The Ecological Crisis in Chiapas: A Case Study from Central America

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The Ecological Crisis in Chiapas: A Case Study from Central America

Most landscapes in Chiapas were recently subjected to a change in land use that has caused various environmental problems in a highland–lowland interactive system. In the Soconusco coastal plain, cash crops with long dry fallow periods caused a decline in precipitation, whereas in the lower escarpment of the Sierra Madre, coffee plantations with unshaded cultivation in rows and inputs of herbicides reinforced major hydrological fluctuations. While these impacts have been reduced during the last decade, demographic pressure in the upper part of the Sierra Madre and in the Altos de Chiapas, resulting in a growing need for land, is responsible for advancement of the frontier of settlement into steeper parts of the Sierra and toward Lacandonia. The resulting soil erosion and leaching cause further degradation, and, together with elevated runoff rates, also have a heavy impact on the forelands. This was evident in September 1998 in the form of disastrous floods and devastation in the Soconusco plain.

Keywords: *Ecological crisis; highland–lowland system; coffee; water balance; political ecology; Chiapas; Mexico.*

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Chiapas and the "Central American Dilemma"

1998 may be recorded in the recent history of Mexico and Central America as the "year of the floods." Beginning in early September with the inundation of the Soconusco plain, the second half of the month brought hurricanes from the Gulf of Mexico, covering entire cities with water, finally followed by Hurricane Mitch, whose wrath was felt over large parts of Nicaragua, Honduras, and Guatemala. The first example, in Chiapas, showed that, although these catastrophic events were triggered by heavy rainfall, their impacts were intensified by the clear-cutting of rainforests and inappropriate subsequent land use with resultant erosion. In the end, the ravaging regional impacts of torrential rains were largely due to anthropogenic factors. Following on years of political turmoil, this ecological crisis has become a new "Central American Dilemma."

This term, derived from the so-called "Himalayan Dilemma," describes ecological and socioeconomic interactions within a highland–lowland interactive system (Ives and Messerli 1989). Some aspects of this Himalayan analysis can be applied to mountain ranges and foothills in the humid and semihumid tropics, as most of the phenomena are more attributable to natural laws and excessive human expectations than to local peculiarities. This includes a chain reaction that results from accelerating population growth rates accompanied by uncontrolled deforestation of montane rain forests. This in turn causes soil erosion and loss of arable land, in addition to more frequent abnormal floods, high levels of suspended material with extraordinary discharge peaks, and lowland flooding. Schickhoff (1998) used the example of mountain forests in northern Pakistan to illustrate this ecological long-distance system. He verified that resource consumers and those who degrade the environment are less responsible for ecological crises than government decision-makers and their agents in the lowlands. Furthermore, he emphasized that it is not forest destruction per se or the rate of deforestation that determines ecological stability but methods of subsequent use. Thus, any analysis of the problem of degradation and potential solutions must include socioeconomic and political causes.

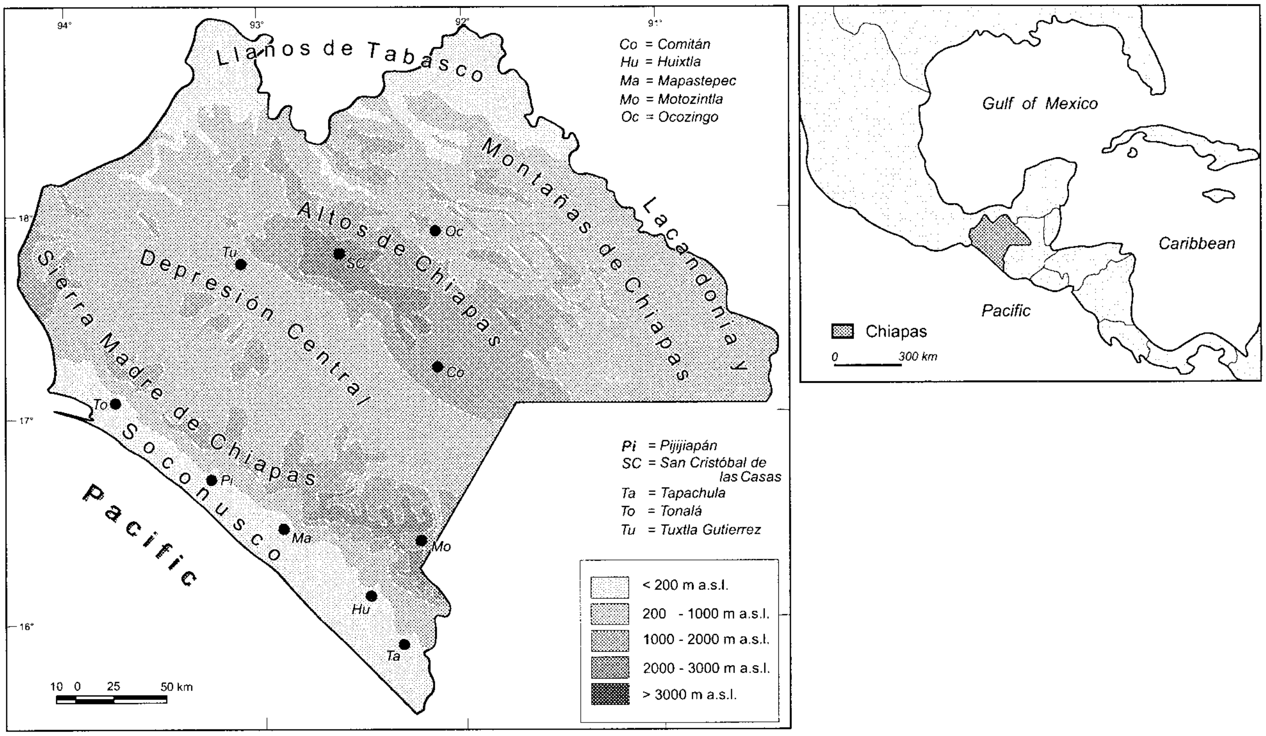
It is true that this scheme cannot be applied everywhere in Central America. But despite weak relief in the mountainous regions and the attendant lowlands, it is still a good model in principle. Chiapas is suitable as a case study due to its key position as a link between Central America and Mexico. Its climatic, geologic, and vegetative patterns warrant including it as part of Central America. The complex land use interests of environmental actors in Chiapas also fit with the Central American model, exhibiting an exclusive tendency to exhaust raw materials, as in Guatemala, El Salvador, and Nicaragua. The region is also structurally dependent on the world market. This set of circumstances offers an initial explanation for the environmental crisis in the region.

