Deforestation, Forest Transitions, and Institutions for Sustainability in Southeastern Mexico, 1900–2000

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ABSTRACT

Research on tropical forest cover change processes identifies myriad driving forces and demonstrates how change dynamics are non-linear and complex. Despite appreciation in the academic literature for the historical patterns and processes of deforestation, however, a simplistic, linear 'deforestation narrative' persists in the popular imagination. Concern arises when this narrative influences environmental policy and effective response to the tropical deforestation problem. Our main goals here are twofold: (1) to contribute to a nuanced history of forest change in southeastern Mexico; and (2) to explore the role of institutional development in reducing deforestation rates. Drawing on forest transition theory, we analyse the twentieth century forest histories of the eastern Yucatán Peninsula, the southern Yucatán Peninsula, and the Lacandón Rainforest. A deforestation narrative rightly dominates characterisations of the 1960–85 period in southeastern Mexico, but it falls short of accurately representing the complex processes of deforestation, forest recovery, and the development of sustainability-oriented grassroots institutions in the 1985–2003 period.

KEYWORDS

Forest transition theory, land-use history, Mexico, sustainable development, tropical deforestation

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DEFORESTATION AND FOREST TRANSITIONS

Recent advances have been made in understanding the particularity, complexity and causality of historical changes in tropical forest cover. These changes can include both deforestation and forest recovery through multiple pathways. Deforestation processes are driven by the interplay of sets of proximate and underlying factors that work in synergetic ways. The growing consensus is that a web of causal factors drives deforestation – the exact combination of which varies from region to region – suggesting that generalisations about deforestation dynamics are difficult to make and that a universal model of tropical deforestation is unlikely. Geist and Lambin's analysis of 152 sub-national case studies of tropical deforestation shows how proximate and underlying driving forces can be identified as inter-linkages between varying sets of tandems. In virtually every case each region 'has its own and very specific type of inter-linkage, and hardly any generalisations are possible on the underlying tandems'. The authors identify, however, the importance of the 'land-migration tandem' in lowland Latin America, the Mexican portion of which is of interest in this article, with land availability at the frontier constituting a strong pull factor.[2]

Research also underscores how deforestation both in and out of the tropics is non-linear, and that processes of forest recovery and 'forest transitions' may be underway in many areas, although with uncertain ecological implications. A forest transition is based on an environmental Kuznets curve, modelled after processes in now-industrialised countries. As Perz and Skole describe it, forest transition theory 'posits that over time forest cover exhibits a U-shaped curve, beginning with an initial decline in forest cover due to deforestation. This decline is later reduced, offset, and eventually outweighed at some point by new forest expansion, allowing for forest recovery'.[3]

A widely cited example of forest recovery in industrialised countries is that of New England in the northeastern United States. A deeper historical view shows that there have been both short and long pulses of forest clearing and re-growth in many other regions, as well. Long-term fluxes are represented by the Maya Forest of Mexico, Guatemala and Belize where mature forest was originally cleared by the Classic Maya, forest recovered after the civilisation collapsed around A.D. 900, and the region's mature secondary forest is now undergoing a new pulse of deforestation in the modern period. In the modern period, short-term twentieth century fluxes from deforestation to forest recovery are evident in Puerto Rico, highland Michoacan, and Oaxaca. It has been argued recently that even parts of the Amazon Basin may have already undergone a forest transition, defined as a period in which rates of forest cover recovery (regrowth) become higher than rates of ongoing forest loss, resulting in a net gain of forested areas.[4]

Forest recovery after agriculture follows unique pathways in different landscapes, including development into stable secondary forest or as a component of short- or long-term forest-fallow. Possible pathways to forest recovery are also conditioned by the presence of particular land uses, such as cattle ranching, and each pathway has different implications for forest structure and composition. Clearly, in most cases, what is being lost is mature forest and what is initially recovered is young secondary forest. Therefore, forest cover recovery should not be used to justify continued forest clearing. However, the reality of forest regrowth trends is an important part of the story of forest change dynamics in the tropics, especially given how quickly tropical forests – under the right human-environment conditions – can recover many important ecological functions, as we discuss in the concluding section.[5]

Despite the plethora of historical perspectives on forest change processes, in both the popular imagination and to a degree in the academic literature, a ‘deforestation narrative’ predominates. Linear views of forest change are often rooted in the concept of pristine, uninhabited nature and continuing into the twentieth century the concept has been used to justify the colonisation and control of frontier locations. For the case of tropical southeastern Mexico in the twentieth century – as explored in this article – the deforestation narrative is justified for certain times and places, however, in others a more nuanced interpretation is required. But updating and revising the narrative is not meant to downplay the significance of tropical deforestation. Recent reports remind us of the ongoing tropical deforestation problem and the vital role that tropical forests play in human and ecological systems.[6] There is cause for concern, however, when a simplistic, linear narrative dominates understanding of forest change dynamics at the expense of understanding the real complexity and opportunities for conservation that exist.[7]

Research on the driving forces of forest change needs to be expanded to emphasise to a greater degree the dynamics of forest recovery. These forces include macro- and micro-economic factors, population change, federal policy shifts, and biophysical conditions. We argue here that a particularly important factor in forest recovery is the development of institutions and organisations at multiple scales that promote sustainable land uses. Klooster, for example, argues that greater attention should be given to ‘the evolution of resource-management institutions, especially at the local level’ as one of the overlooked factors driving forest transitions.[8]

We evaluate forest change in southeastern Mexico during the twentieth century and consider whether or not forest transitions are underway, with particular attention to the emergence of institutions which may support such transitions. We choose Mexico because both authors work there, Mexican forest discourse (both academic and popular) has been dominated by a deforestation narrative, and because the broader Mesoamerican region has been identified as a ‘hotspot’ of ‘exceptional loss of habitat’.[9] A World Bank report from 1995 presents data showing an annual tropical deforestation rate for the country of 2 per cent in the mid-1980s, with some regional rates as high as 12.4 per cent, and a study of the eight states of southeastern Mexico reports a deforestation rate of 1.9 per cent per year from 1977–92. In light of these data, the Mexican and U.S. press has focused almost exclusively on deforestation when they write about Mexican forests.[10]

In an effort to enrich the forest change narrative for Mexico and to contribute to the creation of a regional environmental history, we draw on three representative areas of southeastern tropical Mexico to marshal more detailed data on regional trends within this very large area: central Quintana Roo; the southern Yucatán peninsular region; and eastern Chiapas (the Lacandón Rainforest) (Figure 1).[11] We use the 'land-migration tandem' as an entry point to our analysis of tropical southeastern Mexico. Most research identifies the principal proximate drivers of deforestation in this region to be agricultural and livestock expansion; however, these may be thought of as outputs of an underlying land-migration dynamic.[12]

The framework we use to interpret land change separates forest transitions into two components: a 'land-use' component that focuses on land abandonment or agricultural intensification, as well as the availability of alternative labour markets; and a 'forest-use' component that focuses on forest management practices and the emergence of protected areas. Among the signs of a forest transition, therefore, is evidence of forest cover that tends towards stability or expansion due to changes in these two components. We do not consider social welfare indicators of sustainable development in our assessment of forest transitions due to data and space limitations.[13]

Key institutions for the study areas include land tenure regimes (particularly agrarian land grants and protected areas) and grassroots organisations, such as those involved with community forestry initiatives. Whether initiated by local, national, or international actors, we assume that the possibility of more sustainable ecological and social processes happening sooner rather than later depends on the emergence of institutions that promote community-based management, that promote the cooperation between actors across hierarchical scales, and that reflect attempts to balance environment and development goals.[14] The work presented here also contributes to discussion of the importance of humanised landscapes as part of nature conservation, what Zimmerer and Carter refer to as 'narratives of conservation'. The growing embrace of humanised landscapes and multi-use systems as part of conservation efforts is represented in Mexico, in particular, through its large number of community-managed forests that are an important component of what may be called 'sustainable landscapes'.[15]

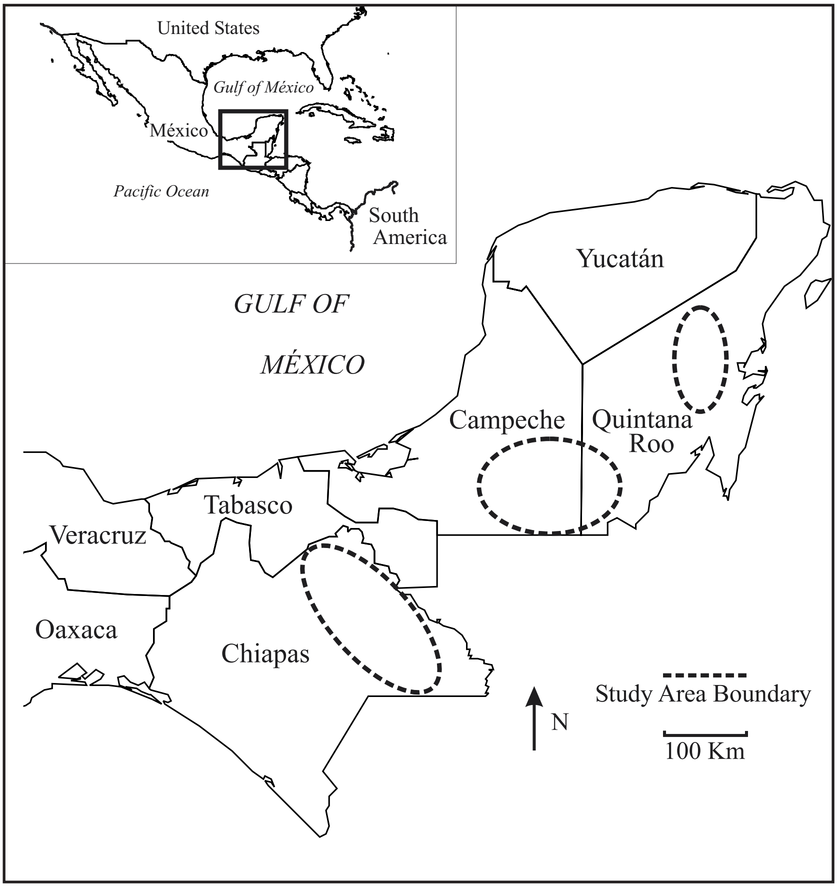

FIGURE 1. General location of study areas in southeastern Mexico

TWENTIETH-CENTURY FOREST-COVER CHANGE IN TROPICAL SOUTHEASTERN MEXICO

The study area in central Quintana Roo is completely demarcated and populated while the southern Yucatán peninsular region and the Lacandón Rainforest are considered the remaining ‘frontier forests’ of tropical southeastern Mexico. Part of what is often referred to as the Lowland Maya region, all three study areas contain wet-dry tropical forest and are noted for being biodiversity hot spots. Semi-deciduous or seasonal tropical forests predominate in the Yucatán Peninsula, which connects with taller and wetter tropical forests in the Petén, Guatemala, and Chiapas. Two features of particular importance in the southern Yucatán Peninsula are its rolling, karstic uplands (as high as 300 m), which are punctuated by large karstic depressions that seasonally inundate with water (bajos).

