Differentiation and concordance in smallholder land use strategies in southern Mexico's conservation frontier

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Forest cover transitions in the developing tropics are conditioned by agricultural change. The expansion, intensification, and diversification of agricultural land uses are tied to regional economic/environmental regimes and decisions of local farming households. Land change science and agrarian systems research share an interest in the drivers of household strategies, land use impacts, and typologies of those land uses/drivers. This study derives a typology of farming households in southern Mexico based on emergent patterns in their land use combinations and analyzes their household and policy drivers. The results reveal broadly diversified household land use portfolios as well as three emergent clusters of farmstead production orientation: (*i*) extensive subsistence-oriented conservationists, (*ii*), dual extensive-intensive farmers, and (*iii*) nonextensive diversified land users. Household membership in these clusters is uneven and strongly related to tenancy, land endowments, wage labor, and policy subsidies. Although most households are following a nonextensive agricultural strategy incorporating off-farm incomes, the likelihood of a regional forest transition remains debatable because of the disproportionate deforestation impacts of the less common strategies. Conservation development policies in the region need to accommodate diverse smallholder farming rationales, increase off-farm opportunities, and target sustainable development with the assistance of community conservation leaders.

smallholder agriculture | land use clusters | sustainability | Mexico

Of fundamental concern in land change and sustainability sciences (1, 2) are the processes driving land use, change, and vulnerability in the forested tropics. Tropical agroecosystems are undergoing widespread changes driven by shifts in economic (3) and environmental (4) regimes. Multiple studies (5) reveal agricultural expansion as the main proximate cause of deforestation globally, as well as in Latin America. Economic-institutional factors drive most deforestation in Latin America, yet they have also been linked to forest resurgence recently (6). For instance, globalization, outmigration, nonfarm employment, structural adjustment, agrarian reform, and/or environmental conservation have spurred forest recovery, referred to as the "forest transition," in some regions (3, 7). The complexity of such forest outcomes is tied to heterogeneous land manager characteristics, livelihood strategies, and land uses. Comprehending farmer strategies as they respond to changing structural/environmental contexts is therefore essential to assessing the drivers of forest change and sustainability in Latin America and beyond.

Land change science benefits from research in agrarian decision making, which has documented the economic and ecological logics of swidden systems and the potential for "win-win" options reconciling environmental sustainability, economic growth, and poverty alleviation (8–10). Farming households, the ultimate agents of land change (11), base land management strategies on food/livelihood security objectives (12); natural, human, financial, and social capital available (13); and broader political-institutional relations (14, 15). Agricultural change in postfrontier regions (after initial colonization-related deforestation) continues to be linked to household life cycles (16) but is increasingly connected to capitalist and intersectoral articulation processes introducing unique income opportunities (17, 18). Nonfarm incomes now constitute up to 40% of rural incomes in Latin America (19), generating cash to finance agricultural inputs, mitigate crop/policy/environmental risks, and enhance food security (12, 20).

Heterogeneity in farming households underpins variability in policy outcomes and the feasibility of win-win scenarios, and research has linked household-specific drivers to land use impacts, often with high spatial specificity (21–23). Efforts to classify farming households have long focused on the divide between subsistence and market farming (24), need- or opportunity-driven livelihood diversification (25), household wealth profiles (10), life cycles (16), and property ownership (17). Such driver-based classification is especially relevant when theory or a priori evidence indicates the preeminence of certain factors. Yet, the actual variability of farming strategies complicates efforts to connect driver typologies (implicating decision processes) to their land use footprints (resulting in land use patterns), revealing few distinct trends (5). An alternative to classifying driving forces is to identify the main combinations of smallholder land uses that emerge in particular regional contexts. A key advantage of working with statistical clusters of land uses [instead of considering them individually or jointly (26)] is the ability to develop a regionally relevant land-centered typology, which can then be linked to driving forces or forest cover implications.