At the same time, implementation of government policies in the region has conformed to the unique nature of politics in Mexico, which was governed by the same party, the PRI (Party of Institutional Revolution), for over 70 years. Political life has been characterized by tension between selfish private interests and openness to social reform, producing continual clashes between resource-exploiting forces and resource-friendly orientation. The most recent flooding disaster in Soconusco permits a new critical analysis of this interplay.

Local climate change in Soconusco

The Pacific Coast region, identified as Soconusco in Figure 1, was once part of the Mayan Empire. In the first half of the 20th century, the landscape was dominated by bovine pastureland and mixed fruit orchards (Waibel 1933; Helbig 1964). This was replaced by cash

FIGURE 1 The State of Chiapas, linking Mexico and Central America, showing the spatial pattern of environmental differentiation.



crops such as cotton, sesame, and later soybeans, at first gradually and then rapidly by the early 1970s. White owners of large properties as well as *mestizo* participants in cooperative enterprises, relicts from the postrevolution *ejido* era, have been largely responsible for international commercialization. The ecological consequence is a decline in precipitation caused by exposure of the previously solid vegetation cover and is evidenced mainly by a delay of about 6 weeks in the initial rainy season in May and June. The changes in the climatic–ecological system, described by Richter (1993) in a broader context, are as follows:

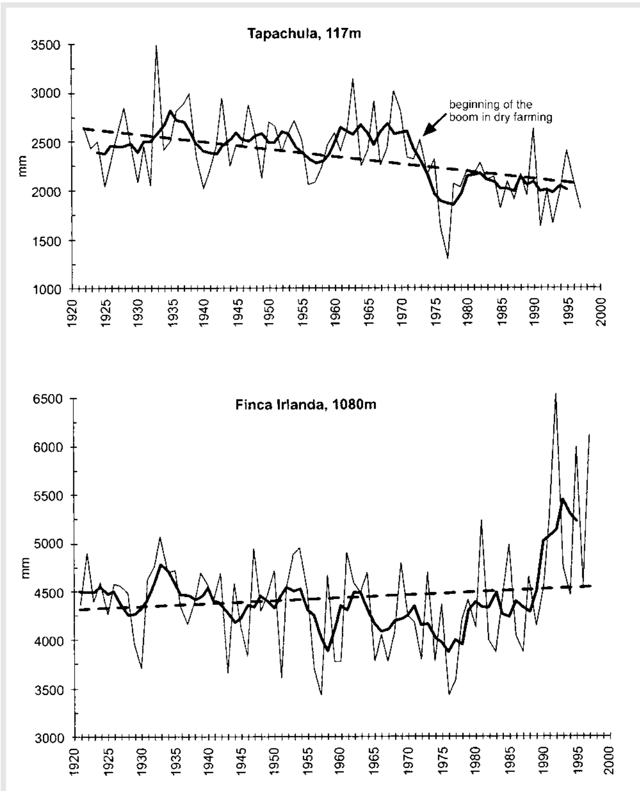
- Replacement of the orchards and pastures by irrigation systems and dry farming processes.
- Dry fallow with drying out of the topsoil lacking humus.
- Change in the energy turnover that favors warming of the topsoil.
- Lengthening of the dry period and an increase in the level of condensation.
- Decrease in the annual amount of precipitation resulting from a delayed rainy season.
- Regional water deficits in the remaining orchards and drying up of springs on the escarpment of the Sierra Madre de Chiapas due to an increase in the lower limit of orographic fog.

The changes in regional water flux in the pedosphere and the biosphere are confined to the zone where there is a boom in dry farming, covering an area approximately 120 km long and 30 km wide, from Huixtla to Retalhuleu on the coastal plain of Guatemala (Flottemesch 1992). The consequences are hardly noticeable on the adjacent escarpment of the Sierra, as shown by a comparison of yearly precipitation at the lowland Tapachula weather station and the Finca Irlanda mountain station 30 km away (Figure 2). Still, this does not suggest that the shift away from cotton fields since the end of the 1980s in favor of large-scale mango and banana plantations, aiming at production for the international market, has brought about an increase in precipitation. A delayed climatic–ecological change has thus taken place only slowly since this shift, if at all.

