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Woody Cover and Local Farmers' Perceptions of Active Pasturelands in La Sepultura Biosphere Reserve Buffer Zone, Mexico

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La Sepultura Biosphere Reserve—created in 1995 in Chiapas, Mexico—is well known for its biodiversity. Its buffer zone, harboring the upper "Tablón" river basin, has been intensively managed by peasants for 48 years. We carried out interviews with cattle producers at the Los Ángeles ejido, *coupled with field surveys of vegetation presence, to determine the nature and allocation of different vegetation associations and their relation to indicators of tree regeneration (sapling presence). Our data showed that 96% of the producers surveyed owned areas with open pastures, and 83% owned at least 1 patch of forested pastures where cattle browse. For oak-forested pastures, the results suggest a trend of high sapling presence with high tree cover. In contrast, for deciduous pastures, the results suggest a trend of high sapling presence with intermediate tree cover. These results are consistent with the hypothesis that woody vegetation within grazing areas may facilitate natural tree recruitment around reserves. Furthermore, these vegetation cover results suggest that within the pasturelands found today in the Los Ángeles* ejido, *some ranchers may be inadvertently conducting practices that are consistent with agro-silvo-pastoral systems.*

Keywords: *Biosphere reserves; tree conservation; pasture management; sapling recruitment; agro-silvo-pastoral systems; buffer zones; Mexico.*

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Introduction

UNESCO's Man and the Biosphere Program has established biosphere reserves with the purpose of trying to integrate biodiversity conservation and sustainable development. Biosphere reserves are designed with a core area (for biodiversity conservation) and a surrounding buffer zone (for sustainable development), which should in principle reduce the human pressure on biodiversity loss in the core area. Nevertheless, in most of the neotropics biosphere reserves are of a fragmented nature, often surrounded by a matrix of conventional agricultural and cattle production systems (DeFries et al 2007; Hansen and DeFries 2007; Vester et al 2007; Harvey et al 2008). Mexico is no exception. With 26 established biosphere reserves covering 71% of the nation's total land area (CONANP 2007), it has become increasingly important to know whether they are achieving their conservation objectives.

Figueroa and Sanchez-Cordero (2008) carried out a national-level evaluation of land-use and land-cover change between 1993 and 2002 to assess the effectiveness of natural protected areas (NPA) in Mexico. In this study, biosphere reserves had the highest proportion of effective areas when compared with national parks and other NPA. Out of 14 reserves evaluated, only 3 were not considered effective areas. La Sepultura Biosphere Reserve, created in 1995 in Chiapas, Mexico, was one of them.

La Sepultura is a biodiversity-rich area that harbors the upper Tablón river basin within its buffer zone; this basin drains toward the central valleys of Chiapas. La Sepultura's high diversity is under increasing pressure from the 23,145 inhabitants who live in the reserve's buffer zone (Carrabias et al 1999). The buffer zone matrix is dominated by maize and cattle production systems that have been intensively managed by peasants for at least 48 years (Aguilar-Martínez 2006). Slash-and-burn *milpa*-type agriculture was practiced on steep slopes during the 1960s and 1970s, followed by land-use intensification in the 1980s with continuous and intensive maize cultivation (or after very short fallow periods) with high use of agrochemicals (Carrabias et al 1999). In 1994, following the North American Free Trade Agreement (NAFTA), maize was no longer cost effective, and peasants shifted to cattle production, which meant intensive and extensive grazing (Nadal 2000). Pasturelands currently occupy half of the cleared land and continue to expand (Valdivieso-Pérez 2008). This shift from fallow to grassland across 5 decades at La Sepultura buffer zone has resulted in a mosaic of pasturelands with different levels of woody plant cover.

