BACK TO THE FOREST
Exploring Forest Transitions in Candelaria Loxicha, Mexico

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Abstract: Declining profitability of agriculture and/or higher prices of forest products and services typically drive an increase in forest cover. This article examines changes in forest cover in Candelaria Loxicha, Mexico. Forest cover increased in the area as a result of coffee cultivation in coffee forest-garden systems. Dependence on forest products and services, and not prices of forest products, drive the process in our study site. Low international coffee prices and high labor demand outside the community might pull farmers out of agriculture, but they do not completely abandon the lands. A diversification in income sources prevents land abandonment and contributes to maintaining rural populations and coffee forest gardens.

INTRODUCTION

The forest transition theory, originally developed from a pattern observed in industrial countries in Europe and North America (Perz 2007), suggests that the area covered with forests changes in predictable ways as societies experience economic development, industrialization, and urbanization. Initially, a large decline in forest cover occurs, but at some point, the trend reverses and a slow increase in forest cover takes place (Rudel, Coomes et al. 2005).

According to forest transition theory, two major forces can explain reforestation. One is associated with the decline in agricultural rent, typically due to better nonfarm employment opportunities. Marginal lands are abandoned and reforestation takes place; this is referred to as the economic development path. The second is associated with an increase in the price of forest products, for example, as a result of the scarcity of such products from deforestation. This offers incentives for farmers to plant trees instead of crops on their lands and has been called the forest scarcity

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path (Mather 1992; Mather and Needle 1998; Rudel 1998; Rudel, Coomes et al. 2005; Angelsen 2007).

Contrary to what has been observed in Europe and North America, in Latin America, forest transitions tend to vary with the increased diversification of rural livelihoods (Rigg 2006). Neoliberal globalization has produced a series of changes in rural Latin American livelihoods that affect forest transition trajectories in the region. In contemporary Latin America, the economic development path and the forest scarcity path might coexist, as smallholders pursue a diversified livelihood strategy, or the "road of many returns" (Rudel, Bates, and Machinguiashi 2002, 89).[1] Smallholders might try to combine economic activities in both urban and rural settings, both in their own country and abroad. These livelihood strategies would allow for the recovery of some forest, because smallholders reduce their pressure on the land when they begin to earn significant amounts of nonfarm income. Although some land is left to reforest, production may intensify on other sites as new opportunities arise (Bebbington 1997), but also some plots might be enriched with productive trees (Rudel, Bates et al. 2002). Evidence of these strategies has been observed in Java (Indonesia), Bolivia, and Mexico (Preston 1989; Preston 1998; Klooster 2003).

Understanding modern (tropical) forest transitions requires taking into account local contexts, as particular factors (e.g., history, environment, institutions) might lead to different outcomes. Also, the interconnectedness of the world, in terms of mobility of people, capital, goods, and ideas, is quantitatively larger and qualitatively different now from in the past.

This article explores the factors associated with increase in vegetation cover in a municipality in southeastern Mexico. The study focuses on a managed forest (Wiersum 1997). In many forest transition studies, the definition of *forest* excludes trees in agricultural production systems.[2] We find this problematic, as agroforestry systems and managed forests in tropical landscapes cannot be ignored: they sustain the lives of millions of people (Clay 2004) and contribute to the conservation of biological diversity (Perfecto and Vandermeer 2008). Managed forest and agro-forests might be among the few remaining areas with significant tree canopy cover in some areas of northern Latin America (Perfecto, Rice et al., 1996; Perfecto, Vandermeer et al. 2005; see also Hecht et al. 2006). It is important to understand the mechanisms that have caused vegetation cover increases in these landscapes so as to better target policy interventions.

1. With respect to those changes, Kay (2004) highlights replacement of tenant labor by wage labor, growth of temporary and seasonal wage labor, increasing feminization of rural wage labor, urbanization of rural workers, and the growing importance of nonfarm employment and incomes.

2. Because many large-scale studies are concerned with cross-country comparisons (e.g., Rudel et al. 2005), they have used the definition of forests by the Food and Agriculture Organization (FAO), which explicitly excludes agroforestry (FAO 2006).

This article is organized as follows. First, we outline a conceptual framework guiding our research questions; then we summarize insights from forest transition studies in Latin America and describe the site where this study was conducted before presenting and discussing our findings.

CONCEPTUAL FRAMEWORK

Forest Transition Theory

Forest transition is a concept used to describe systematic changes in forest cover over time as societies experience industrialization, urbanization, and general economic development (Mather 1992; Mather and Needle 1998; Rudel 1998). From initially high points, forest cover declines as a result of drivers linked to agricultural expansion. But at some stage, agricultural expansion stops, forests become more valuable, and the forested area slowly recovers. In this process, known as the forest transition, forest cover typically follows a U-shaped curve (Rudel, Lugo, and Zichal 2000; Perz and Skole 2003a, 2003b; Mather 2008).

The precise mechanisms that operate in forest transitions vary across locations (Perz 2007; Mather 2008), but two major paths have been recognized to initiate the stage of forest cover stabilization and growth: economic development and forest scarcity (Rudel, Coomes et al. 2005).

In the economic development path, better-paying nonfarm employment opportunities pull labor out of agriculture and often out of rural areas. Agriculture on marginal lands is abandoned and the lands reforest (Rudel, Coomes et al. 2005; Angelsen 2007). This path has been commonly observed in affluent countries, but examples are also found in developing countries. Other factors, such as soil degradation, can also lead to agricultural abandonment (Angelsen 2007).

