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Community Forestry Enterprises in Mexico: Sustainability and Competitiveness

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Community-based forest management, such as Community Forest Enterprises (CFEs), has the potential to generate positive socioenvironmental and economic outcomes. We performed a detailed survey of financial and production parameters for 30 of the approximately 992 CFEs in Mexico in order to estimate costs, income, profits, and sustainability of harvest levels for forest management, harvest, and sawmilling. Fourteen of the 30 CFEs harvested more timber than they grew in 2011, suggesting issues with sustainability, but only two of these had harvest far above annual growth, and five of those were only a fraction more than annual growth. All of the 30 CFEs except one made profits in forest management and timber growing. For timber harvesting, 22 of 30 CFEs made profits, but the losses were small for the other CFEs. For the 23 CFEs with sawmills, 18 made profits and five had losses; the greatest returns for the CFEs accrued to those with sawmills for lumber production. On average, the CFEs surveyed had high costs

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of production relative to other countries, but the CFEs were still profitable in national lumber markets. If Mexico were to begin importing large amounts of lumber from lower cost countries, this could pose a threat to CFE profitability.

KEYWORDS benchmarking, community-based forest management, financial viability, natural forest timber harvesting, sawmilling, tropical forestry, Mexico

INTRODUCTION

The Mexican Context for Sustainable Forest Management

Mexico has a total of 195 million ha of land, of which 65 million ha are forests. Ninety-five percent of the forested area is natural forest (52% primary and 42% secondary) (Food and Agriculture Organization of the United Nations [FAO], 2010). *Comunidades*, which are indigenous people's communities which have received formal ownership of their traditional or customary lands, and *ejidos*, which are groups of previously landless rural people who have received title to land that was expropriated by the state, own more than half of Mexico's forests and have relative autonomy to manage them (Kelley, 1994).

The modern community forestry movement in Mexico began to emerge in the 1970s and 1980s in response to agrarian reform, the Forestry Law of 1986, and other factors (Antinori & Bray, 2005; Bray, Antinori, & Torres-Rojo, 2003, 2006). Before this time, management of forests for timber production was mostly through short-term concessions to private enterprises that were depleting the timber. After the passage of the Forestry Law, *comunidades* and *ejidos* started to organize what are now Community Forest Enterprises (CFEs) that harvest and commercialize their timber based on management plans with the assistance of professional foresters (Antinori, 2005). CFEs in Mexico may be governed in a variety of fashions, with more or less control exerted by or independence from the governance structure of the community itself (Bray et al., 2006).

An estimated 992 CFEs exist throughout Mexico that are categorized according to their capacity and vertical integration as: Type II—communities that own the forests and simply sell concessions to private loggers; Type III—communities that harvest timber themselves and sell it to private sawmills, and Type IV—communities that harvest and process timber (Comisión Nacional Forestal [CONAFOR], 2010). *Comunidades* and *ejidos* that own forest but do not manage it for income are categorized as Type I. In addition to the commercialization of timber, some enterprises generate income from commercializing nontimber forest products (NTFP), conducting ecotourism, and recently, an increasing number are earning revenue from the conservation of natural resources under payment for environmental services (PES) schemes (Klooster & Masera, 2000).

Sustainable forest management (SFM) is widely considered to encompass economic, environmental, and social benefits that are especially important for some countries of Latin America where natural forests are being deforested primarily due to the expansion of agriculture (Geist & Lambin, 2002). Many indigenous communities and rural poor use the forest to supply household needs or as a source of economic income (Forster, Guemes-Ricalde, & Zapata, 2014). Mexico has been a pioneer and model in the effort of supporting a community-based SFM in local *comunidades* and *ejidos* that manage their own natural resources (Asbjornsen & Ashton, 2008). Despite the potential socioeconomic benefits of SFM, there is little scientific literature in Mexico and most of Latin America about the management and economics of native forests by communal landowners, or by small- and medium-sized entrepreneurs.

Sustainability and Financial Viability of Community Forest Enterprises

Profit maximization is not always the main objective of CFEs, though some level profitability should be considered an important one. Profit maximization is a core underlying assumption of the theory of the firm, and Ostrom (1990) clearly rejected the theory of the firm as an underlying model of community-based natural resource management on empirical and theoretical grounds. However, Antinori and Bray (2005) use the theory of the firm as a starting point, and describe Mexican CFEs as "social firms." Rather than shareholders or investors, CFEs' beneficiaries are predefined community members. In contrast to profit or return on investment as the single objective, social firms such as CFEs may have numerous objectives—including employment of community members, production of public goods and services, supplying products for household use to community members, as well as profit (Antinori & Bray, 2005). In addition, communities must have good markets to provide an incentive for the development and consolidation of community forestry. Furthermore, communities must have an adequate forest endowment in order become engaged in market insertion, as well community organization (Forster et al., 2014). Thus it is clear that some level of net income generation is required to ensure sustainability, as a money-losing enterprise is not likely to be kept afloat by poor communities. In this sense, it is important that CFEs demonstrate potential for some net income generation and competitiveness with other forest producers.

Certification of SFM by third parties to standards such as the Forest Stewardship Council (FSC) is utilized by some CFEs in Mexico. Certification seeks to encourage SFM by linking enterprises who utilize sustainable practices to consumers who demand them (Markopoulos, 1999). By 2001, only 51 communities worldwide, or less than 1% of community forests, had received FSC certification (Molnar, 2003), increasing to 109 by 2014 (FSC 2014). As of 2013, there were 39 FSC certified forests in Mexico (Blackman, Raimondi, & Cubbage, 2014). Certification provides some evidence of financial viability and sustainability of CFEs, and in some cases may assist in making them so by opening markets and in some rare cases generating price premiums (Humphries & Kainer, 2006), and by reducing costs and improving administrative practices (Anta Fonseca, 2006). However, economic benefits have not been as great as hoped, and certification comes with substantial cost, leading to low numbers of certified communities and a high rate of decertification (Anta Fonseca, 2006; Wiersum, Humphries, & van Bommel, 2013).

