333333    .5700615           6
---------------+----------------------------------
indiv          |
         trees |     .3125    .1173929          16
      roundwoo |  .0833333    .0808286          12
        lumber |        .2    .1812239           5
      woodpdts |  .8333333    .1541341           6
---------------+----------------------------------
profit         |
         trees |  311386.1      120716          12
      roundwoo |  870498.4    209733.2           8
        lumber |   1557401    591307.3           5
      woodpdts |   3056819    856289.7           5
---------------+----------------------------------
ytot           |
         trees |  573548.5      134049          13
      roundwoo |   1688274    338247.7           9
        lumber |   3020021     1074961           5
      woodpdts |   9578861     3232269           5
---------------+----------------------------------
csal           |
         trees |    1410.4    888.9354          10
      roundwoo |  406718.8    109118.3           8
        lumber |  306387.5    166569.9           2
      woodpdts |    774227    319409.5           3
---------------+----------------------------------
cotr           |
         trees |  272627.4    78404.63          10
      roundwoo |  636218.9    147266.1           7
        lumber |   1097000    704205.7           2
      woodpdts |   2262510    935855.3           3
---------------+----------------------------------
ctot           |
         trees |  304124.8    76823.17          12
      roundwoo |   1010740    200714.4           8
        lumber |   1462620    512898.2           5
      woodpdts |   6522042     2412170           5
---------------+----------------------------------
yrol           |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |   1428228    729096.5           3
      woodpdts |   3625000     1365259           4
---------------+----------------------------------
crsal          |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |    166366           0           1
      woodpdts |   1470000    688490.2           2
---------------+----------------------------------
```

```
crotr          |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |     78993           0           1
      woodpdts |   1207000    71014.08           2
---------------+----------------------------------
crtot          |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |  841800.5    462024.8           2
      woodpdts |   2337505    731370.1           4
---------------+----------------------------------
yot            |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |    104500           0           1
      woodpdts |  985237.5    680584.8           4
---------------+----------------------------------
cotsal         |
         trees | (no observations)
      roundwoo | (no observations)
        lumber | (no observations)
      woodpdts | (no observations)
---------------+----------------------------------
cottot         |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |   1244962    187395.4           2
      woodpdts |   1401549    771804.8           3
---------------+----------------------------------
yas            |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |   1295307    625265.6           3
      woodpdts |   5380671     2363848           5
---------------+----------------------------------
casal          |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |     72010           0           1
      woodpdts |    243000    140296.1           2
---------------+----------------------------------
caotr          |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |     44520           0           1
      woodpdts |     81000           0           1
---------------+----------------------------------
catot          |
         trees | (no observations)
      roundwoo | (no observations)
        lumber |    777401    511908.5           2
      woodpdts |  575385.5    213778.6           4
---------------+----------------------------------
profit         |
         trees |  311386.1      120716          12
      roundwoo |  870498.4    209733.2           8
        lumber |   1557401    591307.3           5
      woodpdts |   3056819    856289.7           5
---------------+----------------------------------
salary         |
         trees |    .10118    .0969783          10
      roundwoo |  .4357297     .056627           7
        lumber |  .2929577    .0629966           2
      woodpdts |  .2821796    .0454569           3
---------------+----------------------------------
juntosno       |
         trees |        .6    .1279881          15
      roundwoo |  .7692308    .1182375          13
        lumber |        .5    .1788688           8
      woodpdts |  .4285714    .1892575           7
---------------+----------------------------------
juntos_3       |
         trees |         0           0          15
      roundwoo |  .0769231      .07478          13
        lumber |         0           0           8
      woodpdts |         0           0           7
---------------+----------------------------------
juntos_6       |
         trees |  .0666667    .0651683          15
      roundwoo |         0           0          13
        lumber |      .375     .173189           8
      woodpdts |  .5714286    .1892575           7
---------------+----------------------------------
juntos_7       |
```

trees	.3333333	.1231566	15
roundwoo	.0769231	.07478	13
lumber	0	0	8
woodpdts	0	0	7
juntos_8			
trees	.0666667	.0651683	15
roundwoo	0	0	13
lumber	0	0	8
woodpdts	0	0	7
juntos_o			
trees	.0666667	.0651683	15
roundwoo	.0769231	.07478	13
lumber	.25	.1549049	8
woodpdts	0	0	7
acuer_1			
trees	.8333333	.1571348	6
roundwoo	0	0	2
lumber	.25	.2236068	4
woodpdts	.25	.2236068	4
acuer_2			
trees	.3333333	.1987616	6
roundwoo	0	0	2
lumber	0	0	4
woodpdts	.25	.2236068	4
acuer_3			
trees	.3333333	.1987616	6
roundwoo	0	0	2
lumber	.25	.2236068	4
woodpdts	.25	.2236068	4
acuer_o			
trees	.3333333	.1987616	6
roundwoo	1	0	2
lumber	1	0	4
woodpdts	.75	.2236068	4
mad1			
trees	0	0	16
roundwoo	.2307692	.2242792	13
lumber	1.375	.8929838	8
woodpdts	.2857143	.2675782	7
mad2			
trees	0	0	16
roundwoo	.3076923	.2990389	13
lumber	.5	.4731144	8
woodpdts	0	0	7
mad3			
trees	0	0	16
roundwoo	0	0	13
lumber	0	0	8
woodpdts	2.428571	.7607569	7
mad4			
trees	0	0	16
roundwoo	0	0	13
lumber	0	0	8
woodpdts	1.142857	.4300717	7
mad5			
trees	0	0	16
roundwoo	0	0	13
lumber	0	0	8
woodpdts	.5714286	.4013672	7
mad6			
trees	0	0	16
roundwoo	0	0	13
lumber	1	.6194521	8
woodpdts	.5714286	.5351563	7
mad7			
trees	.4375	.4285049	16
roundwoo	0	0	13
lumber	0	0	8
woodpdts	.4285714	.4013672	7
mad9			
trees	0	0	16

roundwoo	.6923077	.4844984	13
lumber	1.875	.8839862	8
woodpdts	1.857143	.6908839	7
teqdi			
trees	3.071429	.5827091	14
roundwoo	3.416667	1.231078	12
lumber	1.875	.4173367	8
woodpdts	2.857143	1.010946	7
repq			
trees	2548.438	1517.655	16
roundwoo	312.9231	140.0602	13
lumber	875	453.7073	8
woodpdts	964.2857	651.1489	7
ytot			
trees	573548.5	134049	13
roundwoo	1688274	338247.7	9
lumber	3020021	1074961	5
woodpdts	9578861	3232269	5
csal			
trees	1410.4	888.9354	10
roundwoo	406718.8	109118.3	8
lumber	306387.5	166569.9	2
woodpdts	774227	319409.5	3
cotr			
trees	272627.4	78404.63	10
roundwoo	636218.9	147266.1	7
lumber	1097000	704205.7	2
woodpdts	2262510	935855.3	3
ctot			
trees	304124.8	76823.17	12
roundwoo	1010740	200714.4	8
lumber	1462620	512898.2	5
woodpdts	6522042	2412170	5
yrol			
trees	(no observations)		
roundwoo	(no observations)		
lumber	1428228	729096.5	3
woodpdts	3625000	1365259	4
yas			
trees	(no observations)		
roundwoo	(no observations)		
lumber	1295307	625265.6	3
woodpdts	5380671	2363848	5
caotr			
trees	(no observations)		
roundwoo	(no observations)		
lumber	44520	0	1
woodpdts	81000	0	1
casal			
trees	(no observations)		
roundwoo	(no observations)		
lumber	72010	0	1
woodpdts	243000	140296.1	2
catot			
trees	(no observations)		
roundwoo	(no observations)		
lumber	777401	511908.5	2
woodpdts	575385.5	213778.6	4
regis			
trees	292.5	68.10365	16
roundwoo	721	222.3041	13
lumber	404.25	93.06925	8
woodpdts	517	217.776	7
aqui			
trees	240.875	56.22849	16
roundwoo	557.4167	238.9711	12
lumber	324.25	79.60783	8
woodpdts	360	147.6889	5
muj			
trees	14.92857	3.858533	14
roundwoo	30.66667	15.86234	12

