SUSTAINABLE DEVELOPMENT IN THE MEXICAN TROPICS: BEYOND THE RHETORIC[i]

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Introduction

The concept of sustainable development escapes any precise definition. As Harrington (1992: 1) points out, the notion encompasses issues of "population growth and pollution, deforestation and land degradation, agroecology and energy cycling, erosion and intergenerational inequality, not to mention biodiversity, global warming and the ultimate fate of mankind. It is a formidable topic." When closely examined, the term captures more of an attitude toward issues of economy and environment than an actual theory that accounts for how the world economy currently functions let alone the mechanisms or procedures by which present-day problems of poverty and resource depletion can be satisfactorily resolved. The concept is largely prescriptive and global, leaving the analysis of problems and the chains of causality relatively undeveloped. As such, it provides little guidance regarding the strategic decisions that researchers and development workers must take regarding where and how to engaged in sustainable development. In other words, sustainability goals and inter-disciplinary prescriptions put forward in the sustainability debate are no substitute for an understanding of the history and causes of underdevelopment and environmental degradation.

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[ii] Opinions expressed are not necessarily those of CIMMYT or Carleton University.

Intriguingly, while the concept has radical implications for the entire planet, general expositions of the notion rarely spark off any passionate debate. As with motherhood, few people will question the virtues of an economy that meets human material needs while also renewing the natural resources required to satisfy these wants. The concept is so widely recognized and politically correct that few Thirld World non-governmental organizations will dare seek financial assistance from a North American or European research and/or development agency without first espousing the language of sustainable development.

Why the apparent consensus? Could it be that the vagueness and malleability of the concept makes it profoundly harmless? Unlike socialism, theories of sustainable development will rarely cause a heated debate let alone a real war. Unless of course theorists also become practicioners -- unless theories are converted into concrete strategies that shed light on the actual issues at stake and the social interests involved. Prescriptive notions of ecological wisdom will have little impact on peoples' livelihood unless the actual causes of poverty and resource depletion and the implications of alternative strategies are fully disclosed. This implies that more difficult questions be answered, such as why is there unsustained development in the first place, who designs and benefits from policies of sustainable development, and how the goals of sustainable development can be attained?

The case-study that follows addresses these questions. The analysis centers on a Mexican Indian population known as the Gulf Nahua and problems of deforestation and agricultural underproduction directly affecting their livelihood, problems essentially caused by the expansion of extensive, relatively inefficient cattle ranching activities. The analysis gives a general overview of the Sierra de Santa Marta environment, followed by a discussion of the impact that the cattle industry has had on peasant *milpa* agriculture and the Gulf Nahua environment as well. The analysis concludes with an outline of the strategy adopted by the Sierra de Santa Marta Project (IDRC, UNAM and Carleton University) to counter this particular yet widespread expression of agricultural underdevelopment in Latin America. Given the precise economic, social and environmental conditions prevailing in this area of Mexico, the SSMP has chosen to emphasize sustainability in the agroecological sense, a strategy that emphasizes basic food production, soil conservation and indigenous modes of adaptation. The reaction of local people and the SSMP to pseudo-ecological development strategies catering to the needs of foreign capital (a multi-national pulp and paper company) is also discussed.

The Study Area

The peasant population discussed below inhabit a remote corner of southern Veracruz wedged between the Gulf of Mexico and the massive petro-chemical complex of Coatzacoalcos and Minatitlán (see Map 1). Their territory is part of the Olmec heartland, a hot, humid region where Mesoamerica's Mother culture developed between 1,200 and 400 B.C. The village of Pajapan is the administrative center (*cabecera*) and largest village in the municipality (*municipio*) of Pajapan. It is also the center for an agrarian community whose members live mostly in the *cabecera* but also in the nearby village of San Juan Volador and the hamlets of Jicacal, El Mangal, Palma Real, and Tecolapa. While some 8,000 people live in these congregations, the native *comuneros* form a much smaller group that holds title to

19,158 hectares of land between the Laguna del Ostión and the peak of the volcano San Martín Pajapan. The present-day people of Pajapan are all Nahua speakers.

Together with their Mecayapan neighbors, the people of Pajapan are among the last of a large group of Nahua speakers in southern Veracruz, many of whom were displaced from the best agricultural land in the region and gradually absorbed into the wider mestizo society. The Gulf Nahua language is a variant of the language once spoken by the Aztecs and the people refer to their own dialect as *Mexicano*. Similar variants of the Gulf *pipil* or eastern Nahua dialect are spoken throughout southern Veracruz and eastern Tabasco (García de León 1969: 280). Sierra Popoluca, a Mixe-Zoquean language, is spoken by the neighboring people of Soteapan. All in all, the Gulf Nahua and Popoluca population numbers some 30,000 scattered in small communities in the mountainous area known as the Sierra de Santa Marta.

Beyond the Gulf Nahua area lie the cities of Coatzacoalcos, Minatitlán and Jáltipan which have a total population of over one million. These cities have grown rapidly in the past thirty years as a result of their strategic position between the oil-producing southeast and the industrial Valley of Mexico. They are ideally located on the narrow isthmus that divides the Gulf of Mexico and the Pacific Ocean. Some 70% of Mexico's petro-chemical industries are concentrated there. To the west of this massive and highly polluted urban industrial complex lies the bustling cattle ranching and commercial city of Acayucan. The cattle industry has a long history in the region and is the economic mainstay in rural areas. Stimulated in recent decades by favorable national policies and growing national demand for low quality beef, this land-extensive cattle economy has expanded rapidly, encroaching upon tropical rain forests and agricultural land and causing countless violent confrontations in the countryside. Thousands of peasants have lost their land, forced out of agriculture into unemployment or other poorly-paid sectors of the rural and urban economy. As we shall see, the story of Pajapan is an illustration of the ravages of modern economic history on rain forest environments and mesoamerican native society.

The expansion of state and capital profoundly altered the slash-and-burn subsistence economy and the rain forest environment that used to support it. Peasants and their rain forest environment have been exploited and impoverished by ranching capital, through means other than outright proletarianization and industrialization. But while ranching activities have radically altered previous relations and forces of production, they have fallen short of taking over the whole economy. Some older patterns of slash-and-burn farming and subsistence production have survived. Two important factors account for this distorted reproduction of older economic patterns: peasant resistance and the weaknesses of local capital. On the one hand, the local property system and the overall conditions of production have been shaped by struggles over land and a whole range of peasant survival strategies, from modifications of *milpa* agriculture to the intensification of complementary subsistence activities (e.g., lagoon fisheries). On the other hand, the local economy is marred by the inefficiency and shortsightedness of Pajapan's hinterland ranching industry, a poorly-managed breeding economy harnessed to urban-based operations controlling the more profitable processes of finishing and commercialization. Cattle ranching in the Santa Marta area creates few jobs and imposes poor-quality pastures on diverse rain forest ecosystems. The industry has had a negative impact on *milpa* productivity, causing a loss of food self-sufficiency. A highly-constrained pastoral economy has spoiled the area of its natural riches and undermined long-term prospects for sustainable agricultural production in Pajapan.

Capitalism is adaptable and aggressive but it is also a stupid machine bent on creating obstacles to its own growth. In Pajapan, the expansion of the regional cattle industry has depleted resources and created poverty, unemployment, and economic stagnation. These deplorable effects of capital accumulation in agriculture reflect chronic problems of mismanagement costly to the current profitability and future prospects of local and regional capital. As elsewhere, capitalism develops a measure of irrationality, creates obstacles to growth and sets limits to its own development. In Pajapan, problems of poverty, unemployment (or underemployment), low overall productivity, loss of food self-sufficiency, limited markets, massive resource depletion and economic stagnation are effects of maldevelopment resulting from the expansion of the regional cattle industry. Although these effects are indicative of capitalist development, they also point to capital's chronic tendency to mismanage the economy. Irrational and unbalanced growth places costly restrictions on the profitability and future prospects of local and regional capital.

A Tropical Ecosystem: Diversity's Last Stand

The Sierra de Santa Marta is one of two large volcanic structures comprising the Sierra de los Tuxtlas in southern Veracruz. This coastal mountain range harbors the most northern rain forest on the continent (18 15'N) and one of the most ancient. During the final centuries of the Tertiary era a series of tectonic events pushed sedimentary materials upwards to form the Sierra de los Tuxtlas and Santa Marta, dividing the vast coastal plain into the

Tehuantepec Isthmus and the Veracruz plain (Toledo 1982; Benavides 1986). The thermostatic effects of the Gulf of Mexico provided the region with a degree of climatic stability permitting the survival of many tropical and subtropical flora and fauna during the cool-dry climatic periods of the last ice age. The Sierra was one of only a few "areas of refuge" when most rain fall forests in Mexico disappeared. When temperatures and rainfall increased with the beginning of the modern geological era, these and other refuge areas fanned out to reconquer the tropics of Mexico.

