AN OVERVIEW OF DIFFERENT SOIL CLASSIFICATION SYSTEMS USED IN MEXICO

Una Breve Revisión Acerca de los Sistemas de Clasificación de Suelos Utilizados en México

Nadia Martínez-Villegas[1]

SUMMARY

This paper presents a historical overview of the soil classification systems that the Mexican Institute for Statistics, Geography, and Information Technology (INEGI) has used since it started to classify Mexican soils. The newest adopted system, the World Reference Base for Soil Resources, and its makeup are briefly described. Although INEGI's cartography accounts for almost 100% of the national territory, it lacks of a significant impact on some potential users, such as farmers, because the information is not easily accessible, useful, accurate or current. On the other hand, traditionally, Mexican farmers have classified soils according to local knowledge and utilitarian purposes; some features of it are illustrated here. The integration of local classifications and the establishment of equivalencies between local classifications and the official system of soil classification in Mexico might improve the impact of INEGI's cartography.

Index words: *soil classification in Mexico, Mexican ethnopedology.*

RESUMEN

Este artículo presenta un resumen histórico referente a los sistemas de clasificación de suelos utilizados por el Instituto Nacional de Estadística, Geografía e Informática (INEGI), desde que comenzó a clasificar los suelos del territorio mexicano. También presenta una descripción breve del más reciente sistema adoptado por el INEGI, el World Reference Base for Soil Resources, y su paso por el Soil Map of the World y la Revised Legend FAO/ UNESCO/ISRIC 1988. A la fecha, la elaboración cartográfica de suelos mexicanos realizada por el INEGI es basta y cubre prácticamente 100% del territorio nacional. No obstante, la utilidad de esta información para usuarios potenciales como agricultores es limitada, debido a que la información no es de fácil acceso, útil, exacta o actual. Por otro lado, tradicionalmente, los agricultores mexicanos clasifican utilitariamente sus suelos de acuerdo con conocimientos locales; aquí se ilustran algunas de las características de los sistemas locales de clasificación de suelos. La integración de éstos y el establecimiento de sus equivalencias con el sistema de clasificación oficial potenciarían el uso de la cartografía del INEGI.

Palabras clave: *clasificación de suelos en México, etnopedología mexicana.*

INTRODUCTION

Mexico's 194 million hectare surface area consists of a great variety of soils derived from different geologic origins, topographies, and climates. Since the late 1960's, soils in Mexico have been classified by the Mexican Institute for Statistics, Geography and Information Technology [Instituto Nacional de Estadística, Geografía e Informática (INEGI)]. Prior to 1998, INEGI classified soils according to the FAO/UNESCO 1970 system. Currently, Mexican soils are officially classified (DOF, 2001) according to the FAO/UNESCO/ISRIC 1988 system by the Ministry of the Environment, Natural Resources, and Fishing [Secretaría del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP)] in collaboration with College of Postgraduates (CP) and mapped by the INEGI (INEGI, 1999). By 1998, INEGI had mapped 100, 99, and 33% of the national territory at 1:1 000 000, 1:250 000, and 1:50 000 scales, respectively (Takaki, 1999). In 2003, INEGI decided to follow the World Reference Base (WRB) for Soil Resources and its subsequent updates as the standard for the 1:50 000 soil map of Mexico (Pazos, 2003), which had been suspended in 1983 (Takaki, 1999) and is supposed to be concluded in 2006 (INEGI, 2004).

[1] Department of Crop and Soil Sciences, Penn State University. 116 Agricultural Sciences and Industries Building, University Park, PA 16802, USA. (nvm102@psu.edu)

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In Mexico, other institutions, mainly academic, also classify soils according to a number of different soil classification systems which use technical knowledge such as FAO/UNESCO/ISRIC 1988 (FAO, 1988), Soil Taxonomy (Soil Survey Staff, 1999), WRB (FAO, 2001), and Practical Topsoil Classification (FAO, 1995). Among the main academic institutions are the National Autonomous University of Mexico, the Autonomous University Chapingo, and the CP. Besides these institutions that technically classify soils, Mexican farmers classify soils using traditional, local, folk, and native knowledge. Although different systems of soil classification are used in the country, INEGI only documents Mexican soils according to the official system.

This paper presents a historical overview about the classification systems that INEGI has used to inventory Mexican soils over the past seven lustrums. It includes a brief description of the newly adopted system, WRB, and its makeup. Additionally, it presents some features of the intrinsic, local systems of soil classifications belonging to local people.