```
      lumber |     33.75    23.19321           8
    woodpdts |  84.42857    46.68802           7
-------------+-----------------------------------
for          |
       trees |   15.8125     5.37594          16
    roundwoo |  18.63846    3.761479          13
      lumber |     18.75    2.980191           8
    woodpdts |  26.28571    4.632014           7
-------------+-----------------------------------
nom          |
       trees |    7.6875    5.864191          16
    roundwoo |  10.23077    7.424586          13
      lumber |      8.25    3.212553           8
    woodpdts |  6.714286    2.245373           7
-------------+-----------------------------------
agri         |
       trees |        23    6.880639          16
    roundwoo |  27.33333    9.277706          12
      lumber |     39.75    13.85136           8
    woodpdts |  25.71429    11.34993           7
-------------+-----------------------------------
gnd          |
       trees |    10.875    4.594243          16
    roundwoo |  6.416667    4.456125          12
      lumber |    19.625    12.68322           8
    woodpdts |  .7142857    .4438482           7
-------------+-----------------------------------
fru          |
       trees |    3.3125    2.129062          16
    roundwoo |      1.85    1.230517          12
      lumber |      7.65    4.301897           8
    woodpdts |  4.857143    2.167529           7
-------------+-----------------------------------
caf          |
       trees |    33.375    9.192131          16
    roundwoo |  19.59167    10.14046          12
      lumber |    2.5125    2.364551           8
    woodpdts |         0           0           7
-------------+-----------------------------------
pes          |
       trees |         0           0          16
    roundwoo |         0           0          12
      lumber |         0           0           8
    woodpdts |  .1428571    .1338253           7
-------------+-----------------------------------
res          |
       trees |         0           0          16
    roundwoo |  .0769231    .0747597          13
      lumber |         0           0           8
    woodpdts |         0           0           7
-------------+-----------------------------------
oax          |
       trees |  .7866667    .3698045          15
    roundwoo |  6.157692    3.215668          13
      lumber |     4.925    2.218584           8
    woodpdts |         9    1.769204           6
-------------+-----------------------------------
tie          |
       trees |       5.8    2.334883          16
    roundwoo |      3.95    1.139324          12
      lumber |       4.5    1.173254           8
    woodpdts |  5.666667     1.36348           6
-------------+-----------------------------------
traf         |
       trees |   22.8125    5.154015          16
    roundwoo |    20.525    4.653117          12
      lumber |    20.875    5.055664           8
    woodpdts |  24.33333    6.341672           6
-------------+-----------------------------------
otfu         |
       trees |   11.5625    6.181669          16
    roundwoo |  7.008333    6.003729          12
      lumber |  3.857143    3.313481           7
    woodpdts |        10    4.878809           6
-------------+-----------------------------------
otheryo      |
       trees |    99.175    14.28088          16
    roundwoo |  79.66667     13.5602          12
      lumber |  94.18571    34.75592           7
    woodpdts |  66.66667    13.43484           6
-------------+-----------------------------------
noncom       |
       trees |     17.25    9.766491          16
    roundwoo |  37.18182    25.49115          11
      lumber |        14     11.6888           8
```

