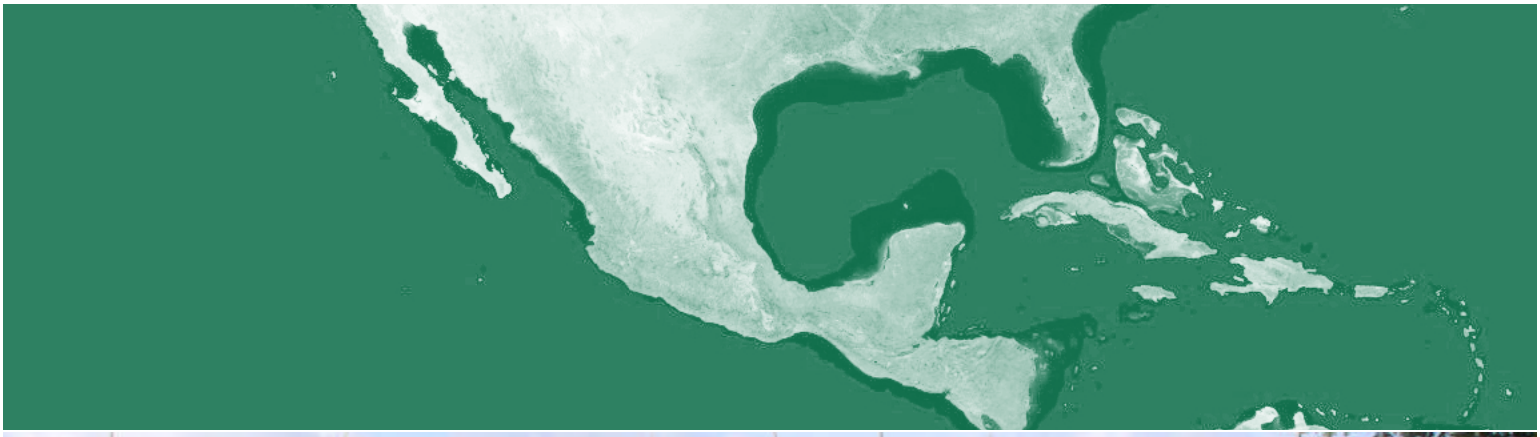
TRADE, POVERTY AND THE ENVIRONMENT:
A CASE STUDY IN THE SIERRA DE SANTA MARTA BIOSPHERE RESERVE



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Foreword

As the world experiences a period of biodiversity loss comparable to earlier mass extinctions, conservation has become a critical imperative. In many cases, the economic forces that are driving this loss include the macroeconomic and sector-level policies that affect production and resource-management strategies at the household level. It is important to better understand how these policies help to shape household survival strategies in order to identify alternatives that are sustainable from both environmental and social equity standpoints.

This study examines the relationships between trade liberalization and the production and survival strategies of poor corn (maize) growers living within the buffer zone of the Sierra de Santa Marta Biosphere Reserve in southern Mexico. This protected area lies in a region that includes tropical and montane forest systems which provide critical environmental services such as aquifers, biodiversity and carbon sinks. Because of its complex topography and great variety of ecosystems, the Reserve hosts many types of vegetation (from tropical evergreen and cloud forests, to highland savannas, to coniferous and oak forests), as well as a wide range of birds and reptiles.

The Reserve is threatened on many sides, but the most significant hazard comes from deforestation and the extraction of endangered animal and plant species. The communities described in this study are located within the buffer zone of the Reserve, where changes in production and survival strategies at the household level have had serious implications for the long-term sustainability of the Reserve. This study examines how impacts on prices of agricultural products affect household incomes and how this, in turn, conditions production strategies which are important for the long-term viability of the Reserve. Some traditional production strategies, centered on the *milpa* multi-cropping system, show promise for improving livelihoods, restoring agro-ecosystems, and recovering agro-biodiversity. Our research also considers how official antipoverty programs modify household incomes and how this affects production and resource-management strategies. Thus, the study allows us to carefully analyze the relationships between conservation strategies, agricultural policies and antipoverty programs.

Trade liberalization of corn in the context of the North American Free Trade Agreement (NAFTA) has had a series of critical impacts on prices and household incomes. During the period from 1995-2006, domestic corn prices in Mexico dropped significantly as corn imports from the United States increased. During that period, Mexican agricultural policy was characterized by a constant reduction of direct and indirect support measures for producers. However, the changes in prices (and imports) were not accompanied by output reductions, as one would have expected. In fact, cultivated surface increased and corn output grew significantly, with yields rising moderately or remaining constant. This occurred because, when making their production decisions, corn producers take into account not only the price of corn but also the prices of other agricultural products that are substitute crops. These prices were falling at a faster rate than maize prices. Viewed in the context of the constellation of agricultural prices, the price of corn actually remained constant or even increased in relative terms. Moreover, the prices of corn-based foodstuffs, such as tortillas, increased dramatically over the past fifteen years. Thus, because corn is a staple food and its production techniques are well known, producers opted for maize production. This explains the resiliency of output levels.

The direction of price variations changed rather abruptly during the first months of 2007, when international corn prices started rising dramatically. By the spring of 2008, the price increases were weighing heavily on consumers and had become a key component of inflation indicators everywhere. These price increases went against a long-term trend of price decreases in corn and other key agricultural products. The explanations offered for these price movements include the diversion of land to produce bio-fuels (especially for bio-ethanol in the United States), increased demand from China, a few cases of crop failure (notably in Australia), and pressure from speculation in futures markets.

A key question is whether these price increases benefited poor corn producers in countries like Mexico. Unfortunately, the answer is no. These price increases were a bonus for intermediaries and large corporations

who buy cheap and sell dear, at least during the first few months where price increases were noticeable. It appears that later, these price hikes started to reach direct producers. However, by the time these higher prices did reach poor producers in Mexico, the crops from the 2007 spring-summer cycle had already been sold and it was too late to benefit. And this applies to producers in the region covered by this study. What will happen in the next cycle?

As this study goes to press, the world is engulfed in a serious financial and economic crisis. The US economy has already entered into what is expected to be a deep and protracted recession. The impact of this crisis on emerging market economies still cannot be predicted with any degree of certainty. However, as the International Monetary Fund downgrades growth forecasts for Mexico, it is clear that not only will macroeconomic aggregates suffer, but effects will be felt at the household level in rural Mexico. Already the prices of most commodities have fallen to their pre-2007 levels and, in many instances, price levels are even lower. Poor farmers are again facing a situation in which they must sell to a depressed market. Traditional production systems (such as the *milpa* multicropping methods discussed in this study) are threatened, and unless public policies provide adequate support, they will be lost and replaced by the expansion of monoculture or livestock-based systems that are more input-intensive and, therefore, less likely to improve the prospects of long-term sustainability for the Sierra de Santa Marta Biosphere Reserve.

