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# Toward Adaptive Community Forest Management: Integrating Local Forest Knowledge with Scientific Forestry\*

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**Abstract:** This case study of indigenous communities in highland Michoacán, Mexico, examines data on forest change, woodcutting practices, social history, and a recent forest inventory and management plan prepared by a professional forester. It assesses the social and environmental fit of both local knowledge and scientific forestry and considers their abilities to contribute to sustainable forest management. Both bodies of knowledge are limited in their ability to inform the social practice of environmental management. The local forest knowledge system is particularly hampered by a limited ability to monitor the forest's response to woodcutting, while scientific forestry lacks the institutional flexibility to ensure the just and effective implementation of restrictions and prescriptions. This article recommends cross-learning between scientific resource managers and woodcutters, participatory environmental monitoring to assess the results of different cutting techniques, and explicit management experiments to facilitate institutional learning at the community level. This kind of adaptive management approach permits the flexible integration of local knowledge, scientific forestry, and appropriate institutional parameters to modulate human needs and goals with the discordant harmonies of inhabited and heavily used forests in a constant state of flux under processes of succession, disturbance, and spatial variation. Several barriers to this kind of institutional innovation exist, but outside intervention has the potential to change the dynamics of institutional evolution.

**Key words:** adaptive management, political ecology, local knowledge, institutions.

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Alleviating poverty and halting environmental degradation in fragile, agriculturally marginal areas requires environmentally sustainable and socially acceptable means of intensifying the use of renewable natural resources, including forests. The alternative is environmental degradation, increased rural poverty, and continued displacement of the rural poor to urban margins and expanding agricultural frontiers (Pichón, Uquillas, and Frechione 1999).

Unfortunately, conventional scientific approaches to resource management in such areas often fail; they are based on

Warf, Francisco Chapela, and several anonymous reviewers pointed out several ways to strengthen an earlier version. The remaining errors are exclusively mine.

faulty models, limited and socially inappropriate goals, and incomplete information on basic parameters. They do not adequately address environmental complexity, heterogeneity, or the role of recurring disturbances (Finlayson and McCay 1998; Zimmerer and Young 1998).

To make matters worse, conventional scientific approaches to natural resource management often fail to create the local social institutions needed to encourage environmentally appropriate social behavior. In this article, *institutions* refer to the “systems of rules, decision-making procedures, and programs that give rise to social practices, and guide interactions among the occupants of relevant roles. Unlike organizations, which are material entities that typically figure as actors in social practices, institutions may be thought of as the rules of the game that determine the character of these practices” (Young et al. 1999, 11). Institutions often have moral dimensions and can even confer identity (Douglas 1986).

Institutional failure has three aspects. First, the locally derived institutions that are needed to coordinate the compliance of resource users are lacking. Centrally imposed regulations for monitoring compliance, meting out sanctions, and distributing access are clumsy and poorly adapted to local conditions. Second, the institutions that may generate information on the state of the resources are lacking. Finally, the ability of centralized resource-use controls to adapt to changing social and environmental conditions is limited (Berkes, Folke, and Colding 1998).

Conventional scientific forestry is no exception. Scientific forestry is a body of knowledge and social practices, “a political-economic system for resource control” (Peluso 1992, 237). Scientific<sup>1</sup> forestry requires a high level of social and spatial

control; favors national interests over local ones; stresses industrial raw materials like pulp or sawmill timber over other forest uses; and discourages agricultural clearings, burning, woodcutting, and grazing. It often results in institutional failure and social injustice (Pincetl 1993; Guha 1989; Peluso 1992; Bryant 1994; Vandergeest 1996; Scott 1998; Klooster 2000b).

In contrast, traditional resource-management systems, often derived over time through a process of cultural learning and adaptation, are frequently successful in generating appropriate local institutions (Ostrom 1990; Feeny, Berkes, McCay, and Acheson 1990). Increasingly, researchers are arguing for approaches that combine the strengths often observed in indigenous knowledge systems with the experimental method of scientists (DeWalt 1999; Altieri and Hecht 1990). In at least some cases, the agricultural and forest-use practices of forest-dwelling people encapsulate management strategies that better address environmental complexity and flux than do conventional approaches; they frequently foster the maintenance and expansion of forest cover (Alcorn 1981; Padoch and Peters 1993; Fairhead and Leach 1996, 1998).

This article, a case study of two indigenous communities in highland Michoacán, Mexico, presents data on change in forest cover, woodcutting practices, social history, and a recent forest inventory and management plan prepared by a professional forester. It assesses the social and environmental fit of both local knowledge and scientific forestry and considers their abilities to contribute to socially just and environmentally sustainable intensified forest management.

By considering the utility of *adaptive management* (Berkes, Folke, and Colding 1998; Walters 1986) for integrating local and scientific systems of knowledge and practice, the article addresses recent calls for a political ecology that is cognizant of nonequilibrium views of nature for conservation strategies amid “second nature,” in which local inhabitants are continually

<sup>1</sup> The word's use here should not be taken to imply that other forms of forest management are un-scientific. “Scientific forestry” is roughly synonymous with “professional forestry.”

modifying nature through grazing, agriculture, and forest extraction (Zimmerer 2000). Furthermore, it takes seriously geographers' calls to analyze critically the role of both local and official environmental knowledge in the generation of management regimes (Robbins 2000), especially the increased value of local environmental knowledge that accompany nonequilibrium visions of nature (Zimmerer 1994). It also explores the nexus of knowledge and institutions in which environmentally sustainable economic production may be embedded (Granovetter 1985).

### **Deforestation and Agricultural Marginality in the Lake Pátzcuaro Basin**

Mexico desperately needs successful strategies for forest management. Recent estimates of deforestation have ranged from 370,000 to 720,000 hectares per year—a 0.8-percent to 2-percent annual rate. In lowland tropical forests, the proximate causes include cattle ranching and agricultural expansion, while in highland pine and oak forests, the immediate causes include logging, woodcutting, forest fires, and agricultural expansion (Masera 1996; World Bank 1995; Cairns, Dirzo, and Zadroga 1995).

In long-settled regions, especially in the highlands, people compensate for the decreasing viability of agriculture by intensifying woodcutting for craft production and informal markets (Klooster 2001). This is the case in the Lake Pátzcuaro Basin on the eastern end of the Purépecha region of highland central Michoacán—an area of common-property forests that has long been occupied by the indigenous Purépecha people (Gorenstein and Pollard 1983; Foster 1988).

The population in the Lake Pátzcuaro Basin increased by 2.7 percent per year for most of the twentieth century (Castilleja 1992). The importance of agriculture, however, has decreased. Erratic rainfall, the absence of irrigation, frosts, windstorms,

and soil constraints contributed to the initial marginality of agriculture in this region, but improvements in the transportation infrastructure, agricultural intensification elsewhere in Mexico, Mexican food policies that subsidize consumers' purchase of maize and beans, and Mexico's entry into international trade agreements, such as the General Agreement on Tariffs and Trade and the North American Free Trade Agreement, have further decreased the viability of rain-fed agriculture during the past 50 years (Appendini 1998; Barkin 1990; Fox 1993; Myhre 1998). Although maize agriculture maintains a role in rural livelihoods because of its cultural importance and household food-security strategies (Mapes 1987), the area planted in maize in the Purépecha region decreased by more than half between 1969 and 1993. In certain regions where the climatic conditions are appropriate, maize fields and forests have been converted to avocado orchards, but abandoned fields are a common sight in dry and frost-prone regions (Carabias, Provencio, Toledo, and Alvarez-Icaza 1994; G. Chapela 1994; Garibay 1996; Paulson 1999).

In many cases, household survival strategies in this region include complex patterns of cyclical migration to Mexican urban areas and the United States (see Jones 1998; Conway and Cohen 1998). In many other cases, however, people take up forest-dependent activities to supplement or replace agriculture in this region. Almost 100 percent of rural people cook with firewood, and there are more than a thousand wood-based small enterprises. Most of these cabin industries are pottery workshops, but they also include brick making, charcoal production, bakeries, and small carpentry workshops (Reyes 1992; West 1947). The demand for wood in the Purépecha region is four to seven times greater than the authorized cut and four times greater than the estimated annual growth increment (Masera, Masera, and Navia 1998). Estimates of the demand for wood and rates of forest growth suggest severe overcutting in the Lake Pátzcuaro

Basin, mostly for firewood (Becerra, Reygadas, and Moreno 1997; for a critique of this narrative of environmental change, see Klooster 2000c). According to official forest inventories in 1963 and 1990, the forested area decreased by 50 percent in the entire Purépecha region, and 45 percent in the Lake Pátzcuaro basin, with some counties completely deforested. The density of the remaining forests also decreased (Alvarez-Icaza and Garibay 1992). Observers blame deforestation for siltation and declines in rainfall that have lessened Lake Pátzcuaro's size and productivity, displacing important small-scale fisheries (Toledo, Alvarez-Icaza, and Avila 1992; ORCA 1997).