```
    woodpdts |  8.142857    3.660288           7
-------------+-----------------------------------
ncfor        |
       trees |         0           0           9
    roundwoo |  20.16667    15.22053           6
      lumber |  6.666667    5.571406           3
    woodpdts |     16.25    10.45291           4
-------------+-----------------------------------
ncnom        |
       trees |         0           0           9
    roundwoo |         0           0           6
      lumber |         0           0           3
    woodpdts |         5    4.432026           4
-------------+-----------------------------------
ncag         |
       trees |  16.66667    11.37258           9
    roundwoo |  18.33333    15.33719           6
      lumber |  3.333333    2.785703           3
    woodpdts |      12.5    11.08007           4
-------------+-----------------------------------
ncgd         |
       trees |  5.555556    5.373898           9
    roundwoo |         0           0           5
      lumber |         0           0           2
    woodpdts |         0           0           4
-------------+-----------------------------------
nccaf        |
       trees |  16.11111    10.90161           9
    roundwoo |  16.66667    15.57255           6
      lumber |         0           0           3
    woodpdts |         0           0           4
-------------+-----------------------------------
ncfr         |
       trees |         0           0           9
    roundwoo |         0           0           6
      lumber |         0           0           3
    woodpdts |         0           0           4
-------------+-----------------------------------
nccaf        |
       trees |  16.11111    10.90161           9
    roundwoo |  16.66667    15.57255           6
      lumber |         0           0           3
    woodpdts |         0           0           4
-------------+-----------------------------------
ncpes        |
       trees |         0           0           9
    roundwoo |         0           0           6
      lumber |         0           0           3
    woodpdts |         0           0           4
-------------+-----------------------------------
ncres        |
       trees |         0           0           9
    roundwoo |         0           0           6
      lumber |         0           0           3
    woodpdts |         0           0           4
-------------+-----------------------------------
ncoax        |
       trees |         0           0           9
    roundwoo |         0           0           6
      lumber |  16.66667    13.92851           3
    woodpdts |         0           0           4
-------------+-----------------------------------
nctie        |
       trees |  1.111111    1.072218           9
    roundwoo |  7.166667    6.152637           6
      lumber |  13.33333    11.14281           3
    woodpdts |         0           0           4
-------------+-----------------------------------
ncta         |
       trees |  5.555556    5.361088           9
    roundwoo |  3.666667    3.425962           6
      lumber |  7.333333    6.128547           3
    woodpdts |       2.5    2.216013           4
-------------+-----------------------------------
ncot         |
       trees |  77.88889    14.11341           9
    roundwoo |  50.33333    20.75536           6
      lumber |        50     24.1249           3
    woodpdts |     63.75    21.05212           4
-------------+-----------------------------------
emig1        |
       trees |       .25     .109598          16
    roundwoo |  .1666667    .1089194          12
      lumber |  .1428571    .1339031           7
    woodpdts |        .5    .2066599           6
```

avail			
trees	.6875	.1172495	16
roundwoo	.6923077	.1295227	13
lumber	.7142857	.1727677	7
woodpdts	.4285714	.1892575	7
campo1			
trees	.25	.1095343	16
roundwoo	.1538462	.1012525	13
lumber	.2857143	.1727677	7
woodpdts	.5714286	.1892575	7
pobtot			
trees	608.2143	80.98247	14
roundwoo	1196.167	237.5533	12
lumber	613.1429	156.8991	7
woodpdts	1071.833	220.7883	6
pobtmas			
trees	302.3571	38.52281	14
roundwoo	588.4167	117.6902	12
lumber	294	77.19754	7
woodpdts	517.3333	105.7379	6
pobtfem			
trees	305.8571	42.92554	14
roundwoo	607.75	120.0359	12
lumber	319.1429	79.80784	7
woodpdts	554.5	115.584	6
totviv			
trees	107.9286	15.98453	14
roundwoo	231	42.94469	12
lumber	127.7143	30.31331	7
woodpdts	233.8333	54.525	6
ppe			
trees	82.90714	6.641477	14
roundwoo	92.81667	1.592116	12
lumber	95.84286	1.303303	7
woodpdts	94.01667	4.193721	6
ppa			
trees	70.24286	7.308076	14
roundwoo	73.675	9.049855	12
lumber	80.42857	12.44145	7
woodpdts	90.01667	7.25145	6
ppd			
trees	8.521429	6.38882	14
roundwoo	15.1	7.021614	12
lumber	23.22857	9.248385	7
woodpdts	63.88333	12.26918	6
p614nsl			
trees	34.42857	11.55067	14
roundwoo	68.41667	19.88704	12
lumber	25.57143	15.85228	7
woodpdts	18.83333	3.740729	6
p15alf			
trees	237.2857	38.49096	14
roundwoo	535.3333	104.3917	12
lumber	303.1429	68.3166	7
woodpdts	590.6667	145.0219	6
p15a			
trees	83	20.29476	14
roundwoo	159.25	47.72282	12
lumber	67.28571	31.58362	7
woodpdts	54.83333	9.304643	6
pp614			
trees	82.44286	5.825348	14
roundwoo	81.64167	3.263884	12
lumber	78.21429	9.764043	7
woodpdts	92.8	1.554112	6
pp614n			
trees	17.25	5.812102	14
roundwoo	18.15833	3.258245	12
lumber	11.64286	4.021515	7
woodpdts	7.6	1.305252	6
pp15			
trees	76.79286	4.526718	14
roundwoo	77.53333	2.700955	12
lumber	82.97143	3.138871	7
woodpdts	83.83333	5.062528	6
pp15an			
trees	23.14286	4.495403	14
roundwoo	22.30833	2.730118	12
lumber	17	3.151144	7
woodpdts	10.11667	2.324115	6
pp5h			
trees	93.46429	3.939404	14
roundwoo	97.58333	1.017413	12
lumber	97.74286	1.892947	7
woodpdts	96.91667	2.296722	6
pp5ne			
trees	6.292857	3.905279	14
roundwoo	2.341667	1.019976	12
lumber	2.257143	1.892947	7
woodpdts	1.8	1.129625	6
probmeno			
trees	.1111111	.1068311	9
roundwoo	0	0	6
lumber	0	0	5
woodpdts	0	0	6
probme_1			
trees	.1111111	.1068311	9
roundwoo	.1666667	.1551582	6
lumber	.2	.1824281	5
woodpdts	.5	.2081666	6
probme_2			
trees	0	0	9
roundwoo	.3333333	.1962614	6
lumber	0	0	5
woodpdts	0	0	6
probme_3			
trees	0	0	9
roundwoo	0	0	6
lumber	0	0	5
woodpdts	.1666667	.1551582	6
probme_4			
trees	.3333333	.1602467	9
roundwoo	.3333333	.1962614	6
lumber	.8	.1824281	5
woodpdts	.6666667	.1962614	6
probme_5			
trees	.2222222	.1413243	9
roundwoo	0	0	6
lumber	.2	.1824281	5
woodpdts	.1666667	.1551582	6
probme_o			
trees	.4444444	.1689149	9
roundwoo	.5	.2081666	6
lumber	.2	.1824281	5
woodpdts	.3333333	.1962614	6
clcvb			
trees	.125	.0836356	16
roundwoo	.4615385	.1398626	13
lumber	.625	.1731421	8
woodpdts	.5714286	.1892063	7
clcpb			
trees	.4375	.1254534	16
roundwoo	.6923077	.1294876	13
lumber	.75	.154863	8
woodpdts	.5714286	.1892063	7
cldanb			
trees	.1875	.0987062	16
roundwoo	.1538462	.1012251	13
lumber	.5	.1788204	8
woodpdts	.5714286	.1892063	7
clem1b			

trees	.5625	.1254534	16
roundwoo	.3076923	.1294876	13
lumber	.375	.1731421	8
woodpdts	.4285714	.1892063	7
clem2b			
trees	.5625	.1254534	16
roundwoo	.1538462	.1012251	13
lumber	.375	.1731421	8
woodpdts	.2857143	.172721	7
clentb			
trees	.3125	.1172178	16
roundwoo	.1538462	.1012251	13
lumber	.375	.1731421	8
woodpdts	.2857143	.172721	7
clbrb			
trees	.8125	.0987062	16
roundwoo	.5384615	.1398626	13
lumber	.375	.1731421	8
woodpdts	.2857143	.172721	7
clcab			
trees	.4375	.1254534	16
roundwoo	.2307692	.1182055	13
lumber	.375	.1731421	8
woodpdts	.2857143	.172721	7
clantb			
trees	.4375	.1254534	16
roundwoo	.8461538	.1012251	13
lumber	.875	.1182786	8
woodpdts	.8571429	.1337891	7
clconfb			
trees	.5625	.1254534	16
roundwoo	.7692308	.1182055	13
lumber	.75	.154863	8
woodpdts	.8571429	.1337891	7
clfeb			
trees	.1875	.0987062	16
roundwoo	.5384615	.1398626	13
lumber	.875	.1182786	8
woodpdts	1	0	7
clvolb			
trees	.75	.1095047	16
roundwoo	1	0	13
lumber	.875	.1182786	8
woodpdts	1	0	7
cltipb			
trees	1	0	16
roundwoo	1	0	13
lumber	1	0	8
woodpdts	.8571429	.1337891	7
cldimb			
trees	.8125	.0987062	16
roundwoo	.9230769	.0747597	13
lumber	1	0	8
woodpdts	.7142857	.172721	7
clexvb			
trees	.1875	.0987062	16
roundwoo	.0769231	.0747597	13
lumber	.25	.154863	8
woodpdts	.2857143	.172721	7

(*) Some variables contain missing values.

Parcels

Mean	Estimate	Std. Err.	Obs
pwhe	45.2	5.986652	5
pnum	490.6667	217.1492	3
pnumf	268	83.63014	5
pnumfc	58.66667	24.33333	3
phow	4	0	5
ppay	1	0	5
pman	2	.4472136	5
pper	72.5	2.5	2
pfix	(stratum with 1 PSU detected)		
pmin	20.75	11.95094	5
pmax	24.2	10.56598	5
pavg	21.8	11.52996	5
precom	1.6	.244949	5

(*) Some variables contain missing values.

Work Groups

Mean	Estimate	Std. Err.	Obs
gtnum	2.5	.2886751	4
gt1	46	2.309401	4
gt2	69.5	18.76388	4
gt3	10	0	2
g1y	92.5	1.443376	4
gt2y	94.5	.2886751	4
gt3y	95	0	2

(*) Some variables contain missing values.