The central lesson derived from this study is that conservation strategies (such as those structured around biosphere reserves) need to be integrated coherently with relevant macroeconomic policies, agricultural policies, and social programs. Without a more coherent approach, natural protected areas will remain endangered, islands surrounded by a sea of poverty. A program for the creation of natural protected areas that coexists with economic policies that generate poverty and migration in rural areas can only build paper parks.

The current economic and financial crisis will undoubtedly pose a formidable threat to these goals if macroeconomic priorities drift away from general sustainability objectives. On the other hand, this crisis has clearly revealed the limitations of unregulated markets, and points to the need for civil society and governments to work together towards a more balanced approach to public policy for conservation and social equity. This study is a modest contribution to this effort in policymaking for sustainability.

January 15, 2009
Mexico City

Introduction

The North American Free Trade Agreement (NAFTA), which has liberalized trade between the United States and Mexico, has had profound impacts on smallholder agriculture in Mexico and, consequently, on the environmental services that support both agriculture and biodiversity. Liberalization has contributed to a fall in the price of corn, the staple crop for many Mexican farmers, as well as even greater declines in most other agricultural prices, which have provoked fundamental changes in the livelihood strategies of these farmers. This study examines the resulting changes in agricultural production among indigenous smallholders in southeastern Mexico and the implications of these changes for viability of the Sierra de Santa Marta Biosphere Reserve. The poor rural communities located near and within this reserve are comparable to many rural communities in Mexico – their experiences with trade liberalization are relevant to many other regions of the country. The environmental importance of the Santa Marta region and its large range of agro-ecological zones offer a valuable opportunity to examine the impact of changes in land use on the diverse array of environmental variables, including soil, water and genetic resources,that provide basic environmental services for the reserve and the farmers.

Study Site

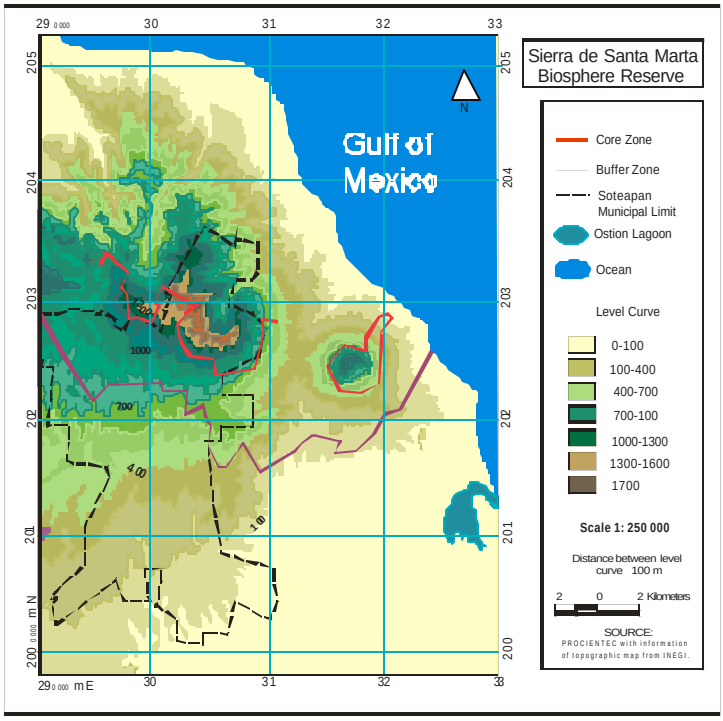
The Soteapan municipality, with a population of 27,000, is located on the southern slopes of the Santa Marta volcano, part of a compact mountain chain bearing the same name in the southern part of Veracruz state (see figure 1). The mountains rise steeply from sea level on the Gulf of Mexico to 1,700 meters above sea level (masl), creating a wide range of climatic and environmental conditions. The region includes most of the humid and subhumid evergreen rain forest in the state of Veracruz. Together with the remaining rain forest in the adjacent state of Tabasco and in Chiapas, the region comprises one of the most important rain forest remnants in Mexico.

The Sierra de Santa Marta Biosphere Reserve (BRSSM), established in 1997, lies partially in the Soteapan municipality. The BRSSM covers 383,300 acres of tropical and montane forest systems. Because of its complex topography, the reserve is home to 11 types of vegetation, from tropical evergreen and montane forests to highland savannas to coniferous and oak forests, which together are home to 1,400 species of vascular plants, 561 bird species, 102 mammal species, 168 species of reptiles and amphibians, 97 species of fish, and 530 species of butterflies.[1] Some 223 migratory species are known to overwinter in the reserve, making it an important wildlife refuge.[2] Endemism is high; and many species are endangered.

Deforestation rates in the region have been high, and today only 30 percent of the original forest cover remains.

In addition to its role as a haven for biodiversity, the BRSSM supplies critical environmental services, including maintenance of aquifers and carbon sinks. Water from the BRSSM watershed supplies not only the surrounding communities but also regional cities, such as Acayucan and Minatitlán. Precipitation is concentrated during the May–September period, when the rising water table leads to the formation of small streams and rivers that bring water to towns and villages at lower levels. In addition, a drainage process allows for the replenishment of underground aquifers in the region. The reserve's forests are critical for the maintenance of these rainfall patterns. Forested areas also supply wood for construction, biomass for fuel, several foods and medicinal plants.

Figure 1: Location and Topography of BRSSM



Within the reserve's core zone of about 44,500 acres, most human activities, including deforestation, burning, hunting, fishing and plant extraction, are prohibited. Federal legislation on natural protected areas and biosphere reserves states that the buffer zone will have a resource management plan, with the aim of reducing human impacts on the core zone. As yet, however, there is no management plan for the BRSSM buffer zone, meaning that there are no restrictions on resource use. The failure to write a management plan is an indicator of the scant federal resources devoted to protected areas. Given the small size of the core zone and the proximity of the communities in the buffer zone, production and livelihood strategies of those communities have important implications for the long-term sustainability of the reserve.