The climatic features of the Sierra de los Tuxtlas and Santa Marta create an island of biological diversity uncommon in the world. The sudden rise from sea level to over 1,700 meters at the highest peak transforms the moisture-laden trade winds from the Gulf of Mexico into torrential rain, over 4,000 mm. on the northern slope. The mountain range also creates a rain shadow on the southern and eastern slopes where annual rainfall drops to as little as 1,000 mm. Altitudinal variations up the volcano slopes and inside the craters create a wide range of temperatures favorable to the development of varied vegetation types and animal habitats. In an area covering only 1,500 km^2, a vast array of biological life is concentrated.

More than 3,000 species, 607 genus and 143 families of vascular plants are present in the Sierra, representing most of the plant families found in the State of Veracruz (Andrle 1964; Paré et al. 1992; Ramírez 1984). Some plants native to the Sierra are new to science, including a genus and species of orchid and bamboo, a fern species, five tropical shrubs belonging to the Myrsinaceae family, a herb species (*Salvia tuxtlensis*) and several others. Approximately 263 native plant species are considered medicinal by the indigenous population, 73 others are collected for food and 54 species have traditional applications for the construction of houses, furniture and tools (Fernández, 1992).

Approximately 1,173 animal species, 21 of which are endemic, inhabit the forests of the Sierra. An estimated 41% of Mexico's bird species, some 410 in all, depend upon the forests and mangroves of the Sierra for survival. In addition, the region provides habitat for 102 mammals, 168 species and subspecies of amphibians and reptiles, 359 bat species, 124 species of dragonflies, and 50 species of aquatic insects. Navarro (1981) argues that the regional diversity of bats is rivalled only by the lowlands of Panama and Costa Rica. Deforestation has all but destroyed this heritage: at least 140 species of fauna (mostly birds, reptiles and mammals) are at the edge of extinction.

Ramírez (1993) describes 8 ecological life zones in the Sierra based mainly on climax vegetation types, soils and climatic factors. The mountain peaks and craters are covered by various kinds of subtropical montane forest known to the Gulf Nahuas as *bawayoj*. At this altitude, average annual temperatures are 18 C. or less and rain falls in excess of 3,000 mm. per year, providing the cool, wet conditions needed for development of these forest types. The mountain peaks are frequently shrouded in clouds, adding through condensation as much water to the local hydrology as falls in rain. The forest drips with mosses, lichens, ferns, orchids and vines. While the forest canopy reaches between 15 and 25 meters in places, on the ridges and in areas exposed to the wind the vegetation does not exceed three meters in height. In their most developed form, cloud forests have two strata characterized by distinct plant communities determined partly by slope and exposure to wind and sun (Andrle 1964; and Ramírez 1991).

Montane forest is Cloud forests are uncommon in Mexico and the world. The Sierra de Los Tuxtlas and Santa Marta, El Triunfo, Sierra Madre and Sierra Norte in Chiapas and the Chimalapas in Oaxaca contain the only Mexican forests of this type. Cloud forest cover on the peak of the volcano San Martín Pajapan has been reduced by fire and clearing to only 338 hectares. This forest remains a sacred and somewhat intimidating place for Pajapeños who believe the area to be inhabited by jaguars, poisonous snakes and *chaneques*, the animal spirits.

The foot hills of the Sierra and much of the coastal plain are characterized by various kinds of **tropical and subtropical rain forests**. In the wetter canyons protected from strong winds the rain forests reach as high as 900 meters above sea level. Within this forest type, known to the Gulf Nahuas as *we bauit*, there are 14 plant associations distinguished by the indigenous population according to the most characteristic (but not necessarily dominant) species.

The longevity of the tropical rain forests of the Sierra is a tribute to the efficiency of rain forest ecology. Constant temperatures and high humidity in the rain forest interior contribute to the rapid decomposition of forest litter and its conversion into humus by soil flora and fauna. The tiny rootlets of trees and other plants quickly recycle nutrients contained in the vegetation, returning to the living forest the remains of previous generations of plant life. This plant-to-plant recycling process is so complete that the rate of nutrients entering the system through litter, rain and dust closely balance the rate of nutrient loss through soil leaching and volatization. The rain forest derives most nutrients needed for plant growth from itself, without drawing on the limited resources of the soil. The soil remains in a state of equilibrium, serving not as a supplier of nutrients but rather as a reservoir for water and a mechanical support system for tall trees.[1]

This remarkable recycling process is aided by the closed-cover architecture of the rain forest. The tallest trees form a dense canopy at approximately 30 meters with occasional emergent trees reaching a height of 40 meters or more. This canopy completely shades the forest floor from the heat of the sun and lessens the force of the heavy rainfall. A middle stratum of trees 6 to 18 meters tall provides additional protection from sun and rain and support for a myriad of vines, orchids, mosses, mistletoes and stranglers that cling to the branches of trees. This luxuriant vegetation intercepts and absorbs a great deal of water before it strikes the ground and traps moisture for use during periods of relative drought. A lower story composed of trees, saplings, shrubs, spiny palms, and ferns completes the protective cover. The ground level of this tall forest is relatively clear and open, covered mainly by fallen trees, branches, and a thin layer of dead leaves.[2]

In addition to the conservation of biological diversity, the montane forests and rain forests of the Sierra provide an important ecological service to the region. The vegetation captures a tremendous amount of water through horizontal precipitation (dew), perhaps as much as falls in rain (Paré *et al.* 1992). This water is gradually released to lower areas throughout the year, supplying the major bodies of water in the region including the coastal lagoons Sontecomapan and Ostión, Lake Catemaco (Mexico's third largest), and numerous rivers feeding both the Coatzacoalcos and Papaloapan watersheds. Along all slopes of the Sierra, springs gush forth from the rock at major breaks in the topography, providing the basis for many human settlements (denoted through water-place names ending with the suffix *-pan).*

Some 80% of Coatzacoalcos' potable water, 20% of the water consumed by Minatitlán and virtually all of the drinking water of Acayucan is drawn from two springs on the southern slope of the Sierra, one near Soteapan and the other near Tatahuicapan. More than a million people in these and numerous small cities, towns and villages in the region depend upon the water captured, stored, filtered and distributed by the forest vegetation in the Sierra.

Drier conditions on the southern and eastern slopes of the Sierra create several other important ecological life zones. Subtropical moist forest is the primary vegetation for an area extending between 100 and 450 meters above sea level from the western margin of the Laguna del Ostión in the municipality of Pajapan around the eastern slope of the Sierra to San Andrés Tuxtla. This relatively open forest is characterized by black oak *(Quercus oleoides),* an evergreen tree found all the way south through mesoamerica to Costa Rica. The forest usually reaches a height of 10 to 15 meters although under some conditions trees may grow to 30 meters.

The sheltered shores of the lagoons Sontecomapan and Ostión are surrounded by **mangrove forests**, a habitat rich in aquatic and land-bound life. Mangrove forests have an amphibious existence that develops in close relationship with the coastal estuary. The aerial roots of the trees disrupt water currents, enhancing "accretion of marine and stream sediments, leaf litter and other organic debris, so that soil levels within the mangrove are progressively raised" (Britton and Morton 1989: 223). Mangrove forests literally reclaim land from the sea. These forests are among the most developed on the western Gulf of Mexico (Bozada and Chávez 1986; Britton and Morton 1989). Four of five Mexican mangrove species are present in these forests, arranged horizontally in bands from the shoreline to higher ground where they are replaced by other plant communities. In contrast to the closed nutrient cycles of the rain forest, mangroves "are systems open to the flux of energy and materials upon which they depend" (Gallegos 1986: 27). As a result, they are very susceptible to both marine and freshwater pollution.

Abundant rainfall, warm temperatures and a bimodal rainfall regime make it possible to produce a wide range of tropical crops throughout most of the year. Rainfall in Pajapan averages 2,700 mm. per year while the annual average temperature is 25 C., ideal conditions for many tropical crops. The rains are distributed bimodally, facilitating agricultural activities through much of the year. The wet season *(temporal)* lasts from June until September, a warm period with heavy downpours and night storms. The rains are briefly interrupted during the later part of August by a dry canicular spell that can have negative effects on local agriculture. A heavy drizzle and strong, cool winds from the north *(nortes)* created by tropical cyclones repeatedly strike the region from October until early March. The *nortes* bring rain that facilitates a second planting season *(tapachole)*. They also bring winds that occasionally peak at 80 km/hr., knocking down maize fields and deflowering fruit trees and bean crops. A short, sharp dry season interrupting all agricultural activity arrives later as hot air masses *(suradas)* sweep in from the south from March to May. These dry winds, sometimes as strong as 40 km/hr., produce clear skies and hot weather that dry out pastures and pose risks during the tapachole.

