Soil Survey and its Relation with Land Type Classification and Cartography by Farmers

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Taking an empirical viewpoint from a farming perspective, there seem to be no names for soil profiles as used in a soil survey. Rather, farmers refer to them geographically as types of land (*clases de tierras*). We believe that the concept of "land" is more general than the concept of "soil." The area of study chosen was the municipality of San Salvador Atenco in the State of Mexico (*Estado de México*), since previous work has been done here regarding rural soil classifications by farmers. Moreover, results from a detailed soil survey were already available. Technically, an observer-participant approach was applied to gather information from farmers. The cartographic material used were maps of ejido-internal parcels (*planos de dotación parcelaria*) of two of the six ejidos of San Salvador Atenco. Field work was carried out between February and May, 1987. The results we obtained show that mapping of soils from a farmers' point of view, i.e. grouped as land types can be done quickly and easily and provides, moreover, additional information compared with a detailed soil survey.

Keywords: soil survey, rural land types, mental map

1. A brief history of the present document

The current edition of this document was motivated by the need of making available relevant information on land cartography, both in analog and electronic form. In particular, we refer on information used to define main lines of research, and that has been a methodological reference point for the subject at hand. This is also due to the fact that, recently, ethno-edaphological studies achieved increasing relevance, since the information provided is crucial for tackling current problems in a local context.

This article originally was written in Spanish in 1987. It has been quoted in other articles as a technical report in a mimeographed version, which served as a base document for other articles related to the cartography of lands. However, it never has been published nor translated in any specialized journal. This documentary gap is herewith closed.

Our gratitude goes out to Anselmo Rosas González for updating graphics and figures, to Enriqueta Tello García for their digitalization, and to Gustavo Márquez Cerecedo for the thorough search for rare and scarce information, mostly in relation with codices.

2. Precedents

2.1 Soil surveys

Soil surveys are a set of methodologies to systematically study and describe the resource "soil". They are, so far, the fastest and most precise procedure to make predictions on the behavior of soils at different management levels. This holds true from a technical viewpoint, and under the assumption that no previous knowledge worthwhile to be

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evaluated exists. Soil surveying is fundamentally based on studies of terrain and soil profiles, taking into account the most stable physicochemical characteristics (Soil Survey Staff, 1960; Clarke, 1971; Hodgson, 1978; Western, 1978; Buttler, 1980; Dent & Young, 1981; Ortiz & Cuanalo, 1981; Breimer et al., 1986). However, there have been attempts to relate this traditional soil surveying approach with the knowledge of farmers (Fisher et al., 1986). This knowledge is considered to be especially useful in areas where no surveys have been conducted in a formal way (Collins 1981, p. 37).

Depending on their level of detail, soil surveys usually are expensive, require time for their execution, relative costly cartographic material and trained technicians to carry them out (Beckett, 1981; Dent & Young, 1981).

In a specific area, there will be both similar profiles and profiles differing in regard of various features. If the profiles are similar, this will result in a soil distribution pattern, which can be presented on a map. The outcome of profile descriptions, lab analyses, and the areas covered by the soil studies will compose the legend. Consequently, map and soil legend together form the memory of each survey. However, it is evident that in Mexico, and particularly in regard to a detailed survey, the soil cartography reported and stored does not have sufficient precision to identify all types of soils present in the area of interest (Ortiz et al., 1973).

2.2 Classification system and cartographic system

In the study of soils, a difference is made between its classification and its mapping. Cartographically, units of soils are identified in situ and then traced from photographic material. Classification units are groups of soil profiles described in situ and named according to a particular classification scheme.

Cartographically, the geographic location of a soil type or group, and the borders in-between are being visualized. The classification unit indicates with names, where similar soils have been observed in different geographic locations .

Regarding soil classification, the two classification systems most widely used in Mexico are the United States Soil Taxonomy, and the Food and Agriculture Organization (FAO/UNESCO) scheme.

The cartographic units used in soil surveys can be grouped into: (1) simple units, when only one soil type is mapped, such as soil series and soil phase; (2) compound units, when geographically related soils are mapped, such as soil complexes or soil association, and (3) indeterminate units, when areas are mapped that have not been studied before (Ortiz & Cuanalo, 1981).

2.3 Scale and cartographic material

Young (1976) states that there is a hierarchy within soil survey types, which vary according to their degree of detail and levels of generalization. These variations are commonly related to scale.

Scale is the ratio of a distance or area on a map to the corresponding distance or area on the ground; e.g.: a scale of 1:50000 scale indicates that 1 cm on the map equals 50000 cm on the ground. Table 1 summarizes the different types of soil surveys regarding scale.

Also related to scale is a quality control criterion for any type of map, known as the minimum mappable area (MMA). MMA is the smallest area that can be represented on a map. Buring et al. (1962) proposed the MMA to be a square of 5 mm on each side, which means that only areas equal to, or greater than 0.25 cm^2 will be represented on a map. Therefore, it is not recommended to trace on a map areas smaller than 0.25 cm^2. Likewise, when parallel lines must be drawn, they must have a separation of at least 2 mm.

Table 1: Types of soil surveys according to their level of detail; adapted from Dent & Young (1981), and Ortiz-Solorio & Cuanalo (1981)

Types of Surveys	Scale	Qualitative Description
Compilations	1 : 1 000 000 to smaller	soil maps based on abstractions from other surveys
Exploratory	1 : 2 000 000 to 1 : 500 000	not surveys in the strict sense; generally consist of terrestrial or airborne information of unknown areas
Reconnaissance	1 : 500 000 to 1 : 250 000	usage of photo-interpretation as principal work tool
Semi-detailed	1 : 100 000 to 1 : 30 000	combination of photo-interpretation and fieldwork
Detailed	1 : 25 000 to 1 : 10 000	principal tool is fieldwork
Intensive	Larger than 1 : 10 000	produced with intensive fieldwork

Topographic maps or aerial photographs can be used to draw the boundaries between cartographic units and the symbols for their identification.

2.4 Stages of a soil survey

Carrying out the survey of any type of soil requires two basic design steps, i.e.: planning and execution. Planning a survey involves the discussion of objectives, the nature of the information available, and the capacity of each survey to provide the required field data. Execution can be divided into three sub-stages: pre-field, field, and post-field activities. Principal task at the pre-field stage is the interpretation of aerial photographs, complemented with a general reconnaissance of the area to be studied. This helps to obtain information on the area´s accessibility, to establish routes by land, and to provisionally select observation sites. If aerial photographs are not available, topographic maps may be an option. However, such maps are often less efficient than aerial imagery (van Zuidam, 1985/1986).

Field activities start with the description of the soils at the previously selected sites. Moreover, they include soil mapping and obtaining information to evaluate the terrains, depending on the purpose(s) the survey has been designed for. Field activities take approximately half of the total time for semi-detailed soil surveys, more than half of the total time for detailed and intensive surveys, and less than half but still more than one third of the total time in reconnaissance surveys.

Post-field activities include photo interpretation and corrections where necessary. Soil samples are being analyzed in the laboratory, along with field data for soil profiles, and other information collected for comprehensive interpretation (Dent & Young, 1981; Ortiz & Cuanalo, 1981).

2.5 Classification and cartography of land types defined by farmers

Knowledge on the resource soil exists since people have realized its importance for food production. Hence, farmers and their knowledge on soil must be taken into account. Some pioneering investigations (Conklin, 1954; Altieri et al., 1987) considered farmers' knowledge of their natural environment from disciplines like ethnohistory, ethnobiology, etc., according to the focus of each field of study. Regarding the international scientific community, additional work has been presented that refers to the farmers' autochthonous or edaphological knowledge (Ollier et al., 1971; Brokensa et al., 1980; Conklin, 1980), incl. from an archaeological perspective (Sandor, 1986).

Ethnoedaphology, a relative new field of research in Mexico, highlights the importance of the participation of farmers. The few investigations carried out on this topic (Williams & Ortiz 1981; Luna, 1980; Luna, 1982; Calderon, 1983; Pérez, 1985 and Quiroz, 1985) emphasize that denomination and grouping of soils using land types by farmers have a clear scientific bases, comparable to technical classification schemes. Moreover, farmers use detailed names that often excel modern classification systems. On the other hand, the aforementioned authors also determine that unlike scientific, (three-dimensional) soil profile based characterization, farmers consider rather a (two-dimensional) surface. This means that farmers don´t employ terminologies in terms of soil profiles, but rather in terms of soils grouped as types of land. The concept of "land" (*tierra*) is a very broad one, but it seems to refer to a geographical area. This means, indirectly, that farmers do not classify soil profiles, but classify geographical areas for agriculture production purposes, amongst others.