In the forest scarcity path, shrinking forest cover and higher demand for forest products due to population and economic growth raise the price of forest products. This increases the incentives for landowners to plant trees instead of crops or pasture, thus resulting in reforestation (Rudel, Coomes et al. 2005). In addition to forest product scarcity, forest recovery can result from high local dependence on forest products and forest-based environmental services (Angelsen 2007).

Although these are broad trends, changes in domestic policies, local institutions, agricultural technologies, and fallowing practices are important in shaping forest transitions (Perz and Skole 2003a, 2003b; Hecht et al 2006; Angelsen 2007; Perz 2007). Furthermore, global forces also play a role, as illustrated in our case study with international coffee prices and international migration opportunities.

Forests can be categorized according to the degree of human intervention (Wiersum 1997). Natural forests consist mainly of native tree species,

and interventions are restricted to tolerant forest management (e.g., natural regeneration slightly manipulated to stimulate the frequency or abundance of useful trees). In managed forests, tree vegetation consists predominantly of indigenous vegetation managed to increase the frequency and productivity of beneficial species (i.e., through thinning, harvesting, and trimming) and planting of native and/or exotic species. Forest plantations consist of forest stands established by planting and/or seeding trees; these forests consist of introduced species or intensively managed stands of native species. Only one or two tree species are planted, with even age classes and regular spacing between trees.

Although the forest transition theory focuses on overall forest cover, the type of vegetation cover resulting from forest transitions is important in terms of differences in species composition, vegetation structure, and sequestration of atmospheric carbon (Perz and Skole 2003a, 2003b; Perz 2007). Biophysical and ecological differences between vegetation cover have important implications for the resources available to people using the forest, and consequently for patterns of land-use change (Perz 2007) and for biodiversity and ecosystem processes. Vegetation cover differs depending on whether reforestation results from the economic development path or the forest scarcity path. In the first scenario, relatively more land will revert to unmanaged forests through natural regrowth. In the latter, a relatively larger share is likely to be managed forests and/or plantations (Angelsen 2007). We return to this issue in discussing our findings.

As opposed to Europe and North America (Staaland et al. 1998; Mather 2001; Houghton and Hackler 2000; Rudel 2001), rural livelihood strategies that are gradually diversified usually characterize forest transitions in the tropics. Migration, nonfarm employment, land abandonment, reforestation, and the enrichment of some plots with productive trees commonly interact in a dynamic way. Current patterns of urbanization and industrialization encourage diversified livelihoods in which remittances and temporary jobs help maintain rural households and support existing livelihoods strategies (Rigg 2006). In the following section, we summarize the directions that forest transitions are taking in Latin America.

Forest Transitions in Latin America

Studies on forest transitions conducted recently in Latin America suggest that processes and outcomes in reforestation differ from the patterns observed in the past in Europe and North America (Aide and Grau 2004).

Forest transitions occur at various scales. Although net reforestation might not be observed at the country level, at microlevels of analysis, it is possible to identify regional or local processes of forest gain (Rudel, Coomes et al. 2005). Site-specific previous land-use dynamics determine

current patterns of reforestation (Rudel and Perez-Lugo 2000; Perz and Skole 2003a, 2003b; Sloan 2008).

Neoliberal policy changes, particularly in the agricultural sector, are transforming local livelihoods in rural areas (Kay 2004). The removal of subsidies to agriculture (a central element in neoliberal policies) differently affects large- and small-scale farmers in the region. The former tend to abandon farming (with consequent reforestation), whereas the latter diversify their economic portfolio with nonfarm income-earning activities, international migration, and remittances and temporary migration to urban areas (Klooster 2003; Hecht et al. 2006; Kull, Ibrahim, and Meredith 2007; Sloan 2008; Redo, Bass, and Millington 2009). This diversification prevents the abandonment of rural areas in the region, and either reforestation or limited change in forest area can be observed. Some studies (e.g., Izquierdo et al. 2008) report depopulation of rural areas, but no clear relationship with reforestation, whereas in other cases, depopulation resulted in reforestation (Rudel, Lugo et al. 2000).

Incentives for large-scale reforestation induce the involvement of private actors, who otherwise are reluctant to participate in this type of project. Small-scale farmers might be excluded from participating in such enterprises because of capital or land constraints (Sloan 2008). Areas with large-scale commercial reforestation are usually reforested with exotic species. Hence, the total area reforested increases, but biodiversity might decrease (Izquierdo, De Angelo, and Aide 2008; Sloan 2008; Baptista 2008). Incentives that do not exclude small farmers from participating might result in reforestation in small-scale properties (Kull et al. 2007). The expansion of agroforestry systems (mainly coffee) is also associated with increase in forest cover, when these systems are counted as forests (Hecht et al. 2006; Redo et al. 2009). Reforestation resulting from the abandonment of small-scale agriculture, particularly coffee, has been reported in Puerto Rico. In that case, depopulation of rural areas and migration to cities also have been reported, but Puerto Rico is an exceptional case because of its special relationship with the United States (Rudel, Lugo et al. 2000).

