Environmental Conservation **31** (1): 11–21 © 2004 Foundation for Environmental Conservation DOI:10.1017/S0376892904001006

Colonization and tropical deforestation in the Sierra Santa Marta, Southern Mexico

LETICIA DURAND[1]* AND ELENA LAZOS[2]

[1]*Centro Regional de Investigaciones Multidisciplinarias, Universidad Nacional Autonoma de Mexico, Av. Universidad s/n Circuito 2, Col. Chamilpa, Cuernavaca, Morelos, CP 62210, Mexico, and* [2]*Instituto de Investigaciones Sociales, Universidad Nacional Autonoma de Mexico, Circuito Mario de la Cueva s/n, Ciudad Universitaria, Coyoacan DF, CP 04510, Mexico*

Date submitted: 11 September 2002 Date accepted: 21 October 2003

SUMMARY

Understanding patterns of tropical deforestation is a crucial issue for Mexico, a country that has lost more than 95% of its original rainforest cover. This paper examines the causes of accelerated deforestation in the Sierra Santa Marta, Veracruz, Mexico, by looking at settlement history and the evolution of productive schemes in the villages of Venustiano Carranza and Magallanes. Both settlements were founded in the 1960s, after the government donated land to landless peasants. Conversion of forests into pastures, after several agricultural enterprises failed, resulted in more than 80% of the original tropical rainforests being removed in both communities between 1960 and 1998. The process of deforestation in the villages differed from models proposed for the Amazon and Central America, in which deforestation responded to capital-intensive efforts to open up the tropical frontier. In the villages, transformation of forests into pastures was, from the beginning, a smallholder phenomenon. Misguided policies and institutional malfunctions appeared to direct households toward deforestation. Nevertheless, environmental deterioration could not only be explained by external causes. Inside the communities, demographic pressure over land, the modification of traditional land tenure systems and the cultural adoption of cattle as a way to overcome poverty were significant factors in the relationship between colonization and forest clearance. Deforestation at Venustiano Carranza and Magallanes cannot be considered an ecologically destructive practice performed by peasants. In fact, the process reflects not only a lack of environmental awareness in national development policies, but also the intricate interaction of ecological, cultural, social and economical variables.

Keywords: tropical deforestation, rainforest, forest clearance, pasture, Mexico, government policy, environmental degradation

*Correspondence: Dr Leticia Durand Tel: +52 55 5622 7838 Fax: +52 777 317 5981 e-mail: leticiad@servidor.unam.mx

INTRODUCTION

In the 1990s, more than 90% of world deforestation occurred in tropical zones, at an annual rate of 14.2 million hectares (FAO [Food and Agricultural Organization of the United Nations] 2001). In Mexico, deforestation has been more intense in the tropical area of the country (Palacio Prieto *et al*. 2000; Velazquez *et al*. 2002). Tropical rainforests showed an annual clearance rate close to 2% (190 000 ha removed every year) between 1976 and 1993 (SEMARNAP [Secretaria de Medio Ambiente, Recursos Naturales y Pesca] 2000). Consequently, México has already cleared more than 95% of its rainforests (CONABIO [Comision Nacional para el Conocimiento y Uso de la Biodiversidad] 1998; Masera *et al*. 1997).

Although it is difficult to isolate a single factor to explain this deforestation, in Latin America spontaneous agricultural colonization has always been linked to forest clearance (Jones 1989; Ledec & Goodland 1989; Moran 1993; Myers 1996; Brothers 1997; Sierra 1999, 2000; Lambin *et al*. 2001; Maki *et al*. 2001; Steininger *et al*. 2001). Poor farmers (*campesinos*) move from areas of insufficient land to colonize uninhabited tropical territories (Moran 1989*a*; Partridge 1989). In the newly occupied areas, colonists developed the 'peasant pioneer cycle', widely considered a major cause of deforestation (Pichon 1996, Rudel & Roper 1997; Lambin *et al*. 2001). In small forest-cleared plots, they cultivate subsistence crops (such as corn or rice) by slash-and-burn agriculture. After a few years, soils are weathered and poor in nutrients, and thus yields diminish. Peasants transform agricultural plots into pastureland and farm new areas of forest. This method of farming removes almost all the original vegetation in a few decades (Joly 1989; Millikan 1992; Myers 1996; Brothers 1997). Around two-thirds of global tropical deforestation is attributed to this process (Myers 1996).

The 'peasant pioneer cycle' suggests deforestation is a consequence of a fragile ecosystem combined with the lack of financial resources to improve productive technology (Myers 1996; Pichon 1996). In fact, agricultural colonization and smallholder farming in frontier areas are much more complex (Durham 1995; Pichon 1996). For instance, agricultural colonization can be considered spontaneous in the sense of being unplanned and unassisted by the government, as pointed out by Moran (1989*a*), yet it is not unpredictable. Migration to the forest ultimately is induced by national

development policies that promote unequal distribution of land and imprecise property rights (Partridge 1989; Myers 1996; Lambin *et al.* 2001). Furthermore, there are situations in which colonists' land-use decisions and patterns of deforestation have been affected by policy, as well as by some cultural and socio-economic characteristics (Bedoya Garland 1995; Godoy *et al.* 1997, Marquette 1998; Sierra 1999; Ochoa Gaona & Gonzalez Espinosa 2000; Shriar 2002). Pichon (1996) identified three factors that determine land-use decisions: (1) the natural resource base (soil quality and topography, etc.), (2) the institutional and technological environment and infrastructure (road access, agricultural inputs, technological assistance, land tenure policies and access to labour markets, etc.) and (3) household characteristics (demographic composition, plot size, farm size and settlers' agricultural background, etc.). All of these factors interact to produce different resource-use patterns. The key question is how they increase or decrease the number of resource-use options available to farmers (Pichon 1996).

In Mexico, some studies have documented the relationship between colonization and environmental degradation in the tropical portion of the country. These studies analysed significant government-sponsored directed settlement projects to stimulate regional economic growth, such as the Papaloapan Project (1947–1969) and the Chontalpa Plan (1966–1975) (Ewell & Poleman 1980; Revel Mouroz 1980; Tudela 1989; Paz 1995). Spontaneous colonization is less well studied but often mentioned as an important cause of recent deforestation in some areas of southern Mexico (Pare 1994; Paz 1995; PSSM AC/GEF/CIIMYT [Proyecto Sierra Santa Marta AC/Global Environmental Facility/Centro Internacional de Investigaciones en Maiz y Trigo] 1996). This is because the government, in an attempt to solve land scarcity problems, decided to open the tropical frontier for occupation, encouraging colonization by small farmers. Between 1940 and 1960, the national authorities distributed nearly 4.5 million hectares of federal lands in the southern states of Veracruz, Yucatan, Quintana Roo, Chiapas and Campeche to farmers (Revel Mouroz 1980).

Until 1960, the Sierra Santa Marta was densely forested. By this time deforestation rates had increased substantially and, by 1990, only about 23% of the original vegetation remained (Figs. 1 and 2; Dirzo & García 1992; PSSM AC/GEF/CIIMYT 1996; Ramirez 1999). Nowadays, this area of southern Mexico is part of one of the major deforestation fronts in Latin America (Myers 1993).

The beginning of deforestation coincided with the government decision to promote the occupation of the tropical frontier, but little is known about the incentives and constraints that shaped resource-use strategies and oriented households toward deforestation. Therefore, the goal of this paper is to analyse the events of colonization and deforestation at Sierra Santa Marta in more detail. We focused our attention on the settlement processes and resource-use strategies at two villages, attempting a careful reconstruction of the local history and causes of deforestation. Three questions guided our analysis. What kinds of productive activities did the new settlers implement at different stages of the colonization process? What was the impact of these resource-use practices on deforestation? Which factors influenced their resource-use choices?