One goal of the managers of this reserve is to understand how different pasture-management practices relate to differences in vegetation associations, and which type of vegetation associations can potentially sustain forest tree regeneration on a long-term basis without deliberate tree restoration efforts (García-Barrios et al 2006). Pasturelands with high grass biomass have been shown to inhibit natural recruitment of trees (Zahawi and Augspurger 1999) by limiting nutrients and light needed for seedling establishment. Nevertheless, woody vegetation cover within grasslands can promote the re-establishment of late successional tree species and facilitate forest regeneration (Kleijn 2003). Hence, acquiring data on woody vegetation and its relationship to sapling presence is a very important step toward formulating conservation and development strategies in the La Sepultura buffer zone. Furthermore, the presence of the Tablón River Basin in and around the buffer zone makes the area of critical importance because the Tablón River is the main source of potable water for a number of down-river valleys. Consequently, transforming the current mosaic of pasturelands to an agro-silvo-pastoral system could create a more suitable habitat for biodiversity in the buffer zone of La Sepultura Biosphere Reserve and enhance the hydrological flow of the river (DeFries et al 2007; Jackson et al 2007).

The development of agro-silvo-pastoral systems is based on designs that incorporate the concepts of ecosystem services (Ricketts 2004) and biodiversity conservation (Kleijn 2003; Perfecto and Vandermeer 2002, 2008). Systems such as these could reduce the isolation and fragmentation of natural forests by creating a landscape matrix that harbors wild species and connects remaining forest fragments (Bhagwat et al 2008; Perfecto and Vandermeer, 2002, 2008). In this case, changing from conventional pasture-management practices to an agro-silvo-pastoral system could be a viable management option for maintaining the integrity of reserve-buffer zone systems, especially in areas where land use was unrestricted prior to the demarcation of the reserve.

Here we present preliminary data on woody cover presence, tree sapling presence (an indicator of tree recruitment), and pasture management across a mosaic of vegetation associations present within the pasturelands of the Los Ángeles *ejido*. An *ejido* is a community that has both privately owned land and communal lands that belong to the entire community. Los Ángeles is the biggest *ejido* and the first *ejido* founded within what today is the limits of the buffer zone of La Sepultura Biosphere Reserve. Therefore, it is an ideal location for the first study looking at vegetation associations and pasture management in the area.

We addressed 3 specific questions. First, what type of vegetation associations can be found in these pasturelands and what is the extent of their woody cover? Second, how does tree sapling presence differ across the various types of vegetation associations found within pasturelands of the *ejido*? Third, how do cattle producers view trees in their pasturelands? We expect pasturelands to be distinguished by the dominant habitat type (grass, shrubs, and trees) and the percentage of tree cover. Pasturelands with intermediate woody cover are expected to have the highest sapling presence across the mosaic of pasturelands present. We expect producers to have basic knowledge of different uses for trees but to have a preference for pasturelands without trees.

The results of this preliminary study will serve as a first step in classifying vegetation associations found in pastureland and in understanding the status of natural tree recruitment across these pastureland types. In addition, data from this study serve as baseline information to assist conservation and development efforts being formulated at El Colegio de la Frontera Sur (ECOSUR) through the establishment of the Participatory Project for the Development of Sustainable Silvopastoral Strategies in the Buffer Zone of La Sepultura Biosphere Reserve (García-Barrios et al 2006).

Methods

Study area

La Sepultura Biosphere Reserve is located in the northeastern part of the mountainous region of the Sierra Madre de Chiapas (between 16°00′18″ and 16°29′01″N and 93°24′34″ and 94°07′35″W). La Sepultura covers an area of 167,309 hectares, 8% of which is occupied by the core area and 92% by the buffer zone. The steep slopes ($>30°$) and the altitudinal gradient (2600–600 m) of the reserve create natural drainage of water to the Tablón River basin. They also have given way to a diversity of forest types such as evergreen pine forest, evergreen forest, mesophyte mountain forest, low deciduous rainforest, medium semievergreen and semideciduous rain forest, foggy chaparral, and savannas (Castro Hernández et al 2003).

The Los Ángeles *ejido* territory is located in the buffer zone of La Sepultura and covers an area of 4000 hectares, with an elevation ranging from 600–2000 m. The *ejido* pasturelands are characterized by steep slopes ($>30°$) and coarse sandy soils (mainly regosoles). The *ejido* has approximately 1000 inhabitants, with the majority making their living raising cattle for the market while cultivating corn and other products mostly for food self-sufficiency.