Travelers' perceptions of deforestation and the scarcity of wood in this region date back more than 100 years (Brand 1951, 123). In 1969, an anthropologist working in Santa Fé de la Laguna decried the uncontrolled woodcutting and timber raiding that was finishing off the forests there. In 1979, George Foster, an anthropologist conducting long-term research in a pottery-making town directly across a bay from Santa Fé, observed that "firewood has all but ceased to exist in the hills around Tzintzuntzan" (Foster 1988, 377; see also Gortaire 1971).

On the other hand, Toledo (1991) among others noted that the ecology of the Lake Pátzcuaro area remains relatively stable, erosion is moderate, and biodiversity remains astounding. This high degree of environmental conservation occurred despite the area's proximity to Mexico City, one of the most populous cities on the planet; evidence of agriculture dating back 3,500 years; high population density at the time of the Spanish conquest; and a long history of intense human occupation and culture building (Gorenstein and Pollard 1983). Indigenous culture, environmental knowledge, diversified production strategies, and land-tenure patterns are said to have conserved the Pátzcuaro landscape. Furthermore, the tenure arrangements of village territories nested within the nation-state provide significant scope for institutional innovation, and rural communities—

especially indigenous communities—are sometimes able to develop robust and successful management systems by drawing on extensive local environmental knowledge and practice. Indigenous knowledge and environmental management strategies are an important resource for sustainable development in this region, especially among Purépecha communities in the Lake Pátzcuaro Basin (Alcorn and Toledo 1998; Toledo 1990, 1991; Toledo and Argueta 1992; Toledo and Barrera-Bassols 1984).

### The Case of Santa Fé and San Jerónimo

Two of these communities are Santa Fé de la Laguna and San Jerónimo Purenchécuaro, which border one another on the northern shore of Lake Pátzcuaro. More than 2,000 residents of San Jerónimo own a 3,000-hectare territory, and nearly 4,700 residents of Santa Fé own a 5,000-hectare territory. Most speak Purépecha in addition to Spanish. Their common-property territories range from the lakeshore, 2,040 meters above sea level, to several rocky mountaintops, 3,000 meters above sea level. A fragmented forest of pine and oak covers some 40 percent of each territory. The clearly defined border between the two communities passes through this forest.

These communities were chosen for further study for several reasons. First, they have maintained their indigenous language, self-governance structures, common-property tenure arrangements, local knowledge of forest resources, and local woodcutting practices. Thus they are strong candidates for having the kind of local knowledge and practice that are often recommended for alternative development strategies. Second, the communities have maintained significant areas of forest cover, but observers generally believe that wood-fueled pottery production in Santa Fé places unsustainable demands on both communities' forests. Third, a nongovern-



mental organization (NGO), the Grupo Interdisciplinario de Tecnología Rural Apropiable A.C. (GIRA), has been active in these communities for several years, generating data on the demand for fuelwood for cooking and pottery production (Masera, Masera, and Navia 1998; Masera et al. 1997a, 1997b; Navia and Ochoa 1998). In addition, historical data on Santa Fé are available from previous research (Brand 1951; West 1947; Gortaire 1971; Dimas 1982; García 1988; Zárate 1993). Fourth, leaders from both communities have, at times, been interested in exploring improved forest-management practices because potters from Santa Fé frequently cut pine trees in the territory of San Jerónimo without permission. Together with the two communities, GIRA requested funds from a Mexican federal program to promote community forestry and used those funds to hire a professional forester to conduct simultaneous forest inventories and management plans in the two communities (Sánchez 1998a, 1998b). Although they have not been implemented in these communities, forest inventories such as these normally form the first step in the legal extraction of timber in Mexican forests under the conventional restrictions and prescriptions of scientific forestry.

Nearly all households in Santa Fé manufacture and sell pottery and make extensive use of the surrounding forests for fuel. San Jerónimo uses the forest much less intensively. Most households there rely on temporary or cyclical migration, combined with weaving straw figures. Therefore, the study presented here considers changes in the forests in both Santa Fé and San Jerónimo, but considers local forest knowledge primarily in Santa Fé.

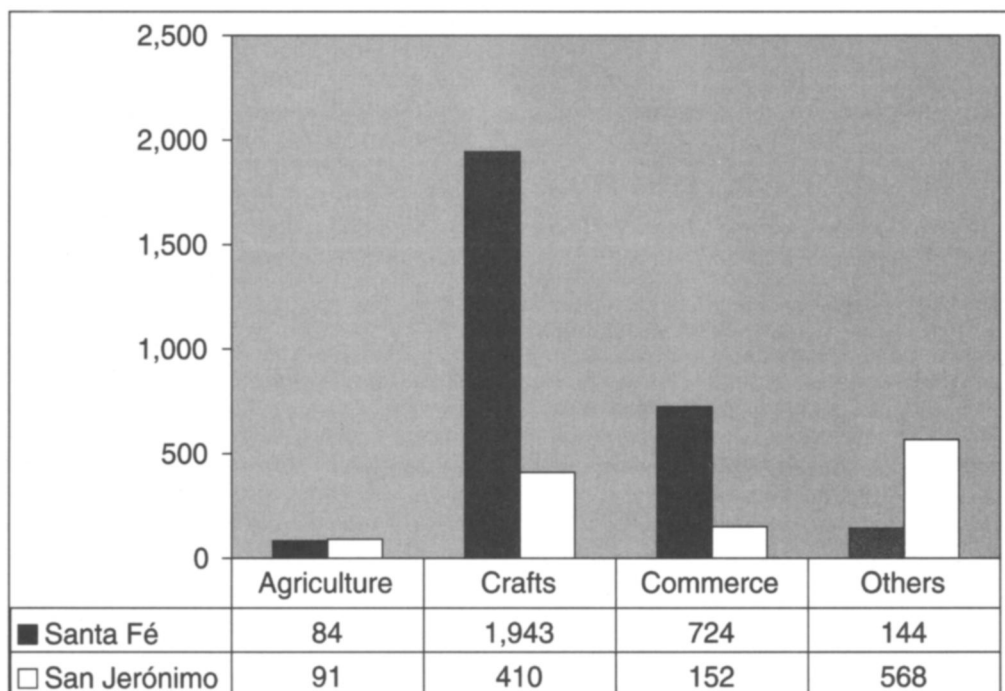
In addition to a careful review of secondary sources, data for the case study came from an analysis of aerial photographs, as well as participant observation totaling approximately two months of field time during 1998 and 1999. Specific fieldwork activities included accompanying woodcutters, timber cruising with professional foresters, observing several work-

shops in which a professional forester discussed management methods with community leaders, participating in community reforestation activities, recreational hiking and squirrel hunting with community members, and conducting both open-ended and guided interviews with community leaders, potters, woodcutters, and foresters. Most of the informants were male. Field notes were compiled and coded in the method described by Bernard (1988), using NUD\*IST software. Together, these data allowed me to analyze the abilities of local knowledge and scientific forestry to regulate the sustainable intensification of forest use in agriculturally marginal areas like this one.

The remainder of the article is organized as follows. First, I establish the recent patterns of population growth and productive activities in the case study communities. Second, I describe a recent struggle over territory in Santa Fé that helped clarify the history of forest use and the general lack of resource-use restrictions. Third, I outline recent changes to the forests of Santa Fé and San Jerónimo, including the depletion of pine trees. Fourth, I describe the local cutting practices and ethics. Fifth, I examine the proposed management plan based on scientific forestry. The discussion that follows assesses the ability of these contrasting systems to improve forest management and considers the possibility for integration through cross-learning, participatory monitoring, and experiments in institutional adaptation. Finally, I outline the main barriers to changing the existing management framework. The conclusion summarizes the argument.

### **Productive Activities**

The population of San Jerónimo, currently 2,000, has been roughly stable for many years, whereas the population of Santa Fé has doubled since 1950, reaching 4,700 in 1999 (Klooster 2000c). As is common in the Lake Pátzcuaro area, the residents of these communities cobble together a rural livelihood based on off-



**Figure 1.** Principal occupations in Santa Fé and San Jerónimo. *Source:* Original data are from the 1997 Santa Fé clinic census of 2,509 working adults, and the 1999 San Jerónimo clinic census of 1,221 working adults, reported in Klooster (2000c). The agriculture category includes roughly an equal number of fishermen and farmers. In Santa Fé, the craft is pottery production, while in San Jerónimo, the craft category refers to weaving figures from straw purchased outside the community. In both communities, most of the merchants in the “Commerce” category buy the local crafts for resale elsewhere. “Others” include temporary emigrants, day laborers, and professionals, such as schoolteachers, most of whom work outside the communities.

farm labor, craft activities, and some farming (see Fig. 1). Census data on economic activities are not available for previous decades, but interviews indicated that agriculture was previously much more important than it is now. The informants reported decreased yields owing to more pests, declining soil fertility, and the increased frequency of frosts, dry spells, and windstorms. At the same time, declining prices, greater availability of subsidized maize and tortillas, and growth of income-generating alternatives decreased the economic viability of agriculture over time.