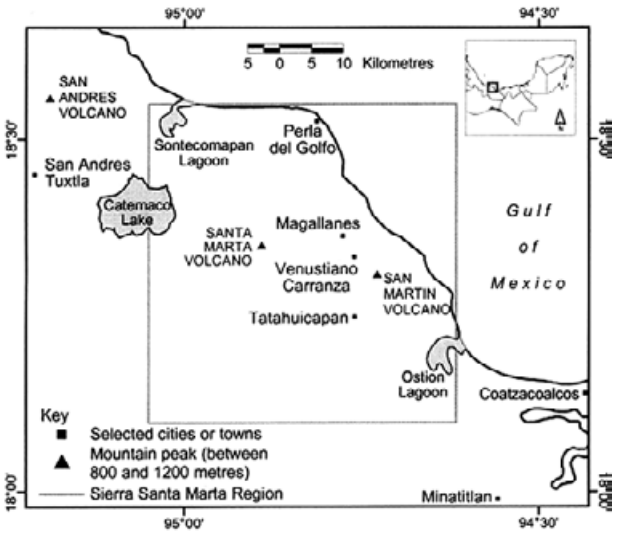

Figure 1 Location of the Sierra Santa Marta region.

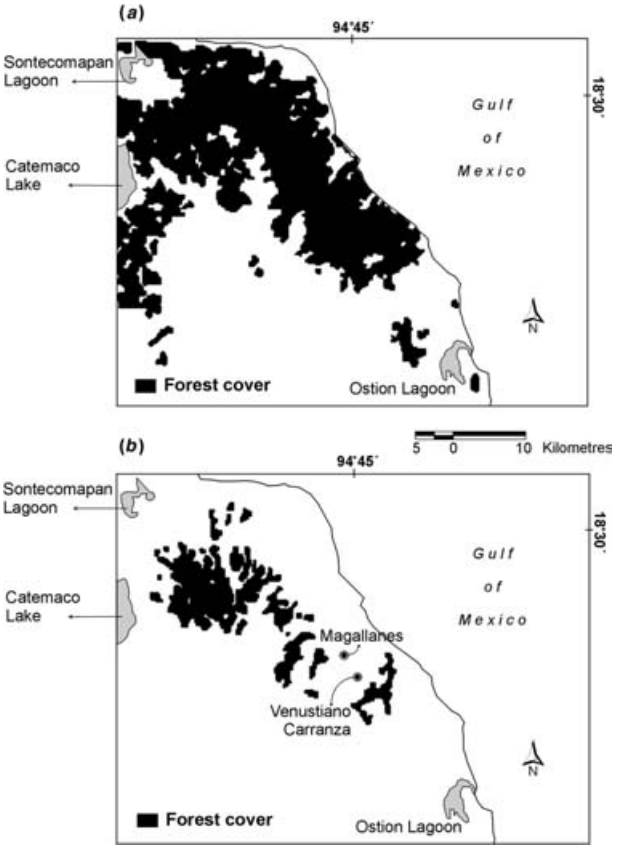

Figure 2 Tropical rainforest cover change in Sierra Santa Marta. (*a*) 1967, (*b*) 1990. Modified from Ramirez (1999).

https://doi.org/10.1017/S0376892904001006 Published online by Cambridge University Press

METHODS

The study area

Located to the south of the state of Veracruz, on the Gulf of Mexico coast, the Sierra Santa Marta region (Fig. 1) covers an area of 150 000 ha, and represents the boreal limit of the tropical rainforest in America (PSSM AC/GEF/CIIMYT 1996; Dirzo & Miranda 1997). Topography and climate are heterogeneous, ensuing great environmental variability and, therefore, high biodiversity. More than 3000 higher plant and 1149 animal species have been reported; many are endemic (INE [Instituto Nacional de Ecologia]/CONABIO 1995). The dominant ecosystem is tropical rainforest, in addition to tropical moist deciduous forests, oak forests, mangroves and savannahs.

In 1995, the population of the study region was approximately 110 000 people. Indigenous folk accounted for more than 40% of the whole population, with *Nahuas* (58%) and *Popolucas* (42%) as the major indigenous groups. *Mestizos*, people who define themselves as non-indigenous because of their different cultural backgrounds, constituted the remainder of the population (INEGI [Instituto Nacional de Estadistica Geografia e Informatica] 1995), coming from a number of places within the state of Veracruz or even from other states of the country. Today in the Sierra Santa Marta, indigenous inhabitants and mestizos coexist in almost every village. In the productive scheme of indigenous households corn cultivation (*Zea mays* L.) is still an important activity, followed by cattle raising. Mestizo families depend for the most part on the sale of cattle and its by-products (beef, milk and cheese) or agricultural goods. All households supplement their income with seasonal labour and trade.

Sources of information

Between 1998 and 1999 we researched two small villages north-east of Sierra Santa Marta, namely Venustiano Carranza and Magallanes (Fig. 1). Each community formed an *ejido*, a Mexican type of collective land tenure. In Venustiano Carranza, the ejido is up to 1020 ha and the population is approximately 270 people, all mestizos. Magallanes encompasses 808 ha and 71.5% of 309 inhabitants are Popolucas (INEGI 1996). Both communities were founded during the 1960s, when most of the area was colonized. As they are neighbouring villages, the original ecological conditions at settlement were similar.

Three data collection methods were employed: open-ended interviews, questionnaires and review of published literature. Interviews about the history of colonization and deforestation were carried out in all households (15 in Venustiano Carranza, 15 in Magallanes) with the male and/or female founders. We directed a questionnaire with closed and open-ended questions focused on general agricultural practices and on the history of individual farming parcels to all male founders in both communities, as well as to other randomly selected, household heads. In total, we addressed the questionnaire to 32 (57%) household heads in Venustiano Carranza, and to 28 (67%) in Magallanes. With this sample, we obtained information about the actual land use in 623 ha (61%) of Venustiano Carranza and 434 ha (54%) of Magallanes.

We estimated the deforestation in each community from questionnaire responses about the actual condition (undisturbed forest, pasture, cultivated) of plots belonging to household heads. We calculated the annual deforestation rate in each community using the following equation (Sader & Joyce 1988):

$$\text{Annual percentage} = ((F_1 - F_2/F_1)/N) \times 100 \quad (1)$$

where F_1 = forest area at settlement foundation, F_2 = forest area in 1999, and N = number of years between settlement foundation and 1999.

This allowed us to quantify forest loss indirectly (questionnaire responses), however, it was not possible to identify variations in deforestation rates over time, even though we know deforestation in the Sierra Santa Marta was more intense in some decades (for example the 1970s) than in others.

RESULTS

Colonization

The Popoluca indigenous people, who founded Magallanes, first arrived in 1960. They came from the old village of Ocotal Chico, located in the lowlands of the Sierra Santa Marta. Oak forests typically covered the area. Land in Ocotal Chico was an open-access resource until the community became an ejido in the early 1960s, and now the land belongs to all group members (*ejidatarios*). In spite of this, the area was frequently divided into individual plots and every ejidatario made their own decisions about the use of resources. Ejidatarios in Ocotal Chico delimited individual plots in 1962, but land was insufficient for all the petitioners. Hence, many Ocotal Chico residents resolved to move to the uninhabited forest of the Sierra Santa Marta offered by the government for the creation of new ejidos. Venustiano Carranza was founded in 1967 by peasants who came from Cuesta Maria, a community located in the adjacent region of Los Tuxtlas. There they were landless and subsisted as wage labourers. Los Tuxtlas has been under intense agricultural and forestry exploitation since the 19th century; sugar cane, tobacco, coffee and cotton plantations dominated the landscape (Guevara *et al*. 1996).