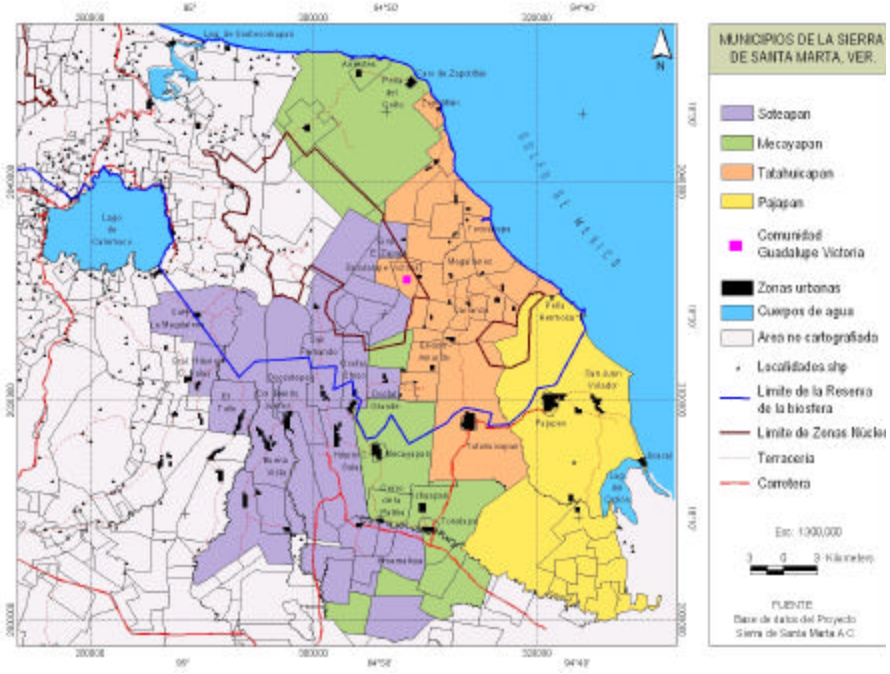
The dominant ethnic group in Soteapan is the Popoluca people, who have inhabited the region since before the Spanish conquest. The economy of the Popoluca is based on agriculture, which serves to organize their religious, social and political life. The region is also inhabited by Nahuas, who emigrated from the central part of Los Tuxtlas in the 1990s and who primarily raise livestock; and by Zapotecans, originally from the northern sierras of Oaxaca and mostly engaged in commerce, who arrived about 50 years ago.

Soteapan is home to approximately 4,800 farmers, all belonging to the Popoluca ethnic group, living throughout the municipality, including in the BRSSM buffer zone (see figure 1). For the purposes of this study, we have categorized them according to agricultural regime, which is largely dictated by geography. Producers in the lowland areas with gentle slopes (40–350 masl) and more productive soils (category A) are primarily commercial producers of corn, as well as several other crops. Producers in the transitional altitudes (350–600 masl) with plots on steeper slopes (category B) have only a small surplus to take to local or regional markets, again primarily of corn. Finally, producers at the highest altitudes (above 600 masl) of the buffer zone (category C) are almost exclusively subsistence producers and rely heavily on extraction of resources from the biosphere reserve.

The traditional form of agricultural production in the region, known as *milpa*, is a mixed-crop system in which anywhere between 8 and 32 different crops, including cereals, vegetables, fruits, legumes and tubers, are grown on a plot of about 12.4 acres. The three core crops—corn, beans and squash—along with the associated and tolerated crops provide food and income security, while forest reserve areas, known as *acahual*, provide wood for fuel and construction. The *milpa* system, developed over hundreds of years, relies on a wide variety of crops that interact in a manner that mimics the rich ecosystems in the region. This has helped conserve soil properties, water resources and genetic diversity and has limited soil erosion. Recent changes in the region have led to alteration and abandonment of many traditional *milpa* techniques and crops.

For this study, a survey was carried out in seven communities. Of the six communities included in Soteapan, three are in the BRSSM buffer zone (San Fernando, Mazumiapan and Ocotal Chico) and three are outside the buffer zone (Soiteapan, Morelos and San Miguel). One community in the Acayucan municipality was also included. In the communities in Soteapan, the survey was administered to 250 producers and included questions on the economics of their agricultural activities and their households. The basic criterion for including a household in the survey was that it was actively involved in production, although a small group of former producers was also included in order to examine the reasons for abandoning production. In addition to carrying out the survey, the research team also accompanied producers to their plots to verify data and gather information on other production systems (especially those devoted to livestock and fruits) and activities such as commerce and methods for raising poultry and pigs. See figure 2.

Figure 2: Communities of the BRSSM Region



Economic Change

Mexico began a process of trade liberalization with its accession to the General Agreement on Tariffs and Trade (GATT) in 1987. However, most of the protectionist structure remained in place, including a quota system and high tariff levels for almost all agricultural commodities. Implementation of NAFTA in 1994 changed this situation dramatically. All commodities subject to Mexico's permit and quota systems were switched to tariff-rate quotas (TRQs), and most tariffs were substantially reduced. Tariff reduction and elimination in the agricultural sector was rapid and extensive. Only the most sensitive products – corn, beans and barley – were protected by long transition periods.

Liberalization of the market for corn (zea mays) posed a serious challenge for Mexico's producers. Corn is the most important crop in Mexico and remains the staple grain for the vast majority of the population.

Approximately 60 percent of Mexico's cultivated surface, some 19.8 million acres, is devoted to corn, and current output is 20 million tons. There are approximately 3 million corn producers, meaning that, with their families, between 15 million and 16 million Mexicans depend directly on corn for their livelihood. Although corn was considered as a sensitive product under NAFTA, and as such was eligible for a 15-year transition period to eliminate the TRQ, the Mexican government opted not to implement the TRQ and has implemented only very low tariffs, of 1 percent and 3 percent, respectively, on yellow and white corn.[3] This decision led to the alignment of the domestic corn price with the international price in just 36 months as corn imports increased significantly. Corn prices fell by 50 percent between 1994 and 2000.[4] It was expected that, as corn prices dropped, the price of food products that use this grain would also fall, thus improving consumer welfare. Unfortunately, this was not the case for tortillas, the staple food of Mexico, in part because of the importance of other inputs to tortilla production (namely fuel) and in part because of the price-setting power of the industrial producers. In real terms, prices of tortillas increased by more than 50 percent between 1994 and 2003. See table 1.

Table 1: Cumulative Price Changes for Key Crops in Soteapan

Source: SIAP, several years.

Period	Corn	Coffee	Beans
1980–1993	-36%	-71%	-18%
1994–2000	-50%	-66%	-41%

Trade liberalization has taken place in a macroeconomic context that includes a monetary policy based on price stability priorities and a fiscal policy centered on the need to reduce public expenditures. One important result of this approach is that inflation has remained largely under control for the past seven years. Nevertheless, the accumulated inflation since 1994, when NAFTA came into force, has been more than 250 percent. Efforts to keep inflation under control, however, have contributed to slow growth rates that have plagued the economy. In the agricultural sector there has been a de facto withdrawal of public support to producers. Public resources allocated to agriculture in Mexico are now well below the aggregate level of support authorized by the World Trade Organization (WTO). This is the result of a policy that diverts fiscal resources from real sectors of the economy to pay financial charges.

The Mexican government did attempt to mitigate the impacts of trade liberalization on farmers through a direct income-deficiency payment, known as PROCAMPO. PROCAMPO was designed to de-link farmers' decisions about output and technology from direct crop subsidies in order to facilitate producer responses to market signals and improve their competitiveness. Unfortunately, PROCAMPO has lost 40 percent of its value in real terms and has become the equivalent of a short-term credit line for agricultural inputs.