Climate, topography, soil, water and vegetation are all delicately balanced in a web of relationships establishing the natural constraints and potentialities of human resource exploitation in Pajapan. The Gulf Nahuas lived within this environment for centuries, applying their intimate knowledge of variations in the distribution and ecology of land and water resources to exploit the natural bounty that surrounded them. The same cannot be said of the production system in the Pajapan of today. The rise of the cattle industry from the 1950s onwards has thoroughly transformed the original landscape. While population pressures under the traditional system of agriculture or the development of commercial agriculture may eventually have displaced the tropical forests and produced some degradation of soil resources, these changes would not have occurred with anything near the speed or voracity that has come to typify the modern cattle economy. As will be seen shortly, the silvo-pastoral and agricultural systems that replaced the primary ecosystems degraded the natural resource base more during the last few decades than in the previous few centuries.

The Receding Forest and the Intensification of Underproduction

The cattle industry is one of the principal agents of ecological change in Latin America (Downing *et al.* 1992; Myers 1980; V. M. Toledo 1989). The history of cattle ranching in Pajapan illustrates the destructive role the industry has played in the conversion of tropical forests into pastures and the decline of *milpa* agriculture. Our case-study also points to the chronic weakness of an industry characterized by an inefficient and destructive use of local resources. While the rise of cattle ranching in Pajapan has contributed to the accumulation of agricultural capital, its has done so only minimally and at great cost to the growth of a regional economy dependent upon the exploitation of limited and vulnerable natural resources. The forces of production and exploitation prevailing in this remote corner of the

Mexican tropics have not only consumed all competing works of nature and culture but also clumsily undermined the basis for future growth in the region.

In the 1930s, forest covered an estimated 70% of the Gulf Nahua territory (Ramírez 1991). Cattle introduced at that time grazed the natural savanna on the plain between the Metzapa River and San Juan Volador. The same area used to be occupied by Spanish *hacendados* in the 17th century while farmers cultivated maize and beans on the rest of the plain and low hills below the village of Pajapan. A growing demand for beef in regional, national and international markets and state investments in credit and technical assistance stimulated the expansion of ranching operations long established on the broad coastal flood plain into new areas of the Santa Marta highlands. Pajapan, conveniently located near the city of Coatzacoalcos, was one of the first points of entry into the Sierra.

Mestizo ranchers from Coatzacoalcos, supported by Indian employees and the local land authorities, invaded the lowland area of Pajapan in the 1950s. The fallow fields of farmers were simply fenced in and burned to induce fire-resistant grasses. Farmers who complained about the loss of access to these fields were ignored by local land authorities receiving cattle of their own from the mestizo ranchers in exchange for their support. As the cattle population increased, the amount of land available for *milpa* cultivation on the fertile plain decreased, forcing peasants to clear forested land further up the hillside. Forest clearing in turn made way for more pasture once the fields were left to fallow. This cycle of land clearing, *milpa* cultivation and conversion to pasture pushed the forest frontier up the slope of the volcano, toward the outer limits of the Gulf Nahua territory.

While initially the cattle grazed on the communal lands of Pajapan were owned by outside ranchers, their Indian allies soon established ranches of their own. The mestizo ranchers were more interested in supplying their regional operations with feeder calves than in controlling all stages of local cattle production. Statistics obtained from the local Rancher Association indicate a growing tendency on the part of Pajapan's ranchers to supply the regional market with immature calves as opposed to full grown cows: from 1961 to 1967, the ratio of calves to all animals sold went up from 39 percent to 59 percent of all sales. By 1972, 77 percent of all animals sold in Pajapan were calves.

Rancher-driven clearing by farmers was supplemented by direct clearing for pasture during the 1960s and 1970s. Guadalupe Hernández, one of Pajapan's first large-scale Indian cattle ranchers, arranged to clear approximately 300 hectares of mature rain forest near Sayultepec on the northern edge of Pajapan's territory.[3] This was followed in the early 1970s by an intensive period of deforestation: ranchers rushed to claim remaining forested lands and establish pastures for rapidly expanding herds.[4] An estimated 1,936 hectares of tall humid forest were cut down at a rate of 215 hectares per year between 1967 and 1976 (Ramírez 1991: 9). The forests of the municipality of Pajapan were reduced from an original endowment of 15,600 hectares to 550 hectares, mainly on the upper slopes of the volcano too steep for cultivation. The mangrove forest surrounding the lagoon was also greatly reduced during this period, from 1,225 hectares in 1967 to approximately 932 hectares in 1986 (Ramírez 1991: 31). While some of the felled trees from both humid forest and mangroves were used to feed a sawmill in Tatahuicapan and to construct houses, rustic furniture and dug-out canoes, the vast bulk of exuberant vegetation was simply burned where it fell.

The receding forest frontier in Pajapan facilitated extensive grazing by large herds on unimproved pastures, a pastoral system that became the norm throughout the region. The clearing of communal forest land and second growth and the use of fire to establish grasslands were inexpensive ways of laying claim to large tracts of land and providing minimum grazing conditions for large herds. The major task of clearing mature forest had already been accomplished by peasants, and grass was an easy crop to grow. Only wild, self-seeding grasses were utilized and animals were allowed to graze freely with little handling by ranchers. The only rotation of pastures was seasonal: the plains and seasonally flooded lowlands, with their greater water retention capacity, were grazed more intensively during the dry season while the medium and high hills were more intensively grazed during the wet season. By the late 1970s, the herd grazing the communal lands of Pajapan totalled some 9,000 animals, 84% of which were owned by some 40 families with herds of between 50 and 500 head of cattle.[5] There were few small or medium-sized herds. Ranchers controlled a minimum of 50 hectares of land and in a number of cases as much as 400 hectares. A few ranchers had even larger tracts of land.

The retreat of primary forest from Pajapan has long term implications for forest survival and the species composition of secondary forest. The seed of many tree species has disappeared from the local environment, effectively undermining natural reforestation. Frequent burning for the establishment of pastures and *milpa* has simplified the ecosystem, leaving behind fire-resistant grasses. Deforestation in Pajapan is permanent for all intents and purposes. While a massive reforestation effort could be undertaken with seedlings brought from outside, such an effort presupposes that the germplasm native to the area be preserved at a regional level and that the current socio-economic conditions prevailing in Pajapan be radically changed. Unfortunately, however, cattle-led deforestation has been repeated on a regional scale. The tropical forests of the Sierra de Santa Marta have been systematically levelled by a land-hungry cattle industry on the rise. Ramírez (1991: 1) reports that Sierra rain forest that once covered the entire region (150,000 hectares) have been reduced to less than 20,000 hectares, mainly during the 1960s and 1970s. While logging, agriculture and forest fires accounted for some of the loss, the rate of destruction fostered by ranching activities was far beyond that dictated by other forces. As is now well understood, the destruction of tropical forests contributes to broader problems affecting the entire planet.[6]

A pastoral system based on deforestation and the extensive use of soil and vegetation came to a halt in the mid to late 1970s as the last of the forested land came under direct exploitation and most cropland was converted to pasture. Extensive grazing by large herds would have continued for some time had it not been for the events surrounding the petro-chemical port project Laguna del Ostión and the resulting changes in land tenure forced upon Indian ranchers. The expropriation of the prime coastal plain to make way for the establishment of an industrial port led to a reallocation of lands demanded by the majority landless population. The ensuing reduction of individual land claims from several hundred hectares to a uniform 12-hectare parcel per *comunero* forced ranchers to sell large numbers of cattle, in some cases to urban markets and in others to local peasant beneficiaries of the land reform. The sudden influx of cash in the form of payment for the expropriated lands partly facilitated the transfer of cattle to a greater number of small and medium-scale ranchers. While some wealthier ranchers managed to regain access to land through rental arrangements and the illegal purchase of *comunero* status and land rights, the very large herds of the 1970s were no longer possible. The largest herd in Pajapan today is probably around 200 head of cattle, compared to former herds of up to 800.