Hydrological change on the Pacific escarpment of the Sierra Madre

Adjacent to a belt of pastureland and cocoa that separates the cash crop zone in the lowlands from the Pacific escarpment of the Sierra Madre de Chiapas is the coffee zone, which is the most important income-producing area for the poorest state in Mexico. The coffee boom began with German immigration to the area about 120 years ago. An ecologically stable plantation system proved to be

FIGURE 2 Variation in precipitation from 1920 to 1997 at the Tapachula weather station in the coastal lowland and the Finca Irlanda station on the escarpment of the Sierra Madre de Chiapas (annual data, 5-year moving average and trend).



profitable for nearly 100 years due to measures employed to protect the highly valued coffee plants. These measures included the planting of nitrogen-enriching legume trees, weed removal by machete, and soil conservation using a dense canopy of shade trees (Schiegl 1990). In the 1970s, however, the *roya* coffee fungus led to crop losses in the lower part of the coffee zone. To fight the fungus, farmers planted rows of new, high-yield plants and dug out the trees that overshadowed the ground and provided ideal moist conditions for fungus growth. Meanwhile, weeds were attacked with pesticides and soil fertility was enhanced through chemical fertilizers. Since yields rose appreciably in these areas, the same methods were introduced in the cooler climate of the escarpment despite a much lower risk of *roya.*

However, after several years of higher profits, these innovations led to a decline in production due to increased erosion of the humic topsoil. Hagedorn (1995) found that these new processes resulted in an initial hundred- to thousandfold increase in soil loss when compared with land under traditional cultivation. At the same time, the runoff rate increased from 2 to 10% in relation to precipitation input. The increased discharge turned out to be particularly problematic for the foothills. Models for a natural rainforest and two types of coffee plantation verify the change in the soil–water balances (Figure 3, left). Here the increase in precipitation input due to reduced interception rates, the change in evaporation rates caused by the clearing of vegetation, and increased losses through greater infiltration have been considered. The graphs in Figure 3 (right) illustrate rapid reaction in terms of average runoff and increased fluctuation in discharge. The changes in the hydroecological system, explained in detail by Richter and Schmiedecken (1993, including water balance equations with specific calculations), can be summarized as follows:

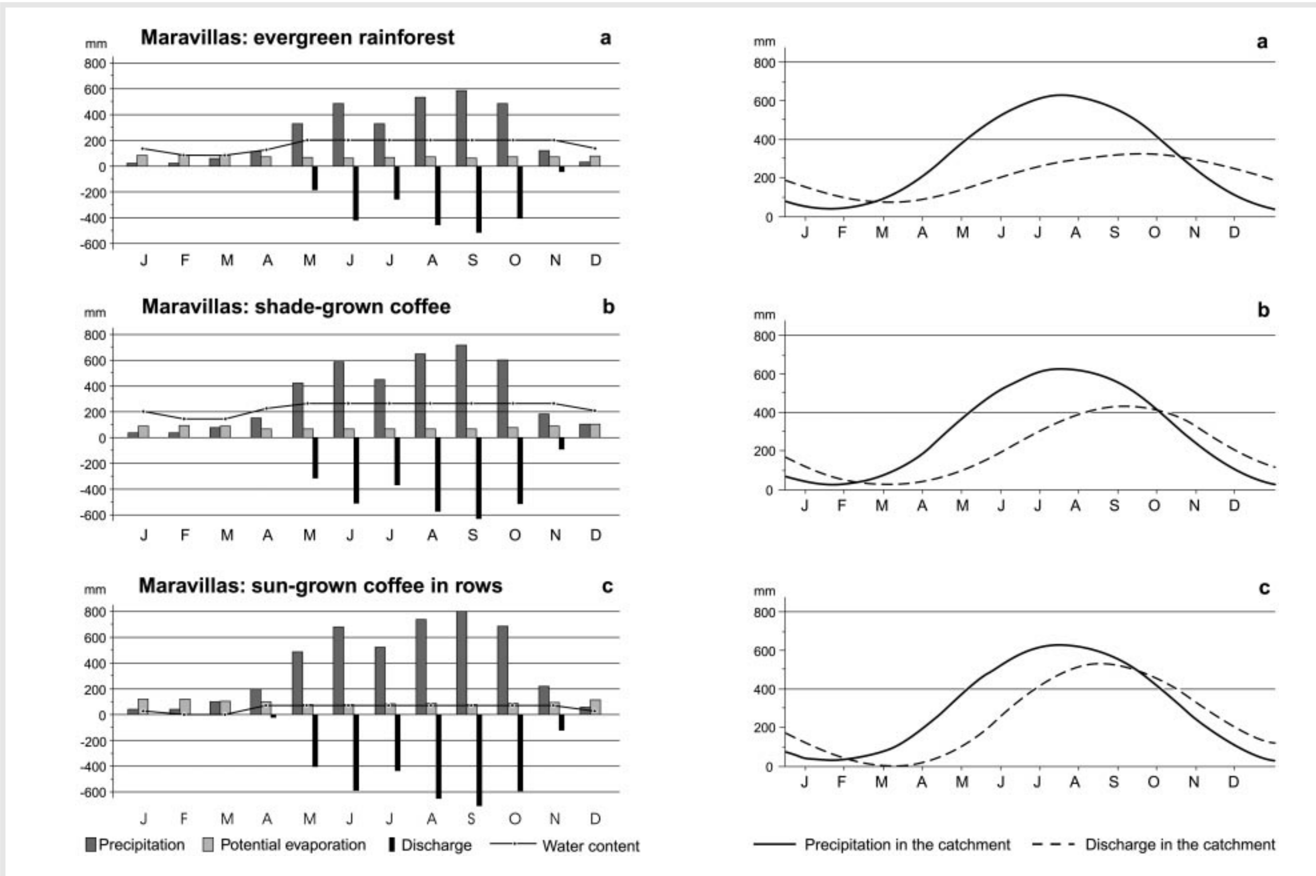
- Appearance of *roya,* triggering production losses in the coffee plantations.
- Cultivation of coffee plants in rows, uprooting of shade trees, and use of pesticides.
- Brief increase in yields, with a loss of humus and a decrease in water retained by the soil.
- Soil compression due to unimpeded downpours (sealing effect).
- Increased erosion of topsoil and more rapid outflow.
- Decrease in yields due to soil degradation, including soil shift through splash erosion, and a simultaneous decline in profits due to increased inputs (fertilizers, pesticides, rapid replanting).

