CHAPTER 10

Land Use/Cover Change in Community-Based Forest Management Regions and Protected Areas in Mexico

ELVIRA DURÁN-MEDINA, JEAN-FRANÇOIS MAS, AND ALEJANDRO VELÁZQUEZ

The rapid deterioration of global forest cover in recent years has been well documented (Lambin et al. 2001). Although patterns of change in natural vegetation cover do occur due to natural causes (e.g., hurricanes, volcanic eruptions), it is widely accepted that the majority of today's environmental degradation is induced by human actions (Cincotta et al. 2000; Vitousek et al. 1997). Human beings are commonly considered the principal agents responsible for increased levels of desertification, deforestation, habitat fragmentation, and loss of biodiversity (Noble and Dirzo 1997). This is particularly the case in tropical regions, where patterns of land conversion from natural conditions to human-dominated conditions prevail (FAO 1996).

As a response to this process of environmental deterioration, conservation policies have been adopted at the global level that promote, among other measures, the establishment of protected areas (PAs; known in Mexico as ANPs [Areas Naturales Protegidas]). However, the effectiveness of PAs is extremely variable, depending on the specific sociopolitical situation in a particular country, demographic conditions, and on the country's level of dependency upon natural resources. Bruner et al. (2001), evaluating the effectiveness of a global sample of PAs, concluded that this system represented the best model to guide future conservation policy. In response, Vanclay (2001) argued that the evidence that PAs represent the best conservation model is not convincing. Especially in the tropics, with some exceptions, PAs do not seem to ensure the permanence of natural capital (Hansen et al. 1991; Velázquez et al. 2001a). In regard to the effectiveness of PAs, it is important to search for alternatives or complementary strategies to guide both conservation policy and the rational use of natural resources that can generate income for poor, rural peoples (Liu and Taylor 2002; Mangel et al. 1996). This is of particular importance for those tropical regions that are major sources of genetic resources, which are also the areas suffering the most significant losses in native vegetation cover (Bocco et al. 2000; FAO 2001; Kiernan 2000).

Mexico is a good example of a country that is home to a large chunk of the planet's biodiversity and that is also experiencing accelerated rates of environmental degradation (Velázquez et al. 2002). An alternative that has developed in Mexico over the last several decades as a strategy to deliver both conservation and increased rural incomes is community-based forest management. The reasons for this are varied, but two of the main ones are that (1) the greater part of the country's forests, and therefore biodiversity, is found in areas of the common property *ejido* and agrarian community land tenure systems (Alcorn and Toledo 1998; Thoms and Betters 1998); and (2) this land tenure reality laid the basis for historical community struggles and policy initiatives that led to a relatively successful sector of community forest enterprises (CFEs), more widespread in temperate forests than in rainforests (Bray and Merino-Pérez 2003; Merino-Pérez 1997; Merino-Pérez and Segura 2002; Negreros-Castillo et al. 2000; Velázquez et al. 2001a). These CFEs are carrying out logging of natural forests and creating community jobs, while also adopting strategies to conserve and increase forest areas. However, there have been few studies that have quantified the effectiveness of community-based logging in the key conservation indicator of forest cover, or compared them with the more conventional PA-led conservation model as a strategy for forest cover conservation (Berry et al. 1996; Kiernan 2000).

Land use/cover change (LUCC) is an important indicator for quantifying the effectiveness of different land use and land management strategies (Kiernan 2000; Masera et al. 1999). It also generates a spatial-temporal model of the processes taking place (Lambin et al. 2001; Turner and Meyer 1994), which can support policy makers in their efforts to slow down and hopefully reverse environmental deterioration (Velázquez et al. 2002).

This study provides evidence to support the hypothesis that areas under a common property regime and characterized by solid social organizational structures maintain forest cover areas just as effectively as PAs. It should be noted, however, that forest cover is only one indicator, and does not address possible changes in forest structure or composition for either community forests or PAs. Specifically, the study analyzed the land cover change processes that took place over two decades in the forests of two organizations of *ejidos* dedicated to community-based forest management. The results were then compared with those from a large sample of PAs in Mexico.

