THE ASSOCIATION FOR TROPICAL BIOLOGY AND CONSERVATION AND UNIDAD ACADÉMICA DEL INSTITUTO DE GEOGRAFÍA DE LA UNAM

INVITE TO THE FIELDTRIP

LANDSCAPE MANAGEMENT LESSONS

THE EXPERIENCE AT NUEVO SAN JUAN PARANGARICUTIRO, MICHOACÁN

Coordinated by

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GENERAL PROGRAM

DAY 1. Departure 7 AM: Morelia (at Campus UNAM), night at Pantzingo

DAY 2. Paricutín volcano, surroundings of cone and lava fields; return to Morelia by 6 PM.

COST (Per person including transportation, accommodation and meals) $250.00 USD

REQUIREMENTS: Field clothes, boots, raincoat, and camera.

TRANSPORTATION MEANS: Van

NUMBER: participants min 10, max 30. The trip will be cancelled if less than 10 participants sign up.

FORM OF PAYMENT AND CANCELLATION POLICY: **To register and pay for the trip on line press HERE**. Any cancellation will have a penalty of 5% for bank fees. In case of having less than 10 registrants before June 20, the trip will be cancelled and money reimbursed to registrants at Morelia, taking 5% for bank fees. Cancellations after June 20 will have a total deduction of $100 USD to allow the payment of transportation and room and reservations that cannot be cancelled. Registration and payment may be still possible at Morelia, but subject to availability. Please consider that paying in advance will help us to sense the feasibility of the trip.

Abstract/ Optimum natural resource management and biodiversity conservation are desirable goals. These, however, are often excluding each other, since maximum economic benefits have promoted drastic reduction in biodiversity throughout the world. This dilemma confronts local stakeholders, who usually go for maximising economic inputs, whereas other social (e.g., academic) sectors are in favour of conservation practices. In this fieldtrip we will witness the way two scientific approaches, namely landscape and participatory research, were used to develop sound and durable land use scenarios. These two approaches included expert knowledge of both social and environmental conditions in indigenous communities. Our major emphasis was given to detect spatially explicit land use scenarios and capacity building in order to construct a decision support system operated by stakeholders of the "Comunidad Indígena de Nuevo San Juan Parangaricutiro" in Mexico. The system for decision-making was fed with data from inventories of both, abiotic and biotic biodiversity components. All research, implementation, and monitoring activities were conducted in close collaboration with members of the indigenous community. As a major result we obtained a number of forest alternative uses that favours emerging markets and makes this indigenous community less dependent of one single market. Furthermore, skilled members of the community are now running the automated system for decision-making. To conclude, our results were better expressed as products with direct benefits in local livelihoods rather than pure academic outputs.

INTRODUCTION

Vast extensions of central Mexico consist of volcanic landscapes with a predominance of cinder and scoria cones and associated forms, known as monogenetic fields, interspersed with large stratovolcanoes such as Popocatépetl and lake basins, all of them in a temperate, seasonally humid climate characteristic of tropical highlands. The region is part of the most densely populated area of the country since pre-Hispanic times. It is also an area where accelerated urbanization and industrial development coexist with traditional agricultural practices in rural areas (see appendix I for details).

This field trip guide focuses on the experiences on landscape management of a large number of old but recently emerging communal organizations devoted for sound landscape management in Mexico. It has been vigorously argued that sustainable natural forest management in the tropics is burdened by almost insurmountable ecological and financial challenges when carried out by private enterprises. Almost unacknowledged is tropical forest management carried out by entities other than private logging enterprises, specifically community forest enterprises (CFEs). Nonetheless, there is also substantial evidence that at least some forms of logging and tropical forest biodiversity can coexist. Strong evidence is depicted by the "Comunidad Indígena de Nuevo San Juan Parangaricutiro" in Mexico. The argument that Sustainable Forest Management has "limited usefulness" as a conservation strategy must be carefully evaluated as to what we mean by "conservation". This argument equates conservation only with the maintenance of large blocks of forests not used for extractive purposes, although the U.S. experience shows that the favored uses of recreation and science can also degrade ecosystems (Chase 1987). But the maintenance of large blocks must have political, social and economic support, and it must be proven necessary for the preservation of biodiversity. Large blocks of unintervened forests may be desirable from multiple points of view but to argue that only that contributes to "conservation" is a remarkably limited and not scientifically substantiated vision that denies the "inherent worth of human-impacted areas". Weather community tropical forest management in San Juan may be considered "sustainable" is still under evaluation, but the available evidence suggests that CFEs merit far more scrutiny than they have thus far received.