Declining profits and the resulting bankruptcy of some plantation owners have led to a reduction in chemical–technical inputs in the past 10 years. It can be assumed that there has also been a downward trend in soil erosion and drainage reactions. The newest problems in the *cafetales* are more likely to be related to the lack of workers, as the Indians of the Sierra Madre and the Altos have since begun long-distance migration (Junghans 1993). Migrant workers from Guatemala have started to succeed them as farmers, although their interest is limited.

Soil erosion on the crestline of the Sierra Madre and Altos de Chiapas

Nowhere in Chiapas is the contrast between profit-oriented agribusiness and survival-oriented subsistence farming clearer than in the Sierra Madre. In this region, the *cafetales,* an important source of state income, border almost indistinguishably on the primitive *milpa* system of the upper escarpment and crest region. Cultivation in this subsistence system is characterized by laborious crop rotation of cornfields with 2-year cycles and 10–15-year fallow periods for soil recovery. However, this *guatál* has become shorter in the last 2 decades due to the rapid rise in demand for land. This is the result of a great increase in the Indian population. Simultaneously, the descendants of the Mam tribe from Guatemala who settled the crest region in the last century are now migrating into the steepest region toward the middle part of the escarpment.

FIGURE 3 Left side: Calculation of the water balance at Finca Maravillas for various stand conditions (coffee plants severely damaged by the storms in September 1998 predominate at this location). The 3 models are derived from precipitation data (1966–1975) at the local weather station. They include a reduction in the amount of measured rainfall by losses through interception and take both soil structure and medium root depth into account (details in Richter and Schmiedecken [1993]; equations according to Schmiedecken [1981]). Right side: Ratios and shift of intervals between regional precipitation and runoff in the upper Rio Cuilco catchment on the Pacific escarpment of the Sierra Madre. Delay and magnitude of discharge are derived from data (1977–1979; details in Richter 1987) from the hydrological station at Huehuetan and were transformed by the calculated input data given by the models on the left side.



This has been accompanied by deforestation of the remaining montane rainforest in a particularly erosion-prone area. This expansion process is obvious on the Pacific escarpment of the Sierra above Mapastepec and Pijijiapán, where there are no competing coffee plantations to block recent colonization. The storms of 1998 typically took their greatest toll in the corresponding catchments, causing landslides and gully erosion that deposited an enormous amount of sediment in the foothills.

These recent developments on the light sandy soil that overlays granodiorite in the Sierra Madre contrast with the degradation process in the Altos de Chiapas. In the latter case, nutrient-poor pine forests are considered to be secondary formations on what was once extensive farmland. Extensive sheep grazing is found here as a result of the decline in productive land resulting from badland formation, terracettes, and soil compaction of the heavy clay soil above limestone. This process takes the following course:

- Increasing pressure on the land due to impeded population growth.
- Shortening of the recovery fallow period and less secondary succession, with pressure from overgrazing.
- Development of terracettes and soil compression due to sealing effects and sharp sheep toes.
- Increased topsoil erosion with more rapid outflow.
- Land shortage due to rill erosion, badland formation, landslides, and soil exhaustion.
- Expansion characterized by deforestation of remaining rainforests on steep slopes, with degradation and migration to the Montañas de Chiapas, Yucatán, and the large cities.

The emigration from the Sierra results from overpopulation and overuse. In the highlands of Chiapas, however, proprietary ethnosocial factors among the indigenous Tsotsil and Tzeltal play an additional role. Families are often denied farmland in traditional Indian communities and are thus in effect forced to migrate elsewhere. Furthermore, religious conflicts between Protestants and Catholics contribute to the splitting up of villages in some communities. Where the FNEZ (Frente Nacional Emiliano Zapata) under "subcomandante Marcos" is active, a social crisis accompanies the ecological crisis.