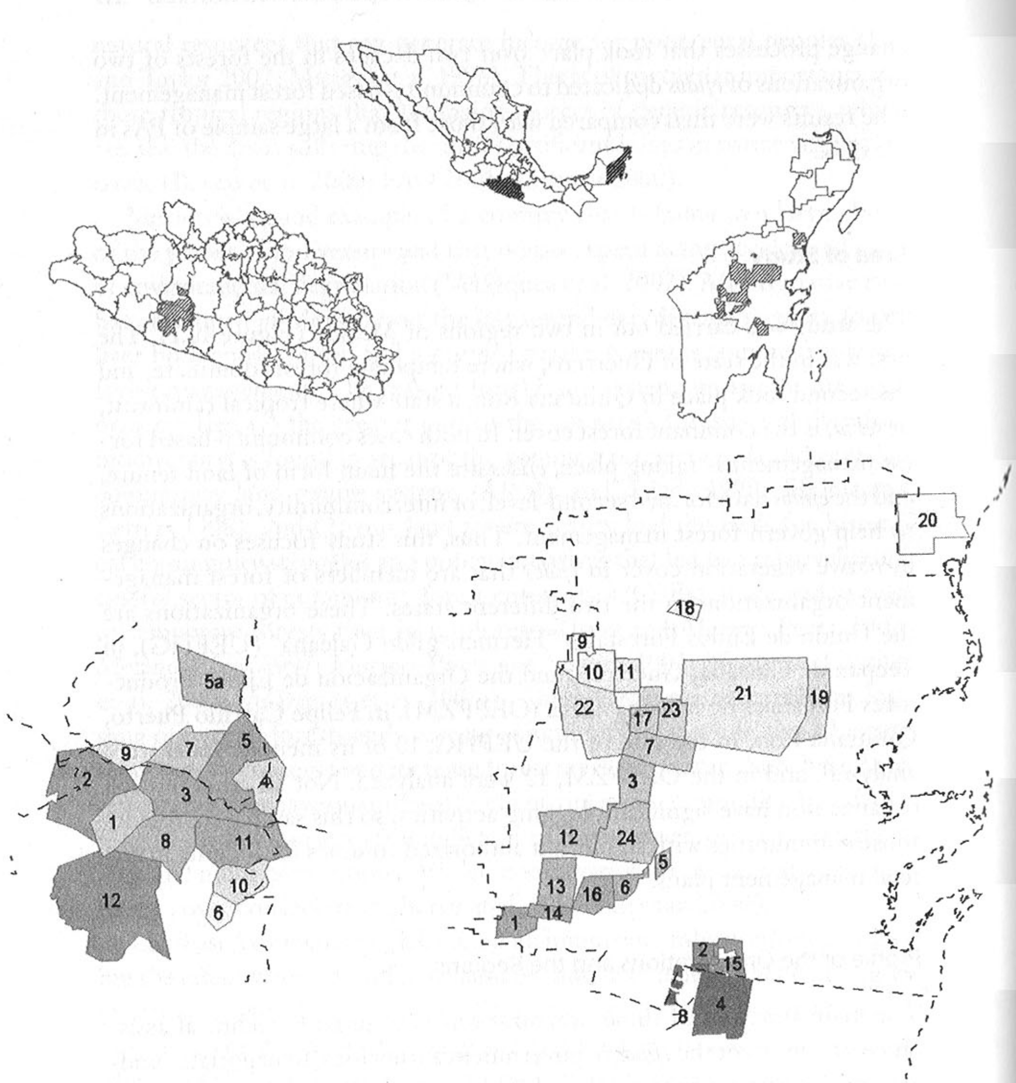
Area of Study

The study was carried out in two regions of Mexico (Figure 10.1). The first was in the state of Guerrero, where temperate forests dominate, and the second took place in Quintana Roo, a state where tropical rainforest, or *selva*, is the dominant forest cover. In both cases community-based forest management is taking place, *ejidos* are the main form of land tenure, and the *ejidos* have formed second-level, or intercommunity, organizations to help govern forest management. Thus, this study focuses on changes in native vegetation cover in *ejidos* that are members of forest management organizations in the two different states. These organizations are the Unión de Ejidos Forestales "Hermenegildo Galeana" (UEFHG), in Tecpan de Galeana, Guerrero, and the Organización de Ejidos Productores Forestales de la Zona Maya (OEPFZM), in Felipe Carrillo Puerto, Quintana Roo. In the case of the UEFHG, 10 of its member *ejidos* were analyzed, and in the OEPFZM, 12 were analyzed. Not all *ejidos* in each organization have significant logging activities, so this sample represents those communities with significant authorized volumes for logging in annual management plans.

Profile of the Organizations and the Regions

The main function of these organizations is to provide technical assistance, to represent the *ejidos* to government authorities, to negotiate funding and logging permits on their behalf, and, finally, to take part in regional negotiations to regulate timber prices and develop timber markets.

Even though the two organizations operate in different cultural, social, and environmental conditions (see Table 10.1), they share the activity of management of natural forest areas for logging under management plans based on selective cutting. With respect to their management plans, most of the *ejidos* in Guerrero employ the Mexican Method of Forest Management (Método Mexicano de Ordenación de Montes; MMOM), a selective method that focuses on the largest, healthiest specimens (SEMARNAP



1998). El Balcón *ejido* (part of the UEFHG-Guerrero) recently switched to the System of Conservation and Silvicultural Development (Sistema de Conservación y Desarrollo Silvícola; SICODESI), a highly flexible logging plan which seeks to maintain the present structure of the forest (Bray and Merino-Pérez 2003). In the OEPFZM-Quintana Roo, the management plan focuses on mahogany (*Swietenia macrophylla*) and uses a polycyclic system of three 25-year cycles and a 75-year turn, with a minimum diameter limit of ≥55 centimeters cutting minimum, on the assumption that it takes mahogany 75 years to reach this diameter. Although this assumption has been questioned, it remains the standard in management plans (Snook 1998; see also Vester and Navarro-Martínez, this volume).

In Guerrero, logging activities began in the mid-1970s with a parastatal enterprise, the Vicente Guerrero Forest Company (Forestal Vincente Guerrero; FOVIGRO). Beginning in the mid-1980s, the *ejidos* formed their own CFEs and began logging their own lands, organized within the UEFHG (Bray and Merino-Pérez 2003; Wexler 1995). In most of central Quintana Roo, commercial logging did not begin until around 1960, and the communities did not take charge of their own CFEs until the mid-1980s, although they had been logging tropical hardwoods for railroad ties since the 1970s without a management plan (Bray 2001). The logging companies operating in the state were responsible for the removal of huge volumes of timber, but generated few benefits for the owners of the forest resources. In Quintana Roo, the initiation of a more responsible form of forest management began with the Plan Piloto Forestal (PPF), a joint effort between Mexican federal and state government, German assistance, and the local communities (Santos et al. 1998), although the parastatal Maderas Industrializados de Quintana Roo (MIQROO) had the first management plan for logging of tropical forests in the Americas, which was largely adopted by the PPF (Snook 1998).

Since the mid-1980s the *ejidos* have been directly responsible for timber extraction carried out under authorized management plans. The *ejidatarios* have tried to organize themselves to conduct sound management of their forests and to secure markets and better prices for their timber.

Figure 10.1 *(opposite page)* The LUCC study sites. Asterisks (*) indicate the forest *ejidos* that were included in the land use cover change processes from each *ejido* organization. Twelve of the 24 OEPFZM member *ejidos* and 10 of the 12 UEFHG member *ejidos;* other *ejidos* in each organization have only minor amounts of logging. The area 5a of the "El Balcón" *ejido* (UEFHG-Guerrero) was not included in the change analysis either since no forest practices are carried out in it.

