

Community-based forest management in Quintana Roo, Mexico

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Abstract: The Mexican model of community forestry is often touted as an example whereby greater community control enhances both conservation and local livelihoods. We examine the conditions that have enabled and challenged sustainable forest management within community forests in Quintana Roo, a tropical state strongly influenced by the Maya culture that currently boasts 91% forest cover. Over time, community forestry has been shaped by land reforms and forest policies that institutionalised common property and local governance systems, granted timber rights to communities, instigated Permanent Forest Areas for commercial management, and laid a foundation to respond to changing market opportunities (i.e. payments for environmental services, railroad ties, polewood, and future carbon credits). Significantly, 16 years of state and international support via the Forestry Pilot Plan further empowered residents and increased local capture of forest benefits. In contrast, recent neoliberal economic and policy changes have promoted parcellisation and privatisation of communal lands, driving some deforestation and weakening governance in vulnerable communities. Corruption, lack of transparency, and contradictory agricultural, forestry, and conservation policies have impeded proper forest-sector investment. This case study explores the dynamic human-forest relationship that has evolved and persisted for more than 3000 years, revealing the resilience of both people and forests.

Keywords: Community forestry, *ejido*, forest cover, Maya Forest, Yucatan

7.1 Introduction

Despite the multitude of pressures at distinct levels to convert forested land to other uses, the Mexican model of community forestry seems to be a case where greater community control over forest management and related benefits have enhanced both forest conservation and local livelihoods (Klooster and Ambinakudige 2005). We examine the conditions under which community-based forest management operates in the tropical state of Quintana Roo, which occupies 50 212 km² of the eastern half of Mexico's Yucatan Peninsula (Figure II 7.1). Although centered between the mid-1980s and 2012, our analysis necessarily begins several millennia before to better understand the historical conditions that shaped modern-day community forestry in Quintana Roo.

We present an overview and analysis of the intertwined socio-cultural, political, economic, and ecological dynamics that have enabled and challenged sustainable forest management (SFM) in the region.

Diverse sources were used for the study, including a myriad of bibliographic resources and the experience of the authors working in the region over different periods of time. This case study is highly relevant due to the dynamic human-forest relationship that has evolved and persisted for more than 3000 years, demonstrating the resilience of both people and forests. There are very few cases globally with such substantiated data over such a long period of time. Lessons learned should inform readers how community forest management can contribute to the overall goal of forest-based sustainable development and conservation in the tropics.

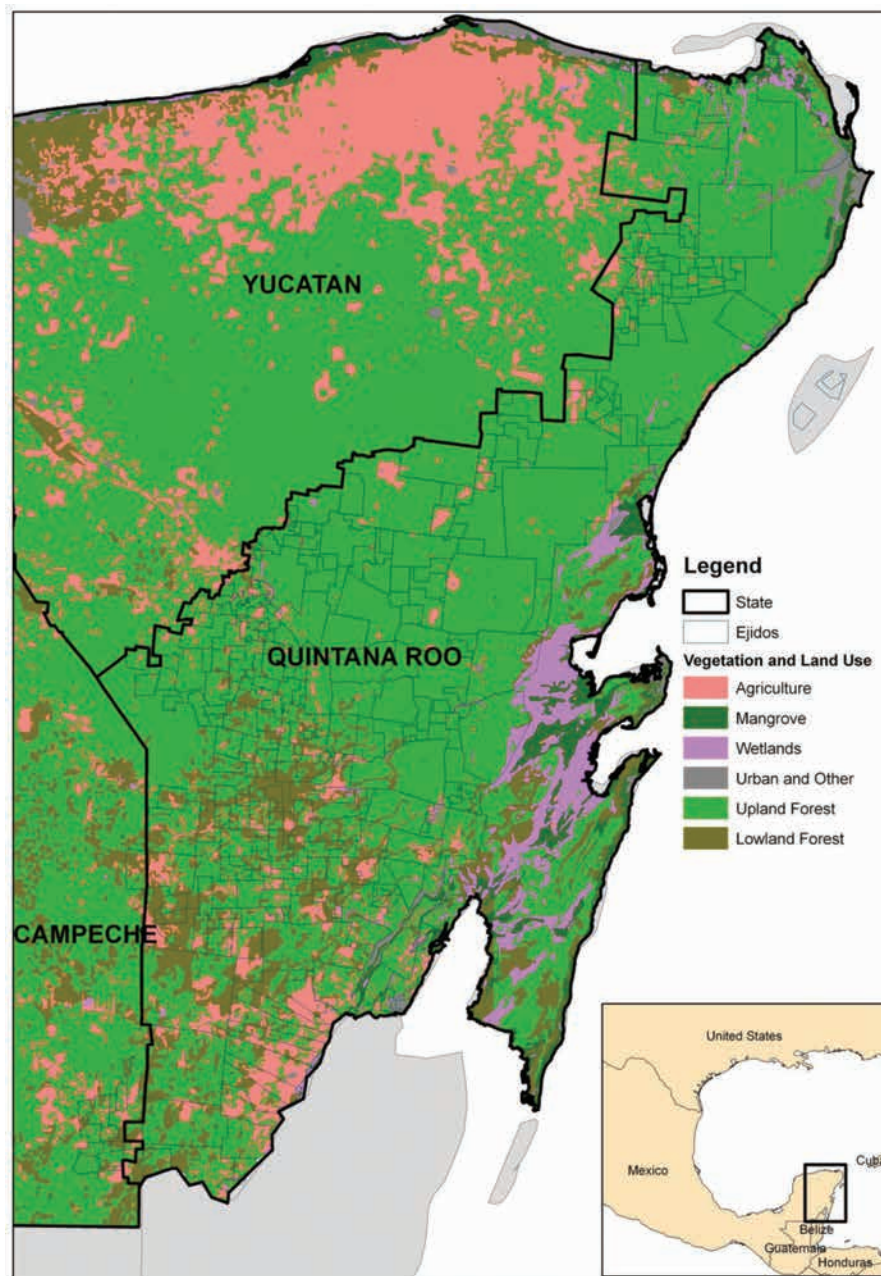


Figure II 7.1 Land use/land cover map of the state of Quintana Roo, Mexico. Three shades of green highlight that the state retains 91% forest cover. © E. Ellis

7.2 People and forests of Quintana Roo

The tropical forests of Quintana Roo are intimately linked with ancient cultures as well as modern-day forest-based communities. Archeological, paleolimnological, and written historical evidence coupled with present-day observations provide insights into a human-nature relationship that has alternately flourished, collapsed, adapted, and been reshuffled many times over (Figure II 7.2). Today's forest reflects

approximately 3000 years of Maya agroforestry, resource extraction, fire, drought, and hurricanes (Gómez-Pompa and Klaus 1992, Gómez-Pompa and Bainbridge 1995).

Ancient Mayas became established on the Yucatan Peninsula between 2000 BC and AD 250, reaching their greatest cultural heights between AD 600 and 800 (Coe 2005). Forests were cleared to construct architecturally magnificent and densely populated cities and to cultivate food crops and trees to support them. Shifting slash-and-burn agriculture was



Figure II 7.2 The pinnacle of an architectural ruin in the Mayan archeological site of Cobá in Quintana Roo peeks out from a blanket of forest. © K. Kainer

the norm and maize the primary crop in a very diverse production system (Hernández 1985) known as *milpa*. The Mayas planted seeds with dibble sticks in ash-laden holes upon the great limestone shelf that forms the bedrock on which extremely shallow soils accumulate (Coe 2005). After abandonment of the milpa fields, natural succession ensued and the Mayas enriched these areas, selecting and tending desirable species while simultaneously eliminating unwanted competition—the present floristic diversity of the region reflects their ancient agroforestry systems (Edwards 1986, Gómez-Pompa et al. 1987).