Residents of the case-study communities have devised slightly different livelihood strategies to address the declining viability

of agriculture. In San Jerónimo Purenchécuaro, villagers discovered work opportunities in the United States during the World War II guest-worker programs.<sup>2</sup> Participation in these programs transformed local perceptions of labor opportunities and established the necessary knowledge and social relationships for future cycles of temporary, cyclical emigration and remittances (ORCA 1997; see also Foster 1988; Jones 1998; Conway and Cohen 1998). In

<sup>2</sup> San Jerónimo is so famous as a source of emigration that it was mentioned prominently in a recent popular survey of the Mexican economic and social situation (Survey Mexico: Revolution ends, change begins 2000, 8).

San Jerónimo, 17 percent of the working population has lived outside the community for more than six months, and 15 percent work for day wages outside the community (Klooster 2000c). In Santa Fé, community members intensified pottery production, a common supplementary productive activity in the community since at least the latter part of the nineteenth century (West 1947). Now, nearly 70 percent of working adults in Santa Fé count pottery production as their primary activity, while selling pottery employs another 20 percent (Klooster 2000c).

### **The Social History of Struggle for Land and Forest in Santa Fé**

For much of the twentieth century, the forests and croplands of Santa Fé de la Laguna were the object of wood theft and land appropriation from nonindigenous (mestizo) neighbors from Quiroga. In the late 1930s, a group of mestizos established a small settlement in the community's forests in a locale known as Tzintziameo, where they sold wood to Quiroga artisans and fuel to Santa Fé potters. In addition, groups of woodcutters from Quiroga would often leave Santa Fé's forest with mule trains loaded with wood (Gortaire 1971; Dimas 1982; García 1988). Brand (1951) noted a long history of small woodcraft industries in Quiroga, but this activity intensified in 1939, shortly after improvements in the Mexico City–Guadalajara highway, which passes through Quiroga and Santa Fé; the end of a period of rural unrest; and the rise of Mexican and international tourism. These shops sold serving trays made of solid slabs of pine, wood furniture, and other wood handicrafts to tourists and retailers (West 1947; Brand 1951).

Members of the Santa Fé community remember this period as one in which they supplied themselves with kiln fuel from the pine branches and slash left in the forest by the Quiroga woodcutters. The community members dared not confront these outsiders, who they suspected of carrying

weapons. In discussions of changes in the forest, they frequently blamed Quiroga woodcutters for virtually eliminating the community's fir trees and largest pine trees and decimating populations of madrone.

The forests of San Jerónimo also supplied clandestinely cut wood to Quiroga markets, but because San Jerónimo was farther away from Quiroga and exercised better communal vigilance in the 1960s and 1970s, they escaped the intensity of woodcutting experienced in Santa Fé. Bordered on all sides by other indigenous common-property territories, San Jerónimo also escaped a history of land appropriation, unlike Santa Fé.

In Santa Fé, however, Quiroga farmers and cattle owners appropriated substantial areas of farming and grazing land. By 1967, outsiders from Quiroga held some 16 percent of the community's territory (Gortaire 1971). The external appropriation of communal land had connections to internal patterns of land concentration. A few indigenous families possessed a disproportionate share of agricultural land, they relied on sharecroppers to make their land produce, and many of these sharecroppers were from outside the community. In other cases, the land rich rented pasturage rights to Quiroga cattle owners. Community members sometimes sold their rights to usufruct plots to cover debts incurred to meet financial obligations for rites and festivals, and these land sales fueled internal land concentration and, sometimes, direct transfer of communal land to outsiders (Dimas 1982).

The conflict between Santa Fé and Quiroga also had a strong ethnic element, as expressed in the heat of the conflict by Nestor Dimas (1982, 44), a native of Santa Fé: "Land litigation goes back to remote epochs, principally with the mestizo town of Quiroga, which is found to the east of the community. These people arrived after the founding of Santa Fé, and because they consider the Indian a despicable being, they have always wanted to humiliate him, looting his properties and natural resources as much as possible



because they are mestizos" (author's translation).

Illegal cutting of trees and the usurpation of communal land by outsiders continued through the 1970s and early 1980s. Under the galvanizing leadership of Elpidio Domínguez, a young community leader exposed to Marxism, indigenous rights, and other leftist ideologies while studying to be a schoolteacher, the community reorganized its traditions of internal governance, became more open to the participation of young men with charisma and relevant training and experience, and mobilized politically in defense of indigenous culture and the specific territory of Santa Fé. After several armed confrontations, shooting deaths on both sides, and adroit political maneuvering, the community was able to recover much of the territory occupied by Quiroga farmers and cattlemen by the mid-1980s (Dimas 1982; Zárate 1993).

To reestablish control of their forest, the community also conducted group patrols of their forest, as often as twice a month, and community members confiscated the animals and cutting tools of trespassers. In 1988 interviews of wood workshops in Quiroga, woodworkers told researcher Yuraima Garcia that pine and fir once came principally from Santa Fé, but that after 1986 they had to start getting their wood from elsewhere. Garcia observed woodcutters selling firewood door to door in Quiroga, and one admitted cutting pine in Santa Fé. "If the people from Santa Fé catch me they could kill me or take away my axe and burros," he told her (García 1988, 50; translated by the author). As of 1999, the theft of wood had decreased to imperceptible levels.

After those victories, Santa Fé's internal organization and mobilization declined owing to disputes over internal land expropriations, changes in the traditional structures of the internal government, and a proposal to install a nuclear research reactor in Santa Fé's territory that Domínguez supported in the face of local opposition. Later, a Quiroga cattle rancher murdered

Domínguez on the outskirts of Santa Fé. Nevertheless, as a result of the struggle he led, the community regained lost territory and maintains effective control over its forest.

### The State of the Forest

The decline of agriculture and woodcutting by woodcutters from both Quiroga and Santa Fé have had repercussions in the forest. Currently, 40 percent of San Jerónimo's and Santa Fé's common-property territories are covered in fragmented pine and oak forests, interspersed with agricultural and grazing lands (Sánchez 1998a, 1998b). Aerial photographs from 1960, 1974, and 1990 show abandoned agricultural fields swallowed up by vigorous stands of pine and oak. Furthermore, many forests and grazing areas show evidence of past agricultural use, such as old plow furrows and stone fences. These land-cover changes reflect the progressive decrease in the importance of agriculture amid household productive activities (Klooster 2000c). A qualitative comparison of other areas in these communities covered by the aerial photographs also reveals greater forest cover in 1990 than in 1974 or 1960. In addition, aerial photographs from a U.S. Air Force mapping flight of 1942 that partially cover the territories of San Jerónimo and Santa Fé reveal a landscape with more distinct field margins, less forest cover, and greater forest fragmentation than in 1990.<sup>3</sup>

The forest also shows the impact of woodcutting, especially for the pottery production that displaced agriculture in the portfolio of household productive activities in Santa Fé. Nearly all households in Santa Fé cook with wood. In San Jerónimo, 80 percent of the households use firewood for cooking, and most supplement wood with gas (Maser et al. 1997a, 1997b). Pine fire-

<sup>3</sup> Dr. Helen Pollard of Michigan State University kindly provided copies of the 1942 photographs.