Table 10.1. Summary outline of the organization of *ejidos* where the LUCC analysis was conducted

Characteristic	*UEFHG-Guerrero*	*OEPFZM-Quintana Roo*
Total surface	115,494 ha	131,842 ha
Ejidos analyzed	10	12
Beginning of organization for forest management	mid-1980s	mid-1980s
Management plan	MMOM	Selective Treatment Method (polycyclic system)
Human settlements[a]	102	22
Population[a]	5,161	6,538
Climate	Temperate, semihumid with summer rains. Annual mean temperature 14 to 22° C. Annual precipitation 1,500 to 2,000 mm	Warm, semihumid (A(w)), with summer rains. Annual mean temperature is 22 to 26° C. Annual precipitation 1,100 to 1,500 mm
Geology	Metamorphic and extrusive igneous rock	Sedimentary rock (limestone)
Geography and topography	Region: Southern Sierra Madre Mountains; Subregion: Coastal Range	Region: Yucatán Peninsula; Subregion: Yucatán karst (plains with rocky or cemented ground and shallow dips)
Elevation (m above sea level)	1,000 m (peaks close to 3,000 m)	<30 m

[a] *Source:* INEGI 2003.

Although these *ejidos* have been faced with various problems, the success of a number of *ejidos* (from both organizations) has led them to be regarded as models for sustainable forest management (Arriaga et al. 2000; Bray and Merino-Pérez 2003; Kiernan 2000). The benefits generated by these CFEs have included direct benefits such as local job creation and social stability, as well as indirect ones such as creating new areas of study of natural resource management alternatives.

Methodology

The Analysis of Conversion Processes

LUCC analysis consists of comparing two or more sets of data from remote sensing from different dates. In this study we made comparisons of spatially explicit data displayed as digital map sets. Use was made of data related to land use and vegetation (t_1), generated by the National Institute of Statistics and Geography (Instituto Nacional de Estadística, Geografía e Informática; INEGI) and designated "Series I" (generated over the period 1968–86). The second database (t_2) was developed by the National Forest Inventory 2000 (Palacio-Prieto et al. 2000). Before the LUCC analysis began, the scale of the work (1:250,000) and the minimum mappable area (1 km^2 = 100 ha) were determined, and the vegetation cover legend was homogenized for both dates in order to make them compatible and comparable (Velázquez et al. 2002).

It was also necessary to carry out field verification to validate reliability of the maps derived from the NFI-2000. As such, a random sampling system was designed with a minimum number of sample units (20 for each region) in the categories with the highest chance of inaccuracy at the vegetation community level (Velázquez et al. 2001a). In Guerrero, the major inaccuracy corresponded to the primary and secondary conditions in pine forests, pine-oak forests, oak forests, and tropical deciduous forests. For Quintana Roo, the main discrepancies were found between the high and medium evergreen and semi-evergreen tropical forests (*selva alta, mediana perennifolia*, and *subperennifolia*) and the medium deciduous and semideciduous tropical forests (*selva mediana caducifolia* and *subcaducifolia*), as well as the primary and secondary conditions of both communities. The fieldwork was carried out with the help of maps, satellite maps, and images (generated in color from geo-referenced satellite images) and a global positioning system (GPS). A fieldwork sheet that included identification of dominant species, geomorphology, soil characteristics, and the degree of vegetation disturbance was used to characterize the sampling sites. Additionally, at each site observations were made in order to compare the maps and the in situ vegetation. Sampling took place over the territory of all the *ejidos* involved in the study, with at least 12 days of fieldwork for each region.

The analysis of land use change largely consisted of crossing and comparing the corrected maps from two different dates: for the UEFHG-