By contrast with the ecological systems of the Soconusco, the crisis in the Sierra and Altos involves

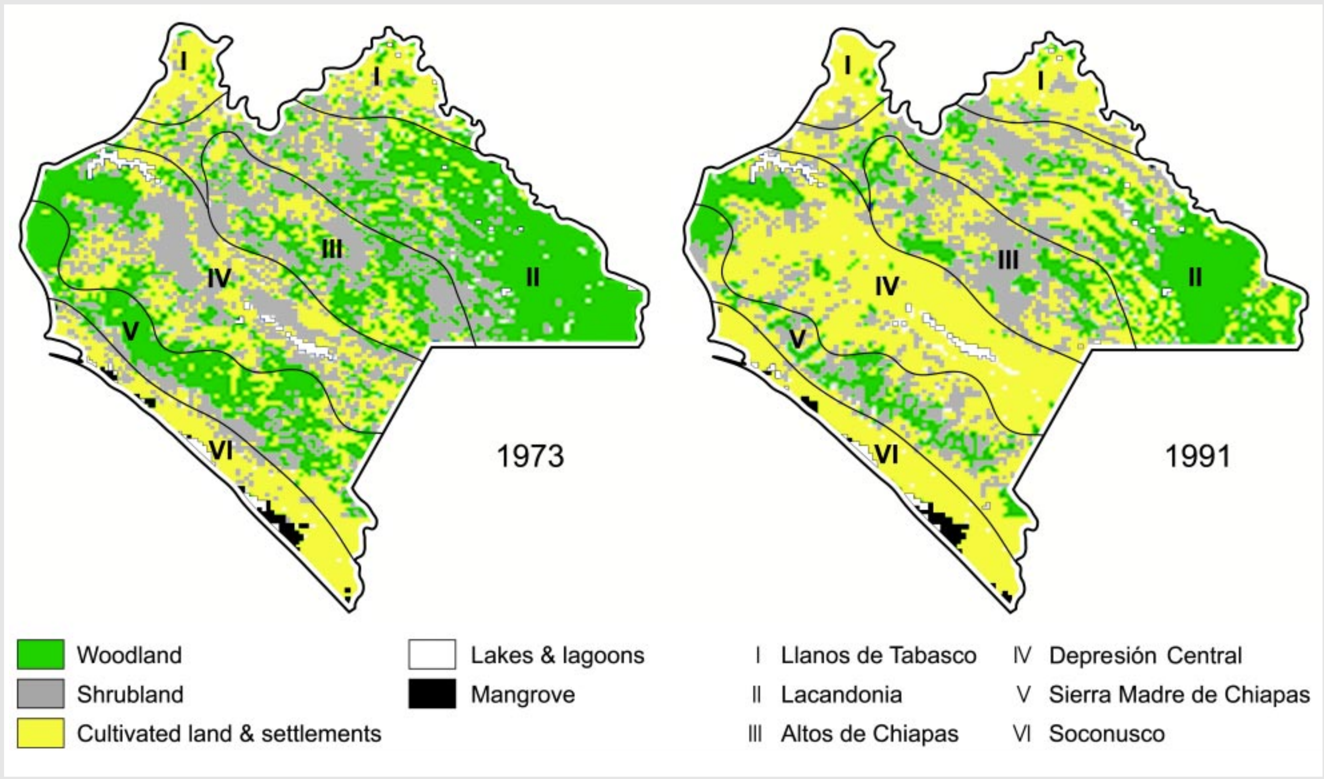


FIGURE 4 Comparison of land use in Chiapas, 1973 and 1991. Note the strong decrease in montane rainforests in the Sierra Madre and in the Montañas de Chiapas. (Source: Evaluation of Landsat data by Ignacio March, ECOSUR, San Cristóbal de las Casas).

ongoing degradation with no end in sight. The potential for environmental crisis in Chiapas is greatest here; a similar crisis affects mountainous areas in Guatemala (Altos de Cuchumantanes, Alta Verapaz), Honduras, and El Salvador.

Loss of Biodiversity in the Montañas de Chiapas and Lacandonia

The eastern escarpment of the Altos gradually becomes a system of *cuestas* that characterizes the Montañas de Chiapas down to the lowlands of Lacandonia. A significant portion of this area is an officially protected nature reserve. Nevertheless, Figure 4 illustrates the advance of a "frontera" of colonizers into formerly untouched forest area in the last two decades. Originally only the very small Lacandone Indian tribe populated this area, but now two groups are engaged in conflict over the region. One is the expansion-minded *hazienderos,* military officers bent on land speculation. The other group is poor farmers whose only goal is self-sufficiency. Together, these groups are responsible for new and unpredictable developments, which can be summarized as follows:

- Colonization and/or speculation in virgin forests.
- Deforestation to create *milpa* in the Montañas and pastureland in Lacandonia.
- Intensified karst processes in the Montañas, loss of biodiversity due to destruction, and homogenization of vegetation through the introduction of non-native plants.

The greatest threat is to the rich variety of flora and fauna. Mountain regions are generally considered hot spots of biodiversity. This is especially true for those that rise over lowland rainforests, which are typically species-rich. In these places, various taxa in different altitudinal belts result in species culmination. The respective high values for Chiapas on the map by Barthlott et al (1996) are easily understandable in light of the typically greater biodiversity in tropical ecosystems, together with the two mountain chains that end in a land bridge with a narrow corridor for genetic exchange. The area's rating of 2 on a diversity scale of 10 means that it contains from 4000 to 5000 different plant species per 10,000 km^2. Nature protection in Lacandonia has a key role to play in the preservation of the Central American plant world due to the great reduction in stands of unique tropical and montane rainforest. This is all the more so as Chiapas and the rest of the land bridge are literally covered by an enormous diversity of epiphytes (Potrykus 1993), which are being just as severely affected by the process of deforestation as the trees themselves.