After six years of research in ethnoedaphology at the Edaphology Center of the *Colegio de Postgraduados* (Mexico), two perspectives can be established in a chronologic manner: The first, influenced by Williams (1972, 1975, 1980a, and 1980b) and Williams & Ortiz (1981), who introduced the existence of autochthonous knowledge of soils registered in codices; and the second perspective, implicit in works mentioned earlier, related to the cartography of lands.

The first perspective clearly indicates, that there is a nomenclature and differentiation of lands, and that attempts have been made to explore its logic and use. Regarding the second perspective, few works on mapmaking are currently known by people outside western societies, untrained in academic cartography (Hutorowics, 1911; Flaherty, 1918; Bagrow, 1948; Spink & Moodie 1972). In Mexico, we know at least one document that may help understanding and systematizing the mapping process of the farmers´ lands (Guzman 1939). However, it is crucial to remember the pictorial evidence of classification and cartography of lands since pre-hispanic times, stored in codices (see figure 1). Likewise, the eloquent testimony by Hernán Cortes in his *Letters of Relation to Charles* V (Lorenzana, 1981) should be considered. These documents make us believe in the existence of a governmental institution dedicated to surveying, indexing, drawing and copying maps before the arrival of Western civilization to Mexico (Vivante, 1956). In the opinion of Adler (cited by Hutorowicz, 1911, p. 675) "some of the maps produced during pre-Hispanic times in Mexico and Peru were better and more useful than those made by Europeans in the Middle Ages. The cartography of Incas and Aztecs was entirely original, uninfluenced by models foreign to those cultures."

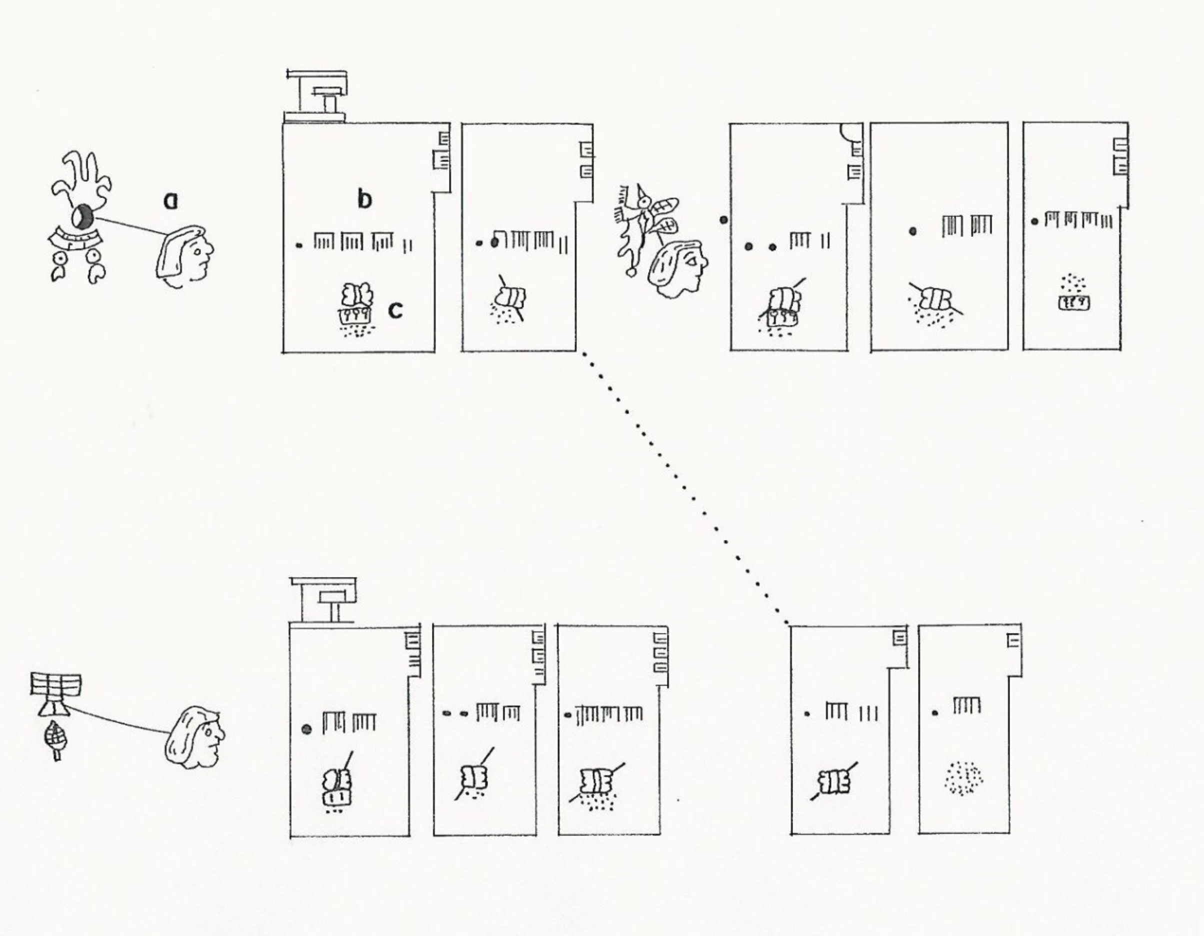


Figure 1. Fragment of the Vergara codex, which illustrates the plot owner (a), its dimensions (b), and glyphs of land types (c) (from Williams, 1980b)

The above led to think that the current edaphological knowledge of farmers could also be systematized and captured cartographically, to be – at some point – compared with academic soil surveying.

Hence, we can deduce from the aforesaid that it is worth exploring some strategies for mapping land types identified by farmers, in order to obtain maps suitable for practical use. These maps can serve as geographic reference framework, closer to the reality surrounding the farmers. Moreover, such maps can set the bases to establish a communication bridge (Posey, 1983) between farmers and technical specialists in soils, since these visualizations refer to the same object.

3. Hypothesis and Objectives

Against this background, the present investigation has been realized as a methodological proposal in order to proof the following hypothesis:

The cartographic knowledge of farmers is represented in maps of land types.

This hypothesis pursues the following objectives:

1. Compare the map reported in a detailed soil survey at a soil phase level with maps of land types of the same area produced by farmers;
2. Obtain information to create a simple soil mapping method;

4. Methodology

4.1 Area of study

The area chosen for our study includes parts of San Salvador Atenco, county in the State of Mexico. The area was chosen for the following reasons: On the one hand, earlier work on soil classification by farmers (Luna, 1980; Luna, 1982) was realized here. On the other hand, San Salvador Atenco is in the sphere of influence of the Rural Development District III - Texcoco, which facilitates practical application of the results obtained (see Figure 2).