In the Maya northern area, which encompasses all of modern-day Quintana Roo, the Mayas excavated and built thousands of underground cisterns (Coe 2005) to compensate for the extreme scarcity of surface water, complementing the numerous sinkholes formed by natural collapse of underground limestone caves. Between AD 800 and 1000, however, the driest interval of the middle- to late-Holocene epoch fell upon the region (Hodell et al. 1995), overlapping with the collapse of the Maya civilisation. This sustained drought coupled with coincident annual crop failure and years of environmental degradation (Coe 2005) created conditions that could no longer support extremely high population densities. Cities were abandoned, but in this northern area, the Mayas

continued, albeit in much lower population densities, such that 500 years later, when the first Spaniard, Hernández de Córdoba stepped foot on the peninsula in 1517, he was swiftly killed by Maya warriors (Coe 2005), descendants of this brilliant civilisation.

Compared to other conquered regions in Latin America, early colonial impacts on forest and peoples of the Yucatan Peninsula were distinctly shaped by a dearth of natural resources of value to the Spaniards (DiGiano 2011). The lack of precious metals, scarce surface water, and shallow karstic soils occasioned limited commercial interest. Coincidentally, the traditional Maya agricultural and land-tenure systems did not suffer wholesale disruption. In the late 1700s, however, a fundamental shift towards a more intensive hacienda mode of production, particularly for henequen (*Agave fourcroydes*), ensued in the northwest part of the peninsula; the Maya of the southeast continued to practice subsistence agriculture (DiGiano 2011). Here, nonetheless, forests were being exploited for export products from dyewood (*Haematoxylon campechianum*), mahogany (*Swietenia macrophylla*), and later *chicle*, a resin extracted from *Manilkara zapota* used to produce chewing gum. These externally valued forest assets became increasingly important to the Mayas as they struggled to gain access to land and resources during the ex-

tended and bloody Caste War (1847–1901) fought against the creole elite of the peninsular northwest (Reed 2001). These forest resources were exchanged with the British for cash and weapons, and the entire forested region of Quintana Roo was converted to a center of jungle warfare and a Maya refuge (Reed 2001). By the time the rebel headquarters were captured by Mexican forces in 1901, the war had reduced the regional population from 85 000 to 10 000 (Konrad 1991). Quintana Roo became a Mexican territory that same year and soon thereafter foreign-owned forest concessions were granted (Kiernan and Freese 1997) to promote territorial control, regulate forest extraction, and sever relations between the Mayas and British Honduras (DiGiano 2011).

A land-tenure framework favourable to common property management arose from the 1910–1917 Mexican revolution (Bray et al. 2005), enabling the first communal land grants or *ejidos* to be established in the territory of Quintana Roo in the 1930s and 1940s; these were also recognised when statehood was attained in 1974. It was not until passage of the 1986 Forest Law, however, that communities across Mexico garnered legal rights to the trees on their lands. This precipitated a shift from timber harvests via industrial concessions to community-based forest management. In Quintana Roo, in particular, this shift was accompanied by an innovative joint Mexican-international program (Plan Piloto Forestal, or Forestry Pilot Plan) “to empower ejido residents and increase the economic returns they receive from the forest” (Kiernan and Freese 1997, p. 98).

Vis-a-vis these reforms, Mexico stands out in Latin America and the world in that the state effectively gave collective land entitlements to thousands of rural communities, resulting in more than 60% of Mexico’s forested land presently being under communal ownership (Bray et al. 2003a, FAO 2010). In Quintana Roo, this figure is slightly higher – at 67%, based on current figures of forest cover (INEGI 2010a) and land-tenure distribution (INEGI 2006). In these rural regions, the 2010 census reveals that population densities are rather low (~5 inhabitants/km²) (INEGI 2010b), yet in an adjacent forest region in the state of Campeche, with half that population density, deforestation is much greater (Ellis and Porter-Bolland 2008).

With approximately 75% of the total state population of 1.32 million concentrated in coastal and tourist-related urban areas such as Cancun (628 306), Playa del Carmen (149 923), the island of Cozumel (77 236), and the state capital Chetumal (151 243) (INEGI 2010b), population pressures in rural Quintana Roo are limited. Yet when compared to the estimated 8 to 10 million Mayas who occupied the lowlands (Mexico’s Yucatan Peninsula, parts of Tabasco and Chiapas states; the Peten of Guatemala; and Belize) in about AD 750 (Coe 2005), it becomes

clear that more than population pressures explain the brand of community-based forest management and relatively successful forest conservation that now characterizes Quintana Roo.

7.3 Natural resource base

Quintana Roo’s natural ecosystems include coral reefs, coastal dunes and marshes, mangroves, freshwater wetlands, and seasonal tropical forests (Flores and Espejel 1994). Topographical variation across the state is minimal. For most areas, changes in elevations rarely exceed 15 m, although the far southwestern corner of the state rises to 310 m AMSL (Vester and Navarro-Martínez 2005). The climate is hot and subhumid, with a mean annual temperature of 25°C and mean annual precipitation of 1200 mm (Gutierrez-Granados et al. 2011). Forest types vary according to soil and topography: medium-stature forest (15 to 25 m) dominates upland, well-drained rendzinas, while lower-stature forests occur on seasonally inundated depressions with poorly drained gleysols and vertisols (Lawrence et al. 2004, Toledo-Aceves et al. 2009). A pronounced dry season (< 60 mm of rain per month) from November to April, followed by 100 to 200 mm of monthly rainfall in the subsequent months, shapes these seasonal forests (Gutierrez-Granados et al. 2011), also referred to as dry, semi-deciduous or semi-evergreen forests. In effect, the forest landscape of Quintana Roo can be described as a mosaic of lowland and upland forest types of different successional stages (Flores and Espejel 1994, Ellis and Porter-Bolland 2008).

Forest structure of the *Selva Maya*, a Spanish term that purposefully links the tropical forest with Maya heritage, consists of three to four tree and shrub layers, 3 to 25 m in height (Snook et al. 2005, Hernández-Stefanoni et al. 2006). Common tree species include *Brosimum alicastrum*, *Manilkara zapota*, *Talisia olivaeformis*, *Bursera simaruba*, *Lonchocarpus longistylus*, *Nectandra salicifolia*, *Psidium sartorium*, *Guetarda combsii*, *Vitex gaumeri*, and *Caesalpinia gaumeri* (Hernández-Stefanoni et al. 2006, Gutierrez-Granados et al. 2011). *Hemotoxylon campechianum*, *Metopium brownei*, and *Pachira acuatica* are frequent in lowland flooded forest, although both upland and lowland forests share many of the same species (Flores and Espejel 1994, Pérez-Salicrup 2004). There are more than 100 tree species per hectare in these forests, of which about 75% are evergreen and the rest deciduous (Snook et al. 2005, Hernández-Stefanoni et al. 2006).

7.4 Policies, institutions, and governance

7.4.1 Agrarian reform and community-based forest management

Three important policy and institutional factors have shaped community forestry over the years in Quintana Roo: 1) agrarian reform, 2) forest policy and related institutions, and more recently, 3) conservation and sustainable development initiatives. Agrarian reform and land distribution to communities arrived in Quintana Roo when ejidos were first established in concert with the promotion of cooperatives for chicle production (Forero and Redclift 2006). Calculating that 420 ha of forest per chicle producer was needed to maintain production, 10 ejidos, averaging 35 000 ha each, were granted to mostly Maya populations between 1935 and 1942 (Barsimantov et al. 2011). Much of the land transferred was remote and often heavily forested, which in turn gave communities access to and use of large forested territories. From the 1960s to early 1970s, much smaller ejidos, averaging only 20 ha per farmer, were distributed, mainly to stimulate agricultural production and also, given that Quintana Roo received statehood in 1974, as a colonisation mechanism (Bray et al. 2004, Ellis and Beck 2004).