An empirical assessment of financial viability, competitiveness, and sustainability of community forests has been difficult as it ideally utilizes detailed data going back many years, whereas many communities have only incorporated CFEs in recent years and others lack adequate record-keeping systems (Forster et al., 2014). Also, the simplest and most common financial analyses of timber investment returns in Latin America are for even-age stands of planted, fast-growing, monoculture exotic species; whereas common CFE systems of uneven-age, naturally regenerated, slow-growing, multiple native species introduce numerous uncertainties into the calculation (Cubbage et al., 2007). For this reason, most estimates of CFE profitability have been single case studies, a sample of just a few CFEs, or rely on incomplete or nonstandardized data.

Several studies have suggested various levels of profitability with various degrees of confidence (Antinori & Bray, 2005). Salafsky et al. (2001) surveyed community-based natural resource enterprises (mostly ecotourism and NTFPs) and found that only 7 of 37 were profitable. Antinori (2005) examined Mexican timber-based CFEs and found high returns on investment (ROI) for temperate natural forest stumpage sales (39%); temperate natural forest logs (48%); temperate forest boards (48%); and temperate forest finished products (32%). However, this was only a "first-order approximation" (Antinori & Bray, 2005, p. 1537) that used differing accounting methods among communities (Humphries et al., 2012). Torres-Rojo, Guevara-Sanginés, and Bray (2005) found ROIs of 20 to 30% for sawn and dried boards in Guerrero State, Mexico, but did not include debt payments, depreciation, or taxes (Humphries et al., 2012).

Elsewhere in Latin America, Humphries et al. (2012) calculated returns on investment for three community forests in the Brazilian Amazon for the entire processing chain from stump to sawmill to lumber manufacture that were 12, 2, and −48%. They also reviewed other studies, not all from community forests, of returns to tropical forest management, harvesting, and sawmilling. One of those studies in Brazil had a negative ROI of −54%. All the others, however, had positive rates of return ranging from a low of 20 to 30%, up to a high of 81%.

Objectives

The main objective of this study was to assess the financial competitiveness and sustainability of CFEs in Mexico in order to identify strengths, weaknesses, and gaps that will guide actions to improve their performance and ensure a sustainable income and biodiversity protection. This was done by: (a) evaluating forest sustainability and its link to the financial performance of the enterprises; (b) calculating financial variables throughout the vertical integration line: forest management, harvesting, and milling; and (c) benchmarking CFEs in Mexico with international forestry enterprises.

METHODS

Data Collection and Analysis

The study took place in 12 different states in Mexico (Figure 1) including: Campeche, Chiapas, Chihuahua, Durango, Guerrero, Jalisco, México, Michoacán, Oaxaca, Puebla, Quintana Roo, and Veracruz. Only Type III and IV CFEs were selected to participate in the survey because they were the most likely to have adequate record-keeping systems and because they

FIGURE 1 Map of the states included in the study (data source: Global Administrative Areas, 2015).

would be the most comparable with each other and with worldwide forestry enterprises. It is important to note that this was not a random sample of all CFEs in Mexico, and as such, should not be seen as representing typical or average situations. Among Type III and IV, CFEs to participate were selected through maximum variation purposive sampling. CFEs were selected by a team of knowledgeable informants at the National Forestry Commission of Mexico (CONAFOR) to represent CFEs at various levels of capacity and vertical integration, various scales of production, and various regions throughout Mexico. Feasibility and cost of reaching the CFEs was also a factor, as some regions of Mexico have an unstable security situation.

The information about management, harvesting, and sawmill activities necessary for calculating the financial variables analyzed in this study was collected in 2012 through a 205 question in-person survey and follow up contacts made to 30 CFEs belonging to Types III and IV. A Spanish-language copy of the survey can be found as an appendix to Cubbage et al. (2013b). Based on our review of the literature, we believe this to be one of the largest samples of CFEs studied to investigate financial profit, competitiveness, and sustainability.

Since performing the study, we found related research that was conducted concurrently in Quintana Roo, which also examined factors affecting CFEs and forest market participation (Forster et al., 2014). That study had a larger sample of communities interviewed (53), but only 10 were still actively extracting wood from their forests, and it did not examine costs and returns, but rather compared the forest endowment and community organizational level to assess market participation.

Our survey design was a result of two workshops with the participation of CONAFOR and other stakeholders, and a pilot test in the field. The survey collected information about forest (area, growth rate, species composition, etc.); forest management practices and production levels, costs, and revenues; harvesting; and sawmilling in 2011.

The net present value (NPV) based on a 30-yr projected rotation and 8% interest rate was calculated to analyze the financial performance of the management of the forest following the methodology in Cubbage et al. (2007, 2013a) and adapted for specific management practices for natural forests in Mexico.

Harvest calculations for the CFEs used 2011 survey data as the base year, and the 30-yr projections were adjusted based on harvested volumes reported in their forest management plans where available. Financial variables–costs, revenues, and profits–were calculated for three different stages in the vertical integration: forest management, harvesting, and milling. In addition, comparisons of costs of CFEs in Mexico with other forests enterprises in the world allowed analysis the competitiveness of the CFEs in Mexico.

Measures of Forests and Sustainability

Responses from the survey related to forest ownership size, forest type (species mixture and production versus conservation), timber inventory and harvesting intensity, growth and yield were summarized. Some CFEs had poor timber inventory records, but these estimates were the best available given the limitations. Forster et al. (2014) also examined forest area, species, and inventories in their study to assess market participation.

The sustainability of the forest was analyzed based on the difference between the mean annual increment (MAI) and the harvested volume for a 30-yr projected rotation since there was no fixed cutting cycle. Where MAI exceeds harvest, timber stocks would be expected to increase, and decrease in the opposite case. Since sustainability also incorporates economics, MAI minus harvest was compared to NPV to determine trends.

Vertical Integration

We classified the production activities into three steps: (a) forest management, (b) harvest, and (c) sawmill. Type III CFEs participate in Steps (a) and (b), while Type IV CFEs participate in Steps (a) through (c). We estimated financial capital budgeting indicators for each of these three steps to determine which steps were the most profitable.

The surveys asked for detailed costs and income using categories based on Cubbage, Davis, Frey, and Chandrasekharan Behr (2013a) and the two stakeholder workshops. Estimates of costs, income, and profits were calculated for each of the steps in the value chain (i.e., forest management, harvest, and sawmill). The cost of harvesting was calculated by adding management costs and harvesting costs and dividing this result by the volume sold, not the volume harvested. The cost at the mill of Type IV CFEs was calculated by adding the cost of the timber processed in the mill and the functioning costs and dividing this by the volume of processed timber. Benchmarks of similar measures from forestry operations around the world were used for comparison to determine the relative competitiveness of these Mexican CFEs. For comparison with other countries, which are reported mainly in United States Dollars (US$), we used a conversion factor for the year 2011 of US$1 = MX$13 (Mexican Pesos).