```
. *TESTING DIFFERENCES IN SURVEY MEANS
.
. svytest [preroad]trees= [preroad]roundwoo

Adjusted Wald test

 ( 1)  [preroad]trees - [preroad]roundwoo = 0.0

       F(  1,    42) =    0.11
            Prob > F =    0.7405

. svytest [preroad]trees= [preroad]lumber

Adjusted Wald test

 ( 1)  [preroad]trees - [preroad]lumber = 0.0

       F(  1,    42) =    5.68
            Prob > F =    0.0218

. svytest [preroad]roundwoo = [preroad]lumber

Adjusted Wald test

 ( 1)  [preroad]roundwoo - [preroad]lumber = 0.0

       F(  1,    42) =    3.01
            Prob > F =    0.0902

. svytest [preroad]roundwoo = [preroad]woodpdts

Adjusted Wald test

 ( 1)  [preroad]roundwoo - [preroad]woodpdts = 0.0

       F(  1,    42) =    2.58
            Prob > F =    0.1154

. svytest [preroad]lumber = [preroad]woodpdts

Adjusted Wald test

 ( 1)  [preroad]lumber - [preroad]woodpdts = 0.0

       F(  1,    42) =    0.10
            Prob > F =    0.7520

. svytest [preroad]trees= [preroad]woodpdts

Adjusted Wald test

 ( 1)  [preroad]trees - [preroad]woodpdts = 0.0

       F(  1,    42) =    4.00
            Prob > F =    0.0520

.
. svytest [preroad]trees= [preroad]roundwoo

Adjusted Wald test

 ( 1)  [preroad]trees - [preroad]roundwoo = 0.0

       F(  1,    42) =    0.11
            Prob > F =    0.7405

. svytest [preroad]trees= [preroad]lumber, accumulate

Adjusted Wald test

 ( 1)  [preroad]trees - [preroad]roundwoo = 0.0
 ( 2)  [preroad]trees - [preroad]lumber = 0.0

       F(  2,    41) =    3.00
            Prob > F =    0.0608

. svytest [preroad]roundwoo = [preroad]lumber, accumulate

Adjusted Wald test

 ( 1)  [preroad]trees - [preroad]roundwoo = 0.0
 ( 2)  [preroad]trees - [preroad]lumber = 0.0
 ( 3)  [preroad]roundwoo - [preroad]lumber = 0.0

       F(  2,    41) =    3.00
            Prob > F =    0.0608

. svytest [preroad]lumber = [preroad]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [preroad]trees - [preroad]roundwoo = 0.0
 ( 2)  [preroad]trees - [preroad]lumber = 0.0
 ( 3)  [preroad]roundwoo - [preroad]lumber = 0.0
 ( 4)  [preroad]lumber - [preroad]woodpdts = 0.0

       F(  3,    40) =    2.63
            Prob > F =    0.0633

.
. svytest [conc]trees= [conc]roundwoo

Adjusted Wald test

 ( 1)  [conc]trees - [conc]roundwoo = 0.0

       F(  1,    42) =    1.67
            Prob > F =    0.2031

. svytest [conc]trees= [conc]lumber

Adjusted Wald test

 ( 1)  [conc]trees - [conc]lumber = 0.0

       F(  1,    42) =   26.79
            Prob > F =    0.0000

. svytest [conc]roundwoo = [conc]lumber

Adjusted Wald test

 ( 1)  [conc]roundwoo - [conc]lumber = 0.0

       F(  1,    42) =    8.90
            Prob > F =    0.0047

. svytest [conc]roundwoo = [conc]woodpdts

Adjusted Wald test

 ( 1)  [conc]roundwoo - [conc]woodpdts = 0.0

       F(  1,    42) =    7.44
            Prob > F =    0.0093

. svytest [conc]lumber = [conc]woodpdts

Adjusted Wald test

 ( 1)  [conc]lumber - [conc]woodpdts = 0.0

       F(  1,    42) =    0.01
            Prob > F =    0.9208

. svytest [conc]trees= [conc]woodpdts

Adjusted Wald test

 ( 1)  [conc]trees - [conc]woodpdts = 0.0

       F(  1,    42) =   21.52
            Prob > F =    0.0000

.
. svytest [conc]trees= [conc]roundwoo

Adjusted Wald test

 ( 1)  [conc]trees - [conc]roundwoo = 0.0

       F(  1,    42) =    1.67
            Prob > F =    0.2031

. svytest [conc]trees= [conc]lumber, accumulate

Adjusted Wald test

 ( 1)  [conc]trees - [conc]roundwoo = 0.0
 ( 2)  [conc]trees - [conc]lumber = 0.0
```

```
      F(  2,    41) =   13.11
           Prob > F =    0.0000

. svytest [conc]roundwoo = [conc]lumber, accumulate

Adjusted Wald test

 ( 1)  [conc]trees - [conc]roundwoo = 0.0
 ( 2)  [conc]trees - [conc]lumber = 0.0
 ( 3)  [conc]roundwoo - [conc]lumber = 0.0

      F(  2,    41) =   13.11
           Prob > F =    0.0000

. svytest [conc]lumber = [conc]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [conc]trees - [conc]roundwoo = 0.0
 ( 2)  [conc]trees - [conc]lumber = 0.0
 ( 3)  [conc]roundwoo - [conc]lumber = 0.0
 ( 4)  [conc]lumber - [conc]woodpdts = 0.0

      F(  3,    40) =   12.05
           Prob > F =    0.0000

.
. svytest [supa]trees= [supa]roundwoo

Adjusted Wald test

 ( 1)  [supa]trees - [supa]roundwoo = 0.0

      F(  1,    42) =    3.77
           Prob > F =    0.0589

. svytest [supa]trees= [supa]lumber

Adjusted Wald test

 ( 1)  [supa]trees - [supa]lumber = 0.0

      F(  1,    42) =    5.40
           Prob > F =    0.0251

. svytest [supa]roundwoo = [supa]lumber

Adjusted Wald test

 ( 1)  [supa]roundwoo - [supa]lumber = 0.0

      F(  1,    42) =    1.08
           Prob > F =    0.3038

. svytest [supa]roundwoo = [supa]woodpdts

Adjusted Wald test

 ( 1)  [supa]roundwoo - [supa]woodpdts = 0.0

      F(  1,    42) =    3.97
           Prob > F =    0.0528

. svytest [supa]lumber = [supa]woodpdts

Adjusted Wald test

 ( 1)  [supa]lumber - [supa]woodpdts = 0.0

      F(  1,    42) =    1.02
           Prob > F =    0.3173

. svytest [supa]trees= [supa]woodpdts

Adjusted Wald test

 ( 1)  [supa]trees - [supa]woodpdts = 0.0

      F(  1,    42) =    9.08
           Prob > F =    0.0044

.
. svytest [supa]trees= [supa]roundwoo

Adjusted Wald test

 ( 1)  [supa]trees - [supa]roundwoo = 0.0

      F(  1,    42) =    3.77
           Prob > F =    0.0589

. svytest [supa]trees= [supa]lumber, accumulate

Adjusted Wald test

 ( 1)  [supa]trees - [supa]roundwoo = 0.0
 ( 2)  [supa]trees - [supa]lumber = 0.0

      F(  2,    41) =    4.14
           Prob > F =    0.0230

. svytest [supa]roundwoo = [supa]lumber, accumulate

Adjusted Wald test

 ( 1)  [supa]trees - [supa]roundwoo = 0.0
 ( 2)  [supa]trees - [supa]lumber = 0.0
 ( 3)  [supa]roundwoo - [supa]lumber = 0.0

      F(  2,    41) =    4.14
           Prob > F =    0.0230

. svytest [supa]lumber = [supa]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [supa]trees - [supa]roundwoo = 0.0
 ( 2)  [supa]trees - [supa]lumber = 0.0
 ( 3)  [supa]roundwoo - [supa]lumber = 0.0
 ( 4)  [supa]lumber - [supa]woodpdts = 0.0