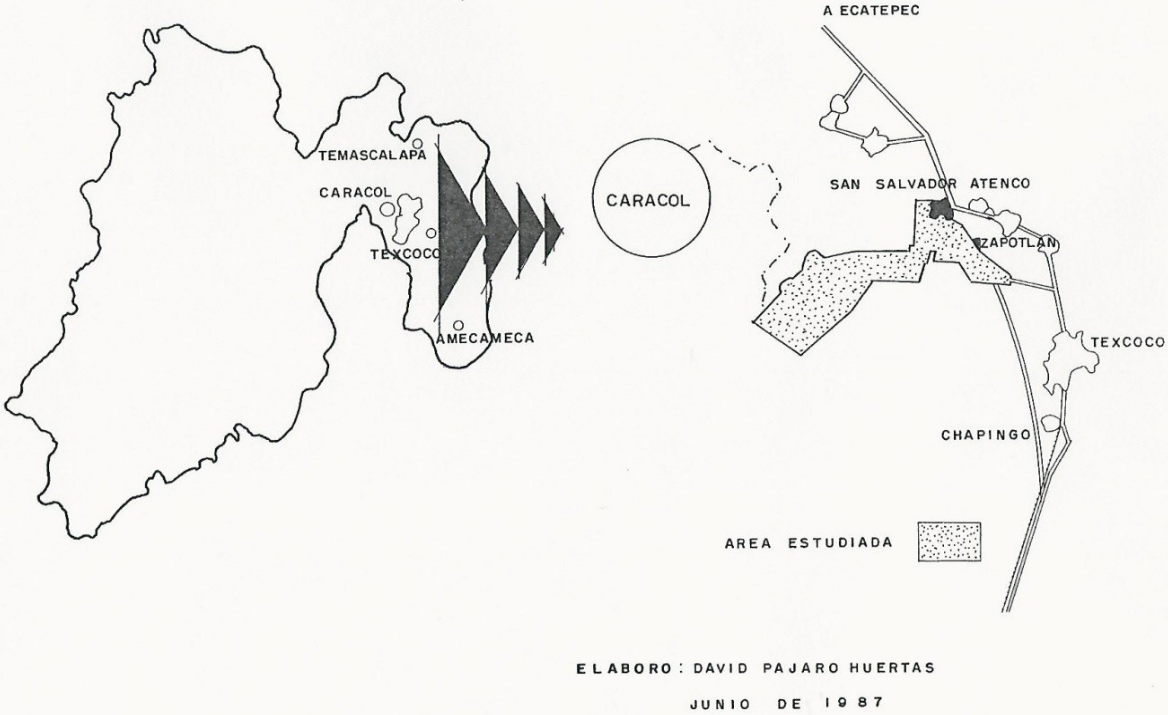


Figure 2. Location of the area of study (own elaboration)

The municipal area of Atenco comprises six *ejidos*[1]: Atenco, Acuexcomac, Nexquipayac, Ixtapan, Francisco I. Madero, and Zapotlán with a total area of 4870.5952 ha (data obtained from the register (*carpetas básicas*) of each *ejido* and consulted in the Texcoco office of the Secretary of Agrarian Reform). We realized our work in the *ejidos* Atenco (956.5 ha agricultural area, out of a total of 1300 ha) and Zapotlán (30.3 ha of agricultural land).

[1] Originally referred to the common surroundings of a village; since 1930: land granted under the land reform program and subject to a special tenure regimen (Van der Hann, 2001, p. 278)

4.2 The informants

The observer-participant technique was used (Long, 1977; Chambers, 1985). Eleven farmers were interviewed, regardless of their age. Their participation was spontaneous and unpaid (see Table 2).

Table 2. Names and ages of informants interviewed

Names (and age) of informants in the ejido of Atenco	Names (and age) of informants in the ejido of Acuexcomac	Names (and age) of informants in the ejido of Zapotlán
Ernesto Cervantes Ponce (65)	Modesto Moran (73)	Juan Rojas Romero (80)
Francisco Méndez Cortez (70)	Julio Zavala Colín (57)	Carlos Segundo (75)
Margarito Ávila (68)	Enrique Jolalpa (59) (Comisariado Ejidal)	
Alfredo Medina (69)		
Gabriel Sánchez Martínez (69)		
Marcelino Leyva Pérez (68)		

All questions aimed on establishing criteria for the cartography of land types, as well as to delimit and mapping them.

4.3 The cartography of farmer land types

After identifying the criteria used for land mapping by farmers in Atenco and Zapotlán, we continued to draw the boundaries between land types in a cadastral map (*planos parcelarios*), (at a scale of 1:5000 for Atenco, and 1:2000 for Zapotlán). This allowed us mapping details at a plot level. The cadastral maps were obtained from the head office of the Rural Development District III-Texcoco.

4.4 Farmers' land type maps

Cadastral maps (*planos parcelarios*) were used as cartographic base in order to draw the boundaries between land types; the final maps resulting from this activity are presented at a 1:10000 scale.

4.5 Visual comparison between farmers' land type map and the map obtained from soil surveys

Relevant information for the *ejidos* in Atenco and Zapotlán was taken from soil surveys in the Chapingo region (Cachón, 1973; Cachón et al., 1976); this information is necessary for the map comparison process. The final land type map was compared visually with the soil survey map at a soil-phase level obtained by Cachón (1973) and Cachón et al., (1976), establishing correspondence or divergence concerning the border lines. This was done on the assumption, that an equivalence between the cartographic units of the afore mentioned survey and the land types defined by farmers should be highly probable.

5. Results

The criteria used by the farmers to identify land types are expressed technically through characteristics like color, consistency, texture, moisture retention, fertility, workability, and salinity. This, basically, corroborates the information obtained by Luna (1982) for the *ejido* in Atenco (cf. table 3). The characteristics mentioned are common for land types both in Atenco and Zapotlán, since the land denomination is the same due the adjacency of the two *ejidos*.

Table 3. Properties of land types according to farmers from Atenco and Zapotlán (from Luna (1982) and interviews with farmers)

Property	Sand	Mud	White soils	Mud with many sediments	"Peanuty"	Slime	Mixture of mud, white soils and slime	Saltpetre
Consistency (dry/humid)	soft/not sticky	hard/sticky and viscous clods	soft/not sticky	hard/sticky clods and viscous like dough	hard/sticky clods	soft/ not sticky	clods not very hard/ like breadcrumbs	loose/does not stick
Texture	does not crack	forms cracks	almost no splitting	forms many clods	cracks	does not crack	looks like hill soil	dust
Retention of moisture	does not store humidity	dry; working it timely stores humidity	Stores little humidity	dry due to "garbage" it contains	very dry; muddy with rain; working it in timely manner stores humidity	stores little humidity	stores humidity	stores humidity
Fertility	fertilizer needed for a good harvest	little fertilizer needed, has products it can provide the plant with	poor, has no strength	only needs water and work	as good as mud	any crop grows; has its own fertilizer	only needs water and work	plants meager and yellow; does not produce
Workability	easy	tightens, fertilizer and ash soften it; heavy when moist	easy	gives in well when worked on	very difficult	easy	flour-like, gives in well	easy to work
Salinity	NP	NP	NP	NP	NP	NP	NP	does not let seed sprout
Color when dry	color of bits of rock or gravel stands out	black, or color of the soil nearby	white or gray	black; pieces of "garbage" visible	black, or color of the soil nearby; the "peanuts" it forms are visible	yellowish	takes colors of soils it is composed of	any color, such as the soils it is composed of

Regarding the characteristics listed in table 3, we found that the color of surfaces in dry conditions plays an important role for land type identification and location. This property defines the presence of mud and white soils (*tierras barro & blanca*). When a land type is being characterized, the set of defining properties is taken into account, as shown in table 3. However, when maps of land types are created, only those that provide cartographic expression are considered.

Three basic questions were made to the farmers in order to execute the mapping process: (1) What type of land is this? The correspondent answer helps us to locate any particular land type; (2) How far does it reach? This allows for delimiting the area covered by this land type; (3) Could you draw your boundaries in the map of the *ejido*? This provides a spatial dimension for the land type (see figure 3).