This article approaches such a typology in investigating emergent patterns of land use and decision making by smallholder farmers in southern Mexico. Agricultural development in recent decades has driven up to 1.3% per annum. the loss of Mexico's forests (27), 80% of which are held in communal lands (28), yet some regions are also experiencing secondary forest regrowth. Economic liberalization has accelerated since the land/agrarian reform policies of the 1980s* were introduced (29), and has coincided with global conservation interest and the expansion of national forest reserves. Widespread environmental concern reflected the southern Yucatán's designation as a "hotspot" of biodiversity and deforestation (30), laying the foundation for the nation's largest protected area and the "greening" of rural agricultural livelihoods (31). Here, as elsewhere, antipoverty programs, neoliberal reform, and environmental policies coincide in the goal of agricultural intensification, although they may diverge in its prescribed forms. Not all households have chosen to intensify production, however, instead combining extensive and intensive agricultural land uses with conservation and nonfarm activities in variable configurations, with implications for forest cover.

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*On a foreign policy level, these trends culminated in the General Agreement on Trade and Tariffs with the United States in 1988 and the North American Free Trade Agreement in 1992.

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Anchored within a land use/cover science framework, this study analyzes household land uses in 2002 to identify trends toward clustering and investigates their drivers. It evaluates the following a priori expectations suggested by the theoretical literature and regional land use dynamics: (*i*) Individual households maintain diversified land uses, yet broad clusters of land use exist, and (*ii*) Land use clusters are linked to household strategies/factors of agricultural production as well as to policies, specifically, household demographic factors, residence times (tenancy) in the region, land endowments, nonfarm and forest extractive activities, and agricultural and conservation policy subsidies. Tracing these connections reveals how key trade liberalization and conservation instruments manifest themselves in southern Mexico, with lessons for other regions facing similar policy contexts. Moreover, they reveal whether households that vary widely (in decision-making drivers) actually follow similar land use strategies (concordance) or whether similar households elect very distinct land use combinations (differentiation). Such patterns of differentiation and concordance influence forest transitions in the region, and elsewhere in Latin America and beyond.

Study Area

The municipality of Calakmul lies in the southeastern corner of Campeche, one of Mexico's most impoverished and biodiverse states. The area's karst soils have little surface drainage and are distributed over elevations of 100–300 m above mean sea level in uplands of medium-tall forests interspersed with large depressions in-filled with sediments (32). Mean annual rainfall varies from 900 to 1,400 mm along a north-south gradient, with the winter-spring dry season lasting 5–6 months. Impacts of anthropogenic land use can exceed those of "natural" environmental variation in forest structure and function (33).

Human use of local forests dates back to the ancient Mayan civilization (34, 35). The region was (re)settled from the 1960s through the 1980s with *ejido* land grants to immigrants arriving from several Mexican states (36). Agriculture initially focused on *milpa*, a swidden-based rotation of maize, beans, and squash for subsistence (34), but, more recently, includes commercial cultivation of jalapeño chili, horticulture, agroforestry, and pasture. Within ejidos, households' land use choices are tied to their specific needs, assets, and aspirations and are subject to ejido land tenure. Households are also increasingly influenced by structural policies in the region. They could receive a variety of payments through government agencies, including the crop "subsidy" PROCAMPO† (24, 37, 38) that was intended to modernize/intensify the Mexican agricultural sector and has been linked to deforestation-based land uses in the region. A national ejidal rights titling program (PROCEDE) now enables land privatization, although most of Calakmul's ejidos have elected to title only their urban house lots and not their agricultural holdings.

Accelerating deforestation rates after ejido settlement (39) raised conservation concern. The Calakmul Reserve was established in 1989 and designated a United Nations Educational, Scientific, and Cultural Organization biosphere reserve in 1993, auguring conservation development policies (40). Households participate in various conservation initiatives endorsed by reserve, state, nongovernmental organization (NGO), and civil society institutions, availing themselves of subsidies and extension programs. Foremost among such programs are (*i*) efforts to sedentarize agriculture by intercropping milpa with "green fertilizers" (leguminous *Canavalia ensiformis* or *Mucuna mucuna*) locally known as roza-pica-siembra (RPS), and (*ii*) small-scale agroforestry-reforestation projects designed to increase local biodiversity, tree cover, and sustainable livelihood opportunities. Such conservation initiatives attempt to divert household land uses away from deforestation-based strategies. The following sections present and discuss the results of an analysis that focuses on two fundamental questions: (*i*) Are there emergent clusters of households based on how they combine land uses such as milpa, chili, pasture, RPS, agroforestry-reforestation, and fallow management? (*ii*) If so, what household characteristics, land tenure attributes, and policy factors explain those clusters?