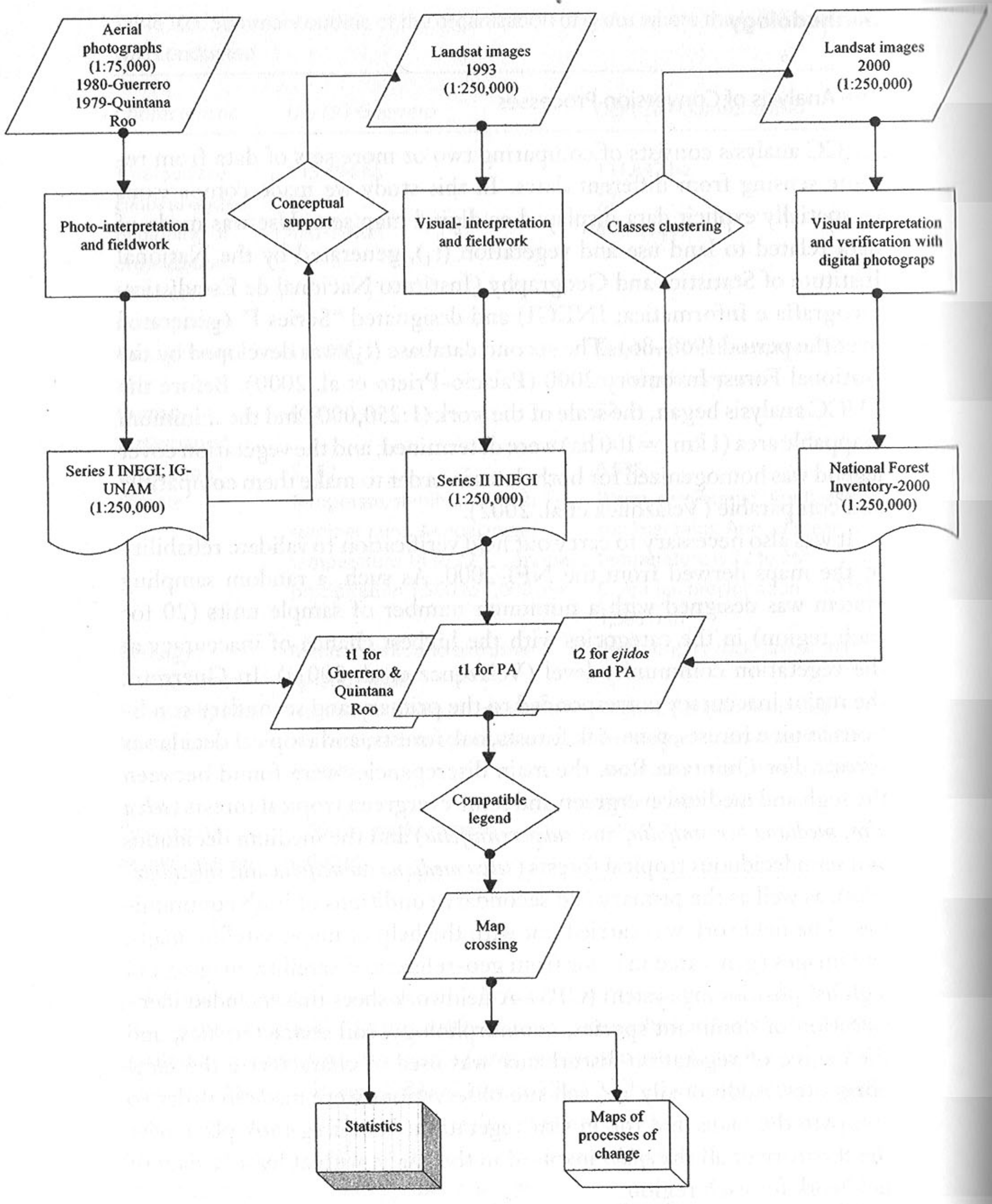
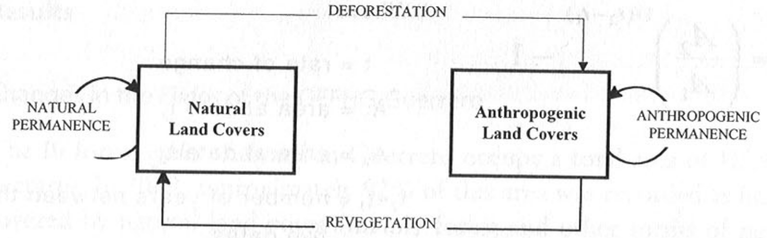


Figure 10.2 Flowchart illustrating the methodological steps followed to produce LUCC analysis and derived statistics and maps.



DEFORESTATION	Conversion of natural land covers (in primary or secondary conditions) to anthropogenic land covers
REVEGETATION	Conversion of anthropogenic land covers to natural land covers (in secundary or primary conditions)
ANTHROPOGENIC PERMANENCE	No change in anthropogenic land covers between two dates
NATURAL PERMANENCE	No change in natural land covers (in primary or secondaryconsitions) between two dates

Figure 10.3 Flows depicting processes of land cover conversion and permanence analyzed.

Guerrero $t_1 = 1979$ and $t_2 = 2000$, and for the OEPFZM–Quintana Roo $t_1 = 1980$ and $t_2 = 2000$. As mentioned earlier, the LUCC analysis was carried out in a subgroup of all *ejidos* in the organizations where logging is a central economic activity (10 *ejidos* in the case of UEFHG-Guerrero and 12 for OEPFZM–Quintana Roo). The *ejidos* included in the analysis are shown in Figure 10.1, and the subgroups chosen for the LUCC analysis are noted with asterisks.

For a more detailed look at the methodology used, see Palacio-Prieto et al. (2000) and Velázquez et al. (2002). A general outline is given in Figure 10.2. To identify the principal processes of forest conversion (Figure 10.3), the study made use of a simplified model (FAO 2001) that looked at two main land covers: those considered "native forest" or as existing in t_1 (temperate forests, tropical forests and other forms of natural vegetation cover) and those defined as anthropogenic (including crops, grassland, and human settlements), but did not include secondary succession.

This model also allowed the reduction of possible inherent errors and confusion among similar categories, resulting in an increase in the level of confidence in the statistics. The model specified the permanence of land use change (either through deforestation or revegetation). The rates of

$$t = \left(\frac{A_2}{A_1}\right)^{1/(t_2-t_1)} - 1$$

Where:

t = rate of change

A_1 = area at date t_1

A_2 = area at date t_2

t_2-t_1 = number of years between the two dates

Figure 10.4 Rates of change calculated according to Puyravaud (2002).

change were calculated according to the equation shown in Figure 10.4 (Puyravaud 2002).

The rates of change obtained are expressed in percentage values multiplying the result by 100. By comparing the maps taken from the dates t_1 and t_2 we constructed a matrix of changes made up of the areas transformed in each category from t_1 to another category in t_2. The different conversion processes were identified and spatially represented in a map showing land use cover change for each region.

Comparison between *Ejidos* and PAs

The rates of change that were observed in the LUCC analysis of the 10 *ejidos* of the UEFHG-Guerrero and the 12 *ejidos* of the OEPFZM-Quintana Roo were then compared with the rates of change observed during analysis (using the same sources of information) for 67 Mexican PAs established before 1993. The reference database (t_1) for the PAs was taken from INEGI (Series II); the technical information for the analysis is described by Smith (2002) and summarized in Figure 10.2. The PAs excluded from the analysis are those in marine environments, those decreed after 1993, or those too small in area to allow for meaningful analysis. The PAs that were analyzed represent about 60% of the total protected area established up to June 2002 in Mexico (www.conamp.semarnat.gob.mx; Mas et al. 2003). A complete list of the PAs analyzed can be found in the appendix at the end of this chapter.

The rate of land use change was compared statistically between the two case study regions (taken as one) and the PAs (Fisher accuracy test; Zar 1984). The hypothesis suggested that there would be no significant difference between the two rates of change.