In both communities, when the government approved occupation of the site and land was distributed between applicants, every peasant become an ejidatario, acquiring usufruct rights over an average 20 ha of tropical rainforest. When asked about their reasons for abandoning their original communities, the majority of the original founders of Magallanes and Venustiano Carranza said they had been seeking land and a better livelihood (Table 1). In contrast with Ocotal Chico migrants, people from Venustiano Carranza had probably been landless for generations, as demonstrated by

Table 1 Summary of selected original founders' responses to the questionnaire. (*a*) Per household: $n = 15$ for Magallanes and $n = 15$ for Venustiano Carranza. (b) Per respondent: $n = 18$ for Magallanes and $n = 21$ for Venustiano Carranza.

Responses	*Topic*	*Magallanes*	*Venustiano Carranza*
Per household	*Arrival Period*		
	0–5 years after initial settlement	15	13
	6–10 years after initial settlement	0	2
	Possessions at arrival		
	Yard animals	9	2
	Money	0	2
	Both	3	2
	None	3	9
	Household composition		
	Single person	0	1
	Married couple	5	0
	Married couple with child/ren	10	14
Per respondent	*Number of previous living places*		
	1 (born there)	14	7
	2	4	9
	3	0	1
	4	0	4
	Reasons for moving to community		
	Seeking land	14	18
	Following husband/family	4	3
	Reasons for choosing community		
	Government granted	8	13
	Husband/family chose place	6	5
	Other (nice place, vicinity to other towns, etc.)	2	3
	No answer provided	2	0

the occurrence of previous migrations (Table 1). Although many ejidatarios stated that the place was inadequate because of its isolation, lack of services and poor soils ('red soils' in their own words), they remained because of an absence of alternative sites (Table 1).

Before becoming established as permanent, colonists performed many visits to the site in order to familiarize themselves with the place and provide minimal living conditions for their families. These first years of the colonization process were remembered, by both indigenous and mestizos inhabitants alike, as very hard times. The area was covered by a dense tropical rainforest with no road access. A trip to Tatahuicapan, the nearest town where colonists could obtain food and other goods, meant at least a three-hour walk. Settlers did not receive government assistance for the occupation of the site or the implementation of productive activities, even when most of them migrated in poor economic condition (Table 1).

Productive system development

We found similar productive system development and use of biological resources in the two study communities. There were minor differences in the types of commercial crops cultivated and in the initial approach to cattle ranching (Fig. 3). During the first years after settlement, productive activities were oriented towards subsistence. Small harvests forced colonists to undertake commercial agriculture and logging in order to satisfy their basic needs. For short periods of time, commercial agriculture proved profitable; however, after some years yields diminished. The limited availability of capital impelled colonists to overcome this situation and, as a result, they converted their plots into grasslands. This general pattern is reviewed in detail below.

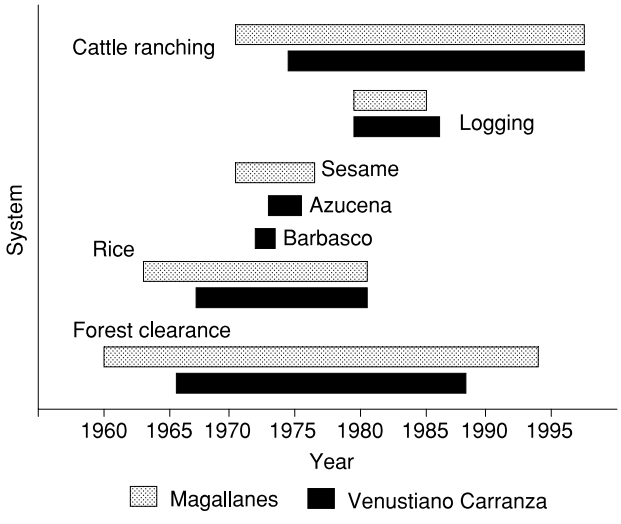

Figure 3 Productive system development in Magallanes and Venustiano Carranza from 1960–1998. Based on questionnaire responses and interviews.

https://doi.org/10.1017/S0376892904001006 Published online by Cambridge University Press

Subsistence and commercial agriculture

In the first stages of colonization, household subsistence was based on corn production, and, consequently, small areas of forest were cut down for this purpose. Slash-and-burn cultivation provided small yields of beans, squashes, manioc, bananas and pineapples. Corn harvests were extremely meagre, approximately 150 kg ha^{-1} yr^{-1} according to questionnaire respondents. In these first stages, household budgets depended on wage labour and on the sale of forest products derived from hunting and gathering.

After some years, colonists started to grow commercial products and they cleared other forested areas. Rice and sesame were the main commercial crops cultivated by colonists in Magallanes. According to inhabitants, these products, unlike corn, suited the climatic and soil conditions and they could yield a surplus for sale. Colonists later abandoned sesame cultivation because of low market demand. The Popoluca settlers grew rice until 1980, when plague resulted in decreased yields.

Venustiano Carranza settlers produced rice too, but their principal income came from husbandry of an ornamental flower, the so-called giant azucena (*Lilium longiflorum* Thunb.). Settlers sold azucena root staples and flowers. This cultivation produced large profits between 1973 and 1976; after that, a fungal disease destroyed the plantations in the region. Another important activity was the collection of barbasco (*Dioscorea composita* Hemsl. and *Dioscorea floribunda* Mart. and Gal.). The barbasco roots were valued during the 1960s and 1970s for the extraction of *diosgenina*, a steroid precursor that enabled production of the first contraceptive pills (Huerta 1998). This plant was collected between 1972 and 1973 in Venustiano Carranza and sold to the state company PROQUIVEMEX (*Productos Quimicos Vegetales Mexicanos* [Mexican Vegetable Chemical Products]). Collection in this and other communities of the Sierra Santa Marta was so exhaustive that barbasco almost disappeared from the area in just a few years (Lazos Chavero & Godinez Guevara 1996).

Logging

The government began the construction of the road that links Venustiano Carranza and Magallanes to Tatahuicapan around 1980. Colonists financed road building through an unpaid labour force and by delivering logged wood from individual plots to forestry authorities. After the road was finished, colonists continued to harvest timber.

Founders of Magallanes mentioned during interviews that they sold extracted timber to a mill established in Tatahuicapan in 1979. Logging apparently continued for five or six years even though federal authorities in the Sierra Santa Marta had prohibited timber extraction from 1980, when the area was officially declared a national protected area. In 1990, the government finally shut down the mill and reinforced the prohibition of timber extraction. In Venustiano Carranza, there were no references to the mill. According to informants, the timber extracted was sold to the National Railroad Company, which required timber for crossties. The effects of logging on deforestation are difficult to assess just from interviews, but from the colonists' point of view, commercial plantations and accidental wildfires were more significant.