Results

Summarizing Land Use Patterns and Household Characteristics. Households practiced a variety of land uses across the surveyed ejidos. They cultivated 0–9 ha of milpa, planting 3.48 ha on average (SD = 2.14). Farming chili requires significant capital for agrochemical inputs and labor during weeding and harvests (41). Households cultivated 0–3 ha of chili, with an average of 0.67 ha (SD = 0.76). Households kept variably sized pastures of 0–14 ha (mean = 2.48, SD = 4.24). They invested 0–3 ha in RPS (mean = 1.11, SD = 0.99) and 0–7.5 ha in agroforestry-reforestation (mean = 1.41, SD = 1.71), which are both promoted conservation uses. Although all households produce forest fallows, one ejido has a nonparcelized land tenure structure wherein households do not retain rights to their formerly farmed plots unless they continue production or fallow improvement through agroforestry-reforestation. The relinquished plot may revert to secondary vegetation, be claimed by another household, or both. Fallows in the other two ejidos occur within households' demarcated land parcels and are managed by them. A dummy variable captures whether or not the household managed parcelized fallows. Table 1 summarizes households' demographic and land tenure (duration and areal size of ejido land rights) characteristics. It reports household livelihood diversification beyond the agricultural plot, detailing the number of distinct products/uses derived from primary/secondary forests and diversity of nonfarm income sources accessed since arrival in the region. Finally, it lists households' land area subsidized through policy instruments (PROCAMPO for agricultural crops, typically milpa; RPS subsidies for green fertilizers; and NGO payments for agroforestry-reforestation plots).

Identifying Emergent Clusters of Household Land Use. K-means clustering yielded a multivariate classification (42) of diverse land uses (milpa, chili, pasture, RPS, agroforestry-reforestation, and parcelized vs. nonparcelized fallow management). Three clusters of households emerge (Table 2), with comparable between-cluster Euclidean distances of 10.658 (clusters 1 and 2), 10.320 (clusters 2 and 3), and 8.314 (clusters 1 and 3). Examining each cluster's land uses suggests that households may be broadly characterized as (*i*) extensive subsistence-oriented conservationists, (*ii*) dual extensive-intensive agriculturalists, and (*iii*) nonextensive‡ diversified§ land users. Cluster 1 consisted of three households (6.5% of the sample), which invested the largest areas in milpa (cluster center = 10.42 ha, range: 5.96–13.3 ha) as well as the conservation land uses of RPS (cluster center = 1.77 ha, range: 1–2.31 ha) and agroforestry-reforestation (cluster center = 5.08 ha, range: 1–7.5 ha). On

†PROCAMPO, introduced in 1992 in lieu of price supports after the North American Free Trade Agreement, is an income transfer program that compensates farmers in the medium term for income lost as a result of trade liberalization. It involves the payment of a fixed sum of money per hectare of area cultivated in major crops, including maize, based on regional averages. Most farmers in Calakmul collect PROCAMPO payments for area planted in maize (milpa), although a few include agroforestry and milpa intercropped with green fertilizers within their PROCAMPO hectares.

‡These households are characterized as nonextensive rather than intensive, because, despite the smaller areas dedicated to various land uses, the evidence does not explicitly point to agricultural intensification (e.g., greater focus on chili cultivation).

§It is important to keep in mind that despite the "diversified" label attached to group 3, all households maintain a mix of diverse land uses, although households in group 3 tend to have smaller extents but more even mixes of the diverse land uses in question relative to households in group 1 or 2.