A central rationale for both NAFTA and the PROCAMPO payments was to reallocate resources in order to increase productivity. Mexico's corn sector was considered to be noncompetitive. As imports of corn increased and prices dropped, it was expected that corn production would decrease in favor of alternative crops and migration. However, over the past 12 years, corn output has remained stable and even shown some increase. The explanation for this can be found in the fact that liberalization of imports led to a fall in the prices of all agricultural products, not just corn. In fact, corn prices dropped less than other crops; thus, relative to other crops, corn prices actually increased. Nevertheless, corn producers continue to suffer from lower real incomes and scant support in terms of credit, technical assistance and investment in rural infrastructure. The following section describes the response of the producers in Soteapan to these changes.

Production and Livelihood Strategies

Production and livelihood strategies of the communities in Soteapan have undergone significant changes over the last decade in response to major changes in their economic and social context, a result in large measure of trade liberalization and associated policies. Before 1993, Soteapan was considered one of the most important centers for production of corn, beans and coffee in the region (PSSM, 1996). By 2004, however, foodstuffs were in deficit during at least four months of the year. Agricultural practices had begun to undergo important transformations. The traditional methods of cultivation that relied heavily on agro-biodiversity are being gradually replaced by methods based on mono-cropping and chemical inputs, conversion of forest reserves *(acahual)* to agriculture and grassland and a reduction in labor. These changes in turn increase the demand for monetary income and off-farm employment, which served as a detonator for out-migration beginning in the mid-1990s.

Before NAFTA, agriculture in Soteapan was already suffering several difficulties. First, the production of beans collapsed in 1989 as the result of disease that destroyed almost half the crop (PSSM, 1996). Second, market prices of corn and coffee dropped beginning in 1986 because of increased supply in the international market and in southeastern Mexico. Nevertheless, the *milpa* system remained the most important component of local livelihood

strategies, and the region remained an important supplier of corn and beans for local and regional markets. The region's corn surplus was destined primarily for regional tortilla production (Blanco, 2004; Hewitt de Alcántara, 1992).

In 1993 a farming family in Soteapan who had 19.8–22.2 acres, with 12.4–14.8 acres under cultivation, obtained the equivalent of between 2.13 and 3.50 times the minimum wage,[5] which was enough to maintain a family of six people. This income was almost entirely from agricultural production, supplemented beginning in 1993 with payments from state-level social programs. The migration rate was close to zero.

Category A producers, those with the greatest commercial capacity, allocated up to 70 percent of their land to *milpa* production, with the rest as *acahual* (forest reserve). These producers practiced a system of land rotation that allowed lots to be exploited for five to eight years before being left fallow for three years. Category B and C producers, those in the transitional altitudes and subsistence farmers, allocated about 40 percent of their land to *milpa*, dividing the rest equally between coffee production and *acahual*. Producers without coffee dedicated a larger share of their land to *milpa* systems; in addition to *acahual*, they had areas with fruit trees, including mango, papaya and banana.

Subsistence strategies, particularly for category C producers, relied on the extraction of natural resources from the biosphere reserve. This included extraction of wood for construction and fuel for cooking; collection of plants for food, medicine, ornaments and religious purposes; and hunting animals for food. Some 90 percent of households reported obtaining a significant part of their food and construction materials from the reserve (PSSM, 1996). Similar findings were reported in an earlier study (CONAPO, 1990), which found that 70 percent of households in Soteapan extracted plants for medicinal purposes and 40 percent hunted animals, including snakes, armadillo, deer and badger.

During the late 1990s, Soteapan farmers were affected by several factors. First, there was another significant drop in the prices of corn, coffee and beans. Second, the regional market shares of these producers were significantly reduced by the increase in imports of corn by Maseca, the leading industrial corn-flour producer in Mexico, and other corn distributors in the region. Because the main entry point for corn imports is the port of Coatzacoalcos in the state of Veracruz, trade liberalization not only caused price reductions but also led to the displacement of local producers from the regional markets. Third, there was a generalized drop in all agricultural prices in Mexico. The result of these price changes, plus rising labor costs after 1998, has been a dramatic fall in the income-generating capacity of the traditional *milpa*. In 1993, an average *milpa* plot of 12.4 acres could generate as much as 3.5 times the minimum wage. Today, even the most productive *milpa* generates less than 1.5 times the minimum wage.

Fourth, local population has grown rapidly and family plots have been subdivided. In 1993 there were 1,650 households owning land devoted to agriculture, with an average per family of 19.8–22.2 acres. By 2005, the average farm size had dropped to 12.4–14.8 acres, while the number of farm families increased to 3,150. And while the number of farms was increased through subdivision to accommodate the natural population growth, the average cultivated surface remained at 12.4–14.8 acres. This meant a substantial expansion in the area under cultivation in Soteapan.

In response to falling incomes and shrinking farms, Soteapan farmers have changed their livelihood strategies. Many have addressed the problem of falling farm income in part by finding off-farm employment in small-scale commercial activities, transportation services or the logging industry. Others migrate to local cities (Acayucan and Minatitlán) for three to four months a year to work in factories or workshops. As a result, daily wages have risen from 20 pesos/day in 2000 to 30–35 pesos/day in 2005 and have occasionally reached 40 pesos/day. Rising labor costs means that there is less labor available for traditional, labor-intensive agricultural and soil conservation practices.

Soteapan producers also changed their agricultural strategies. As of 1993, most of Soteapan's productive land was devoted to *milpa* and coffee. By 2005, new crops had emerged, including palm trees, papaya and horticultural production. Land under coffee fell by 30 percent – a change explained in large part by the fact that many plots did not meet the altitude requirements for the government's coffee-support programs. Palm cultivation developed, probably because of its low labor requirements and the existence of marketing channels that keep prices fairly stable. Many producers have established grassland, which they rent to cattle owners, because of the low labor requirements.

An important transition has also occurred in corn production. The fall in corn prices, rather than driving Soteapan out of the market, led producers to maintain or even increase output in order to compensate for lost income. The area allocated to *milpa* fell by 18 percent, replaced

primarily by monoculture of corn. Although the regional market has expanded substantially, Soteapan producers have not been able to increase their output as quickly, with the result that their regional market share has fallen from 10 percent to 6 percent. Between 1990 and 2004, corn imports that were marketed directly into the regional market increased from 100,000 tons to 236,000 tons. Soteapan's producers were unable to keep up with this growth because their location entails high transportation costs that impose greater risks and higher transaction costs.

In this context it is important to note that PROCAMPO payments became a powerful signal for corn producers to maintain production levels. PROCAMPO required producers to report the cultivated surface devoted to corn every year, despite the intention to de-link payments from particular crops. For producers, this was a clear signal to continue corn production that was reinforced when, at a later stage, PROCAMPO officials failed to channel payments to plots devoted to other crops.[6] See table 2.