Results

Changes in the *Ejidos* of the OEFHG-Guerrero

The 10 forest *ejidos* analyzed in Guerrero occupy a total area of 115,494 hectares. In 2000, approximately 92% of this area was recorded as being covered by natural land cover (mainly forest and other forms of natural vegetation). The LUCC analysis documented two change processes: deforestation and revegetation (Figure 10.5). Analysis also identified the extent to which areas of natural vegetation cover had remained. In the OEFHG-Guerrero, the study showed that deforestation had affected 8,986 hectares between 1979 and 2000, representing 7.78% of the original forested area (see Figure 10.6 at http://indy2.igeograf.unam.mx/ua_morelia/_private/2004/prensa.pdf). The annual rate of change from natural to anthropogenic was 0.97%, but began from a very low base of 1,282 hectares in t_1 and resulted in 9,896 hectares for t_2. The opposite process, regrowth of vegetation, had taken place in 29% of the 1,282 hectares originally occupied by anthropogenic land cover. Thus, 92% of original forest area was retained over a 20-year period, and the net annual loss of forest cover was −0.4%, including all the land use change dynamics.

Changes in the *Ejidos* of the OEPFZM-Quintana Roo

Analysis involved 12 forest *ejidos* that occupy an area of 131,842 hectares. In 2000, approximately 95% of this area was covered by native forest. The LUCC analysis carried out in this region showed that deforestation affected 5,364 hectares between 1980 and 2000, representing 4.9% of the original forest area (t_1; Figure 10.5b). The opposite process, regrowth of vegetation, took place in 94.8% (20,763 hectares) of the area originally occupied by forms of anthropogenic land cover. As a result, only 5.2% of such land use areas remained for t_2, while 94.8% of native forest remained (see Figure 10.7 at http://indy2.igeograf.unam.mx/ua_morelia/_private/2004/prensa.pdf). Thus, there was a net annual gain in forest cover of 0.63%. In contrast, areas of anthropogenic land cover decreased at an annual rate of 5.8% with respect to original coverage (Figure 10.7a). However, it should be noted that these figures might change if a more detailed study (at finer scales and on an annual basis) were carried out in order to understand the dynamics of slash-and-burn agriculture in this landscape, where every year both fallow and forestlands are converted to agriculture while other areas are left for secondary succession. Some of the large-

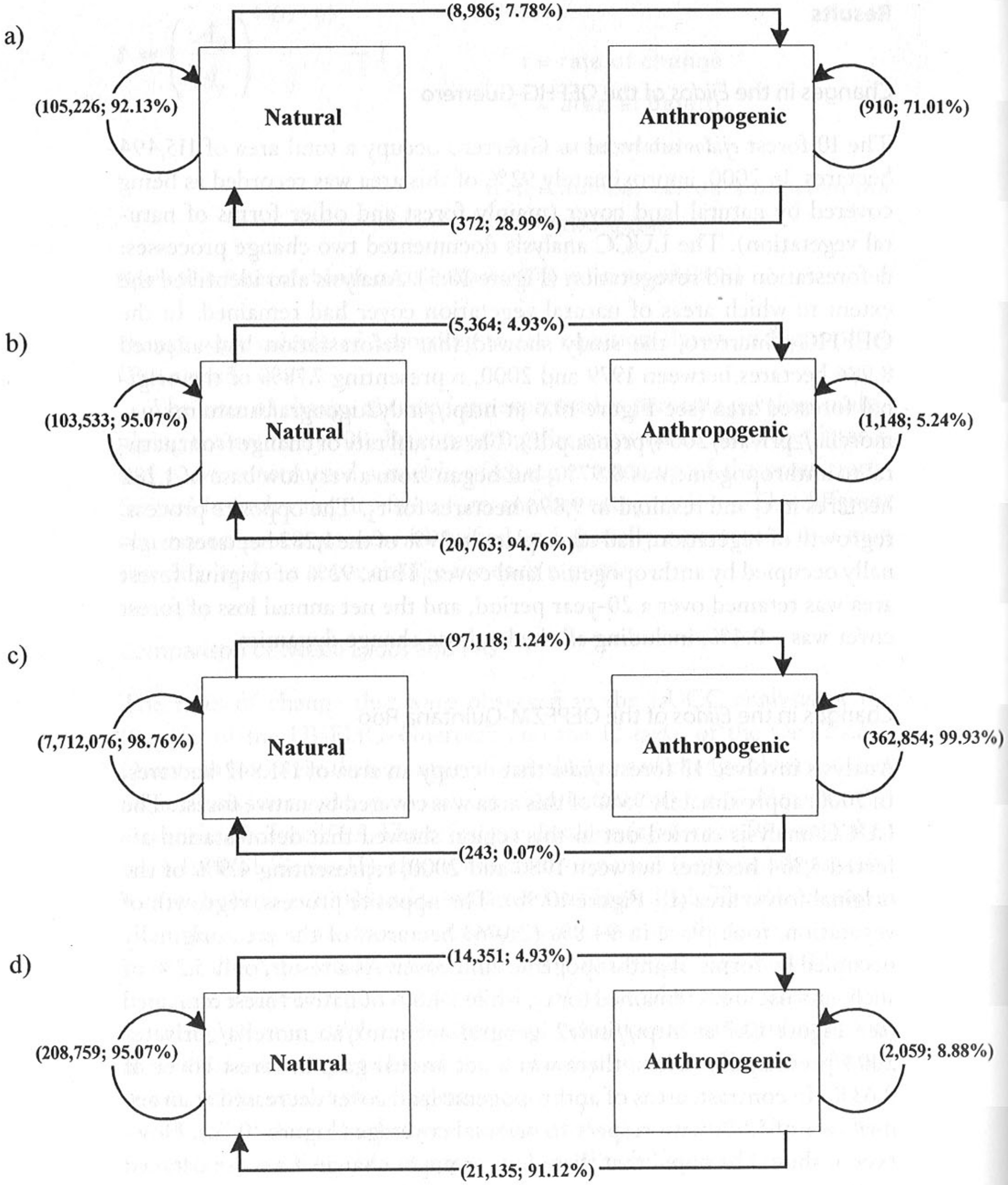


Figure 10.5 Trends of change between anthropogenic and natural cover for the *ejidos* of UEFHG-Guerrero (a); the *ejidos* of OEPFZM–Quintana Roo (b); the protected areas (c); and both groups of *ejidos* (Guerrero–Quintana Roo) (d).

scale shift from anthropogenic to forest could also be accounted for by several thousands of hectares that were opened for pasture by government programs in the late 1970s, much of which was apparently abandoned to secondary succession because the promised cattle never arrived.