Historical aspects of the Soil Map of the World and its evolution to the WRB

Soil classification arose a long time ago when humans noticed and tried to explain differences in the suitability of soils for different crops (Brady and Weil, 2002). Throughout history various systems of classification have been used to organize knowledge of soils and name them. In fact, the use of so many different classification systems around the world hobbled international soil science communication. To overcome these difficulties FAO (Food and Agricultural Organization of the United Nations) and UNESCO (United Nations Educational, Scientific, and Cultural Organization) proposed in 1961 the Soil Map of the World (SMW), which was published in 10 volumes from 1970 to 1978 (see for example: FAO/UNESCO, 1974). The objectives of the SMW were to provide a worldwide correlation of soil units and to obtain an inventory of the world soil resources through a set of soil maps with a common legend that facilitated land use transfer and informed land management (Buol *et al.*, 2003). Initially, the Legend of the SMW consisted of 26 Major Soils Groups made up of 106 Soil Units. In 1988, an improved second version was published (the Revised Legend FAO/ UNESCO/ISRIC 1988 (FAO, 1988)). This included a third hierarchical level, Soil Subunits. The Revised Legend consisted of 28 Major Soil Groups and 152 Soil Units; Soil Subunits were not defined as such, but guidelines for their identification and naming were given. In 1990, a working group of the International Society of Soil Science (ISSS) started to develop another classification system based on the FAO/UNESCO Soil Map of the World: the WRB for Soil Classification. In 1994, they presented its initial version to the members of the 15th World Congress of Soil Science (WCSS) held in Acapulco, Mexico. It was not until 1998, during the 16th WCSS in Montpellier, France, that the International Union of Soil Sciences (IUSS; formerly the ISSS) officially adopted the WRB for Soil Resources as the union's system for soil correlation (FAO, 2001). The WRB proposes 30 Reference Soil Groups and more than 200 Soil Units. The 30 Reference Soil Groups make up 10 sets composed as follows: a first separation is made between organic and inorganic soils; all organic soils are grouped in Set #1. Afterwards, the remaining (mineral) Major Soils Groups are each allocated to one of nine sets on the basis of dominant identifiers (FAO, 2001). The intermediate system in the evolution of the SMW through the WRB, the FAO/UNESCO/ISRIC 1988, was enacted in Mexico for classifying its soils in 2001 (DOF, 2001).

Technical Classification of Soils in Mexico

Although soils are officially classified under the FAO/ UNESCO/ISRIC 1988 system, the FAO/UNESCO 1970 is still highly used among soil scientists in Mexico.

According to INEGI, 25 Major Soil Groups can be found in Mexico (INEGI, 1999). Figure 1 shows the 16 dominant soils found in the country and their occurrence. Figure 2 shows the spatial distribution of these dominant groups (SEMARNAP/INEGI, 1998). Although INEGI´s inventory of Mexican soils (at 1:250 000 and 1:1 000 000 scales) accounts for almost 100% of the national territory (Takaki, 1999), it lacks of a significant impact on potential users. Some of the most important reasons for such a low impact are that the information is not easily accessible, useful, accurate or current. Today, INEGI is still facing the problematic of bridging the gap between the information producer and the potential users of this information, so that the information would be (more) accessible. For example, INEGI's soil maps, at a 1:250 000 scale for federal entities, do not allow for projecting soil management