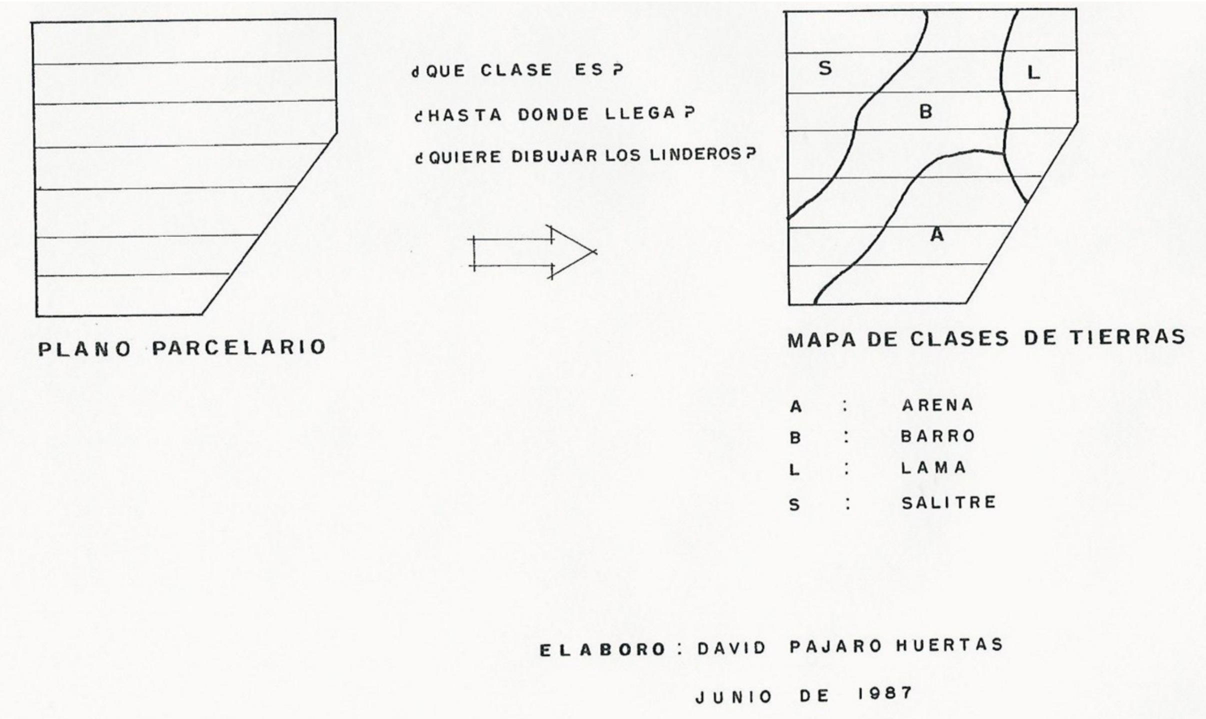


Figure 3. Mapping farmers' land types (based on the cadastre map and interviews with informants)

"Ejido tables" (*tablas ejidales*), which is the group of parcels located in the same region, containing the parcels belonging to the informant(s) (see Table 4 and Figure 4) served as cartographic base unit. Since the group of "tables" defines the *ejido* in question, the following formula for the geographic location applies to both *ejidos* studied: parcel – table – *ejido*. This, in turn, defines the level at which the farmers' land types can be mapped, based on the assumption that farmers know and recognize lands presented in at least one of these geographic reference levels. This assumption turned out to be true and useful: When asking informants of the same *ejido* table about the location of lands, it was possible to map several classes, locate the adjacent lands, and draw them onto a map of *ejido*-internal parcels (*dotación parcelaria* - a modality of assigning rights of exploitation within an *ejido*), all at once. Consequently, the creation of maps by farmers provides a simple model to communicate distance (scale), direction (projection), and characteristics of the landscape or site (abstract signs) like a conventional map does, but in terms of a cognitive map (Blaut & Stea, 1971). More generally speaking, the creation of maps by farmers with environmental information reveals, in an obvious manner, the structure or the designation of elements visible and mappeable (inherent to cartographers), as opposed to those that are intangible, since affective (attributed to farmers). It is particularly interesting to note that land type maps, in contrast to conventional maps, combine both characteristics. Land types are not

remembered by their physical presence, as such, but rather by what they represent, functionally, socially, or symbolically. The words of Pocock (1979, p. 285-286) regarding mental maps could also include land type maps, if we consider the simple fact that farmers are human: "[…] mental maps are an externalized version of an internal mental process, derived from the motivation of one or several questions that have been related to greater psychological theories of cognitive development, such as those developed by Piaget and Inhelder (1967)".

Table 4. Names of the *ejido* tables for the San Salvador Atenco *ejido* (from interviews with informants, and the cadastral maps); all numbers are referenced in figure 4

	Name of table		Name of table
1	Common lands (summer pasture)	16	Espíritu Santo I
2	Huatepec	17	Espíritu Santo II
3	Tepetzingo	18	San Francisco
4	Santa Rosa II	19	El Gachupin
5	Santa Rosa I	20	El Amanal Chico
6	El Corral	21	El Amanal Grande
7	El Pantano	22	La Purísima
8	La Soledad	23	El Llano Grande
9	La Galera	24	El Horno
10	Guadalupe II	25	Cambray
11	Guadalupe I	26	San Antonio
12	San Enrique II	27	San Juan
13	San Bartolo II	28	San Fermín
14	San Bartolo I	29	La Pastoria
15	San Enrique I	30	San José
		31	El cornejal

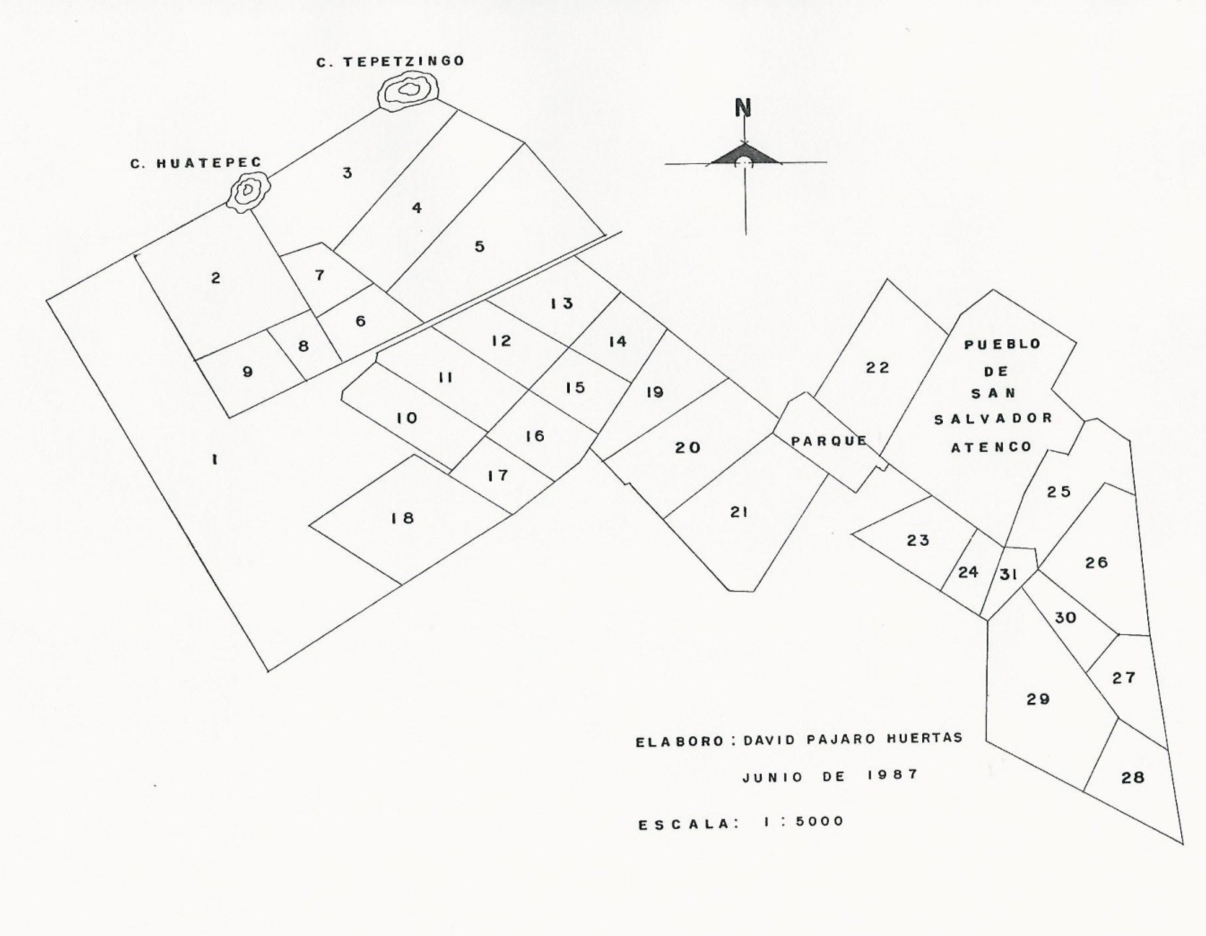


Figure 4. The *ejido* tables in San Salvador Atenco (from the cadastral maps and interviews with informants)

Mapping like this is easy and quick, and even the borders between land types can be considered to be definitive, since their distinction in the area is evident. However, it is convenient to notice that boundaries between two or more land types are usually characterized by a mixture, thus seemingly defining a land type on its own.