Landscape science ("landschaftskunde") is an applied discipline with two elements "land" and "scape"; "land" being considered as a complex of interacting and interrelated components within a real space, while "scape" refers to the chorological patterns of the units across the real space. The landscape results from the interactions between features of the real world such as climate, rock, parental material and landform. Vegetation and animal life are the biological components differentiated over space and time, and considered as entire assemblages. The soil component links processes between the landscape components, which is the core issue in. The social component is inherent to real spaces and its role as a driving force is site-dependent. The landscape science has from its origin onward been conceived as a holistic, spatially explicit, scale-independent participatory study approach. This type of approach has been largely neglected during the last decades, in spite of its applicability on concrete natural resource management and conservation actions.

DAY 1. MORELIA-PÁTZCUARO-URUAPAN

Morelia - Pátzcuaro

Morelia, a major colonial town and state capital of Michoacán, is a fast growing city (ca. 800,000 inhabitants). Its area has enlarged 600 % in the last 35 years. Water demand has increased proportionally, contrib uting to the lack of balance in the Cuitzeo basin.

Pátzcuaro - Uruapan

The area is also characterized by late Quaternary volcanic formations. The main changes in the landscape along this roadway are related to a gradual descent of ca. 500 from Pátzcuaro (2100 m) to Uruapan (1600 m). The latter has a moister and warmer climate that represents a transition between the temperate Tarascan Plateau and the tropical lowlands of Michoacán (*Tierra Caliente*). Near Uruapan deep, red soils are common, except on young volcanic rocks with Andoslols. A noticeable change in land use is the gradual replacement of pine-oak forest in the Pátzcuaro area to avocado orchards around Uruapan. Avocado as a domesticated plant originated in Mesoamerica in pre-Hispanic times. Nowadays it is the base of the rural economy of the Uruapan region, which is considered as the most important producer of this crop in the world.

Uruapan-San Juan

The “Comunidad Indígena de Nuevo San Juan Parangaricutiro” (CINSJP) is a “Purépecha” community is located in about 15 km west off Uruapan City. Dominant temperate climate prevails, soils are of recent volcanic origin, and altitudes range from 1,800 to 3,000 masl. The CINSJP holds 190 km^2 out of which 30% are covered with Paricutin Volcano ashes. The major economic activity is the community´s forestry enterprise, though about 20% of the territory is still used for traditional agricultural practices. This CINSJP comprises about 1,300 “comuneros” (community members) and their families. These community members either work in permanent or temporary jobs in all timbering activities conducted in the community enterprise (Alvarez-Icaza 1993). Thus, over 8,000 people depend financially on this forestry enterprise.

Up to 1993, the CINSJP harvested *ci.* 100 thousand m^3 of timber per year, this yielded about half a million 1993 American dollars a year, as a result of selling their products in national and international markets. Hence, the CINSJP has been considered as a successful model of community enterprise for timbering activities. After 1994, when Mexico, Canada and United States of America signed the NAFTA agreement, the markets for timber Mexican products were negatively affected; the yearly income of the CINSJP was reduced in 25 %. Therefore, the leaders of the community considered the need to generate new marketable products through alternative activities. Academic institutions were consequently invited to explore new financially and ecologically sound approaches for natural resource management.

STOP 1. COMMUNITY FOREST ENTERPRISE

Introductory film of the community

Visit of the community headquarters and forest enterprise

Small breakfast

STOP 2. COMMUNITY FOREST MANAGEMENT (WHILE HAVING LUNCH)

Visit of a plot where forest extraction is taking place

Visit the control-experimental plot

STOP 3. PANTZINGO TOURIST CENTER

The ecotourism project emerged as demand from the community in order to reduce forest extraction compensating the incomes by means of ecologically sound tourist activities. Up to know over 1000 visitors a year are attended and about US$100,000.00 a year is the estimated profit for the community. In addition a number of permanent jobs have been created. There is a strong demand to strengthen the accountability and efficiency of this project.

STOP 4. WALK AROUND PANTZINGO TOURIST CENTER

Visit the efforts for ecological restoration on accumulation plains filled in with lava ashes Because the area consists of volcanic materials of different age, the soils present a wide range of evolution. Deposits of the most recent event, the Paricutin eruption, buried soils formed on older materials. The purpose of this stop is to examine a roadcut displaying a soil profile buried by Paricutin ash fall and witness the process of reforestation by means of relief-soil-management. Before the eruption of Paricutín, nearly 75% of the area had soils with a clayey texture, with light brown color and a thick bed of organic material. The rest of the area had soils with a variable texture with predominance of clay, locally called charandosa lands, followed by soils with silty-clay texture.

STOP 5. DINNER AT PANTZINGO TOURIST CENTER (OVERNIGHT & BREAKFAST)

DAY 2 PARICUTÍN VOLCANO AND SURROUNDINGS

Introduction to Paricutin

The eruption that produced Paricutín volcano provided a unique opportunity to examine in detail the eruptive mechanisms of a monogenetic volcano, as well as the impact of volcanism on the landscape and population.