Pasture and animal management practices changed considerably following the land redistribution and proliferation of small-scale ranching units. While a far cry from the ecologically stable forest systems, extensively grazed pastures are less destructive of soils and secondary vegetation than the overgrazing system that has developed in recent decades. Land use has become more intensive but without any corresponding increase in productivity. The fragmentation of ranching capital and the subordinate position that Indian ranchers occupy within the regional economy impose significant limitations on the ability of local capital to overcome ecological and technical constraints on the development of the forces of production. As a result, the contribution to regional economic growth is far below resource potential and of questionable benefit to the long-term interests of capital accumulation in the region.

The gap between resource potential and actual use is a striking feature of Pajapan's ranching sector. During the wet season, large amounts of biomass are created but much of this is underutilized. Ranchers have not divided their parcels into smaller paddocks to facilitate pasture rotation and the efficient use of solar energy concentrated in pasture production. Animals are typically grazed in a single paddock for the entire rainy season, far in excess of optimal monthly or bi-weekly rotations (Williamson and Payne 1978; Romanini 1978). Long grazing periods augment the proportion of inedible plant species unbrowsed by cattle, a situtation which leads to long term degradation of the remaining pastures. Brush clearing and burning is required to remove this unwant plant growth, increasing labor costs and provoking pasture wildfires.

While pastures are underutilized during the wet season, they are severely overgrazed during the dry season. On the hillsides, the land dries quickly once the rainy season ends and pasture production drops off completely. By contrast, the soils of the plain and seasonally flooded lowlands retain residual soil moisture. As a result, pastures in this area remain green longer into the dry season and grow faster with the June rains. This advantage places an extra premium on the plain and lowland area for dry season grazing.

Prior to the land reform, ranchers managed seasonal fluctuations in pasture production by moving their cattle between the highland and lowland areas. The Secretary of Agriculture and Water Resources (SARH) estimated that the annual stocking rate in Pajapan during the 1970s was about two hectares per head of cattle. The land redistribution, however, has greatly restricted rancher mobility, and contributed to seasonal increases in stocking rates and overgrazing of both the lowland and highland areas. Ranchers with land in the lowlands concentrate all of their animals during the dry season and take on additional animals of ranchers who can afford to rent access to their pastures. Stocking rates in the lowland area increase during this period, to an estimated 1.2 hectares per head. Stocking rates on rented land are even higher (0.8 hectares per head), indicating a 'mining' approach to the management of rented pastures. Meanwhile, ranchers restricted to the hillsides by the land redistribution continue to graze their animals on the poorer quality upland pastures. Both strategies result in land and pasture degradation. The soil is compacted under the hooves of animals concentrated in the lowland area and erosion is provoked on the hillsides when the roots of grasses are pulled out by cattle seeking any kind of sustenance at all. Much of the hillside area facing the Gulf of Mexico has been permanently deflected to *talquetzal (Paspalum virgatum)*, a tough grass of little grazing value or agricultural potential.

The scarcity of dry season pastures in Pajapan imposes severe constraints on the productivity of cattle production. Cattle in Pajapan typically lose 25 percent or more of their live weight during the dry season due to pasture shortages and climatic stress. Weakened and dehydrated animals are in turn more susceptible to intestinal and pulmonary parasites. While these loses can be compensated during the wet season, calving rates are depressed and the normal growth of calves is retarded. Under these conditions, fewer animals are produced and newborns require two years or more to attain slaughter weight, compared to a 10 month development cycle for healthy, well-fed animals.

Ranchers in Pajapan have adapted to seasonal fluctuations in pasture production in part by increasing stocking rates on the lowland area and mining upland pastures. In addition, however, many ranchers find themselves forced to sell a large proportion of their herd at the onset of the dry season, flooding local markets with young calves and depressing prices. Small-scale ranchers with few financial resources are particularly vulnerable to this situation; they must sell their younger and weaker animals at very low prices or risk losses during the dry season.

Very low levels of technical development prevent the ranchers of Pajapan from realizing the productive potential of cattle raising, thereby imposing significant barriers to the growth of local agricultural capital as a whole. This form of development allows cattle merchants and capitalized producers to exercise tight control over regional markets for calves and adult animals, with significant benefits to these branches of capital. First, most ranchers in Pajapan are effectively restricted to breeding calves, the riskiest stage of cattle production. Second, cattle brokers benefit from a supply of cheap, immature feeder calves purchased at critical stages in the production process. These animals are transported to regional centers on the coastal flood-plain where they are grown out and fattened up under more intensive conditions for resale to slaughterhouses in Minatitlán, Jáltipan, Acayucan and elsewhere. The final product is shipped in refrigerated trucks, often owned by the same producers, to markets in Mexico City, Puebla and other large urban centers. Third, quick profits can be realized by cattle merchants from the purchase and treatment of calves weakened by malnutrition and parasitic diseases. Given these local conditions of production, the village of Pajapan and other communities in the Sierra de Santa Marta raise fewer animals than the natural environment can potentially support and realize relatively little of the profit of production.

All in all, Pajapan's ranchers have been largely excluded from technical developments and adaptive strategies appropriate to the full development of local forces of production. The level of expertise deployed by Indian ranchers is far below industry potential. The care and handling of pasture and cattle is limited to such rudimentary tasks as annual burning of pastures, supplying salt, branding, spraying animals with tickicide, and ensuring that animals do not escape from the paddock. Traditional skills have been largely by-passed by industry developments and ranchers have not acquired the modern skills needed to manage pastures, detect animal diseases or oversee breeding. The low productivity of cattle production in Pajapan derives largely from these socially determined limitations, in sharp contrast to the natural potentialities of the local environment. The recent intensification of livestock production has exacerbated problems of soil erosion and land degradation but without the technical changes normally associated with capitalist development. As discussed in the following section, ranching has also undermined the traditional *milpa* system and limited the development of crop production in Pajapan.

The Milpa Transformed

During the 1960s and 1970s, a land hungry cattle industry on the rise displaced farmers and undermined the traditional farming system. Pasture became the dominant land use. According to census data from the Secretary of Agriculture and Water Resources (SARH), agricultural land uses for the nine *ejidos* in the municipality of Pajapan dropped from 48% in 1950 to 24% in 1988. By contrast, the area under pasture increased from 28% to 52%. Our survey data indicate that in 1986 an estimated 1,183 hectares or 6% of the communal lands of Pajapan were devoted to *milpa* cultivation including 1,083 hectares of maize and 100 hectares of other food crops such as black beans, sweet potatoes, manioc, chayote, and bananas. A few farmers grew malanga and watercress in stream beds and watermelon in sandy soils along the beaches of Jicacal. Fruit trees including mangos, oranges and hog plums were also cared for by a small number of farmers. Ramírez (1991) indicates that pastures currently represent some 80% of the Gulf Nahua territory. Agricultural land accounts for 14% of the communal land area and forests (mangroves and cloud forest), no more than 5%. This represents a dramatic shift away from *milpa* cultivation.

Total maize production dropped significantly during this period, undermining local self-sufficiency in basic foodstuffs. A *milpa* in Pajapan was on average only three quarters of an hectare compared to two hectares a few decades ago. The occupation of the fertile plain by cattle ranchers has also reduced the amount of land available for the dry-season *milpa*. Only 22% of farmers produced *tapachole* maize in 1986 due to constraints on access to suitable land. Maize production for the 12-month period extending from 1985 (summer maize) to 1986 (winter maize) amounted to 1,100 metric tons of shelled maize, worth approximately $150,000 U.S. on the local market. The total harvest and market value of other agricultural products was negligible compared to maize. Pajapan and neighboring communities went from a situation of net maize production in the 1950s to one of severe deficit in the 1990s (Paré *et al.* 1992). Our survey data suggest that while 80% of all households in Pajapan produced some maize in 1986 (1 metric ton per household on average), 45% of these families purchased maize during the year, typically for a period of four to six months. Peak short-falls bordering on conditions of famine for some families occur in the months of July and August, immediately before the wet season harvest.

The creation in 1992 of an *ejido* from the expropriated lowland area is stimulating a revival of crop cultivation in Pajapan. It has also opened the possibility of agricultural alternatives to the ranching economy (see Conclusion). Nevertheless, the impact of the cattle industry on local land use patterns has radically altered the cropping system per se. As argued below, the *milpa* of today differs in many key respects from the traditional *milpa* as described by local informants and also by Stuart (1978), an anthropologist who in the mid 1970s studied an isolated hamlet called Peña Hermosa composed of emigrants from Pajapan. At the time of his study the cattle industry had not extended to Peña Hermosa, external inputs were not used and land was abundant.

A *milpa* (*milli* in classical Nahuatl) is an area of land planted in maize and other food crops. The term applies to a wide range of cropping systems in environments as diverse as the central valley of Mexico and the humid tropics of Central America. The *milpa* in Pajapan is a form of shifting cultivation subject to particular environmental and social conditions that have changed over time.