Contextual factors prove important in explaining local- or country-level forest transitions. Unfavorable commodity prices (e.g., for beef and coffee) affect the resurgence of forest (Rudel, Lugo et al. 2000; Kull et al. 2007). In El Salvador, the civil war caused the reduction of livestock production and hampered change in coffee production. The agrarian reform that followed the end of the war gave land to small-scale farmers who adopted agroforestry systems. All these factors contributed to an increase in the total area reforested. In Costa Rica, tourism-related property investment and forest conservation initiatives are correlated with reforestation. In an area in Michoacán, Mexico, the agricultural frontier has contracted despite growing populations, and reforestation is observed, but forest use

instead of promoting forest conservation (as predicted by the forest scarcity path) has resulted in a degraded quality of forests (Klooster 2003). Also in Mexico, lowland settings with cattle ranching and little out-migration induce deforestation, whereas highland regions with significant sources of nonfarm employment and out-migration are associated with reforestation (Rudel 2008).

Although some of the relationships hypothesized in the forest transition theory are found in some sites in Latin America (e.g., depopulation correlates with reforestation), no clear pattern is observable across the region. In areas where reforestation is taking place, rural out-migration is not always present.

Another issue is what counts as forests. Agricultural systems that include trees might contribute to reforestation, but the systems have to be recognized as forests. It is perhaps more appropriate to refer to forest transitions (plural) in Latin America (table 1).

In Latin America, given the effects of neoliberal policies on agriculture, a changing array of rural economic activities, which might decouple rural livelihoods from farming, are more significant than rural depopulation in explaining changes in land use that eventually lead to reforestation. The relationship between reforestation and deforestation depends on specific local institutions, national policies, and global economic changes (e.g., commodity prices, international migration, remittance flows). These may have different impacts on local economies, which in turn affect local demographic dynamics and livelihood strategies.

BACKGROUND AND STUDY SITE

We selected coffee forest gardens (as defined by Wiersum 2004) as our case study based on the following rationale: northern Latin America accounts for 34 percent of global coffee production, involving 3.1 million hectares of land, 33 percent of which are managed as forest gardens (Rice 1999). Despite differences in individual country processes, the coffee landscape in northern Latin America is strikingly similar across countries (Rice 1999). A case study can therefore offer insights relevant for more than just the particular site. Second, coffee prices have reached record lows during the past fifteen years (for a detailed account, see Daviron and Ponte 2005), which could induce farmers to cut down their (managed) forests and plant new crops or pasture (Perfecto et al. 1996; Perfecto et al. 2005). So-called agricultural landscapes in Latin America are complex mosaics of patches of vegetation of different types with unclear distinctions between agriculture and forest. Hecht and colleagues (2006) suggest the category "anthropogenic forests" to refer to human modified landscapes. Vegetation types that do not fall under a definition of *forest* without human intervention have largely been invisible (Michon 2005). These types of forest might

Table 1 Summary of Factors Involved in Forest Transitions in Latin America

Country/ author	Cattle ranching	Agroforestry	Local nonfarm employment opportunities	Out-migration/ abandonment of rural areas	Remittances	Resulting type of tree cover
Panama (Sloan 2008)	Yes	No	Yes	Yes/no	No	Commercial reforestation (exotic tree species)
Ecuador (Rudel, Bates et al. 2002)	Yes	Yes	Yes	Yes/no	No	Trees in agricultural systems
El Salvador (Hecht et al. 2006)	Yes	Yes	No	Yes/no	Yes	Trees in agricultural systems and spontaneous regeneration
Honduras (Redo et al. 2009)	Yes	Yes	Yes	Yes/no	No	Trees in agricultural systems
Costa Rica (Kull et al. 2007)	Yes	No	Yes	Yes/no	Yes	Spontaneous regeneration
Mexico (Klooster 2003)	No	No	Yes	Yes/no	Yes	Spontaneous regeneration
Brazil (Baptista 2008)	Yes	No	No	Yes/Yes	No	Commercial reforestation (exotic tree species)
Puerto Rico (Rudel, Lugo et al. 2000)	No	Yes	No	Yes/Yes	Yes	Spontaneous regeneration

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be among the few remaining areas with considerable tree canopy cover in some areas of northern Latin America (Perfecto et al. 1996; Perfecto et al. 2005; see also Hecht et al. 2006), and it is important to understand the mechanisms that have made possible vegetation cover increases in these landscapes so as to develop better development and conservation interventions.

We hypothesize that forest transition at our study site does not imply complete land abandonment or depopulation and that dependence on forest products and services is a key underlying factor in the process. Diversified livelihood strategies help farmers maintain their coffee forest gardens in expectation of better coffee prices while they can continue reaping benefits from other forest products.

The main research questions guiding this article are the following: What factors drive increases in vegetation cover in an area of coffee cultivation? How do forest transitions driven by high dependence on forest products and services affect vegetation cover? How will dependence on forest products be explained by forest transitions?

Candelaria Loxicha

Candelaria Loxicha is a municipality located 120 kilometers southwest of Oaxaca City, Mexico, with a total population of 8,686 inhabitants, of whom 45 percent are of Zapotec descent. Land use in the area is distributed as follows: 66 percent, secondary vegetation (including 5,147 hectares of shade-cultivated coffee); 24 percent, agriculture (e.g., maize); 0.9 percent, pasture; 0.7 percent, cloud forest; and 8 percent, evergreen forest (Instituto Nacional de Estadística y Geografía [INEGI] 2006).

Zapotecs inhabited the area before the arrival of the Spanish, and agriculture dates back several hundred years in the region (de Burgoa 1674; Arroyo 1957). The population of Candelaria Loxicha increased during the second half of the nineteenth century as a consequence of immigration of people from other parts of Oaxaca attracted by sugarcane cultivation (Cuadros Sinópticos 1883).