Table 1. Summarizing household characteristics and institutional subsidies (n = 46)

	Minimum	Maximum	Mean	SD
Duration of land right/access, years	8.00	42.00	16.20	7.10
Total land entitlement, ha	40.00	100.00	72.61	23.61
Labor/consumer ratio	0.17	1.00	0.61	0.22
No. diverse forest uses	1.00	9.00	4.00	1.99
No. diverse wage jobs held during land right/access	0.00	4.00	1.35	0.99
PROCAMPO payments, ha	1.50	9.00	4.12	1.98
Institutionally supported milpa with green fertilizers, ha	0.00	4.00	1.48	1.03
Institutionally supported agroforestry-reforestation, ha	0.00	8.00	0.85	1.48

average, they kept the smallest chili plots (cluster center = 0.33 ha, range: 0–0.5 ha) and a small to moderate extent of pasture (cluster center = 1.25 ha, range: 0–2.75 ha). In contrast, the nine households that comprised cluster 2 (dual extensive-intensive agriculturalists, representing 19.6% of the sample) cultivated moderate areas of milpa (cluster center = 6.33 ha, range: 1.44–9.5 ha), smaller areas in RPS (cluster center = 1.64 ha, range 0.25–3 ha) and agroforestry-reforestation plots (cluster center = 1.32 ha, range: 0–4.5 ha), but the largest areas of chili (cluster center = 1.12 ha, range: 0.5–3 ha) and pasture (cluster center =10.31 ha, range: 6–14 ha). Finally, the third cluster (nonextensive diversified land users) constituted the largest number (n = 34) and vast majority (73.9%) of households, planting the smallest areas in all land uses but chili. Within this group of households, milpa led the set of land uses in areal allocation (cluster center = 3.21 ha, range: 0–7 ha), followed by agroforestry-reforestation (cluster center = 1.11 ha, range: 0–3 ha), RPS (cluster center = 0.92 ha, range: 0–3 ha), chili (cluster center = 0.57 ha, range: 0–2.5 ha), and pasture (cluster center = 0.51 ha, range: 0–5 ha). Table 2 also lists relevant F statistics and significance levels.

Explaining Clusters of Household Land Use Strategies. The drivers of emergent land use clusters were analyzed using multinomial logistic regression. The model fit the data well (pseudo-R^2 = 0.5473; Wald χ^2 = 56.08, P = 0.000); Table 3 denotes the statistical significance and parameter estimates of variables predicting cluster membership relative to the base case (cluster 3, the nonextensive diversified households). The duration of household land rights is a significant and positive predictor of household membership in cluster 1 (extensive subsistence-oriented conservationists) and cluster 2 (extensive-intensive agriculturalists) relative to cluster 3 (nonextensive diversified). Other hypothesized drivers were not statistically significant in distinguishing household membership between clusters 1 and 3. Membership in cluster 2 relative to cluster 3 is related positively to total land entitlements and PROCAMPO subsidies and negatively to wage labor participation. Forest product dependence and conservation subsidies did not significantly explain household cluster membership. Hypothesized drivers/independent variables (e.g., labor-consumer ratios) that were not statistically significant indicate that households similar in those (e.g., demographic) aspects are nevertheless diverging in their emergent land use combinations, possibly attributable to the effects of other household (e.g., land endowments), policy (subsidies), or unobserved variables.

Discussion

The results provide evidence of an uneven clustering of land use strategies in Calakmul as its farming sector is exposed to the dual effects of trade liberalization and conservation. K-means clustering has been effectively used in land characterization (43–45). In interpreting the results, it is important not to overemphasize the predominant land use in clusters (e.g., large milpa extents of cluster 1), because the statistical method explicitly combines assemblages of diverse land uses into a typology. The three household land use clusters detected have asymmetrical membership rates and broadly correspond to (i) extensive subsistence-oriented conservationists (smallest membership), (ii) dual extensive-intensive agriculturalists (intermediate membership), and (iii) nonextensive diversified land users (largest membership). The typology confirms the hybridity of the region's farm sector, with no households specializing exclusively in subsistence or commercial farming.