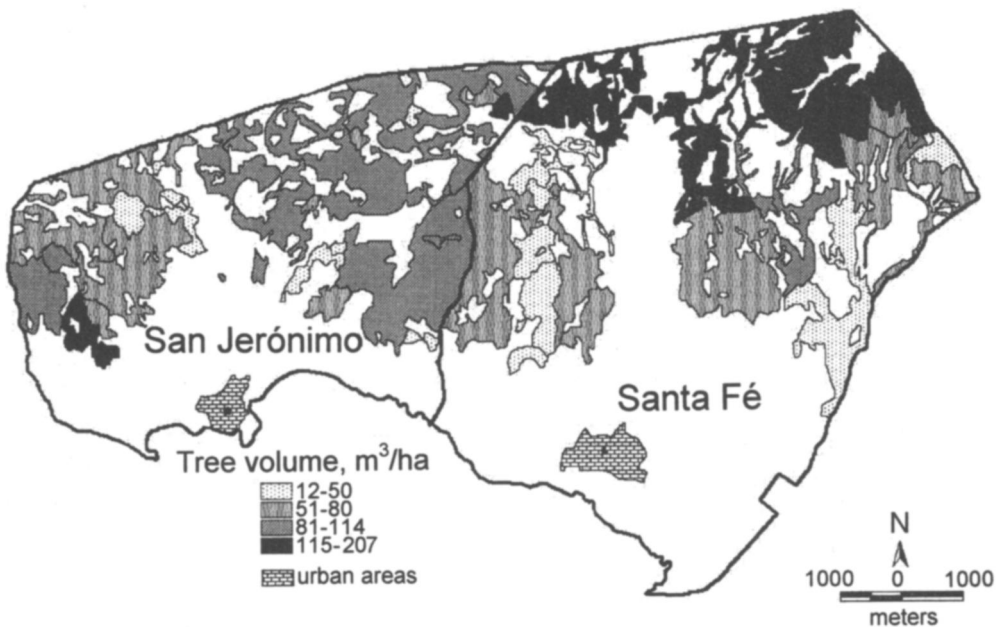
wood is critical for pottery production in Santa Fé, where there are 600 kilns, 450 of which are in use at least twice a month. The village-wide inferred demand for pine is conservatively estimated at 2,000 m<sup>3</sup> per year (Navia and Ochoa 1998).

Woodcutting affected the forest. Cross-sectional data from the forest surveys (Sánchez 1998a, 1998b) revealed marked differences in the density of the forest and proportion of pine between Santa Fé, where woodcutting for pine is most pronounced, and San Jerónimo, where it is less pronounced. On average, San Jerónimo has 250 percent more pine per hectare than Santa Fé does (Klooster 2000c). The 1998 forest inventories also indicated marked differences in density across the border from Santa Fé to San Jerónimo (see Fig. 2).

These forests are adjacent, occupy the same altitudinal gradients, have similar expositions, and grow on similar soils. Although available data do not eliminate the possibility of different histories of forest clearing, fire, and disease, the most

obvious difference between these forests is human use: Santa Fé woodcutters use much more wood, especially pine trees, for kiln fuel (Klooster 2000c).

The differential effects of woodcutting over time are also visible in aerial photographs. A particularly accessible area of forest near the border with San Jerónimo, for example, used to be forested with large pines, according to interviews with 45-year-old woodcutters. Aerial photographs from 1960 show a similar pattern of closely spaced crowns of pine and oak on both sides of the gully marking the border between the two communities. Photographs from 1974 and 1990, however, show no change on San Jerónimo's side of the border but a progressive thinning of Santa Fé's forest. Woodcutters confirmed what the photographs revealed. Little by little, they finished off the pines from that area, carrying them off mule load by mule load to kilns in Santa Fé and, until the early 1980s, to carpentry workshops in Quiroga. As pine became scarce near the town of



**Figure 2.** Tree volume by stand in San Jerónimo and Santa Fé. *Source:* Sánchez 1998a and 1998b.

Santa Fé, woodcutters extended their trips and now frequently cut in the territory of San Jerónimo (Klooster 2000c).

Because of the combined influences of agricultural decline and intensified woodcutting, the forests of Santa Fé and San Jerónimo are increasing in extent but decreasing in quality. Woodcutting for kiln fuel decreases the forest's ability to meet the demands that people place on it. Furthermore, Santa Fé's woodcutting in the territory of San Jerónimo is a potential source of social conflict, like Quiroga's theft of wood in the past. These communities need a resource-management strategy that harmonizes people's demand for wood with the forest's ability to produce it.

### The Role of Local Knowledge and Practice in Santa Fé

One solution to the problem of forest mismanagement may be found in existing local cutting practices, ethics, and rules. Perhaps they could form the basis for intensified sustainable forest management, as Toledo (1991) and others have argued.

Woodcutters in Santa Fé already exercise sophisticated selection criteria that often avoids diminishing the living biomass of the forest. In Santa Fé, women and older men typically gather dry branches from the ground or glean the branches from trees that others have felled. They also find dry branches from bushes and acacia trees (*huizache*) in pastures and abandoned fields; much of the area from which they gather fuel lies outside the tree-covered forested areas surveyed by Sánchez (1998a, 1998b). During Masera et al.'s (1997a, 1997b) surveys, 45 percent of the woodcutters in Santa Fé and 22 percent of those in San Jerónimo reported that they mainly gathered deadwood.

There is a gender and age division of land use and ecological knowledge in these communities (see Rocheleau and Edmunds 1997; Rocheleau, Jama, and Wamalwa-Muragori 1995). Women play an active role in the collection of medicinal

and comestible wild plants, for example, but they rarely cut trees. Women and older men, for both cultural and sometimes physical reasons, eschew handling axes. Woodcutting is considered the work of young and middle-aged men, and the area outside town is considered a masculine territory, so when widows, single women, and wives whose husbands are engaged in other activities reluctantly gather firewood for the hearth or kiln, they go in groups, both to combat the spread of rumor and to enjoy each other's company. Because of this gendered division of forest use, men's knowledge of the forest and cutting activities have a disproportionate influence on trees in the forest.

Young men with axes and pack animals travel for hours to cut standing trees, but they also prefer deadwood because it is easier to transport and does not need time to dry. Woodcutters therefore seek dead or dying trees that have been burned or show signs of infestation from bark beetles or parasitic plants. In burned areas, scorched trees often bear the shallow mark of a woodcutters' axe, a test for dryness before cutting. In this way, woodcutters spare the trees that are most likely to survive. In 1998 and 1999, roughly half the wood I observed drying in front of houses consisted of small, dead branches and parts of burned or dead trees.

In addition to the practical considerations favoring the dry wood of dead trees over the wet and heavy wood of living trees, woodcutters in Santa Fé express, and partly practice, an ethic of woodcutting. They know which local oaks resprout after cutting and can survive continuous lopping for long periods; the forests of Santa Fé and San Jerónimo are full of trees that show evidence of lopping, resprouting, and continued vigorous growth, especially along paths and near the two towns. Woodcutters also say that cutting and gathering dry and diseased wood is better for the forest than cutting healthy trees and that it is better to travel a little farther to find such wood than to cut wood near town. They also say that cutting mature

trees is better than cutting young ones, which have not had a chance to grow.

Other than a ban on selling the community's wood to outsiders and on cutting trees in areas of reforestation, however, there are no formal restrictions on woodcutting in Santa Fé. Woodcutters who flout the incipient woodcutting ethic face no sanctions, either formal or informal. Woodcutters like Juan Luciano can clearly point out the kinds of mature and diseased trees that are proper for cutting, but he is very much aware that not everyone exercises this ethic. As Luciano told me while he was cutting wood, "The others don't have the same concern. I think it is best to cut only the big trees. I have sons, and if they don't get a profession out of going to school, they will have to support themselves with this same firewood. Other people just come to cut any which way. They just go somewhere, cut down a small tree, the right size for just one mule load of wood."

Woodcutters are usually in a hurry; "So we can leave soon" is a frequent explanation for why they choose what and where to cut. During the dry season, it is less critical to find dry wood because even the greenest pine dries quickly. Woodcutters who are eager to return to town and conduct other activities often cut the 15-cm-diameter living pines that are the easiest to fell and split and produce approximately a mule load of good wood. Although none of the woodcutters I accompanied admitted to cutting these young pines, numerous stumps of this diameter indicate that the practice is common. Even in areas of reforestation, where communal rules ostensibly prohibit cutting, stumps attest to cutting for building materials and firewood (Klooster 2000c).

### **Equity, Internal Differentiation, and the Ethic of Access**

This dearth of internal restrictions on woodcutting is related to internal differentiation and the social history of struggle over territory. Elpidio Domínguez's move-

ment galvanized indigenous identity in Santa Fé and focused it on a specific territory and the territorial rights that community membership entails. Community membership implies rights to land, water, clay, and forest resources. In practice, however, clay and firewood are the only resources with an egalitarian distribution of access, while agricultural land and house lots are effectively private and concentrated. Continued social differentiation in Santa Fé only increases the importance of access to the forest there, especially for the poorest community members. These poorest households often enter into patron-client ties with local pottery merchants, taking out loans in exchange for the promise of future sales, selling unfinished pottery to avoid the cash outlays for glaze, or selling pottery in town to avoid cash outlays for travel to sell elsewhere (Gortaire 1971; Zárate 1993; Dimas 1982). Cutting firewood is an important way to avoid money expenses in the production process and thus decreases exposure to obligations with local pottery buyers. Furthermore, selling firewood is an important source of income for a small number of woodcutters. Access to the forest thus partly compensates for the concentration of wealth in Santa Fé de la Laguna. This *ethic of access* (see Peluso 1996) is strong. Even trees and bushes in agricultural fields are available to all community members for cutting.