Table 2
Land Ownership and Land Use Patterns

	1993 Categories of Producers			2005 Categories of Producers		
	A	B	C	A	B	C
Average acres	49.4	54.4	61.8	22.2	17.3	12.4
% Milpa and Corn	70	40	40	90	30	30
% Grassland	0	0	0	10	10	15
% Coffee	0	30	30	0	30	35
% Reserve	30	30	30	0	15	20
% Other	0	0	0	0	15	0

Note: Categories of producers are described.
Source: Authors' calculations with data from PSSM, 1996; and PROCIENTEC, 2005.

The degree and the way in which productive strategies were altered depended on the type of producer. The most important changes are observed in the generalized reduction of *acahual*, which has been converted to agriculture and grassland. Commercial producers (category A) have completely eliminated *acahual* in favor of corn and pasture. Producers in the transition category (B) have diversified, with reductions in forest reserve area in favor of palm cultivation and the reallocation of land from *milpa* to grassland. Coffee has been reduced because these transition farms do not meet altitude requirements for coffee. Finally, subsistence producers (C) have reduced the area in *milpa* and reserve in order to increase coffee production and grassland. All three types of producers have adopted livestock production. Grassland was increased because cattle production provides greater income than monoculture corn and requires less labor than *milpas* or coffee. Income per 2.5 acres, however, is lower than *milpa* income.

Human Well-Being Impacts

Marginalization and poverty in Soteapan are severe. The most critical factors explaining this are related to the dynamics of relative prices and the terms of exchange (i.e., the high ratio of prices of manufactured products to locally produced commodities), the volatility of agricultural prices and the lack of adequate local employment opportunities. Trade liberalization has contributed to falling agricultural prices. In combination with rising prices of agrochemical inputs and labor over the period 1993–2005, commercial producers experienced a 37 percent reduction in income from sale of agricultural products; transition producers experienced a 35 percent income drop; and subsistence producers suffered a 44 percent income drop. In order to understand the changes in production strategies in Soteapan, we examine the relative profitability of each productive system. In this section, data derived from production accounts provide information on net incomes and allow us to compare the short- and long-term advantages of each of these strategies. See table 3.

The traditional *milpa* system has almost disappeared, and most remaining *milpa* producers now use only two crops, corn and beans. This weakened *milpa* system provides a meager net income of US$720 per 2.5 acres.[7] The occasional sale of a few associated products (such as bananas or squash) allows these producers to supplement their incomes. The cost of managing a traditional *milpa* is now very high because the process is labor intensive, absorbing some 210–240 days of waged labor during the spring–summer cycle for a 12.4-acre plot; the weakened *milpa*, however, requires only 50–80 days. In response to the increases in labor costs and the drop in corn prices, many producers intensified production and resorted to monoculture, abandoning the *milpa* system completely.

Livestock production was introduced to the region through a state-sponsored program in the late 1980s that demonstrated the strong income-producing potential of this activity. Net income per 2.5 acres generated through cattle production can surpass US$3,000 because of the low labor requirements for grassland and animal management. However, there are very high barriers to entry, including the initial costs of conversion to grassland, purchase of animals, veterinary treatment and food supplements.

Table 3: Marginalization in Soteapan, 1990-2000

	Percent			Total People		
	1990	2000	2015	1990	2000	2015
Net population	100.0	100.0	100.0	23,181	27,486	44,726
% Illiterate population (above 15 years)	56.8	48.8	40.9	13,169	13,425	18,281
% Without primary education	85.3	76.5	67.6	19,766	21,014	30,250
%Without sanitation services	78.5	65.2	51.8	18,190	17,908	23,183
%Without electric energy	49.9	23.9	12.0	11,560	6,561	5,367
%Without piped drinking water	52.4	13.9	7.0	12,145	3,808	3,131
% Living in homes with some level of overcrowding	79.5	76.1	72.7	18,434	20,926	32,538
% Living in homes with dirt floors	81.2	79.0	76.9	18,818	21,719	34,375
% Living in towns under 5000 inhabitants	100.0	100.0	88.0	23,181	27,486	39,359
% Earning less than 2 minimum wages	89.8	91.5	80.0	20,810	25,158	35,781
Marginalization Index	1.68	1.98	1.87			

Source: National Population Council CONAPO.

Moreover, producers need to be trained in management practices suitable for local conditions. As a result of these costs, the shift toward this activity has been gradual (Vázquez Garcia, 2002).

The shift to coffee began around 1988 using conventional systems that required large quantities of chemical inputs to ensure high yields. However, because no processing was carried out locally, incomes were low. Eventually, some local processing capacity was installed, and net incomes rose as high as US$582 per 2.5 acres. The number of required wage-labor days for a typical cycle varied between 80 and 120. The adoption of this conventional system was supported by COVERCAFE, a state-level program that made direct payments to compensate the income loss when monoculture of corn was abandoned by producers operating at altitudes above 600 masl. Today coffee producers in Soteapan have switched to a system known locally as "natural coffee" and carry out more of the processing locally. Natural coffee is a production technique between conventional and organic coffee; it requires no agrochemical inputs in the coffee fields and substantial handling in the drying, pulping and packing processes. This type of production has allowed growers to increase their net monetary incomes. A few producers have even begun roasting and grinding, which increases labor costs but has further increased their net incomes, up to US$1,600 per 2.5 acres. See table 4.

Table 4: Income Accounts by Categories of Producer

	1993 Categories of Producers			2005 Categories of Producers		
Items (USD)	**A**	**B**	**C**	**A**	**B**	**C**
Milpa	$4,677	$1,935	$1,290	$2,118	$636	$136
Coffee	$ -	$806	$1,452	$ -	$455	$909
Livestock	$ -	$ -	$ -	$227	$273	$136
Perennials	$ -	$645	$ -	$ -	$182	$ -
Services	$ -	$ -	$ -	$182	$ -	$ -
Commerce	$ -	$ -	$ -	$227	$91	$91
Remittances	$ -	$ -	$ -	$136	$455	$ -
Social Programs	$484	$484	$484	$291	$336	$409
Total Annual Avg.	$5,161	$3,870	$3,226	$3,181	$2,428	$1,681

Source: PSSM, 1996; and PROCIENTEC, 2005.
Note: Amounts are expressed in dollars at the current exchange rate in each year: 3:1 pesos/dollar (1993) and 10.8:1 pesos/dollar (2005). Incomes were estimated from average incomes as reported in our Natural Resource Management Survey (PROCIENTEC, 2005).