Even without considering the genetic potential that has been lost, the decrease in epiphyte richness represents an incalculable economic loss for farmers. Few in the area are aware that transformation of the natural forests into extensive pastures brings just a fraction of

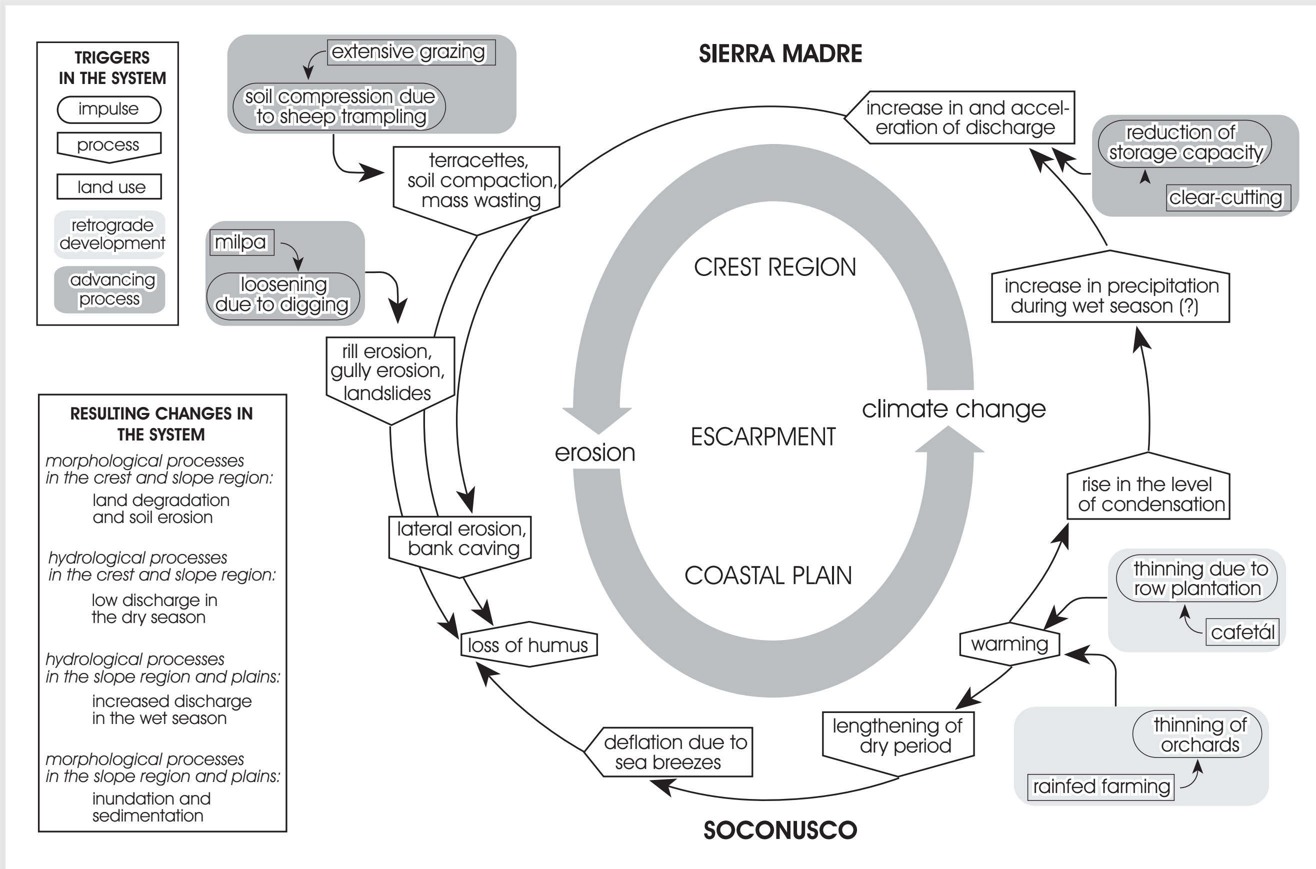


FIGURE 5 A highland–lowland interactive system showing an economic–ecological correlation between the lowland of Soconusco and the crest region of the Sierra Madre de Chiapas. Ecological impacts marked in light squares are valid for the Soconusco but not for Central America in general.

the potential profits represented by the destroyed epiphytes. Extinction of these epiphytes is a loss of resources. Projects by nongovernmental organizations (NGOs) in the Guatemalan Cobán have revealed that targeted and selective use of trees bearing cultivated and harvestable epiphytes in montane forests has been accepted by farmers as a welcome source of income and high yields.

Transferability and characterization of the floods in 1998

Figure 5 shows that the 1998 floods resulted from a complex interplay between erosion in the Sierra Madre de Chiapas, change in river discharge, and sediment accumulation in the Soconusco. Disasters such as these do not necessarily originate in the mountains, as argued by Hofer and Messerli (1997). However, the effect of floods over small distances in the immediately neighboring forelands as a result of deforestation on the escarpment cannot be refuted. In the case of the storms in Soconusco, it can be assumed that, in addition to very heavy precipitation in the lowlands, the mountainous hinterland was hit with even more rain (see below). This fact might distinguish the devastation here from that in Honduras and Nicaragua, which was only secondarily attributable to verifiable degradation of rainforests. In this case, the special dynamics of Hurricane Mitch must be seen as the main cause, as huge whirlwinds provided enormous amounts of precipitation. Although the overlap of many factors in an area as large as Honduras and Nicaragua does not allow for more precise assessment, it is clear that the impacts were intensified by anthropogenic factors.