The idea of replacing sugarcane with coffee can be traced back to the end of the nineteenth century, when Matías Romero, then minister of agriculture, wanted to modernize the Mexican agricultural sector. Sugarcane production was considered inefficient, as illustrated by the following quote on sugarcane cultivation in Loxicha:

> [Peasants who produce sugarcane] destroy the fields without measure or scruples. To avoid the work of fertilizing the lands, they constantly seek new land, they cut down virgin fields and the fallows exhausted are then abandoned. The hillsides, even if they are not appropriate for sugarcane cultivation, are cleared. . . . The peasant cares little for the land, he will seek other spots to repeat his abuses. . . . [I]t will be fortunate if coffee replaces sugarcane. . . . [Loxicha] has land that is

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very apt for coffee cultivation. . . . [T]he fields are so extensive. . . . [M]illions of trees could be the source of richness for the inhabitants and even foreigners could be settled here. (Romero 1886, 123–124)[3]

Coffee was introduced in Candelaria Loxicha around 1930. The government initially supported its establishment in large estates and later in smallholdings.[4] Around 1970, the Mexican Coffee Institute (Instituto Mexicano del Café, or INMECAFE) launched and implemented a public initiative to foster peasant organization, and it offered plants, financial and technical assistance, and a guaranteed market. It also encouraged peasants' participations in coffee production (Vargas-Hernández 2005). High international coffee prices resulted in the expansion of acreage as a result of the increased number of producers (Nolasco 1985; Porter 2000). It seems that coffee cultivation had completely replaced sugarcane cultivation in Candelaria Loxicha by the end of the 1970s.

However, as a result of the neoliberal policies introduced by President Carlos Salinas de Gortari at the end of the 1980s, public support to coffee producers was restructured.[5] Policy makers expected that the Mexican agricultural sector would benefit from its opening to world markets and that agricultural exports would flourish (Kay 2004).

The agricultural sector in Mexico had, during the import-substitution period, become dependent on the state for agricultural services and inputs, which was judged unhealthy. In the 1980s, the government put into action a systematic program of privatization of all state-owned agricultural agencies (Eakin 2005). In the case of coffee, the government withdrew its technical assistance; canceled the provision of fertilizers, seeds, and credit; and stopped buying coffee from small producers (Hernández-Navarro and Célis-Callejas 1994). The international regime regulating the coffee

3. Romero failed to understand the dynamics of the Oaxacan peasant farming system. According to his estimates, peasants were losing money by producing sugarcane and maize. He also calculated that peasants did not occupy every day of the year working their plots. To Romero, introducing coffee was a win-win situation: peasants would earn a wage working in large coffee estates while they were not working their lands, and the owners of the coffee estates would have access to cheap labor. Although things never turned out as he expected, peasants eventually started to work temporarily on large coffee estates. During his time as minister, he also managed to attract foreign capital into coffee production in Mexico, particularly in Chiapas (Nolasco 1985).

4. Public intervention in coffee production was institutionalized formally in the 1940s and 1950s. By the end of the Second World War, Mexico (as many Latin American countries) was pursuing an import-substitution industrialization strategy. This model privileged policies seeking to diversify the economy by supporting agricultural, mining, and industrial sectors (Kay 1995; Lächler and Aschauer 1998).

5. The process of neoliberal globalization has involved a shift from a state-led inward-directed development strategy to an outward-oriented development strategy. Through policies designed to free markets and minimize government regulation of resource distribution, neoliberal reforms sought to integrate the agricultural sector into the global economy (Kay 2004).

market had broken down by the early 1990s. Coupled with increased coffee production in Asia, this resulted internationally in a dramatic fall in coffee prices (Daviron and Ponte 2005).

Despite these unfavorable developments, coffee is still the main cash crop produced in Candelaria Loxicha. Most coffee producers in the area have plots of fewer than five hectares (in the state of Oaxaca, 89 percent have plots smaller than five hectares, and only 0.4 percent have plots larger than twenty hectares). Coffee is produced in a so-called forest-garden system, in which coffee is cultivated under the canopy of native or seminative forest (Aguilar-Støen 2008). For peasants, coffee is part of a production system that includes management of different land-use units such as maize and fallow land, coffee forest gardens, home gardens, and forest.[6] The system integrates both subsistence and commodity production. Home gardens, maize, and fallow lands are mainly used to produce food for own consumption, whereas the coffee forest gardens are used to generate cash income (Aguilar-Støen, Moe, and Camargo-Ricalde 2009). Nonfarm employment also supplements farmers' income. In recent years, nonfarm employment has extended to include international migration, and remittances from migrants are important sources of cash.

METHODOLOGY

This study uses a microlevel approach to explore how forest transition theory can explain driving forces in the dynamics of a production system that lies between forest and agriculture. As such, the study required gathering the following information: change in vegetation cover, changes in the character of forest, changes in household livelihood strategies, and socioeconomic and political changes.

To infer the change in vegetation cover (from sugarcane to coffee), we used a holistic approach. We combined information from interviews, historical documents, Ministry of Agriculture databases, and other unpublished and published material. The period for which we infer change in vegetation cover is from the end of the 1990s to 2005. Forest transition theory explains the relationship between forest and agriculture. In our study, we examine an in-between type, that is, agricultural production that includes trees. Our study concerns changes in land-use practices that result in an agricultural system that resembles forest.