      F(  3,    40) =    5.23
           Prob > F =    0.0038

.
. svytest [old]trees= [old]roundwoo

Adjusted Wald test

 ( 1)  [old]trees - [old]roundwoo = 0.0

      F(  1,    42) =    1.62
           Prob > F =    0.2106

. svytest [old]trees= [old]lumber

Adjusted Wald test

 ( 1)  [old]trees - [old]lumber = 0.0

      F(  1,    42) =    0.00
           Prob > F =    1.0000

. svytest [old]roundwoo = [old]lumber

Adjusted Wald test

 ( 1)  [old]roundwoo - [old]lumber = 0.0

      F(  1,    42) =    1.04
           Prob > F =    0.3143

. svytest [old]roundwoo = [old]woodpdts

Adjusted Wald test

 ( 1)  [old]roundwoo - [old]woodpdts = 0.0

      F(  1,    42) =    7.19
           Prob > F =    0.0104

. svytest [old]lumber = [old]woodpdts

Adjusted Wald test

 ( 1)  [old]lumber - [old]woodpdts = 0.0

      F(  1,    42) =    1.92
           Prob > F =    0.1728
```

```
. svytest [old]trees= [old]woodpdts

Adjusted Wald test

 ( 1)  [old]trees - [old]woodpdts = 0.0

       F(  1,    42) =    2.57
            Prob > F =    0.1166

.
. svytest [old]trees= [old]roundwoo

Adjusted Wald test

 ( 1)  [old]trees - [old]roundwoo = 0.0

       F(  1,    42) =    1.62
            Prob > F =    0.2106

. svytest [old]trees= [old]lumber, accumulate

Adjusted Wald test

 ( 1)  [old]trees - [old]roundwoo = 0.0
 ( 2)  [old]trees - [old]lumber = 0.0

       F(  2,    41) =    0.97
            Prob > F =    0.3877

. svytest [old]roundwoo = [old]lumber, accumulate

Adjusted Wald test

 ( 1)  [old]trees - [old]roundwoo = 0.0
 ( 2)  [old]trees - [old]lumber = 0.0
 ( 3)  [old]roundwoo - [old]lumber = 0.0

       F(  2,    41) =    0.97
            Prob > F =    0.3877

. svytest [old]lumber = [old]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [old]trees - [old]roundwoo = 0.0
 ( 2)  [old]trees - [old]lumber = 0.0
 ( 3)  [old]roundwoo - [old]lumber = 0.0
 ( 4)  [old]lumber - [old]woodpdts = 0.0

       F(  3,    40) =    2.33
            Prob > F =    0.0888

.
. svytest [mech2]trees= [mech2]roundwoo

Adjusted Wald test

 ( 1)  [mech2]trees - [mech2]roundwoo = 0.0

       F(  1,    42) =    8.32
            Prob > F =    0.0062

. svytest [mech2]trees= [mech2]lumber

Adjusted Wald test

 ( 1)  [mech2]trees - [mech2]lumber = 0.0

       F(  1,    42) =    3.72
            Prob > F =    0.0606

. svytest [mech2]roundwoo = [mech2]lumber

Adjusted Wald test

 ( 1)  [mech2]roundwoo - [mech2]lumber = 0.0

       F(  1,    42) =    0.92
            Prob > F =    0.3431

. svytest [mech2]roundwoo = [mech2]woodpdts

Adjusted Wald test

 ( 1)  [mech2]roundwoo - [mech2]woodpdts = 0.0

       F(  1,    42) =    0.44
            Prob > F =    0.5130

. svytest [mech2]lumber = [mech2]woodpdts

Adjusted Wald test

 ( 1)  [mech2]lumber - [mech2]woodpdts = 0.0

       F(  1,    42) =    2.35
            Prob > F =    0.1328

. svytest [mech2]trees= [mech2]woodpdts

Adjusted Wald test

 ( 1)  [mech2]trees - [mech2]woodpdts = 0.0

       F(  1,    42) =   10.37
            Prob > F =    0.0025

.
. svytest [mech2]trees= [mech2]roundwoo

Adjusted Wald test

 ( 1)  [mech2]trees - [mech2]roundwoo = 0.0

       F(  1,    42) =    8.32
            Prob > F =    0.0062

. svytest [mech2]trees= [mech2]lumber, accumulate

Adjusted Wald test

 ( 1)  [mech2]trees - [mech2]roundwoo = 0.0
 ( 2)  [mech2]trees - [mech2]lumber = 0.0

       F(  2,    41) =    4.71
            Prob > F =    0.0145

. svytest [mech2]roundwoo = [mech2]lumber, accumulate

Adjusted Wald test

 ( 1)  [mech2]trees - [mech2]roundwoo = 0.0
 ( 2)  [mech2]trees - [mech2]lumber = 0.0
 ( 3)  [mech2]roundwoo - [mech2]lumber = 0.0

       F(  2,    41) =    4.71
            Prob > F =    0.0145

. svytest [mech2]lumber = [mech2]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [mech2]trees - [mech2]roundwoo = 0.0
 ( 2)  [mech2]trees - [mech2]lumber = 0.0
 ( 3)  [mech2]roundwoo - [mech2]lumber = 0.0
 ( 4)  [mech2]lumber - [mech2]woodpdts = 0.0

       F(  3,    40) =    4.98
            Prob > F =    0.0050

.
. svytest [tech2]trees= [tech2]roundwoo

Adjusted Wald test

 ( 1)  [tech2]trees - [tech2]roundwoo = 0.0

       F(  1,    42) =    1.51
            Prob > F =    0.2260

. svytest [tech2]trees= [tech2]lumber

Adjusted Wald test

 ( 1)  [tech2]trees - [tech2]lumber = 0.0

       F(  1,    42) =    0.01
            Prob > F =    0.9108
```

```
. svytest [tech2]roundwoo = [tech2]lumber

Adjusted Wald test

 ( 1)  [tech2]roundwoo - [tech2]lumber = 0.0

       F(  1,    42) =    1.24
            Prob > F =    0.2716

. svytest [tech2]roundwoo = [tech2]woodpdts

Adjusted Wald test

 ( 1)  [tech2]roundwoo - [tech2]woodpdts = 0.0

       F(  1,    42) =    0.32
            Prob > F =    0.5756

. svytest [tech2]lumber = [tech2]woodpdts

Adjusted Wald test

 ( 1)  [tech2]lumber - [tech2]woodpdts = 0.0

       F(  1,    42) =    0.12
            Prob > F =    0.7291

. svytest [tech2]trees= [tech2]woodpdts

Adjusted Wald test

 ( 1)  [tech2]trees - [tech2]woodpdts = 0.0

       F(  1,    42) =    0.09
            Prob > F =    0.7610

.
. svytest [tech2]trees= [tech2]roundwoo

Adjusted Wald test

 ( 1)  [tech2]trees - [tech2]roundwoo = 0.0

       F(  1,    42) =    1.51
            Prob > F =    0.2260

. svytest [tech2]trees= [tech2]lumber, accumulate

Adjusted Wald test

 ( 1)  [tech2]trees - [tech2]roundwoo = 0.0
 ( 2)  [tech2]trees - [tech2]lumber = 0.0

       F(  2,    41) =    0.84
            Prob > F =    0.4386

. svytest [tech2]roundwoo = [tech2]lumber, accumulate

Adjusted Wald test

 ( 1)  [tech2]trees - [tech2]roundwoo = 0.0
 ( 2)  [tech2]trees - [tech2]lumber = 0.0
 ( 3)  [tech2]roundwoo - [tech2]lumber = 0.0