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TABLE 1 Qualitative description of the 4 main pastureland units found at the Los Ángeles *ejido*.

Pastureland units	Description
1. Open pasture (OP)	Hills with few or no trees (<10% cover). Dominant habitat type is grass with few if any shrubs.
2. Shrubby pastures (SP)	Hills with some trees (<30% cover), dominated by shrubby vegetation 1–1.5 m tall with high grass cover.
3. Woody pastures (WP)	Hills with some trees (<50% cover), dominated by young trees higher than 1.5 m with variable grass cover.
4. Forested pastures (FP)	Hills with dense tree cover (>60% cover) with an understory composed primarily of shrubs with low grass cover.

Pastureland types

Aerial photographs were used to determine a priori the sample areas for qualitative assessments. Qualitative assessments were done in June 2006. We selected 100 hills distributed variably in all cardinal directions from the *ejido* center. For all hills, we recorded aspect (north versus south facing to the river), forest zone (oak versus deciduous tropical), and dominant habitat type (grass, shrub, and tree). Based on the dominant habitat type of our qualitative observations, we determined that we could group our hills into 4 main pastureland types: (1) open pasture, (2) shrubby pastures, (3) woody pastures, and (4) forested pastures (Table 1).

Quantitative assessment of pastureland types was conducted in July 2006. Two parallel transects 10 m apart and perpendicular to the slope were established at the middle height of each hill ($N = 47$). All transects pulled together covered a total of 5788 linear meters on the north-facing and south-facing slopes of the drainage basin within the Los Ángeles *ejido* territory. Using the Point Intercept Sampling Method with 1-m intervals (Mueller-Dombois and Ellenberg 1974), we measured presence and abundance of woody cover (tree, shrub, and regrowth), percentage of ground cover (grass, rock, leaf litter, bare ground), and sapling presence and abundance (height <30 cm).

Natural tree recruitment

To look at the correlation between tree sapling presence and woody cover, we defined woody cover using 2 different indexes to reflect shrub or tree cover, as both types could facilitate recruitment at a certain level regardless of structural differences. The 2 vegetation cover indexes were as follows: (1) Local Tree Cover Index (LTCI), which corresponded to the number of meters that had tree cover within a sapling's 3-m linear neighborhood along the transect, and (2) Local Shrub Cover Index (LSCI), corresponding to the number of meters that had shrub cover within a sapling's 3-m linear neighborhood along the transect.

For tree sapling recruitment analysis, we divided the transect into 4 pooled pastureland types based on the forest zone (oak versus tropical deciduous) as well as a nonmetric multidimensional scaling (NMS) spatial ordination done for all hills, which suggested a separation of forest (including forested pastures) and pastures (including open pastures + shrubby pastures + woody pastures). The 4 pooled pasturelands are as follows: (1) oak forest, (2) oak pastures, (3) tropical deciduous forest, and (4) tropical deciduous pastures.

Cattle producers' view of trees in pasturelands

We conducted interviews with cattle producers during January 2007 based on the 4 main types of pastureland (open pastures, shrubby pastures, woody pastures, and forested pastures). These pastureland types were used as focal points to conduct 23 interviews with cattle producers from the Los Ángeles *ejido*. Each cattle producer was shown digital photographs of each of the 4 pastureland types. They observed and decided which pasturelands occurred on their property and which ones did not. A questionnaire containing 13 multiple-choice questions was designed for each pastureland on a property. The purpose of the questionnaire was to establish a baseline for determining the way that producers view trees, in terms of their importance for cattle production and their potential for conservation. The frequency of each answer was later computed for each question.