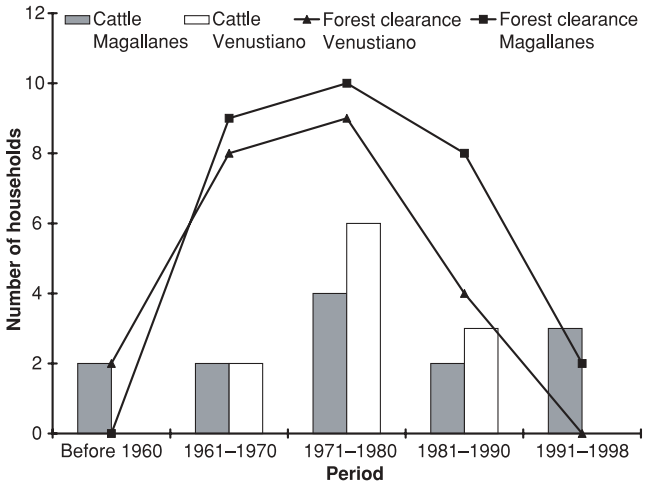

Figure 4 Number of households that bought cattle for the first time (bar charts) and number of households undertaking forest clearance (line plots) by period, based on questionnaire responses from original founders ($n = 15$ in Magallanes and Venustiano Carranza).

In 1982, the government provided the financial aid and technical advice to implement rubber (*Hevea brasiliensis* Muell. Arg.) plantations in Venustiano Carranza. The first step was to clear the forest in order to introduce rubber trees. Colonists explained that in just a few months they cleared around 200 ha, which represents 25% of the total ejido area. Trees and shrubs were cut down and burned. Only a small part of the wood could be used for construction and fuel. When almost all the plantation area had been cleared, government institutions suspended the project, arguing that soil characteristics were inadequate. Rubber plantations could not be implemented, but cleared forest plots allowed the pioneers to try other commercial enterprises.

For the people of Magallanes forest loss is mainly explained by two or three wildfires that took place between 1982 and 1985. In the entire Sierra, farmers use fire for field preparation, but fire easily escapes control and consumes large areas of native vegetation. Local authorities and non-governmental organizations (NGOs) discourage this practice, but non-natural wildfires keep reducing the remaining forest area.

Cattle ranching

Although cattle ranching and pasture conversion in the two communities began in the early years of colonization, it became more intensive soon after 1970 (Fig. 4). Cattle ranching was not part of the traditional productive system of the Popoluca and, until 1960, herds were rare amongst indigenous communities of the Sierra Santa Marta (Felix Baez 1990).

https://doi.org/10.1017/S0376892904001006 Published online by Cambridge University Press

Table 2 Cattle ranching features in Venustiano Carranza and Magallanes households. From original founders' questionnaire responses.

Topic	*Magallanes (n = 12)*		*Venustiano Carranza (n = 14)*	
	Mean	*SD*	*Mean*	*SD*
Per household				
Plot area (ha)	18.08	6.27	20.50	14.53
Pasture area in plot (ha)	10.04	7.36	8.92	13.88
Head of cattle	6.00	6.43	4.38	14.91
Head of cattle per ha of pasture	2.25	1.30	1.98	1.02
Households	*n*	%	*n*	%
Involved in cattle ranching	11	92	11	78
Actually own cattle	9	75	3	21

Indigenous colonists became engaged in this activity as they worked for the big cattle ranchers from the coastal area of the Sierra. These cattle ranchers financed the establishment of pasturelands in already cleared areas in Magallanes, but also supported further forest clearance. Indigenous colonists covered the debt with ranchers by allowing them to graze cattle free of charge in the new pasture plots. After that, ranchers had to pay to introduce cattle to Magallanes pasturelands. With this income, almost all colonists, after four or five years, could afford their own cattle. The size of stocks and pastureland area owned by Magallanes household heads increased with financial credits and other facilities provided by the government.

In Venustiano Carranza, the first grazing lands date from 1974. In this case, the capital needed to seed pasture and buy cattle came from the azucena cultivation. Interviewees did not mention deals with cattle ranchers. Farmers also used financial credits from the government to increase pasture area and the size of their herds of cattle. In fact, cattle acquisition and plot clearance appeared to be closely related, since most of the colonists of Magallanes and Venustiano Carranza performed both actions in parallel, particularly during the 1970s (Fig. 4). The switch from agriculture to cattle ranching in the studied communities came about at the peak of governmental economic incentives for cattle ranching, which during the decade amounted to US$ 1100 million (Perez Lopez & Camou Healy 2001).

Almost all founders in both communities took part in cattle ranching, acquiring their own cattle and transforming plots into pastures (Table 2). Nevertheless, with cattle ranching colonists faced the same problems that affected cropping. After only a few years, low soil fertility together with plague outbreaks hindered the growth of sufficient pasture. The poor economic conditions of the colonists prevented an adequate management of the herds and pastures. In Venustiano Carranza, 73% of the founders who brought

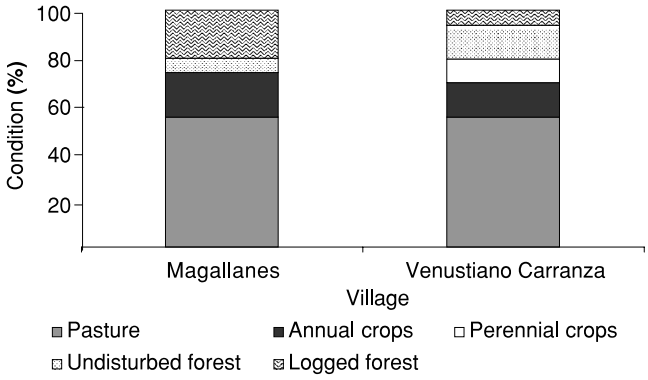

Figure 5 Average condition of plots belonging to household heads from Magallanes ($n = 28$) and Venustiano Carranza ($n = 32$) in 1999. Results from questionnaire responses.

cattle failed to sustain their herds. In Magallanes, a great number of founders still had their own animals, but as in Venustiano Carranza, herds were small (Table 2). In both communities cattle ranching was an extensive and low profit activity. Even though most households in both communities had no livestock, the majority still depended on cattle ranching because they received income from renting pasturelands.

Introduction of cattle ranching to both communities did not bring radical changes to the colonists' living standards, but they found two advantages in this activity. Cattle ranching demands considerably less labour input, and at the same time, allows practitioners to obtain cash money more readily than cropping, as they can more easily sell a cow than any harvest. A head of cattle represents a 'savings account' for households to overcome economic emergencies (such as illness), or to pay for some festivity (for example a wedding), in which offering meat for the guests' consumption is almost mandatory. By looking at the actual composition of individual parcels in the communities under study, the relevance of cattle ranching became obvious: approximately 55% of the plot areas in Venustiano Carranza (336.4 ha) and Magallanes (234.6 ha) were grasslands (Fig. 5).

Colonization and deforestation

Patterns of deforestation in the studied communities differed in spite of the similarities found in the colonization process and productive system development (Table 3). In Venustiano Carranza, about 535.3 ha of rainforest was cleared between 1967 and 1999 (86% of the area sampled). In the Popoluca community of Magallanes, around 407.5 ha of the original forests have been lost since 1960 (94% of the area sampled). Although the annual rate of deforestation was very much alike in both communities, the number of hectares deforested annually was higher in Venustiano Carranza. Surprisingly, this community holds a large percentage of standing forest and a great number of individual plots with forest patches (Table 3). Venustiano Carranza peasants cleared the forest faster but for a shorter time, probably because of easier access to financial resources coming from the rubber project. In

Table 3 Deforestation in Magallanes and Venustiano Carranza. Information derived from actual land use in 32 plots (623 ha) from Venustiano Carranza and 28 plots (434 ha) from Magallanes. See Methods for further details. SD = standard deviation.