Despite this, when surveying these border zones, it becomes evident that they form a transition area between types rather than an additional land type (see Figure 5). This is due to the fact that boundaries between units (cartographic or taxonomic) are frequently variable and gradual (Campbell & Edmonds, 1984). Our observation in this respect can be underpinned with one of the first manuals for the creation of soil maps, edited by the Department of Soil Studies of the former Secretary of Water Resources:

"It is crucial to remember that boundaries are not precise limits of separation of one soil type with another; they are lines that indicate changes in the characteristics or qualities of the soil studied, and that represent, in most cases, approximate averages in changes in soil quality or transition areas, although there are, however, cases in which these boundaries are more exact, corresponding to places in the ground in which the nature of soils show the separation of some lands and others in a clearer way. Most of the boundaries coincide with some easily observable external characteristics, although not all soil boundaries are easily perceivable, and at other times, soil boundaries are well-defined and are clearly evident; other times, they must be located in the middle of the path followed inside a transition zone, as a certain type disappears gradually into another ..." (SRH 1947: p. 54, 55).

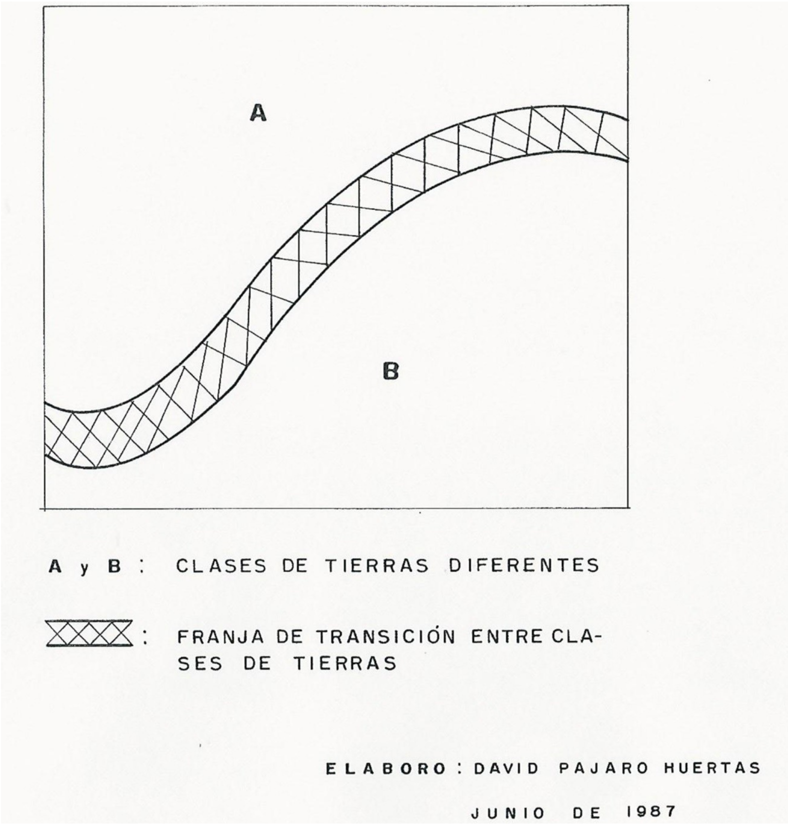
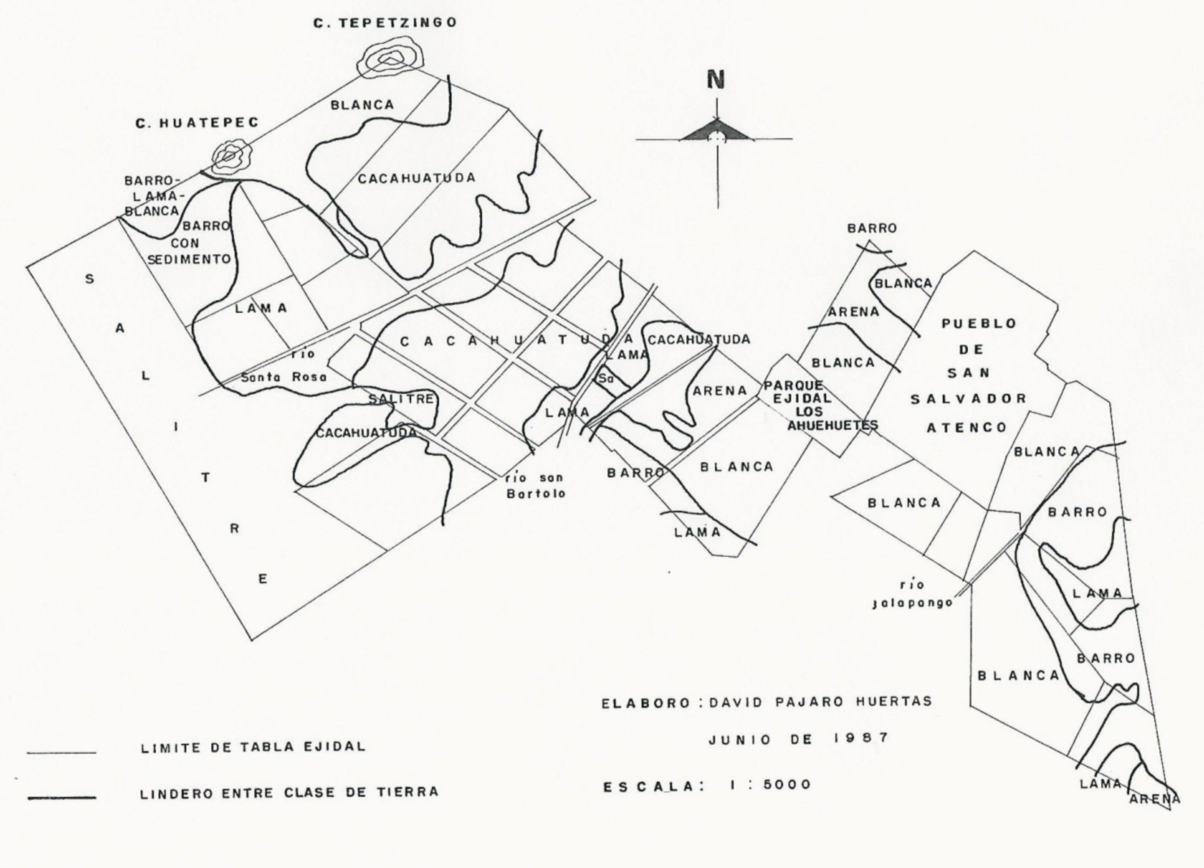


Figure 5. Boundaries between land types, represented as a transition area (from observations in the field)