The devastation in Soconusco, which resulted unofficially in over 1000 deaths, can be linked to the following factors:

1. The disaster was unquestionably the result of heavy rainfall in the second week of September 1998, an extraordinary event of proportions that might be expected statistically at intervals of 15–20 years. Analyses indicate that the region around Mapastepec and Pijijiapán was especially hard hit 7–9 September (Tapachula = 403 mm, Mapastepec = 650 mm, Pijijiapán = 627 mm). On the western escarpment of the Sierra Madre, an analogous measurement of about 1100 mm was recorded at the La Esperanza weather station. Several tropical depressions, which moved along the coast in a SE-NW direction in the first half of September, triggered the disaster. Maximum flooding intensity in the entire region was concentrated during the night of 8–9 September.

2. The above-average cyclonic activity between July and November 1998 may be attributed to the El Niño phenomenon, which led to an increase in sea surface temperature in the tropics and subtropics at the beginning of the year. The "Cape Verde Hurricanes" in particular, originating off the West African coast, were responsible for countless penetrations into the Caribbean and the eastern Pacific.
3. Two strong earthquakes on 8 January and 22 February 1998 (with magnitudes of 6.3 and 5.5) with epicenters near the Guatemalan border quite possibly caused the formation of crevasses in the rock as well as changes in soil structure. This may have also raised drainage reaction and the risk of mudslides. Hypothetical examinations indicate that such subduction quakes could also be a byproduct of El Niño since pressure on the relevant continental plate through changing water masses could have been increased at that time (personal communication, Dr. Pablo Liedo, ECOSUR, Tapachula).
4. The catchment structure of several mountain river systems accelerated drainage toward the foreland. This was especially true for the dendritic river network of the Rio Novillero above Valdivia and the upper section of the Rio Huixtla. Flooding was particularly severe in the accumulation area of both rivers. The houses of all residents in the village were literally covered by 3 m of sediment.
5. Clear-cutting in catchment areas in the mountains must be seen as the decisive human factor. This is especially true in places where relatively dense *cafetales* recede up the slope of the Sierra Madre. Above Mapastepec and Pijijiapán, *milpa* dominates in open fields, providing ideal conditions for extensive erosion. Erosion in this region was especially heavy, resulting in above-average accumulation in the foreland.
6. Settlements further downriver and in the foreland are concentrated along riverbanks. Bank caving in valleys was thus a basic destructive element, whereas inundation was typical on the plains. In the first case, buildings simply collapsed due to lateral erosion and powerful mudslides, while whole villages were inundated in the latter case.

These floods were predicted, and with appropriate and cautious agricultural planning, they could have been prevented. Soconusco was already severely hit in the last major hurricane year, 1988, providing ample experience and time to plan, and numerous seminars in the area itself and subsequent articles (eg, a Spanish edition of Richter 1986) warned of the dangers. The extent and consequences of the erosion had been documented as well (von Seggern 1993; Hagedorn 1995). Since mid-1998, a cooperative project involving the Comisión Nacional de Aguas (CNA) and the German technical development cooperation service (GTZ) has been working to address problems on the slopes of the Sierra Madre and in Soconusco and to develop workable solutions. This project illustrates different ways of controlling erosive and sedimentary processes: CNA pursues short- and medium-term strategies to minimize damage through artificial construction, such as strengthening of embankments, retention reservoirs, and dikes. GTZ attempts to prevent damage through various agroforestry methods by developing longterm strategies.

Political ecology as an approach in addressing the responsibility of environmental agents

Since each pattern of land use serves a socially determined purpose (Geist 1992), "political ecology" can be used in the final analysis to examine connections between environmental agents and environmental problems and ask which economic interests and demands in different population groups are tied to the ecological crisis. A central question here is what party has which responsibility. Special interest groups and their economic and political goals are listed below.

1. In terms of the state's interest in producing cash crops such as soybeans, bananas, mangos, and coffee, the big landowners and collectives of the former *Ejidales* in Soconusco are closely connected with the international market and the corresponding financial framework. In the case of the lowlands and the lower foreland, repeal of measures with regional climatic and agricultural consequences would seem to reveal a growing awareness of the problem. In fact, however, the return to ecologically stable methods has more to do with changes in international demand, to which this well-informed and capital-rich group is better able to react.
2. The success of this entrepreneurial group contrasts with the losses of indigenous groups, principally composed of small farmers from the highlands of the Sierra Madre and Altos as well as marginalized colonists in the Montañas de Chiapas. While the effects of expansion in the latter case are only now becoming apparent with the first signs of karstification, extreme soil erosion and hydrological long-distance impacts are alarming effects in the former case. But the struggle for survival leaves no alternative, even when workable solutions are apparent, above all in the agroforestry sector (Richter 1993). There is a lack of serious will on the part of responsible agricultural extensionists to visit or even take note of these "unattractive" regions, which are peripheral in cultural and economic terms.
3. The heretofore unmentioned supporters of intensive pasturing in northwest Soconusco, in a vast area

around Tonala and in large parts of the Central Depression of Rio Grijalva, are worthy of mention at this point. Because these actors carry on a traditional form of land use, no new environmental problems are coming to the fore, as the possibilities for expansion are now exhausted. Use is still made of such possibilities by speculators in Lacandonia, however, who play a direct role in the destruction of lowland rainforest and are also in conflict with the FNEZ.