The agricultural year in Pajapan is divided into two maize seasons, the wet season *temporal* and the dry season *tapachole*. The *temporal*, planted in June and harvested between November and January, is the main maize crop of the year. *Tapachole* is a minor season crop planted in November and harvested between March and April. While other food crops play a role in the local farming system, the requirements of maize set the tone for all agricultural activities. Land preparations for the *temporal* begin during the dry season when the secondary vegetation forming an *acaual* is cut down by hand with a machete and burned in the field once it has thoroughly dried. The cleared field is then planted using a dibble stick to punch a hole in the ground into which maize seeds are placed. Maize in Pajapan is planted in rows a meter apart at densities of approximately 30,000 to 40,000 plants per hectare. Since moisture is critical to the germination of maize seed, most farmers plant their maize when they feel certain that the rainy season has begun in earnest, typically by early

June. While premature planting can result in crop failure due to poor germination, planting too late increases the risk of damage to the crop caused by strong winds (*nortes*).

Maize is very susceptible to weed competition for nutrients, light and soil moisture. As a result, it requires relatively clear cultivation, especially during the early stages of plant development. *Milpas* are typically weeded twice during the *temporal*, in July and then in August. To weed a field, the worker proceeds down the rows of maize loosening the earth around the weeds with the tip of a machete or hoe and leaving them to dry. Manual weeding is the most time consuming of farming operations and in recent years an increasing number of farmers in Pajapan have turned to herbicides to control weeds. The contact herbicide Paraquat is the most common, sprayed directly on the weeds between rows of maize using a back-pack sprayer. Herbicides are also occasionally used during land preparations.

The pace of plant growth is determined by plant physiology, soil nutrients, sunshine and rainfall. Virtually all farmers in Pajapan use local maize varieties requiring approximately 100 days to attain physiological maturity under the prevailing environmental conditions. Depending upon the time of planting, the first tender ears of maize may be harvested beginning in late August. By late September the maize has usually reached physiological maturity, at which point the stalks are doubled below the main ear. Rain runs off the down-turned husks, thereby allowing the grain to continue drying in the field. The doubled maize plant is also less likely to break under the strong winds *(nortes)*. Thus protected, maize can be harvested piecemeal throughout November, December and January. A horse or the back of the farmer are used to carry the harvest from the field to the home where the maize is stored on the cob, typically in the kitchen loft called a *tapanco*.

In much of Mexico, the wet season *temporal* is the only maize season. In the lowland tropics of southern Veracruz, however, periodic rainfall in the months of November, December, January and February makes it possible to grow *tapachole* maize with certain modifications to the cropping system. In the Pajapan area, *tapachole* is planted in November and harvested throughout March and April. Maize is usually planted on the same field as the previously harvested *temporal,* hence little vegetation is cleared when preparing the land. The slash produced from weeds and the stalks of *temporal* maize is not burned as in the wet season but rather is chopped and left on the field. The resulting mulch conserves soil moisture during the height of the dry season and provides the growing plants with some additional nutrients. Drier climatic conditions during the *tapachole* reduce the number of weeding operations to one as compared to the two weedings characteristic of the *temporal.* Although less labor intensive than wet season maize, cultivation during the dry season presents other problems. The hot and strong southern winds *(suradas)* blowing in February, March and April can have severe negative impacts on yields. Also, the mulch created by crop residues provides habitat for a variety of corn-eating insects. Birds are more problematic during this season as well. These problems combined with the drier conditions reduce yields by one third compared to wet season production (see below).

Bush beans, the common black bean of Veracruz, is the most important secondary crop planted in Pajapan. Prior to the development of the cattle industry, bush beans were grown by Pajapeños on the plain. The area dedicated to this crop consequently declined as farming was displaced to the less fertile hillsides. The recent revival of *milpa* cultivation on the lowland has facilitated a resurgence of bean production, a potentially important cash crop (see Perales 1992).

The riskier *aventurero* crop is planted as a sole crop in June. *Aventurero* beans fetch a higher price on the market but disease problems caused by wet conditions are common. The *cosechero* planting in September involves fewer risks and less work as the beans can be intercropped in the drying *temporal* maize. Nevertheless, the strong winds and heavy rains of September and October can damage the bean flower and promote sprouting in the bean pod. The risk of wet conditions at harvest time and limited access to appropriate land limit the amount of beans planted per farmer.

Other crops grown in Pajapan include manioc and sweet potatoes on poorer quality soils, chayote and plantains on humid soils, and watermelon on the sandy soils of the coastal corridor. Fruit trees such as orange, mango and hog plum are cultivated throughout the area.

Recent farming practices in Pajapan and throughout the Sierra de Santa Marta are increasingly breaking basic rules of shifting cultivation, at great cost to both the farmers and their immediate environment. Foremost among changes in the cropping system is the degradation of the *acaual*, the secondary forest vegetation established on fallow land. Fallow periods in Pajapan have been dramatically reduced and tree species virtually eliminated from the fallow, with grave implications for agricultural resources and system performance.

Shifting cultivation in the humid tropics has frequently been characterized as a "robber economy" bent on the rapid destruction of the rain forest and the depletion of soil fertility. Forest land is cleared, cultivated for a few years and abandoned in search of a new forest and nutrient horizon. In recent years, however, science has reached a better understanding of the logic and merits of shifting cultivation. The *milpa* system practised in Peña Hermosa (observed by Stuart in the mid 1970s) was based on a plant-to-plant nutrient recycling process involving the rotation of secondary forest and cultivated fields. Shifting cultivation was circular; peasants abandoned a field when maize yields declined below acceptable levels (800 kg/ha) and returned to the field once agricultural potential had been regained under secondary forest. Farmers in Peña Hermosa managed *acauales* as future *milpas*, noting subtle changes over time in soil characteristics, weed populations and plant species indicating the fertility status of the *acaual*. Maize fields were surrounded by *acauales* at various stages of regrowth and areas of mature forest from which natural vegetative succession on abandoned land could occur. It was a forest-linked system based on the continuous regeneration of forest species and food crops. As Redclift argues (1987: 28), "from the standpoint both of energy efficiency and the productivity of the agricultural system (in energy terms) per unit of land, the most successful systems are those which combine crop rotation and fallow with low energy inputs, such as the peasant maize-production system dominant in most of rural Mexico."

Abandoning a field to secondary forest is an effective strategy for restoring agricultural potential. In contrast to temperate environments, natural vegetation in the tropics accumulates biomass and nutrients rapidly (Romanini 1978: 16, 19). The plant species characteristic of secondary forest are well adapted to the low nutrient status of the soil and exposure to direct sunlight. They grow very rapidly in the first few years, thereby providing protection for the soil. Large amounts of biomass are accumulated in the form of trees, vines and herbaceous plants. Nutrients and organic matter depleted from the soil as a result of burning, cropping and exposure to the elements are replaced under secondary forest and imbalances in the availability of nutrients are corrected. Soils compacted and hardened under the impact of rain are softened and weeds that compete with food crops for plant nutrients are shaded out. The plant to plant recycling process is completed by slash-and-burn techniques of land preparation. Burning clears the field for planting, kills weed seeds, temporarily neutralizes acid soils and converts the abundant vegetation into a layer of nutrient-rich ash available for cultivated crops.

The time period required to fully restore agricultural potential varies greatly from one area to another depending upon rainfall, plant species composition in the *acaual,* soil type, the period of cultivation and farming techniques. In Peña Hermosa, the cropping ratio consisted of two to three years of cultivation followed by four to five years of fallow. "No informants reported having used longer fallow periods in the past, nor do they consider fallows longer than five years to be in any way superior to present fallowing periods" (Stuart 1978: 315).

Fallow periods of four to five years are much shorter than those reported for many parts of the humid tropics. Agronomists generally hold that if long-term soil impairment is to be avoided in shifting cultivation systems, two to three years of cultivation should be followed by nine years or more of fallow. The heavy rainfall of southern Veracruz does allow, however, for very rapid plant regrowth, permitting shorter periods of regrowth without impairing soil quality. Stuart's analysis of soil samples from *acauales* in Peña Hermosa indicates that regrowth of four to five years is enough to restore the nutrient status of the soil to the same levels found in mature forest conditions. He also notes that the land cultivated by the villagers of Peña Hermosa did not suffer from soil erosion or other evidence of land degradation (Stuart 1978: 311).