All three study areas are key sites of contestation over sustainable development initiatives. Today they are relative forest islands within Mexico, although they are connected to and form part of the northern tier of the Maya Forest.[16] Until relatively recently, however, they were part of a far larger forest mass that extended throughout the southeastern Mexican lowlands and into Central America. In the last several decades, the tropical forests of southern Veracruz and Tabasco have been reduced to fragments by roads and agricultural and pasture expansion. For example, in the 1960s and 1970s the forest cover in the municipio of Pajapan, Veracruz, was reduced from 15,600 to 550 hectares, while the forest cover of the Sierra Santa Marta, Veracruz, fell from 150,000 to 20,000 hectares, mostly due to the expansion of cattle ranching. It is estimated for the Tuxtlas region of southern Veracruz that 84 per cent of the original vegetation was lost by 1986.[17] But it was the land-migration tandem of colonisation, both spontaneous and government-directed and often linked to cattle production or large-scale agricultural projects, which most affected the forests of southeastern Mexico and left the study areas as relatively isolated remnants of this once much larger forest mass.[18] We consider forest-use and land-cover change processes in each of the three regions for the periods 1900–60, 1960–85, and 1985-present, episodes in which major transitions occurred.

1900–60: Forest Extraction, Land Grants, and Forest Cover Maintenance

For the first half of the twentieth century the three study regions all experienced geographically restricted forest extraction activities, with associated forest concessions to national and international companies and the introduction of *ejido* collective land grants, but there are significant differences in their demographic and settlement histories.

(1) *Central Quintana Roo* is the only region that was significantly populated at the beginning of the twentieth century. Virtually uninhabited for centuries after the collapse of the Ancient Maya civilisation, the area was resettled by Maya refugees fleeing religious taxes and expanding henequen (*Agave sisalana* Perrine) plantations in Yucatán State in the mid-nineteenth century. These 'Santa Cruz' Maya mounted an armed uprising, known as 'The Caste War', with an estimated 50,000 of them initially populating the forests, but declining to some 12,000 by 1874.[19]

The first two decades of the twentieth century were marked by the conquest of the Santa Cruz Maya rebels by the Mexican army and the practical ceding back to the Maya of the region during the upheavals of the Mexican Revolution (1910–17). But in 1920, their land claims were unrecognised, unsurveyed, and were considered national territory despite being the home of the group for 70 years. This situation began to change through markets for chicle, the sap of the chicozapote tree (*Manilkara zapota* L. Van Royen, formerly, *Achras sapota* L.), used to manufacture chewing gum.[20] Agrarian reform and cooperatives arrived during the presidency of Lázaro Cárdenas (1934–40) who established chicle ejidos in the region. These land grants were termed 'forest reserves' but were in fact chicle reserves. With 420 hectares per person calculated to allow for a continuous harvest of resin, the ten ejidos established from 1935–42 averaged almost 35,000 hectares each.[21] Given the fluctuating penetration of markets for chicle and with virtually no commercial logging during the period forest-cover change was limited to slash and burn or shifting agriculture.

(2) In the *southern Yucatán peninsular region* vast forest concessions were awarded under the 1894 Laws of Surveying and Colonisation. Between 1902 and 1905, for example, 11 concessions covered nearly 3.5 million hectares in southern Quintana Roo. There were a few small Maya villages that were established during the Caste War but the region did not begin to be more heavily populated until the chicle (1903–45) and logging (1940s-55) boom periods. By the 1950s the selective logging of mahogany (*Swietenia macrophyla* King) and cedar (*Cedrela odorata* L.) was intensive, with one estimate suggesting that some 156,000 mahogany trees were extracted from 1900–90.[22] Chicle extraction declined after World War II and logging became much less intense due to the dramatic depletion of marketable trees during the logging boom. By 1960, the relatively few permanent settlements that existed had been established primarily during the 1930s and 1940s and were designated for chicle extraction, with limited impact on forest cover. Land tenure regimes in the region, therefore, were similar to those in central Quintana Roo, although the ejidos and forest reserves established during the chicle boom included commercial logging given under concession to foreign companies.

(3) In the *Lacandón Rainforest*, what De Vos calls the golden age of mahogany exploitation occurred from 1895–1913 and was carried out by US logging companies acting with Mexican partners under a forest concession model.[23] As in the southern Yucatán Peninsula, the environmental impact of this period was relatively minor. Extraction was limited to mahogany and cedar, it was focused only along the rivers, clearings made for workers and equipment were small and few, and virtually no permanent population centres developed. In the post-Revolutionary period, the logging industry was dominated by small timber companies with a low capacity to harvest trees. De Vos notes that up until 1949 there was not a single firmly established population centre, but only 'small settlements of *indios caribes* and the primitive camps of the Tabasco loggers' that were 'provisional and passing'.[24] Land tenure in the Lacandón during this period took a quite different path from the other two study regions. During the mahogany boom at the beginning of the twentieth century the entire region was

privatised, with almost all of it divided between a small number of Mexico City and Tabasco interests.

In sum, at the end of the first six decades of the twentieth century, non-timber forest product (NTFP) extraction and government-organised common property land tenure systems had penetrated central Quintana Roo and the same two elements along with commercial timber extraction occurred in the southern Yucatán peninsular region. These economic systems, as reviewed below, laid the basis for subsequent community-based sustainable development initiatives. In both areas there were small scattered settlements in a matrix of largely intact forest where residents undertook shifting agriculture. It is important to note that shifting agriculture under low population density is frequently considered positive in creating forest mosaics favourable to biodiversity and conditions for mahogany regeneration.[25] Timber extraction in the Lacandón was heavy in the first part of the period but declined precipitously by its end. The region was insular, and timber extraction and a confused private property state reigned. In all three areas, forest cover change was small and localised, although there were depleted mahogany and cedar stands in riparian zones of the Lacandón, with depletion more severe and widespread in the southern Yucatán peninsular region.

1960–85: Colonisation, Land Clearing, and a Deforestation Narrative

After 1960, both directed and spontaneous colonisation – playing out the land-migration tandem – began in the southern Yucatán Peninsula and the Lacandón, leading to a pulse of large-scale deforestation in Chiapas, a milder pulse in the southern Yucatán peninsular region, and a more limited colonisation pattern in central Quintana Roo led to only a very mild pulse of deforestation there (Table 2).[26]

(1) In *central Quintana Roo*, commercial logging began in the late 1950s as roads were opened through the existing Santa Cruz Maya ejidos. Colonisation and the establishment of new ejidos could only occur around the edges of the large chicle reserve ejidos that were established in the 1930s and 1940s. These new ejidos were largely for migrants from the state of Yucatán and were designated only for farming, with an average holding per *ejidatario* (ejido member with land rights) of 20 hectares. It is in these small ejidos that there was a localised pulse of deforestation in the 1970s and 1980s. In the mid-to-late 1970s, government cattle-promotion policies led to the clearing of thousands of hectares in some of the large chicle ejidos, but in most cases the cattle never arrived, and these areas reverted to secondary succession, either abandoned or as part of forest-fallow. In the large forest ejidos the major land use was extensive shifting agriculture (regionally called *milpa*), which created small clearings and then patches of secondary succession. This pattern, combined with small-scale selective logging, kept deforestation rates to a relatively low 0.4 per cent per year during the 1970s and 1980s. In retrospect, and with further evidence considered below, it seems

that the establishment of the large chicle ejidos laid the basis for more stable forest cover in a region where large-scale clearing never took place. Similarly, those areas in the southern Yucatán Peninsula that witnessed the least amount of forest clearing in the twentieth century are also areas designated for large chicle ejidos.[27] Although it wasn't the government's intent, in practice, these areas were an early incarnation of the reserve-matrix model celebrated by conservation biologists and sustainable development advocates (where the 'matrix' refers to landscapes not designated primarily for nature conservation). This model endorses an integrated regional system of protected areas and sustainable land-use systems that combines top-down and bottom-up elements of land management. In the Mexican case, local inhabitants were given control over land resources for economic purposes where the standing forest had significant value for a non-timber forest product (although, in the southern Yucatán peninsular region case the ejidos had rights to chicle but not timber).[28]

(2) In the *southern Yucatán peninsular region*, the most intensive logging for mahogany and Spanish cedar occurred in the 1950s in southeastern Campeche by the parastatal company, *Caobas Mexicanas/Impulsora Forestal Peninsular*. After the mid-century boom the parastatal company, MIQRO (*Maderas Industrializadas de Quintana Roo*), focused on the Quintana Roo portion of the study region, and was active until the early 1980s. By 1983 the last of the parastatal forest concessions ended without being renewed because of depleted mahogany and cedar reserves (making large-scale forestry operations unprofitable) and rising pressure for land and logging rights by ejidatarios in the region. The decline in forestry led government officials to focus on colonisation and agriculture.