Extensive subsistence-oriented conservationists (group 1) were the smallest group[¶] but accounted for large holdings (up to 13.3 ha) of milpa, the most common regional land use. These households combined milpa with some chili and pasture but, significantly, devoted substantial land and labor to conservation uses (up to 2.31 ha in RPS and 7.5 ha in agroforestry-reforestation). The head of one of the households in group 1 had been trained as a local promoter of RPS. Certain social and economic factors characterize group 1: By 2002, households had held their land rights for a long period (19–26 years), varied from 40 to 100 ha in land entitlements, had medium-sized families (6–8 people) of variable labor-consumer ratios (0.38–1), harvested diverse types (3–6) of timber and nontimber forest products (NTFPs) to supplement their household economy, and engaged in few (1–2) wage labor activities. They benefited strongly from farm subsidies (up to 6.5 ha in PROCAMPO) and conservation payments (up to 2 ha in RPS and 8 ha in agroforestry-reforestation). The analysis reveals distinct but partial support for these hypothesized drivers of land use clusters in the region. The length of household tenancy was a significant predictor of membership in group 1: By 2002, all three households in this group had held land rights in the region for a long time (19–26 years), and two households were founding members of their respective ejidos (24–26 years in residence).

Independent of the model, qualitative data from in-depth interviews indicated that these households also held strong political ties to the regional inter-ejido union and its robust agroforestry program initiated a decade before the advent of conservation subsidies in 1999–2002. Such informal connections and networks can leverage social capital (46, 47) and influence portfolios (26) or changes (21) of land use. Interactions of external projects with local social capital in Mexico are complex (48); although the availability of projects created opportunities region-wide in Calakmul, those with greater social capital may have been better positioned to take advantage of them. Interestingly, none of group 1's households hailed from the ejido that received the least state conservation investment as revealed in ancillary data. Group 1 represents long-term resident, subsistence-oriented agriculturalists who have incrementally built a green diversification strategy consistent with their experience and networking with community-based conservation projects over the past decade. Community founders and conservation leaders are typically the minority in ejidos, and it is thus unsurprising that this group has the lowest membership of the three clusters identified. The forest cover impacts of this group are complex. Although their conservation leadership is leading to increasing forest recovery in improved and managed fallows (e.g., agroforestry-reforestation), these gains are offset by their continued reliance on agriculturally extensive uses. Previous analyses (26) of household land allocations to individual uses (instead of their emergent clusters as examined here) demonstrated that although

[¶]It is possible that a larger survey over a greater number of ejidos or a stratified random selection may reveal greater proportions of membership in cluster 1. Yet, a random sampling strategy remains useful to contrast dominant vs. rare groupings and to highlight the overall unevenness of chosen strategies.

Table 2. K-means cluster analysis: Emergent household land use groups and analysis of variance among them

	Cluster centers (no. households)						
	1 (3)	2 (9)	3 (34)	Cluster mean square (df = 2)	Error mean square (df = 43)	*F*	Significance
Milpa	10.42	6.33	3.21	94.979	4.798	19.797	0.000
Chili	0.33	1.12	0.57	1.233	0.554	2.227	0.120
Pasture	1.25	10.31	0.51	343.507	2.828	121.480	0.000
Milpa-green fertilizers	1.77	1.64	0.92	2.542	0.921	2.761	0.074
Agroforestry-reforestation	5.08	1.32	1.11	21.784	2.061	10.569	0.000
Fallow parcelization	1.67	1.44	1.68	0.194	0.240	0.806	0.453

conservation subsidies strongly drove conservation land uses, they were also linked to larger milpa and chili holdings.