Changes in PAs

The 67 PAs included in the analysis cover an area of 8,834,201 hectares, approximately 79% of the total area covered by PAs in Mexico. In 2000, approximately 93.8% of the lands held by these PAs had natural land cover. The LUCC analysis (Figure 10.5c) indicated that deforestation affected 97,118 hectares, or 1.24% of the original area (t_1), an annual rate of growth in anthropogenic areas of 0.38%. With regard to revegetation, the analysis showed that 0.07% (243 hectares) of the original area occupied by forms of human land cover had been converted to a form of natural land cover. Thus, it was deduced that 99.9% of the areas of human land use remained for t_2, while 98.8% of areas of natural land cover remained. The annual conversion rate (−0.2%) also demonstrated a minimal loss of natural land cover.

Comparison between PAs and *Ejidos*

Figure 10.8 shows two sets of comparisons between rates of change in natural cover and anthropogenic cover. Figure 10.8a compares PAs with the Guerrero and Quintana Roo regions separately, while Figure 10.8b compares PAs with the *ejidos* in both regions grouped together. The *ejidos* have managed to conserve, for more than 20 years, approximately 95.1% of the original forest cover (t_1). In comparison, PAs have maintained 98.8% of such covers between 1993 and 2000. On the other hand, if we compare past and present areas of anthropogenic land cover, *ejidos* as a group have decreased by 29.3%, with appropriate caveats about slash-and-burn agriculture in the case of Quintana Roo, while PAs have seen an increase in anthropogenic land cover of 26.7% (both percentage figures are in relation to the original anthropogenic areas). Further, the *ejidos* showed a net annual gain in forest cover of 0.14%; that is, conversion from anthropogenic to natural land cover occurred at a higher rate than forest to anthropogenic land cover, while in the PAs there was an annual net loss of −0.18%; see Figure 10.8b. With rates of change for areas of anthropogenic land cover, the PAs showed an annual increase of 0.38%, while in the *ejidos* a negative rate of change was observed (−0.17%). Statistical

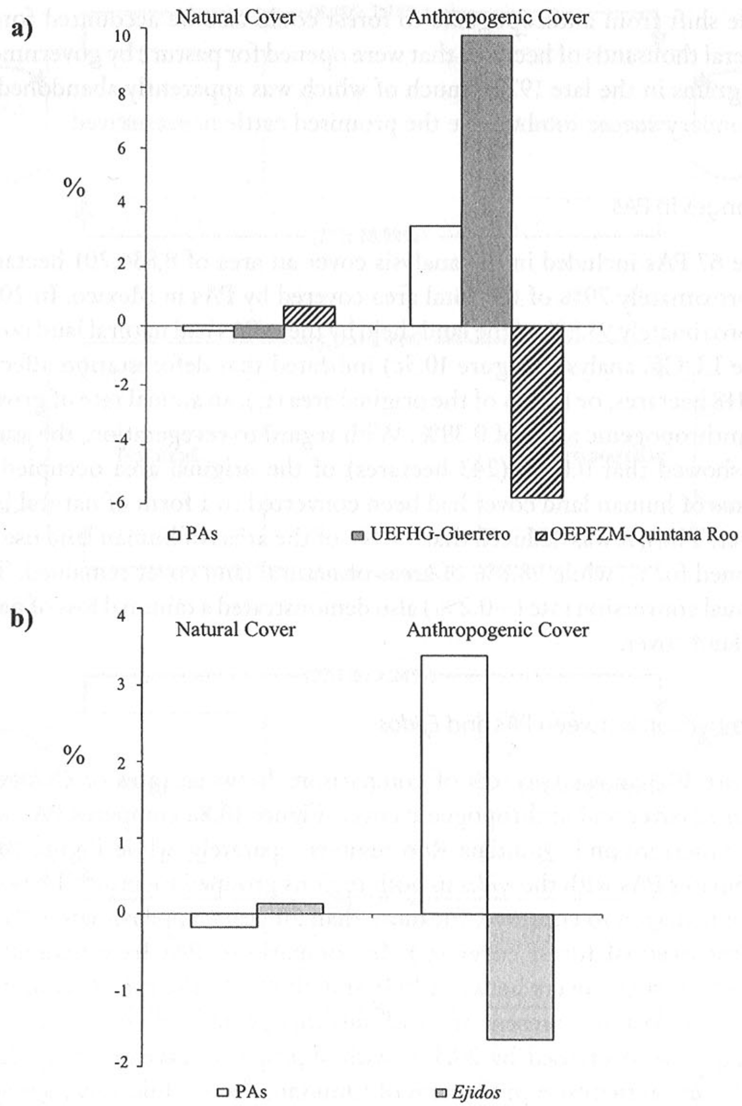


Figure 10.8 Annual rate of change (a) for the *ejidos* analyzed in each region independently and the PAs; and (b) for the *ejidos* combined and the PAs.

analysis (Fisher accuracy test; Zar 1984) did not show significant differences between the rates of change in the *ejidos* and the PAs ($Z = 81.45$, $p < .05$). However, the balance between regrowth and deforestation in the *ejidos* and the PAs (Figure 10.5d) suggested that the PAs had a slightly greater tendency to lose natural land cover, while such areas were more likely to increase in *ejidos* (see Figure 10.8b). Although a large part of the areas with regrowth of vegetation are in a secondary condition, those areas are recovering their ecological functionality and acting as a buffer to connect the patches with forest in prevailing primary states. In *ejidos*, as noted, most of the net gain in forest cover and decrease in anthropogenic areas occurred in Quintana Roo, while Guerrero showed net losses in forest area, although at a low rate.