       F(  2,    41) =    0.84
            Prob > F =    0.4386

. svytest [tech2]lumber = [tech2]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [tech2]trees - [tech2]roundwoo = 0.0
 ( 2)  [tech2]trees - [tech2]lumber = 0.0
 ( 3)  [tech2]roundwoo - [tech2]lumber = 0.0
 ( 4)  [tech2]lumber - [tech2]woodpdts = 0.0

       F(  3,    40) =    0.55
            Prob > F =    0.6495

.
. svytest [q40]trees= [q40]roundwoo

Adjusted Wald test

 ( 1)  [q40]trees - [q40]roundwoo = 0.0

       F(  1,    42) =    4.93
            Prob > F =    0.0319

. svytest [q40]trees= [q40]lumber

Adjusted Wald test

 ( 1)  [q40]trees - [q40]lumber = 0.0

       F(  1,    42) =    9.06
            Prob > F =    0.0044

. svytest [q40]roundwoo = [q40]lumber

Adjusted Wald test

 ( 1)  [q40]roundwoo - [q40]lumber = 0.0

       F(  1,    42) =    1.09
            Prob > F =    0.3025

. svytest [q40]roundwoo = [q40]woodpdts

Adjusted Wald test

 ( 1)  [q40]roundwoo - [q40]woodpdts = 0.0

       F(  1,    42) =    5.48
            Prob > F =    0.0240

. svytest [q40]lumber = [q40]woodpdts

Adjusted Wald test

 ( 1)  [q40]lumber - [q40]woodpdts = 0.0

       F(  1,    42) =    1.23
            Prob > F =    0.2728

. svytest [q40]trees= [q40]woodpdts

Adjusted Wald test

 ( 1)  [q40]trees - [q40]woodpdts = 0.0

       F(  1,    42) =   19.59
            Prob > F =    0.0001

.
. svytest [q40]trees= [q40]roundwoo

Adjusted Wald test

 ( 1)  [q40]trees - [q40]roundwoo = 0.0

       F(  1,    42) =    4.93
            Prob > F =    0.0319

. svytest [q40]trees= [q40]lumber, accumulate

Adjusted Wald test

 ( 1)  [q40]trees - [q40]roundwoo = 0.0
 ( 2)  [q40]trees - [q40]lumber = 0.0

       F(  2,    41) =    4.91
            Prob > F =    0.0122

. svytest [q40]roundwoo = [q40]lumber, accumulate

Adjusted Wald test

 ( 1)  [q40]trees - [q40]roundwoo = 0.0
 ( 2)  [q40]trees - [q40]lumber = 0.0
 ( 3)  [q40]roundwoo - [q40]lumber = 0.0

       F(  2,    41) =    4.91
            Prob > F =    0.0122

. svytest [q40]lumber = [q40]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [q40]trees - [q40]roundwoo = 0.0
```

```
 ( 2)  [q40]trees - [q40]lumber = 0.0
 ( 3)  [q40]roundwoo - [q40]lumber = 0.0
 ( 4)  [q40]lumber - [q40]woodpdts = 0.0

       F(  3,    40) =    6.79
            Prob > F =    0.0008

. svytest [labor]trees= [labor]roundwoo

Adjusted Wald test

 ( 1)  [labor]trees - [labor]roundwoo = 0.0

       F(  1,    42) =    3.65
            Prob > F =    0.0628

. svytest [labor]trees= [labor]lumber

Adjusted Wald test

 ( 1)  [labor]trees - [labor]lumber = 0.0

       F(  1,    42) =    5.01
            Prob > F =    0.0306

. svytest [labor]trees= [labor]woodpdts

Adjusted Wald test

 ( 1)  [labor]trees - [labor]woodpdts = 0.0

       F(  1,    42) =    9.13
            Prob > F =    0.0043

. svytest [labor]roundwoo = [labor]lumber

Adjusted Wald test

 ( 1)  [labor]roundwoo - [labor]lumber = 0.0

       F(  1,    42) =    0.01
            Prob > F =    0.9122

. svytest [labor]roundwoo = [labor]woodpdts

Adjusted Wald test

 ( 1)  [labor]roundwoo - [labor]woodpdts = 0.0

       F(  1,    42) =    1.53
            Prob > F =    0.2226

. svytest [labor]lumber = [labor]woodpdts

Adjusted Wald test

 ( 1)  [labor]lumber - [labor]woodpdts = 0.0

       F(  1,    42) =    1.40
            Prob > F =    0.2440

.
. svytest [labor]trees= [labor]roundwoo

Adjusted Wald test

 ( 1)  [labor]trees - [labor]roundwoo = 0.0

       F(  1,    42) =    3.65
            Prob > F =    0.0628

. svytest [labor]trees= [labor]lumber, accumulate

Adjusted Wald test

 ( 1)  [labor]trees - [labor]roundwoo = 0.0
 ( 2)  [labor]trees - [labor]lumber = 0.0

       F(  2,    41) =    4.08
            Prob > F =    0.0243

. svytest [labor]trees= [labor]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [labor]trees - [labor]roundwoo = 0.0
 ( 2)  [labor]trees - [labor]lumber = 0.0
 ( 3)  [labor]trees - [labor]woodpdts = 0.0

       F(  3,    40) =    5.35
            Prob > F =    0.0034

. svytest [labor]roundwoo = [labor]lumber, accumulate

Adjusted Wald test

 ( 1)  [labor]trees - [labor]roundwoo = 0.0
 ( 2)  [labor]trees - [labor]lumber = 0.0
 ( 3)  [labor]trees - [labor]woodpdts = 0.0
 ( 4)  [labor]roundwoo - [labor]lumber = 0.0

       F(  3,    40) =    5.35
            Prob > F =    0.0034

. svytest [labor]roundwoo = [labor]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [labor]trees - [labor]roundwoo = 0.0
 ( 2)  [labor]trees - [labor]lumber = 0.0
 ( 3)  [labor]trees - [labor]woodpdts = 0.0
 ( 4)  [labor]roundwoo - [labor]lumber = 0.0
 ( 5)  [labor]roundwoo - [labor]woodpdts = 0.0

       F(  3,    40) =    5.35
            Prob > F =    0.0034

. svytest [labor]lumber = [labor]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [labor]trees - [labor]roundwoo = 0.0
 ( 2)  [labor]trees - [labor]lumber = 0.0
 ( 3)  [labor]trees - [labor]woodpdts = 0.0
 ( 4)  [labor]roundwoo - [labor]lumber = 0.0
 ( 5)  [labor]roundwoo - [labor]woodpdts = 0.0
 ( 6)  [labor]lumber - [labor]woodpdts = 0.0

       F(  3,    40) =    5.35
            Prob > F =    0.0034

.
. svytest [qbio1]trees= [qbio1]roundwoo

Adjusted Wald test

 ( 1)  [qbio1]trees - [qbio1]roundwoo = 0.0

       F(  1,    42) =    0.28
            Prob > F =    0.5990

. svytest [qbio1]trees= [qbio1]lumber

Adjusted Wald test

 ( 1)  [qbio1]trees - [qbio1]lumber = 0.0

       F(  1,    42) =    2.91
            Prob > F =    0.0953

. svytest [qbio1]roundwoo = [qbio1]lumber

Adjusted Wald test

 ( 1)  [qbio1]roundwoo - [qbio1]lumber = 0.0

       F(  1,    42) =    0.99
            Prob > F =    0.3258

. svytest [qbio1]roundwoo = [qbio1]woodpdts

Adjusted Wald test

 ( 1)  [qbio1]roundwoo - [qbio1]woodpdts = 0.0

       F(  1,    42) =    2.68
            Prob > F =    0.1092

. svytest [qbio1]lumber = [qbio1]woodpdts
```

```
Adjusted Wald test

 ( 1)  [qbio1]lumber - [qbio1]woodpdts = 0.0

       F(  1,    42) =    6.41
            Prob > F =    0.0152

. svytest [qbio1]trees= [qbio1]woodpdts

Adjusted Wald test

 ( 1)  [qbio1]trees - [qbio1]woodpdts = 0.0

       F(  1,    42) =    1.53
            Prob > F =    0.2229

.
. svytest [qbio1]trees= [qbio1]roundwoo

Adjusted Wald test

 ( 1)  [qbio1]trees - [qbio1]roundwoo = 0.0

       F(  1,    42) =    0.28
            Prob > F =    0.5990

. svytest [qbio1]trees= [qbio1]lumber, accumulate

Adjusted Wald test

 ( 1)  [qbio1]trees - [qbio1]roundwoo = 0.0
 ( 2)  [qbio1]trees - [qbio1]lumber = 0.0