Village	*Annual rate*		*Forest remnant*		*Standing forest area per plot*		*Plots with standing forest*	
	ha	*%*	*ha*	*%*	*ha*	*SD*	*n*	*%*
Magallanes	19.4	2.4	27.0	6.2	3.0	2.7	9	32
Venustiano Carranza	28.3	2.8	87.7	14.0	3.8	2.0	23	72

Magallanes, the close relationship established between the indigenous colonists and cattle ranchers made it possible to sustain removal of the original vegetation cover for a longer period. This condition, together with wildfires, could explain the high deforestation of Magallanes. It is worth noting that the average area of standing forest per plot was almost the same in both communities (Table 3). According to interviews, for some ejidatarios it was important to leave a small portion of forest uncut within their parcels, in order to protect streams, some wild animals (such as *Agoutii paca* Linnaeus, *Dasypus novemcinctus* Linnaeus) and plants (such as *Astrocaryum mexicanum* Liebm.) traditionally used for consumption.

We did not find strong differences in deforestation rates between indigenous and mestizo colonists in the two communities under study. Customary, Popoluca households relied on a kind of subsistence cultivation known as *milpa* (Felix Baez 1990; Velazquez 1994). This is a system of mixed crops (i.e. beans, squashes, tomatoes, peppers) growing together in shifting plots, with corn as the central product. According to interviewees, the milpa never grew well in the soils of Magallanes, so areas assigned to the milpa were gradually reduced to make room for commercial crops and pasture lands. Today in Magallanes, indigenous colonists produce subsistence crops, but with over 50% of their individual plots devoted to pasture, budgets depend fundamentally on cattle ranching.

Deforestation has promoted soil erosion and has led to the disappearance of wild animals and plants that were an important food resource in the first stages of colonization. Some studies estimate a 60% reduction in the number of mammal and bird species in the area between 1982 and 1989, and at least 9% of vertebrate species are considered in danger (INE/CONABIO 1995; PSSM AC/CRUO-UACH/SEMARNAP [PSSM AC/Universidad Autonoma de Chapingo/SEMARNAP] 1997). Climatic conditions have changed, and colonists perceive such alterations as hotter summers, insufficient rainfall during the wet season and stronger winds. Paradoxically, after more than three decades of occupation, basic services and infrastructure in the communities are improving. Now both villages have access roads, electric power and water supply. Elementary schools and medical care clinics are available close by. Despite these facilities, most people in Magallanes and Venustiano Carranza live in poverty. Thus, recent colonization of this part of the Sierra can be considered a failure from a social, economic and ecological sense, even though, from the colonists' point of view, they are now landowners.

DISCUSSION

Land-use decisions in Magallanes and Venustiano Carranza resulted in the allocation of approximately 50% of parcel area to pasture, a similar proportion to that reported for many other agricultural frontiers in Latin America (Sierra 2000). Although the environmental consequences are almost the same, we found differences in the processes of colonization and deforestation in relation to other well-studied areas in Latin American. In the Brazilian Amazon, for example, road construction preceded the human advance into the forests, the latter stimulated by direct-settlement programmes (Fearnside 1986; Moran 1989*b*, 1993; Laurance 1998; Steininger *et al.* 2001; Laurance *et al.* 2002). After the area was opened up for settlement, thousands of shifting cultivators arrived. Furthermore, most clearing is done on large (over 100 ha) cattle ranches (Partridge 1989; Fearnside 1993, 1998; Laurance 1999). Some have argued that small farmers have accounted for only 30% of the deforestation in the Amazon, and 10% in Rondonia, one of the most devastated states in Brazil (Park 1992; Fearnside 1993, 1998; Laurance 1999). In other Amazonian countries (i.e. Ecuador, Bolivia, Peru), deforestation by small-scale agriculture has also been facilitated by road construction (Sierra 2000; Maki *et al.* 2001; Steininger *et al.* 2001). Land speculation has also played a critical role in Amazon deforestation. Colonists could triple the land value by cutting forests and sowing it for pasture, and so, almost half of the settlers sold their plots between one to three years after getting land rights (Fearnside 1998).

In Central America, the development and expansion of perennial cash crops (i.e. cotton, coffee, bananas, sugarcane) and cattle into tropical lands has been a major motor for colonization and deforestation, often facilitated by road construction (Sader & Joyce 1988; Jones 1989; Partridge 1989). Smallholder colonization and deforestation have occurred in almost all countries in the region, but settlers have often established themselves near large-scale plantations and ranching enterprises (Partridge 1989; Harrison 1991; Stonich 1995).

In general, tropical colonization and its associated deforestation in South and Central America fit well into the historical sequence of two main models of deforestation described by Rudel and Roper (1997). In the initial stages,

https://doi.org/10.1017/S0376892904001006 Published online by Cambridge University Press

deforestation responds to capital-intensive efforts to open up the tropical frontier to exploitation (frontier model). After forests are made more accessible, impoverished peasants occupy the area. In this phase, deforestation is best explained by small farm clearance (inmeserization model). The same situation occurred in certain areas of southern Mexico, like the Yucatan peninsula, where the construction of a highway and the economic boom resulting from oil extraction in the late 1970s stimulated development projects and land occupation (Turner *et al.* 2001). In the states of Tabasco, Campeche, Chiapas and some areas of Veracruz, colonization and deforestation were derived from big development projects with enormous capital investments (Revel Mouroz 1980; Tudela 1989; Paz 1995).

In the studied communities, a capital-driven process did not initiate deforestation. The absence of roads, land speculation or commercial enterprises that could attract migrants supports this conclusion. The scheme of deforestation in this area shows more resemblance to the process described by Brothers (1997) for the Caribbean, in which pasture conversion was from the beginning a smallholder phenomenon. This is attributable to the limited original extent of rainforest area in the Sierra Santa Marta region (52 000 ha) and its proximity to medium-size cities such as Coatzacoalcos and Acayucan. This allowed settlers to advance without capital improvements like roads or bridges, without which the access to more remote rainforest regions was harder (Rudel & Roper 1997).

In contrast to other studies that have reported small rates of deforestation for indigenous colonist settlements (Arizpe *et al.* 1993; Bedoya Garland 1995; Schmink 1995), in this case popoluca and mestizo peasants showed similar clearance patterns. This result could be explained by the fact that the indigenous people of Ocotal Chico never implemented their traditional resource-use system or milpa in Magallanes. In this community the actual land use is similar to that reported for non-indigenous small migrant farmers in other tropical areas of Latin America (Sierra 1999).

The high deforestation rates in Magallanes and Venustiano Carranza could easily be explained by the adoption of the 'peasant pioneer cycle' by farmers, but why was this the case? Misguided policies and institutional failures appear important causes, since they were closely related to (1) the occupation of an area with low farming potential by people who were looking to improve living standards through agricultural practices, and (2) the rise of cattle ranching as the main productive activity in the communities. The following brief review of the national political and social context provides an explanation of the role of government policies in Magallanes and Venustiano Carranza deforestation.

In Mexico, the agrarian reform was an irregular process. Initiated in 1915 after the revolutionary period, the subdivision of large private properties and reassignment to campesinos reached a peak between 1930 and 1940. After that, subsequent government administrations tended again to favour possession of big private lands as a way to stimulate the development of a 'modern' agricultural sector. Land distribution to the poor slowed down, while latifundias expanded faster. In 1958, more than three million landless peasants threatened the political stability of the country (Gutelman 1974). The government, instead of making an effort to redistribute already-occupied lands, encouraged the spontaneous colonization of the tropical frontier. At that time, the south-western portion of Mexico was a large tropical and subtropical forest that represented a way out of social problems (Paz 1995). Between 1940 and 1960, 48% of these tropical lands were allocated and 36.2% of the beneficiaries of agrarian reform were located in the humid tropics (1946–1966; Revel Mouroz 1980). Magallanes and Venustiano Carranza peasants acquired land rights over uninhabited areas of Sierra Santa Marta during this period, but it is difficult to think about them as beneficiaries of the agrarian reform because redistribution of land did not take place. The founders of the communities we studied were best understood as impoverished migrants tolerated by the state.