Our oldest informants gave an account of the changes in land-use practices. The informants told us about the work they did when they cultivated

6. Land tenure in Candelaria Loxicha is organized in a communal tenure regime governed by the Land Resources Committee (Comisariado de Bienes Comunales). However, in practice, farmers hold individual usufruct rights to their maize, coffee forest gardens, and fallow lands, whereas the committee controls the communal forest.

sugarcane, showed us relics of infrastructure used for sugarcane processing, and even introduced us to some old popular *corridos* that describe the people of Candelaria Loxicha as producers of sugarcane.[7] After the first fieldwork, it was apparent that the change from sugarcane to coffee cultivation was an interesting lead to follow, and we consulted historical documents and archive material in Oaxaca City (e.g., Cuadros Sinópticos 1883; Romero 1886). These sources confirmed the accounts from our informants; sugarcane combined with maize and bean production was the main activity in Candelaria Loxicha for several decades.

Evidence from satellite images and aerial photos confirm the presence in our study area of forestlike vegetation (where coffee is produced) and that the vegetation has not been cleared after the coffee crisis. These data come from a discussion paper (Blackman et al. 2005) and a report in preparation (Hernández, G. *Detección de cambios de cobertura vegetal en la Sierra Sur de Oaxaca,* Universidad Autónoma Metropolitana, Mexico). Both studies examine satellite images and aerial photos from the 1990s to 2005. In addition, we examined aerial photos from 1983 and 1985. To document the expansion of the area cultivated with coffee, we used statistical yearbooks of Oaxaca for the years 1980–2005 and databases from the Ministry of Agriculture (http://www.sagarpa.mx) and the International Coffee Organization (http://www.ico.org). We also consulted policy documents and reports available from the area (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación [SAGARPA] 2005, 2007). Although we do not quantify annual changes in vegetation cover, our sources provide enough evidence of a process of change in land-use practices in Candelaria Loxicha.

Fieldwork was conducted in March–April 2005, January–March 2006, and January–April 2007. To describe the character of the forest-garden system, botanical surveys of the vegetation were conducted in a parallel study (for a description of the methods, see Aguilar-Støen 2008).

To study changes in peasants' livelihood strategies, we combined questionnaires, semistructured interviews, and participant observation. A questionnaire was administered to fifty-six households of small producers (landholdings less than ten hectares). Questions included information about household composition (sex and age), land assets, sources of nonfarm employment, management of coffee fields, migration, responses to environmental and economic changes, and participation in welfare programs.

Qualitative interviews were undertaken with sixteen farmers (including six informants with landholdings greater than fifteen hectares), and

7. In Mexico, corridos are forms of telling and remembering past events of historical significance and are important in terms of group identity (see, e.g., Simmons 1953; Chamberlain 2003).

group discussions were carried out with five members of the Land Resources Committee in Candelaria Loxicha. Issues explored during qualitative interviews included the role of the coffee forest garden in household economic strategies, how it is integrated into the overall land-use system at the study site, how and why people select the plants to be maintained in the coffee forest garden, and farmers' responses to economic and environmental crisis as well as changes in land use and/or vegetation cover. Interviewed farmers included both respondents from the original survey and new respondents. Thirty-four randomly selected families were visited at their farms to discuss vegetation use and changes in land use. Group discussions, observation and discussions with farmers and their families, and field notes were used to understand the dynamics of land use in Candelaria Loxicha. Two civil servants from the Ministry of Agriculture were interviewed in Oaxaca City.

FINDINGS AND DISCUSSION

In this section, we start by describing the vegetation in the coffee forest garden in our study site. In doing so, we highlight the relationship between farming strategies and vegetation cover. Next, we discuss the role of local institutions in the establishment of coffee cultivation and factors triggering associated reforestation in Candelaria Loxicha. We highlight two factors: the links between agriculture and forest products and services, on the one hand, and the links between livelihood strategies and forest cover, on the other hand. We conclude by discussing how our findings contribute to refining forest transition theory.

Forest Resulting from Forest Transitions in Candelaria Loxicha

Structurally, coffee forest gardens in our study site have four height strata (the highest includes trees taller than fifteen meters). On average, eleven different tree species (minimum of four species and maximum of twenty-two species) per plot (plot size is three hundred square meters) were recorded in coffee forest gardens. Informants reported useful a total of seventy-five species; 68 percent of the species had more than one use.

Farmers depend on natural regeneration for the establishment of shade trees (which reduces labor input), but they also introduce new species to their fields. They prefer trees with leaves that drop regularly as shade, because fallen leaves cover the ground, preventing the proliferation of weeds and reducing the work of weeding. They collect, store, and use as firewood branches of trees removed to regulate shade cover for coffee shrubs. All respondents use organic fertilizer (prepared by composting the coffee skins, chicken manure, chalk, and leaves) in their fields. By using the leaves of shade trees and other readily available materials, farmers

lower or eliminate their dependence on agrochemicals (which increases production costs). Forest gardens in Candelaria Loxicha resemble, in species richness and structure, secondary vegetation in tropical evergreen forests, the dominant forest type in the area before the expansion of agriculture (Aguilar-Støen 2008). As opposed to monoculture sites, forest-garden systems retain native woody species that can function as source islands for forest regeneration. Trees therefore regenerate more quickly in agroforestry and slash-and-burn systems than in monocultures (Finegan 1996; Ferguson et al. 2003).