Statistical analyses

We performed a NMS spatial ordination for all hills to determine if they grouped into distinct clusters based on woody cover and ground cover presence. In addition, to determine if our qualitative classification of pastureland types was consistent with our hypothesis of tree cover presence, we conducted a Wilcoxon/Kruskal–Wallis Test with a Chi-Square approximation for each pastureland type (open pastures, shrubby pastures, woody pastures, and forested pastures). The relation of tree sapling presence to LTCI and LSCI for each pooled pastureland (oak forest, oak pastures, tropical deciduous forest, and tropical deciduous pastures) was determined using a 1-way ANOVA analysis of variance. All statistical analysis

FIGURE 1 Percent of linear meters (line transect with no width) with tree presence across pastureland types: open pastures (OP), shrubby pastures (SP), woody pastures (WP), and forested pastures (FP); Wilcoxon/Kruskal–Wallis test, $\chi^2 = 36.94$, df = 3, $P < 0.001$).

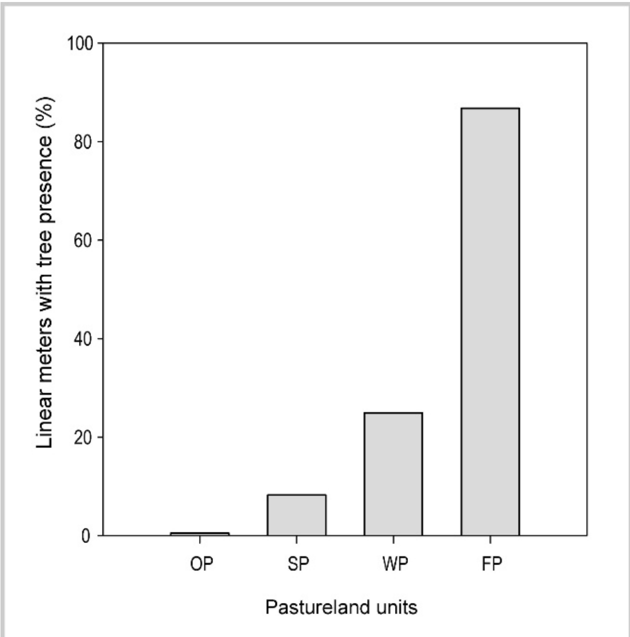
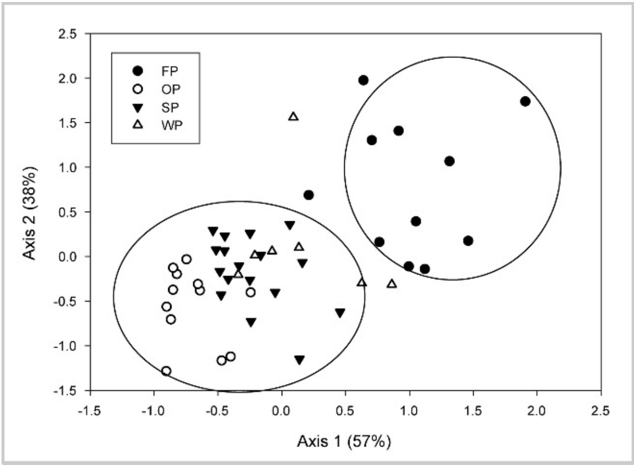


FIGURE 2 Pastureland hills ($N = 47$) in NMS (nonmetric multidimensional scaling) ordination space of the 4 types of pasturelands: open pastures (OP), shrubby pastures (SP), woody pastures (WP), and forested pastures (FP). Axis 1 captured 57% total variance. Axis 2 captured an additional 38% of total variance (cumulative total = 95%). Hills ordered by tree presence measured as relative Sorensen's distance. Two groups are established (circles): forest and pastures.



was done in JMP 7 (SAS Institute, Cary, NC, USA) and PC-ORD version 5.

Results

Pastureland types

Our qualitatively predefined pastureland types (open pastures, shrubby pastures, woody pastures, and forested pastures) differed in frequency of tree cover ($\chi^2 = 36.94$, df = 3, $P < 0.001$). Forested pastures types had the highest tree cover, while open pastures had the lowest (Figure 1). In addition, open pastures had the highest percentage of bare ground (18%) and an average of 72% grass cover.