Forest Management

Forest management consisted of activities related to the growth of trees up until their harvest, including silviculture. Forest management costs were classified as site preparation, reforestation, periodic management, roads, fire control, technical assistance, and payment to communities. Payments to communities represented financial support from the forest enterprise to the community, and could be considered a user fee since the forests were owned by the communities themselves rather than the enterprise. Survey responses included income from timber, NTFPs, and PES payments.

Harvest

Harvest of the standing timber included cutting and hauling to roadside. Harvesting costs were classified as maintenance and depreciation of capital, labor, and machine operation. Income was the price paid for the logs at the roadside.

Sawmill

Sawmilling is the process of turning roundwood timber into lumber, as well as loading and transport from the forest roadside to the mill. Loading and transport costs were included in the cost of the wood purchased by the mill). Sawmill costs were classified as the cost of timber, operation and maintenance of machines, depreciation, indirect labor costs, and energy. Income was the price paid for sawn lumber, summed across the variety of different lumber products.

RESULTS

Measures of Forests, Sustainability, and NPV

The total area of the forests for each community ranged from 151 to 62,493 ha, with a mean of 12,269 and a median of 6,189 ha. This was a large range, which allowed us to make observations about many different conditions, though the data had considerable variability. Thirty-three percent of the CFEs in our sample were certified as sustainable under the FSC standard.

On average, communities categorized 72% of their forests as production forests, and 28% in conservation uses. This varied considerably also, with one community (3% of the sample) categorizing 88% of its forests under conservation, and 13 (43%) of CFEs in our sample having less than 15% of their area for conservation. The average size of production forest was 7,717 with a median of 4,182 ha.

Ninety percent of the sampled CFEs were located in temperate forests. This kind of forest was a mixture of pine (*Pinus* spp.), fir (*Abies* spp.), and oak (*Quercus* spp.) species from which pine was the most common and commercialized. On average, 85% of the harvest on these enterprises was pine, 8% fir, and 8% oak. Oak was not commercialized but used for household consumption by members of the enterprise. Three enterprises (10%) of our sampled CFEs were located on the Yucatán Peninsula in the states of

TABLE 1 Timber Growth and Harvest per Hectare for CFEs in Mexico, 2011

	Standing volume	Total harvest 2011		Mean annual increment (MAI)	MAI minus harvest 2011
	(m^3/ha)	m^3/yr	m^3/ha/yr	(m^3/ha/yr)	(m^3/ha/yr)
Average	178	11,393	4.04	2.83	−1.22
Standard deviation	106	11,264	5.38	1.98	5.33
Maximum	450	46,095	22.12	8.82	4.28
Minimum	21	389	0.03	0.70	−19.35
Median	153	6,265	2.32	2.50	0.1

Campeche and Quintana Roo which have tropical forests and commercialize common tropical species. The most valuable species in this forest was mahogany (*Swietenia* spp.) which was commonly commercialized but to a lesser extent than other species. On average, 15% of tropical CFE harvest was comprised of mahogany and the rest was comprised of other common tropical species.

Table 1 summarizes the basic information about average timber inventory per hectare, timber harvest volume, total standing volume, and the MAI of the species commercialized in 2011 as reported in the surveys. The average roundwood standing inventory at the start of 2011 was 178 m^3/ha, with a range from 21 to 450 m^3/ha. All but seven (77%) of the CFEs had initial standing inventories of more than 100 m^3/ha, which is a substantial volume, indicating a large amount of mature timber that was probably about 50 yr old or more, and could be harvested. Six (20%) of CFEs had standing inventories of more than 280 m^3/ha, which indicated that they were more than 100 yr old—essentially older growth and very mature timber.

The mean harvested volume per year was 4 m^3/ha, with a minimum of 0.03 and a maximum of 22 m^3/ha. This was greater than the average mean annual increment of 2.8 m^3/ha/yr. However, the median MAI was slightly higher than the annual harvest, since the later was not affected by a couple of very high observations. Fourteen (47%) of the CFEs harvested more timber per hectare than they grew in 2011, suggesting some issues with long-run sustainability, but only two (7%) had harvests far above annual growth, and five of those (17%) had harvests that exceeded annual growth by only a fraction of a cubic meter per hectare per year.

Figure 2 shows the sustainability (i.e., MAI minus harvest in 2011) versus the financial performance of the enterprise represented by their NPV for 30 yr. The average NPV for the 30 CFEs was MX$26,576/ha (US$2,044/ha) with a maximum value of MX$160,309/ha (US$12,331/ha) and a minimum of −MX$11/ha (−US$1/ha). As Figure 2 shows, only one enterprise had a slightly negative NPV and 16 enterprises (53%) were sustainable with positive values “MAI minus harvested volume.” Those two enterprises (7%) with the

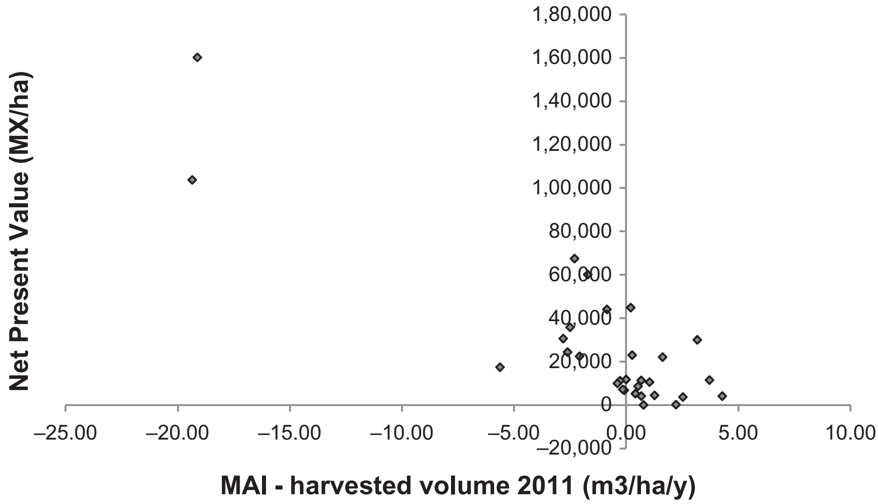

FIGURE 2 Sustainability (MAI minus harvested volume 2011) versus net present value.

largest NPV were also those that harvest a lot more than what the forest grew (i.e., MAI) which made them unsustainable at that rate. Although two or three of the 30 enterprises appeared to be unsustainable, with harvests exceeding annual growth by more than 5 m^3/ha/yr, the amount of overcutting was still relatively small or not a problem for the other 27 (90%) of CFEs in our sample.