Starting in the 1970s, large scale government-directed colonisation began. The influx of people, combined with large-scale rice and cattle projects and subsidised clearing for shifting agriculture, led to a strong pulse of forest clearing in both lowland and upland areas. There was a deforestation rate of 2 per cent per year from 1975–85 for a swath of forest cutting across the center of the region, east to west. The projects and new ejidos spawned an increase in the regional population from approximately 2,200 people in 1960 to roughly 40,000 by the year 2000. Most of the ejido land grants awarded in the 1970s and 1980s were designated for agriculture in contrast to the chicle ejidos established in the 1940s and 1950s. Well over 10,000 hectares of forest were cleared between 1975 and 1982 in Quintana Roo projects alone, and upland forest was cleared for subsistence milpa such that people had disturbed the forest cover of 8–10 per cent of the region (in its modern period) by the early 1980s.[29]

After the national debt crisis of 1982, mismanagement, and problems with water control and pests, most of the rice and cattle projects were discontinued. Much of the lowland forest that was cut as part of big projects remains cleared today, although recent evidence shows that these zones are being increasingly abandoned. Much of the upland forest recovered, with lands abandoned in the 1980s or incorporated in forest-fallow. After 1982, smallholders gained more control over the land and land use diversified: shifting agriculture for subsistence, small-scale forestry and cattle production, and a growing focus on cash crops, in particular, jalapeño chili, which has led to more intensive land use (i.e., increasing reliance on chemical inputs and mechanised field preparation).[30]

(3) In the *Lacandón Rainforest*, the period 1960–85 was marked by a failed attempt by multinational capital to enter into logging, the establishment of a parastatal logging enterprise by the government, and a major wave of colonisation. Spontaneous colonisation from the highlands of Chiapas and immediately adjoining areas into the Cañadas region of the Lacandón began as early as the late 1940s and early 1950s, and continued expanding in 'cycles of colonisation' in the succeeding decades as lands were exhausted or occupied by cattle.[31] As De Vos notes, 'From 1964 to 1974, loggers, peasants, and cattlemen thus formed three fronts of destruction that united to devastate, in record time, the northern part of the rainforest.' In 1967, the government took steps to try and control spontaneous colonisation in the northern Lacandón and to carry out planned colonisation in the southern Marqúes de Comillas region by declaring 401,959 hectares national territory, although with limited success.[32]

In the early 1970s, amidst growing concerns about conservation, a series of overlapping land decrees were made, directed at both logging and protection. In 1972 the *Comunidad Lacandona* was declared, putting 614,231 hectares in the control of 66 Lacandón Indian families, which prompted the existing parastatal company to sign a contract with the Lacandons that initiated a new wave of logging. In 1978, increasing international environmental consciousness and intensive lobbying by environmentalists caused the government to declare an area of 331,200 hectares as the Montes Azules Biosphere Reserve, with 21 scattered settlements of indigenous colonists relocated. The decree was superimposed over a major portion of the existing declaration of the Comunidad Lacandona, creating confusion that continues today.

1985–2003: Experiments in Sustainable Land Use, Institution Building, and a Recovery Narrative

(1) Recent studies in *central Quintana Roo* show that net deforestation has been relatively low and that rates declined after the mild pulse in the 1976–84 period. One of the components of this rough forest cover equilibrium, despite deforestation in the smaller ejidos in the 1970s and 1980s, is significant agricultural abandonment in the larger ejidos, an indicator of the land-use component of a forest transition. The annual deforestation rate for 1976–85 was 0.4 per cent, and from 1984–2000 it fell to 0.1 per cent. This represents the lowest recorded rate of deforestation in any region of tropical Mexico (Table 2). From 1984–2000, the 12 forest ejidos with the largest logging volume in the region had new deforestation take place on 5,364 hectares, but 20,763 hectares of previously deforested areas were in various stages of regrowth. During this period, 10

per cent of the total area reverted back to forest. While secondary succession exists throughout tropical Mexico (due to shifting fallow cycles, agricultural abandonment, or the establishment of conservation land) and many areas cannot be referred to accurately as permanently deforested, the central Quintana Roo case is unique in that a low rate of deforestation was followed by an even lower rate, and extensive forest recovery. It is not clear from the available data how much of this may be permanent secondary forest and how much was in short and long-term fallow, although it is clear that in many large forest ejidos the fallow areas have been confined to a more restricted space because of the establishment of permanent forest areas (see below). The availability of off-farm labour in the Cancun-Tulum tourism corridor may have also had an impact on reducing demand for agricultural land in this area.[33]

In the forest-use component of a forest transition significant steps were taken in Quintana Roo during this period towards sustainable forest management, although no formal protected areas were declared (the 528,147 hectares of the Sian Ka'an Biosphere Reserve, established in 1986, is immediately to the east of the study region and under little pressure from it). A government community forest programme known as the Plan Piloto Forestal (PPF) began working in both southern and central portions of Quintana Roo in 1983, resulting in the creation of a community logging regime.[34]

In a series of institutional innovations, government organisers and foresters helped the communities in declaring permanent forest areas (PFAs), conducted participatory forest inventories, established community forest enterprises (CFEs), and erected second level organisations which served as the channels for technical assistance, foreign donor support and negotiations with government agencies. From 1985–89, nearly 250,000 hectares were placed in PFAs in central Quintana Roo, and a somewhat smaller amount in southern Quintana Roo. The PFAs constituted forest estates for selective logging under management plans and were declared by the communities as not subject to forest clearing, a restriction to which the larger forest ejidos have largely adhered. Many areas of fallow agriculture that had been in what became the PFAs then followed a pathway of uninterrupted secondary succession. Although there are continuing concerns about the sustainability of the mahogany harvest, selective logging has taken place under government-regulated management plans and remotely sensed data show an expansion of forest cover in the large forest ejidos, which are the 'drivers' of forest cover retention in the zone.[35]

Beyond its apparent contribution to maintenance of forest cover, PPF helped expand livelihood options for local land managers. The PPF represents a process of adaptive management by local ejidatarios to changing social and ecological conditions that was supported at multiple institutional scales by state, federal, and international actors (primarily, the *Gesellschaft für Technische Zusammenarbeit* or GTZ – German Association of Technical Cooperation), which empowered communities to gain a livelihood from the forest. Local land managers gained technical and management skills necessary to manage their own forest resources and compete economically in the forestry sector. The goal of the PPF was to encourage the establishment of local institutions that would continue to manage the forest sustainably even when the major phase of government support ended. The legacies of PPF are the establishment of permanent forest extractive reserves, the use of participatory forest inventories to formulate sound management practices, the creation of civil organisations to represent ejidatarios, provide technical assistance and explore marketing strategies, training in forest planning and management, the enhancement of the political skills of ejidatarios who gained valuable organisational, political, and technical capabilities, and the creation of community forest enterprises. The program served to engage ejidatarios in forest management in addition to agriculture and ranching, and it brought international conservation and development attention to the study region.[36]

The grassroots organisation that was the outcome of the PPF in central Quintana Roo, the *Organización de Ejidos Productores Forestales de la Zona Maya* (OEPFZM), has also served as a conduit for a variety of government and foundation supported programs, which taken as whole, tend to reduce or mitigate whatever loss in forest cover is occurring, and to combine traditional and new production techniques in potentially more sustainable combinations. New research is showing that traditional agriculture practices leave forest fragments as firebreaks and boundary dividers known as *t'olchés*. At the same time, over half of the farmers in the majority of the communities in central Quintana Roo recently planted in the agricultural areas 3,000–4,000 hectares of trees in *taungya* agroforestry, a form that uses the annual maize crop as stepping stone to small-scale tree plantations. Smaller numbers are experimenting with sustainable agriculture methods such as green manures and deep tilling that would allow them to 'fix the milpa' or reduce areas needed for shifting agriculture. Incipient efforts have begun to address the dramatic decline of Maya stingless bees (*Melipona beechi*) and traditional beekeeping in the region. There is also research underway to address new silvicultural methods that could help to mitigate the long-term decline in mahogany production, and community-based ecotourism projects are now being implemented. [37]

(2) In the *southern Yucatán peninsular region*, rates of deforestation from 1969–97 ranged from 0.32 per cent to 0.39 per cent per year, with the highest rate (2 per cent per year) occurring from 1975–85 in a central swathe through the region. Six per cent of this subregion was cut from 1969–87 and another 2.8 per cent from 1987–97. Between 8.8 and 10 per cent of the entire region was disturbed by people from 1969–1997, justifying a deforestation narrative. But both the subregion and the region as a whole had declining rates of forest clearing after the 1982 debt crisis due to a combination of factors. First, there was a decrease in federal investment in the region in the 1980s, which meant that the large rice and cattle projects that had been heavily subsidised were no longer viable because of problems with weeds, pests and water access and

management. The drop in investment led to significant agricultural abandonment and forest recovery through secondary succession in *lowland* forests between 1987 and 1997 (Table 1). Analysis of satellite images from 1995 and 2000–01 shows less land in cultivation than in succession or fallow and a reduction in the loss of older forest.[38]

At the same time that former project zones in the lowlands are reverting to forest, forest recovery in *upland* forests is connected to changes in crop-fallow cycles:

> Over the last decade examined [1987–97], the amount of cultivated lands taken from mature upland forests seems to have decreased, and the focus of cultivation shifted to successional growth … This shift may suggest a reduction in the milpa fallow cycles (less land taken from mature forest; more taken from early successional growth) …[39]

The changing crop-fallow cycles in upland forests is likely linked to a combination of three factors. First, government and NGO programs emphasise the intensification of land use (Note 37). Second, there has been independent experimentation by smallholders, in particular with jalapeño chili, the region's primary cash crop. By 2000, chili was cultivated by some 90 per cent of smallholders in the region. Chili production relies on a new version of shifting agriculture that involves the use of chemical inputs, which both lengthens the cropping portion of the cycle (although, while still employing fallow) and combats the range of pests associated with intensive cultivation. There is also the rising use of 'mechanised' or disked plots. Third, demands on household labour have shifted. Between 1986 and 1997, there was an increase in the number of households relying on markets for goods and services. And the input costs (considering both labour and chemicals) of chili production are as much as five times more than those required to produce maize. Shifts in household labour allocation toward chili cultivation and off-farm labour may partly explain why there is less pressure on mature forest.[40] Labour migration is less of an alternative in this region than in central Quintana Roo. While some 80 per cent of households sell labour off of the farm, the majority participate as day labourers in their local area. To a much lesser degree, temporary wage labour is sought in urban locations, such as Cancun, especially during periods of crisis (e.g., hurricane, drought).