### **Local Knowledge Is Inappropriate**

Even if the ethic of selecting the "mature" or dominating pine trees in a stand were enforced, this might not be the best management approach for sustainable harvests of pine. Local knowledge draws parallels between the life cycle of individual trees and annual crop cycles or the life cycles of livestock; the big trees are "ripe" for harvest. It has little cognizance of longer-term processes of forest succession (see Balee 1993). Given the successional ecology of pine-oak forests, however, the selective cutting of pine speeds the transition to the dominance of oak. Pine requires

more intense disturbances than does oak; it does not regenerate well on the shaded forest floor (Snook and Negreros 1986; Styles 1993). By removing individual pines from a stand of trees, woodcutting in Santa Fé represents a kind of low-level disturbance that gradually eliminates the species without creating the conditions for its regeneration.

Other kinds of disturbance, especially fires and agricultural abandonment, are frequent, however. These disturbances do create the exposed mineral soils and high light-intensity conditions that favor the regeneration of pine. The effects of these disturbance patterns are also evident in the forest and are partly reflected in the statistic of oak dominance in Santa Fé. The least-disturbed stands are on the slopes of Mount Tzirate in the northwest section of Santa Fé (see Fig. 2), which are infrequently traversed by cigarette-smoking woodcutters and partly insulated from forest fires by moister conditions and their greater distance from the agricultural areas where many fires start. These oak-dominated, old growth-like stands were also subject to the selective cutting of pine by Quiroga woodcutters who sought large pines and firs for trays and furniture, however.

Furthermore, there have been sporadically successful reforestation efforts with pine, which are now the pine-dominated stands closest to Santa Fé. Similarly, the enrichment of pine through reforestation on the Santa Fé side of the San Jerónimo–Santa Fé border are reflected in higher figures for that species than would otherwise be expected in those areas.

The human impacts on the forests of Santa Fé are multiple and complex. Some are purposeful and others inadvertent, and their interpretation is complicated by history, patterns of disturbance, and spatial variation. Nevertheless, current woodcutting practices appear to have reduced the availability of pine. Woodcutters' recollections and observations, cross-sectional data, and time-series data of the increasing scarcity of pine seem to corroborate this

observation. If the local system of woodcutting is currently inadequate, can Santa Fé woodcutters develop a superior alternative that is based on local knowledge? This possibility seems unlikely because of the difficulties in monitoring the forest's response to their actions.

### **Monitoring Limits Evolution of the Local Knowledge System**

In Santa Fé, there is a great deal of knowledge about the forest. Many woodcutters know Purépecha names for trees, which correspond closely to the Linnean system of names of species, and the burning and construction qualities of different kinds of wood. Many are also intimately familiar with their territory, which is thick with Purépecha place-names that do not appear on official maps. Even though a given individual's estimates of how long a specific field was abandoned are often several decades at odds with what aerial photographs reveal, collectively, woodcutters remember some of the forest's history of fire, disease, and agricultural clearing. Woodcutters are also aware that they are traveling farther to find pine than they did in the past, and they easily recognize the border of San Jerónimo when they cross it. So why have Santa Fé woodcutters been unable to develop a more appropriate knowledge system to inform their woodcutting practices?

Santa Fé woodcutters face great difficulties monitoring the forests' response to their woodcutting techniques. First, the time scale of forest response to woodcutting is not conducive to woodcutter's learning. The successional cycle of pine-oak forests takes more than a century, and oral histories rarely transmit sufficiently detailed information on forest history or past woodcutting practices. Individual woodcutters cannot know the history of fire and disease and agricultural clearing that has also shaped the forest their woodcutting affects (see Balee 1993). Second, since woodcutters' actions are spatially disbursed and overlap, it is difficult for them to trace



the effects of their own actions over time or to know what other woodcutters have been doing in a given plot of forest. Furthermore, the appropriate management unit is bigger than the woodlot. Ultimately, the sustainability of the forest occurs at the landscape level, which must maintain a mosaic of stand ages and compositions (Baker 1992). Finally, Mexican villagers have increased spatial mobility these days. They spend a smaller part of their lives in the forest and intersperse woodcutting and livestock-herding activities in the forest with long absences for schooling, work in Mexican cities, and emigration to the United States. The learning context of woodcutters' forest management knowledge is different from that of a small-scale farmer, who exercises relative autonomy over a given plot; has a greater ability to experiment directly with different crops, cropping patterns, and weeding styles; and can see the results of such tinkering within a year or two. Local forest knowledge and cutting practices thus provide a poor foundation on which to base the intensified use of forests.

### Scientific Forestry's Approach to Management

Another possible method of harmonizing the demands for wood with the forest's potential to produce it is found in scientific forestry. The management plans recently prepared for Santa Fé and San Jerónimo measure stand volume and growth rates, quantify a sustainable cut, and use aerial photographs to map the information (see Fig. 2). The plans call for the application of the Mexican Method of Managing Irregular Forests (*Método Mexicano de Ordenación de Bosques Irregulares*), which seeks to maintain permanent forest cover, regularize the distribution of age classes, and allow low-intensity harvests.

In Santa Fé and San Jerónimo, for example, the method divides the forest into five blocks of three to seven management units each (*rodales*) and returns to each block

every five years (see Fig. 2). Depending on the characteristics of the stands within each management unit, foresters who implemented the method would choose to eliminate dominated, damaged, burned, and diseased trees, so that the stand would accumulate biomass more efficiently over time. Once the stand is dominated by large trees that no longer grow efficiently and prohibit the regeneration of pine, the plan calls for partial clear-cuts (*aclareo mediante selección*) to maintain one-third to two-thirds of the original tree cover, with surviving trees selected for good form and even spacing for efficient growth. In areas of moderate slope, partial clear-cuts can be sufficiently intense to allow regeneration through seed fall. Moderately intense cuts such as these maintain a regular distribution of age classes among stands and a diversity of species within stands (Sánchez 1998a, 1998b; for a critique of the Mexican Method of Managing Irregular Forests, see Snook and Negreros 1986).

The scientific forestry model must overcome several hurdles to contribute to resource management in communities like Santa Fé, however. First, it requires extreme spatial control, such that the forest is divided into zones of cutting, where other activities are excluded. The same right of unfettered forest access that complicates enforcement of the existing woodcutting ethic generates resistance to such spatial restrictions, especially when imposed by outsiders. Community members in Santa Fé clearly remember their recent struggle against land usurpers from Quiroga, so they view such spatial restrictions as a step toward expropriation. Several decades ago, when Mexican authorities promoted resin tapping in the forests of the Lake Pátzcuaro Basin, Santa Fé refused to participate in this income-earning nontimber use of the forest. Community members were unwilling to risk a de facto expropriation of their fuelwood resources by governmental foresters who would enforce management plans and spatial restrictions.

Second, to meet the needs of rural woodcutters, scientific forestry must overcome a bias toward the industrial production of pine-saw logs. Volume estimates, for example, come from methods focused on sawmill-sized timber. They ignore or poorly estimate deadwood, branches, bushes, and small-diameter trees, but Santa Fé woodcutters seek deadwood throughout the forest. They cut branches and resprouting oaks and make use of many other species besides pine.

Third, and most critical, scientific forestry is also a limited form of environmental knowledge. The case of the growth rates of oak is the clearest example. In highland Mexico, foresters' growth rates for pine come from in situ measurements of the spacing of growth rings, but oaks are not believed to produce reliable rings at this latitude. A common but arbitrary surrogate for annual growth is 2.5 percent of volume, which follows the practice of professional foresters who manage forests for the production of pine (Becerra, Reygadas, and Moreno 1997). There is little evidence to support this convention, however, especially given the ability of many oaks to resprout and survive lopping.<sup>4</sup> Scientific forestry, therefore, lacks reliable data on a basic parameter of forest management.<sup>5</sup>

The fourth limitation of scientific forestry as normally practiced in Mexico is the lack of explicit attention to monitoring the forests' response to logging. Sánchez's (1998a, 1998b) management plans for San Jerónimo and Santa Fé, for example, do not contain provisions for monitoring plots

or conducting follow-up visits to logged areas. No single section or subsection of the 65-page documents is devoted to monitoring; the stand-level effects of logging treatments are not systematically monitored. Information on cutting intensities and the presence of disturbances, such as forest fires, outbreaks of disease, or other disturbances, that might complicate the analysis of the forests' response to cutting is not routinely collected or accessibly archived. Long-term monitoring presumably occurs in the course of repeating forest management plans every 10 or 20 years. In practice, however, foresters rarely consult data from previous studies, which frequently used different inventory methods and cutting prescriptions. Finally, conventional forestry in Mexico monitors compliance through a federal environmental enforcement agency, but the goal of this monitoring is to mete out sanctions to offenders, not to assess institutional fit.