While rising costs, falling prices and subdivision of land have aggravated poverty in the region, several factors have mitigated falling incomes. Official antipoverty programs have helped to alleviate some of the income losses associated with trade liberalization, but they have not had the multiplier effect needed to increase local economic activity. In fact, in some cases, these resources have been used to implement input-intensive technological packages

that are not well suited for the region's or the households' needs. Employment in off-farm activities has also contributed modestly to local incomes, but this also has failed to generate a renewal of local economic activity. Migration is a new experience in Soteapan, but today it has become an important mechanism for income generation.[8] While migration has mitigated some of the more negative impacts of poverty, it forces changes in production patterns that have important social and environmental implications. Transition producers are more likely to migrate than commercial or subsistence producers because, while they present intermediate levels of poverty, they have enough resources to cover the costs of migration. Thus, 20 percent of households in the transition group reported one family member migrating temporarily every year. For example, in the San Fernando community, one of the communities of transition producers at a high elevation, 30 percent of the population migrates during the Sonoran tomato-harvest season. Permanent migration is still relatively rare; however, already 10 percent of households in the transition category report permanent migration of one family member within Veracruz and 12 percent in other states such as Sinaloa and Sonora, where agricultural workers are in demand. And already 20 percent of transition households have one member in the United States.

Migration rates are lower for the group of commercial producers because of their greater income-generating capacity. The group of subsistence producers reports even lower migration rates. This is explained by the lack of resources to cover the costs of migration. Those subsistence producers who do migrate go largely to Jalisco state during the harvest season for corn and beans. Because this coincides with the period in which labor is required on their own plots, these producers are the ones that transform their *milpa* systems into grasslands for livestock production, as a way to reduce labor requirements.

A comparison of income accrued to a typical family of six in 1993 and 2005 shows that diversification of income sources has not been able to compensate loss of income in real terms over this period. Income increased by as much as 118 percent (mainly from remittances, small trade and services), but costs rose by 350 percent. A new threat looms as the environmental deterioration that is resulting from the abandonment of traditional cultivation practices and the extraction of materials from the biosphere reserve endangers the long-term survival of the region's ecosystem services.

Environmental Impacts

The core area of the BRSSM, just over 44,500 acres, is barely adequate for the conservation of the flora and fauna endemic to the zone. Although no detailed studies have been carried out, it is clear that the reserve is close to critical thresholds needed to prevent species loss (Ramírez, 1999). Throughout the region, new production techniques are causing critical environmental changes in both the farmland and *acahual*, changes that are also creating pressure on the core zone. The most important effects identified by this study are loss of agro-biodiversity, soil erosion, greater pollution of soils and aquifers and increased deforestation and extraction rates of plants and animals from the reserve.

Agro-biodiversity

The rich agro-biodiversity associated with *milpa* production in Soteapan was maintained through the 1970s, with some plots containing as many as 32 different species. Today the largest number of crops to be found in one plot is eight (PROCIENTEC, 2005), and many *milpa* plots have been converted to other uses. The adoption of hybrid and improved varieties of corn, instead of traditional landraces that were adapted to this environment over centuries (Rice, Smale, and Blanco, 1997; Blanco, 2004), is common among commercial and transition producers trying to improve yields. This is accompanied by the introduction of more input-intensive practices to ensure the success of these varieties. Where the *milpa* survives, it has been significantly altered and the number of species greatly reduced, with the result that agrochemical inputs become a necessity and the old methods of pest and weed control based on agro-biodiversity are no longer functional.

The reduction in biodiversity has taken place to different degrees among the three classes of producers. Commercial producers seeking higher yields have switched to monoculture technology and have thus forgone the short-term and long-term benefits of cultivating squash, tubers, horticultural crops, woody products and, to a lesser degree, certain legumes. These producers rely heavily on the use of chemical inputs and intensive land use, thus increasing pollution of aquifers and soil and aggravating erosion. The use of chemical inputs greatly exceeds recommended levels.[9] Yet, because yields are tending to fall, greater doses of fertilizer are being applied. Commercial producers employ a variety of soil management practices, including slash and burn, that often reduce agricultural biodiversity. These producers are also experimenting with hybrid seeds. Increased reliance on monoculture corn production, without crop diversification or rotation, means that the agro-biodiversity index on these farms is very low.

Transitional producers have developed some greater diversification, particularly through the cultivation of palm. However, the use of agrochemical inputs and

common soil-use practices endanger both soil and agro-biodiversity conservation. The basic structure of the *milpa* has been dismantled and reduced to the association of corn with either beans or squash. Generally, these producers rely on minimum tillage methods, although there are some producers who use plows and animal traction. The majority of these producers use seeds known as "mestizos," which have been developed with their local landraces.

At the other extreme, we find subsistence producers with low yields in corn production but a greater variety of crops in their traditional *milpa* systems. Traditional practices and the use of landraces are important assets for the majority of subsistence producers in the uplands. Although their use of herbicides is high, the conservation of a higher degree of agro-biodiversity is fundamental to their agricultural practices.

Soil erosion

Soil erosion, including loss of topsoil and of soil nutrients, is one of the most immediate environmental problems facing Soteapan producers (Turrent Fernández, Uribe Gómez and Francisco Nicolás, 2002). The vast majority of plots suffer from erosion, and intensification of production has worsened this problem. Fertilizer use increases as nutrients are lost through erosion. Plots used by commercial producers are concentrated in areas with slopes of less than 15 percent, while transition plots at higher altitudes generally have slopes of greater than 15 percent. Risk of erosion, of course, is a direct function of slope, especially in regions of heavy rainfall, so one would expect a lower risk of erosion on the commercial plots. Surprisingly, the reverse is the case in Soteapan because of the production techniques employed. Since commercial producers practice monoculture without the use of vegetative cover, their land is more subject to erosion. Transition producers maintain the use of certain traditional practices, such as crop rotation, zero tillage and cover crops, which explains why erosion levels on their steeper plots are lower than those of commercial producers. Notably, the subsistence producers, who rely on systems closest to the old *milpa* tradition, suffer the fewest problems with erosion.

Pollution of soils, rivers and aquifers

Pollution of soils and aquifers is a severe problem in Mexico due to fertilizer runoff and use of pesticides (RAPAM und.). Trade liberalization has coincided with increased use of many agrochemical inputs in Mexican agriculture, in part because it opened the Mexican market to the activity of big commercial firms specializing in selling these products. This took place at a time when agricultural extension from the public sector virtually vanished; thus, any "technical assistance" is provided by the agrochemical firms and cannot be distinguished from sales (Nadal, 2000). Use of these agrochemicals affects soil ecology and disturbs the functional relations of soil microbiology. Problems include soil salinization, elimination of microorganisms essential for stability of the agro-ecosystem and overflow of toxic substances into rivers and aquifers. The impact of these agrochemicals differs among regions due to different features of the ecosystems. Growers in Soteapan have resorted to indiscriminate use of several agrochemical inputs, without due regard to doses, adaptation to local soils or target species.