In the land-use component of a forest transition, therefore, land abandonment and agricultural intensification of land use may partly explain the declining deforestation rates and regrowth in the southern Yucatán peninsular region. Other possible factors include slowing population growth due to decline in land availability for new ejidatarios (thereby, reducing one of the region's primary 'pull' factors for would-be colonists) and outmigration. Reasons for the recent outmigration are unclear at present but may be linked to a combination of biophysical and social factors. For example, the constant recutting as part of recent forest-fallow cycles seems to result in a decline in soil nutrients, lower overall

Table 1. Land-cover change (km^2) in the southern Yucatán peninsular region[41]

Year	Mature forest	Secondary growth[a]	Agriculture	Bracken fern[b]
SYPR Subregion[c]				
1969	11,042	111	228	—
1987	10,356	634	391	—
1997	10,068	845	468	—
Entire SYPR[d]				
1987	15,816	847	473	18
1997	15,199	1,271	592	92

a Secondary growth is defined as 4–15 years old.

b Bracken fern (*Pteridium aquilinum* L.)

c Based on aerial photographs (11,318 square kilometres).

d Based on TM Landsat imagery (17,154 square kilometres).

biomass, and the dominance of short-lived rather than long-lived species. Fifty-five to 95 years are needed to reach mature forest levels of biomass for stands left fallow after shifting agriculture in the southern Yucatán peninsula region, although in upland forests 80 per cent of biomass and a composition of tree species indistinguishable from mature forests is achieved in 25–30 years. Second, maize yields per unit area are much lower now than three decades ago. Finally, there are indications of an increasing problem with three invasive species that are taking agricultural land out of production, one of which is bracken fern or *helecho* (*Pteridium aquilinum* L.) (Table 1). Thus, while the implications for stabilisation of forest cover are important, additional ecological indicators of sustainability are less positive, and most ejidatarios continue to struggle with market production. The range of new land uses, including that of tourism and chili, has not demonstrated its economic viability to date. All markets in the region are thin, and household access to capital is low. Obtaining the chemical inputs necessary to combat fertility and weed problems is therefore prohibitive for many farmers, a problem that is exacerbated in light of the rapid increase in pests associated with the chili boom. While there is evidence of increasing diversification of land use and market production, intermediaries (*coyotes*), distance to markets, water scarcity, and inadequate capital and agricultural extension services are among the limiting factors in the development of a diverse, healthy and sustainable regional economy. In short, what may be good for forest cover may not be good for people.[42]

In reference to the forest-use component of a forest transition, government, NGO, and local actors have attempted to both slow deforestation rates and boost economic growth by creating protected forests, initiating tourism schemes, and developing more sustainable timber and NTFP use systems. The PPF also affected directly the Quintana Roo portion of the southern Yucatán peninsular region, and indirectly its Campeche side. In both states, significant tracts of upland forest are designated off-limits to clearing. The main conservation initiative was the establishment in 1989 of the 723,185 hectare Calakmul Biosphere Reserve in southeastern Campeche; however, the reserve is in many respects a 'paper park' and afflicted by overlapping and conflicting land tenure regimes. Forty-four ejidos have portions of their land within the buffer zone of the reserve, 21 have holdings within the nuclear zone, management of the reserve is inadequate, squatters occupy many areas, monitoring of the reserve is largely non-existent, and land clearing continues. That said, apart from the biosphere reserve, ejido lands that are designated as Permanent Forest Areas represent about 25 per cent of the study region's land area, which when combined with national land that lies within the biosphere reserve, means that over one third of the region is supposed to be off-limits to agriculture.[43]

In another attempt to introduce more sustainable economic uses from the standing forest, the international archaeological and ecological tourism scheme, El Mundo Maya (The Maya World), was started in 1993, with goals to spur economic development while maintaining forest cover. El Mundo Maya has led to road improvements, the restoration of Maya ruins, and an expansion in services for tourists (e.g., hotel construction); however, its impact on forest cover is unclear and appears to affect only small, isolated pockets near Maya sites.

In addition to conservation and tourism schemes, there are numerous experiments with alternative land uses, such as agroforestry, apiculture, and fruit and vegetable production, some of which have been fostered by the *Consejo Regional Agrosilvopecuario y de Servicios de Xpujil* (CRASX) and *Bosque Modelo de Calakmul* (Model Forest of Calakmul, which is part of the Canadian Model Forest network). At its height of importance, CRASX consisted of 3,000 members in 58 ejidos, and oversaw the establishment of nurseries, reforestation projects, the establishment of agroforestry plots and permanent forest areas, and the promotion of organic agriculture and apiculture. Due to organisational problems, corruption, financial mismanagement, and the creation of the municipality of Calakmul in 1997, however, CRASX is no longer a major factor in land-use decision-making. The development of sustainable grassroots institutions is therefore weaker in the Campeche region than in central Quintana Roo.[44]

(3) In the *Lacandón Rainforest*, deforestation has occurred at much higher rates than in the other two regions. From the mid-1970s to the mid-1990s, two regions of the Lacandón Rainforest underwent clearing at a rate of 2 per cent per year while in a third – with 80 per cent under protected status – the decline was only 0.3 per cent per year. Some estimates are that roughly 40 per cent of the Lacandón Rainforest was cleared between the 1960s and the mid-1990s, and

that the Marques de Comillas region underwent a 2.8 per cent annual deforestation rate from 1979–89.[45]

High rates of colonisation from the 1960s-80s appear to have tapered off by the 1990s, but population growth in established communities continued to apply pressure to nearby forested areas, and invasions and land clearings in both the *Comunidad Lacandón* and the Montes Azules Biosphere have occurred frequently since 1994. Efforts at both conservation and development in the region were affected severely by the emergence of the Zapatista guerrilla movement in 1994 (the Zapatista Army of National Liberation/Ejército Zapatista de Liberación Nacional is an armed revolutionary group). But, despite the political tensions and continued forest loss, albeit apparently at lower rates, there was also vigorous forest recovery in a study of three sub-regions of the Lacandón Rainforest, and it was most dramatic in that which had been deforested the longest. One study found that 'mature forest' declined by 31 per cent, from 91 per cent of total area to 63 per cent, although 'secondary forest' grew from 0.2 per cent to 18.2 per cent of the region, meaning that the combination of mature and secondary forests still covered 81.2 per cent of the total area. During the same period, 'pasture' and 'agriculture' went from 5 per cent of total land area to 10 per cent, but it is unclear how much agricultural abandonment occurred and an expansion of agriculture would also imply an expansion of fallow.[46] Out-migration from the Lacandón does not appear to be happening at a significant rate.

In the forest-use component, efforts towards protection have been vigorous, but sustainable forest management has been difficult to implement. State government policies in Chiapas favoured continued parastatal dominance of logging in the Lacandón in the 1980s and actively quashed efforts by PPF staff from Quintana Roo to implement a community forestry regime there on two different occasions. Then, in 1988, a ban on logging was enacted, which included dismantling the forest industry, putting forestry engineers in jail for approving logging, forbidding *campesinos* from clearing land for their milpa, and making it illegal to carry an unregistered chainsaw, among other measures. One of the complaints of the Zapatistas was the logging ban. New efforts to promote community forestry began in 1996 in the Marques de Comillas region but were unsuccessful. Outright protection has been more vigorously pursued, with the establishment of Montes Azules in 1978, followed by the Lacantún Biosphere Reserve, three communal forest reserves, and two national parks. Although under pressure, it appears that these protected areas have been successful in reducing deforestation rates within their boundaries. As a result of the political tensions in the regions, however, other institutions for sustainable development are incipient to non-existent. The militarisation of the region has made it difficult to expand the range of land-use options that have emerged in the other two study regions.[47]

FOREST AND SUSTAINABILITY TRANSITIONS?

Table 2 presents regional deforestation rates for southeastern Mexico for the last three decades. Deforestation rates from the 1970s through the early 1990s

TABLE 2. Tropical Deforestation Rates and Forest Recovery (in case study regions only) in Southeastern Mexico (1970s–2000)

Region	Years Studied	Deforestation Rate	Forest in Secondary Succession	Source
Tuxtlas Veracruz	1976–86	4.3%	-	Dirzo & Garcia (1992)
SE Mexico	1970s–90s	4.3 – 12.4%	-	World Bank (1995)
States of SE[a] México	1977–92	1.9%	-	Cairos et al. (2000)
C. Qroo[b]	1984–2000	0.1%	10% (2000)	Bray et al. (2004)
SYPR subregion	1975–90	2.0% (1975–85) 0.2% (1985–90)	10% (1990)	Cortina V. et al. 1999
SYPR[c]	1969–97	0.32 – 0.39%	2.8% (1997)	Turner II et al. (2001)
Lacandón Community subregion	1970s–90s	0.3%	-	De Jong et al. (2000)
Lacandón (each of two subregions)	Mid 1970s–90s	2.0%	-	De Jong et al. (2000)
Marques de Comillas (Lacandón Forest subregion)	1979–89	2.8%	-	O'Brien (1998)
Entire Lacandón	1970s–90s		0.2 % (1970s) to 18.2 % (1990s)	

a Southeastern

b Central Quintana Roo

c Southern Yucatán peninsular region

were often quite high, which validates the deforestation narrative for that period. There was a deforestation rate of 1.9 per cent per year for the eight states of tropical southeastern Mexico from 1977–92, with local rates varying dramatically. The Tuxtlas area of Veracruz, for example, underwent a 4.3 per cent per year deforestation rate from 1976–86.[48] When we turn to the three case study subregions and include more recent periods, however, a more complex picture emerges. Central Quintana Roo, in particular, stands in stark contrast to other parts of southeastern Mexico due to its relative stabilisation in forest cover, with only a 0.1 per cent deforestation rate from 1984–2000. During the same period, 10 per cent of the study area went from agriculture and pasture to secondary succession despite a lack of protected areas. The Central Quintana Roo broader region is clearly passing through a forest transition where rates of forest recovery are higher than those of ongoing deforestation.[49]

In the southern Yucatán peninsular region, a central subregion had a high deforestation rate from 1975–85, when colonisation was in full swing, but the rate dropped to 0.2 per cent from 1985–90 and as much as 10 per cent of the subregion reverted to secondary forest by 1990 (Table 2). For the broader region and over a longer time period, the rates have been comparatively low as the land-migration tandem has declined in importance. From 1987–97, 474 square kilometres reverted from pasture and agriculture to secondary succession, although there was still a net loss of forest cover for the same period (Table 1). But with falling deforestation rates and a growing area in secondary forest, there are signs of an incipient forest transition.[50]

Regions of the Lacandón have had high deforestation rates in periods ranging from the mid-1970s (and probably earlier) to the late 1980s or early 1990s, depending on the region. Even in a subregion where forest conservation dominates, with 80 per cent in protected areas, there are high rates. The seriousness of the deforestation problem in Chiapas notwithstanding, there are also signs of forest recovery, with secondary succession growing from 0.2 per cent to 18.2 per cent from the mid-1970s to mid-1990s. Overall, while Quintana Roo is the only case in which the rates of forest recovery are higher than those of ongoing deforestation, and therefore the only region in which a forest transition can be declared, all three study areas exhibit trends towards more forest cover in secondary succession and declining rates of forest clearing.[51]

The situation with respect to transitions to more sustainable institutions at various scales, but particularly at the grassroots level, is much more variable. Central Quintana Roo is composed almost entirely of community-managed forests, the existence of which is due, in part, to a longer settlement history that led to the establishment of mostly large chicle ejidos as opposed to the numerous smaller land grants for agriculture that took place in the other two regions. These early land grants were later strengthened in forest management by the PPF initiative in the mid-1980s. Despite PPF's narrow focus on logging and forest management, lesser attention to community enterprise administration, and unclear impacts on the sustainability of mahogany extraction, it has helped develop natural resource-management institutions and business skills at the local level and it exemplifies effective cross-scale cooperation between communities, government officials, national NGOs, and international actors. These achievements are widely recognised in the literature as important characteristics of a transition to sustainability.