       F(  2,    41) =    1.78
            Prob > F =    0.1808

. svytest [qbio1]trees= [qbio1]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [qbio1]trees - [qbio1]roundwoo = 0.0
 ( 2)  [qbio1]trees - [qbio1]lumber = 0.0
 ( 3)  [qbio1]trees - [qbio1]woodpdts = 0.0

       F(  3,    40) =    3.00
            Prob > F =    0.0415

. svytest [qbio1]roundwoo = [qbio1]lumber, accumulate

Adjusted Wald test

 ( 1)  [qbio1]trees - [qbio1]roundwoo = 0.0
 ( 2)  [qbio1]trees - [qbio1]lumber = 0.0
 ( 3)  [qbio1]trees - [qbio1]woodpdts = 0.0
 ( 4)  [qbio1]roundwoo - [qbio1]lumber = 0.0

       F(  3,    40) =    3.00
            Prob > F =    0.0415

. svytest [qbio1]roundwoo = [qbio1]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [qbio1]trees - [qbio1]roundwoo = 0.0
 ( 2)  [qbio1]trees - [qbio1]lumber = 0.0
 ( 3)  [qbio1]trees - [qbio1]woodpdts = 0.0
 ( 4)  [qbio1]roundwoo - [qbio1]lumber = 0.0
 ( 5)  [qbio1]roundwoo - [qbio1]woodpdts = 0.0

       F(  3,    40) =    3.00
            Prob > F =    0.0415

. svytest [qbio1]lumber = [qbio1]woodpdts, accumulate

Adjusted Wald test

 ( 1)  [qbio1]trees - [qbio1]roundwoo = 0.0
 ( 2)  [qbio1]trees - [qbio1]lumber = 0.0
 ( 3)  [qbio1]trees - [qbio1]woodpdts = 0.0
 ( 4)  [qbio1]roundwoo - [qbio1]lumber = 0.0
 ( 5)  [qbio1]roundwoo - [qbio1]woodpdts = 0.0
 ( 6)  [qbio1]lumber - [qbio1]woodpdts = 0.0