Parícutin volcano (2780 msnm) first appeared on February 20th of 1943 on a cornfield belonging to the village of San Salvador Parícutin, Municipality of Parangaricutiro, in the state of Michoacán, México. It is located within the physiographic province of the Trans-Mexican

Volcanic Belt at 19°29’32” North and 102°15’03” West, about 330 km west of México City and 20 km northwest of the town of the Uruapan. The volcano is bordered by two high mountain masses: Cerro de Angahuan (3292 msnm) to the north, and by the Tancítaro Peak (3860 msnm, the highest in the region), whose summit lies 11 km SW of the new volcano (Bocco et al., 1998).

STOP 1. PARICUTIN AT GLANCE

Summary of the history of the Paricutín eruption

The descriptions of the geomorphic setting before the birth of the volcano characterize the area as a generally flat terrain, slightly undulated, and with a dominant SE-NW slope (Ordóñez, 1943; Segerstrom, 1950; Foshag y González-Reyna, 1956). The small basin (2275 msnm) where the volcano appeared was 1.5 km long and 0.8 km wide. It was used as agricultural land. The southern parcel where the volcano was born belonged to Dionicio Pulido, a native of Parícutin village. The parcel was called Cuiyutziro.

During 9 years of activity, the landscape dynamics changed drastically due to the fall of ash and the emission of lava flows, the latter having been almost constant since the beginning. The following summary of the activity of Paricutín is based on observations and accounts of a number of authors summarized by Segerstrom (1950 and 1960), Foshag and González Reyna (1956), Bullard (1956), Luhr and Simkin (1993), and Rees (1979).

On the day of the eruption, Mr. Dionisio Pulido was planting maize on his field and witnessed a small explosion from a vent that had suddenly opened in a shallow hollow where storm runoff had infiltrated during the past rainy season. The initial explosion was followed by the emission of steam and sulfurous gases and by a small eruptive column of fine dust and small incandescent stones. The 30-cm vent widened with the slumping of molten materials, and the eruptive column gradually increased in size. By midnight, the fissure activity had become violent. A large eruptive column was accompanied by a roaring sound, lightning flashes, and the violent ejection of great number of incandescent rocks. The cone measured approximately 6 m high at midnight of the first day; 30 m after one day, and 167 m after 6 days; by the end of the first year, the cone had grown to a height of 325 m. Intermittent eruptions continued until 1952 when the cone reached a height of 410 m above the original maize field; its total height, however, is not apparent because of repeated lava flows that covered the lower slopes of the cone. During the phase of construction the cone lost part of its height several times, due to the great number of explosions and landslides (e.g. nearly one third of the height between 1943 ands 1944).

The first month of Parícutin’s activity was dominated by the explosive ejection of volcanic bombs, blocks, and lapilli that brought about the rapid cone building. Most of the ejecta were angular chunks of old rock (from the walls of the magma conduit), and bombs (globs of magma, some of which were still plastic enough to alter their shapes on impact). Most bombs were from 30 cm to 1 m in diameter and fragmented on impact with the ground. Every few seconds showers of incandescent rock material were ejected from the crater. The explosive violence could be heard as far as Guanajuato, 350 km distant. By March 6th 1943, about 83 million m^3 of bombs, blocks, lapilli, and ash had been ejected from the crater vents of

Parícutin. The jection of pyroclastic material averaged 6 million m^3/day in the early period and then decreased to an average of 76,000 m^3 for several months.

Lava flowed from the cone vents since the first day and by February 24 a broad sheet 700 m long was advancing at a rate of 5 m/hr. Surges of lava flow repeatedly breached the weak walls of the cone during the first day of the eruption. Pauses in the flow allowed the cone wall to build up again by accumulation of volcanic bombs, lapilli, and ash. The shape of the cone thus alternated from a horseshoe to a cone. After the first month of activity the buildup of the cone mass was such that lava no longer broke through the walls of the crater. Instead, surges of lava flowed from vents on the outer flank of the cone, causing slumping and partial collapse of a cone section that was later filled in by the bombs of the next explosive period.