Discussion

Processes of Change (*Ejidos* versus PAs)

Anthropogenic activities are considered to be one of the major threats to the conservation of biological diversity and the native vegetation covers (Lambin et al. 2001; Mangel et al. 1996). However, the changes in vegetation covers observed in the *ejidos* show that community forest management for the commercial extraction of timber does not necessarily translate into the permanent loss of natural land cover (see Vester and Navarro-Martínez, this volume, for an analysis of the impact of logging on forest diversity and structure in Quintana Roo).

In PAs, the tendency for areas with native vegetation covers to decrease while areas designated for human land use increase contrasts the situation observed in the *ejidos*, particularly Quintana Roo. The contrasting tendencies, however, do not differ significantly considering the rhythm and magnitude by which these changes occur. It is important to consider that the goals and objectives of both conservation and development models are substantially different. The *ejidos* focus on selective logging under regulated management plans and other forms of commercial and subsistence forest use. These are "multiple-use" forests, while PAs are subject to a policy of protection and conservation. The decrease in areas of anthropogenic land cover, observed in Quintana Roo, but not in Guerrero, has taken place despite population growth over the past few decades. In contrast, an increase of 97,118 hectares (1.24%) in the area of anthropogenic land cover in the PAs indicates that despite decrees for their protection, agriculture and livestock activities in particular continue to have a negative impact on native vegetation covers. This tends to occur more in those portions of PAs with characteristics such as easily accessible land, reasonably flat topography, and soil quality suitable for the development of agriculture and livestock (Smith 2002). This suggests that the conservation effectiveness of PAs depends more on the kind of physical characteristics mentioned above than the form of its legal decree or the official management plan to which it is subject (Mas et al. 2003). A similar situation has been documented both in other tropical regions of the world (Hansen et al. 1991; Vanclay et al. 2001) and other regions of Mexico (Ramírez 2002; Velázquez and Romero 1999; Velázquez et al. 2001a).

Deforestation in PAs occurs across all types of original natural vegetation, and principally involves conversion into agricultural plots and pasturelands in equal proportions. In contrast, deforestation in the *ejidos* is the result of a more managed process, with a generally well-observed zoning of land use that prohibits change in the managed forest. In the case of Guerrero, areas of pasture were increased, and in the case of Quintana Roo, the changes from natural to anthropogenic land uses were for agriculture. It should also be emphasized that deforestation in the UEFHG-Guerrero occurred principally in forest areas of less commercial importance (tropical deciduous forest). This suggests that in the UEFHG-Guerrero, the population has geared land use toward the commercially most profitable activities (forestry and livestock rearing). Deforestation in the OEPFZM-Quintana Roo has been confined mainly to areas covered by tropical perennial forests, which have been converted into agricultural areas. In Quintana Roo, in contrast to Guerrero, most of the area is suitable for forest activities. This implies that stakeholders are confronted with a dilemma in defining areas suitable for cropping activities. In some places, unavoidably, there is an overlap in terms of spatial demand. Local stakeholders, as a result, in 1985 delimited specific areas devoted to permanent forest areas where cropping has diminished, whereas areas devoted to agriculture have increased upon remaining forest patches.

The process of regrowth of vegetation is proportionally greater in the *ejidos* than in the PAs (Figures 10.5c and 10.5d). In the PAs, regrowth seems to be part of a natural succession (from anthropogenic land cover to incipient areas with native land cover) taking place in a limited fashion when compared with the total area affected by deforestation. In the *ejidos*, regrowth is observed mainly in those areas that are considered important for commercial forestry activities (pine-oak and pine forests in Guerrero and tropical semideciduous forests in Quintana Roo). The vegetation regrowth patterns in the PAs follow natural processes that are independent

of their legal condition, while in the *ejidos* the recovery of forest areas is governed by a social process that promotes forest recovery of commercially valuable areas through the avoidance and control of forest fires, reforestation, and community forestry.

In summary, the *ejidos* use their land in an organized manner under a model of territorial zoning, while processes of change taking place in the PAs, as shown in the study, follow a more unpredictable model and are not directly connected to their standing as PAs. The question needs to be examined with more robust data, but it appears that land inside PAs that is more likely to lose its original cover is land suited to the development of agriculture and livestock activities.

Final Remarks

Evaluating the effectiveness for both conservation and economic development of PAs and community-managed forests must eventually go beyond studies of LUCC, as important as these are. On the basis of our data, we have attempted to suggest the dimensions of some of these contrasting study cases within the framework of the LUCC analysis. Policies shaping PAs in Mexico have become stronger, both operationally and legally, over the past 10 years, thanks to a range of different programs, new decrees, and greater financial support (Melo 2002). To promote conservation in PAs, the government directs human and economic resources through agencies and other stakeholder groups to restrict and regulate human activities within PA boundaries. These resources frequently fail to provide a direct or indirect social and environmental benefit, and on occasions they bring social interests into conflict with conservation interests. In the case of the forest management *ejidos*, the *ejidatarios* are those principally responsible for the actions that determine LUCC. Furthermore, the *ejidos* have managed to translate a great part of their management actions into economic goods that have led to direct benefits for their social communities and the natural environment. From the long-term view, the cost-benefit balance suggests that PAs will be under increasing pressure to demonstrate their economic benefit to society. Well-organized *ejidos* that have developed a community-based forestry plan, on the other hand, must be considered among the conservation strategies with the greatest long-term potential.