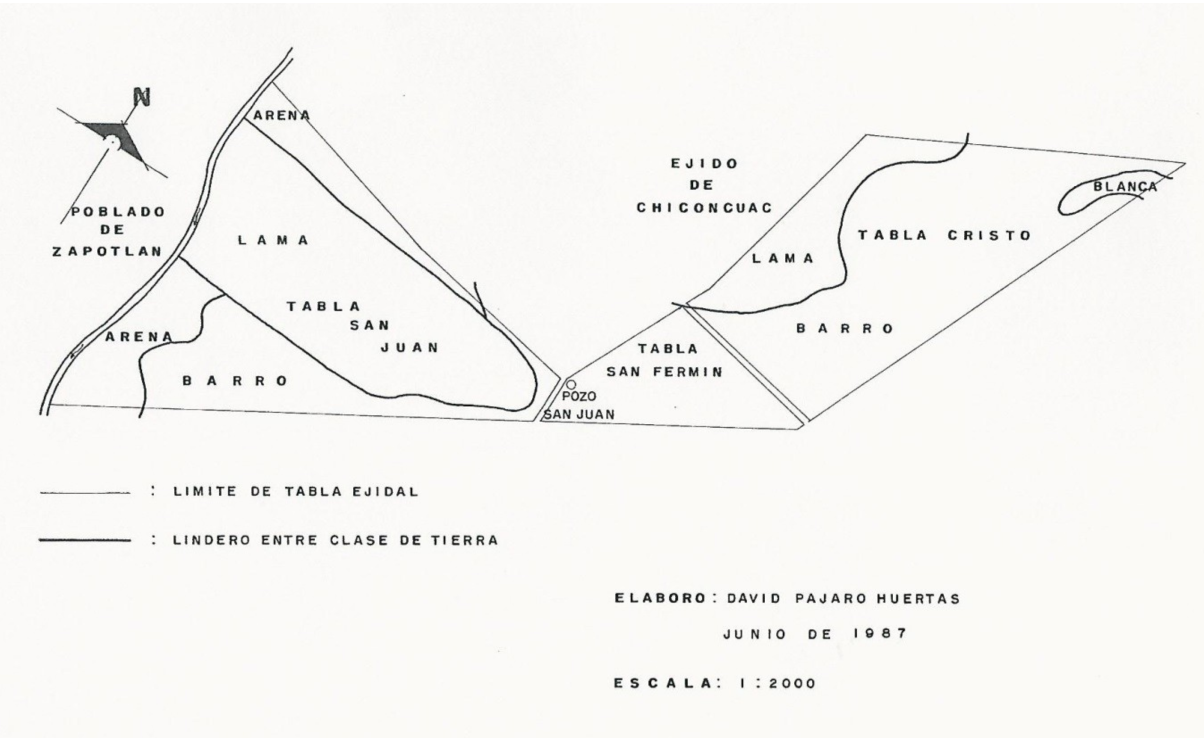
With this information, repeated interviews and revisiting the boundaries of several land types, we reached a level of knowledge where technicians can easily map land types according to the level of geographic location chosen with the informants. The criteria used to cartographically locate land types in the *ejidos* of Atenco and Zapotlán are listed in Table 5. Obviously, when changing the area of study, some criteria may change as well. Maps 1 and 2 show the cartography for each *ejido*, while Map 3 merges the results of both.

Table 5. Criteria to cartographically locate land types in the *ejidos* of Atenco and Zapotlán (gathered from interviews with informants and field work); *Romerito (Suaeda nigra), Zacahuistle (Distichlis spicata)

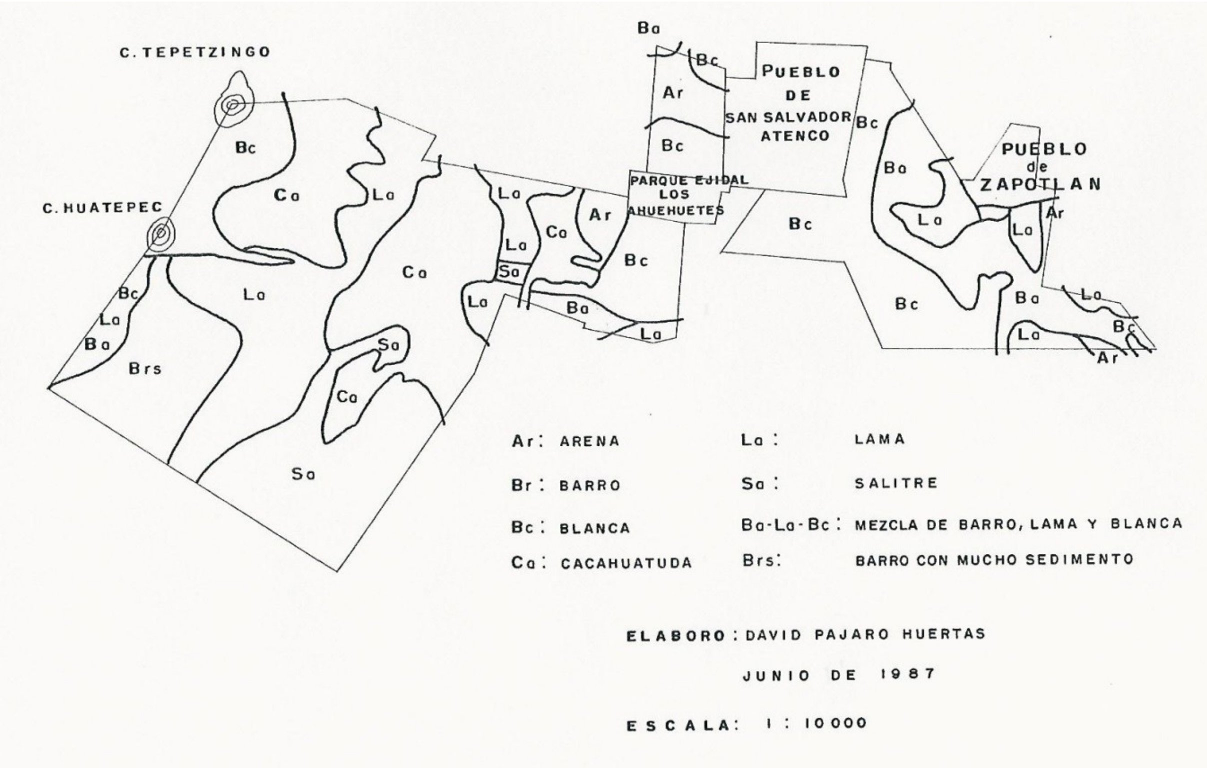
Objective Evidence	Sand	Mud	White soils	Mud with sediments	"Peanuty"	Slime	Mixture of mud - white-slime	Saltpeter
color when dry	-	black	white and grey	black	-	-	-	-
texture and aggregation	river sand and gravel are visible	cracks	-	cracks	forms "peanuts"	-	-	-
land marks	next to river	-	-	located on lower parts of the ejido; beside saltpeter	-	near river or river mouth	near river mouth or where water accumulates; next to Huatepec hill	at limits of former Lake Texcoco
walking on surface	sound of sand can be heard when walking	sticky when humid	-	sticky when humid; pieces of "garbage" can be seen	feels like walking on peanuts, if dry; very sticky when humid	-	soil mixture noticeable	when dry, plants don't grow and salt crust can be seen; if humid, romerito and zacahuistle grow*



Map 1. Land types in the *ejido* of San Salvador Atenco, State of Mexico (information gathered from interviews with informants and field work)



Map 2. Land types in the *ejido* of Zapotlán, State of Mexico (information gathered from interviews with informants and field work)



Map 3. Land types in the *ejidos* of San Salvador Atenco and Zapotlán, State of Mexico (merged from Maps 1 and 2)