Complementing communal ownership, another major influence of agrarian reform was installation of an ejido governance system that still operates today, with some modifications. Decisions on commonly owned land and natural resource assets, as well as other community issues, are voted upon by a General Assembly composed of *ejidatarios*, who are usually male heads of household (Antinori and Bray 2005). Further, each community is represented by an elected *comisariado ejidal* (ejido commission), responsible for administrative management of the ejido, including its resources, and carrying out decisions of the General Assembly. The commission consists of a president, a secretary and a treasurer, who each hold three-year terms. In addition, it includes a *consejo de vigilancia* (oversight council), which polices and enforces community regulations and serves as a check-and-balance and auditing system (Bray et al. 2006). This ejido governance system was modeled after colonial and indigenous systems in rural Mexico (Antinori and Bray 2005) and is credited with facilitating the community forest management movement and creation of community forest enterprises in Mexico (Bray et al. 2006).

7.4.2 Social movements and policy reforms related to timber rights

Still, well up to the mid-1980s, communities did not have complete control of their forest resources. The government had the right to superimpose logging concessions on ejidos, with communities receiving little or no benefit from concessions on their lands. In 1958, the parastatal company Maderas Industriales de Quintana Roo (MIQRO) gained control of about 550 000 ha of forest concessions for a 25-year period and began unsustainable logging, profiting from about 400 000 m³ of valuable timber (mostly mahogany and Spanish cedar, *Cedrela odorata*) (Taylor and Zabin 2000, Taylor 2001). In the mid-1960s, however, grassroots mobilisations sprung up across Mexico demanding communal rights to manage and profit from commercial timber on ejido land. In Quintana Roo, the ejidos of Tres Garantías and Noh-Bec organised against MIQRO (Taylor and Zabin, 2000, Taylor 2001, Bray et al. 2003a). Academic activists and even government reformists supported these grassroots movements – all instrumental in the transition from concession logging to community-based forest management (Bray et al. 2003a, Merino-Pérez 2004). The federal government responded with the 1986 Forest Law, which ended all private concessions, required more environmentally sound forest management and harvesting, and allowed communities or community organisations direct control of management and marketing of forest timber resources on ejido land (Taylor 2001, Bray et al. 2006).

Termination of the MIQRO concession and the beginning of the Forestry Pilot Plan in 1982 marked a new era of community-based management with timber rights (Figure II 7.3). The pilot plan was a joint venture of the Mexican government and GTZ, the German cooperation agency, and was also widely supported by state government and the governor of Quintana Roo (Merino-Pérez 2004) to empower and benefit local communities. It provided forestry technical teams and services that worked completely autonomously with communities, supporting over 40 forest ejidos and delimiting about 500 000 ha as Permanent Forest Areas specifically for forestry activities (Taylor and Zabin 2000, Taylor 2001). These areas are considered a unique example in Latin America of communities controlling land-use change and effectively slowing deforestation in the region (Bray et al. 2003a, Bray et al. 2004). By 1991, five ejidos in Quintana Roo became the first tropical forests to be certified by the Forest Stewardship Council (FSC) (Markopoulos 1999), with some also obtaining chain-of-custody certification (Macqueen et al. 2008).

Although the creation of intermediate-level forestry organisations was not part of the original Forestry Pilot Plan, the need to effectively harvest, process,



Figure II 7.3 Mayan and mestizo communities in Quintana Roo, Mexico, own timber rights on their lands and are highly engaged in forest management and timber harvests. © E. Ellis

and market timber and compete against MIQRO, still present as a buyer, spawned the creation of forest civil societies, such as the Society of Forest Ejido Producers of Quintana Roo (SPFEQR) in the south and the Organization of Forest Ejido Producers of the Maya Zone (OEPFZM) in the central part of the state (Taylor and Zabin 2000, Taylor 2001). These forest civil societies helped empower ejidos and helped them gain political credibility, blocking a state government attempt in 1987 to obligate ejidos to sell timber to MIQRO, and more importantly, laying an institutional foundation to allow continuity of community-based forest management and their corresponding community enterprises beyond the pilot plan (Taylor and Zabin, 2000, Taylor 2001). Though the Forestry Pilot Plan ended in 1998, its legacy remains in the approximately 729 592 ha of Permanent Forest Areas and the continued technical support available in Quintana Roo (Snook 2005). Here, as elsewhere in Mexico, the original civil societies allied ejidos and provided technical support personnel who fundamentally facilitated community access to government forestry programs and compliance with the many and complicated forest-management legal requirements. Civil societies have slowly transformed from a focus mainly on timber extraction to also assist communities in developing strategies for multiple-forest use (product diversification). Increasingly, the technical forestry aspects of ejido support have been filled by the some 37 private individuals and eight firms now registered in Quintana Roo (Registro Forestal Nacional 2012), who may or may not be affiliated with civil societies. These technical consultants support themselves largely through government programs that are channelled through ejidos for this purpose as well as by volume-based commissions per ejido and through obtaining external funding to carry out community projects – akin to fundraising strategies adopted by NGOs. These institutional arrangements that emerged from those years of policy reforms and forest-based development initiatives helped shape a socio-economic landscape apt for the community forest management observed today in Quintana Roo.

7.5 Livelihoods, commodity chains, and continued adaptations

Forests, almost exclusively community-owned, remain the cornerstone of rural Quintana Roo despite the increasing importance of wage labour and migration to coastal tourism developments (Murray 2007). Cultural, economic, and environmental reliance on forests is substantial although highly variable among communities (DiGiano and Racelis 2012). Also variable is the degree to which any particular community is engaged with timber and/or non-timber forest products (NTFPs), including environmental service payments (PES) and ecotourism.

7.5.1 Local variability of forest-based revenues, benefit distribution, and employment

Wide varieties of timber and NTFPs are managed and harvested for commercial and subsistence purposes from the Selva Maya. Direct timber revenues in the state were USD 6.7 million in 2007, but total forest-related revenue would be considerably higher if other forest products and services were considered in this number (González Canto 2007). Mahogany and Spanish cedar continue to be the most prized timber species, and *Manilkara zapota* the most important non-timber species for its chicle (Snook 1998, Negreros-Castillo et al. 2003). Other commercial timber species include softwoods such as pa'sak (*Simarouba glauca*), jobo (*Spondias mombin*), chakaj (*Bursera simaruba*), amapola (*Pseudobombax ellipticum*), sak chakaj (*Dendropanax arboreus*), and hardwoods such as tzalam (*Lysiloma latisiliquum*), chechem (*Metopium brownei*), ciricote (*Cordia dodecandra*), machiche (*Lonchocarpus castilloi*), and granadillo (*Platymiscium yucatanum*) (Gobierno del Estado de Quintana Roo 2005).

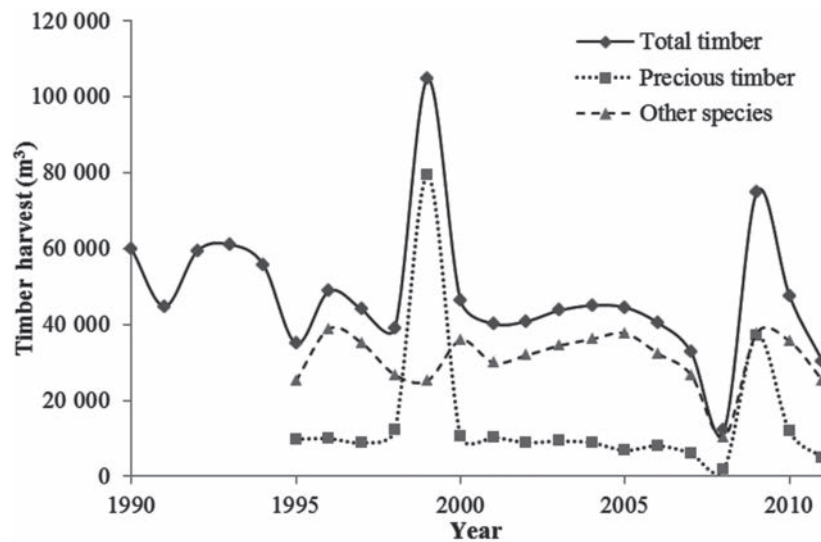


Figure II 7.4 Timber harvests in Quintana Roo from 1990 to 2011. Data from 1990 to 1994 was obtained from Instituto Tecnológico de México 2004; data from 1995 to 2011, from Sistema Nacional de Información Forestal 2013.