A NMS ordination revealed a 2D solution where tree presence, measured as relative Sorensen's distance, explains 57% of the variance between hills. Based on this ordination, we grouped pasturelands in 2 distinct groups: (1) forested pastures and (2) pastures (Figure 2).

Natural tree recruitment

On average, tree saplings were found on less than 6% of the sampled linear meters. Forested pastures had a significantly higher density of sapling presence than pastures (Table 2; $\chi^2 = 206.783$, df = 1, $P < 0.0001$). Furthermore, when comparing between forest zones, sapling density was consistently higher in tropical deciduous forest than oak forest (Table 2; $\chi^2 = 9.876$, df = 3, $P = 0.0017$). No clear association exists between local tree/shrub cover (LTCI/LSCI) and sapling presence for each pastureland type. Nevertheless, we found different patterns between sapling presence and LTCI and LSCI for pooled pastureland types. In tropical deciduous pastures, higher sapling recruitment occurs at intermediate tree cover (Figure 3; Adj $R^2 = 0.99$, df = 3, $P < 0.0001$), while in oak forest, higher sapling recruitment occurs at high tree cover (Figure 4; Adj $R^2 = 0.99$, df = 3, $P < 0.0439$).

Cattle producers' view of trees in pasturelands

Out of 23 cattle producers interviewed at the Los Ángeles *ejido*, 74% were members of the local cattle association, and 26% were independent producers. All producers were males between the ages of 29 and 81. The 2 most common pastureland types owned by cattle producers were open pastures and forested pastures (Figure 5). Producers commonly apply slash-and-burn as a method of pastureland management. Nevertheless, this was not done uniformly; exclusive slash management occurred mostly on shrubby pastures (80%), while exclusive burn

TABLE 2 Sapling density (individuals per square meter) for the 4 pooled pastureland units where sampled area is equivalent to 0.2 m^2 ($\chi^2 = 9.876$, df = 3; $P = 0.0017$).

Pooled pastureland units	Sapling density
Tropical deciduous pastures	0.25
Tropical deciduous forested pastures	2.39
Oak pasture	0.05
Oak forested pastures	0.81

FIGURE 3 Percent of linear meters (line transect with no width) with sapling presence based on LTCI (3-m linear neighborhood, where 0 = no tree presence, 1 = 1 m with tree presence, 2 = 2 m with tree presence, 3 = 3 m with tree presence) for hills in pooled pastureland types of deciduous pastures. Results suggest a trend of high sapling presence with intermediate tree cover (Adj R^2 = 0.99, df = 3, $P < 0.0439$).

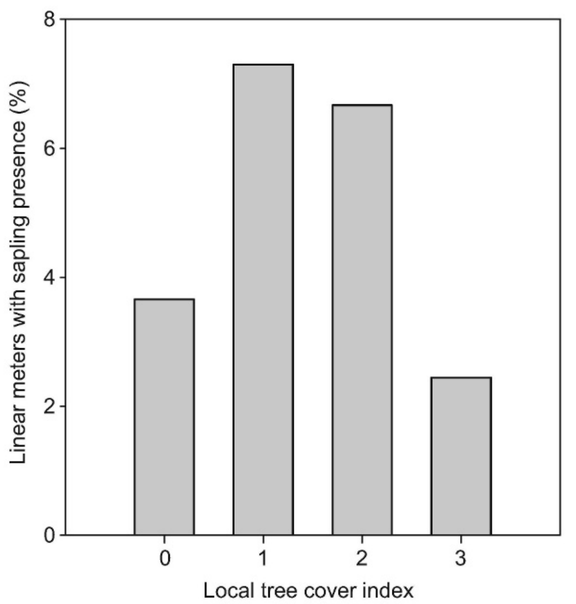


FIGURE 4 Percent of linear meters (line transect with no width) with sapling presence based on LTCI (3-m linear neighborhood, where 0 = no tree presence, 1 = 1 m with tree presence, 2 = 2 m with tree presence, 3 = 3 m with tree presence) for hills in pooled pastureland types of oak forested pastures. Results suggest a trend of high sapling presence with high tree cover (Adj R^2 = 0.99, df = 3, $P < 0.0001$).