Reforestation can result from various processes, and the character of the vegetation varies across locations. In our case study, the coffee forest garden, a type of managed forest, resembles secondary forest. Tree diversity in our study site was comparatively greater than in other coffee-producing areas in Mexico and elsewhere (Aguilar-Støen 2008). Biodiversity is high in natural and managed forests, and the two forest categories also offer benefits to peasants, in that they can harvest products for consumption from the forest. Commercial plantations with exotic trees, in contrast, increase forest cover but negatively affect the livelihoods of local peasants. Large-scale plantations can concentrate land, reduce biodiversity, and disrupt ecosystem processes at higher levels (Izquierdo et al. 2008; Sloan 2008).

Agro-Forests and Local Institutions

In Candelaria Loxicha, the Land Resources Committee regulates timber harvests. A permit is required to fell trees both in the communal forest and in the coffee forest gardens. Commercial extraction of timber is banned, and permits are granted only for domestic uses such as construction. There are few timber species with high densities and significant market value in Candelaria Loxicha. This factor probably reduces potential conflicts of interest among members of the general assembly of the Land Resources Committee and prevents the incursion of outsiders into the lands of Candelaria Loxicha. The economic value of the species present in the coffee forest garden is mostly related to the production of fruit. Fruit trees are intercropped in coffee fields and either are used for family consumption or the fruit sold. Land tenure in Candelaria Loxicha is common property, although in practice, peasants have individual usufruct rights to their plots. Land-tenure security was instrumental in the establishment of coffee cultivation. The crop requires some time to reach harvest maturity, and some degree of security was important for peasants' decisions to adopt coffee. Maintaining coffee in individual plots is required for membership in the general assembly of the Land Resources Committee.

Civil servants from the Ministry of Agriculture explained that peasants could apply for funds to plant timber in their lands. The Land Resources Committee and our informants were aware of this possibility, but in their

judgment, forestry regulations were problematic. They conflict with coffee production and thus with membership in the general assembly of the Land Resources Committee, and the time required to completely replace coffee with timber was too long to be a realistic option for peasants.

Forest transition theory suggests that the price of timber or other forest products could offer incentives for tree planting, but conventional forestry incentives are inadequate for maintaining trees in agricultural systems. Other types of incentives, such as payment for environmental services (PES), in agroforestry systems might be more appropriate. The incipient Mexican program on PES in agroforestry (the program was not in operation in our study site) indicates that the character of these types of agriculture is starting to be recognized. It appears that PES is an attractive instrument for forest conservation in Latin America (e.g., Costa Rica, Mexico, Guatemala, Brazil; Engel, Pagiola, and Wunder 2008; Kaimowitz 2008). Because the size of the area with agroforestry systems in the region is considerable, PES could be a viable option to address biodiversity conservation and carbon storage and to improve income levels of the people involved in their management. Agroforestry PES schemes should be designed so that they do not interfere with peasants' production strategies or with local institutions.

Forest Services' Dependent Agriculture: Forest Transitions and Coffee Cultivation

Contrary to the situation in historical forest transitions in Europe and North America, where a few crops planted across large areas dominated agriculture, a mosaic of large plantation-type agriculture, interspersed with medium and small farms and forest fragments, characterizes rural landscapes in Latin America. The rural landscape involves many land uses and land-use practices, for example, cash crops combined with crops for own consumption, and varying degrees of forest management. In the sugarcane cultivation system of Candelaria Loxicha, some areas were initially planted with sugarcane and later maintained for some years as fallow (Romero 1886). Coffee was planted on the same lands where sugarcane had been cultivated. Previous land use, land-use practices, and land ownership set the stage for forest transitions to unfold. Coffee is the main source of cash for peasants in Candelaria Loxicha, but maize, fallows, forests, and home gardens are also found in the area. These other land-use types are located at different altitudes in the landscape to take advantage of environmental conditions suitable for each type of crop or combination of crops.

The introduction of coffee was successful because of a combination of factors: land tenure (secure), public incentives (subsidies, technical assistance, and a guaranteed market), stable coffee prices (due to international regulation and coffee quotas), improved infrastructure for the commercialization of coffee (roads connecting to marketing centers), and

ecological factors (altitude and climate).[8] Local institutions (e.g., the Land Resources Committee) are also important in regulating access to timber (Angelsen 2007) and in maintaining vegetation cover.

The replacement of sugarcane with coffee as the main cash crop in our study site contributed to the reestablishment of vegetation cover, basically because the type of coffee cultivated requires tree shade. Farmers benefited from natural regeneration of shade trees for this purpose. The fallow system of sugarcane cultivation enabled farmers to gradually introduce coffee to their lands. In addition, peasant households pursue a strategy in which they combine the production of cash crops with the production of food for family consumption. Labor input into each land-use type (coffee forest gardens, maize, fallow, and forest) depends on the availability of nonfarm sources of cash and family labor. Peasants seek to increase the products they can harvest from their lands so that, depending on the circumstances, they can sell the produce or consume it. Shade trees maintained in coffee forest gardens are also sources of firewood, timber, food, spices, and medicines for the family. During the 1970s and 1980s, INMECAFE attempted, without success, to promote sun-grown coffee and to replace multispecies with single-species shade trees. This alternative was rejected, as it was not compatible with the multiple objectives pursued in peasant livelihood strategies. The technical package promoted by INMECAFE also included pesticides and fertilizer, which increase production costs. Fewer shade trees in coffee forest gardens would require greater participation in cash-generating activities to purchase goods that farmers otherwise would harvest from their gardens. Increased participation in nonfarm cash-generating activities could interfere with food production (e.g., maize culivation), with consequences for food security. Although in times of crisis farmers can neglect some labor-demanding activities in coffee forest gardens (e.g., clearance, pruning), they try to secure the production of food.