The distribution of marginal lands with an irregular topography helped to meet the social and political demands of campesinos, but it did not improve their life conditions. Failure of agricultural production in Magallanes and Venustiano Carranza was a result of the common constraints that colonists face in tropical environments, namely lack of roads, reduced initial capital, scarce labour and absence of educational and health services (Moran 1989*a*). Governmental agrarian reform policies neglected all these aspects; assumed that providing land would suffice to overcome poverty (Moran 1989*a*). Moreover, such government policies transmitted the notion that land had no value unless forests were removed. Authorities reinforced this perception while establishing forest clearing as a prerequisite to obtain and assure official usufruct rights, which stood in clear disagreement with the national protected area statement of 1980. As many ejidatarios of Venustiano Carranza expressed, landowners that did not clear forest from their plots often put their own land rights at stake.

At the same time, the design of agricultural polices with no feasibility assessment and resource surveys that could adjust productive activities to environmental characteristics, resulted in the application of homogeneous measures in an ecologically diverse country (Toledo *et al.* 1993). Extensive cattle ranching was encouraged and financed between 1960 and 1980 all around the country, but especially in the south. The idea was to integrate the undeveloped southern states of the country with the national economy, by transforming tropical forest areas into grasslands for extensive cattle ranching and commercial plantations. To achieve this purpose, Mexico attracted 60% of the credits for cattle ranching projects in Latin America coming from the World Bank and the Inter-American Development Bank (Perez Lopez & Camou Healy 2001). During this period, the overall area devoted to pastures in southern Mexico increased 156.9%, with the consequent removal of the original forest cover (Rustch 1980; Toledo *et al.* 1993). Hence, the attribution of 58.1% of the tropical deforestation in the country to cattle ranching is justifiable (Makundi *et al.* 1992).

Nevertheless, migration to uninhabited areas and the adoption of cattle ranching as the main productive activity in the

studied communities could not be explained only by looking at external causes (Lazos Chavero 1996). In Magallanes, for example, displacement of people from the original community resulted in the loss of their traditional land-tenure system based on common access, as well as in demographic pressure over land resources. Overpopulation was also a factor that encouraged colonization in the case of Venustiano Carranza founders. In both communities, people arrived from ecological scenarios dissimilar from those dominated by tropical rainforests. The lack of knowledge of the ecosystem and productive experience with this particular landscape constrained colonists' agricultural enterprises (Moran 1989*a*). Another important factor was the cultural prestige of cattle ranching in Hispanic society, accentuated by the influence of neighbouring big cattle ranchers that created a vision of success and of cattle raising as the way to overcome poverty (Brothers 1997; Lazos Chavero 2001). Even when cattle ranching incomes are low, people who own cattle are seen as more prosperous or influential, in what is known in Mexico as the '*becerro de oro*' (gold calf) illusion (Lazos Chavero 1996, 2001). What we see is an interaction of national policies and a local socio-cultural dynamic that influenced colonization and encouraged the prevalence of cattle ranching in the study areas.

As in other Latin American regions, deforestation at Venustiano Carranza and Magallanes cannot be considered simplistically as an ecological destructive process performed by peasants and small farmers (Partridge 1989; Pichon 1996). In reality, the process reflects not only the omission for decades of an environmental dimension in national development policies (Landa *et al.* 1997), but also an intricate interaction of ecological, cultural, social and economical variables expressed in local, regional and national contexts. Local studies and multidisciplinary approaches to tropical forest losses should always be considered when attempting to unravel the complexity of deforestation processes.

Prospects for the future

The last remnants of tropical forest in the Sierra Santa Marta are now legally protected under a biosphere reserve designation, but their successful conservation will also require a development strategy that incorporates the particular environmental, cultural, social, and economic characteristics of the region. Such a strategy would make it possible for inhabitants to perceive greater benefits from conservation as opposed to resource depletion. It will be necessary to take into account the local people's perceptions of rainforest conservation. Although incongruities and conflicts persist between some of the agencies and institutions involved, since 1990 the Mexican government has tried to incorporate many of the concepts of sustainable development and conservation into national development programmes. Yet, the ideas that give shape to the environmental discourse are often inconsistent with the life and representations of the world of a significant segment of the rural population. For the agrarian-reform beneficiaries, especially those who undertook colonization, the land represents their most valuable possession, a trophy after years of fighting for their rights and against injustice after the Mexican Revolution made it possible for peasants to have access to a piece of land of their own for survival. Thus, land means work, and work frequently implies transformation of the landscape into commercially-productive schemes. This explains why during interviews some local residents of the Sierra made such comments as: '. . . now in this place everything looks more beautiful without so many trees . . . ' or '. . . before forest clearance this town was ugly because it was more dangerous, with a lot of snakes . . . ', or even '. . . I do not understand why the authorities forbid us to cut down the forest; this land was given to us to survive, to work. How do they expect us to work?'.

Conservation can therefore be contradictory to the personal experience of colonization and even to the agrarian reform ideology, useful for and constructed by the state, and centred on the notion of progress and social justice. In Mexico, as in other countries, we must avoid designing conservation projects without considering the historical factors that give shape to local perceptions about nature (i.e. the rainforest) and its protection. Understanding how people feel and think about their environment and its conservation must be a first step in any environmental planning strategy, because conservation needs, above all, a collective reconstruction of the relationship between humans and nature. Conservation may be important for government agencies, environmentalists and academics, but it may not be a priority for rural communities that have been exposed for several decades to contradictory policies and poor living standards, where the urgency to solve daily needs make it impossible to think about the future. In this scenario, more realistic participatory approaches are needed in which the interests, expectations and needs of all actors involved are considered.

ACKNOWLEDGEMENTS

The Direccion General de Asuntos del Personal Academico (DGAPA) at the Universidad Nacional Autonoma de México financially supported this study. We want to thank all the people of Venustiano Carranza and Magallanes for their help and interest in our work, especially Mr Fernando Malaga and Mr Juan Gutierrez and their families. Lourdes Godinez and Fernando Ramirez allowed us to use the forest clearance data from the PSSM AC geographical information system. We are also indebted to Claudia Aguilar Zuñiga and Viviana Gudarrama Villegas for making the maps of Sierra Santa Marta, and Ariel Alarcon for his comments on and improvements to the English of the original manuscript. We would like to thank the two anonymous referees for adding focus and insight to this paper.

References

Arizpe, L., Paz, F. & Velazquez, M. (1993) *Cultura y Cambio Global: Percepciones Sociales Sobre la Deforestacion en la Selva Lacandona*. Distrito Federal, Mexico: Universidad Nacional Autonoma de Mexico/Miguel Angel Porrua: 230 pp.

Bedoya Garland, E. (1995) The social and economic causes of deforestation in the Peruvian Amazon basin: natives and colonists. In: *The Social Causes of Environmental Destruction in Latin America*, ed. M. Painter & W.H. Durham, pp. 217–246. Michigan, USA: The University of Michigan Press.

Brothers, T.S. (1997) Deforestation in the Dominican Republic: a village-level view. *Environmental Conservation* **24**: 213–23.

CONABIO (1998) *La Diversidad Biologica de Mexico. Estudio de Pais*. Distrito Federal, Mexico: CONABIO: 341 pp.

Dirzo, R. & García, M. (1992) Rates of deforestation in Los Tuxtlas, a Neotropical area in southeast México. *Conservation Biology* **6**: 84–90.