Soil features in Soteapan do not facilitate the assimilation, degradation or recycling of these products, the majority of which are not biodegradable. Moreover, fertilizer use averages 100–170 kilos per 2.5 acres over recommended applications in Soteapan. This means that for the municipality as a whole there is an estimated excess of 1,680 tons of fertilizer that is not productively assimilated, and that can be expected to contribute to environmental problems in soils and aquifers. In general terms there are two agricultural cycles in the region, with different implications for fertilizer usage. During the spring–summer cycle a higher dose of fertilizer is used. Because this is the rainy season, nitrate compounds are washed into rivers and aquifers, particularly when applied on steep slopes. During the dry autumn–winter cycle, lesser amounts of fertilizer are used and nitrate compounds tend to accumulate in soils. Loss of agro-biodiversity and intensified erosion aggravate the problem of accumulation of residues.

Pesticides too are applied indiscriminately, up to three times a year, without regard to appropriate doses. The impacts on soils, microbiology and agro-biodiversity are devastating. Many of these products are organochlorates (such as Paraquat and Glyphosphate), which cause cancer, teratogenic problems and neurotoxicity as well as gastrointestinal problems in humans. Organophosphates are also in use (such as Parathion and Cipermetrina), which cause neuropsychological problems, muscular atrophy, dermatitis and cardiac and ocular problems. These chemicals likewise have negative effects on all plants and other life forms, such as insects and nematodes, in and around the plots. These accumulate in soils and water bodies.

Deforestation

Deforestation in the study region has been relatively well monitored because of its implications for biodiversity and the BRSSM (Ewel, 1986; Dirzo and Garcia, 1992; Ramírez, 1999; Flint Hughes, Kauffman and Jaramillo, 2000). Forest cover, including the *acahual*, has suffered severe

degradation over the past 40 years. Some 86 percent of forest cover was lost between the 1960s and 1987 (Dirzo and Garcia, 1992). Deforestation rates peaked in 1986 and have since fallen off sharply. This slowing of deforestation does not necessarily reflect improved environmental stewardship – more likely it reflects the dwindling of forest resources and the increasing distance of the remaining forest from most farms.

Deforestation has clearly been driven by the need for more cropland and grassland that is the result of the factors discussed above: rising populations and falling prices. *Acahual* (forest reserve) in particular has been converted to farmland. Other factors have also driven deforestation. One is the demand for construction material. Clandestine extraction of timber from local forests supplies not only local demand but also demand from regional urban centers including Soteapan, Morelos and San Fernando. PEMEX, the state-owned oil company, purchases wood for scaffolding and platforms for its installations in southeast Veracruz. More than 60 percent of subsistence producers report that they extract wood for sale, and many producers operating in the buffer zone hire their services as chainsaw operators. Wood is also extracted for fuel, particularly the ocote pine, which is rich in flammable resin. More than 80 percent of families still use wood to cook their food. Formerly, fuelwood was extracted from forest reserves; now that much of this reserve has been converted to agriculture, fuelwood is increasingly extracted from the buffer and core zones of the BRSSM.

The cumulative impacts of this extraction for the BRSSM are severe. There is a serious risk that critical thresholds will soon be reached below which natural replenishment of forest resources will be compromised. As of 2000, only 37,100 acres of forest remained in Soteapan, meaning that, at the current deforestation rate of 1.5 percent per year, an additional 7,400 acres will be lost by 2010. The loss of forest cover may lead to species extinction, changes in rainfall patterns and local climate changes (Ewel, 1986).

Resource extraction

Resource extraction from the forest has a long tradition among the people of Soteapan. Today, however, extraction of animals and plants, especially from the core zone of the BRSSM, has broken the balance between extraction and regeneration rates. Wild animals are sold to supplement income. The main species caught are the giant toucan, ocelot, emerald iguana, yellow parrot, macaw and turtles. Sale of these animals takes place directly or through intermediaries in the urban centers. About 10 percent of households report that they engage regularly in this type of activity. For the communities close to the core zone, this percentage may be as high as 80 percent.

Animals are also hunted for food – about 40 percent of transitional and subsistence producers supplement their diets this way. The most frequently hunted animals are armadillos, badgers, iguanas and rabbits. A decade ago it was not uncommon for hunters to bring down deer, wild boar, and other medium-sized animals; today, these species are extremely difficult to find and many believe they are now locally extinct. Plants and fruits are extracted from the BRSSM for food and medicine by about 70 percent of households. The species of plants collected are not considered endangered; some 32 wild species, including berries, hot peppers, coriander and onions, are used (PSSM, 1996). Fishing used to be common, too, but pollution of the rivers, probably in combination with overfishing, has led to the collapse of fish populations. For example, the Huazuntlán River was well known for its abundance of mullets, mojarras, catfish and several crustaceans; today, these species have disappeared. Subsistence producers are still able to fish above 800 masl at the source of local rivers.

The ecological impact of these activities is difficult to gauge. The degree of danger that extraction brings to an individual species or to complete ecosystems, and to the integrity of the biosphere reserve, depends not only on the intensity of extraction but also the combined impacts of deforestation, habitat destruction, pollution and the particular place of individual species in the ecosystem.

Poverty and Environment

Changes in production strategies of the local population have had a strong impact on the natural-resource base that will affect the long-term viability of the BRSSM. Most of these changes have taken place under conditions of severe constraints on agricultural options and in the context of generalized economic stagnation or decline. In many cases the alternative strategies chosen require the abandonment of the traditional base of knowledge and resource management practices, further undermining the capacity of producers to overcome the difficulties that confront them. Not only have these changes failed to reverse the negative situation, but they have endangered the ecosystem services upon which these people depend.

The reduction in agro-biodiversity has negative repercussions in resource management practices and increases the risk of crop failure (Méndez and Gliessman, 2002). Vulnerability to lowered risk-management capacity

increases as producers come to rely more and more on single product markets. The case of coffee in 1990, when domestic and international prices collapsed, is a sad example of this. The switch from *milpa* to monoculture or grassland disturbs the agro-ecological balance, often leading to increased pest and weed problems. This in turn provokes the use of pesticides and herbicides that destroy beneficial diversity, forcing ever-increasing use of chemicals. Even in the slightly modified *milpa* systems, the use of herbicides leads to loss of agro-biodiversity and higher dependence on pesticides as time goes by.

During this period of transition, local producers have been unable to identify a set of production systems that would allow them to overcome poverty and attain environmental sustainability. On the contrary, the relation between changes in economic conditions and producers' survival strategies has generated a vicious circle in which outmigration leads to a shrinking labor force, which in turn reinforces the tendency to abandon traditional, labor-intensive cultivation methods. As these methods are abandoned, there is a serious risk of losing agro-biodiversity, of increasing pressure on land, forest and water resources and of jeopardizing the biosphere reserve.