Recalling the two typical paths of forest transition, we note that the stabilization of vegetation cover is not directly associated with increase in the price of forest products or decline in agricultural rent. The key factor seems to be a kind of forest dependency, where a particular type of agriculture (coffee forest gardens) and the livelihood strategies pursued depend on products and services the forests provide.

Mexico together with U.S. representatives at the International Coffee Organization (ICO) strongly supported the dissolution of the ICO's quota system. Withdrawing support from the ICO system was considered necessary for Mexico to be able to free its coffee from restrictive export quotas. This move was in line with the new economic paradigm that Salinas de

8. Between 1980 and 2002, in the state of Oaxaca, the area planted with coffee increased from 106,148 hectares to 191,612 hectares.

Gortari introduced in the 1980s (Hernández-Navarro and Celis-Callejas 1994). At the domestic level, a series of changes occurred in the relationship between the state and the coffee sector. During the 1990s, the government canceled direct subsidies to agriculture but maintained price stabilization for coffee producers. By way of this program, poorer producers (with holdings of less than ten hectares) received a payment to cover the difference between the price at which they sold their coffee and a ceiling price set previously each year. The program ended in 2006. Since then, producers have received a payment according to the size of their holding (limit of less than ten hectares), provided that they can document that they commercialize their coffee production. The social welfare program Oportunidades is also important for coffee producers; it targets women with children attending school and elders in low-income households. Changes in domestic policies (e.g., removal of subsidies, technical assistance, and credit) and changes at the international level (e.g., collapse of the regulatory system, which resulted in record-low coffee prices at the beginning of 1990s) changed the livelihoods of coffee producers.

In the following section, we argue that farmers' strategies to cope with changes in the price of the main cash crop (coffee) are linked to diversification and maintenance of the coffee forest garden.

Farmers' Strategies in the Aftermath of the Coffee Crisis: The Option Value

The area planted with coffee in Candelaria Loxicha (5,147 hectares) has remained stable in recent years (2002–2006), but the area harvested has decreased (of the total area planted, only 3,605 hectares have been harvested in the same period). Yield has also decreased (1.58 tons per hectare in 2003, 0.63 tons per hectare in 2004, and 0.45 tons per hectare in 2005 and 2006).

To cope with lower coffee prices and the retreat of public support to small coffee producers, peasants in Candelaria Loxicha have sought to diversify their sources of income. Nonfarm employment increasingly includes international migration. All respondents in the survey reported other sources of income besides agriculture: 89 percent reported receiving benefits from federal welfare programs; 68 percent, temporary jobs; 27 percent, remittances; 34 percent, other sources, such as a small business or jobs in the service sector. Most households (68 percent) reported having a migrant member of the family. Respondents frequently mentioned temporary migration to the United States (often illegal) and Canada, but they also reported migration to nearby cities and towns. Migration also affects the availability of local hired labor for harvesting coffee on larger properties. Larger producers have problems recruiting workers, and as a result, larger farms have been completely abandoned in the area, although none

of the respondents in our survey reported abandonment. Immigration also affects the age at which the younger generation takes over the farm; in our sample, farmers were, on average, fifty years old (in comparison, interviewed farmers with holdings larger than fifteen hectares were, on average, sixty-five years old), and they expressed uncertainty as to who, if anyone, was to take over their farms.

To be able to earn cash and to balance the work needed to secure self-provision of food (i.e., to cultivate maize and beans), peasants reduce their labor input in coffee forest gardens and increase their participation in non-farm employment. Respondents frequently reported reduced investments in the coffee forest gardens (renovation and maintenance)—respectively, 86 percent and 27 percent of households in the sample reported these changes, although only 7 percent reported harvesting less coffee. Previously, peasants had access to credit and technical assistance from INMECAFE, but this offer has been reduced—71 percent of households in the sample reported having received technical assistance ten years previous, whereas they did not receive any in 2005. In total, 54 percent received loans from local coffee buyers, whereas in the past they had access to credit from INMECAFE. The area planted with maize, beans, and minor edibles has remained stable (1,400 hectares in 2000–2005); farmers have not switched to intensified maize production, despite the coffee crisis.

Forest transition theory suggests that increased migration and participation in nonagricultural jobs would lead to land abandonment and reforestation (Rudel, Lugo et al. 2000). The population in Candelaria Loxicha has remained fairly stable over the past fifteen years, with 8,832 inhabitants in 1990 and 8,686 in 2005 (INEGI 1994, 2006). Participation in nonagricultural jobs and migration do not necessarily result in land abandonment. Coffee-producing communities across Mexico have been characterized more by out-migration than by attracting migrants, apparently because of land scarcity and lack of nonagricultural jobs in the community (Nolasco 1985).

Some demographic trends may, however, become more important in the future and eventually lead to land abandonment. In the past, there was a population structure in which men outnumbered women in coffee-producing locations. In 1985, the male-to-female ratio for the region was 57 percent to 43 percent (Nolasco 1985). In the 1990s in Candelaria Loxicha, the ratio was close to 50 percent to 50 percent (INEGI 1995), whereas in 2005 it changed to 48 percent male and 52 percent female (INEGI 2006). This reflects a change in household strategies in relation to who migrates, which demands a restructuring in the division of labor in migrant households. Less input into labor-demanding activities (e.g., clearing and pruning, activities typically the responsibility of men) was observed in migrant households. As a consequence, coffee yields reduced.