Under the conditions prevalent in Peña Hermosa in the early 1970s, shifting cultivation could easily avoid turning into a voracious consumer of forest species and limited soil resources. These conditions no longer hold, however, in Pajapan and throughout much of the Sierra de Santa Marta. Direct competition for land by the cattle industry and population growth have undermined the management of the *acaual.* Survey data from Pajapan indicate that two years of cultivation are typically followed by only one or two years of regrowth, less than half the fallow period used in Peña Hermosa (Chevalier and Buckles, in press). Frequent crop cultivation and annual burning of vast areas used for pastures have virtually eliminated the plant species associated with the traditional *acaual.* The Pajapan landscape is dominated by fire-resistant grasses, not the woody tree species, shrubs, vines and herbaceous plants characteristic of secondary forest. Some 38% of the farmers interviewed in 1986 had established their *milpas* on *zacatales*, a fallow composed entirely of grass species.

The degradation of the *acaual* has important implications for land management practices. Slashing and burning grasses cannot support crop cultivation without drawing heavily on the limited resources of the soil. Soils subject to frequent cultivation are consequently depleted, resulting in poor crop yields and soil chemical imbalances as some nutrients are mined from the soil. The soils of agricultural land in Pajapan and neighboring communities are extremely poor in major nutrients, compared to local soils under rain forest cover.[7] Maize yields are far below historical levels (3 t/ha). The 1985 *temporal* harvest in Pajapan averaged 1.4 tons per hectare (t/ha) while the 1986 *tapachole* averaged 0.8 t/ha. As should be expected, variations in soil quality had a significant impact on maize yields (Table 1).

Table 1: Maize yield per hectare (Pajapan village, 1986)*

	Good Land	**Average Land**	**Poor Land**
Wet Season	1.6 t/ha	1.4 t/ha	0.9 t/ha
Dry Season	1.2 t/ha	0.8 t/ha	0.5 t/ha

* Evaluation of soil quality made by farmers.

- Shorter fallow periods and the elimination of tree species in fallow land have also contributed to the build up of grassy weeds in many farmers' fields. Stuart reports that weeds were not considered a major issue in Peña Hermosa. By contrast, weed control currently represents the major labor demand during the crop cycle in Pajapan and an important constraint on increases in maize productivity. Mechanical weeding is not feasible on the sloping lands of Pajapan and manual weeding is an increasingly problematic method for managing maize grown in grasslands. Farmers frequently note that weeding is a losing battle; by the time they finish weeding the *milpa* new weeds have developed where they began.

The degradation of the *acaual* threatens future land productivity in the region. The soil organic matter destroyed by frequent cultivation and burning is not replaced by short fallows dominated by grasses, thereby reducing the capacity of the soil to retain moisture and increasing the risk of soil erosion. Channel and sheet erosion has scarred the local landscape and filled the streams with sediments that not only represent a permanent loss of agricultural potential but also a threat to silt-sensitive oysters banks in the Laguna del Ostión. Soils on the medium and high hills of Pajapan have been compacted and permanently resort to *talquetzal*, a tough grass of little value even for grazing.

Farmer Adaptations

The decline of shifting cultivation and the development of intensive patterns of land use have led farmers in Pajapan to adopt a number of new practices. These include the use of external inputs, reductions in the amount of land cultivated, specialization in the production of maize at the expense of other food crops and, recently, the use of green manures.

Low and declining soil fertility has been compensated in recent years by the introduction of chemical fertilizers. In 1986, very few farmers in Pajapan used chemical fertilizers but by 1993 the practice had become more common. Subsidized credit made available to some farmers beginning in 1989 by the *Instituto Nacional Indigenista* (INI) for a package of fertilizers, herbicides, pesticides and improved varieties of maize provided a catalyst for the partial adoption of these inputs. Currently, an estimated two thirds of the farmers of Pajapan use some fertilizer on their fields; many now believe that fertilizers must be used to obtain acceptable maize yields. Farmers have also turned to contact herbicides to ease weeding operations. While they were rarely used in 1986, by the early 1990s most farmers in Pajapan were using some herbicides during land preparations and weeding operations (Buckles and Arteaga 1993). This transition was also facilitated by INI's credit program and has been enthusiastically embraced by farmers hard pressed to control weeds in their fields.

While fertilizer and herbicide are effective means of addressing immediate problems such as low soil fertility and weed invasion, they imply higher production costs. Many farmers cannot afford to purchase the required inputs needed to manage a full-sized *milpa* and have opted instead to use small amounts of fertilizer on particular parts of their fields. Most farmers surveyed in 1993 had used fertilizers only two or three years out of the previous five. Furtermore, the INI credit program can offer only partial coverage of the hundreds of farmers in Pajapan and is severely limited by the ongoing fiscal crisis of the Mexican state. It is unlikely that the fertilizer needs of the farming population can be met by existing credit schemes.

Learning costs and health hazards associated with greater reliance on agro-chemicals are also significant. No extension has accompanied the provision of agricultural inputs in the community, a shortcoming leading to inefficient and unsafe farming practices. Farmers do not observe standard recommendations regarding the method, rate and timing of fertilizer applications or understand the basic logic behind chemical fertilization. Paraquat, the most commonly used herbicide in Pajapan, is a highly toxic chemical that in the few years of common usage in Pajapan has caused several deaths from toxic poisoning and numerous cases of toxic shock due to improper handling. Farmers use unnecessarily high concentrations of Paraquat and commonly wash the sprayers in local streams, thereby contributing to water contamination and disturbance of aquatic life.

Farmers have a well-developed understanding of soil fertility and weed management through shifting cultivation, knowledge only partially applicable to external-input agriculture. According to Nahua farmers, cultivated land becomes tired (Sp. *cansado*) when it dries out. In ideal conditions, "soil strength" (Sp. *fuerza*) may be recovered by letting the land "rest" for seven years. The "abandoned field" (*acaual*) generates a large amount of *tasol* garbage -- plant litter that "gives life to corn" by shading out weeds, rotting and keeping the soil wet, cold or fresh (*cece*). The fallow is aided by "cold" plant species such as *jonote* that produce a great deal of litter, soften the soil and "easily release the juices" of the earth. By contrast, "hot" plants such as oak dry out and harden the land, fixing soil juices in their thick bark. The leaf litter that falls on the ground during the fallow period "becomes soil", as does the ash (Nahua *banesh*, "lime made from wood") created through burning. The recovery of soil fertility is perceived by Nahua farmers as a process of "healing" obtained through a balanced combination of the cold and the hot: a maize plant "does not want sun or heat only, nor does it want water or cold only" (*aguinegui niat, aguinegui tonati; aguinegui ni cece, aguinegui ni totoni*). While farmers know that dry-season mulching and plant decomposition in fallow lands will enhance the coldness or wetness of the soil, they also count on the spring burning to fertilize the soil and prevent food plants from "burning" (usually described as *chahuiste*) due to excess humidity accumulating over the wet season cycle. It should be noted that in the native perspective, the soil is primarily a medium for these complex operations, not the source of fertility per se.

A perception of soil as process is not entirely compatible with the atomistic view of soils implicit in chemical fertilization. While resembling ash, fertilizer does not involve the alchemy of rotting and burning. The cultural memory of long fallows is fading yet there is no development of new farmer knowledge of external-input agriculture. Pajapan farmers fall back on their traditional knowledge to explain the action of new inputs. The application of herbicides, especially contact herbicides such as Paraquat, is likened to the use of fire:

both techniques "burn" the vegetation. The current popularity of Paraquat is due mainly to the considerable labor savings afforded by the herbicide, but the ease of adoption also proceeds from the transparent logic of the technology. Farmer understanding of herbicides is nonetheless incomplete. In the native view, weed control (burning) is assumed to increase with the rate of herbicide application, a perception that partly accounts for incorrect and excessive application rates. Furthermore, the dangers of a toxic chemical to human health are not immediately apparent to the native perspective.

Land degradation and constraints on the use of external inputs have forced farmers to modify other central features of *milpa* agriculture. Farmers in Pajapan have limited competition for scarce soil fertility by favoring maize and reducing the variety and number of food crops in the *milpa*. Only one fifth of all village households in Pajapan cultivate food crops other than maize, usually three or four staple plant species such as bush beans, manioc and plantains. These crops are simply grown in a corner of the *milpa*, not intercropped per se. Most plots are kept relatively free of weeds and even food plants that might compete with the maize. Changing weed control practices (herbicide use) have also reduced the incidence of volunteer food plants in the *milpa* such as *quilites*.