Components of a forest transition in the southern Yucatán peninsular region include land abandonment and involve changes in the crop-fallow cycle: these dynamics are likely linked to the need for ejidatarios to diversify absent the wage labour provided by forestry and the big projects, the failure of the big projects themselves, and the gradual stabilisation of population, but they also may be due to the end of new land grants since 1992 (land reform) and the closing of ejidos to new ejidatarios (available land is 'assigned'). The number of forest set-asides has increased dramatically in recent decades, with growing social capital invested in balancing environment and development concerns. In short, there has been a diversification and increasing complexity of both institutions and land use, which is a far cry from the single-sector boom and bust that dominated the region's twentieth century history. The number and diversity of programs and projects operating in the region reflects a dynamic institutional base, and regional interest groups increasingly try to reconcile the competing goals of economic development and environmental conservation.

There is much less institutional development connected to sustainable development initiatives in the Lacandón than in the other two regions because it is a contested terrain in the literal sense: there are tense confrontations between a land-use component that is still expressing an ongoing process of tropical colonisation, although now under severe constraints, and a forest-use component focused on protected areas and communal reserves. Currently, although numbers vary according to the source, there are 71 irregular groups in the Lacandón Rainforest, 49 in protected areas and 22 in the Comunidad Lacandona. Some of these communities are within five 'autonomous municipalities' that have been declared by the Zapatistas. Efforts at sustainable forest management in the Marques de Comillas subregion in the late 1990s failed, and there are few and limited efforts to sustainable alternatives in the region at the time. A major government initiative is currently underway to try and solve the land tenure conflicts in the region; however, the prospects for the development of more sustainable grassroots institutions in this region remain murky.[52]

The signs of forest cover recovery and associated institutional development in parts of lowland southeastern Mexico have important ecological implications. It is common for conservationists to ignore or diminish the significance of processes of forest regrowth. For example, a recent global study of forest-cover change processes noted:

> Large nonforest areas were also reoccupied by forests, but these areas were mainly young regrowth on abandoned land, along with some forest plantations. Both are

> very different from natural forests in ecological, biophysical, and economic terms and therefore are not an appropriate counterbalance to the loss of mature forests.[53]

It is true that secondary forests are not mature forests, but they may not be as different as described. The assertion above ignores studies of forest succession that show how, under specific human-environment conditions, tropical forests can regain relatively quickly many important ecological services. Many studies report the rapid recovery of species biodiversity and biomass in secondary tropical forests of southeastern Mexico. In the southern Yucatán peninsular region, it is estimated that after 25 years of uninterrupted secondary succession 80 per cent of the basal area of a mature forest is achieved and, as already noted, the composition of species is similar to extant mature forests. A 2004 review on tropical forest secondary succession says 'Forest structural characteristics such as canopy height and basal area may reach values similar to those of primary forest in as little as two decades'. These forests are also of enormous importance in terms of carbon sequestration and other ecological services. There appears to be less work on the restocking of these secondary forests with fauna, but if they are connected with larger forest masses then faunal biodiversity could also recover.[54] While these secondary forests do not have the full complement of ecological services that mature forests have, they are not ecologically trivial, and merit more recognition and discussion of the implications for conservation and land-use processes.

It is too early to say whether the secondary forests of southeastern Mexico will be left to mature, given that an unknown percentage of them are in multiple stages of fallow, but the comparative history presented here supports cautious optimism that forest transitions will occur region wide. While there are many examples in and out of Mexico where a deforestation narrative continues to be used to advance nature conservation strategies that focus primarily on using reserves to exclude people and to protect pockets of 'wilderness', the forest history of southeastern Mexico reflects a Latin American trend in recent decades towards an embrace of integrated reserve-matrix systems.

The comparative history supports narratives of conservation and recovery as well as narratives of deforestation, offering balance to the region's environmental history. Comparison between the three study regions reveals an uneven north-south continuum in the impacts of the land-migration tandem, deforestation, forest recovery and the development of more sustainable cross-scale institutions. The twentieth century land-use histories show that the deforestation narrative was highly salient for the 1960–85 period in southeastern Mexico, but that it is not an accurate characterisation of the complex processes of deforestation, forest recovery, and the development of sustainability-oriented grassroots institutions in the 1985–2003 period.

Efforts to balance environment and development have grown in the last few decades. The institutional development that corresponds to reduced deforestation rates is rooted in community-managed lands that receive environmental

NGO and federal support, which combine to foster diversified and potentially more sustainable land uses, complemented by protected nature reserves. These insights suggest that efforts to strengthen local control of land resources and promote a mosaic of conservation and extractive reserves have had a positive effect in addressing southeastern Mexico's deforestation problem.

NOTES

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[2] K. Brown and D.W. Pearce, ed. *The Causes of Tropical Deforestation: The Economic and Statistical Analysis of Factors Giving Rise to the Loss of the Tropical Forests* (London: University College London, 1994); S.E. Place, ed., *Tropical Rainforests: Latin American Nature and Society in Transition*, 2nd edn (Wilmington, Del: Scholarly Resources, 2001); J. Vandermeer and I. Perfecto, *Breakfast of Diversity: The Truth about Rainforest Destruction* (Oakland: The Institute for Food and Development Policy, 1995); H.J. Geist and E.F. Lambin, *What Drives Tropical Deforestation?: A Meta-analysis of Proximate and Underlying Causes of Deforestation Based on Subnational Case Study Evidence* (Louvain: LUCC International Project Office, 2001), 54.

[3] S.G. Perz and D.L. Skole, 'Secondary Forest Expansion in the Brazilian Amazon and the Refinement of Forest Transition Theory', *Society and Natural Resources* 16 (2003): 277–94. Other examples of forest recovery in A.E. Lugo, 'Can We Manage Tropical Landscapes? – An Answer from the Caribbean Perspective', *Landscape Ecology* 17 (2002): 601–615, and D. Klooster, 'Forest Transitions in Mexico: Institutions and Forests in a Globalized Countryside', *The Professional Geographer* 55 (2003): 227–37. We acknowledge recent studies, such as that by D.I. Stern, 'The Rise and Fall of the Environmental Kuznets Curve', *World Development* 32 (2004): 1419–39, which question the statistical foundation of environmental Kuznets curves in developing contexts. Our intent is to highlight recovery processes and institutional development rather than debate the underpinnings of forest transition theory.

[4] The New England and Maya cases are presented in D. Foster, F. Swanson, J. Aber, I. Burke, N. Brokaw, D. Tilman, and A. Knapp, 'The Importance of Land-use Legacies to Ecology and Conservation', *BioScience* 53 (2003): 77–88, and T. Whitmore, B.L. Turner II, D. Johnson, R.W. Kates, T. Gottschang, 'Long-Term Population Change', in *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years*, eds. B.L. Turner II, W.C. Clark, R.W. Kates, J.F. Richards, J.T. Mathews, W.B. Meyer (Cambridge: Cambridge University Press, 1990). The recent cases are in Klooster, 'Forest Transitions in Mexico: Institutions and Forests in a Globalized Countryside', 227–37; Lugo, 'Can We Manage Tropical Landscapes? – An Answer from the Caribbean Perspective'; A.S. Matthews, 'Suppressing Fire and Memory: Environmental Degradation and Political Restoration in the Sierra Juárez of

Oaxaca, 1887–2001', *Environmental History* 8 (2003): 77–108; E.F. Moran and E. Brondizio, 'Land-Use Change after Deforestation in Amazonia', in *People and Pixels: Linking Remote Sensing and Social Science*, eds. D. Liverman, E.F. Moran, R.R. Rindfuss, and P.C. Stern (Washington, D.C.: National Academy Press, 1998).

[5] Perz and Skole, 'Secondary Forest Expansion in the Brazilian Amazon and the Refinement of Forest Transition Theory'; T.K. Rudel, D. Bates, and R. Machinguiashi, 'A Tropical Forest Transition? Agricultural Change, Out-migration, and Secondary Forests in the Ecuadorian Amazon', *Annals of the Association of American Geographers* 92 (2002), 87–102; B. Finegan and R. Nasi, 'The Biodiversity and Conservation Potential of Shifting Cultivation Landscapes' in *Agroforestry and Biodiversity Conservation in Tropical Landscapes,* eds. G. Schroth, G.A.B. da Fonseca, C.A. Harvey, C. Gascon, H.L. Vasconcelos, A.N. Izac (Washington, D.C.: Island Press, 2004); D. Lawrence, H. F. M. Vester, D. Pérez-Salicrup, J. R. Eastman, B. L. Turner II, J. Geoghegan, *Integrated Analysis of Ecosystem Interactions with Land-Use Change: The Southern Yucatán Peninsular Region*, Unpublished manuscript.