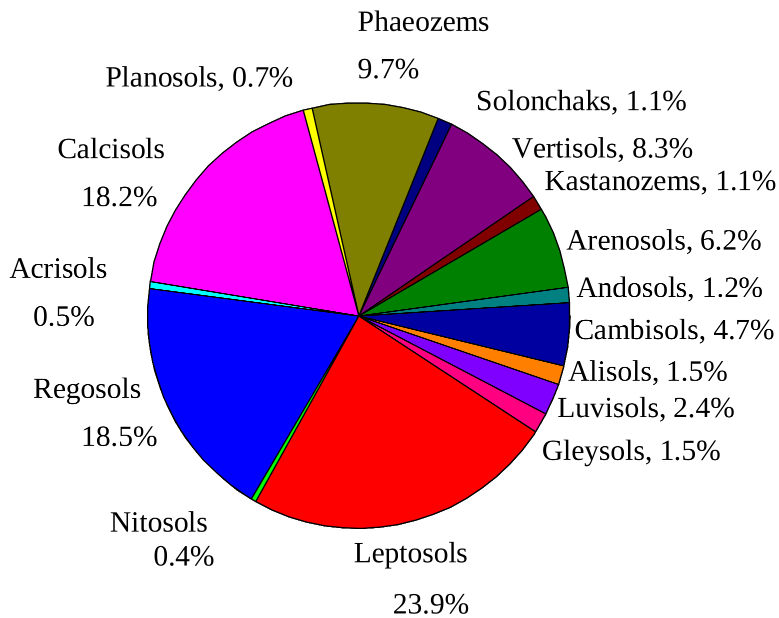

Figure 1. Dominant soils in Mexico according to FAO/UNESCO/ISRIC 1988 (SEMARNAP/INEGI, 1998).

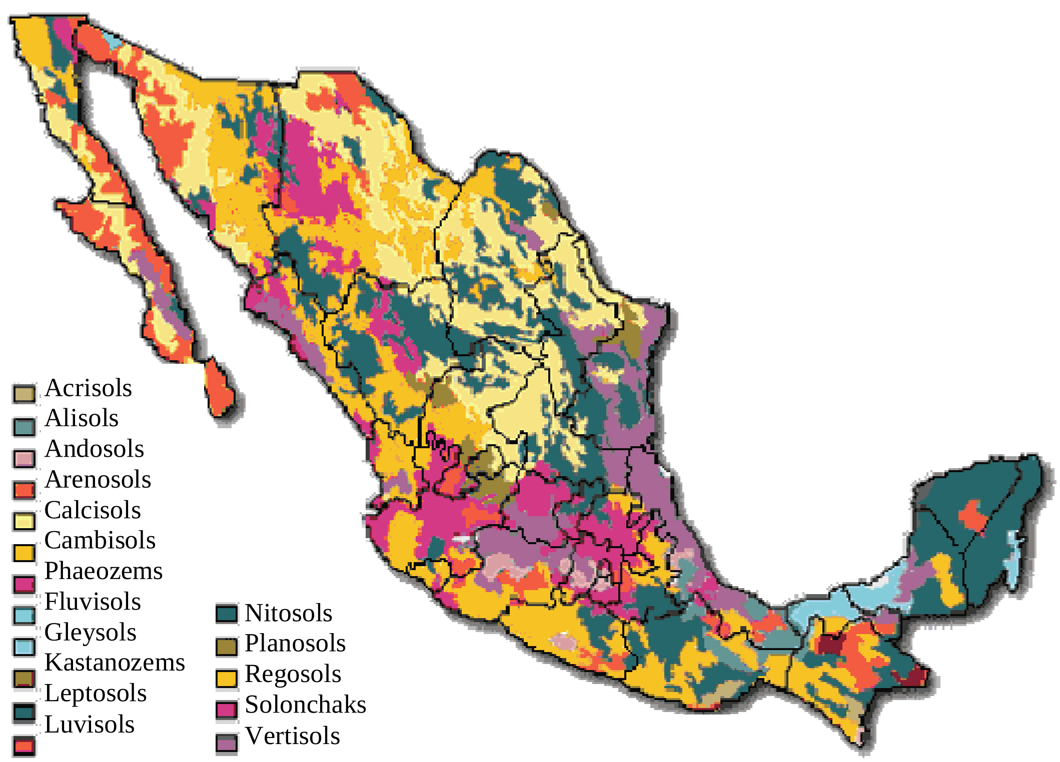

Figure 2. Soil map of Mexican soils (SEMARNAP/INEGI, 1998). Detailed descriptions of the major features of each group can be found at INEGI (1999).