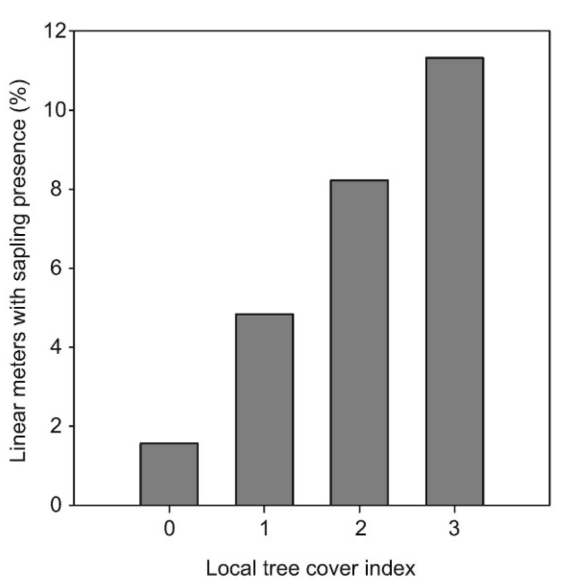
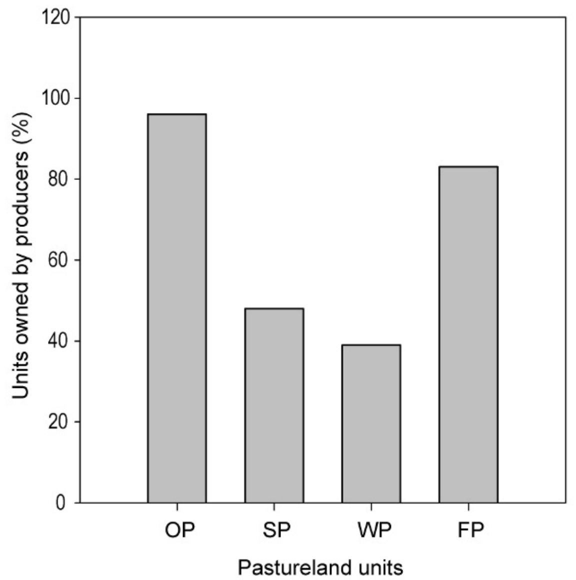


FIGURE 5 Percent of cattle producers who own each pastureland unit (N = 23 interviews) based on interviews and photographic inventory. Open pastures (96%), shrubby pastures (48%), woody pastures (39%), and forested pastures (83%).



management occurred mostly on open pastures (50%). When asked what they wanted for the future of their pasturelands, most producers (regardless of pastureland type) were content with their land and did not want to change anything. Only 50% of producers who owned shrubby pastures wanted to convert these pasturelands into open pastures. Surprisingly, 20% of producers wanted to have more trees on their pasturelands.

In general, the main reason that producers conserved trees was for cattle shading and wood extraction for fences, while producers that owned woody pastures conserved trees largely for their value as feed for cattle. The most common tree species conserved on the 4 pastureland types were as follows: *Quercus* sp (wood and fences), *Guazuma ulmifolia* (cattle forage), *Ficus* sp (shade), *Enterolobium cyclocarpum* (shade and cattle forage), *Byrsonima crassifolia* (fruit), *Gliricidia sepium* (cattle forage, live fences), and *Erythrina goldamanii* (cattle forage). Among the producers who opted to eliminate trees, the most common reason was that they were annoying to both humans and cattle. Some producers also mentioned that trees were eliminated because they shade the grass and lower its productivity. *Acacia* spp is described by most producers (>90%) as being one of the most bothersome trees because of its spines, and *Vernonia leiocarpa* is a shrub said to grow so big and wide that it covers the grass and lowers grass productivity.