The heavy cinder phase began on 18 March and lasted until 9 June 1943. The change from volcanic bombs stage (characterized by little ash but great amount of bombs) to the succeeding cinder phase was a result in part of choking of the vents in the cone by debris as volcanic bombs rolled back down the inside slopes of the cone. During the cinder phase a nearly continuous eruptive column of ash rose to heights of 8000 m above the cone. During this period the ashfall was the greatest in Parícutin history. Winds carried the ash to the north and east. Fine ash fell in Mexico City (320 km away), while in Uruapan (25 km to the east) street lamps and auto headlights were necessary during the daytime. In nearby San Juan Parangaricutiro the roofs of houses were cleared every 2 or 3 days to prevent collapse. During the summer of 1943 ash emission decreased, and the lava rose from the central cone at higher rates than in any subsequent period. Soon after, lava cascaded from a lava fountain 100 m below the crater rim. In July other flows injected under earlier flows carried the crusted earlier flows along for 400 m. In October 1943, a parasitic cone developed at the northeast base of Parícutin, and erupted with vigor until January 1944. This second cone, called Sapichu, rose to over 70 m and developed a horseshoe shape as lava flows breached the northeast side. In January 1944 the main cone renewed explosive activity after the relative quietness of the Sapichu period. New lava vents opened at the southwest base of the Parícutin cone; vents in this area produced all of the lava flows for the next 3 years.

From January to August 1944 these vents yielded the San Juan flow that moved east, north, and then west, to flow over and past the village of San Juan Parangaricutiro. This flow was the most voluminous of the Parícutin flows and extended over 10 km in length. From September to November 1944 the Parícutin flow advanced to a rate of 6 m/hr northward through Parícutin village and completely covered the village site, and reached the earlier San Juan flow. During mid-November 1944, additional vents opened on the southwest base of the cone; lavas from these vents flowed mostly over the San Juan and Parícutin lavas. Similar activity from these southwest vents continued through 1945 and 1946.

In January 1947 the cone walls of the main cone slumped on the northeast and southwest sides, and new vents adjacent to the slumping began emitting lava that flowed intermittently during 1947. From December 1947 until the end of activity in 1952, most of the major lava flows came from the northeast vents, the most prominent of which was called new Sapichu. Flows from this vents were nearly continuous from February 1948 to the sudden cessation of lava emissions on February 25, 1952. Flows of the later years piled up in depth around the cone and in some cases moved far enough north to cover more uncovered ground enclosed by the San Juan and Parícutin flows of 1944.

During the last year of the eruption, ash emissions and explosive ejection of bombs continued to occur at intervals. After lava eruption ceased only weak explosions occurred and eruption of pyroclastics ended on 4 March 1952. The only form of activity since that time has been the gentle emission of warm acid water vapor from fumarole vents near the cone rim and from 12 vents on the lava flow immediately west of the cone.

In the 9 years and 11 day of eruption history, the Parícutin lava flows covered 24.8 km^2 of the old ground area. The general outline of the lava field was established by 1944, because the subsequent lava flows in most cases spread over previous flows The flows have a calculated total volume of 700 millions m^3. Lava thickness is at a maximum (over 242 m) near the cone, where lava piled up over previous flows, and a minimum of 3 m at the outer edge of the lava field. The lava flows are of the AA type, with scoriaceous fragments.

Post-eruptive evolution

Open fields dammed by lava flows (called ash *playas* by Eggler (1959) and Segerstrom (1966) and subsequently *llanos* by the peasants) formed during the heavy cinder phase. The *llanos* consist of deposits of ash, pre-eruptive soils and organic material transported from adjacent slopes by water-flows and dammed by the lavas. Since 1945 it was anticipated that these places could support vegetation soon. In 1950, these floodplains were more extensive and deeper, and became the first agricultural fields after the end of the eruption.

The adjacent cerros (older volcanic cones) were heavily covered by deposits of ash fall (from centimeters to several meters of thickness), which increased the erosive processes during the rainy season.

Segerstrom (1966) determined that Parícutin volcano and its surroundings were close to stability by 1965. However, Inbar et al. (1994) estimated that in the early 1990s the rates of erosion were still 50% higher than normal.

For the cone, according to Eggler (1959), the two most important changes in 1959 in relation to 1950 were the presence of great number of plants surrounding the crater edge (in 1957 Segersttom found lichens and two species of angiosperms at the crater edge) and the formation of numerous fissures and landslides inside and outside of the cinder cone. The general result of such landslides is a tendency for the cinder cone to become wider at the base and lower in elevation.

In 1965 Segerstrom (1966) noticed the absence of rocks falls, which still affected many slopes in 1957. This suggested a certain stability of the cone. By 1965 the pyroclastic materials on the slopes were still too coarse and permeable to allow the formation of runoff and related erosional features on the flanks of the cinder cone.

According to Inbar et al. (1994) the depth of the crater decreased from 50 m in 1957 to 40 m in 1990, due the filling produced by landslides from the inner slopes of the crater. In his fist visit to the area in 1972, Inbar et al. (1994) observed residues of ash fall deposits, which were almost completely absent by 1987. Inbar et al. (1994) also noticed the existence of some stream erosion on the lower parts, although he didn’t find evidence of centripetal drainage. He also found the presence of anthropic erosion over the southwest flank, as result of the continuous descent of tourists.