       F(  3,    40) =    3.00
            Prob > F =    0.0415
```

Appendix B

Regression Results

Table B.1: Ordered Logit Regressions: Vertical Integration (4 levels)

Independent Variable	(1)	(2)	(3)
Theory:			
Initial Roads	-0.33	0.12	-0.21
	(-0.98)	(-0.41)	(-0.62)
Initial Mechanical Training	3.82**	4.08**	4.05**
	(2.71)	(2.98)	(2.82)
Past Nontimber Marketization	1.89	1.65**	1.35
	(1.42)	(2.04)	(1.58)
Parastatal Existence	3.52**	3.06**	3.38**
	(3.86)	(3.71)	(3.73)
Forested Hectares (logarithmic)	0.91**	-6.56	-5.23
	(2.32)	(-1.45)	(-1.08)
Forested Hectares (logarithmic), squared		0.47	0.39
		(1.64)	(1.27)
1940 Forest Quality	2.01**		1.89**
	(2.59)		(2.41)
cut 1	16.52	-19.51	-7.32
Standard error	4.57	17.54	18.91
cut 2	19.33	-16.99	-4.5
Standard error	4.86	17.52	18.94
cut 3	21.54	-14.85	-2.13
Standard error	5.12	17.41	18.86
Number of Observations:	43	43	43
LR chi-squared	48.16	42.86	49.75
d.f	6	6	7
Prob. $> \chi^2$	0.00	0.00	0.00
Pseudo R-squared	0.42	0.37	0.43
Log Likelihood	-33.22	-35.86	-32.42

NOTES: Numbers in parentheses are z statistics. "**" denotes statistical significance at the 5% level and "*" at the 10% level.

Table B.2: Marginal Effects of One Unit Change

Independent Variable	$\frac{\partial P(y=1)}{\partial x}$	$\frac{\partial P(y=2)}{\partial x}$	$\frac{\partial P(y=3)}{\partial x}$	$\frac{\partial P(y=4)}{\partial x}$
Initial logging roads (logarithmic)	0.02	-0.00	-0.01	-0.01
Forested hectares (logarithmic)	-0.07	-0.04	0.04	0.07

NOTES: Marginal effects are calculated from Regression 3 in Table B.1 for each observation, holding all else constant.

Table B.3: Marginal Effects for Binary Variables (Probabilities in Percentage Points)

Independent Variable	$P(y=1)$	$P(y=2)$	$P(y=3)$	$P(y=4)$
Initial mechanical training =0	52	28	12	8
Initial mechanical training =1	13	25	27	35
Change	-39	-3	15	27
Parastatal leasing =0	53	30	12	5
Parastatal leasing =1	15	31	29	26
Change	-38	1	17	20
Nontimber marketization=0	42	28	17	13
Nontimber marketization=1	29	28	22	22
Change	-13	0	5	8
Quality of forest, 1940 =0	37	30	18	16
Quality of forest, 1940 =1	20	27	24	29
Change	-17	-3	6	13

NOTES: Marginal effects calculated from Regression 3 in Table B.1 for each observation, then averaged.

Table B.4: Generalized Ordered Logit Regressions

	POM Ordered Logit	Generalized Ordered Logit		
Independent Variable		Equation 1	Equation 2	Equation 3
Initial Roads	-0.33	-0.90	0.42	-1.25
	(-0.98)	(-1.42)	(0.47)	(-1.03)
Initial Mechanical Training	3.82**	7.51**	0.79	0.95
	(2.71)	(2.31)	(0.24)	(0.30)
Past Nontimber Marketization	1.18	-0.78	2.93	1.92
	(1.42)	(-0.49)	(1.28)	(1.39)
Parastatal Existence	3.52**	3.16*	4.56**	0.46
	(3.86)	(1.84)	(2.38)	(0.26)
Forested Hectares (log)	0.91**	1.29*	0.79	1.62
	(2.32)	(1.81)	(0.90)	(1.55)
1940 Forest Quality	2.01**	3.53**	0.70	2.45
	(2.59)	(2.01)	(1.16)	(1.13)
cut 1	16.52			
Standard error	4.57			
cut 2	19.33			
Standard error	4.86			
cut 3	21.54			
Standard error	5.12			
Constant		-24.45**	-22.38*	-22.79*
		(-2.25)	(-1.67)	(-1.86)
Number of Observations: 43				
Model χ^2	48.16	61.88		
Degrees of Freedom	6	18		
Prob > χ^2:	0.00	0.00		
Pseudo R-squared:	0.42	0.54		
Log Likelihood:	-33.22	-26.35		

NOTES: Each column is a separate regression. Numbers in parentheses are z statistics unless otherwise noted. "**" denotes statistical significance at the 5% level and "*" at the 10% level.

Table B.5: Ordered Logit Regressions: Vertical Integration (3 levels)

Independent Variable	(1)	(2)	(3)
Theory:			
Initial Roads	-0.27	0.21	-0.12
	(-0.75)	(0.62)	(-0.31)
Initial Mechanical Training	3.86**	4.20**	4.39**
	(2.34)	(2.72)	(2.48)
Past Nontimber Marketization	1.49	1.71*	1.62*
	(1.59)	(1.84)	(1.65)
Parastatal Existence	3.99**	3.41**	4.16**
	(3.59)	(3.65)	(3.46)
Forested Hectares (logarithmic)	1.09**	-9.40*	-8.95
	(2.45)	(-1.67)	(-1.64)
Forested Hectares (logarithmic), squared		0.66*	0.64*
		(1.83)	(1.82)
1940 Forest Quality	2.32**		2.45**
	(2.44)		(2.37)
cut 1	19.50	-29.57	-17.95
Standard error	5.99	21.47	20.65
cut 2	22.55	-26.83	-14.64
Standard error	6.42	21.43	20.64
Number of Observations:	43	43	43
LR chi-squared	45.49	41.47	49.12
Degrees of Freedom	6	6	7
Prob. $> \chi^2$	0.00	0.00	0.00
Pseudo R-squared	0.48	0.44	0.52
Log Likelihood	-24.18	-26.19	-22.37

NOTES: Numbers in parentheses are z statistics. "**" denotes statistical significance at the 5% level and "*" at the 10% level.

Table B.6: Alternative Theories: Vertical Integration (4 levels)

Independent Variable					
Theory:	(1)	(2)	(3)	(4)	(5)
Initial Roads	-0.25	-0.01		-0.26	-0.18
	(-0.70)	(-0.02)		(-0.72)	(-0.54)
Initial Mechanical Training	4.43**	5.50**	3.06**	4.16**	4.04**
	(2.76)	(2.89)	(2.26)	(2.83)	(2.83)
Past Nontimber Marketization	1.53*	0.48	1.09	1.54	1.52
	(1.67)	(0.44)	(1.31)	(1.61)	(1.72)
Parastatal Existence	3.66**	2.81**	3.04**	3.60**	3.06**
	(3.49)	(2.93)	(3.53)	(3.44)	(3.32)
Forested Hectares	-5.42	-22.80**		-5.00	-4.32
(logs)	(-1.11)	(-2.35)		(-1.03)	(-0.87)
Forested Hectares	0.41	1.47**		0.38	0.33
(logs, squared)	(1.31)	(2.46)		(1.25)	(1.07)
1940 Forest Quality	1.92**	1.65*	2.05**	1.87**	2.10**
	(2.46)	(1.84)	(2.61)	(2.38)	(2.56)
Controls:					
Driving Hours from Oaxaca	0.08				
	(0.58)				
Transport Time to Client		0.001			
		(0.02)			
Road Density			-0.15		
			(-0.06)		
Coffee				0.50	
				(0.50)	
Parceled Forest					1.44
					(1.18)
cut 1	-6.97	-78.66	9.60	-5.53	-1.62
Standard error	19.11	38.81	3.00	19.25	19.86
cut 2	-4.14	-74.30	12.30	-2.71	1.21
Standard error	19.15	38.25	3.24	19.29	19.88
cut 3	-1.71	-71.75	14.34	-0.32	3.68
Standard error	19.07	38.03	3.47	19.22	19.81
Number of Observations:	43	35	39	43	43
LR chi-squared	50.07	48.48	38.18	49.97	51.26
Degrees of Freedom	8	8	5	8	8
Prob. > χ^2	0.00	0.00	0.00	0.00	0.00
Pseudo R-squared	0.44	0.52	0.36	0.45	0.45
Log Likelihood	-32.26	-22.50	-33.89	-32.31	-31.66

NOTES: Numbers in parentheses are z statistics. "**" denotes statistical significance at the 5% level and "*" at the 10% level.

Table B.7: OLS and Instrumental Variables Regressions: Occurrence of Nontimber Investment

	OLS	IV
Independent Variable	(1)	(2)
Vertical integration	0.42**	0.46**
	(3.93)	(3.33)
Percent of forest with high biodiversity	0.01**	0.01**
	(2.03)	(1.97)
Firm size	0.003	0.003
	(1.54)	(1.28)
Constant	-1.20**	-1.27**
	(-5.22)	(-4.73)
Number of observations	42	42
R-squared	0.49	0.49
Adjusted R-squared	0.45	0.45

NOTES: Numbers in parentheses are z statistics. "**" denotes statistical significance at the 5% level and "*" at the 10% level. Instruments are: past mechanical training, history of parastatal leasing, forested hectares (logarithmic), past timber marketization and quality of the forest in 1940.

```
*WALD TESTS FOR ESTIMATORS

. test preroad

 ( 1)  preroad = 0.0

           chi2(  1) =    0.38
         Prob > chi2 =    0.5357


. test mech2

 ( 1)  mech2 = 0.0

           chi2(  1) =    7.97
         Prob > chi2 =    0.0048


. test old

 ( 1)  old = 0.0

           chi2(  1) =    2.49
         Prob > chi2 =    0.1142


. test conc

 ( 1)  conc = 0.0

           chi2(  1) =   13.94
         Prob > chi2 =    0.0002


. test lsupa

 ( 1)  lsupa = 0.0

           chi2(  1) =    1.17
         Prob > chi2 =    0.2787


. test lsupa2

 ( 1)  lsupa2 = 0.0

           chi2(  1) =    1.61
         Prob > chi2 =    0.2045


. test q40

 ( 1)  q40 = 0.0

           chi2(  1) =    5.81
         Prob > chi2 =    0.0159


. test _cut1

 ( 1)  _cut1 = 0.0

           chi2(  1) =    0.15
         Prob > chi2 =    0.6987


. test _cut2

 ( 1)  _cut2 = 0.0

           chi2(  1) =    0.06
         Prob > chi2 =    0.8122


. test _cut3

 ( 1)  _cut3 = 0.0

           chi2(  1) =    0.01
         Prob > chi2 =    0.9102


. test _b[_cut1] = _b[_cut2]

 ( 1)  _cut1 - _cut2 = 0.0

           chi2(  1) =   13.54
         Prob > chi2 =    0.0002


. test _b[_cut1] = _b[_cut3]

 ( 1)  _cut1 - _cut3 = 0.0

           chi2(  1) =   22.43
         Prob > chi2 =    0.0000


. test _b[_cut2] = _b[_cut3]

 ( 1)  _cut2 - _cut3 = 0.0

           chi2(  1) =    9.15
         Prob > chi2 =    0.0025


. test preroad mech2 old conc lsupa lsupa2 q40 _cut1 _cut2 _cut3

 ( 1)  preroad = 0.0
 ( 2)  mech2 = 0.0
 ( 3)  old = 0.0
 ( 4)  conc = 0.0
 ( 5)  lsupa = 0.0
 ( 6)  lsupa2 = 0.0
 ( 7)  q40 = 0.0
 ( 8)  _cut1 = 0.0
 ( 9)  _cut2 = 0.0
 (10)  _cut3 = 0.0

           chi2( 10) =   26.69
         Prob > chi2 =    0.0029
```

Appendix C

Definition of Variables

Appendix D

Survey (Spanish)

Appendix E

Survey (English)