Discussion

The Los Ángeles *ejido* presented a heterogeneous landscape composed of a gradient of pastureland types with different vegetation associations. Qualitative pastureland classification was consistent with distribution of woody elements encountered in transects. As expected, forested pastures had higher tree cover and low grass cover, while open pastures had low tree cover and high grass cover. Studies have shown that it is possible to maintain biodiversity as well as agricultural productivity in systems with high vegetation heterogeneity at the landscape, local, and even patch level (Fuhlendorf et al 2006). Agroforestry systems are known to maintain heterogeneity at both the local and landscape scale (Pandey 2007; Bhagwat et al 2008; Reyes 2008). Thus one possibility is that the high levels of vegetation heterogeneity, such as those observed in the Los Ángeles *ejido* at a local scale, if also expressed at larger scales, may facilitate desirable transformations of current conventional systems to sustainable systems. We are currently conducting studies that address the large-scale landscape-level characterization of the vegetation, specifically looking at the spatial distribution of active pasturelands and how they relate to different environmental and socioeconomical attributes of the landscape.

Our study shows that sapling density (an indicator of recruitment) is significantly higher in forested pastures than in pastures. This apparent habitat-dependent recruitment can be attributed to pasture run-down, where forested pastures tend to be less run-down than open pastures. Pasture run-down has been related to overgrazing and intense usage without a rest period, causing nitrogen limitations in the soil among other deficiencies (Myers and Robbins 1991). One long-term economical way to combat nitrogen deficiency in soil is by incorporating nitrogen-fixing trees such as legumes (Myers and Robbins 1991; Bouman and Nieuwenhuyse 1999; Bhagwat et al 2008). Although we have no quantitative data on the differences in cattle grazing intensity between pastureland types, cattle producers stated that forested pastures had lower grazing levels than pastures because they were only used when there was not enough food available on open pastures.

Our preliminary results are consistent with studies that have shown how different cattle management practices could generate differences in vegetation structure across the landscape (Stern et al 2002; Esquivel et al 2008; Van Uytvanck et al 2008). In particular, our study supports the idea that intermediate grazing can increase the establishment of woody species when there is enough seed availability (Posada et al 2000; Castro et al 2002; Duncan and Chapman 2003; McIntyre et al 2003; Padilla and Pugnaire 2006). These species act as nurse plants by creating suitable microclimate conditions (Castro et al 2002) and by providing fertile soils that facilitate native tree recruitment within pasturelands (Holl 1999; Zahawi and Augspurger 1999; Kleijn 2003). If grazing is seen as a disturbance to the Los Ángeles ecosystem, then this idea is consistent with the intermediate disturbance hypothesis, which states that high levels of biodiversity can be maintained in an ecosystem subjected to disturbances of intermediate intensity or frequency (Rambo et al 1999; Verdú et al 2007). In addition, some studies have shown that shrubs may limit sapling growth at a certain density threshold (Duncan and Chapman 2003). In contrast, trees can act as facilitators of forest regeneration on abandoned pastures (Posada et al 2000; Ruiz et al 2005). Remnant trees can also function as recruitment foci in rangelands (Zahawi and Augspurger 1999; Slocum 2001; Guevara et al 2004; Zahawi and Augspurger 2006) and become an important seed source for pasture restoration (Holl 1998, 1999; Cubiña et al 2001; Zahawi 2005). This suggests that trees on active pastures can promote natural tree sapling establishment while maintaining a functional and productive pasture for cattle producers.

We found different patterns between sapling recruitment and tree cover in the 2 forest zones (deciduous and oak). What drives these differences needs to be explored. However, our data suggest sapling recruitment in oak forest had positive and negative interactions with tree and shrub cover, respectively. Therefore, further species analysis coupled with further data collection on seed availability, environmental factors, soil and nutrient availability as well as differences in important biotic interactions, cattle movement, and intensity of pasture usage is needed to determine if the heterogeneous structure and composition could account for the higher sapling density in the tropical deciduous forest compared with the oak forest.