A fifth of the households simultaneously engaged in extensive and intensive agriculture (group 2), investing substantially in extensive land uses (up to 9.5 ha of milpa and 14 ha of pasture) but also cultivating the largest extents (up to 3 ha) of labor- and capital-intensive chili. Their land uses are centered in traditional agripastoral domains (although they experiment with conservation alternatives, their relative extents of green land uses vis-à-vis milpa and pasture are small). This strategy clearly has negative impacts on forest cover, and increased group membership could be expected to reduce the possibilities of a regional forest transition. By 2002, group 2 held 80–100 ha of land for 9–24 years. Both endowments and duration of land rights are significant for this cluster (relative to the base case of group 3), as confirmed by the logit model (Table 3). Group 2 includes demographically diverse households (family sizes of 3–11 people and labor-consumer ratios of 0.4–1), which also varied substantially in their uses of forests (1–8). Wage labor participation and PROCAMPO receipts differentiate membership in this cluster relative to group 3. Group 2 households engaged in few (0–2) wage labor activities and benefited from PROCAMPO subsidies of 3–9 ha, which appears to be quite relevant to their extensified land use combinations. They availed themselves of some conservation subsidies. With up to 3 ha subsidized for RPS, their average areal extents in RPS were marginally lower than those of group 1 but much higher than those of group 3. Group 2 households had low subscription rates in agroforestry-reforestation projects, with only 0–3 ha subsidized compared with up to 8 ha for certain farming households in group 1. Conservation subsidies were not significant predictors of membership in group 2 (Table 3).

The vast majority of households are following a third strategy, foregoing major investments in extensification, intensification, or conservation land uses. This third group is instead adopting an agriculturally cautious diversification of land use, combining a small to moderate amount of milpa with a little chili, pasture, and conservation. The households have wide land tenure and socioeconomic differences: land entitlements of 40–100 ha, land rights over 8–42 years, family sizes of two to nine people with labor-consumer ratios of 0.17–1, and one to nine diverse uses of forests. Wage labor is a significant predictor of membership in group 3, especially relative to the extensive, agripastoralists of group 2. Group 3 households engaged in zero to four wage labor activities, on average, tapping almost double the sources as households in group 2 (and more than double the sources as household in group 1). This group thus incorporates the greatest nonagricultural livelihood diversification of the households. Interestingly, all surveyed households of one of the ejidos were classified into this strategy cluster. This ejido, the most recently settled of the three surveyed, has seen increasing labor migration of its residents, an important recent phenomenon further attesting to the importance of nonfarm income streams (49). It also received the least funding from state conservation programs over the previous decade, corresponding to the smallest average holdings in conservation land uses here. Group 3 received the smallest PROCAMPO payments on average (3.65 ha) compared with group 1 (5.17 ha) or group 2 (5.56 ha). This economic variable was a significant predictor of membership in group 3 (especially compared with group 2). Despite being the least oriented toward conservation land uses, group 3 may be of greatest interest with respect to a regional forest transition. Rather than embracing the "green" practices displayed by the extensive subsistence-oriented conservationists of group 1, the smaller agricultural areal footprints of group 3 households are linked instead to their shorter durations in the region with vested land rights, smaller land entitlements, increased reliance on nonfarm livelihood income streams, and lower agricultural subsidies (PROCAMPO). Whether or not such a strategy will lead to a forest transition depends strongly on continued regional residence times and the viability and articulation of wider nonfarm economic opportunities with regional agriculture.

Conclusion

As the North American Free Trade Agreement (NAFTA) unfolded, a large national survey in 1994 (24) of Mexico's ejidos found that land entitlements determined whether rural households were net buyers, sellers, or self-sufficient in maize production. Although the demise of ejido agriculture after NAFTA was heralded by some (50), the region examined here reflects the continuing reliance of ejido households on farming livelihoods. This reliance is deeply differentiated and remains connected to entitlements; however, instead of a clear divide between subsistence vs. commercial farmers (or buying, selling, or self-sufficiency), this study reveals a more complex pattern of household differentiation combining both subsistence maize and commercial chili cultivation with wage labor, pasture production, and conservation land uses. This differentiation, furthermore, is linked to household tenancy and tenure, engagement with nonfarm opportunities, and policy factors. In light of the results obtained, this work joins with other calls for a refined focus that illuminates the diversity of farm and nonfarm livelihoods in rural Mexico and Latin America, fundamentally complicating the notion of a "typical" postfrontier farmer. This complexity, however, can be distilled into a few sets of emergent strategies and analyzed in relation to household and policy drivers.