[6] The notion of a 'deforestation narrative' is discussed in D. Klooster, 'Beyond Deforestation: The Social Context of Forest Change in Two Indigenous Communities in Highland Mexico', *Conf. of Lat. Am. Geog.* 26 (2000): 47–59. In Mexico, the notion of the pristine myth has been countered for decades. See, for example, A. Gómez-Pompa and A. Kaus, 'Taming the wilderness myth', *Bioscience* 42 (1992): 271–9, and T.M. Whitmore and B.L. Turner II, 'Landscapes of Cultivation of cultivation on the eve of the Conquest', *Annals of the Association of American Geographers* 82 (1992): 402–25. A. Sluyter, *Colonialism and landscape: postcolonial theory and applications* (Landham, Md: Rowman & Littlefield Publishers, 2002) describes the effect of the pristine myth on development policy. The relevance of the deforestation narrative is presented recently in D. Kaimowitz, B. Mertens, S. Wunder, P. Pacheco, *Hamburger Connection Fuels Amazon Destruction* (Jakarta: Center for International Forestry Research, 2004, accessed on 11 August 2004 at http://www.cifor.cgiar.org). Place, *Tropical Rainforests: Latin American Nature and Society in Transition*, highlights the vital role that tropical forests play in human and ecological systems.

[7] The authors of this article disagree over the relative importance of the deforestation narrative in the region. D.B. Bray, E.A. Ellis, N. Armijo-Canto, L. Somarriba, and C.T. Beck, 'The Drivers of Sustainable Landscapes: A Case Study of the "Mayan Zone" in Quintana Roo, Mexico', *Land Use Policy* 21 (2004): 333–46, suggest, for example, that a deforestation narrative is not the most appropriate discourse for the rates described over time in the southern Yucatan peninsular region. P. Klepeis, 'Development Policies and Tropical Deforestation in the Southern Yucatán Peninsula: Centralized and Decentralized Approaches', *Land Degradation and Development* 14 (2003): 1–21, and his colleagues have presented carefully analysed data and argue that deforestation has been a serious problem in the region. The work presented here is an effort to establish a nuanced characterisation of forest change processes in southern Mexico that takes both views into account.

[8] D. Klooster, 'Forest Transitions in Mexico: Institutions and Forests in a Globalized Countryside'; and Perz and Skole, 'Secondary Forest Expansion in the Brazilian Amazon and the Refinement of Forest Transition Theory', on causes and patterns of deforestation and regrowth. The range of explanation for patterns of deforestation in southeastern Mexico are found in B.L. Turner II, J. Geoghegan, D.R. Foster, eds. *Integrated Land-Change Science and Tropical Deforestation in the Southern Yucatán: Final Frontiers*

(Oxford: Oxford University Press, 2004); R.B. Primack, D. Bray, H. A. Galletti, and I. Paciano, eds. *Timber, Tourists, and Temples: Conservation and Development in the Maya Forest of Belize, Guatemala, and Mexico* (Washington, D.C.: Island Press, 1998); and K.L. O'Brien, *Sacrificing the Forest: Environmental and Social Struggles in Chiapas* (Boulder: Westview Press, 1998).

[9] N. Myers, R.A. Mittermeir, F. Mittermeier, G.A.B. Fonseca, J. Kent, 'Biodiversity Hotspots for Conservation Priorities', *Nature* 403 (2000): 24.

[10] See World Bank, *Mexico: Resource Conservation and Forest Sector Review: 13114-ME* (The World Bank, SARH, Washington, DC, 1995). The 2000 National Forestry Inventory, the most definitive study of land-use change in Mexico to date, found that for the entire country, for the period 1976–2000, the annual rate of deforestation for temperate forests was 0.25 per cent and for rainforests was a significantly higher 0.76 per cent. See J.L. Palacio-Prieto, G. Bocco, A.Velázquez, J.F. Mas, F. Takaki-Takaki, A. Victoria, L. Luna-González, G. Gómez-Rodríguez, J. López-García, J.R. González, M.P. Muñoz, 'La condición actual de los recursos forestales en México: resultados del inventario forestal nacional 2002', *Gaceta Ecológica* 62 (2002), 21–37. For the rate of 1.9 per cent from 1977–92, see M.A. Cairns, P.K. Haggerty, R. Alvarez, B.H.J. de Jong, I. Olmsted, 'Tropical Mexico's recent land use change: a region's contribution to the global carbon cycle', *Ecological Applications* 10 (2000): 1426–41. A typical report in the Mexican press is A. Enciso, 'Empresas privadas sobreexplotan los bosques', *La Jornada* June 16 (2004): 44, and from the U.S. Press, G. Thompson, 'Where Butterflies Rest, Damage Runs Rampant: Illegal Loggers Endanger Mexican Habitat', *New York Times* June 2 (2004).

[11] Southeastern Mexico is usually defined to include southern Veracruz, Tabasco, Chiapas, and the three states of the Yucatán Peninsula: Yucatán, Campeche, and Quintana Roo; see M. Szekely and I. Restrepo, *Frontera Agrícola y Colonización* (México, D.F.: Centro de Desarrollo, 1988). The southern Yucatán peninsular region is defined by the 1997–2000 SYPR project, which is a collaboration between El Colegio de la Frontera Sur (ECOSUR), Mexico; Harvard Forest, Harvard University; The George Perkins Marsh Institute, Clark University; and the Center for Integrated Studies on Global Environmental Change, Carnegie Mellon University (CIS-CMU). It has core sponsorship from NASA's LCLUC (Land-Cover and Land-Use Change) program (NAG5-6406 and NAG5-1134) and the CIS-CMU (NSF-SBR 95–21914). The region consists largely of semi-deciduous tropical forest, and spans approximately 22,000 km^2 across the southern portions of the states of Campeche and Quintana Roo.

[12] E.B. Barbier and J.C. Burgess, 'Economic Analysis of Deforestation in Mexico', *Environment and Development Economics* 1 (1996): 203–39, find agricultural and livestock expansion to be the primary drivers of deforestation in southeastern Mexico.

[13] A. Grainger, 'The forest transition: an alternative approach', *Area* 27(1995): 242–51, and Klooster, 'Forest Transitions in Mexico: Institutions and Forests in a Globalized Countryside', highlight the 'forest-use' and 'land-use' components of a forest transition. As reviewed in T.M. Parris, 'Toward a Sustainability Transition: The International Consensus', *Environment* 45(2003): 12–22, sustainable practices are defined loosely here as human-environment conditions that achieve relative balance between development, equity, and maintained or improved environmental services.

[14] Select characteristics of more sustainable institutions are described in A. Bebbington, 'Movements, Modernization, and Markets: Indigenous Organizations and Agrarian Strategies in Ecuador', in *Liberation Ecologies: Environment, Development, Social Movements*,

eds. R. Peet and M. Watts (London: Routledge, 1996); B.I. Logan and W.G. Moseley, 'The Political Ecology of Poverty Alleviation in Zimbabwe's Communal Areas Management Programme for Indigenous Resources (CAMPFIRE)', *Geoforum* 33 (2002): 1–14; J.C. Ribot, *Democratic Decentralization of Resources: Institutionalizing Popular Participation* (Washington, D.C.: World Resources Institute, 2002); D. Rocheleau, L. Ross, and J. Morrobel, 'From Forest Gardens to Tree Farms: Women, Men, and Timber in Zambrana-Chacuey, Dominican Republic', in *Feminist Political Ecology: Global Issues and Local Experiences*, eds. D. Rocheleau, B. Thomas-Slayter, and E. Wangari (London: Routledge, 1996); W. Sachs, ed., *The Jo'burg-Memo: Fairness in a Fragile World* (Berlin: The Heinrich Böll Foundation, 2002).

[15] Find the goals of sustainability science, the notion of a sustainability transition, and the importance of historical perspective in land change studies in S.P.J. Batterbury and A.J. Bebbington, 'Environmental Histories, Access to Resources and Landscape Change: An Introduction', *Land Degradation & Development* 10 (1999): 279–89; R.W. Kates, W.C. Clark, R. Corell, J.M. Hall, C.C. Jaeger, I. Lowe, J.J. McCarthy, H.J. Schellnhuber, B. Bolin, N.M. Dickson, et al, 'Sustainability Science', *Science* 292 (2001): 641–2; Parris, 'Toward a Sustainability Transition: The International Consensus', 12–22; P. Raskin, T. Banuri, G. Gallopín, P. Gutman, A. Hammond, R. Kates, and R. Swart, *The Great Transition: The Promise and Lure of Times Ahead* (Boston: The Stockholm Environment Institute, 2002). For narratives of conservation, see K. S. Zimmerer and E.P. Carter, 'Conservation and Sustainability in Latin America and the Caribbean', in *Latin America in the 21st Century: Challenges and Solutions*, ed. G. Knapp (Austin: Conference of Latin Americanist Geographers, 2002). On sustainable landscapes in Mexico, see D.B. Bray, L. Merino-Pérez, P. Negreros-Castillo, G. Segura-Warnholtz, J.M. Torres-Rojo, H.F.M. Vester, 'Mexico's Community Managed Forests as a Global Model for Sustainable Landscapes', *Conservation Biology* 17 (2003): 672–7.

[16] The remaining tropical forest blocks in Mexico are too small to usually be considered in the frontier forests category globally but they are the 'frontier forests' of Mexico and highly significant nationally and regionally. In WRI, *The Last Frontier Forests: Ecosystems and Economies on the Edge* (Washington, D.C.: World Resources Institute, 1997), the three study regions are identified as 'frontier forests'. In F.E.H. Achard, A. Glinni, P. Mayaux, T. Richards, H.J. Stibig, eds. *Identification of Deforestation Hot Spot Areas in the Humid Tropics* Trees Publ. Series B. Research Report No. 4 (Brussels: Space Application Institute, Global Vegetation Monitoring Unit. Joint Research Centre, European Commission, 1998), they are referred to as 'hot spots' of deforestation. A fourth major block of tropical forest in southeastern Mexico is the Chimalapas region of southern Oaxaca and northern Chiapas – see A. de Ávila and M. A.García Aguirre, 'La Reserva Campesina en Chimalapa', in *Semillas para el Cambio en el Campo: Medio Ambiente, Mercados y Organización Campesina*, eds. L. Paré, D.B. Bray, and Sergio M. Vázquez (Mexico City: Instituto de Investigaciones Sociales, Universidad Autónoma de México, 1997), which is not included here because it is not usually considered part of the southeastern lowlands.

[17] The Sierra Santa Marta, Veracruz, case is described in J.M. Chevalier and D. Buckles, *A Land without Gods: Process Theory, Maldevelopment and the Mexican Nahuas (*London and New Jersey: Zed Books, 1995, 194). The Tuxtlas data is from R. Dirzo and M.C. Garcia, 'Rates of Deforestation in Los Tuxtlas, a Neotropical Area in Southeast Mexico', *Conservation Biology* 6 (1992): 84–90.