Nevertheless, scientific forestry—and forest ecology more generally—has the potential to make substantial contributions to monitoring the impact of different kinds of woodcutting interventions, including those prescribed by conventional management plans or experimental hybrid systems. Techniques may include long-term monitoring plots, periodic photography, data from remote sensing, more careful reporting of harvest data, and follow-up visits to logging sites.

## The Possibility of Integration

Sustainable development in forests requires management systems that are based on adequate knowledge of the resource and an institutional framework that encourages forest users' compliance with restrictions and prescriptions for action. Local indigenous knowledge and traditional management practices in Santa Fé do not have these characteristics. Existing ethics and rules do not include internal enforcement and a theory of stand or landscape management. They promote selection criteria that lead to stands

<sup>4</sup> Personal communication from Rafael Sánchez Concha, a professional forester working in central western Mexico and author of the management plans for San Jerónimo and Santa Fé.

<sup>5</sup> The dearth of information on growth rates for harvested and accompanying species is even more pronounced in tropical forests, where diversity is higher and Western management experience with homologous species is much shorter.

dominated by less-desirable species. Conventional scientific resource management also does not have these characteristics. It has little to say about management techniques for the kinds of nonlumber wood that woodcutters require and does not provide a reliable parameter of growth rates for the species that woodcutters prefer for cooking fuel. The greatest failure of scientific forestry, however, is its poor institutional fit. It assumes that there is a single actor with perfect control over rotating areas of cut and has no mechanism to adapt such restrictions to the multiple-actor environment of a village composed of hundreds of woodcutting households (Table 1 highlights these differences).

Although individually, neither scientific forestry nor the traditional woodcutting practices and ethics of these indigenous people are adequate for sustainable forest management, there are several complementarities that suggest the potential for integration. The greatest hurdle for local forest-management systems, for example, is the difficulty of systematically monitoring and reporting the response of forests to people's actions. The techniques of scientific forestry and forest ecology, in contrast, provide a basis for monitoring and reporting. The main barrier for scientific resource management is the lack of institutional fit, and this is where local knowledge and practice are the strongest.

**Table 1**

Summary Comparison of Management Goals and Characteristics of Scientific Forestry and Local Practice in Santa Fé de la Laguna

	Scientific Forestry	Local Knowledge and Practice
View of Ecology	Succession	Agricultural Cycles
Species focus	Pine trunks	Pine, oak, others; branches, deadwood
Selection within stands	Removal of dominated individuals Removal of diseased, damaged, imperfect, or dying individuals Save most "fit" for seed	Removal of dominating individuals Removal of "dry" individuals (fire-damaged, diseased, dead, and dying trees) Harvest "mature" so that young can grow
Stand renewal	Clear focus of management Partial clear-cuts to create conditions for pine regeneration	Inadvertent management Fires, insect damage, and agricultural abandonment create conditions for pine regeneration
Knowledge of resource	Aerial photographs Sampling of vegetation Maps Management plan	Walking and seeing
Recordkeeping and communication	Writing, maps, aerial photographs	Memory, oral history
Monitoring	Comparisons with management plan	Personal experience
In situ experimentation	Inadvertent and unaware	Inadvertent and unaware
Institutional monitoring	None	Community assemblies Woodcutters' observations of each others' behavior
Equity	Not an issue	A central concern Ethic of access
Space	Tight control, zoning, view from above	Freedom of movement, view from the path
Power	Concentrated in foresters and the state	Dispersed among woodcutters

## The Adaptive Management Approach

As has been argued by a small group of scholars for some time now, an integrated knowledge system may better facilitate the sustainable use of natural resources like forests (Altieri and Hecht 1990; DeWalt 1999). Berkes, Folke, and Colding (1998) presented one of the more advanced proposals for the integration of scientific and local management systems. Pointing out the frequent institutional failures of conventional scientific management and recognizing the institutional and knowledge resources of local people, they called for adaptive management. Their approach emphasizes the opportunity for environmental feedback to shape policy. It is a process through which people learn about the potentials of natural populations to sustain harvesting mainly through experience with management itself, rather than through basic research or the development of general ecological theory (Walters 1986). As Berkes and Folke (1998, 11) noted:

Adaptive management is a relatively new approach in resource management science, but its common-sense logic that emphasizes learning by doing and its elimination of the barrier between research and management resemble traditional resource management systems. Both rely on feedback and learning, and on the progressive accumulation of knowledge, often over many generations in the case of traditional systems. Adaptive management has the advantage of systematic experimentation and the incorporation of scientific research into the overall management scheme.

Adaptive management explicitly considers social learning and institutional evolution, and these require active monitoring that is designed to achieve understanding and to identify remedial responses (Gunderson, Holling, and Light 1995, 9). A typical weakness of conventional scientific resource management is the way it ignores the local knowledge of resource users. The

quotidian environmental knowledge of such people has great value, especially for monitoring (Pálsson 1998; see also Zimmerer 1994). But monitoring will also benefit from the tools of scientific resource management; it enables social learning (see Fig. 3).

Robbins (2000) analyzed how conflict and collusion among knowledge groups may lead to the creation of unquestioned commonsense notions about the cause of forest degradation that partly determines the goal of management in an Indian forest. In his case study, diverse groups of villagers and foresters attributed the decline in the forest to different social causes.

Whether or not locals are actually degrading the forest through browsing and fuelwood collection or foresters are actually dismantling the forest through bribery and tree harvesting are not the most immediate questions. In either case, the account that prevails as truth will narrate who controls the forest and what form the strategy of conservation will take. The normal view of the forest, the normal account of ecological change, and the normal management system will be dictated through the creation of discursive hegemony. (Robbins 2000, 141)

For the sake of the people who depend on it for fodder, fuel, and building materials, however, it does matter whether this Indian forest is degrading under fuelwood cutting or illicit logging. The normal management system *ought* to correspond to the actual situation in the forest. Environmentally adequate systems of knowledge inspire human actions that, in turn, have the desired and expected environmental effects. They permit subsequent rounds of using the environment. Under adaptive management, explicitly gathered environmental information contributes to an understanding of environmental change that informs and underlies a socially embedded process of environmental management.

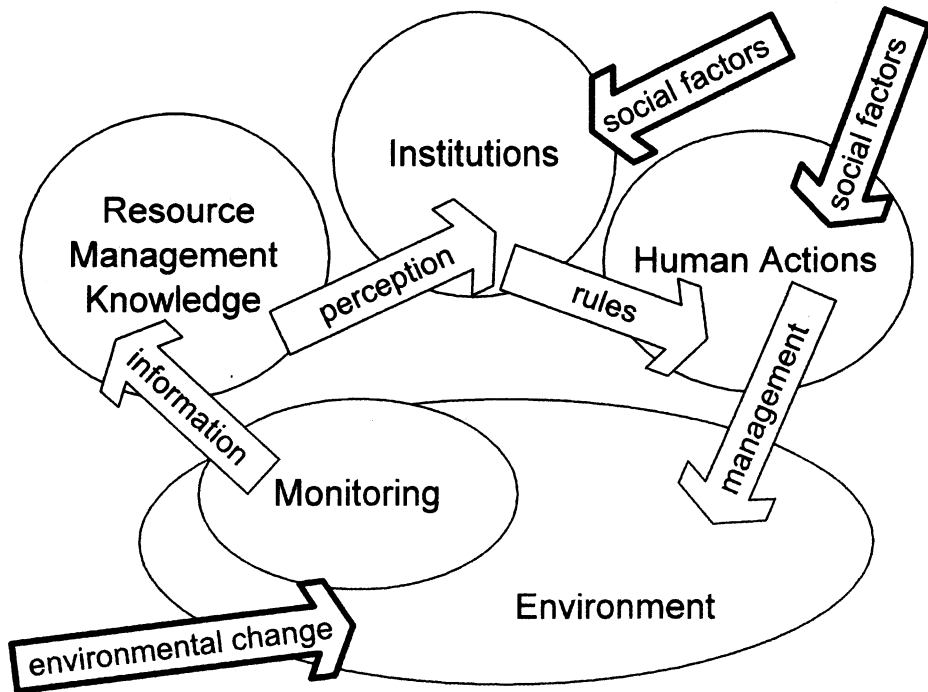


Figure 3. An heuristic model of adaptive management.