Vertical Integration

Figure 3 shows the average costs, incomes, and profit along the vertical integration chain. The enterprises analyzed in this study did not sell the standing timber in the forest directly. However, income and profit were calculated for the forest management part for comparisons along the steps in the vertical integration supply chain. On average, both the forest management component of the chain and the sawmill component had profits, the latter being more profitable. Harvesting operations were slightly unprofitable on average partly due to the high labor cost mainly caused by low technology, as well as due to the proportion of harvested volume not sold, which increased the cost per cubic meter. Seventy-seven percent of the harvested timber was sold and 23% was waste. The lowest costs were at the stage of forest management, probably as a result of the little management (e.g., planting, thinning, and pruning) done by the enterprises.

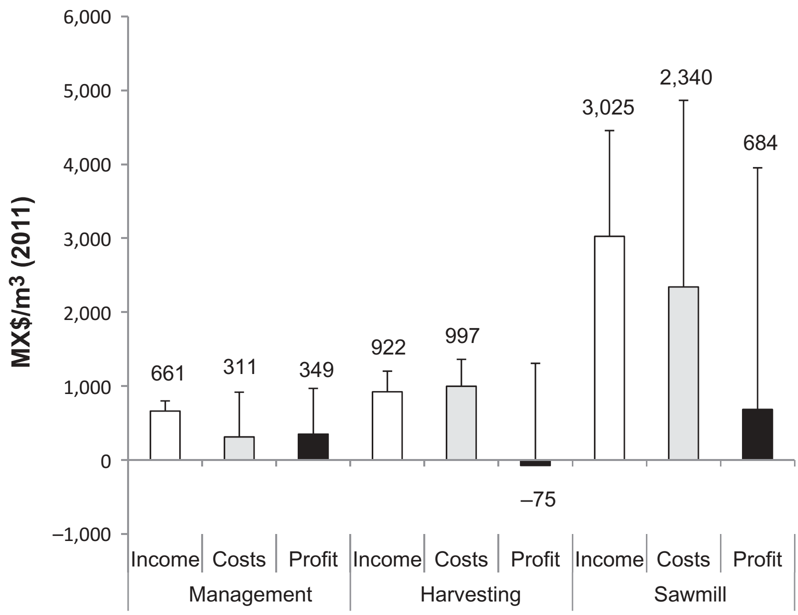

FIGURE 3 Average costs, incomes, and profits along the vertical integration.

Forest Management

Costs

Table 2 summarizes different categories of costs in the forest. Costs in the periodic management category included: use of fertilizer, pesticide, controlled fire, pruning, noncommercial thinning, and insect and disease prevention and control. Technical assistance included: technical services, consultants, and administrative activities. The category with the highest cost was technical assistance and site preparation had the lowest cost. The average total costs are MX$765/ha (US$59/ha) and MX$311/m^3 (US$24/m^3). Most of the CFEs did not spend money on site preparation and reforestation activities since they depend on natural regeneration. Payment to communities was around 13% of the total costs and only nine (30%) of enterprises did not report a payment to the community. This expenditure has demonstrated to be important for community well-being as it helps in the construction of necessary infrastructure such as schools and roads.

Income and Profits

Table 3 presents the income that forests generate by different activities: timber commercialization, nontimber forest product (NTFP) commercialization, and payment for environmental services (PES). Total income was MX$3,111/ha/yr (US$239/ha/yr) or MX$880/m^3 (US$68/m^3). Income from

TABLE 2 Forest Management Cost Categories for CFEs in Mexico, 2011

	Site preparation		Reforestation		Periodic management		Roads		Fire control		Technical assistance		Payment to communities		Total costs	
	MX$/ha	MX$/$m^3$	MX$/ha	MX$/$m^3$	MX$/ha	MX$/$m^3$	MX$/ha	MX$/$m^3$	MX$/ha	MX$/$m^3$	MX$/ha	MX$/$m^3$	MX$/ha	MX$/$m^3$	MX$/ha	MX$/$m^3$
Average	27	15	162	10	90	27	87	51	54	32	248	132	98	45	765	311
Maximum	150	225	4,503	211	751	193	563	792	375	320	1,701	1,814	843	407	6,830	3,417
Minimum	0	0	0	0	0	0	0	0	0	0	1	1	0	0	27	24
Median	6	4	0	0	41	16	30	19	21	11	97	50	18	7	324	169

TABLE 3 Income from Forest Management Activities for CFEs in Mexico, 2011

	Timber		NTFPs	PES	Total income	
	MX$/ha	MX$/m^3	MX$/ha	MX$/ha	MX$/ha	MX$/m^3
Average	2,796	661	206	108	3,111	880
Maximum	17,083	1,037	3,331	1,904	18,751	3,241
Minimum	18	369	0	0	90	403
Median	1,198	679	1	0	1,794	730

Note. NTFPs = nontimber forest products; PES = payments for environmental services.

timber accounts for 90% of the total income while NTFPs and PES generated 7 and 3%, respectively. Sixteen (53%) of CFEs obtained income from the commercialization of NTFPs and only eight (27%) from PES. NTFPs included: fuelwood, resins, medicines, tourism, and employment (from activities other than timber commercialization). Most of the enterprises (27, 90%) reported a benefit from fuelwood; however, only 10 (33%) received income from its commercialization. This indicated that fuelwood was mainly used for household consumption but that there could be a potential product to sell. PES were received for the following services: prevention of erosion, water conservation, and prevention of habitat and biodiversity loss. Six CFEs (20%) reported income from water conservation and it was the most frequent service enterprise to perform as a source of income.

Profits for forest management were on average for 2011 MX$2,345/ha (US$180/ha) with a maximum of MX$15,963/ha (US$1,228/ha) and a minimum of −MX$5/ha (US$0/ha). Only one CFE had a negative profit, which indicated that in general enterprises perform well at the management stage.