When we analyze the financial situations and benefit flows of the two forms of land management, we see some clear differences emerge. PAs, as commonly conceived, are solely the responsibility of government, while forest management can be thought of as a comanagement between the government and the *ejido*, given the strong regulation of logging by the federal government (Klooster 2000). Financial support in the form of investments in PAs must come exclusively from government funds, while most forest *ejidos* invest in their forests with capital generated by the community enterprise. This suggests that the financial viability of PAs depends on the capacity of governments with multiple pressures on them to continue supporting PAs, while CFEs have been demonstrated to be financially viable (see Antinori, this volume). As for benefit flows, although efforts are being made in some cases to involve local communities in the management of PAs, the social and economic benefits from these efforts must be classified as incipient, while the benefit flows from community forest control are multiple and substantial (Antinori 2000; Negreros-Castillo et al. 2000). Thus, PAs and community forests are equivalent in terms of maintenance of forest cover and associated environmental benefits, but the financial situations and benefit flows from PAs are far more uncertain than those from community forests.

However, although issues concerning the financial and social viability of PAs could affect their protective function in the long run, it is also clear that unsuccessful community-based forestry negatively affects the functional integrity of ecosystems (Klooster 2000; Merino-Pérez and Segura 2002). For well-organized *ejidos*, though, these activities translate into multiple benefits that ensure the conservation of their forests and thereby a range of indirect environmental goods and services such as the replenishment of aquifers, the long-term productivity of ecosystems, and the contribution of products to multiple local markets, among others (Daily et al. 1996).

The regions of greatest deforestation found in both PAs and non-PAs coincide with zones where the local social community structure has been seriously weakened, independent of any financial resources assigned. This is the case, for example, in the PAs in the southern part of the Mexican basin (Velázquez and Romero 1999; Velázquez et al. 2001b), the Monarch Butterfly Biosphere Reserve (Ramírez 2002), Montes Azules (Ochoa 2000), and Calakmul (García et al. 2002), among others. In each case, economic, environmental, cultural, and social losses are significantly greater than those experienced in the two *ejido* regions analyzed in this paper.

The environmental costs resulting from social disorganization have been expressed through high deforestation rates in various regions of the country. Nonetheless, throughout history, governmental programs favoring deforestation and the disintegration of social groups have predominated and promoted "productive" and "conventional" activities such as livestock rearing and agriculture (Merino-Pérez and Segura 2002). The social component can be considered as an ally to the conservation of Mexico's genetic resources (Velázquez et al. 2001a). From this perspective, and in view of the results of this study, it is recommended that programs be developed to strengthen the consolidation of environmentally friendly community-based forestry management plans, as a complementary alternative to current conservation programs.

Appendix

Appendix 10.1. List of the protected areas (PAs) studied

	Protected area	*Decree date*	*Area (ha)*
1	Bonampak	1992	4,357
2	Bosencheve	1940	14,008
3	Cabo San Lucas	1973	3,996
4	Cajón del Diablo	1937	115,000
5	Calakmul	1989	723,185
6	Cañón del Río Blanco	1938	55,690
7	Cañón del Sumidero	1980	21,789
8	Cascada de Bassaseachic	1981	5,803
9	Cascadas de Agua Azul	1980	2,580
10	Cerro de Garnica	1936	968
11	Cerro de la Estrella	1938	1,100
12	Cerro de la Silla	1991	6,039
13	Chan-Kin	1992	12,185
14	Cofre de Perote	1937	11,700
15	Constitución de 1857	1962	5,009
16	Corredor Biológico Chichinautzin	1988	37,302
17	Cumbres del Ajusco	1947	920
18	Cumbres de Majalca	1939	4,772
19	Cumbres de Monterrey	1939	246,500
20	Desierto del Carmen o Nixongo	1942	529
21	Desierto de los Leones	1917	1,529
22	Dzibilchaltún	1987	539
23	El Chico	1982	2,739
24	El Cimatario	1982	2,448
25	El Jabalí	1981	5,179
26	El Potosí	1936	2,000
27	El Tepozteco	1937	24,000
28	El Triunfo	1990	119,177
29	El Veladero	1980	3,617

Appendix 10.1. Continued

	Protected area	Decree date	Area (ha)
30	El Vizcaíno (Includes El Complejo Lagunar Ojo de Liebre)	1988	2,546,790
31	Gogorrón	1936	25,000
32	Grutas de Cacahuamilpa	1936	1,600
33	Insurg. José María Morelos	1939	4,325
34	Insurg. Miguel Hidalgo y Costilla	1936	1,580
35	Iztaccíhuatl-Popocatépetl	1935	25,679
36	La Michilía	1979	9,325
37	La Primavera	1980	30,500
38	Lacan-Tun	1992	61,874
39	Lagunas de Chacahua	1937	14,187
40	Lagunas de Montebello	1959	6,022
41	Lagunas de Zempoala	1936	4,790
42	Lomas de Padierna	1938	670
43	Malinche or Matlalcuéyatl	1938	45,711
44	Mapimí	1979	200,000
45	Mariposa Monarca	1986	16,110
46	Montes Azules	1978	331,200
47	Nevado de Toluca	1936	46,784
48	Palenque	1981	1,772
49	Pantanos de Centla	1992	302,707
50	Pico de Orizaba	1937	19,750
51	Pico de Tancítaro	1940	23,154
52	Ría Celestún	1979	59,130
53	Ría Lagartos	1979	60,348
54	Selva El Ocote	1982	48,140
55	Sian Ka'an	1986	528,148
56	Sierra de Ajos/Bavispe	1936	184,776
57	Sierra de Álvarez	1981	16,900
58	Sierra de Manantlán	1987	139,577
59	Sierra de Quila	1982	15,193
60	Sierra de San Pedro Mártir	1947	63,000
61	Sierra la Mojonera	1981	9,252
62	Tulúm	1981	664
63	Valle de los Cirios	1980	2,521,776
64	Volcán Nevado de Colima	1936	9,600
65	Xicoténcatl	1937	680
66	Yaxchilán	1992	2,621
67	Zoquiapan y Anexas	1937	19,418

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