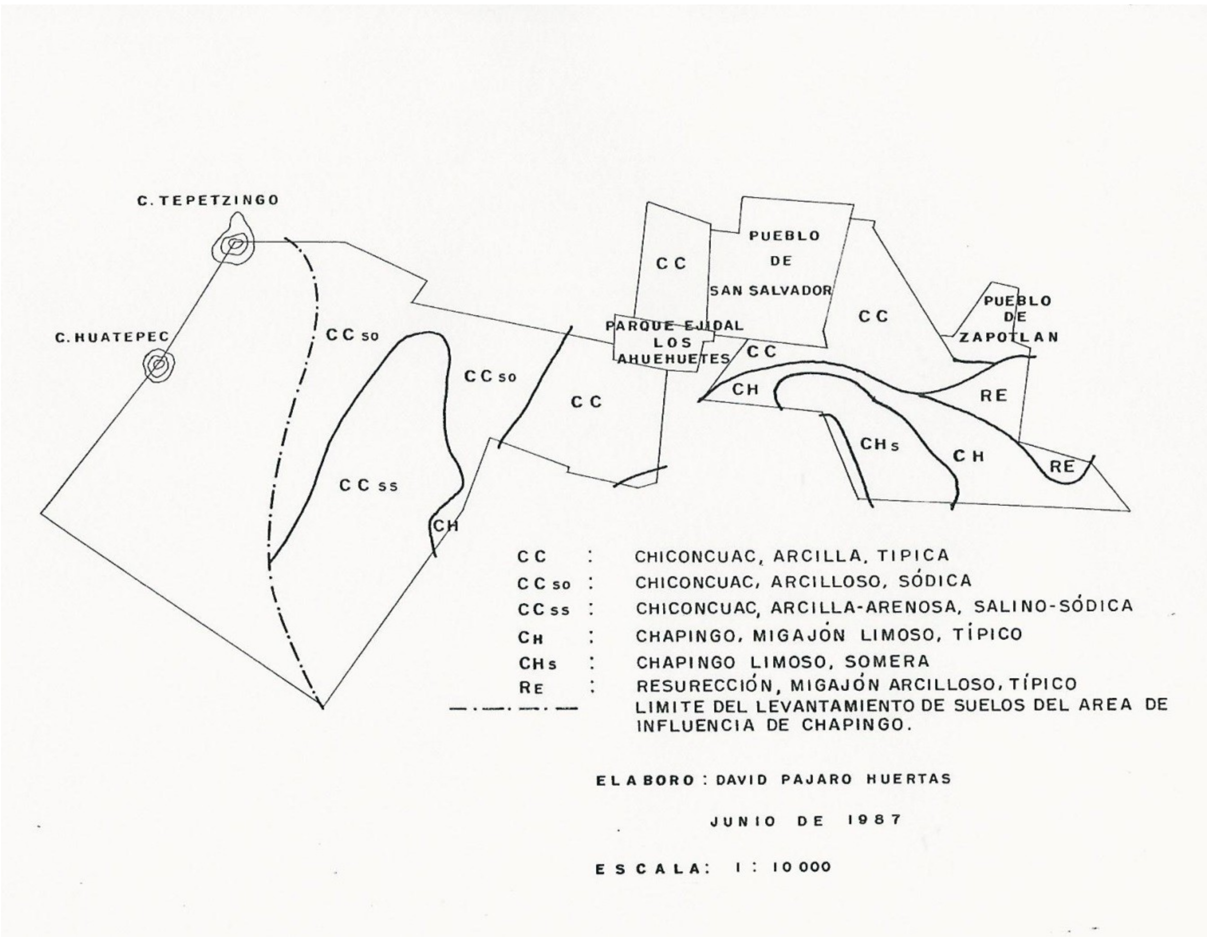
Table 6 shows the surface mapped in both *ejidos*. A total area of approx. 990 ha has been analyzed, mainly classified as saltpeter (21.8 %). This dominance can be explained if we remember that the municipal area of San Salvador Atenco is adjacent to former Lake Texcoco. Almost equally widespread are white soils (21.3 %) and "peanuty" soils (21.2%), followed by slime (19.8%), mud (8.8 %), sand (3.3%), mud with sediments (2.6 %), and finally, the mixture of mud-slime-white soils (0.8 %).

Table 6. Surface by land types in the *ejidos* of Atenco and Zapotlán, State of Mexico (cf. Map 3)

Land type	*Atenco*	*Zapotlán*	*Total (ha)*	*Percentage (%) of total*
Sand	30.06	3.2	33.26	3.35
Mud	71.71	15.22	86.93	8.8
White soils	210.96	0.28	211.24	21.39
Mud with sediments	26.41	-	26.41	2.67
"Peanuty"	209.64	-	209.64	21.23
Slime	184.22	11.6	195.82	19.83
Mixt. of Mud- Slime- White soil	7.99	-	7.98	0.8
Saltpeter	215.97	-	215.97	21.87
Total	*956.95*	*30.3*	*987.25*	*99.94*

The Atenco *ejido* highlights the presence of well-spotted areas with land types such as slime, "peanuty" soils, and mud. These originally salty soils represent land reclaimed by farmers, hence delineating a subject of future research from a soil genesis perspective.

Following the objectives of this investigation, we visually compared the land types mapped by farmers against the corresponding soil map at a phase level. In accordance with existing soil-mapping work (Cachón 1973 and Cachón et al., 1976), the area studied includes six phases: 1. Chiconcuac, clay, typical (CC); 2. Chiconcuac, clay, sodic (CCso); 3. Chiconcuac, clay-sandy, saline-sodic (CCss); 4. Chapingo, silty loam, typical (CH); 5. Chapingo, silty loam, sallow (CHs), and 6. Resurrección, clay loam, typical (RE) (cf. Map 4).

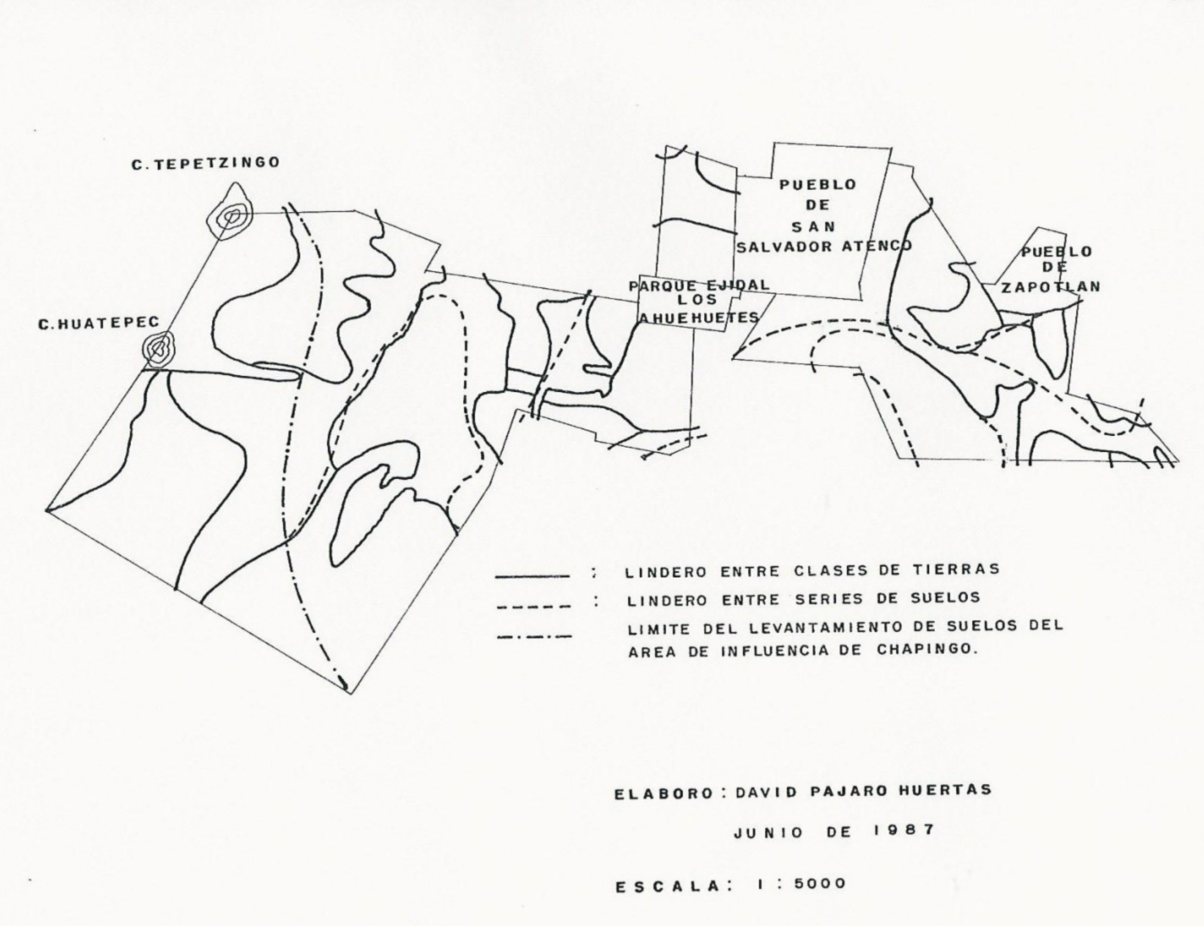


Map 4. Soil phases in the *ejidos* of San Salvador Atenco and Zapotlán, State of Mexico (from Cachón (1973) and Cachón et al., (1976))

A visual comparison of Map 3 and 4 shows two aspects: (1) The boundaries for soil phases do not coincide with the corresponding for land types, and (2) The areas limited by farming land types are more detailed than the areas defined by the soil phases (see Map 5).

Regarding the first point mentioned, it is evident that farmers possess detailed knowledge, and that the separation of areas by soil phases has been surpassed. However, in some sections and for some boundaries land types and soil phases coincide perfectly, as occurs with a part of the boundary between the phases Chapingo, silty loam, sallow (CHs) and Chapingo, silty loam, typical (CH).

As for the second point, it is clear that the mapping of land types by farmers is more detailed and captures the variation of existing soils more appropriately.