Benchmarks

Figure 4 compares the Mexican CFEs' average timber production costs and prices with other countries in the world. The Mexican CFEs grew and harvested mostly pine. Cubbage et al. (2010) calculated total forest management costs for a variety of pine and eucalyptus species in the world in 2008, which was used to calculate a comparable cost per cubic meter to grow wood for a typical plantation rotation without any discounting of costs included. There were 3 yr of difference in the years the costs were estimated, but there was much variation in the costs for Mexico, and not much inflation during this time, so values were not adjusted for inflation to make the comparisons.

These comparisons indicated that Mexico has been a generally a high cost to very high cost producer of roundwood, depending on the accounting stance taken. In Mexico, the average cost of timber without any payments to the communities was US$20/m^3 and with payments to communities US$23.

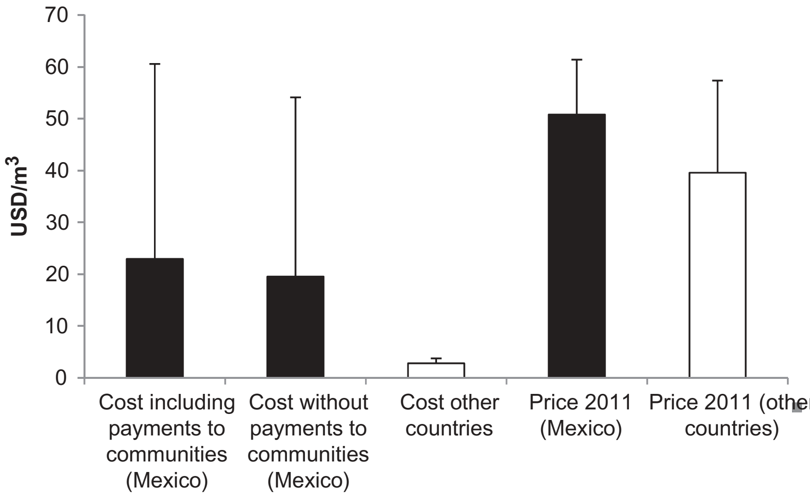

FIGURE 4 Average costs and prices of forest management activities of 30 CFEs in Mexico versus other countries. Costs were calculated by dividing the total 30-yr cost, without discounting or compounding, by the total volume harvested within 30 yr. Other countries included: USA, Chile, Brazil, Argentina, Uruguay, New Zealand, South Africa, Colombia, Venezuela, and Paraguay. (Taken from Cubbage et al., 2010).

In contrast, the cost of timber in other countries was US$2.8/m^3, or around one-eighth the cost in Mexico including taxes and administration, which are approximate equivalent to payments to communities for private forests in other countries.

Regarding the situation for the future costs of roundwood production compounded over the rotation of 30 yr, the global benchmarks had a compounded cost of producing wood with an average of US$28/m^3 while Mexico had an average of US$91/m^3. Again, some of this may have been due to underaccounting of administration costs in other countries, or compounding for somewhat longer in Mexico. However, the differences were indicative of higher production costs in Mexico, particularly when carried at the 8% discount rate used. The typical annual discount rates used for CFEs in Mexico were commonly about 12%, which exacerbated this disadvantage in roundwood production cost.

As Figure 4 shows, Mexico had greater prices per cubic meter for its stumpage prices. These prices were actually relatively uniform in Mexico, with a mean of US$51/m^3, and a standard deviation of US$11/m^3. Global roundwood prices were less on average (US$39/m^3), with a standard deviation of US$18/m^3. Even when CFEs in Mexico had higher roundwood production costs, they also had higher stumpage prices. This allowed enterprises to generate a profit from forest management from the selling of timber to local markets in Mexico. However, these prices have prevented CFEs from competing in export markets, where their production costs have been too high compared to other countries, especially low-cost producers like Chile and Brazil, or even small private landowners in the U.S. South and Pacific Northwest.

Harvest

Costs

Table 4 summarizes the average harvesting costs by different categories. CFEs averaged a harvest of 10,721 m^3/yr, with a broad range from 389 to 46,095 m^3/yr. The commercial timber volume sold was less, with an average of 8,259 m^3. This was about 77% of the total harvest. The total harvest cost per cubic meter was calculated based only on the commercial harvest, since there were not sales of the noncommercial harvest material. Thus, those costs were possibly slightly high considering the amount of wood cut, but using the same metric as commercial timber sold was better for calculating profits.

The average harvesting cost was MX$138/$m^3$ (US$11/$m^3$) for capital costs: MX$176/m^3 (US$14/$m^3$) for operating costs, and MX$193/$m^3$ (US$15/$m^3$) for labor costs. Most of the equipment consisted of old tractors and chainsaws, but there were some purchase and depreciation costs, and certainly some maintenance costs. The operating costs were a slightly smaller share, and labor costs were the largest share of total costs. The overall average cost for harvesting was MX$506/$m^3$ (US$39/$m^3$).

This average harvesting cost was somewhat high, but reasonable based on the likely levels of harvest and low-tech equipment used by the CFEs—only chainsaws and tractors in most cases, and even oxen in a couple of cases. The variation, however, indicates that the costs–and records–varied substantially. The cheapest cases had costs of less than MX$200/$m^3$ (US$15/$m^3$). Several cases were very expensive, at more than MX$700/$m^3$ (USD$55/$m^3$). These costs were possible, and if accurate, indicated that CFEs produced higher-cost wood or receive less for their derived stumpage prices.

Income and Profits

The summary of the calculations for the profitability of timber harvesting is presented in Table 5. It was possible to estimate the total amount of the timber sales price *en brecha* —at the roadside—from the survey. The total profit for each community was the price *en brecha* minus costs of harvesting and management.