4. The principal blame for this miserable situation, however, should be given to the former economic and agricultural administration as representatives of the national interest, whose principal interest was to support the party in political power (the PRI). Hence, the 6-year legislative period was divided into 5½ years of support for the financially influential innovators through lucrative activities and services and 6 months of support for the poor population during the election campaign in order to win votes. This also sheds light on the trade-off between self-interest and desire for reform. Adding to the frustration of outside observers is the nepotistic structure of these groups, which explains their agroecological incompetence. After all, there is no lack of obvious ways to improve economic performance!

A certain fatalism is induced by the recognition that even the majority of critical intellectuals is connected with the administrative system. It is clear that nepotism and incompetence in the system are well known to this largely well-off segment of society, from which many local environmentalists are recruited. Their dilemma is that they see themselves as a critical exception without recognizing that they are a part of the system they criticize. Only time will tell whether the flood disasters finally cause decision-makers to recognize their responsibility for a neglected group of people who are causing the Central American Dilemma. In the case of Chiapas, it can only be hoped that the experiences of the villages of Valdivia in Soconusco, Belisario Dominguez on the Rio Huixtla, and Motozintla on the Rio Mazapa signal a definite turning point characterized by new environmental awareness. The recent victory of PAN (Partido de Acción Nacional) in late 2000 might represent new hope for solving problems. The problems seem to be less a question of choosing the right management than a question of whether any political and ecological reform can succeed against a centuries-old economic mentality based on principles of local or regional power and possession.

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REFERENCES

Barthlott W, Lauer W, Placke A. 1996. Global distribution of species diversity in vascular plants: towards a world map of phytodiversity. *Erdkunde* 50:317–327.
Flottemesch F. 1992. *Niederschlagsfluktuationen im Bereich des südmexikanisch-nordguatemaltekischen Pazifikküstentieflandes* [MA thesis]. Erlangen, Germany: University of Erlangen.
Geist H. 1992. Die orthodoxe und politisch-ökologische Sichtweise von Umweltdegradierung. *Die Erde* 123:283–295.
Hagedorn A. 1995. Untersuchungen zur Bodenerosion in der Kaffeeregion Soconusco/Südmexiko. *Mitteilungen der Fränkischen Geographischen Gesellschaft* 42:165–181.
Helbig C. 1964. *El Soconusco y su Zona Cafetalera en Chiapas*. Tuxtla Gutierrez: Instituto de Ciencias y Artes de Chiapas.
Hofer Th, Messerli B. 1997. *Floods in Bangladesh. Process Understanding and Development Strategies*. Berne: Institute of Geography, University of Berne, Swiss Agency for Development and Cooperation, and the United Nations University.
Ives JD, Messerli B. 1989. *The Himalayan Dilemma: Reconciling Development and Conservation*. London and New York: Routledge.
Junghans Ch. 1993. *Die Beziehungen zwischen den Indianern aus den Dörfern der Kammregion der Sierra Madre de Chiapas und den Fincas in der Kaffeezone des Soconusco, Südmexico* [MA thesis]. Erlangen, Germany: University of Erlangen.
Potrykus A. 1993. *Die Epiphytenvegetation in Abhängigkeit vom Bestandsklima in verschiedenen Höhenstufen in der Sierra Madre de Chiapas* [MA thesis]. Erlangen, Germany: University of Erlangen.
Richter M. 1986. *Natürliche Grundlagen und agrarökologische Probleme im Soconusco und im Motozintla-Tal, Südmexico*. Erdwissenschaftliche Forschung 20. Stuttgart, Wiesbaden: Franz Steiner.
Richter M. 1987. Ökologische Auswirkungen unzweckmäßiger Anbauverfahren im Soconusco/Südmexico. *Tübinger Geographische Studien* 96:123–141.
Richter M. 1993. Ecological effects of inappropriate cultivation methods at different altitudes in the Soconusco Region/Southern Mexico. *Plant Research and Development* 37:89–114.
Richter M, Schmiedecken W. 1993. Cambios hidrológicos en la zona cafetalera del Soconusco. *In:* Richter M, editor. *Investigaciones Ecogeográficas Sobre la Región del Soconusco*. San Cristóbal de las Casas, Mexico: ECOSUR. pp 69–93.
Schickhoff U. 1998. *Die Degradierung der Gebirgswälder Nordpakistans* [habilitation thesis]. Bonn, Germany: University of Bonn.
Schiegl U. 1990. *Die Möglichkeiten des organischen und biologisch-dynamischen Kaffeeanbaus im Soconusco, Südmexico* [MA thesis]. Erlangen, Germany: University of Erlangen.
Schmiedecken W. 1981. Humidity and cultivated plants. An attempt at parallelizing zones of humidity and optimal locations of selected cultivated plants in the tropics. *Applied Geography and Development* 17:45–57.
Seggern J von. 1993. Algunas observaciones sobre la erosión del suelo en el Soconusco. *In:* Richter M, editor. *Investigaciones Ecogeográficas Sobre la Región del Soconusco*. San Cristóbal de las Casas, Mexico: ECOSUR. pp 53–68.
Waibel L. 1933. Die Sierra Madre de Chiapas. *Mitteilungen der Geographischen Gesellschaft in Hamburg* 43:12–162.