### Community Forestry in Mexico

In Mexico's commercial-quality forests, community forestry sometimes approaches the adaptive management model. In Mexico, community forestry refers to community-based logging businesses operating under the tenets and controls of scientific forestry and state regulation. Hundreds of communities have been able to integrate some of the practices of scientific forestry into their traditional common-property management traditions—logging in accordance with sustainable management plans, restoring productivity to damaged zones, reforesting abandoned agricultural areas, patrolling forest territories to prevent illegal cutting, and implementing the necessary restrictions of sustainable forestry fairly and effectively. Community forest management provides some of Latin America's most impressive examples of sustainable development (Bray 1998;

Klooster 1999; Merino 1997; World Bank 1995; Jaffee 1997). In most cases, community forestry relies on frequent community assemblies in which the participants discuss forest management and delegate administrative authority to selected community members. Through the adaptation of the restrictions of scientific forestry to community management traditions and ethics, successful communities avoid the problems of poor institutional fit that often plague conventional scientific resource management and accompanied past approaches to forestry in Mexico (Klooster 1996, 2000c; Bray and Wexler 1996; World Bank 1995).

A small number of these communities are developing their own versions of adaptive management that are based on village participation, professional forestry techniques, monitoring, and accountable experts on resource management. Four logging communities in the Zapotec-



Chinantec Union (Uzachi), for example, evaluate the forest's response to logging with 27 permanent-monitoring plots and 15 erosion-monitoring sites. They consider the habitat needs of commercial mushrooms in their management plans and set aside conservation, woodcutting, and watershed management zones (F. Chapela 1999; F. Chapela and Lara 1995; Bray 1991). Similarly, some of the Mayan communities of Quintana Roo are beginning to tackle the difficult questions of managing diverse tropical forests for more than just a few species of valuable timber. In an explicit recognition of the limited scientific knowledge base for tropical forest management, they also established permanent monitoring plots and periodically reevaluate their forest inventories (Santos, Carreon, and Nelson 1998; Lanz, Arguelles, and Montalvo 1995; Bray, Carreon, Merino, and Santos 1993).

### Potential Techniques for Adaptive Community Forestry

All the examples of adaptive community forestry in Mexico are in forests of commercial quality. But what may adaptive management look like in commercially marginal forests that are used by multiple households for fuelwood and craft inputs, like those of Santa Fé and San Jerónimo? A consideration of participatory mapping and rural appraisal techniques, discussions with forester Rafael Sánchez Concha, discussions with NGO practitioners<sup>6</sup> who are familiar with Santa Fé and San Jerónimo, and, most important, talking about the issue with village members and authorities from Santa Fé and San Jerónimo permit a preliminary—and explicitly speculative—outline of the approach. Adaptive management requires at least three attributes: better communication between villagers and foresters; participatory monitoring; and

systematic experiments in institutional adaptation.

Adaptive management would require better communication of management goals and forest knowledge between local Purépecha forest experts and university-trained managers, such as foresters and ecologists. The Mexican experience with participatory rural appraisals in forest communities suggests a number of cross-learning techniques (F. Chapela and Lara 1996). Transects, or “walking workshops,” for example, could facilitate communication about the local goals of forest management and the character of indigenous knowledge of forest management. These transects would involve a facilitator and a core of local experts on vegetation, especially older men and women. In a transect through different types of vegetation, including abandoned fields and areas of recent forest fires, these local experts could identify trees with Purépecha and Spanish names and comment on their firewood and other uses, whether the species is more or less common than in the past, the species' requirements for regeneration, and the best way to harvest the species. Women could point out the medicinal and comestible plants with which they are particularly familiar. Collections made during this process could be identified by botanists who are familiar with the local vegetation and local knowledge compared to the botanical literature.

Professional foresters, ecologists, and botanists could accompany the local experts on some of these transects, but they should not dominate conversations, in accord with the objectives and philosophy of participatory rural-appraisal methods (Chambers 1983, 1997; Schoonmaker Freudemberger 1994; Oltheten 1995). In addition, the variation in both locals' and foresters' knowledge should be ascertained through an approach like Robbins's (2000), using preference sorts of forest photographs, conversations, and written questionnaires. Once the extent of local forest knowledge is clear, however, these resource-management professionals could

<sup>6</sup> Especially Jaime Navia, Omar Masera, Miriam Ramírez, Virginia Puentes, and other professionals with GIRA.

discuss and compare their understanding of forest succession, technical approaches to selecting trees for felling, and the philosophy of rotational cutting and engage in more general conversations about forest management.

Adaptive management would also require systematic monitoring, data gathering, and appropriate ways of reporting data to gatherings of villagers and village leaders. Otherwise, resource users can only guess at the results of the iterative social and environmental experimentation inherent in management practice. Monitoring should be participatory. If it remains the purview of expert resource managers, woodcutters are denied a chance to participate in the interpretation of results and are unlikely to undertake institutional change. Test plots should be established to monitor the forest's growth and response to woodcutting. In particular, they should establish local growth rates of oaks and the forest's response to different styles of woodcutting and fallowing. Although the results of many of the monitoring experiments would not be obvious for many years, the experiments would also provide an arena for continued conversations and learning among community members, foresters, and ecologists. Experience with test plots in community management of logging cooperatives could guide monitoring experiments (Santos, Carreon, and Nelson 1998; F. Chapela 1999).

Various modern technologies can facilitate communication and the participatory interpretation of results. Repeated photography at eye level, perhaps using the Global Positioning System, could serve as a valuable conversation stimulator in the field and facilitate communication with community assemblies about succession and the effects of woodcutters' selection criteria. Similarly, remote sensing is increasingly appropriate for the participatory monitoring of change and persistence in forest cover and could facilitate communication in village gatherings. Villagers could take aerial photographs and appropriate projections of satellite images with

them on the walking workshops to discuss the type of forest and changes to it.<sup>7</sup> They could also gather Purépecha place-names and locate them on the images. Doing so would help demystify the spatial data presentation of scientific forestry. The techniques of participatory territorial mapping could inform some of these approaches to gathering and communicating forest data (Momborg, Atok, and Sirait 1996; Poole 1995a and 1995b). Eventually, Geographic Information Systems (GIS) might also play a role in monitoring forests and communicating the results of management. However, GIS is a decision-making tool that favors certain kinds of information and disproportionately empowers experts who necessarily filter the information they encode, analyze, and display. The use of GIS in village-level adaptive management will require local capacity building and a participatory process that is designed to counter its top-down tendencies (Harris, Weiner, Warner, and Levin 1995).

Adaptive management also implies institutional experimentation, in which communities adapt existing institutional resources to solve management problems and evaluate whether these adapted resources work. Over the past several decades, the Mexican federal government and the Michoacán state government have promoted reforestation efforts in highland Michoacán, including abandoned agricultural fields above the towns of Santa Fé and San Jerónimo. Several of these areas now support dense stands of 15-cm-diameter pine trees that could benefit from well-managed thinning cuts that produce building posts and firewood for the communities' use. Such thinning cuts could be experiments to discover appropriate institutional forms of organized, intensified forest management. They would help the communities learn which of their orga-

<sup>7</sup> Specific techniques could be modeled on the fieldwork methods used by the Center for the Study of Institutions, Population and Environmental Change, Indiana University.

nizational traditions are most useful for stand control, for coordinating woodcutting in specific places, and perhaps for distributing the fruits of harvesting the forest. With the participation of a professional forester indicating which trees to fell, thinning cuts could simultaneously provide another arena for discussing and testing different selection criteria.

Through these participatory-monitoring activities and management experiments, the communities and collaborating foresters and ecologists could learn about each other's management goals, knowledge, and techniques. They would learn to evaluate what kinds of cutting guidelines and management practices are both effective and socially appropriate. In doing so, the communities would establish an iterative process of management and learning about the social and environmental effects of adaptive management.

### Barriers to Institutional Innovation

The adaptive management approach just outlined requires the adoption of numerous novel institutions to help coordinate people's behavior. Even institutional experiments in reforestation, for example, would require some kind of an agreement (an institution) to conduct the experiments. Creating novel institutions, however, requires people to take action to change their existing institutional framework.

In Santa Fé, internal differentiation, equity goals, and the conflation of community identity with unrestricted rights to firewood constitute an ethic of access, which presents a formidable barrier to institutional change. In open-ended interviews, however, most woodcutters and village authorities expressed the belief that woodcutters would respect specific institutional changes, such as experimental zones where cutting was temporarily restricted, *only if* there was a general agreement, arrived at by consensus in the village's general assem-

bly. None denied the possibility. Although general and speculative, informants' statements affirmed the *prospect* of adopting new forest-management institutions. At the same time, the informants identified the need for a consensual agreement, which would require frequent discussions and contentious debates in lengthy community meetings. In Santa Fé and elsewhere, people need strong motivations to invest time and energy in messy struggles to construct institutional alternatives (Ostrom 1990; Klooster 2000a).