Recommendations

Because monoculture systems and livestock production entail serious environmental problems that were not associated with traditional *milpa* production, it is important to consider possible ways of improving the economic viability of *milpa* production in order to provide additional income without degrading environmental services. A traditional *milpa* with eight crops (corn, beans, peppers, bananas, watermelon, yucca, pineapple and mangoes or lemons) sold at market prices would provide a net income of more than US$2,500 per 2.5 acres. The combination of crops allows for a much better performance of each crop than in the case of monoculture: yields are 40–50 percent higher for corn and beans and 20–30 percent higher for other-crops. Wage-labor requirements are similar to those of the reduced *milpas* currently operated in Soteapan, and costs of production total US$650/2.5 acres. Net income in the case of the traditional *milpa* appears to be significantly higher and, in some areas, comparable to what may accrue to producers from livestock production. A policy oriented toward the recovery of the traditional *milpa* could have positive effects both in terms of employment generation and migration reduction.

The authors of this study propose the implementation of a set of productive and technological options – options already tested in Mexico – that could allow producers in the region to recover and strengthen traditional *milpa* systems. These technological options based on integrated management strategies are designed to reduce soil erosion, increase agro-biodiversity, reincorporate organic matter and nutrients in soils, allow for integrated pest management and increase monetary income. They are conservation tillage, contour plowing, terracing, recovery of organic matter, intercropping and crop rotation. Since the shift from monoculture back to traditional *milpa* would be difficult to achieve in a single step, the authors recommend the promotion of a system that combines *milpa* production (corn and beans) with fruit trees, known as MIAF (*milpa intercalada con árboles frutales*). This system has been tested in diverse ecosystems in the states of Oaxaca and Veracruz. Under this system, about 30 percent of land is allocated for fruit trees and 70 percent for cyclical crops. MIAF provides a number of the elements that would contribute to soil protection and agro-biodiversity conservation: a main crop with a supporting crop that increases nitrogen intake, a cover crop (squash, watermelon, etc.), and a system of live fences. MIAF could easily serve as a stepping-stone toward a return to traditional *milpa* practices. Completion of a successful conversion program would require financial support, which could be provided through a system of loans and transfer payments for environmental services. It is worth noting that there are several successful experiences in Mexico demonstrating that these systems, in addition to their immediate benefits, are also compatible with carbon capture and payment for environmental services (Jiménez Ferrer et al., 2005).

Conclusions

Trade liberalization under NAFTA was not the only source of problems encountered by corn producers in Soteapan. Trade liberalization and related policies brought about two important effects on the corn-producing sector. One was a significant contribution to price declines of corn and of most agricultural products associated with traditional multi-cropping systems. This caused a more than 50 percent drop in average family income that acted as an important catalyst for changes in production and income-generating strategies. The second effect, important in the study region, was the displacement of producers from the local and regional markets. These changes took place in the context of a serious reduction in agricultural support systems, including credit, technical assistance and construction of infrastructure. At the same time, demographic dynamics also contributed to making the traditional *milpa* system an unviable strategy for providing sufficient family income and food security. Migration transformed the labor market, making labor-intensive production strategies too costly.

This combination brought about the abandonment of multi-cropping systems in favor of monoculture. As production strategies were transformed, important environmental effects followed.

The most common recourse for people in Soteapan has been the conversion of *milpa* to more conventional monoculture and, when this is not enough to restore lost income, the transition heads in the direction of conversion to grassland for livestock. Monoculture cultivation brings with it a series of practices that are ill suited for resource management in this region. Relying on chemical inputs to increase yields has not led to the desired results and, in addition, contributes to soil deterioration, loss of agro-biodiversity and pollution of aquifers. Conversion to grasslands leads to loss of agro-diversity in a pattern that destroys the stability of neighboring ecosystems.

Milpa systems can make positive contributions to the integrity of the biosphere reserve. It is important to take into consideration that approximately half of the *milpa* production in the Soteapan study area lies within the buffer zone of the BRSSM and the remainder within the so-called influence zone. First, enhanced *milpa* production systems have a greater ability to interact with the various component elements of the surrounding natural ecosystems. This is beneficial both in terms of insect populations, pest-related risk management schemes and soil erosion. Agriculture is always rather aggressive from the environmental point of view; however, as agro-ecological systems mimic their natural surroundings, the detrimental environmental effect is reduced. This is precisely the logic of *milpa* production systems in the study area. Second, a shift away from monoculture will reduce the use of chemicals that affect soils, water, plants and animals in the reserve. And third, *milpa* can contribute to recovery of disturbed forest areas in the reserve. Resource extraction rates from the BRSSM are lower with an enhanced *milpa* production system because greater agro-biodiversity implies less pressure on the resources of the biosphere reserve.

Endnotes

[1] These represent a considerable share of Mexico's biodiversity: 27 percent of the country's mammals, 40 percent of birds and 16 percent of reptiles.

[2] By way of comparison, 193 migratory species overwinter in Costa Rica.

[3] This very modest tariff should be compared with the TRQ of 91 percent (for the year 2003) that Mexico was permitted to impose under the terms of NAFTA. Forgone fiscal revenues have been estimated at more than US$3.2 billion.

[4] The degree to which NAFTA was responsible for the decline in corn prices has been the object of some debate. For example, it has been argued (Lederman, Maloney and Servén, 2003) that (1) corn prices during NAFTA implementation followed a downward trend that had been ongoing since at least 1981 (with a brief interruption for the peso devaluation in 1994); and (2) corn prices in Mexico and the United States have generally moved together in the periods before and after NAFTA, and the price differential before NAFTA was no greater than the price differential after NAFTA, indicating that NAFTA had little price effect. In relation to the first point, it is important to note that the policy structure that maintained guaranteed prices in Mexico started to be dismantled during the '80s. This explains price reductions during that decade. Furthermore, Table 1 shows that price reductions accelerated after 1994, when NAFTA began to be implemented. During the early '90s, these policy changes were introduced in anticipation of (and preparation for) NAFTA. The second point is simply not confirmed by the evolution of corn prices (see Nadal 2000 and Keleman and García-Rañó, 2007).

[5] In 1993, the minimum wage was set at 13.06 pesos per day.

[6] This policy implementation failure was a common element in all the *ejidos* covered by our survey.

[7] Figures in this section are as of 2005.

[8] Figures in this section are drawn from the survey carried out for this study.

[9] Levels used exceed even the doses recommended by the firms selling these products. Specifications in the commercial packages of these inputs state that pesticides must not exceed 6 liters per 2.5 acres, and herbicides 5 liters per 2.5 acres. These maximum doses are considered too high by technicians working in the Secretariat of Agricultural Promotion in Soteapan, and actual use exceeds the recommended levels.

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