Fine materials accumulated in the fissures and depressions of the lava flows, which favored the evolution of a primary succession of vegetation by 1950 consisting of algae, mosses and ferns (Eggler, 1959). By 1990 most of the edges of the lava flows were covered by plants, showed signs of weathering processes and soil development, while drainage at the base of the lavas had integrated (Inbar et al., 1994).

The *llanos* developed not only around the lava field but also inside it. In 1985 Inbar estimated that that the *llanos* covered an area of 5.06 km^2, most of them located on the eastern part of the lava field. Some ash fields have internal pipes that produce sinkholes on cornfields.

In the first half of the 1990s the surrounding volcanoes Capatzun and Equijuata already had a dense vegetation cover. Ash had been almost completely removed to lower areas. The flanks of both cones are affected by gullies that cut even the pre-eruptive soil and form alluvial fans as they reach the *llano*.

The cerros of Canicjuata, Corucjuata y Coaxadarán still have a thick ash cover. This, in combination with a strong dissection of their flanks and base, produces processes of landsliding and gully deepening, in particular at the area of contact between the cones and the lava flows of Parícutin. The present stop will allow to witness the mayor trends on vegetation recovery patterns at recent Mexican volcanic formations These suggested an array of two vegetation trends: one depicting early edaphoxeric conditions dominated by heliophylous elements and another where mature conditions prevailed harbouring umbrophylous and tree-like elements.

STOP 2. RUINS OF SAN JUAN PARANGARICUTIRO

San Juan Parangaricutiro or *San Juan de Las Colchas* was the main populated center in this part of the Purépecha region until July 1944, when it was entirely covered by a lava flow 15-20 m thick, which forced all the villagers to abandon definitively their houses and fields. The village, founded between 1500 AD and 1540, was famous for its manufacture of textile products of diverse types. On May 3 1944 the lava covered the graveyard of the village. On May 9 the statue of The Lord of the Miracles was carried out from the church to Angahuan, and from there to Uruapan. On May 13 1944, as result of another large migration of people from San Juan Parangaricutiro, the new town of Nuevo San Juan is founded 6 km to the west of Uruapan. On June 8 1944 the front of the lava flows arrived at the presbytery of the church and the lava was divided in two fire tongues that destroyed the walls and arcs of the building. The altar and all the interior of the chruch were destroyed. Surrounding the church the lava flow moved through the main plaza of the village destroying everything along its path. The ruins of the church are surrounded by a basaltic-andesitic lava flow ~15 m thick.

The flows before 1944 were more extensive and less thick than those produced after 1944. This was probably a result of the change in chemical composition of the lava and also of the topography free of obstacles at the beginning of the eruption. Slopes were 4° to 8° at the top part and 1° to 4° at the lower part of the flows. One outstanding lava flow was The San Juan Flow with 10 km long and an thick massive structure, in contrast with other flows having a blocky structure and AA lavas.

STOP 3. ON THE SHORE OF LAKE PATZCUARO

The Lake Pátzcuaro catchment area is situated in the Transmexican Neovolcanic Axis, a Plio-Quaternary igneous-tectonic mountain system stretching from east to west, in central Mexico. One fourth of the 100 settlements located on the basin are indigenous communities. Some were established more than 3,000 years ago. The indigenous natural resource management (including the lake) is based on multi-purpose ecosystem exploitation, including 12 agricultural systems. A set of other agro-productive activities, besides agriculture, conforms the land management strategy of these indigenous villages.

From an environmental point of view, Pátzcuaro constitutes a fragile region and is highly susceptible to land degradation due to:

(1) Being a small basin (1000 km²) surrounded by volcanic sierras with an elevation range of 1,300 m, with short and steep slopes.

(2) Being still geologically active; more than 150 young volcanoes (Holocene) are located at the base of older (Pliocene) monogenetic volcanoes (Demant, 1978 and 1992). Volcanism has been a common phenomenon, even when Pátzcuaro was already inhabited, since at least 5,000 years ago (Arnauld et al., 1994).