Eight (27%) of the 30 CFEs had a loss per cubic meter, indicating that their costs exceeded their incomes. Most of those losses were large, at more than MX$200/$m^3$ (US$15/$m^3$). On the other hand, 22 (73%) of the CFEs made

TABLE 4 Harvesting Costs by Different Categories in 2011

	Total harvest	Commercialized volume	Capital: Maintenance and depreciation		Labor		Machine operation		Total costs		
	m^3/yr	m^3/yr	MX$/yr	MX$/$m^3$	MX$/yr	MX$/$m^3$	MX$/yr	MX$/$m^3$	MX$/yr	MX$/$m^3$	US$/$m^3$
Average	10,721	8,259	961,783	138	889,755	193	1,141,107	176	2,992,645	506	39
Maximum	46,095	39,181	4,897,940	519	5,172,160	1, 189	6,568,972	740	12,674,374	1,550	119
Minimum	389	195	10,400	5	36,000	9	2,400	1	206,200	114	9
Median	6,182	5,254	440,279	109	558,750	99	591,320	132	2,304,408	397	31

TABLE 5 Harvesting Costs, Income, and Profits for CFEs in Mexico, 2011

	Commercialized volume	Total harvesting costs		Management and harvesting costs	Income at roadside	Profit at roadside	
	m^3/yr	MX$/yr	MX$/$m^3$	MX$/$m^3$	MX$/$m^3$	MX$/$m^3$	US$/$m^3$
Average	8,259	2,992,645	506	997	922	−75	−6
Maximum	39,181	12,674,374	1,550	7895	1794	960	74
Minimum	195	206,200	114	187	524	−7,195	−553
Median	5,254	2,304,408	397	645	866	243	19

a profit on their timber harvesting even taking into account forest management costs. The median case was more representative since one of the CFEs lost a huge amount (−MX$7,195/$m^3$ or −US$553/$m^3$). In the median case, there was a profit of MX$243/$m^3$ (US$19/$m^3$). Overall, the profitability of the harvesting operations varied widely, but given the relatively high product prices at roadside, there appeared to be a good opportunity for profits if harvesting costs were not excessive.

Benchmarks

For timber harvesting costs, the costs calculated for CFEs were compared with a few examples in the United States. We expected that costs in the southern U.S were less than other parts of the country, because of the well-managed, high-volume production harvesting crews with high levels of mechanization. The harvesting costs for the mountains of the U.S. provided a more fitting comparison with the Mexican CFEs.

Table 6 summarizes the harvesting cost benchmarks from USA, Argentina, Brazil, and Uruguay and CFEs in Mexico. In the U.S. South (Timber Mart-South, 2011) the average harvest cost from the stump-to-loaded on a truck at roadside was US$12.17/ton (one ton corresponds approximately to one cubic meter). This was much less than the average cost for CFEs in Mexico, which was US$39/$m^3$. However, the stump-to-loaded on a truck costs, cited from an old study in Montana of ground-based systems, were much higher and ranged from 37 to US$52/$m^3$ (Keegan, Charles, Fiedler, & Stewart, 1995). These costs, from about 16 yr ago, were still greater than the Mexican average harvesting costs. The U.S. costs included loading onto a truck, but this is generally not expensive, perhaps US$2–3/$m^3$.

The harvesting costs in Mexico ranged from 8.75 to US$119/$m^3$. The mean for harvesting operations in Mexico was about 39, and the median US$30/$m^3$. There were not many very expensive timber harvesting operations overall; however, there were several that were small, less than US$10/$m^3$. Overall, timber harvesting costs appeared to be in a reasonable range for typically mountainous conditions found on Mexico CFEs.

TABLE 6 Harvesting Benchmarks for Timber Harvesting Costs

Region	Average cost (US$/m^3)
South USA (Timber Mart-South, 2011)	12.17
USA Mountains—Montana, 1995 (Keegan et al., 1995)	37–52
Argentina, Brazil, Uruguay (Patricio MacDonagh, personal communication, 2013)	7.41–14.82
Mexico CFEs	39

Sawmill

Costs

Table 7 summarizes selected sawmill data for total costs, total income, and profits. Note that there were only 23 CFEs that had sawmills (Type IV). The average costs for lumber production at sawmills was MX$2,340/m^3 (US$180/m^3). This was comprised of MX$1,207/m^3 (US$93/m^3) of wood costs (including loading and transport from road side); MX$287/m^3 (US$22/m^3) of equipment and operation costs; MX$638/m^3 (US$49/m^3) of depreciation; and MX$209/m^3 (US$16/m^3) of indirect labor and energy costs. The cost of timber was the largest.

The variation again indicates that the costs, and records, varied substantially. The cheapest cases had sawmilling costs of less than MX$1,200/m^3 (US$92/m^3). Only a few CFEs actually had costs per cubic meter greater than the average, which was distorted by one very expensive enterprise. Without that case, the average sawmilling total cost was MX$1,676/m^3 (USD$129/m^3)–still expensive, but not nearly as costly.

Income and Profits

The summary of the calculations for the timber harvesting profitability is presented in Table 8. We estimated the weighted average lumber price by species and product class, ranging from low grade to the highest grade of lumber produced. These were then used to estimate total income, or total sales revenue. The total profit for each sawmill was the total sales revenue minus the cost of lumber production. Twenty-two percent of the CFE sawmills had a loss, indicating that their lumber manufacturing and wood purchase costs exceeded their total sales incomes. The rest of the 18 enterprises (78%) each made a lumber manufacturing profit. Average profits were quite large—US$53/m^3 (MX$684/m^3). These profits reflected high prices for lumber and panel products in Mexico. The profitability of the sawmill operations varied widely, but there were clearly opportunities for profitable sawmilling operations extending back through the lumber-to-timber supply chain.

TABLE 7 Sawmill Costs for CFEs in Mexico, 2011

	Cost of timber		Cost of machines: Operation and maintenance		Depreciation		Indirect labor costs and energy		Total cost sawmill		
	MX$/yr	MX$/m^3	MX$/yr	MX$/m^3	MX$/yr	MX$/m^3	MX$/yr	MX$/m^3	MX$/yr	MX$/m^3	MX$/ board ft
Average	9,147,155	1,207	1,221,347	287	658,071	638	1,323,574	209	12,350,147	2,340	11
Maximum	24,436,416	2,865	2,926,106	2,433	1,466,543	12,652	7,031,902	1,082	30,242,979	16,968	77
Minimum	13,346	695	25,000	18	14,000	14	6,000	29	174,346	941	4
Median	8,038,742	1,035	981,135	101	581,500	82	1,074,400	175	9,921,971	1,503	7