Although a deeper investigation of livelihood divergence and convergence requires long-term panel data to highlight processes of livelihood change and path dependence (e.g., land use choices that are irreversible in some time frame), this cross-sectional analysis reveals some important patterns. Households follow hybrid land use strategies but also tend toward certain broad mixes of land use subject to policy or household/community drivers, especially the areal extent and duration of land rights, wage income sources, and agricultural policies. These factors exert leverage in driving otherwise similar (e.g., demographically comparable) households into distinct pathways/clusters of com-

Table 3. Multinomial logistic regression results: Parameter estimates and variable significance for cluster membership as a function of household and policy drivers

Cluster no. of case (base case = cluster 3)		B	Robust SE	Z	Significance
1	Intercept	−0.535	3.908	−0.014	0.891
	Duration of land right/access, years	0.154	0.065	2.37	0.018
	Total land entitlement, ha	−0.019	0.035	−0.054	0.590
	Labor/consumer ratio	−0.092	2.596	−0.04	0.972
	No. diverse forest uses	−0.262	0.787	−0.33	0.739
	No. diverse wage jobs held during land right/access	−3.170	2.779	−1.14	0.254
	PROCAMPO payments, ha	−0.726	0.538	−1.35	0.177
	Institutionally supported (subsidized) milpa with green fertilizers, ha	−0.464	0.689	−0.67	0.501
	Institutionally supported (subsidized) agroforestry-reforestation, ha	2.433	1.893	1.29	0.199
2	Intercept	−15.929	1.881	−8.47	0.000
	Duration of land right/access, years	0.068	0.010	6.72	0.000
	Total land entitlement, ha	0.112	0.043	2.61	0.009
	Labor/consumer ratio	0.381	1.051	0.36	0.717
	No. diverse forest uses	0.396	0.318	1.25	0.213
	No. diverse wage jobs held during land right/access	−1.571	0.383	−4.10	0.000
	PROCAMPO payments, ha	0.635	0.218	2.92	0.004
	Institutionally supported (subsidized) milpa with green fertilizers, ha	1.225	1.179	1.04	0.299
	Institutionally supported (subsidized) agroforestry-reforestation, ha	−0.677	0.493	−1.37	0.169

bining land uses (differentiation). As well, the region exhibits a broad concordance of land use strategies across a large diversity of households as captured in group 3. It is plausible that this particular combination of land uses minimizes livelihood risk. Most households appear to be progressing along this trajectory of agriculturally cautious diversification, maintaining smaller agricultural holdings with a greater reliance on off-farm income sources. Yet, a preference, even by a few households, for traditional agripastoral domains centered on pasture can pose threats to forest cover and sustainability. The agricultural subsidy PROCAMPO, rather than promoting agricultural intensification, appears to enable extensive agripastoral clusters of land use strategies among Calakmul's households. Households with lower PROCAMPO payments are significantly more likely to combine smaller agricultural allocations with wage income sources. On the other hand, environmental conservation projects and subsidies to promote "green" land uses may succeed in increasing households' landholdings in those precise uses (26). However, such subsidies are not significant in explaining how households actually combine those green land uses with milpa, chili, and pasture holdings more broadly to produce emergent land use groupings; other economic and land tenure factors emerge as far more influential. Green policies may have unintended consequences, such as enabling corollary agricultural deforestation in regions of parcels not under conservation uses (21, 26). Although ejido conservation leaders target food security and sustainability through a simultaneous focus on subsistence cultivation and green land uses, their overall green diversification strategy is rare and linked to their identities as community founding members; their ability to sustain this strategy remains unclear in the absence of secure markets for NTFPs; the purported benefits of some of those institutionally endorsed land uses may be uncertain[⊥] (51); and their simultaneous extensification-led deforestation justifies environmental concern (21).