[18] Szekely and Restrepo, *Frontera Agrícola y Colonización,* describe in detail the dynamics of the land-migration tandem. Although we refer to the study areas as 'islands' and 'isolated remnants' of mature forest, the Lacandón Rainforest and that of the southern Yucatán peninsular region are connected by forest, albeit much of it fragmented and in various stages of secondary succession. The fragmentation of the Maya Forest, and the possibility of maintaining and improving some of the tenuous forest connections, led to the formalisation of the MesoAmerican Biological Corridor in 1997. Despite these connections, however, the three study areas are still distinct regions, and relatively isolated forest masses compared with the early to mid-twentieth century.

[19] G.D. Jones, *Maya Resistance to Spanish Rule: Time and History on a Colonial Frontier* (Albuquerque: University of New Mexico Press, 1989). H.W. Konrad, 'Capitalism on the Tropical-Forest Frontier: Quintana Roo, 1880s to 1930', in *Land, Labor, and Capital in Modern Yucatan: Essays in Regional History and Political Economy*, ed. J.G. Brannon (Tuscaloosa: University of Alabama Press, 1991).

[20] C.L. Lundell, 'Preliminary Sketch of the Phytogeography of the Yucatan Peninsula', *Field and Laboratory* 21 (1934): 15–21; A.R. Villaseñor, 'Los Bosques y su explotación', in *Los Recursos Naturales del Sureste y su Aprovechamiento*, ed. E. Beltran (Mexico City: Instituto Mexicano de Recursos Naturales Renovables, A.C, 1958), 273–326.

[21] U. Hostettler, 'Milpa Agriculture and Economic Diversification: Socioeconomic Change in a Maya Peasant Society of Central Quintana Roo, 1900–1990's' (PhD diss., University of Berne, 1996), 103–43.

[22] P. Klepeis, 'Forest Extraction to Theme Parks: The Modern History of Land Change in the Region', in *Integrated Land-Change Science and Tropical Deforestation in the Southern Yucatán: Final Frontiers*, eds. B.L. Turner II, J. Geoghegan, and D.R. Foster (Oxford: Oxford University Press, 2004).

[23] De Vos, *La Paz de Dios y del Rey: La conquista de la Selva Lacandona (1525–1821)*; J. De Vos, 'Una Selva Herida de Muerte, Historia Reciente de la Selva Lacandona', in *Reserva de la Biósfera Montes Azules, Selva Lacandona: Investigación para su Conservación*, ed. M.A. Vásquez-Sánchez and M.A. Ramos (San Cristobal de las Casas: Publicaciones Especiales Ecosfera No. 1, 1992).

[24] De Vos, 'Una Selva Herida de Muerte, Historia Reciente de la Selva Lacandona', 260.

[25] Mahogany regeneration after shifting cultivation is described in L.K. Snook, 'Sustaining Harvests of Mahogany (Swietenia macrophylla King) from Mexico's Yucatán Forests: Past, Present, and Future', in *Timber, Tourists, and Temples: Conservation and Development in the Maya Forest of Belize, Guatemala, and Mexico*, eds. R.B. Primack, D. Bray, H.A. Galletti, and I. Paciano (Washington, D.C.: Island Press, 1998). Fallow cycles and ecology are described for the southern Yucatan Peninsula in P. Klepeis, C. Vance, E. Keys, P. Macario Mendoza, and B. L. Turner II, 'Subsistence Sustained: Swidden or Milpa Cultivation', in *Integrated Land-Change Science and Tropical Deforestation in the Southern Yucatán: Final Frontiers*, eds. B.L. Turner II, J. Geoghegan, and D.R. Foster (Oxford: Oxford University Press, 2004); D. Lawrence and D. Foster, 'Changes in Forest Biomass, Litter Dynamics and Soils Following Shifting Cultivation in Southern Mexico: An Overview', *Interciencia* 27 (2002): 400–08; B.L. Turner II, S. Cortina Villar, D. Foster, J. Geoghegan, E. Keys, P. Klepeis, D. Lawrence, P. Macario Mendoza, S. Manson, Y. Ogneva-Himmelberger, A.B. Plotkin, D. Pérez Salicrup, R. Roy Chowdhury, B. Savitsky, L. Schneider, B. Schmook, C. Vance, 'Deforestation in

the Southern Yucatán Peninsular Region: An Integrative Approach', *Forest Ecology and Management* 154 (2001): 353–70.

[26] The terms mild, milder, and high are relative to published reports of deforestation rates in both Latin America and worldwide. The FAO reports a 1.08 per cent per year average deforestation rate (all forest types) for Mexico for 1990–2000 and an average tropical deforestation rate worldwide of 0.55 per cent for the same period; see FAO (Food and Agriculture Organization of the United Nations), *Global Forest Resources Assessment 2000*, FAO Forestry Paper 140 (Rome: FAO, 2001). Achard et al. find an annual deforestation rate (for humid tropical forests, and as a percentage of 1990 forest cover) in select Latin American 'hot spots' to be 0.33 per cent and worldwide to be 0.43 per cent both estimates of which represent net forest change (i.e., cutting and regrowth); see F. Achard, H. Eva, H.J. Stibig, P. Mayaux, J. Gallego, T. Richards, and J.P. Malingreau, 'Determination of Deforestation Rates of the World's Humid Tropical Forests', *Science* 297 (2002): 999–1002. Geist and Lambin, 'What Drives Tropical Deforestation?: A Meta-analysis of Proximate and Underlying Causes of Deforestation Based on Subnational Case Study Evidence', 76–8, in their analysis of 108 published studies of tropical deforestation from cases around the world, distinguish between relatively low (0.3 to 0.7 per cent) and relatively high (1.9 to 2.9 per cent) mean annual tropical deforestation rates.

[27] Bray, Ellis, Armijo-Canto, Somarriba, Beck, 'The Drivers of Sustainable Landscapes: A Case Study of the "Mayan Zone" in Quintana Roo, Mexico'; Klepeis, 'Forest Extraction to Theme Parks: The Modern History of Land Change in the Region'.

[28] The reserve-matrix model as it relates to biodiversity conservation is described in D.B. Lindenmayer and J.F. Franklin, *Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach* (Washington: Island Press, 2002).

[29] On the rate of deforestation, see S. Cortina Villar, P. Macario Mendoza, and Y. Ogneva-Himmelberger, 'Cambios en el uso del suelo y deforestación en el sur de los estados de Campeche y Quintana Roo, México', Boletín del Instituto de Geografía de la UNAM. *INVESTIGACIONES GEOGRAFICAS* 38 (1999): 41–56; On the degree of anthropogenic disturbance by 1982, see Klepeis, 'Forest Extraction to Theme Parks: The Modern History of Land Change in the Region'; On population, see P. Klepeis, 'Development Policies and Tropical Deforestation in the Southern Yucatán Peninsula: Centralized and Decentralized Approaches'.

[30] On the rise in chili production, see E. Keys, 'Jalapeño Pepper Cultivation: Emergent Commercial Land-Use of the Region', in *Integrated Land-Change Science and Tropical Deforestation in the Southern Yucatán: Final Frontiers*, eds. B.L. Turner II, J. Geoghegan, D.R. Foster (Oxford: Oxford University Press, 2004).

[31] X. Leyva Solano and G. Ascencio Franco, *Lacandonia al Filo del Agua* (Mexico City: CIESAS, 1996). De Vos, *Una Tierra Para Sembrar Sueños: Historia Reciente de la Selva Lacandona 1950–2000.*

[32] De Vos, 'Una Selva Herida de Muerte, Historia Reciente de la Selva Lacandona', 281. Colonization program described in Gobierno del Estado, 'Propuesta de Plan de Manejo para la Reserva Integral de la Biósfera de Montes Azules, Selva Lacandona, Chiapas, Mexico', Coordinación de Programas Especiales, Equipo Técnico Planificador (Unpublished report, 1990), 58.

[33] Deforestation rate for central Quintana Roo in Bray, Ellis, Armijo-Canto, Somarriba, and Beck, 'The Drivers of Sustainable Landscapes: A Case Study of the "Mayan Zone"

in Quintana Roo, Mexico'. Estimate of deforestation in the 12 *ejidos* in E. Durán, J-F. Mas, and A. Velásquez, 'El Cambio en la Cobertura y Uso del Suelo Como Indicador de la Conservación: Un Resumen de Estudios de Caso en Regiones con Manejo Forestal Comunitario y Áreas Naturales Protegidas', in *Investigaciones en Apoyo de una Economía de Conservación en la Zona Maya de Quintana Roo*, eds. D.B. Bray, V. Santos Jiménez, and N. Armijo (Felipe Carillo Puerto, Quintana Roo: OEPFZM/Institute for Sustainability Science in Latin America and the Caribbean, Florida International University, 2003).

[34] H.A. Galletti, 'The Maya Forest of Quintana Roo: Thirteen Years of Conservation and Development', In *Timber, Tourists and Temples: Conservation and Development in the Maya Forest of Belize, Guatemala, and Mexico*, eds. R.B. Primack, D.B.Bray, H.A. Galletti, and I. Ponciano (Island Press: Washinton, DC, 1998); A.M. Vargas-Prieto, 'Effective Intervention: External and Internal Elements of Institutional Structure for Forest Management in Quintana Roo, Mexico' (Ph.D. diss. University of Wisconsin-Madison, 1998).

[35] Bray, Ellis, Armijo-Canto, Somarriba, Beck, 'The Drivers of Sustainable Landscapes: A Case Study of the "Mayan Zone" in Quintana Roo, Mexico'; D.B. Bray, 'Community Forestry as a Strategy for Sustainable Management: Perspectives from Quintana Roo, Mexico', in *Working Forests in the America Tropics: Perspectives from Quintana Roo, Mexico*, eds. D. Zarin, J. Alavalapati, F.E. Putz and M.C. Schmink (New York: Columbia University Press, 2004). D.B. Bray, M. Carreón, L. Merino, and V. Santos, 'On the Road to Sustainable Forestry', *Cultural Survival Quarterly* 17 (1993): 38–41.