The number of ejidos involved in legal harvest of forest products has fluctuated over the years, varying from 61 in 1995 to 80 in 2006 (SEMARNAT 2006) and 46 in 2010 (SEMARNAT 2010). Annual timber production also has varied, with annual minimum and maximum harvests associated with particular events such as hurricanes (e.g. Hurricane Dean in 2007 caused a spike in 2008) (Figure II 7.4). Overall precious timber production follows a decreasing trend (Figure II 7.4), perhaps associated with silvicultural aspects of mahogany management (Box II 7.1). While harvested volumes of non-precious timber species have varied less, over time, targeted species and products derived from them have changed according to market demand. Pole-sized trees exemplify these changes as product demand from this size class has shifted from railroad ties to construction materials. Known simply as polewood, this most recent commercial product is derived from more than 30 hardwood species and is used mainly for construction material demanded by the tourism industry (Racelis and Barsimantov 2008) (see Box II 7.2, Figure II 7.5). Charcoal production is particularly important in secondary forests close to the urban markets in northern Quintana Roo (V. Santos, OEPFZM, pers. comm). Thatch from *Sabal yapa* and *Thrinax radiata* palms are also harvested for commercial and subsistence purposes (Pulido and Caballero 2006, Calvo-Irabién et al. 2009). Moreover, ornamental plants (palms and orchids) and game are commonly extracted NTFPs. Fallow fields as well as Maya home gardens are also valuable sources of tree-based products used for fuel, food, medicine, and construction materials (De Clerck and Negreros-Castillo 2000), providing a diverse set of products harvested from

heterogeneous forest landscapes (Rico-Gray et al. 1991, Toledo et al. 2008). Beekeeping, the second largest economic activity in the state, heavily depends on flowering plants in this forested landscape (Guemes and Villanueva 2002, Villanueva 2002). Finally, local economic benefits derived from commercial forestry vary widely among ejidos, partially driven by native abundance of valuable hardwoods. Bray et al. (2007) also have found that timber versus non-timber producing communities generally tended to have greater incomes per person and were above the poverty line; however, among these timber-producing ejidos, incomes were still low when associated with Maya communities and those without sawmills. A diverse suite of factors may cause variation in timber production and, very importantly, ejido engagement and disengagement in forest management and associated derived benefits. A detailed study exploring these factors would help inform effective conservation and development policies.

The forest regrowth phase of traditional slash-and-burn agriculture, which continues to be central to the living Maya culture, maintains and/or renews soil fertility and reduces agricultural pests and weeds (De Frece and Poole 2008, Bruun et al. 2009, Padoch and Pinedo-Vasquez 2010). This provision of ecosystem services at the local level (soil enrichment, watershed protection) is now interacting with external valuation of ecosystem services via PES (Elizondo and Lopez Merlin 2009). Increasingly, since 2005, both timber-focused and non-timber ejidos have been setting aside additional forest land under PES programs sponsored by the National Forest Commission (CONAFOR, Spanish acronym), both for hydrological and biodiversity purposes (CONAFOR 2009,

Box II 7.1 Sustaining the forests where mahogany grows: Silvicultural and other technical challenges

In 1953, after decades of unregulated precious-timber extraction, the large parastatal forest company MIQRO implemented the first harvesting system in Quintana Roo (Flachsenberg and Galletti 1998). Intended to allow repeated harvests over time, MIQRO constructed a system of logging roads and established a selective polycyclic system based on forest inventories, minimum cutting diameters, and a distinct focus on mahogany (Flachsenberg and Galletti 1998). Mahogany was managed on a 75-year rotation and 25-year cutting cycle to produce veneer, with minimum cutting diameters of 60 cm dbh originally, which then fell to 55 cm dbh (Snook 1993). Regeneration was not considered.

Sustained harvest pressures over decades have widely depleted mahogany stocks across Quintana Roo and elsewhere in the neotropics. Although few ejidos still count on this species as a major income source, its extremely high commercial value continues to drive most forest management plans and silvicultural research. Still, information gaps, harvest pressure, and even public policies and opinion continue to impede application of regionally appropriate, scientifically sound silvicultural systems for this species, as detailed below.

Regeneration. Mahogany is a shade-intolerant species that regenerates almost solely in very large ($\geq 5,000 \text{ m}^2$) gaps (Dickinson and Whigham 1999, Negreros-Castillo and Mize 1993, Snook and Negreros-Castillo 2004, Toledo-Aceves et al. 2009). Current harvest intensities considering all species are low (1–3 trees ≥ 35 dbh ha⁻¹), and the full light conditions that mahogany requires for regeneration are rarely attained (Toledo-Aceves et al. 2009). Artificial gaps, either created by machine or fire, have been shown to provide the necessary conditions to successfully regenerate mahogany (Snook and Negreros-Castillo 2004). Interestingly, traditional slash-and-burn agriculture historically creates these ideal conditions: small clear-cuts with full sunlight and minimal woody competition (Negreros-Castillo et al. 2003). Notwithstanding, the segregation of community lands into production forest and agricultural areas that accompanied the 1986 Forest Law eliminated this highly effective method for mahogany regeneration.

Minimum cutting diameter. Aggravating inadequate site conditions, the current 55 cm dbh minimum cutting diameter for mahogany contrasts with the ≥ 75 cm diameter at which mahogany reaches its maximum seed-producing potential (Camara-Cabrales 2005, Camara-Cabrales and Kelty 2009). Although rarely successful, some ejido communities conduct enrichment plantings to compensate for persistent regeneration failure.

Rotation length and cutting cycles. The continued 75-year rotation (in 25-year cutting cycles) assumes an average diameter growth of 0.73 cm/yr opposed to the comparatively low growth rates of 0.22–0.40 cm/yr observed for Quintana Roo (e.g. Mize and Negreros-Castillo 2007, Snook 2005, Vester and Navarro-

Martínez 2007). In response, scientists propose either to extend cutting cycles, apply silvicultural practices to enhance individual tree growth, or a mix of both (Grogan et al. 2011). The estimate of up to a 250-year rotation needed to sustain mahogany under typically low-growth conditions and current harvest regimes is considered to be economically unfeasible.

Tree mortality. This vital rate and important production variable has received minimal attention. While some ejidos have been trained in reduced-impact logging techniques to minimise residual tree mortality, management plans do not make explicit assumptions of tree mortality rates, let alone mortality related to extreme events such as hurricanes and wildfires. After such events, salvage harvests have been the norm. Hurricane Dean in 2007 clearly highlighted the need to develop strategies for coping with extreme events before a hurricane hits.

Current thoughts on mahogany silviculture include the opening of 0.25 to 1 ha clear-cuts as one feasible regeneration method. Some researchers and technicians advocate re-establishing slash-and-burn agriculture in production forest areas as a win-win strategy to generate agricultural products while also promoting regeneration of key commercial tree species. A second approach that is being implemented in one community consists of machine-made clear-cuts around individual focal seed trees. While evidence indicates that small clear-cuts coupled with enrichment plantings do improve mahogany's productive potential, several factors limit widespread acceptance of this low intensity, even-aged silvicultural system (Kelty et al. 2011): biodiversity conservation concerns, stakeholder perceptions of clear-cuts as synonymous with deforestation, and the increased interest in reducing carbon emissions (e.g. burns) from forest operations. Additionally, even-aged silviculture poses market, financial, and logistic challenges. Currently, timber is harvested on demand. In contrast clear-cutting implies a harvest of all above-ground woody material regardless of its immediate and future marketability.