Map 5. Cartographic comparison between land types and soil phases in the *ejidos* of San Salvador Atenco and Zapotlán, State of Mexico (from Maps 3 and 4)

5. Discussion

The results of this investigation can be discussed regarding two basic aspects: (1) The methodology followed, and (2) the comparison of the maps obtained by farmers through the land type method against the soil survey method.

Concerning the methodology tested, considering farmers and their knowledge allows for a simple soil mapping procedure, which is inexpensive, simple, quick, and detailed. Basic requirement is to give credibility to this knowledge. It is worth mentioning, therefore, that the cartographic support provided by the map of *ejido*-internal parcels and the denomination of each table, are relevant. Both were crucial when mapping lands and provided excellent support, because drawing the boundaries between classes allows to express all the information accumulated by the informant in a cartographic manner. This constitutes a mnemonic support, which makes us realize that the mapping of land types by farmers must lead to cognitive issues, e.g. the creation of mental maps (Tolman, 1948; Yi-Fu Tuan, 1975; Graham, 1976; Hallowell, 1977) or the different perceptions of landscapes by farmers. Let us further remember that the human perception is influenced culturally; and although the basic process of perception is the same for all human beings, its content changes due to different perceptual inference habits (Marshall et al., 1966), as is the case of the different perceptions that farmers and technicians have of soils.

The aforementioned allows introducing the following proposition that also could become another contrasting hypothesis: "Farmers capture the genetic units of the soil, which are creations of nature, in concordance with the soil's formative processes, while technicians are interested in taxonomic units, which are creations of the human mind (Campell & Edmonds, 1984)."

On the other hand, the materials used (i.e. maps of ejido-internal parcels) to support mapping land types are simple, inexpensive, and easily accessible, as opposed to aerial photographs or photographic mosaics, which are currently rather expensive. What is most relevant here is that the maps of *ejido*-internal parcels are reference materials in agreement with the farmers' idiosyncrasy, since they represents his/her field, the "table" where it is located, or the *ejido* it belongs to; in other words: they are part of his/her environment! In cognitive terms, the content of the land maps, which are mental maps on principle, consist of elements that are used and valued in a highly significant way for farmers.

It is always worth remembering that personal findings, which sometimes may be - arrogantly - taken as first-time discoveries, fall apart if no thorough revision of relevant bibliography is made. However, when the reciprocal becomes evident, such findings are conclusive and backed by historical information that puts the results obtained into context. In tone with these statements, we can say that the land type maps of Atenco and Zapotlán have similarities and differences with those reported by the first soil studies carried out in the 1940s (see Figure 6) and which had the outstanding characteristic of taking the farmers in the study area into consideration. Map 3 and Figure 6 share several characteristics, but also show some differences worth commenting on: (1) people from the areas studied and their knowledge on soils are involved; (2) in both cases, location names are included; (3) accurate soil maps are reported, where the idiosyncrasies of farmers are juxtaposed with those of technicians. The first difference between both figures is the gap of over 40 years, if we consider that our first map of land types by farmers was presented in 1987 (see Map 1); this nullifies any possibilities of having detailed soil maps with the soil survey procedure, so that the methodology of mapping land types by farmers proposed here provides a good alternative for the study of the soils of any *ejido*. The second difference is that the methodology of mapping land types by farmers does not consider the soil profile description; however, we do not discard this possibility.

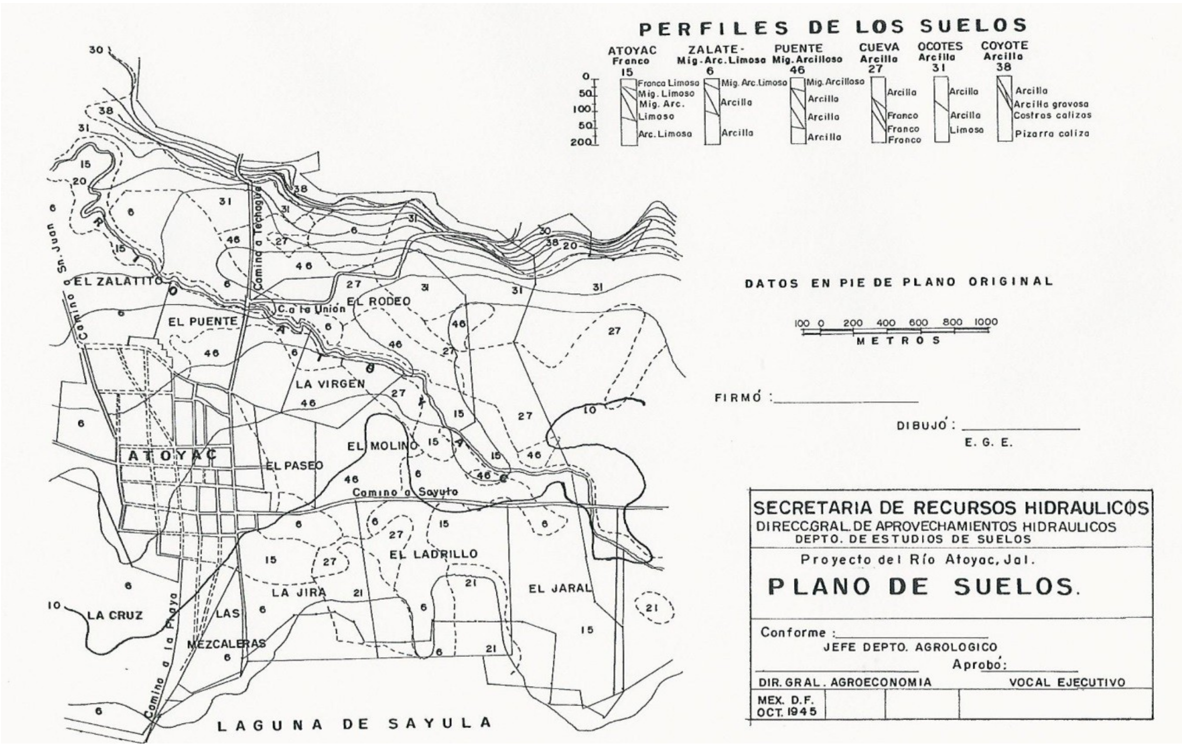


Figure 6. Soil Map for the Rio Atoyac, Jalisco Project (SRH 1947: 58)

Regarding the comparison of maps, it is evident that they are different due to the different methodological perspectives applied. However, although both consider the resource soil, it is a paradox that the information obtained by soil surveying is incompatible with the reality of the soil within the ejidos.

It is well known that in-detail soil surveys imply intensive fieldwork and use of aerial photography. Although the soil maps of the area studied here were produced with these sophisticated methods, they show only very schematic boundaries between soil phases and just a few cartographic units; this is quite contrary to what one would expect, namely a more detailed mapping of boundaries and a greater number of cartographic units (Pomerening & Cline, 1954, p. 815). However, we must not forget that some boundaries between soils have no evident expression in the soil surface, while others are particularly evident (Gile, 1975a; Gile, 1975b). Despite these incompatibilities and difficulties, it is important to remember that the focus of soil surveys is basically a taxonomic one (Campbell, 1978), while the land type mapping by farmers concentrates on geography and landscape. This could both indicate that the soil surveys, used as cartographic comparison, was poorly conducted, or that the responsible technicians did not correctly capture the existing soil variation. The latter could be interpreted in favor of traditional soil surveying. But evidence in situ shows that mapping of land types based on farmers' knowledge allows for a demarcation of a greater number of cartographic units (in agreement with the Minimum Mappable Area criterion: greater or equal to 0.25 cm^2), This more detailed delimitation, as we can assume, reduces the variance within classes and maximizes the variance between them, a criterion considered optimal to obtain an adequate soil map (Webster & Beckett, 1968).

6. Conclusions

Generally speaking, the farmers interviewed in the area of study captured soil variation in accordance with the soil's formative processes, since they categorize (i.e.: they build a taxonomy) and differentiate landscapes (i.e.: they produce cartographies), because they subordinate themselves to nature. Probably, the technicians performing the soil surveys we used as a cartographic comparison did not proceed in this way.

The land type boundaries do not coincide with the boundaries of soil phases, since each approach searches for the same object, but with different perceptions.

It is possible to map the soils of a given area grouped as types of farming lands.

Maps of land types generated by farmers are cognitive maps.

The goals established were achieved and the hypothesis tested accepted.

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