TABLE 8 Sawmill Costs, Income, and Profit for CFEs in Mexico, 2011

	Volume processed		Total cost		Total income		Profit	
	m^3/yr	Board ft/yr	MX$/yr	MX$/$m^3$	MX$/yr	MX$/$m^3$	MX$/yr	MX$/$m^3$
Average	8,556	1,819,903	12,350,147	2,340	20,245,459	3,025	7,895,312	684
Maximum	27,187	5,760,000	30,242,979	16,968	73,736,000	11,344	45,315,181	6972
Minimum	10	2,259	174,346	941	33,878	1,090	−1,087,637	−13671
Median	7,200	1,452,000	9,921,971	1,503	13,824,000	1,996	3,189,853	483

TABLE 9 Select Random Lengths Lumber Prices, October 2011

Product/Species	Southern pine central (US$/MBF)	Douglas fir (US$/MBF)	Western spruce-pine-fir (US$/MBF)
Kiln dried dimension (2 × 4 #2 & better)	263	285	308
Structural light framing (RL10/20′)	286	340	370
Kiln dried framing (2 × 8 12′)	275	270 (green)	290
Selects & commons (#2 & better, 1 × 8)	365	335 (green 1 × 6)	445
Selects & commons (D, 1 × 8)	720		930
Average cost Mexico CFE (2011): US$827/MBF			

Note. MBF = thousand board feet.

Benchmarks

Twenty-three of the CFEs owned sawmills, thus they incorporated the complete value chain from forests to sawmills. The mean cost of lumber production for the CFEs was US$827 per thousand board feet (MBF), with a large standard deviation of US$1,130. The minimum cost was 340 and the highest US$5,938/MBF; the median cost was US$564/MBF.

Random Lengths (2011) reported lumber market prices in the U.S., providing a benchmark for Mexican costs (Table 9). These were sales prices, which were presumably higher than U.S. production costs, but not that much. Margins for manufactured U.S. lumber have reportedly been razor thin, and indeed many sawmills have been incurring losses and selling lumber below their costs of production. Thus, the Random Lengths (2011) were suitable for comparison, given the accuracy of Mexican data and the large differences between the prices.

The weighted average Random Lengths Framing Lumber Composite Price for October 7, 2011 was 263, and it was US$248/MBF in October 2010 (Random Lengths, 2011). Random Lengths reported prices for a wide variety of products and regions in the United States, free-on-board (f.o.b.) mill, i.e., the mill gate price. A few select price comparisons are shown in Table 9.

For standard 2 × 4 material and the most common grade produced in the U.S., the average production costs for Mexican sawmills was grater than the U.S. cost. At the high end of the lumber grades, the average Mexican lumber costs were closer to U.S. costs, but little wood was processed at that grade. However, much of the old growth timber in Mexico still has been composed of higher grades, rendering higher production costs less detrimental to competitiveness. In addition, prices within Mexico must have been high enough for the CFEs to continue to sell their products within domestic markets. However, Mexican producers have faced considerable pressure from global wood sources, who have produced a glut of cheap lumber since the 2008 recession.

On the other hand, the returns on investment for the Mexican mills were still generally positive for the entire value chain, based apparently on the relatively high prices for lumber in the Mexican market, where demand has been high. Five of the 23 CFEs had negative ROIs, ranging from −81 to a −2%. Positive ROIs ranged from 3 to 445%. At the very least, the ROI results indicate that high lumber prices in Mexico have allowed at least the efficient CFEs to make reasonable to quite attractive profits on their overall operations, even when including payments to communities.

DISCUSSION

Measures of Forests, Sustainability, and NPV

Community forest enterprises located in temperate forests commercialized mainly pine even though there were other commercial species in the forest such as fir and oak. Enterprises located on the Yucatán Peninsula–in Chiapas and Quintana Roo–commercialized mainly a mix of common tropical tree species and, to a lesser extent, mahogany, which has been considered a valuable species.

Sustainability was estimated by asking the CFEs for information on their total timber inventory and harvest in 2011, the area of their production forests, and the average growth rates of their forests per hectare. Based on their answers, we calculated an average removal rate per hectare and compared it with the average growth rate per hectare. Growth rates per hectare exceeding removal rates per hectare indicated sustainable harvests, and vice versa.

Fourteen (47%) of the CFEs were harvesting more than their annual growth rate in 2011, though most of these CFEs with excess harvests over growth had higher standing inventories of older growth forests as their base. Two of the CFEs (7%) had harvests that greatly exceeding growth, at 19 m^3/ha/yr more. This harvest rate could not be sustainable for long, though these CFEs included the largest standing inventory base of old growth timber volume per hectare of more than 360 and 450 m^3/ha. Six (20%) were harvesting about 2 m^3/ha/yr more than the growth rate, but this could be continued for decades without seriously depleting the base volume, which ranged from 80 to 300 m^3/ha for the relevant CFEs. In addition, the harvests may have decreased in the years after 2011 for those CFEs. In fact, the forest management plans for all CFEs indicated that they should be sustainable over the next decade, if they followed the plans.

In general, CFEs were performing well, since the average NPV of forest management was US$2044/ha. Twenty nine (97%) of the 30 CFEs considered in this study had positive NPVs for a 30-yr rotation and 16 (53%) are also sustainably harvesting with harvest volumes lower than the MAI. This result suggests that enterprises generally were profitable and sustainable at the same time. The remaining 14 enterprises (47%) harvested more than the MAI but in general the difference was small. Only two enterprises (7%) severely overharvested in comparison to the MAI. These two also had the largest NPV values, but were working with high standing inventories. They probably would decrease harvests once the large old growth forest base was harvested and they converted to younger forest estates. Continued monitoring would be necessary to ensure that CFEs harvesting more than annual growth do not continue this pattern for so long that the long-term harvest becomes unsustainable.

Forest Management

The cost-benefit analysis showed that all but one enterprise was profitable in its forest management. This result could be attributed to the low costs reported. These low management costs could be partly due to low investment into site preparation and regeneration activities. There were many cases where enterprises reported no costs in these two categories, suggesting that they rely mainly on natural regeneration. Costs could have been even lower if CFEs spent less than the average 13% on investments for the community such as schools and roads, though this was not an excessive amount given the importance of the forestry enterprise to sustainable livelihoods in the *comunidades* and *ejidos*. The largest cost category was technical assistance; this cost could be reduced if community members were trained to do the technical activities for which they currently have to pay. However, the growth rates for Mexican forests were quite low, on average 2.8 m^3/ha/yr, so the average forest management costs per cubic meter were still greater than for exotic fast grown plantations in other countries.