The emergence of new markets for species traditionally regarded as lesser known has reduced the economic centrality of mahogany. For example, diverse species were communally harvested for railroad ties over a 20-year period until the national train system was privatised in the mid- to late-1990s. Currently, the different resource conditions and the weight that each community gives to different species groups are resulting in an incipient differentiation of silvicultural systems in Quintana Roo. The clearest example of this ongoing differentiation is represented by the charcoal-producing ejidos in northern Quintana Roo, where secondary forests are intensively managed via a coppicing system. While further research on silvicultural systems is needed, in the end, forest management practices will be shaped by markets and societal choices.

Box II 7.2 Tourism fuels polewood management in the Maya forest

As in many other tropical regions, thatched huts and other rustic buildings are an essential part of the natural paradise image promoted by the tourist industry that flourishes on the Caribbean coast of Mexico (Haldeman Davis 2007, Quiroz-Rothe 2010). Polewood, the stems of small diameter (5 to 35 cm dbh) hardwood trees, is one of the indispensable materials needed to build these structures (Figure 7.5). Since the early 2000s, many local communities have responded to this new demand by including polewood in their official forest management plans (V. Santos and R. Ledesma, OEPFZM, pers. comm.). By 2007, polewood was considered one of the most important forest products in the state: 11 886 m³ were harvested (23% of total wood volume), representing at least USD 1.08 million in direct revenue to approximately 40 communities of the central southern region of Quintana Roo (González Canto 2007). This product has become particularly important for small forest communities with limited volumes of merchantable sawtimber (Racelis 2009).

The structural use of polewood for housing is a long-standing tradition in lowland Mayan communities (Wauchope 1938, Villers et al. 1981, Rico-Gray 1991). More than 40 tree species have been used and 14 structural categories described (Wauchope 1938, Villers et al. 1981, Rico-Gray 1991, Racelis 2009). Expanding this repertoire, tourism-related buildings are far more variable in terms of function, size, species used, budget, and architectural influences. Indeed, polewood is used in a growing list of structures with little precedent in the Maya tradition, ranging from trash bins to large theaters, and these commercial ventures represent an exponential increase in harvested polewood volumes. Several small-statured tree species are harvested solely

as polewood, while some larger species are harvested for both polewood and sawtimber.

Polewood can be legally extracted only in the designated Permanent Forest Areas where sawtimber is also harvested. In reality, some communities harvest smaller polewood classes (< 15 cm dbh) from secondary forest fallows in zoned agricultural areas, representing just one example of the various polewood management strategies adopted by communities. Differences in land area, forest resources, harvest technology, internal land-tenure arrangements (see Box 7.1), benefit-sharing, and market chain structures also vary greatly among communities. While early evidence suggests differential harvest impacts on species populations at the local level (Racelis 2009), formal assessment is still needed. Complicating matters, from the mid-1950s to the late 1990s, some polewood species were intensively harvested for railroad ties (Shoch 1999), resulting in cumulative historical impacts that are difficult to assess.

In periods of economic crisis and limited new construction, a considerable proportion of polewood demand is for building maintenance, given that naturally decaying polewood elements need replacement every 10 to 20 years. Additionally, although most polewood production is marketed in-state, some ejidos have important commercial relations with buyers on the Pacific coast, more than 2000 km away. All in all, polewood is likely to remain one of the most important forest products in Quintana Roo, serving as an evolving experiment to test the management and marketing of lesser-known species, the oft-pursued forest product diversification hypothesized to contribute to sustainable forest management.

McAfee and Shapiro 2010, Shapiro 2010) (Figure II 7.6). Some ejidos, such as Yoactun, currently receive more income from PES than from timber sales (V. Santos, OEPFZM, pers. comm.). Communities such as Naranjal Poniente have zoned out forest areas as voluntary conservation areas (Bray et al. 2006), an increasing trend observed in ejidos (Elizondo and López Merlin 2009). As harvest volumes of mahogany decline, some ejidos are moving towards exploiting other valuable hardwoods, including polewood (see Box II 7.2). Still others, such as Betania and Noh-Bec, are involved in multiple-use forest management with areas set aside for ecotourism and biodiversity conservation, in addition to forest for timber production. These strategies of multiple forest use, land-use zoning, and diversification of forest income sources show promise in the region as local community adaptations respond to national

and global forest conservation initiatives.

There is no industrial forestry in the region in the sense of large for-profit timber corporations (Herbonh 2006). Local communities have significant land rights and the final say in forest management; however, private participation is present. In many cases, local companies and individuals conduct logging operations, operate sawmills, and commercialise forest products; in others, ejidos possess an integrated vertical structure, participating in all the aspects of forest management from planning and harvesting to commercialisation of processed products (Arguelles and Garcia 2008). For these community forest enterprises, continued challenges include increased enterprise transparency, greater reinvestment of forest revenues in the enterprise, and dispelling the notion that community forest enterprises are safety nets (Wilshusen 2009).



Figure II 7.5 Polewood (of various species and dimensions) is readied for sale, harvested from the ejido of Dzula in the state of Quintana Roo, Mexico. © K. Kainer



Figure II 7.6 The ejido of Betania in Quintana Roo signals its participation in Mexico's ProArbol Program, accepting payment for environmental services by dedicating 1632 ha to hydrological protection. The sign also declares that no hunting, faunal and floral extraction (including logging), or trash dumping is permitted. © E. Ellis

The type and structure of ejido governance and entrepreneurial organisation partially determine how revenues from forest products are shared. Agrarian reforms in the first half of the 20th century set the stage so that an elected ejidal commission administers communal forest enterprises. Noh-Bec, an ejido with a large centralised community forest enterprise, divides revenues from mahogany, *Manilkara zapota* timber, and polewood between ejidatarios, while revenues from other timber species are designated for communal works that benefit not only ejido members but also the larger population residing in the ejido (G. Martínez-Ferral per. comm.). In some communities, however, permitted by a 1992 reform of Constitutional Article 27 (see Box II 7.3), internal ejidatario producer subgroups have emerged that operate as independent commercial entities separate from the elected ejidal commission (Taylor and Zabin 2000). In the economically important forestry ejidos of Petcacab and X-Hazil, this division of the ejido community forest enterprise has led to multiple (10 or more) work groups (Taylor and Zabin 2000, Taylor 2001, Antinori and Bray 2005, Bray et al. 2006). Work-group formation may be an attempt to eliminate problems with corruption and inefficiency within the ejido governance system. Wilshusen (2009), however, demonstrates how the formation of work groups in Quintana Roo represents a downside to social capital, a term often used positively to describe social networks based in trust and reciprocity. He describes a scenario in which elite ejido member work groups flourish and obtain greater rewards from forest management due to better networking, capital, and influence in the community. Thus, while individual ejidatarios benefit from these work groups, forest profits are no longer invested in community assets such as schools or even sawmills or the forest itself. Additionally, unit production costs increase with these numerous small groups (Taylor and Zabin 2000, Taylor 2001). Across Quintana Roo ejidos, distribution of polewood revenues is highly dynamic and variable but does not seem to be used for communal works. In Reforma Agraria, a de facto privatised and non-Maya ejido, each ejidatario harvests, processes, and markets products, mostly polewood, from his/her own plot of land with significant investments in agroforestry systems and plantations for future wood harvests.

Employment creation also is a significant local benefit from forest activities in Quintana Roo, providing unique opportunities for jobs in home villages, particularly valued by landless young men. The quantity and types of forestry-related employment at the local level varies with the degree of vertical integration. In Noh-Bec, forestry is the central livelihood and forest management and enterprise activities are credited with creation of 90 permanent and 100 temporary jobs (Arguelles and Garcia 2008).