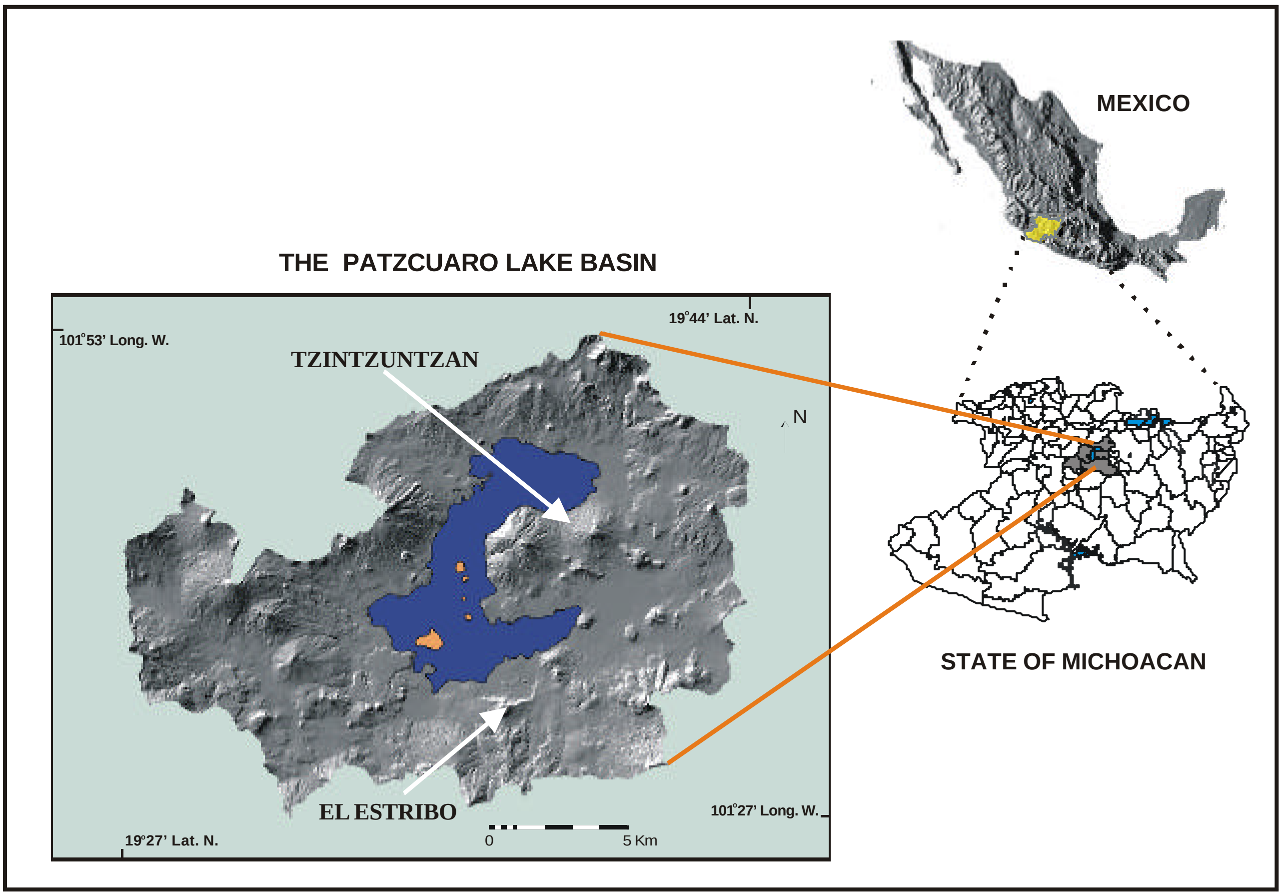

Figure 5. Location map of the lake Pátzcuaro.

(3) Its climatic variability; fluctuations in the climate over the last 4,000 years have had a significant impact on the lake and on the subsistence strategies of the population (Endfield and O'Hara, 1997; Florescano, 1972; Chacón, 1989 and 1993 Street-Perrot, et al., 1989; O'Hara, 1991; O'Hara et al., 1993; O'Hara et al., 1994;). Minor climatic fluctuations and resulting shifts in lake level, perhaps exacerbated by human environmental modification, have occurred with some frequency in the past, including a period just after the Spanish conquest (Pollard, 1993) and during the last 25 years of the 20th century.

KEY REFERENCES

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Appendix I

The Trans-Mexican Volcanic Belt

The route of the fieldtrip falls entirely within the Trans-Mexican Volcanic Belt, a major geologic province where andesitic and basaltic volcanism and active tectonics have played a major role in the configuration of the landscape.