On average, only 7 and 3% of the forest management incomes for CFEs came from commercializing NTFPs and implementing PES schemes, respectively. Ninety percent of forest management income came from timber sales. NTFPs and PESs could have more potential to increase the income and profitability of the enterprises, but would need market development.

Harvest

The results from the timber harvesting analysis and profitability indicate that those costs were moderately expensive. The mean of MX$506/$m^3$ (US$38/$m^3$) and the median of MX$397/m^3 (US$30/$m^3$) were greater than in some countries, considering these were just the cost to cut and haul the timber from the forest to the roadside. Several CFEs were more efficient, with costs of less than MX$200/$m^3$ (US$15/$m^3$). This timber, however, required transport costs to the mill as well, which added another MX$235/$m^3$ (US$18/$m^3$) on average. The majority of CFEs—22 of 30 (73%)—were profitable in their harvesting operations, but a few had very high costs.

Not all the volume that was harvested was for commercial sale. On average, CFEs sold 77% of their timber harvest, and the rest was considered waste or was used for household consumption. The harvesting included mainly pine, fir and oak. Pine accounted for 85% of the harvest on average while 8% was fir and 8% was oak.

Sawmill

The mean cost of lumber production was MX$2,340/$m^3$ (US$180/$m^3$) and the median cost was MX$1,503/$m^3$ (US$116/$m^3$). The product mix on average for the CFE was: 43% of Mill Run, 9% of Grade 1, 6% of Grade 2, 16% of Grade 3, 15% of Grade 4, and 11% of Grade 5. The more that any individual sawmill produced in large, high grade, high value lumber, the more it could justify higher costs.

The Mexican sawmills were generally profitable, with five exceptions, and with a median excess of sales revenues over manufacturing costs of about MX$483/$m^3$ (US$37/$m^3$). This constituted an approximately 30% profit margin, which was attractive for businesses.

Benchmarks

Benchmarks from other studies of community forests indicated that our survey results were both more variable and more optimistic in its ROIs and profits, despite relatively high costs. Still, the international competitiveness of Mexican CFEs has been challenging. At least two-thirds of the CFEs examined had costs of forestry, harvesting, and sawmilling that were higher than the costs reported from other countries producing pine. The slow growth of native forests made wood production costs high for many species and country, and Mexico cannot escape this problem. Logging on land with steep slopes has been expensive, but small-scale systems in Mexico could fare quite well in this regard since they have been labor intensive systems providing employment in processing. Sawmills have appeared to possess substantial production capacity, but have had low levels of annual production. This had led to high lumber production costs, at almost double the costs in the neighboring United States or in Southern Cone countries.

The large national demand for forest products and solid wood products has allowed the CFEs to have positive profits despite high average production costs. Thus, CFEs have been financially sustainable in Mexico. Other countries could produce cheaper wood but have needed to seek additional markets while facing depressed markets in the United States and Europe. Thus, the financial sustainability of communities could require policy interventions—incentives, tariffs, subsidies, or other—in the long run, and could need to improve the competitiveness of the local production compared to international markets.

CONCLUSIONS

This article has presented an extensive study of the value chain for a sample of CFEs in Mexico. The sample included 30 Type III and IV CFEs, which were those that generally have had the highest human capacity and best management. There were 992 CFEs in Mexico, with a wide range of sizes and manufacturing capacity. The sample for estimating the sustainability and profitability of the Mexican CFEs was relatively large; the sample included about 3% of all Mexican CFEs and about 10% of the 291 total CFEs belonging to Categories III and IV (291). This constituted one of the largest studies of community forestry to date, extending throughout the entire value chain from forest management to lumber manufacturing. Characteristics of the CFEs sampled varied considerably, but this could be expected for a study spanning 12 states and 30 CFEs across a large country, and given the challenges of collecting sensitive production and cost data from a variety of communities.

Overall, the study has indicated that while there is considerable variability in Mexican CFEs, they were mostly sustainable in the long run, and more of their operations in the forest management to lumber manufacturing value chain were profitable. Two of the CFEs were harvesting far more than a sustainable yield level, but both had extremely large base inventories, so could probably taper off the timber harvests as inventories declined. The other CFEs either had a moderate base inventory, or were actually harvesting less than they were growing in 2011. Their harvests of relatively rich natural forest estates almost always made forest management for the CFEs profitable, except in one case. Still, the CFEs could not exploit their rich natural forests excessively or indefinitely, especially those that were harvesting substantially or slightly more than they were growing. Otherwise, they would become unsustainable from financial, environmental, and social perspectives.

The concurrent Forster et al. (2014) study found that only 10 of 53 interviewed community forests in Quintana Roo were currently marketing timber, though 29 had at one time harvested timber, and 14 never had. That study concluded that the forest inventory, better species, and community organization were keys to determining if communities were still harvesting timber. Perhaps this could imply that communities that harvest too much timber also could stop being sustainable, and would have to cease market participation, though the authors lacked adequate inventory volumes per hectare to be able to empirically test this relationship (Forster et al., 2014).

The CFEs of this study also were fairly sophisticated in their management, as indicated by the fact that all had forest management plans to complement their land ownership and most had timber processing all the way through the forest value chain. Most CFEs also made profits on timber harvesting and lumber production, but there were more firms that lost money on these operations. It is important to note that this study was restricted to Type III and IV CFEs; the level of management and profitability were likely much different for Types I and II.

The profitability of the CFEs was encouraging, but was based on high prices for timber from forestry, high harvesting prices paid, and high lumber prices. These high lumber prices and high costs could be a threat by inviting cheaper wood to be imported, and from not so far away—the U.S. South or Chile. Thus, increased efficiency throughout the value chain could be more important in the future. Continued adaptations and improvements in their operations would be required for CFEs to prosper with global competition, but they have had a good forest resource and have demonstrated reasonable management skills and experience to recognize and make such improvements, with capacity building, the technical assistance from government organizations, and continued financial assistance. It is important to consider that many CFEs have obtained government subsidies and it would be interesting for future studies to analyze the effect these have had on the financial performance and sustainability of CFE operations. The CFEs could also expand income from NTFPs and PES, which still have been minor contributors to income on average, and explore the commercialization of the 23% of wood that had been wasted during harvesting, as done by other CFEs in Mexico not included in this study.

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