A win-win policy scenario in Calakmul would need to achieve forest conservation, poverty alleviation, and economic development. Conservation concern may most aptly center on the activities of households in traditional agripastoral domains, although poverty alleviation and food security remain relevant for the majority of farmers, the agriculturally cautious diversifiers, a heterogeneous and land-poor group trying to buffer livelihood risks through off-farm incomes. It is doubtful that win-win solutions can be realized in the region if the vast majority of its land managers remain its most vulnerable denizens. The results suggest that regional economic and environmental policies are not likely to meet with success unless they recognize patterns of differentiation and concordance in smallholder farming decisions and emergent land use strategies, accommodate the need for seasonal and longer term off-farm opportunities, and support local food security with subsistence and commercial agriculture—within a broader vision for regional sustainability. The last goal may be best targeted by enlisting the assistance of local conservation leaders, the green diversifiers, to strengthen social capital, networks, and institutional infrastructure.

Materials and Methods

Data used herein are predominantly derived from household and land use surveys conducted in 2002 to elicit land use and livelihood strategies in three ejido communities in Calakmul. All surveys were conducted with informed consent. Farmers in each ejido were randomly chosen for interviews and represent ≈30% of total registered *ejidatarios*. *Pobladores*, farmers without *ejidatario* rights, make up 3% of the households and are not included in the survey sample. The three ejidos were selected to lie along a north-south rainfall gradient along the buffer zone of the Calakmul Biosphere Reserve as well as a gradient of state investment in agricultural and conservation-based projects over the previous decade (1991–1999), as derived from state records in Campeche City. The ejidos differed in ethnicity: one ejido housed predominantly *mestizo* families originally from the state of Tabasco, another was comprised of Chol families hailing from Chiapas, and the third was settled by Mayan households from Campeche's Dzitbalché region. Although all three ejidos were internally parcelized,** only two practiced parcel-based agriculture. The third ejido permits household agricultural activities anywhere within its (undivided) common use zone. This complicates a one-to-one mapping of households to their secondary forest fallows, because the

[⊥]Soil analyses conducted by the author in 2002 did not display significant differences in soil nutrient content among milpa and RPS plots, although some differences in ground cover and weed encroachment were apparent. Agroforestry-reforestation plots had higher species richness but lower heterogeneity (Shannon-Weiner indices) compared with secondary forest fallows of similar age and use history.

**An internal parcelization is undertaken by the ejido for its autonomous land tenure regulation and does not involve registering with PROCEDE, the national ejidal rights titling program. Usually, such parcelization entails the allocation of a specific measured parcel of land to each *ejidatario*, who then locates agricultural activities within that designated area. Most formal parcelization (registered with PROCEDE) occurs within the "urban" zone of ejidos and involves the demarcation and titling of households' residential house lots.

latter are not assured to remain under the producing household's management unless "improved" through tree plantings. A total of 48 households and all their fields (over 450 fields) were surveyed in the three ejidos; 46 households were retained after outlier removal. Data were collected on major land uses derived from Global Positioning Systems-assisted field surveys of parcels in joint visits with the land manager (milpa, chili, pasture, milpa intercropped with green fertilizers, agroforestry-reforestation, and fallows under household management) as well as on household characteristics and institutional subsidies received. Labor-consumer ratios were calculated using the age range of 13–75 years for available labor, because field research and participant observation revealed this broad participation in agricultural work. K-means clustering of land use data was used to derive emergent clusters of household land use combinations. A solution of three clusters was chosen among solutions of two to six clusters for better predictive ability, higher per-cluster sample sizes for subsequent statistical analysis, and easier interpretation. Multinomial logistic regression investigated theorized drivers of group membership using cluster 3 as the base case and controlling for group effects [via the cluster function in STATA (Stata Corp.)]. Two additional variables were considered for inclusion in the model but were dropped after correlation analyses to avoid multicollinearity: household age (proxied by tenancy) and ejido (dummy variable, proxied by land entitlement). Statistical analysis was performed with SPSS 17.0 (SPSS, Inc.) and STATA 10.0.

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