Lack of motivation is the central barrier to innovations in forest-management institutions. Two contrasting experiences with reforestation in Santa Fé illustrate this issue. One of the most successful reforestation events took place in the late 1970s, during the period of struggle against land usurpers from Quiroga. In that tense and urgent atmosphere, a mobilized community adapted existing institutions to organize forest patrols. Under Domínguez's leadership, the community assembly authorized forest patrols, and each of the community's eight distinct neighborhoods, or *barrios*, imposed communal labor taxes (*faenas*) and organized armed brigades to inspect a given part of the forest, confiscating the axes and animals of any woodcutters they found. This was a novel application of the community's institutional resources; previously, the *barrios* organized *faenas* only to coordinate religious celebrations or to construct roads and public buildings. The community subsequently adapted that institutional innovation to reforestation, using *faenas* organized by *barrios* to plant seedlings supplied by a governmental reforestation program. That area of reforestation is now a vigorous young forest of pine. This example clearly illustrates the potential for indigenous communities, such as Santa Fé, to make use of traditional institutional resources for novel purposes, as observed in experiences of community forestry elsewhere in Mexico (Klooster 2000a).

A 1999 reforestation effort was much less successful. In response to a similar governmental reforestation program, communal authorities paid a small group of community members to erect a barbed-wire fence and plant seedlings in an area of abandoned agricultural lands selected by governmental officials. The fenced-off area was previously used for grazing and intercepted a well-worn path, and the woodcutters refused to walk around the fenced area. They demanded the installation of a gate, and the communal authorities complied. Despite the authorities' repeated admonitions, however, the woodcutters consistently failed to close the gate after they passed through it. Cattle entered and trampled the pine and cedar seedlings, so that few took root.

This differential outcome of reforestation efforts reflects the disparity in community motivation in 1980 and 1999. In the first example, struggle against a clear external threat created an atmosphere of community mobilization, with frequent and active community assemblies. Under those circumstances it was relatively easy to extend an already-active institutional form to consolidate and demonstrate the community's recent control over Quiroga's theft of wood by planting trees in an area of the community's choosing. Currently, the assembly meets infrequently and attendance is poor, so getting meaningful participation and general agreement about how and where to reforest would require an almost-Herculean effort of communication and cajoling from communal authorities.

Currently, community members do not care about forest management nearly as much as they cared about mestizos usurping their land. This lack of local urgency to address forest management issues is the biggest barrier to innovations in forest management. The lack of motivation to change has two aspects: the absence of a perception of scarcity and the absence of a perception of the potential benefit of change (see Ostrom 1990, 210 ff.).

First, problems from the scarcity of pine are not sufficiently intense to motivate villagers to participate in the collective action required to change forest-management practices. Because of past reforestation and the recovery of pine trees following forest fires and agricultural abandonment, woodcutters may be able to "muddle through" with existing cutting practices without an immediate, change-galvanizing crisis. Furthermore, porous borders hide the costs of failing to invest in new resource-management institutions. The ability of Santa Fé's woodcutters to leave their territory and cut in San Jerónimo's forest partly drowns the feedback of scarcity from the environment. It is easier to walk farther in search of wood than it is to organize neighbors or invest time in collaborating with an NGO's attempts to conduct management experiments. Second, the benefits of change are far from obvious. Neither the local cutting ethic nor scientific forestry provides a clear and compelling vision of what may be gained from change.

Furthermore, an inhospitable macro-institutional environment reinforces these barriers to community-level change in forest-management institutions. The prevailing perception of drastic deforestation prevails among urban voters and policymakers in this region and has led to restrictive forest policies, including a ban on logging the Lake Pátzcuaro Basin<sup>8</sup> (Klooster 2000c). Current policy precludes experiments with the community forestry route to intensifying use of the forests. Although communities like San

<sup>8</sup> The ban, and the informally institutionalized corruption associated with it, favored the forest bureaucracy and sawmill owners at the expense of communities (Alvarez-Icaza and Garibay 1992; Garibay 1996). The social imposition of the view that a natural equilibrium must be protected from human interference leads to social injustice and environmental malaise (Zimmerer 2000).

Jerónimo have enough forests for a modest commercial logging business, they have no legal route for making productive use of the forests and little incentive to protect their forest resources against organized timber thieves or small-scale woodcutters from other communities. At the same time, the dearth of legal options has deadened community members' ability to imagine forest-management scenarios that are superior to the status quo. The evolution of novel forest-management institutions, including some form of adaptive management, would require legal openings to allow new styles of community forestry and to create the means and incentives for communities to restrict outsiders' access to their forests. Under these conditions, communities would better recognize the value of their forests and the relative scarcity of forest resources, and might begin to envision better alternatives than current management methods.

At that point, personnel who are experienced in participatory techniques could catalyze community-level experiments in adaptive management.<sup>9</sup> In a specific context like San Jerónimo and Santa Fé, where forest uses differ between the communities and there are cross-boundary cutting issues, outside catalyzers would need to work with both communities, helping them discover mutually acceptable agreements on woodcutting restrictions, compensations, and continued access to avoid sudden territorial closures and the risk of conflict. Over time, successful demonstrations of adaptive environmental management would change perceptions of the potential benefits of change and motivate villagers to construct their own versions of adaptive management.

<sup>9</sup> The global environmental services provided by forest protection may offset some of the costs (Klooster and Masera 2000).

## Conclusion

In highland Mexico and similar areas of marginal agriculture and inhabited forests, the viability of agriculture decreases amid current patterns of global economic integration, and so forests are increasingly a source of fuel, nontimber forest products, and raw materials for craft industries. In the neighboring indigenous communities of Santa Fé de la Laguna and San Jerónimo Purenchécuaro, pottery production has created livelihood opportunities that agriculture no longer provides. The resulting intense woodcutting for kiln fuel has led to a scarcity of wood, however. These communities, and others like them, would benefit from forest-management systems that would enable the sustainable intensification of forest use.

Local woodcutters have a great deal of knowledge about the forest and can express a woodcutting ethic, but neither has been sufficient for successful forest management. A professional forester recently prepared forest-management plans for these communities. In the context of a common-property territory, numerous indigenous woodcutting households, and a poor fit with the kinds of wood needed for pottery production and cooking, however, scientific forestry does not provide an adequate basis for forest management either.

Adaptive management calls for the integration of these kinds of knowledge in a flexible system in which management consists of a series of systematic experiments (Berkes, Folke, and Colding 1998). Similar to the situation in successful traditional resource-management systems, adaptive managers iteratively adjust their behavior in accordance with the careful and constant monitoring of both social and environmental aspects of the system. In communities like Santa Fé, however, one of the greatest failures of local knowledge comes from difficulties in monitoring and communicating the results of woodcutting techniques. Conventional scientific forestry and forest ecology provide a suite of monitoring tools



that could contribute to an integrated, adaptive, management system.

The worst hurdle for conventional scientific forest management, on the other hand, is the poor institutional fit between foresters' restrictions and forest users' social structures and customs. Adaptive management eliminates this stark separation between expert resource managers and disempowered resource users. It pays greater attention to the social side of resource-management systems, including institutional fit. In integrated adaptive management, traditional systems, such as those found in Santa Fé, are a source of institutional capacity for the flexible implementation of resource-management restrictions and prescriptions.

Adaptive management, therefore, has the potential to integrate local forest knowledge and traditional self-organization with the monitoring and data communication abilities of scientific forest management. In Mexican communities like Santa Fé and San Jerónimo, creating an adaptive management system involves at least three functions. First, it requires better communication and cross-learning between university-trained resource managers and local experts, perhaps through participatory resource-appraisal exercises. Second, participatory monitoring and appropriate data reporting should enable resource users to assess the impact of different woodcutting techniques and learn from the successes and failures of management. Third, through experiments in institutional design, village communities could discover socially appropriate ways of coordinating users' behavior to cut in prescribed ways.

Several barriers block these kinds of steps toward an integrated, adaptive management system, however. Internally, an ethic of access discourages institutions that restrict woodcutting. At the same time, porous community boundaries dissipate perceptions of the scarcity of wood, removing incentives for people to craft better woodcutting institutions. Externally, state support for enforcing the boundaries of

common-property territories is limited. Furthermore, current forest policies inhibit communities' productive use of forests; they make it difficult even to imagine alternative forest-management systems. The state, therefore, has a role in creating a framework within which adaptive resource management policies may evolve.<sup>10</sup> Outside intervention could also modify the dynamics of institutional evolution. Actors, such as NGOs, could collaborate with resource-owning communities to develop adaptive forest-management models, demonstrating viable alternatives that stimulate villagers' imagination and motivate their collective action to develop new forest-management institutions. A different policy context would lower the barriers to change, and forest-owning communities could explore paths toward adaptive resource-management systems that modulate human needs with the discordant harmonies of intensively used, "second nature" forests (see Zimmerer 2000; Botkin 1990).

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<sup>10</sup> Part of this role will include coordinating community forest owners to better address the spatial dynamics of sustainable uses of forests at the landscape scale.

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