Migration in Candelaria Loxicha is often temporary and cyclical in nature. This strategy helps families with migrants maintain their coffee

farms (Rudel, Bates et al. 2002; Klooster 2003; Hecht et al. 2006; Kull et al. 2007). Peasants' migration places constraints on the local availability of hired labor, which in turn affects the ability of large producers to harvest coffee and to conduct other farming activities in their properties. Land abandonment will likely occur unevenly; larger properties will be abandoned, whereas small properties may not be abandoned at all, a pattern already observed in Costa Rica (Kull et al. 2007). As our findings indicate, nonfarm employment, remittances, and support from welfare programs might all be important in preventing permanent peasant out-migration from Candelaria Loxicha. This also reflects a decline in the importance of agriculture and an increase in the importance of diversified sources of rural income (Klooster 2003; Rigg 2006). In other parts of Oaxaca, abandonment of coffee production, intensification of resource extraction in communal forests, and intensification of maize cultivation have been reported both for small and large producers (Emanuel and Greenberg 2000). Other studies however, report that, despite the coffee crisis, small coffee producers continue cultivating coffee and have not switched to more intensive agriculture (Eakin, Tucker, and Castellanos 2006; Ponette-González 2007). Differences in terms of local institutions, local networks, and access to nonfarm jobs and migration patterns probably differentially affect the flexibility of peasants' responses to change and decisions with regard to land use. Studies of current forest transitions need to take into account local contexts and links between those and global processes.

Another factor that might contribute to slowing down land abandonment, and prevent vegetation clearing by converting the land to other crops, is infrastructure. Candelaria Loxicha is situated close to a coffee market town, Pochutla. It has been suggested that, for agro-forests (or coffee forest gardens), proximity to urban centers (or coffee market towns) reduces the probability of clearing vegetation (Blackman et al. 2008). Better connectivity also allows peasants to access temporary jobs in nearby towns. Infrastructure, which in this case facilitates access to markets, thus functions as a stabilization force (Angelsen 2007).

CONCLUSION: HOW DEPENDENCE ON FOREST PRODUCTS FITS IN FOREST TRANSITIONS

Our findings suggest that, in places where agriculture depends on forest products and services, an increase in vegetation cover is not necessarily linked to a decrease in the agricultural rent. Increase in vegetation cover in our case study is not connected with an increase in forest rent but with forest use (see Klooster 2003). This has important implications for how to theorize forest transition in so-called anthropogenic landscapes and subsequently in measures to support or stimulate reforestation. The dichotomy of forest rent–agricultural rent is not sufficient to explain

modern forest transitions because reforestation is associated with several different causes and constraints that vary across time and space. As this study has demonstrated, past land use, land-use dynamics, land tenure, and distribution of land use in the landscape set the stage for the development of forest transitions.

Rudel and colleagues (2005) note that governments can support forest transitions in two ways. In the economic development path, purchasing abandoned land for parks and forest reserves reinforces forest transitions. In the forest scarcity path, programs promoting reforestation and raising the price for forest products support forest transitions. None of these options would be satisfactory in forest transitions in agroforestry systems. In this case, interventions should support forest-dependent agriculture and multifunctional and diversified landscapes. Options like PES may be more adequate and will increase the value of standing forest (higher forest rent).

Increasing forest rent through higher timber prices might result in reforestation from commercial plantations. These plantations often consist of stands of one or two (usually exotic) tree species, but with negative consequences for local livelihoods and biodiversity. Conventional forestry incentives might conflict with local institutions and land-use practices as well, and thus might not result in expected reforestation levels (see Klooster 2003).

Forest transition theory suggests a relationship between processes of national development and forest area. In the case presented here, the development paradigm the Mexican government pursued until the 1980s, which sought to stimulate the agricultural sector through state intervention, encouraged coffee production in marginal, peasant-controlled lands. Changes in land use resulting in the adoption of coffee production in forest gardens were the outcome of a combination of factors, including household economic strategies; the introduction of coffee production into already-existing farming systems; and subsidies, technical assistance, and credit from the government.

Forest transitions are often conceptualized as resulting from changes generated within countries that affect national markets in land, labor, and agricultural and forest products (Perz 2007). In our case study, global coffee prices and the International Coffee Agreement (administered by ICO to establish coffee quotas for producing and consuming countries) were also important for the adoption of coffee cultivation in coffee forest gardens. More participation in nonfarm employment and international migration (with associated remittances) and state welfare programs prevent farmers from completely abandoning their lands. Understanding the dynamics of current forest transitions in Latin America requires reference to processes associated with globalization.

The short-term effect of unexpected changes (i.e., the fall in coffee prices and the restructuring of public support) might not be as dramatic in certain places as one would expect (for our study site, see also Eakin et al. 2006).

Uncertainty and diversification in livelihood strategies there are associated with maintaining the coffee forest garden rather than with switching to other (perhaps more intensive) land uses. Diversified landscapes also contribute to food security and allow farmers flexibility in land use.

The study of forest transitions in Latin America should broaden the alternative pathways and land types considered (beyond forest and nonforest). It must recognize the multiplicity of variables involved in the dynamics of land-use change, the variation in space and time, and not least the diversity of land use and farming practices that characterize rural areas in the region. Global forces must also be included in the analysis. Changes in global commodity prices might induce changes in land use. International migration and associated remittances can support forest-based activities and trees in agricultural systems (agroforestry).

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