Producers describe 2 specific species as being the most bothersome, and therefore they are eliminated from pasturelands (*Acacia* spp and *V. leiocarpa*); however, bothersome shrubs and trees can facilitate seedling establishment in the early stages of recruitment by protecting the seedlings from cattle grazing (Smit et al 2005; Padilla and Pugnaire 2006; Van Uytvanck et al 2008). The local farmers in the Los Ángeles *ejido* have shown an interest in changing their conventional practices to more sustainable practices. Having local stakeholders active in decision-making is of utter importance if a successful transition is to take place. Velázquez et al (2009) worked in the entire state of Michoacán, Mexico, using participatory workshops and GIS to try and determine how different stakeholders (academics, government, and farmers) decided which areas are important for conservation. Their results show that involving social actors (ie farmers) can increase knowledge of the local area and provide much-needed insight into the aspects that need to be considered in designing conservation and development strategies. The current mosaic of pasturelands, the location of the *ejido*, and the interest of local farmers create a perfect study site for establishing a participatory conservation and development project that could support the transition from conventional systems to more sustainable production systems at this site.

Buffer zones were created around reserves to minimize the negative impact of the surrounding landscape on the core area. Nevertheless, buffer zones often do not seem to achieve their intended purpose because there is an increase in human land use and intensification of the surrounding landscapes, resulting in ecological changes in the core area (Hansen and DeFries 2007). La Sepultura Biosphere Reserve was considered by Figueroa and Sanchez-Cordero (2008) to be a noneffective area given that vegetation cover failed to increase between 1993 and 2002. Our study at the Los Ángeles *ejido*, located at the buffer zone of La Sepultura, suggests at least 2 factors that may relate to this ineffectiveness. First, local farmers are not allowed to cut adult trees. However, it is not stated in the reserve guidelines that they cannot cut saplings or young trees not yet fully developed. Second, some pastureland uses, and specifically those related to intensive agricultural and cattle grazing, were associated with low tree recruitment—evidence of pasture run-down. To the extent that land uses related to pasture run-down were more common between 1993 and 2002, increases of vegetation cover would not necessarily have occurred. Restoration ecology that looks at methods of increasing tree cover across abandoned and degraded pasturelands has pointed to the possibility of seeded and resprouting trees and shrubs as a solution to accelerate forest recovery and henceforth increase tree cover (Holl 1998; Holl et al 2003; Zahawi 2005). In this case, farmers in the Los Ángeles *ejido* who tolerate trees may be the key to reducing intensification of the surrounding landscape and increasing tree cover by combining conservation and sustainable development practices (ie agro-silvo-pastoral systems).

The conservation success of biosphere reserves is disputed (Adams et al 2004). Understanding the tradeoff between biodiversity conservation and human well-being is of utmost importance (Banks 2004) when working in and around reserves, and La Sepultura Biosphere Reserve is no exception. The high population and land-use intensity found in the buffer zone make this an ideal scenario for establishing multipurpose production systems such as agro-silvo-pastoral systems, which are considered less intense than conventional production systems. These are viewed as potentially sustainable and may offer a way for farmers to participate in biodiversity conservation while still sustaining their livelihoods. Our preliminary studies suggest that although trees are still conspicuous in the buffer zone landscape, sapling recruitment in pasturelands might be insufficient to sustain tree cover in the long term. Some current farmer practices in the Los Ángeles *ejido* can set the stage for the development of agro-silvo-pastoral systems that could facilitate natural tree recruitment in the landscape.

The efforts of this preliminary study have opened the path for research, education, and collaboration through the Participatory Project for the Development of Sustainable Silvopastoral Strategies in the Buffer Zone of La Sepultura Biosphere Reserve. Today, this project has grown to include approximately one third of the Los Ángeles cattle producers, the Comisión Nacional de Áreas Naturales Protegidas (CONANP), ECOSUR researchers, and graduate students from around the world. For conservation and development projects to be effective and successful, it is imperative to understand and work with farmers in buffer zones surrounding protected areas because they are the cornerstone of conservation in biosphere reserves and elsewhere.

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