Because this particular ejido had also invested heavily in local capacity-building and collective forest governance, system shocks such as Hurricane Dean were met with quick internal assessments of forest damage and multidirectional lines of communication with important external actors (DiGiano and Race-lis 2012). These authors have concluded that strong internal institutions coupled with a well-developed network of partners at higher scales impart increased robustness and enhanced adaptive capacity. In other communities, permanent forestry positions are non-existent and temporary labour opportunities are often limited to timber cruising and NTFP and polewood harvesting. Nonetheless, under some arrangements, a skilled polewood harvester can make up to five times the local daily wage for agricultural activities. Participation of local labour in specialised activities such as tree felling and hauling, wood processing, and management depends on development of local enterprises. While women are not commonly involved in commercial forestry, they do participate in paid activities like polewood debarking in some ejidos. Moreover, wood-based handicraft production is an activity frequently led by women.

7.5.2 Commodity chains and markets: opportunities and challenges

Commodity chains vary greatly among forest products. Chicle production in Quintana Roo has a single commercialisation channel with fixed prices. The Consorcio Chiclero, an association of 56 cooperatives, consolidates chicle production from communities in Quintana Roo and Campeche and coordinates the logistics, trade, and finances for gum manufacture and export (Forero and Redclift 2007, CHICZA 2012). In contrast, polewood value chains are more variable (Racelis 2009). In some cases, the same ejido member who harvests polewood also builds and sells huts as a finished product. In most cases, however, polewood passes through various hands, possibly including a harvester, foreman, local middleman, wholesalers, and contractors (see Box II 7.2) – a complex value chain mimicked by palm leaves for thatching (e.g. Caballero et al. 2004). Commercial charcoal production has existed for decades in northern Quintana Roo, although management has only recently been legalised (Mex 2011). Timber market chains are more complex and vary by species, quality, processing, certification status, and the particular contacts that the ejido or seller may have. For example, mahogany from Noh-Bec may reach regional, national, and international markets (mainly in United States) requiring high-quality standards, while lower-quality pieces are used for local

Box II 7.3 The push to privatise: Mexico's 1992 reforms and impacts on forest ejidos

Control and access to land and forest resources have been central to the history of the Selva Maya and have played a critical role in shaping land use. While the original agrarian law of 1917 established firm limits to privatisation of communal property, the 1992 reform of Article 27 explicitly allowed ejidos to divide and parcelise communal agricultural land, which could then be sold, purchased, or rented (Taylor and Zabin 2000, Bray et al. 2006). Land under forest cover was theoretically exempt from parcelisation and sale, but no measures were in place to prevent deforestation of that land and then subsequent privatisation (Taylor and Zabin 2000, Taylor 2001, Bray et al. 2006).

While many speculated that the 1992 reforms would lead to widespread privatisation, less than 10% of ejidos nationwide have opted for formal privatisation (RAN 2007). In Quintana Roo, the vast majority of ejidos (98%) chose only to certify common-use lands (whereby individual ejidatarios receive certificates to their share of these lands) and only three ejidos opted for formal privatisation of common-use lands (RAN 2007). Despite the tepid response of the formal push to privatise, research has demonstrated how ejidos have selectively adopted some aspects of privatisation, without undergoing the formal process of certifying and titling ejido lands (Nuitjen 2003, Haenn 2006, Perramond 2008, Barsimantov et al. 2010, DiGiano 2011). To circumvent an important clause that prohibited the division and alienation of commonly held forest lands (Agrarian Reform, Article 59), some ejidos opted to informally privatise these lands. As a result, ejidos legally recognised as commonly held may, in fact, have diverse

configurations of individual and commonly held rights and are neither wholly individual nor communal but somewhere on a continuum from private to communal (Barsimantov et al. 2010).

DiGiano et al. (in press) studied eight ejidos in the Selva Maya to understand how different land-tenure configurations impacted land use and forest conservation, using institutional and land cover change analyses. Ejidos that maintained collective land rights experienced less forest cover change than ejidos that underwent informal parcelisation. Lower rates of deforestation were linked to the predominance of smaller landholdings (a lower average of hectares per ejidatario) and land-use activities oriented towards traditional *milpa* agriculture or forest management. Conversely, in informally privatised ejidos, members tended to have larger landholdings, more land under cultivation, and livelihood activities that were capital intensive and characterised by long-term payoffs.

Privatisation, formal and informal, was linked to increased conversion of forests to other land uses, while at the same time providing opportunities for greater individual investments in land and new livelihood activities. Commonly held ejidos were more effective at conserving forested areas when forests provided economic benefits to ejido members via community forest management and/or payments for environmental services. In sum, Mexico's reforms did not have a homogenous impact on forest ejidos but rather facilitated a complex continuum of individual and communal rights with distinct land-use and land-cover change outcomes.

carpentry and beehive construction (Arguelles and Garcia 2008). Katalox (*Swartzia cubensis*) is sold in a small European niche market (Arguelles and Garcia 2008), and particular softwood species (e.g. *Dendropanax arboreus*) are sold for production of matches, tongue depressors, and toothpicks (Forster et al. 2003). Tzalam is increasingly sought after and for many ejidos currently provides their main source of forest revenue. Other highly valuable species have local and international niche markets, such as holywood (*Guaicum sanctum*), granadillo, ciricote, and machiche, which feed a growing flooring market. On the other hand, some species considered internationally as lesser-known species have local markets, such as kaniste (*Pouteria campechiana*).

Diverse efforts have been made to upgrade the market position of local producers. One example is a timber-marketing fund established with federal monies to secure higher prices and to find national and international outlets for lesser-known timber species

(Wilshusen 2009). Unfortunately, poor administration, including informal loans and petty corruption, resulted in termination of the fund (Wilshusen 2009). The aforementioned Consorcio Chiclero is a more successful initiative that resulted from the merging of the chicle-tapper cooperative movement with the Plan Piloto Chiclero, a derivate of the Forestry Pilot Plan (Forero and Redclift 2007). FSC certification was another huge marketing initiative of the early 1990s in which 11 communities began the certification process and six actually obtained it (Arguelles and Garcia 2008). Adding value to forest products has been an important strategy promoted by forest civil societies and NGOs and has included on-site milling with micro sawmills and wood-based handicrafts (V.J. Santos Jimenez pers. comm., UNDP 2012) (Figure II 7.7). Impacts of the myriad marketing initiatives are diverse, and in many cases, it may be premature to accurately assess them.



Figure II 7.7 A log is processed to add value and facilitate transportation by members of a community forest enterprise in Quintana Roo, Mexico. © E. Ellis

7.5.3 Continued policy reforms, credit and soft loans

Public policy and private opportunities continue to influence community forest management. Policy reforms of 1992 marked a notable challenge. In an era of free trade agreements such as GATT and NAFTA, government support for community forestry was declining, the private sector was lobbying to push forest management and production back to industry and private markets (Taylor and Zabin 2000, Taylor 2001, Bray et al. 2006), and the administration of President Carlos Salinas de Gortari adopted a neoliberal legal framework. The 1992 Forest Law focused on plantation forestry, eliminated government-supported technical assistance (relegating these services to private markets), and, notably, did not distinguish or support community forestry in any way (Taylor and Zabin 2000, Bray et al. 2006). Second, the 1992 reform of the original 1917 agrarian law also known as Constitutional Article 27 introduced privatisation on ejido lands (see Box II 7.3). Although strong social and bureaucratic barriers may have impeded a widespread and notable parcellisation and privatisation effect of the 1992 reform in Quintana Roo, its influence has been significant on two counts: to weaken internal ejido governance, and seemingly to precipitate formation of the aforementioned ejido work groups

(Taylor and Zabin 2000). Moreover, another government intervention, the 1993 PROCAMPO program, provided incentives and subsidies to farmers with land specifically under agricultural production, which effectively promoted deforestation (Keys and Roy Chowdhury 2006, Schmook and Vance 2008).