Dirzo, R. & Miranda, A. (1997) El limite boreal de la selva humeda en el continente Americano: contradiccion de la vegetacion y solucion de una controversia. *Interciencia* **16**: 240–47.

Durham, W.H. (1995) Political ecology and environmental destruction in Latin America. The social and economic causes of deforestation in the Peruvian Amazon basin: natives and colonists. In: *The Social Causes of Environmental Destruction in Latin America*, ed. M. Painter & W.H. Durham, pp. 249–266. Michigan, USA: The University of Michigan Press.

Ewell, P.T. & Poleman, T.T. (1980) *Reacomodo y Desarrollo Agricola en el Tropico Mexicano*. Xalapa, Mexico: Instituto Nacional de Investigaciones sobre Recursos Bioticos: 282 pp.

FAO (2001) *Situación de los Bosques del Mundo*. Rome, Italy: FAO: 175 pp.

Fearnside, P.M. (1998) Missing a moving target? Colonist technology development on the Amazon Frontier. *Environmental Conservation* **25**: 285–286.

Fearnside, P.M. (1986) Spatial concentration of deforestation in the Brazilian Amazon. *Ambio* **15**: 74–81.

Fearnside, P.M. (1993) Deforestation in Brazilian Amazonia: the effect of population and land tenure. *Ambio* **22**: 537–545.

Felix Baez, F. (1990) *Los Zoque-popolucas*. Distrito Federal, Mexico: Instituto Nacional Indigenista/Consejo Nacional para las Artes: 245 pp.

Godoy, R., O'Neill, K., Groff, S., Kostishack, P., Cubas, A., Demmer, J., McSweeney, K., Overman, J., Wilkie, D., Brokaw, N. & Martinez, M. (1997) Household determinants of deforestation by amerindians in Honduras. *World Development* **25**: 977–987.

Guevara, S., Laborde, J., Leinsenfeld, D. & Barrera, O. (1996) Introduccion. In: *Historia Natural de Los Tuxtlas*, ed. E. Gonzalez Soriano, R. Dirzo & R.V. Vogt, pp. 7–21. Distrito Federal, México: Universidad Nacional Autónoma de México.

Gutelman, M. (1974) *Capitalismo y Reforma Agraria*. Distrito Federal, México: Era: 290 pp.

Harrison, S. (1991) Populations growth, land use and deforestation in Costa Rica, 1950–1984. *Interciencia* **16**: 83–93.

Huerta, C. (1998) El barbasco: paradigma y paradoja de la riqueza vegetal de México. *Biodiversitas* **4**: 7–14.

INE/CONABIO (1995) *Reservas de la Biosfera y Otras Areas Naturales Protegidas de México*. Distrito Federal, México: INE/CONABIO: 163 pp.

INEGI (1996) *Anuario Estadistico del Estado de Veracruz*. Tomo I y II. Distrito Federal, Mexico: INEGI: 656 pp.

INEGI (1995) *Veracruz. Conteo de Poblacion y Vivienda 1995. Resultados Definitivos. Tabulados Basicos*. Tomo I. Distrito Federal, Mexico: INEGI: 435 pp.

Joly, L.G. (1989) The conversion of rain forests to pastures in Panama. In: *The Human Ecology of Tropical Lands Settlement in Latin America*, ed. D.A. Schumann & W.L. Partridge, pp. 86–130. USA: Westview Press.

Jones, J.R. (1989) Human settlement of tropical colonization in Central America. In: *The Human Ecology of Tropical Lands Settlement in Latin America*, ed. D.A. Schumann & W.L. Partridge, pp. 43–85. USA: Westview Press.

Lambin, E.F., Turner, B.L., Geist, H.J., Agbola, S.B., Angelsen, A., Bruce, J.W., Coomes, O.T., Dirzo, R., Fischer, G., Folke, C., George, P.S., Homewood, K., Imbernon, J., Leemans, R., Li, X., Moran, E.F., Mortimore, M., Ramakrishnan, P.S., Richards, J.F., Skanes, H., Steffen, W., Stone, G.D., Svedin, U., Veldkamp, T.A., Vogel, C. & Xu, J. (2001) The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change* **11**: 261–269.

Landa, R., Meave, J. & Carabias, J. (1997) Environmental deterioration in rural México: an examination of the concept. *Ecological Applications* **7**: 316–29.

Laurance, W.F. (1998) A crisis in the making: responses of Amazonian forests to land use and climate change. *Trends in Ecology and Evolution* **13**: 411–415.

Laurance, W.F. (1999) Reflections on the tropical deforestation crisis. *Biological Conservation* **91**: 109–117.

Laurance, W., Albernaz, A.K.M., Schroth, G., Fearnside, P.M., Berger, S., Venticinque, E.M. & Da Costa, C. (2002) Predictors of deforestation in the Brazilian Amazon. *Journal of Biogeography* **29**: 737–748.

Lazos Chavero, E. (1996) El encuentro de subjetividades en la ganaderia campesina. *Ciencias* **44**: 36–44.

Lazos Chavero, E. (2001) Ciclos y rupturas: dinámica ecológica de la ganadería en el sur de Veracruz. In: *Historia Ambiental de la Ganadería en México*, ed. L. Hernandez, pp. 133–153. Xalapa, Mexico: L'Institut de Recherche pour le Developpement/Instituto de Ecología AC.

Lazos Chavero, E. & Godinez Guevara, L. (1996) Dinamica familiar y el inicio de la ganaderia en tierras campesinas del sur de Veracruz. In: *El Ropaje de la Tierra. Naturaleza y Cultura en Cinco Zones Rurales*, ed. L. Pare & M.J. Sanchez, pp. 243–354. Distrito Federal, Mexico: Instituto de Investigaciones Sociales/Universidad Nacional Autonoma de Mexico/Plaza y Valdes.

Ledec, G. & Goodland, R. (1989) Epilogue: an environmental perspective on tropical land settlement. In: *The Human Ecology of Tropical Lands Settlement in Latin America*, ed. D.A. Schumann & W.L. Partridge, pp. 435–467. USA: Westview Press.

Maki, S., Kalliola, R. & Vourinen, K. (2001) Road construction in the Peruvian Amazon: process, causes and consequences. *Environmental Conservation* **28**: 199–214.

Makundi, W., Sathaye, J. & Masera, O.R. (1992) Carbon emissions and sequestration in forests. Case studies from seven developing countries. In: *Report Number LVL-33119*, ed. W. Makundi & J. Sathaye, Energy and Environment Division, Lawrence Berkeley Laboratory, WS Environmental Protection Agency, Berkeley, CA, USA.

Marquette, C.M. (1998) Land use pattern among small farmer settlers in the Northeastern Ecuadorian Amazon. *Human Ecology* **26**: 573–598.

Masera, O., Ordoñez, M.J. & Dirzo, R. (1997) Carbon emissions from Mexican forests: current situations and long-term scenarios. *Climatic Change* **35**: 265–295.

Millikan, B.H. (1992) Tropical deforestation, land degradation and society. Lessons from Rondonia, Brazil. *Latin American Perspectives* **19**: 45–72.

Moran, E. (1989*a*) Adaptation and maladaptation in newly settled areas. In: *The Human Ecology of Tropical Lands Settlement in Latin America*, ed. D.A. Schumann & W.L. Partridge, pp. 20–39. USA: Westview Press.

Moran, E. (1989*b*) Government-directed settlement in the 1970s: an assessment of transamazon highway colonization. In: *The Human Ecology of Tropical Lands Settlement in Latin America*, ed. D.A. Schumann & W.L. Partridge, pp. 20–39. USA: Westview Press.

Moran, E. (1993) Deforestation and land use in the Brazilian Amazon. *Human Ecology* **21**: 1–21.