The paucity of food crops in Pajapan contrasts sharply with the traditional *milpa* system observed in Peña Hermosa. Stuart reports that in Peña Hermosa maize was widely planted in rows and inter-seeded with other crops at various times of the year. Most plots contained from three to 10 additional crops. Vine and bush beans, sweet potatoes, squash and dasheen were intercropped in the maize while sugar cane, bananas and manioc were planted in a section or along the edge of the *milpa*. Volunteer quilites and chiles were allowed to grow scattered in the maize field. Other plants grown by some farmers in Peña Hermosa include rice, tannia, chayote, yam bean, annato, papaya, pineapple, garlic, pigeon pea and sesame, crops virtually absent from the Pajapan farming system (Stuart 1978: 147).

The diversity of food crops found in the *milpas* of Peña Hermosa presents a significant advantage over mono-cropping. In a field inter-seeded with many food crops, plants of the same species are relatively isolated from each other by plants of another species, a feature inhibiting the spread of some pests and plant diseases. The various species grow at different rates and root at different levels in the soil, making wide use of available soil nutrients and rainfall. Stumps of burned trees, an occasional living tree and perennial plants such as bananas and fruit trees protrude through the main crop, creating a partial upper canopy of sun-protecting vegetation and a wind break. Vining, low lying plants such as squash and sweet potato provide additional ground cover. This planting strategy lessens the erosive force of the rain, provides shade to the soil and helps conserve soil moisture. It also offers greater food security against the failure of staple crops.

Farmers in Pajapan have specialized in the production of maize but without fully adjusting the cropping system to monoculture. Maize plants remain widely spaced, leaving the soil relatively unprotected and lowering the land productivity of the *milpa*. Pesticides and fungicides have not been introduced to compensate for reduced biological control. The particular variant of *milpa* cultivation in Pajapan is plagued by weed control problems and increasing dependence on external inputs. In short, the traditional *milpa* has been displaced by an unproductive and unsustainable cropping system that neither maximizes the potential of new technology nor retains important adaptive features of the traditional cropping system.

To sum up, the conversion of mature forest into pasture has destroyed the rain forest environment and with it the abundant supply of water and the fauna and flora that used to play a vital role in the native subsistence economy. While fishing once offered some compensation for the loss of hunted animal protein, the fisheries too have suffered serious declines due to over-fishing and contamination. The great diversity of a native environment characterized by many different ecosystems, vegetation types and soil variations has been replaced by a relatively uniform farming system based mainly on extensive grazing of poor quality pastures. Stable patterns of land use based on the pursuit of food security (rather than market profit) have given way to an extensive pastoral system that violates the essence of *milpa* cultivation in the tropics.

The redistribution of land in the early 1980s allowed many Gulf Nahua peasants to resume *milpa* cultivation, yet cattle ranching remains the dominant activity. An agricultural system originally devoted to the production of a wide variety of foodstuffs has been reoriented toward the production of specialized surpluses (beef) exported from the local economy. Under such conditions, the expansion of cattle ranching was bound to affect the traditional system of shifting cultivation. The amount of fallow land available for crop rotation in Pajapan has been greatly reduced, resulting in a severe agricultural crisis affecting soil resources and weed management practices. Agricultural production has become more specialized (mainly beef and corn), and the total amount of land dedicated to food agriculture and the size of individual *milpas* have declined, resulting in the loss of local food self-sufficiency. All in all, the productivity of the *milpa* system as a whole has fallen dramatically and many of the adaptive features of *milpa* ecology have been lost, without any compensatory development of new agricultural knowledge and technology.

The forces of production that have emerged in Pajapan do not conform to the narrowly defined logic of technical advances normally associated with capitalist development. While intensifying production, the division of land into parcels and the restriction of cattle to many smaller paddocks has not resulted in the concentration of energy output. On the contrary, the data indicate that problems of inefficient land use, animal mismanagement and low productivity have been exacerbated for both large and small ranches alike. Local maldevelopment is nonetheless a direct offshoot of developments in the broader world system. The Gulf Nahua economy has been systematically harnessed to the outside accumulation of agro-capital produced at the expense of native peasants, their subsistence livelihood and their immediate environment. What is more, the new ranching economy has been so destructive of its own resource base as to actually undermine all long-term prospects for sustainable production in Pajapan. The local beef industry is far from being an efficient source of productive exploitation and commercial profit. Cattle ranching in Pajapan has been relegated to a very poorly-managed stage of breeding while outside capital-intensive operations control the more profitable processes of fattening for slaughter, transportation and commercialization. The integration of native cattle ranching activities into the wider market economy has resulted in a chronic underdevelopment of local forces of production; the result is a highly constrained pastoral economy serving a short-sighted process of capital accumulation in privileged sectors of the regional and national economy.

The Sierra Santa Marta Project

What will life be like in Pajapan some 20 or 30 years from now? Recent history suggests that cattle ranching will continue to dominate the local economy and that the process of land concentration temporarily halted by the land redistribution of 1981 will once again gather momentum. Recent reforms to land tenure legislation in Mexico legalize the current practice of land rental and sale of agrarian rights, allowing native ranchers in Pajapan to continue acquiring larger tracts of land. While new federal taxes on land are a burden to cash-poor peasants engaged in subsistence cultivation, new inheritance laws facilitate the conversion of disputed land into a market commodity. These and other reforms are bound to stimulate a process of land concentration as better-off ranchers and farmers buy land from impoverished peasants (A. Bartra 1991; Paré 1991a).

The transfer of land is proceeding especially in the lowland area where the interests of ranchers and peasants have always clashed. To make matters worse, there is little indication that the land-extensive techniques of cattle production will change in the near future. Pajapan's ranchers will by and large remain a weak link in a chain of breeding and marketing of poor-quality beef in national markets. While subsistence maize production may provide a survival strategy for many peasants in Pajapan, current trends of land degradation offer little hope for improvement in productivity.

But Gulf Nahua history also suggests that the interests of native ranchers and peasants can clash with predatory forces far more powerful than local capital. Mexico's current neo-liberal policies (privatization of collective lands, price deregulation, dismantling of state corporations, entry into GATT and the North American Free Trade Agreement between

Mexico, Canada and the United States) are an invitation to exploit the countryside (Bartra 1991; Paré 1991a; Oswald Spring 1992). The prospect of foreign investment in *ejidos* and agrarian communities, once unthinkable, is now a real possibility. The North American pulp and paper industry is a case in point, one that is particularly relevant to our Gulf Nahua case-study. Driven by a weakening supply of industrial pulp for paper, international paper companies have initiated tree plantation projects in many developing countries including Mexico, Thailand, India, Brazil, Chile, Uruguay and Indonesia. Tropical tree plantations present many advantages over temperate sources of pulp, including the low costs of land and labour and the rapid growth of tropical species such as the Australian eucalyptus. These developments have particular importance for Mexico's Indian people and peasants as some 75% of the forest lands belong to agrarian communities and *ejidos*. As fortune would have it, Pajapan was selected by the multinational Simpson Investment Company for a massive plantation project that has embroiled the community in a national debate concerning eucalyptus plantations, forest ecology, foreign investment and the future of the *ejidos*.

In a masterful use of ecological rhetoric, the first version of the eucalyptus plantation proposal defined itself as a project for environmental regeneration and reforestation, an alternative to the current wasteland of cattle production. A close examination of the proposal tells a different story (Paré, Buckles, Chevalier and Ramírez 1992). First of all, the lands proposed for the plantation were not the degraded upper slopes of the volcano where even pastures are of poor quality. Rather, the company planned to use the prime lowland area previously claimed for the industrial port project and only recently reconquered by peasants for the cultivation of maize and beans. Second, evidence from many countries show that extensive areas of eucalyptus can lower the water table and eliminate local fauna. Third, chemical substances released by the eucalyptus suppress other forms of vegetation, thereby threatening the long-term diversity of local plant species. Fourth, monoculture plantations such as the one proposed for Pajapan are susceptible to pest and disease problems that require agrochemical control, eventually leading to problems of water and soil contamination. Finally, the plan to use the Laguna del Ostión as a waterway for rafts loaded with tree trunks would do irreparable damage to the lagoon aquatic environment and undermine the recovery of currently degraded oyster banks.[8]

While the ecological implications of the Simpson Investment Company plan were disastrous, the economic terms offered to the owners of the land were scandalous. Although direct land purchases by foreign companies are still prohibited in Mexico, the recent reforms permit the development of joint ventures between foreign companies and *ejidos*. Companies are expected to provide the capital and technical skills while *ejidos* provide land and labor. The Simpson Investment Company proposed such a structure to the agrarian community of Pajapan with a minimum required commitment of 10,000 hectares for a period of 30 years. The company offered capital for which high interest would be charged back to the joint venture. While the company and the community would each have three votes on the administrative board, the company would have the power to veto all major decisions affecting the project. The rent offered to landholders was extremely low, approximately $50 U.S. per hectare per year, an amount that barely matched what landholders could expect from the rental of poor quality pastures. Increased local employment, one of the key arguments put forward by the company, was equally misleading; peasant employment during all operations would amount to between five and ten days per hectare per year, much less than the level of labor currently employed on the same land area.