In the late 1990s and into the 21st century, there has been a reverse trend in policy, once again supporting community forestry and promoting more sustainable and multipurpose forestry. The 1997 Forest Law provided measures to regulate management of natural forest, bring avenues to support community forestry, and promote new incentives for plantations, creating three new programs for these purposes, PRODEFOR (Forestry Development Program), PROCYMAF (Community Forestry Development Program), and PRODEPLAN (Forestry Plantation Development Program), respectively (Bray et al. 2006). The 2003 Forest Law created the National Forest Commission (CONAFOR), and included a 10-fold budget increase in the PROCYMAF program directed particularly to community forestry in several states, including Quintana Roo, the major recipient of these funds (Bray et al. 2006). In sum, various government programs provide subsidies to individuals, communities, or organisations (Bray et al. 2006) that may cover a range of activities: agricultural and animal husbandry improvements, agroforestry, fire prevention practices, payment to technical consul-

tants for local capacity-building and management planning, or infrastructural investments. While some grants and subsidies – to establish mills, for example – have been instrumental investments in community forest enterprises, deficient administration and petty corruption have undermined other development opportunities (Wilshusen 2009).

In addition to these federal policies and programs, conservation and community forestry are also present and very evident in the most recent development plans of the state of Quintana Roo, with language concentrating on increasing sustainability, improving production, enhancing information, and especially in linking development and conservation with international agendas such as REDD+ (Gobierno del Estado de Quintana Roo 2005, 2011). However, concerns and confusion are prevalent among communities and forest civil societies on how to meet REDD requirements to measure and monitor carbon stocks and reduce emissions. Moreover, at both national and state levels, agricultural, forestry, and conservation policies tend to be conflictive and contradictory, impeding a holistic landscape perspective and proper integrated management of ejido lands. Regulation and policy designed to protect forests and biodiversity have in many cases been highly regulatory and costly in pursuit of SFM. This is evident after hurricanes when conflict and chaos ensue as ejidos attempt to legally harvest fallen wood and deal with forest restoration and emergency actions. While some ejidos lost FSC certification because they were unable to comply with cumbersome process requirements, the ecological and socio-economic disturbance from Hurricane Dean further interrupted renewal of FSC certification of other Quintana Roo ejidos, resulting in fewer currently certified.

In rural Mexico, access to formal credit through banks and credit unions is limited. Credit is particularly restricted for the forestry sector, which accounts for only 0.88% of the primary-sector credit and is mainly represented by loans for commercial forest plantations (Torres-Rojo 2004). In this context, individuals rely mostly on informal credit through moneylending, *tandas* (rotational credit associations), and pawning (Carreon and Svarch 2007). Whether the entrepreneurial organisation is structured as a communal enterprise or through working groups or individuals also influences access to particular subsidies, credits, or grants. In communities where timber and polewood volume rights are distributed among ejidatarios, if an emergency need arises, volume rights can be sold beforehand at reduced prices to local elites (Wilshusen 2005a). Even after the neoliberal reforms of the 1990s, subsidies and soft loans continue to be an important part of livelihood strategies in rural Mexico (Poole et al. 2007).

Despite these legal changes and economic trends, many communities in Quintana Roo persist in forest

management. Land-tenure conflict on forest lands is low (Zepeda 2000) and illicit activities are minimal, consisting mainly of small-scale timber theft and non-compliance with forest management plans (e.g. PROFEPA, 2012). Communities have weathered periods of economic hardship and unfavourable timber prices, and ejidos such as Noh-Bec and Laguna Kaná, willingly reduced logging volumes by more than 30% to sustain production over the long term (Bray et al. 2006). Others have paid higher prices for technical services – all with a genuine desire to promote SFM (Taylor and Zabin 2000). Ejidos also tried to respond as rapidly as possible to salvage downed logs in the approximately 22 000 km² of forests damaged by Hurricane Dean in 2007 (Rogan et al. 2011). Clearly, continuity and survival of community forest management in Quintana Roo, in the past and present, has been related to adaptive management and diversification strategies by local communities, forest civil society organisations, and NGOs, all working in the region.

7.6 Forest cover conserved

Despite millennia of disturbances, forest cover of the Selva Maya has remained relatively resilient and persistent; suggesting that the brand of community forestry practiced in Quintana Roo has positive conservation outcomes. Quintana Roo boasts the largest percentage (91%) of forest cover of all Mexican states and is among the top three states with the most conserved natural vegetation (SEMARNAT 2009) (Figure II 7.1). Two studies on land-use/land-cover change demonstrated very low recent deforestation rates (Bray et al. 2004, Ellis and Porter-Bolland 2008). A subset of forestry-focused ejidos in the central portion of Quintana Roo had significantly lower and even null (0.002) deforestation rates between 2000 and 2005 (Ellis and Porter-Bolland 2008) compared with an adjacent region in Campeche (-0.7) (Ellis and Porter-Bolland 2008) and also lower than the national average (-0.24) between 2005 and 2010 (FAO 2010). Statistical models have shown significant positive relationships between forest cover conservation and both community-zoned Permanent Forest Areas and timber volumes harvested from ejidos (Bray et al. 2004, Ellis and Porter-Bolland 2008). In addition, these particular conditions are associated with bigger and older ejidos with typically large areas of communal forest property and a historical tradition of chicle extraction (1920s and 1930s) and, since the 1980s, community-based timber management (Bray et al. 2004, Ellis and Porter-Bolland 2008). Low rates also were associated with poor agricultural soils and external labour markets in the coastal tourist regions. Still, higher defores-

tation rates are present among some communities in the region, mostly associated with smaller, more recent (1960s to 1980s) agriculturally based ejidos (Bray et al. 2004, Ellis and Porter-Bolland 2008). In fact, at the ejido level, a wide variety of deforestation rates can be observed in the region. DiGiano (2011) reports that some smaller non-forestry-based ejidos that have parcelled and privatised communal land, have been trending toward deforestation. Typical deforestation drivers in the region are proximity to roads and settlements, population of settlements or number of registered community members, urban expansion, cultivation, agricultural policy, and soil characteristics (Bray et al. 2004, Porter-Bolland et al. 2007, Ellis and Porter-Bolland 2008, Schmook and Vance 2008). In contrast, forest conservation at the landscape level can be associated with cultural values and local community governance and institutional promotion of land-use zoning and regulations for natural resource management (Dalle et al. 2006, Ellis and Porter-Bolland 2008, DiGiano 2011).

7.7 Research and monitoring

The study of Maya ethnoecology, a central research topic across the Yucatan Peninsula (Gómez-Pompa 1987), laid a research foundation for integrating this time-tested wealth of information into regional SFM strategies. The devolution of forest rights to communities in the mid-1980s, coupled with significant institutional support to form community forest enterprises, ignited unprecedented international research interest in Quintana Roo and Mexico in general (e.g. Cabarle 1991, Richards 1991, Bray et al. 2006). Two main research agendas have emerged: the ecological basis for sustainable management and the social dimensions of this pioneer experience of community forestry in the tropics. Ecological research has homed in on forest dynamics (e.g. Whigham et al. 1991, Macario et al. 1995, Dickinson et al. 2000, Toledo-Aceves et al. 2009), silviculture (e.g. Negreros-Castillo and Hall 2000, Snook and Negreros-Castillo 2004, Negreros-Castillo and Mize 2013), demography and management of NTFPs (e.g. Martínez-Ballesté et al. 2008, Calvo-Irabien et al. 2009), autoecology of mahogany (e.g. Camara-Cabrales and Kelty 2009), and effects of logging on plant-animal interactions (e.g. Gutierrez-Granados and Dirzo 2010).

Forest governance has been the central theme in the social science research agenda. Social capital, business management, markets, certification, cultural values, and public policies, particularly as related to land tenure, have been key topics (e.g. Bray et al. 1993, Galletti 1998, Antinori and Bray 2003, Forster et al. 2003, Klooster 2006). Community adaptation and resilience to environmental, institutional and

market changes have stimulated further studies in the region (e.g. Wilshusen 2005b, Bray et al. 2006, Wilshusen 2009, Barsimantov et al. 2010, DiGiano et al. 2011, DiGiano and Racelis 2012). Throughout, forest cover change has been used to gauge conservation outcomes of myriad interacting factors that collide in a community (Bray et al. 2004, Ellis and Porter-Bolland 2008, Dalle et al. 2011, DiGiano 2011).