Myers, N. (1993) Tropical forests: the main deforestation fronts. *Environmental Conservation* **20**: 9–16.

Myers, N. (1996) The world's forests: problems and potentials. *Environmental Conservation* **23**: 156–68.

Ochoa Gaona, S. & Gonzalez Espinosa, M. (2000) Land use and deforestation in the highlands of Chiapas, Mexico. *Applied Geography* **20**: 17–42.

Palacio Prieto, J.L., Gerardo, B., Velazquez, A., Mas, J.F., Takaki Takaki, F., Victoria, A., Luna Gonzalez, L., Gomez Rodríguez, G., Lopez Garcia, J., Palma Muñoz, M., Trejo Vazquez, I., Peralta Higuera, A., Prado Molina, J., Rodríguez Aguilar, A., Mayorga Saucedo, R. & Gonzalez Medrano, F. (2000) La condición actual de los recursos forestales en Mexico: resultados del Inventario Forestal Nacional 2000. *Investigaciones Geograficas. Boletín del Instituto de Geografia, UNAM* **43**: 183–203.

Pare, L. (1994) La deforestacion en la Sierra de Santa Marta, Veracruz o el desencanto del Dios jaguar de la montaña. Causas, impactos y unas pocas alternativas. In: *De Bosques y Gentes. Aspectos Sociales de la Deforestacion en America Latina*, ed. M.F. Paz, pp. 89–128. Cuernavaca, Morelos, Mexico: Centro Regional de Investigaciones Multidisciplinarias/Universidad Nacional Autonoma de Mexico.

Park, C.C. (1992) *Tropical Rainforests*. London, UK: Routledge: 188 pp.

Partridge, W.L. (1989) The human ecology of tropical land settlement in Latin America. Overview. In: *The Human Ecology of Tropical Lands Settlement in Latin America*, ed. D.A. Schumann & W.L. Partridge, pp. 3–19. USA: Westview Press.

Paz, M. F. (1995) Selvas tropicales y deforestacion. Apuntes para la historia reciente del tropico humedo mexicano. In: *De Bosques y Gentes. Aspectos Sociales de la Deforestacion en America Latina*, ed. M.F. Paz, pp. 53–88. Cuernavaca, Morelos, Mexico: Centro Regional de Investigaciones Multidisciplinarias/Universidad Nacional Autonoma de Mexico.

Perez Lopez, E.P. & Camou Healy, E. (2001) Pecurización y mercado internacional. In: *Historia Ambiental de la Ganadería en México*, ed. L. Hernandez, pp. 233–240. Xalapa, Mexico: L'Institut de Recherche pour le Developpement/Instituto de Ecología AC.

Pichon, F.J. (1996) Settler agriculture and the dynamics of resource use allocation in frontier environments. *Human Ecology* **24**: 341–371.

PSSM AC/CRUO-UACH/SEMARNAP (1997) Programa de desarrollo regional sustentable de Los Tuxtlas-Santa Marta. Documento preliminar. Unpublished report. Xalapa, Mexico: Proyecto Sierra Santa Marta AC: 83 pp.

PSSM AC/GEF/CIIMYT (1996) Desarrollo sustentable y conservación de la biodiversidad: un estudio de caso en la Sierra de Santa Marta, Veracruz. Resultados preliminares. Unpublished report. Xalapa, Mexico: Proyecto Sierra Santa Marta AC: 102 pp.

Ramirez, R.F. (1999) Flora y vegetación de la Sierra de Santa Marta. Lic. Thesis, Universidad Nacional Autonoma de México, México: 409 pp.

Revel-Mouroz, J. (1980) *Aprovechamiento y Colonizacion del Tropico Humedo Mexicano*. Distrito Federal, Mexico: Fondo de Cultura Economica: 391 pp.

Rudel, T. & Roper, J. (1997) The paths to rain forest destruction: crossnational patterns of tropical deforestation, 1975–90. *World Development* **25**: 53–65.

Rustch, M. (1980) Acerca de la ganaderia capitalista en Mexico. *Nueva Antropologia* **13–14**: 147–86.

Sader, S.A. & Joyce, A.T. (1988) Deforestation rates and trends in Costa Rica, 1940–1983. *Biotropica* **20**: 11–19.

Schmink, N.B. (1995) La matriz socioeconomica de la deforestacion. In: *De Bosques y Gentes. Aspectos Sociales de la Deforestacion en America Latina*, ed. M.F. Paz, pp. 17–52. Cuernavaca, Morelos, Mexico: Centro Regional de Investigaciones Multidisciplinarias/Universidad Nacional Autonoma de Mexico.

SEMARNAP (2000) *La Gestion Ambiental en Mexico*. Distrito Federal, Mexico: SEMARNAP: 374 pp.

Shriar, A.J. (2002) Food security and land use deforestation in northern Guatemala. *Food Policy* **27**: 395–414.

Sierra, R. (1999) Traditional resource-use systems and tropical deforestation in a multiethnic region in north-west Ecuador. *Environmental Conservation* **26**: 136–45.

Sierra, R. (2000) Dynamics and patterns of deforestation in the western Amazon: the Napo deforestation front, 1986–1996. *Applied Geography* **20**: 1–16.

Steininger, M.K., Tucker, C.J., Townshend, J.R.G., Killeen, T.J., Desch, A., Bell, V. & Ersts, P. (2001) Tropical deforestation in the Bolivian Amazon. *Environmental Conservation* **28**: 127–134.

Stonich, S.C. (1995) Development, rural impoverishment, and environmental destruction in Honduras. In: *The Social Causes of Environmental Destruction in Latin America*, ed. M. Painter & W.H. Durham, pp. 63–99. Michigan, USA: The University of Michigan Press.

Toledo, V.M., Carabias, J., Mapes, C. & Toledo, C. (1993) *Ecologia y Autosuficiencia Alimentaria en Mexico*. Distrito Federal, Mexico: Siglo XXI: 118 pp.

Tudela, F., coord. (1989) *La Modernizacion Forzada del Tropico: el Caso de Tabasco. Proyecto integrado del Golfo*. Distrito Federal, México: El Colegio de México/Centro de Investigación y Estudios Avanzados del IPN/Federación Internacional de Centros de Estudios Avanzados/Instituto de Investigaciones de las Naciones Unidas para el Desarrollo Social: 475 pp.

Turner II, B.L., Cortina Villar, S., Foster, D., Goeghegan, J., Keys, E., Klepeis, P., Lawrence, D., Macario Mendoza, P., Manson, S., Ogneva-Himmelberger, Y., Plotkin, A.B., Perez Salicrup, D., Roy Chowdhury, R., Savitsky, B., Schneider, L., Schmook, B. & Vance, C. (2001) Deforestation in the southern Yucatan peninsular region: an integrative approach. *Forest Ecology and Management* **154**: 353–370.

Velazquez, A., Mas, J.F., Mayorga Saucedo, R., Diaz, J.R., Alcantara, C., Castro, R., Fernandez, T., Palacio, J.L., Bocco, G., Gomez Rodríguez, G., Luna Gonzalez, L., Trejo, I., Lopez García, J., Palma, M., Peralta, A., Prado Molina, J. & Gonzalez Medrano, F. (2002) Estado actual y dinamica de los recursos forestales de Mexico. *Biodiversitas* **41**: 8–15.

Velazquez, E. (1994) La apropiacion del espacio social entre nahuas y popolucas de la Sierra de Santa Marta, Ver. Unpublished report. Xalapa, Mexico: Centro de Investigación y Estudios Superiores en Antropologia Social: 27 pp.