The Simpson Investment Company proposal, and the industrial port project before it, illustrate a basic weakness of underdeveloped regions: drained of resources and power, peasant communities can do little more than react to outside initiatives that show little concern for problems of local poverty and environmental destruction. Although vigorous reactions may change the course of events in ways unforeseen by the dominant powers, they rarely offer alternative visions of regional development. In an effort to remedy this problem, the authors and the Mexican anthropologist Luisa Paré initiated in 1990 an applied research project sensitive to peasant views on major regional problems and aspirations for the future. With funding from the International Development Research Centre (IDRC, Canada), a multidisciplinary team that includes the authors has developed an analysis of regional issues and broad development guidelines drawing on the knowledge and expressed needs of the local population (Paré et al. 1992). In contrast to conservation oriented projects, guidelines developed by the Sierra Santa Marta Project (SSMP) promote a sustainable resource-use strategy for resolving problems of poverty and ecological degradation. The project relies on a thorough analysis of current ecological and economic conditions and on local participation in problem identification as well.

One important accomplishment of the SSMP to date is a careful revision of the plantation project developed by the Simpson Investment Company. At the invitation of the state government, members of the SSMP participated in interinstitutional meetings to examine the potential impact of the project in the region. The main contribution of the SSMP in this forum was to elucidate the terms and conditions of the project from an ecological and economic point of view. While the eucalyptus project received considerable support in principle from government agencies at all levels, official assurances following this review process emphasized the need for a thorough environmental impact study and full, informed support from the affected communities. Analysis by Pajapeños of all aspects of the project (facilitated by the SSMP) eventually resulted in local rejection of the project, and withdrawl of the company offer.

On a more general level, the SSMP has contributed to a debate concerning the establishment of legal norms for the use and protection of the remaining forest in the region. In 1980, some 82,000 hectares of the Santa Marta highland forest were formally declared a protected area. Six years later, both the Mexican government and the United Nations (UNESCO) recognized the area as a Special Biosphere Reserve. These declarations, however, remained virtually unknown to the local population and to many government agencies as well. Major land use projects such as Simpson's and land redistributions by the Secretaría de Reforma Agraria proceeded without paying the slightest attention to these official conservation policies (Paré 1991b). The SSMP has identified numerous land tenure anomalies and inconsistencies affecting the remaining fragments of the regional forest, prompting government authorities to strengthen the implementation of the reserve principles.

The SSMP has confronted externally controlled development projects and helped catalyze conservation efforts. Measures to protect both the forest and the local population from further impoverishment do not preclude, however, alternative development strategies based on the sustainable use of resources. To this end, the SSMP has initiated a series of applied research and extension projects to combat poverty and thus reduce human pressure on remaining forested areas.

Alternative development projects have focused to date on the declining productivity of shifting cultivation, a priority problem identified with farmers using their own concepts and understanding of causes. A land extensive cattle industry and population pressures are deep rooted causes of the crisis in shifting cultivation, with consequences for fallow periods, weeding costs and land productivity. Our first look at solutions to these problems were those developed by farmers themselves. Farmers in several villages of the Sierra were using a leafy legume called *pica pica mansa (Mucuna sp)* as a green manure and cover crop in maize. In one village, the legume was broadcast into degraded maize fields to enhance the fallow, a practice known locally as 'making a fallow' (*hacer acaual*). Farmers indicated that a field allowed to 'rest' for two years under *pica pica mansa* is relatively free of weeds and produces good maize yields. Farmers in another village used *Mucuna* as a rotation crop with dry season maize. These farmers plant the legume with a digging stick between rows of dry season maize where it develops as a sole crop until the following dry season. The aggressive legume chokes out competing weeds during the wet season, thereby facilitating land preparations for dry season maize. The thick layer of decomposing leaves left on the surface of the field provides nutrients to subsequent maize plants and conserves soil moisture during the dry season. Similar uses of *Mucuna* have recently attracted the attention of scientists in other parts of Mexico and Central America (Miranda Medrano 1985; Bunch 1990; Buckles et al. 1994).

Farmer participatory research in the Sierra subsequently built on this locally developed technology (Buckles and Perales 1993). Farmers indicated that a limitation on use of *pica pica mansa* as an enchanced short fallow or rotation crop was the loss of access to the field during the wet season. Intercropping strategies with wet season maize and pica pica mansa, a potentially more intensive form of management, were proposed to farmers in a number of villages and on-farm trials established to test their feasibility. Farmers were invited to choose from a 'basket' of management options including several variations on *Mucuna* intercropping and the rotation strategy already developed by local farmers. Farmer evaluation of these trials, combined with technical observations, determined that a mid-season intercrop of *Mucuna* in wet season maize (30-40 days after maize planting) helped control weeds and improve soil fertility with few additional labor costs. Participating farmers spontaneously extended the area under this management practice, a clear indication of their continued interest in the technology. Thus, while taking indigenous knowlege systems seriously, we did not try to disengage local experience from western science. To do so would be to romanticize indigenous knowledge and, what is more, deny indigenous farmer/scientists the right to further develop their knowledge base with information from western science.

Farmer-based experimentation with *Mucuna* contributed to the rapid identification of a viable intercropping strategy new to the region. However, new problems were encountered making this information available to all farmers in the region and sustaining the process of participatory research we had initiated. Faced with inumerable other technical and social problems in need of research and thousands of farmers outside our experimental group, we had to recognize the vulnerability and limited scope of our accomplishments. Farmers in the Sierra de Santa Marta have always been neglected when it comes to access to information they need regarding agricultural opportunities and options, and attention from the national research system. This problem is even more acute now as the rhetoric of privatization sweeps aside agricultural research and extension. As of 1993, the Mexican state no longer has responsibility for providing Mexican farmers with information on agricultural technology. Expectations that the private sector will provide technical assistance are totally unrealistic, especially with respect to small and medium-scale farmers.

The Sierra de Santa Marta Project has struggled with this dual problem of difusing research results and enhancing an indigenous research capacity by creating and supporting a network of *promotores*, farmers trained in the use of new technology and participatory ways of communicating ideas and information to other farmers. Through this network, the green manure intercropping, rotation and enhanced short fallow practices were introduced to more than 3,500 farmers (Buckles and Arteaga 1994). Local *promotores* organized formally in a network now provide technical assistance to other farmers on a wide range of issues including fire prevention techniques, the use of contour hedge rows to control soil erosion, improved maize seed selection practices, home gardens and the establishment of vanilla plantations. Between the promotores and farmers, research needs are being identified and priorities established which inform the activities of the professional research team. The role of researchers in this process is gradually shifting from one of coordination to a consulting capacity as an increasing proportion of the financial resources of the project come under the direct control of the network. Through the network, a demand-driven system of research and development is taking shape.

Unlike the eucalyptus plantation proposal put forward by the Simpson Investment Company, with its pseudo-ecological claims, the green manuring project and network of promotores is responding to the felt needs of Indian peasants who are by far the principal victims of unsustainability in Mexico. The potential of technology to redress the profound economic and political problems and imbalance of power in the region is nevertheless limited. The future in store for the Santa Marta highlands and its native population will emerge not only from this and other local initiatives but also from regional, national and international efforts to counter current trends of social and ecological impoverishment.

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[1] For details on the nutrient cycles of tropical rain forest see Richards 1952; Buringh 1970; Fearnside 1986; Forsyth and Miyata 1984.

[2] For more details on the architecture of the tall rain forests of the Sierra see Stuart (1978: 64-7) and Andrle (1964).

[3] Interviews with Santos Martínez, May 19, 1990 and Genaro Antonio, May 20, 1990. The cleared area, still surrounded by mature rain forest, can be seen in aerial photos from 1971.

[4] Interview with Andrés Martínez, June 10, 1986.

[5] The estimate of herd size is based on survey data and has been corroborated by data collected by SARH and also by interviews with Andrés Martínez, Simón Antonio and other native ranchers.

[6] For a discussion of rainforest ecology and the global implications of deforestation, see Myers 1980; Gómez-Pompa *et al.* 1972; Fearnside 1987; and McNeely *et al.* 1990.

[7] Based on soil analyses conducted at the International Maize and Wheat Improvement Center (CIMMYT) in 1992.

[8] Faced with these criticisms, the company has now distanced itself from the rhetoric of born-again ecologists by admitting that the eroded slopes of the volcano would entail lower potential yields and greater transportation costs as well.