[36] D.B. Bray, 'Adaptive Management, Organizations and Common Property Management: Perspectives from the Community Forests of Quintana Roo, México', Paper Presented at the Eighth Biennial Conference of the International Association for the Study of Common Property, Bloomington, Indiana, May 31-June 4, 2000; Bray, 'Community Forestry as a Strategy for Sustainable Management: Perspectives from Quintana Roo, Mexico'.

[37] While it is uncertain the degree to which milpa drives forest degradation, government and non-government actors alike assume that milpa agriculture is a major problem in southeastern Mexico, and they are seeking to intensify agriculture and move away from shifting cultivation as a means to reduce pressure on remaining mature forest. On *taungya* agroforestry, see A. Racelis, 'Policies, Pests, and Unplanned Biodiversity: Interactions between Social and Ecological Dimensions of Agroforestry Projects in Central Quintana Roo, Mexico' (MS Thesis, Florida International University, 2003). On beekeeping, see C. Cairns, 'Effects of Invasive Africanized Honey Bees (*Apis Mellifera Scutellata*) on Native Stingless Bee Populations (*Meliponinae)* and Traditional Mayan Beekeeping in Central Quintana Roo, Mexico' (MS Thesis, Florida International University, 2002). On mahogany production, see H.F.M. Vester and M.A. Navarro Martínez',Asuntos Ecológicos del Manejo Forestal en Quintana Roo, México', in *Investigaciones en Apoyo de una Economía de Conservación en la Zona Maya de Quintana Roo*, eds. D.B. Bray, V. Santos Jiménez, and N. Armijo (Felipe Carrillo Puerto, Quintana Roo: OEPFZM/Institute for Sustainability Science in Latin America and the Caribbean, Florida International University, 2003). On community-based ecotourism projects see S. Cohan, 'Análisis y Sugerencias para un Turismo Sustentable en el Ejido X-Maben', in *Investigaciones en Apoyo de una Economía de Conservación en la Zona Maya de Quintana R*oo, eds. D.B. Bray, V. Santos Jiménez, and N. Armijo (Felipe Carrillo Puerto, Quintana Roo: OEPFZM/Institute for Sustainability Science in Latin America and the Caribbean, Florida International University, 2003). On tolches, see M. Zirkelbach, 'Emerging Mayan Conservation Practices in

Response To Ejido Degradation: A Comparative Study In Quintana Roo, Mexico' (MS thesis proposal, Florida International University, 2004).

[38] J. Ronald Eastman (pers. comm.), Graduate School of Geography Clark University, Worcester, MA, is in the process of analysing recent satellite images and secondary growth in the southern Yucatán peninsular region.

[39] Quotation and deforestation rate (1969–97) from Turner II, Cortina Villar, Foster, Geoghegan, Keys, Klepeis, Lawrence, Macario Mendoza, Manson, Ogneva-Himmelberger, Plotkin, Pérez Salicrup, Roy Chowdhury, Savitsky, Schneider, Schmook, Vance, 'Deforestation in the Southern Yucatán Peninsular Region: An Integrative Approach', 464.

[40] Klepeis, Vance, Keys, Macario Mendoza, and Turner II, 'Subsistence Sustained: Swidden or Milpa Cultivation'; C. Vance, P. Klepeis, B. Schmook, E. Keys, 'The *Ejido* Household: The Current Agent of Change', in *Integrated Land-Change Science and Tropical Deforestation in the Southern Yucatán: Final Frontiers*, ed. B.L. Turner II, J. Geoghegan, and D.R. Foster (Oxford: Oxford University Press, 2004).

[41] Data in Table 1 from Turner II, Cortina Villar, Foster, Geoghegan, Keys, Klepeis, Lawrence, Macario Mendoza, Manson, Ogneva-Himmelberger, Plotkin, Pérez Salicrup, Roy Chowdhury, Savitsky, Schneider, Schmook, Vance, 'Deforestation in the Southern Yucatán Peninsular Region: An Integrative Approach', 364–65.

[42] E. Keys (pers. comm.), Department of Geography, Arizona State University, Tempe AZ, reports recent outmigration from the southern Yucatán peninsular region. Data on ecosystem structure and function are from Lawrence and Foster, 'Changes in Forest Biomass, Litter Dynamics and Soils Following Shifting Cultivation in Southern Mexico: an Overview', 400–08; and B.L. Turner II (pers. comm.), Graduate School of Geography and George Perkins Marsh Institute, Clark University, Worcester, MA. On maize yields, see Klepeis, Vance, Keys, Macario Mendoza, Turner II, 'Subsistence Sustained: Swidden or Milpa Cultivation'. On diversification of land use, market production, and ecological impacts see Keys, 'Jalapeño Pepper Cultivation: Emergent Commercial Land-Use of the Region'. P. Klepeis and C.Vance, 'Neoliberal Policy and Deforestation in Southeastern Mexico: An Assessment of the PROCAMPO Program', *Economic Geography* 79(2003): 221–40, Turner II, Geoghegan, Foster, *Integrated Land-Change Science and Tropical Deforestation in the Southern Yucatán: Final Frontiers*; Vance, Klepeis, Schmook, Keys, 'The *Ejido* Household: The Current Agent of Change'; and Lawrence, Vester, Pérez-Salicrup, Eastman, Turner II, Geoghegan, 'Integrated Analysis of Ecosystem Interactions with Land-Use Change: the Southern Yucatán Peninsular Region'.

[43] Klepeis, 'Forest Extraction to Theme Parks: The Modern History of Land Change in the Region'.

[44] On CRASX, see P. Klepeis and R. RoyChowdhury. 'Institutions, Organizations, and Policy Affecting Land Change: Complexity Within and Beyond the Ejido', in *Integrated Land-Change Science and Tropical Deforestation in the Southern Yucatán: Final Frontie*rs, eds. B.L. Turner II, J. Geoghegan, D.R. Foster (Oxford University Press, Oxford, forthcoming).

[45] B.H.J. de Jong, S. Ochoa-Gaona, M.A. Castillo-Santiago, N. Ramírez-Marcial and M.A. Cairns, 'Carbon Flux and Patterns of Land-Use/Land-Cover Change in the Selva Lacandona, Mexico', *Ambio* 29 (2000): 504–11; O'Brien, *Sacrificing the Forest: Environmental and Social Struggles in Chiapas*, 42–3.

[46] De Vos, 'Una Tierra Para Sembrar Suenos: Historia Reciente de la Selva Lacandona 1950–2000'. On conservation, development, and the Zapatistas see J.D. Nations, 'The Ecology of the Zapatista Revolt', *Cultural Survival Quarterly* Spring (1994): 31–33. On regrowth, see de Jong, Ochoa-Gaona, Castillo-Santiago, Ramírez-Marcial and Cairns, 'Carbon Flux and Patterns of Land-Use/Land-Cover Change in the Selva Lacandona, Mexico', 504–11.

[47] Bray, 'Adaptive Management, Organizations and Common Property Management: Perspectives from the Community Forests of Quintana Roo, México'; De Jong, Ochoa-Gaona, Castillo-Santiago, Ramírez-Marcial and Cairns, 'Carbon Flux and Patterns of Land-Use/Land-Cover Change in the Selva Lacandona, Mexico', 504–11. P. Muench (pers. comm.) reports that there are new government-led efforts to resolve some of the land tenure conflicts in the region, which could lay the groundwork for more sustainability-oriented institutions to emerge.

[48] On Mexico's regional deforestation rates, see World Bank, *Mexico Resource Conservation and Forest Sector Review*. On deforestation rate for southeastern Mexico (1977–92), see M.A. Cairns, P.K. Haggerty, R. Alvarez, B.H.J. de Jong, and I. Olmsted, 'Tropical Mexico's Recent Land Use Change: A Region's Contribution to the Global Carbon Cycle', *Ecological Applications* 10 (2000): 1426–41. On deforestation rate for Tuxtlas, see Dirzo and Garcia, 'Rates of Deforestation in Los Tuxtlas, a Neotropical Area in Southeast Mexico', 84–90.

[49] The study of 12 ejidos in central Quintana Roo is in Durán, Mas, and Velásquez, 'El Cambio en la Cobertura y Uso del Suelo Como Indicador de la Conservación: Un Resumen de Estudios de Caso en Regiones con Manejo Forestal Comunitario y Áreas Naturales Protegidas'.

[50] Cortina Villar, 'Cambios en el uso del suelo y deforestación en el sur de los estados de Campeche y Quintana Roo, México', 41–56. Secondary growth in the southern Yucatán peninsular region is from Turner II et al., 'Deforestation in the Southern Yucatán Peninsular Region: An Integrative Approach', 353–70, and J. Ronald Eastman (pers. comm.).

[51] Signs of forest recovery in Chiapas are presented in de Jong, Ochoa-Gaona, Castillo-Santiago, Ramírez-Marcial and Cairns, 'Carbon Flux and Patterns of Land-Use/Land-Cover Change in the Selva Lacandona, Mexico', 504–11; and O'Brien, *Sacrificing the Forest: Environmental and Social Struggles in Chiapas*, 42–3.

[52] P. Muench, pers. comm.

[53] Achard, Eva, Stibig, Mayaux, Gallego, Richards, Malingreau, 'Determination of Deforestation Rates of the World's Humid Tropical Forests'.

[54] E. Ceccon, I. Olmsted, C. Vázquez-Yanes, J. Campo-Alves, Vegetation and Soil Properties in Two Tropical Dry Forests of Differing Regeneration Status in the Yucatan', *Agrociencia* 36 (2002): 621–31; Turner II, Cortina Villar, Foster, Geoghegan, Keys, Klepeis, Lawrence, Macario Mendoza, Manson, Ogneva-Himmelberger, Plotkin, Pérez Salicrup, Roy Chowdhury, Savitsky, Schneider, Schmook, Vance, 'Deforestation in the Southern Yucatán Peninsular Region: An Integrative Approach', 353–70; S. Brown, A.E. Lugo, 'Tropical Secondary Forests', *Journal of Tropical Ecology* 6 (1990: 1–32; A. Gómez-Pompa, Vázquez-Yanes, R.S. de Amo, *Investigaciones sobre la regeneración de selvas altas en Veracruz, México, 1st Edition* (Compañia Editorial Continental, México, 1976); quote from Finegan and Nasi, 'The Biodiversity and Conservation Potential of Shifting Cultivation Landscapes'.