(Sánchez *et al.*, 2002) in farms because the scale is too big. In this kind of situation, when INEGI does not satisfy farmers´ needs, Mexican farmers and soil scientists combine efforts to create detailed Mexican soil maps useful for local land use and soil management. Since 1980, soil scientists have been mapping Mexican soils combining both technical and local knowledge (Ortiz-Solorio *et al.*, 2005; Sánchez *et al.*, 2002). Sánchez *et al.* (2002) classified and mapped soils from Southern Veracruz by carrying out the following procedure. First, farmers brought relevant information (the major features of the soils and their local classification) to soil scientists. Second, soil scientists used this information to map the spatial distribution of those soils. Third, representative soil profiles were analyzed and classified according to WRB and Soil Taxonomy. This procedure, first proposed by Ortiz *et al.* (1990), has also been followed in other studies (Alfaro-Ortiz *et al.*, 2000; Lleverino-González *et al.*, 2000; Sotelo Ruiz y Ortiz Solorio, 2001) because the generated maps are on a detailed scale (1:37 000), use the local soil classification system, and are locally useful for better land management. Another major reason accounting for the low impact of the data published by INEGI is that the necessary and minimal required information for making the descriptions and classifications of soil profiles was only partially published in INEGI's data base (Alcalá-de-Jesús *et al.*, 2001). For example, the chemical, physical, and mineralogical data is incomplete. This fact has arisen questions about the error involved in the original classification and in further reclassifications. Recent studies have demonstrated that when soil profiles, classified previously by INEGI, are strictly classified, the classification does not correspond to INEGI's own classification (Alfaro-Ortiz *et al.*, 2000; Alcalá-de-Jesús *et al.*, 2001). Alcalá-de-Jesús *et al.* (2001) analyzed 13 soil profiles previously analyzed and classified by INEGI. Their results were quite different from INEGI's at Group level but rather similar at Subunit levels because INEGI did not take into account the moisture regimen. They state that the classification carried out by INEGI is not accurate. In the same sense, Lleverino-González *et al.* (2000) showed that INEGI´s soil maps of the "Ejido" Atenco in the state of Mexico have low quality as measured by precision (8%) and accuracy (0%) using the selection, sampling, and analysis of 79 sites. Finally, soil classification systems as well as the technologies that allow current inventories are constantly improved, so an actualized soil classification system and state-of-the-art technology should be incorporated in the analyses of Mexican soils in order to generate and keep INEGI's inventory current.

In order to improve Mexican soil maps, INEGI recently decided to follow the WRB and subsequent updates as the standard for the 1:50 000 (Pazos, 2003) and 1:250 000 Serie II (INEGI, 2004) soil maps of Mexico. Currently, INEGI's soil scientists are reclassifying old soil data as well as classifying newly surveyed soil profiles according to the new system. The task is not easy since the newly adopted system differs significantly from the previous system. For example, in the WRB system major changes were introduced in the definitions of the diagnostic horizons without changing any of the old 1988 names (except for the fimic horizon, which was dropped). Also, a considerable number of new horizons were defined as diagnostic horizons (Nachtergaele, 2003). By 2004, out of 143 sets (at a 1:250 000 scale), 19 digital sets covering 13% of the national territory had been totally completed and 70 sets covering 49% of the national territory had been verified at field level. Additionally, 3000 samples had been collected (INEGI, 2004). The migration to the WRB system is supposed to be concluded by 2006.

After the historical overview about the classification of soils in Mexico by INEGI, let's move to the other type of soil classification, which, by itself, is accessible, useful, and current to their users; local systems of soil classification, comprised into ethnopedology[1]. In this paper, the term ethnopedology is restricted to

[1] The term *Ethnopedology* was firstly proposed by Williams and Ortiz-Solorio (1981) as a discipline that encompassed "folk perception of soil properties and processes, folk soil classification and taxonomy, folk theories and explanations of soil properties and dynamics, folk soil management, folk perceptions of the relationships between soil and plant domains, comparison between folk and technical soil science, assessment of the role of folk soil perception in agricultural practices and other behavioral realms." Currently, *Ethnopedology* is considered a sub-filed of *Ethnoecology* and a hybrid discipline structured from the combination of natural and social sciences, such as soil science and geopedological survey, social anthropology, rural geography, agronomy, and agro-ecology that concerns itself with local perceptions, knowledge, and management of the soil/land component of the environment (WinklerPrins and Barrera-Bassol, 2004). For a complete definition of ethnopedology see Williams and Ortiz-Solorio (1981), Barrera-Bassol and Zink (2003), and WinklerPrins and Barrera-Bassol (2004).

Ethnoecology has been defined as an interdisciplinary study of how nature is perceived by humans through a screen of beliefs and knowledge, and how humans, through their symbolic meanings and representations, use and/or manage landscapes and natural resources (Toledo, 1992; Barrera-Bassol and Toledo, 2005).

the local knowledge and understanding of soil morphology, genesis or a local system of soil classification.