The Trans-Mexican Volcanic Belt (TMVB) is a strip of late Tertiary and Quaternary volcanoes that extends for more than 1000 km across central Mexico from near the Pacific coast to near the Gulf of Mexico, mostly between the 19°N and 20°N (Figure 1). The TMBV consists of a large number of Late Tertiary and Quaternary cinder cones, maars, domes, and stratovolcanoes, the chemical and mineralogical composition of which is largely calc-alkaline. Although several hypotheses for the origin of the TMVB have been proposed, most authors relate it to the subduction of the Cocos plate beneath the North American plate. Several key questions related to this major volcanic belt remain unanswered. In contrast with other subduction-related volcanic belts, the TMVB does not run parallel to a deep-sea trench, but is oriented obliquely, forming an angle of ca. 15 ^{o} with the Middle America Trench. Prior to the existence of the TMVB, a subduction zone oriented roughly NNW-SSE existed along the western margin of North America. We do not know the exact sequence of events that lead to the present configuration with a subduction zone oriented WNW-ESE and the development of the TMVB. Another particularity of the TMVB is the abundance of scoria cones and other monogenetic volcanic structures, which outnumber by several orders of magnitude, the much larger stratovolcanoes. This is especially the case of the Tarascan Plateau in Michoacán. In addition, several areas with alkaline volcanic rocks have been identified in recent decades, and satisfactory answers regarding the origin of these anomalous lavas are still lacking. Some of the major stratovolcanoes are roughly aligned in a N-S direction, perpendicular to the general trend of the TMVB. The most prominent examples of such alignement are the volcanic chains Cofre de Perote - Pico de Orizaba, Iztaccíhuatl - Popocatépetl, and Nevado de Colima - Volcán de Colima. In each of these cases, the older and more eroded volcano is located to the north, while the younger and more active one is located to the south at the front of the TMVB. These relationships also lack consistent explanation (Siebe et al. 1997).

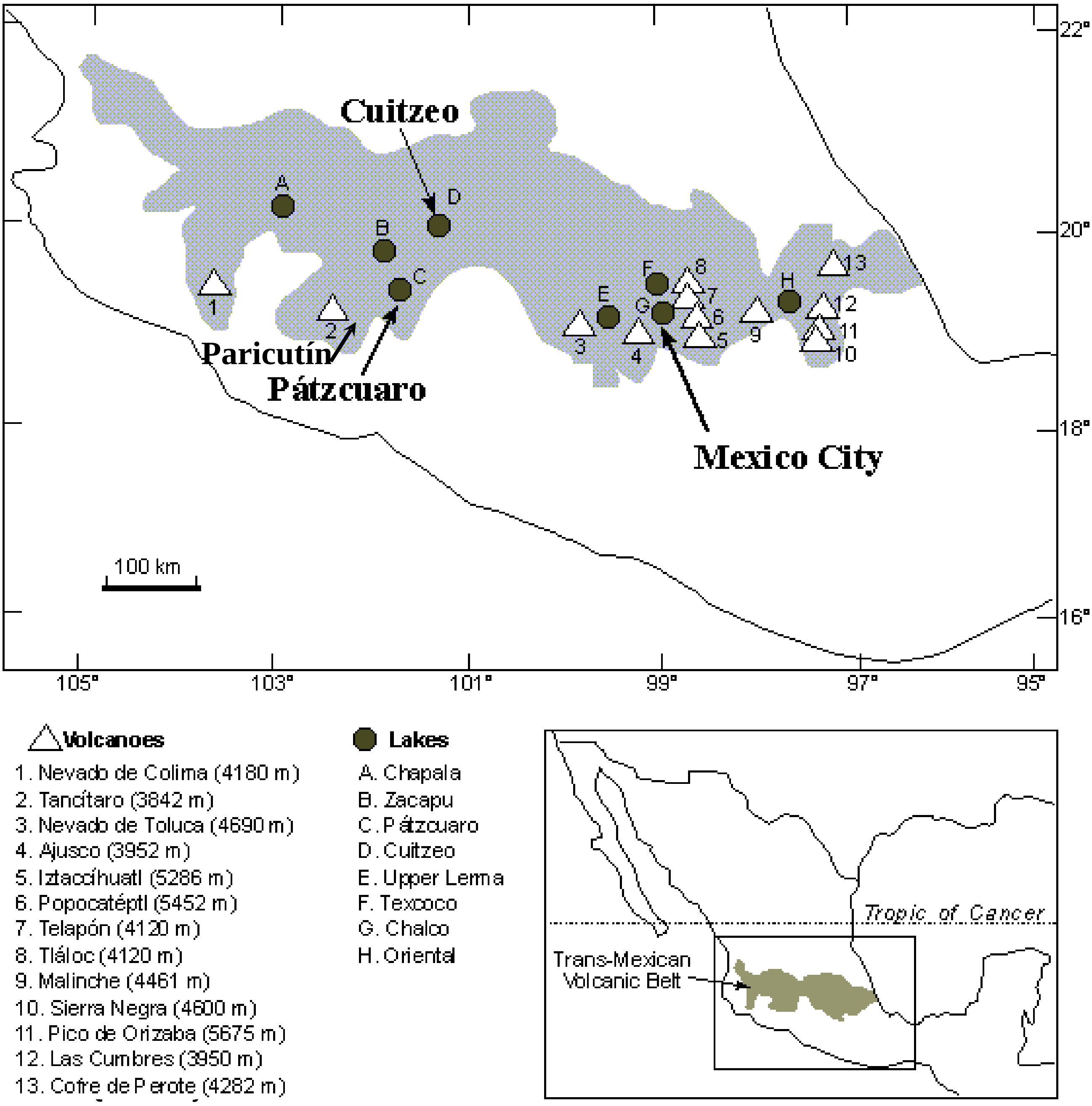
The TMVB intersperses with the southern portion of the Central Mexican Highlands, creating a landscape of tectonic depressions bordered by volcanoes. In detail, the TMVB consists of areas with numerous small volcanoes (monogenetic fields) intercalated with areas dominated by large stratovolcanoes. Examples of monogetic fields are the area to the south of the Valleys of Mexico and Toluca (Sierra Chichináutzin) and the area of central Michoacán state or Meseta Tarasca (including Paricutín volcano). Fourteen stratovolcanoes peak above 3800 m, and the three highest of them - Pico de Orizaba or Citlaltépetl (5675 m), Popocatépetl (5452 m) and Iztaccíhuatl (5286 m) - are high enough to support small glaciers at present.