Since inception of community forestry, both knowledge and institutional research support have consistently increased. Local institutions and regional efforts have played a very important role in producing relevant information for forest management, although only a fraction has been published and rarely in international venues. A forestry research station has existed near the state capital of Chetumal since 1974, and it became a National Institute for Forestry, Agricultural, and Livestock Research (INIFAP, Spanish acronym) Center in 1985. This station was established to focus on forestry research, and technology; sustainable management of natural forests, and agroforestry were included in the research agenda, but plantation research predominated, and the Center contains Mexico's few mahogany plantations (INIFAP 2010). Nonetheless, in 1986, INIFAP supported the first off-station silvicultural study established on communal forest land in X-Hazil (Negreros-Castillo and Mize 1993).

International and national scholars have published a wealth of scientific papers; however, interaction with local actors has tended to be limited except for some notable exceptions (e.g. Snook and Jorgenson 1994, Primack et al. 1998, Bray et al. 2003b). Second-tier organisations, including forest civil societies and NGOs, have played a fundamentally critical role in linking researchers with local communities and in many cases actively participating in the research itself (Galletti 1998, Santos Jimenez et al. 2005, Arguelles and Garcia 2008). More recently, a network of researchers, academic institutions, and NGOs has emerged to develop best management practices for forest management, made possible through a National Council of Science and Technology (CONACYT, Spanish acronym) initiative to link scientists in joint development and environmental goals. Also, the recent creation of regional public universities and colleges with an intercultural perspective (Llanes Ortiz 2009) constitutes a unique opportunity for future initiatives and partnerships.

The state government has been a major proponent of regional and community land-use zoning plans in the state and has sought formal collaborations with national environmental organisations such as Pronatura and the National Institute of Ecology to pursue environmental sustainability goals (Gobierno del Estado de Quintana Roo 2011). Important international collaboration has emerged, particularly in pursuit of

climate change adaptation. With Mexico as a major REDD+ partner (CONAFOR 2010), planning within Quintana Roo has explicitly included the reduction of emissions through deforestation and forest degradation, collaborating in REDD+-related projects with international organisations such as The Nature Conservancy, GIZ, US Agency for International Development, Japan International Cooperation Agency, and others (Gobierno del Estado de Quintana Roo 2011). Measuring carbon emissions, capture, and storage, have been a major research concern with REDD+-related initiatives (Gobierno del Estado de Quintana Roo 2011), and climate change adaptation programs are already being developed for forest ecosystems in the region (CONANP 2011a, 2011b).

Monitoring and long-term ecological research in general has been acknowledged as a necessity for informing forest management. One of the first large-scale monitoring initiatives was conducted under the Forestry Pilot Plan, which established a sizeable system of permanent forest plots (Alder 1997). More recently, the Mesoamerican Biological Corridor Project developed an extensive monitoring strategy, expanding the original permanent plot system (Vester et al. 2007) and extending to assess wildlife conservation (CBMM 2012). Integrating local priorities and technicians, Peters monitored diameter growth of commercial tree species (Peters 2006), and for 15 years Mize and Negreros-Castillo (2007) accompanied growth of 30 tree species. Individual initiatives, without the security of sustained funding, have also permitted long-term forest dynamics research (e.g. Macario Mendoza 2003, Mize and Negreros-Castillo 2007). Still, a lack of permanent funding and institutional infrastructure has compromised systematic data collection over extended periods, and the need remains to expand, consolidate, and institutionalise a network of permanent forest plots for research and monitoring of silvicultural treatments, regeneration, growth, and carbon capture and storage. Moreover, a regional system for monitoring deforestation, forest degradation, and land-use change is sorely needed.

Although ecological knowledge for this region is fragmented, it is significant compared to other larger tropical forests. Dialogue concerning research findings exists among researchers, NGOs, and local communities; however, implementation of research findings in actual forest management is still limited. Constraints that hinder adoption of innovative, potentially more sustainable, silvicultural practices lie beyond technical limitations and still have to be fully acknowledged and tackled (Walters et al. 2005). Although far from perfect, the ejido communities of Quintana Roo are living examples of tropical residents who have commercially harvested from their forests for decades while maintaining regional forest cover (Ellis and Porter-Bolland 2008). In a time when the definition of sustainable tropical forestry is

still debated (Putz et al. 2012, Zimmerman and Kormos 2012), a region like this will continue to attract researchers from different origins and disciplines.

7.8 Conclusions: Drivers of and deterrents to SFM in Quintana Roo

Quintana Roo is often cited as an example of successful community forestry in the tropics, where sustainable landscapes go hand in hand with low deforestation rates (Bray et al. 2004, Dalle et al. 2006, Ellis and Porter-Bolland 2008). Our findings suggest that the collective resource rights and community forest enterprises that have emerged in this Mexican state are integral to this success. A combination of several drivers has enabled many of the SFM successes observed in this region. The Maya heritage, embedded in the land and its people, is an underlying factor; the knowledge accumulated over millennia and the Maya way of approaching the forest pervades the region. Moreover, agrarian reforms of the early- to mid-1900s, fomented by grassroots efforts, academics, and government reformers, institutionalised common-property forest ejidos and local governance systems. Changes in the forestry laws in the 1980s were also crucial in returning rights to harvest and profit from forests to their owners – the communities. In Quintana Roo, in particular, it is evident that the Forestry Pilot Plan was instrumental in transforming industrial timber management via concessions to community-based management. This 16-year program brought about technical assistance, fostered the creation of forest civil societies, and supported timber-processing and marketing initiatives. The concurrent decision to dedicate more than 500 000 ha of tropical forest (owned by several communities) to commercial management via Permanent Forest Areas is regarded as the main reason for conserving forest lands and slowing deforestation in the region. Notwithstanding, shifting cultivation practices that create various successional stages have also contributed to the creation and maintenance of forest diversity over the centuries, although this positive forest-agriculture interaction has been jeopardised. Paradoxically, forest maintenance and corresponding management investments can also be attributed to the underlying poor soils that dominate the Yucatan, limiting expansion of industrial agriculture, animal husbandry, and other activities that clearly compete with forestry in other regions of Mexico. Witness the limited alluvial soils in southern Quintana Roo that are increasingly dedicated to monocultural production of sugar cane.

In contrast, neoliberal economic and policy changes since the 1990s have challenged and per-

haps set back SFM. Parcellisation and privatisation of ejido lands has not only driven deforestation in some areas but it has more importantly weakened governance in vulnerable ejidos. Corruption and lack of transparency have impeded proper investment in the forest sector, and conflicting and contradictory agricultural, forestry, and conservation policies have also put a damper on sustainable forestry development. Furthermore, recent hurricanes have underscored the conflicting and/or lack of effective policies for post-disaster adaptation and recovery. Unfavourable forest product prices, inadequate investment in processing and marketing, and a lack of appropriate silviculture have decreased the values and volumes of products that could be harvested from Quintana Roo forests.

Throughout, however, many forest communities in Quintana Roo have proven exceptionally resilient in adapting to all these challenges and setbacks. Indeed it has been their capacity in adaptive management and diversification of activities that have enabled sustainable community forestry to survive by continually shifting products marketed and by capitalising on other forest values and opportunities, such as PES (biodiversity and hydrological) and eco-tourism activities. Similarly, while the growing tourism industry has caused migrations that drain labour from rural areas, it has also created a positive demand for forest products, even further bolstered after hurricanes. While adaptation has been the norm, each community and individual has dealt with change and complexity in different ways. As a result, an increasingly diverse array of local governance schemes, livelihood strategies, and management practices coexist throughout the state. To date, local communities have been key in ensuring the survival of the Selva Maya and its diverse inhabitants – from Maya descendants to traditional chicle producers to more recent small-scale farmers and entrepreneurs.

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