Mexican Ethnopedology

In a worldwide view on the soil knowledge of local people, Barrera-Bassol and Zinck (2003) found that not only 41% of Mexico's 56 ethnic groups had been studied from an ethnopedological point of view, but Mexico was also the most studied country using ethnopedology with a total of 71 studies. Mexican ethnopedology studies have been carried out since 1980 (Ortiz-Solorio *et al.*, 2005) and cover issues such as description of local systems of soil classification (Ettema, 1994; Sánchez *et al.*, 2002; Alcalá de Jesús *et al.*, 2001) and correlations of local classification systems with scientific methods (Sánchez e*t al.*, 2002; Lleverino-González *et al.*, 2000; Sotelo-Ruiz and Ortiz-Solorio, 2001).

In general, local soil classification has two components: a physical (morphological) and a perceptual (non-morphological) dimensions (Ettema, 1994). The physical dimension concerns the most readily apparent criteria that farmers use to differentiate soils, while the perceptual dimension is not always readily recognized and concerns the suitability of soils for different uses. Four sets of classification criteria have been globally identified: 1) color and texture; 2) consistence and soil moisture; 3) organic matter, stoniness, topography, land use, and drainage; and 4) fertility, productivity, workability, structure, depth and soil temperature (Barrera-Bassol and Zinck, 2003). The morphological attributes, such as color and texture, are the diagnostic attributes most frequently used to label soils, while the comprehensive attributes, such as fertility or workability, are the less commonly used (Barrera-Bassol and Zinck, 2003; Ettema, 1994).

In particular, color and texture are two common criteria used by Mexican farmers to classify soils. In Chiapas state and Tepetlaoxtoc, Mexico state, soil color is the main differentiating criterion for soil classification and texture is the subordinate criterion (Ettema, 1994). In contrast, in Southern Veracruz, where 33 classes of soils are identified by local farmers, texture is used as the main distinguishing factor and color as the second criterion (Sánchez *et al.*, 2002). In Santa Maria Jalalpa, Mexico state, farmers have established five soil types using color and texture as well as crops, cemented materials, and other criteria (Alfaro-Ortiz *et al.*, 2000). Along with morphological attributes, comprehensive ones are actually highly used by Mexican farmers allowing hierarchical soil classifications. Nahua and Purhépecha ethnics have hierarchical soil classifications based mainly on topographic attributes (WinklerPrins and Barrera-Bassol, 2004). Aztec and Otomi ethnics hierarchically classify their soils according to moisture retention capacity, workability, fertility, consistency, texture, and salinity (Ortiz-Solorio and Gutiérrez-Castorena, 2000). Yucatec Maya soil classification is also hierarchical and is based on color, relief position, depth, stoniness, drainage, moisture retention capacity, consistency, texture, fertility and workability of the top soil (Barrera-Bassol and Toledo, 2005). In Mexico, naming, characterization, and land use and management of soil classes are relatively homogeneous over thousands of square kilometers (WinklerPrins and Barrera-Bassol, 2004) revealing the existence of a region-wide soil knowledge among the Maya, Nahua, Otomi, and Purhépecha peoples (Barrera-Bassol and Zinck, 2003).

CONCLUSIONS

- The soil classification system used in Mexico until 1998 was FAO/UNESCO 1970. Afterwards, soils in Mexico were reclassified according to the FAO/UNESCO/ ISRIC 1988 system, which was enacted as the official system in 2001. The latter system is supposed to be totally replaced by WRB in 2006. The reclassification of the Mexican soil profiles according to WRB could throw new soil maps into question, if old and unclear information is used for the new maps.
- The lack of a soil classification system that serves farmers' and other users' needs makes soil scientists and farmers in the country generate their own maps according to different soil classification systems. Integration of local and technical knowledge has allowed the development of accurate soil maps that are useful for both farmers and soil scientists.
- Utilitarian, local soil classification systems of contemporary ethnic groups in Mexico have been studied for more than 20 years and are currently recognized to have some universal principles, categories, and levels similar to those systems used by modern soil scientists.
- The data integration for the system newly adopted in Mexico should incorporate local knowledge and establish equivalencies between the WRB system and local systems used in the country as well as incorporate inventories carried out by other institutions provided

these inventories are standardized according to NOM-023-RECNAT-2001.

- Soil management could be improved in the country, if INEGI provided easy access to detailed and accurate information on Mexican soils.

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