Elevation in the lowlands of the TMBV ranges from 2000 to 2500 m, depending on the basin. Under the present temperate climate with seasonal rainfall and high evaporation, some basins support small lakes, among them Cuitzeo (the second of Mexico by size) and Pátzcuaro lakes. There is clear evidence of fluctuating lake levels and environmental conditions in these lacustrine basins during the Late Pleistocene and Holocene (Metcalfe et al., 2000).

The fertility of the volcanic soil, favourable climatic conditions, and the availability of water in the intermontane lacustrine basins within the TMVB attracted Prehistoric nomadic people and fostered the rise of ancient civilizations. Urban development gave rise to major Prehispanic cities during the first 1300 years A.D., such as Teotihuacan, Cholula, Tenochtitlan (ancient Mexico-City), and the Páztcuaro area, among others, leading to a significant population concentration in central Mexico. Conquest by the Spaniards temporarily reduced population growth, mostly because of deaths from epidemic diseases introduced from Europe and Africa.

The climate of Mexico

The climate of Mexico is strongly influenced by the position and strength of the subtropical high pressure systems of the North Atlantic and North East Pacific, and by the seasonal shifting of the intertropical convergence zone lying to the south of the country. During the half year centered in winter the subtropical high-pressure belt shifts to its southernmost position and creates stable, dry conditions over most of Mexico. At the same time polar continental air masses from North America penetrate, associated with westerly flow. called. They are called “Nortes”. The winter westerly flow can extend as far south as central and south central Mexico. Because of the high altitudes of central Mexico, the land intercepts the upper westerlies, resulting in cold conditions and occasional snowfall at high elevation (Metcalfe et al., 2000).



During the half year centered in summer the subtropical high-pressure belt shifts northward and easterly flow (the trade winds) dominates, bringing in moisture from the Gulf of Mexico and the tropical east Pacific. Convection and the moist trade winds cause a maximum of rainfall over most of the country. Additional heavy rainfall is associated with hurricanes occurring in late summer and early fall.

In the highlands of central Mexico temperatures peak in mid-Spring (April-May) and decrease as the rain season starts (Table 1). Freezing occurs above 1900 m, while ice-days occur only above 3500 m. Approximately 75 to 80% of the annual precipitation falls from June through September (90% from May through October), and <5% from January through March, the driest months. Mean annual precipitation locally fluctuates between 700 and 1000 mm. On the mountain slopes it reaches a maximum of ca. 1300 mm between 2700 and 3200 masl, where vegetation appears as a kind of “cloud coniferous forest”. At higher elevation precipitation decreases, reaching 900 m around the timberline (4000 m) and 800 mm near the snowline (5000 m) (Lauer, 1978).

Michoacan receives moisture from the Gulf of Mexico and from the Pacific. Precipitation on most of the Tarascan highlands is 750-1000 mm, while a local maximum of ca. 1600 mm occurs on around Uruapan in connection with orographic uplift of tropical air masses from the eastern Pacific. Table 1 summarizes climatic data for Mexico City, Pátzcuaro and Uruapan.

Table 1. Temperature (T) and precipitation (P) in Mexico city, Pátzcuaro and Uruapan (García, 1981).

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Uruapan, Michoacán (1610 masl)	T (°C)	16.2	17.0	18.8	20.4	21.3	21.0	20.1	19.8	19.5	19.1	17.7	16.4	**18.9**
	P (mm)	23.2	12.4	8.2	9.4	39.6	277.4	341.7	334.6	349.5	151.0	38.2	22.6	**1607.7**