Agriculture and Human Values **21:** 139–156, 2004.

Latin American ethnopedology: A vision of its past, present, and future

Antoinette M. G. A. WinklerPrins[1] and Narciso Barrera-Bassols[2]
[1]*Department of Geography, Michigan State University, East Lansing, Michigan, USA;*
[2]*Instituto de Geografía, Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico*

Accepted in revised form September 15, 2003

Abstract. Ethnopedology is the study of local knowledge of soil and land management in an ecological perspective. It is an emerging hybrid discipline that is a component of ethnoecology and stands to offer much for land-based studies. This paper reviews the field of ethnopedology in Latin America and compares some of the many case studies from that region. Various literature sources are considered, including the ethnographical, ethnohistorical, archaeological, geographical, agronomic, ethnoecological, and development studies. Our review invokes the theory of ethnoecology that focuses on the linkages between *kosmos* (beliefs and symbolic representations), *corpus* (environmental knowledge), and *praxis* (the set of practical operations through which the material appropriation of nature takes place) of local land-users. The main topics covered are the ethnohistorical and archaeological evidence of ethnopedology, local soil and land classification, local land management systems, local perceptions and beliefs of soil and land resources, and local soil fertility management. After analysing past and present research trends, recommendations are given on how ethnopedological studies can contribute to enhance sustainable land use and management in Latin America.

Key words: Ethnoecology, Ethnopedology, Local/indigenous soil knowledge, Latin America, Soil fertility management, Sustainable land management

Antoinette M. G. A. WinklerPrins *is a geographer specializing in the political and cultural ecology of the Brazilian Amazon. She completed her PhD in geography at the University of Wisconsin-Madison in 1999. She was then a post-doctoral fellow at ITC in Enschede, The Netherlands, and is now Assistant Professor of Geography at Michigan State University. She has 10 years experience working in the Brazilian Amazon, doing local level qualitative research on land use change and agriculture, particularly in the floodplain environment. Her early work in the region focused on soil use and management and specifically on indigenous soil knowledge systems. Currently she is conducting research on urban agriculture, specifically on urban homegardens in the city of Santarém in Pará State.*

Narciso Barrera-Bassols *is a Mexican geographer who studied at UNAM in Mexico City and has two master's degrees, the first in anthropology (nature-culture-society studies) and the second in rural development studies. He recently completed his PhD at the University of Ghent, Belgium and ITC, Enschede, The Netherlands, with a dissertation on ethnopedology at global, regional, and local scales. He has been conducting field research with indigenous peoples and mestizo smallholder farmers in Middle America since 1977 (mainly Purhépecha, Totonac, and Maya from the highlands of Chiapas). He was recently appointed senior researcher at the Institute of Geography at UNAM-Morelia, Mexico. He specializes in environmental history, landscape anthropology, people-environment geography, and ethnopedology.*

Introduction

The study of local environmental knowledge, or ethnoecology, is increasingly seen as key to both the conservation of agro- and biodiversity and the increased effectiveness of sustainable land-use (e.g., Gadgil et al. 1993; Haverkort and Millar, 1994; Berkes 1999; Nazarea, 1999; Berkes et al., 2000). Ethnopedology, also known as the study of local or indigenous soil knowledge and management, is a sub-component of ethnoecology that focuses on soil/land[1] knowledge and management by autochthonous populations. Local management of the soil resource can be critical to maintaining or enabling sustainable land management systems, especially in ecologically fragile areas of the world (WinklerPrins and Sandor, 2003).

This paper reviews the field of ethnopedology in Latin America and compares some of the many case studies from that region. Toledo has called for an urgent need to conduct a "comparative analysis of

the many case studies to foster a rigorous systematization and conceptualization" within the field of ethnoecology (Toledo, 2002; Descola, 1996a). We try to do just that with ethnopedologic case studies in Latin America by using our own research as well as published materials and analyses.

We review the field of ethnopedology, discuss why so many significant contributions to the field have come from Latin America, and then give examples of indigenous soil knowledge of people in the past and in the present. Specific objectives of this paper are to demonstrate that ethnopedology is

- more than a listing and comparison of indigenous soil classification systems with scientific classification systems; it includes local knowledge and use of soil genesis and soil formation processes; and
- a dynamic and open field of study that can be used as social theory since it is held individually but framed by social institutions. It is complex and infused with local values and belief systems both in the past and the present.

In the conclusion we offer thoughts on the future of ethnopedology in Latin America and the linkages between ethnopedology and sustainable land management.

Definitions and theoretical framework

> Ethnoecology an interdisciplinary approach exploring how nature is viewed by human groups through a screen of beliefs and knowledge, and how humans use their images to acquire and manage natural resources (Toledo, 2002: 514).

Central to the ethnoecological theoretical framework as developed by Victor Toledo (1992a; 2002) is the *kosmos – corpus – praxis* triad (k-c-p). *Kosmos* is the belief system or cosmovision of a local people; *corpus* is the repertory of knowledge or cognitive systems; and *praxis* is the set of practical operations of that knowledge system. Together, this k-c-p complex offers an "integrative approach to the study of the process of human appropriation of nature" (Toledo, 2002: 514. A parallel conceptualization of Toledo's k-c-p complex is Gadgil et al.'s knowledge, practice, and belief triad (Gadgil et al., 1993: 154; Berkes, 1999: 13).

Ethnopedology then, as a sub-field of ethnoecology, concerns itself with local perceptions, knowledge, and management of the soil/land component of the environment. Ethnopedology has been defined as 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 agroecology" (Barrera-Bassols and Zinck, 2000: 11) (Figure 1). The ethnoecological triad of k-c-p helps articulate the empirical wisdom of local people about the soil and land resources.

Pedology refers to "the entire [...] field of soil genesis, classification, morphology, survey, and interpretations" (Buol et al., 1997: 3). Of note is that pedology is seen as the dynamic component of soil science, since it concerns itself with the understanding of how soil develops over time and under variable environmental circumstances. Duchaufour has stated that the fundamental concept of pedology is the "study of the [soil] profile and the horizons [which] explain to the investigator the stages, the phases of development of the soil, in a word its history (pedogenesis)" (Duchaufour, 1998: 1). The twin notions of dynamism and historicity are important in linking pedology to ethnopedology.

Ethnopedology is, therefore, the local knowledge and understanding of soil morphology, genesis, and/or a local system of soil classification. In this paper, we take a broad definition of ethnopedology, one that encompasses local knowledge and management of landscape processes such as erosion and sedimentation. These landscape processes frequently include soil-upbuilding activities that improve the quality of the soil (e.g., Sandor and Eash, 1995). Such activities as the creation and maintenance of terraces and raised fields are obvious human manipulations of the soil landscape that demand an intimate and elaborate knowledge of the land (Donkin, 1979; Siemens, 1989). We use this broad definition of ethnopedology because it is becoming increasingly clear that there are many more landscape processes that are well understood by local people and that these processes are often manipulated in both subtle as well as very obvious ways to improve soils for agricultural purposes (e.g., Bocco, 1991; Sillitoe, 1996; Grossman, 2003; Niemeijer and Mazzucato, 2003).

The literature to date

Ethnopedological studies to date can be categorized into three main genres. These are the ethnographical literature, the nomenclature descriptions, and the more utilitarian studies. There has been an emphasis on studies describing local systems of soil classification, correlations of local classification systems with scientific systems, and those works where soil knowledge was simply a component of an ethnography (WinklerPrins, 1999; Barrera-Bassols and Zinck, 2000, 2003a).

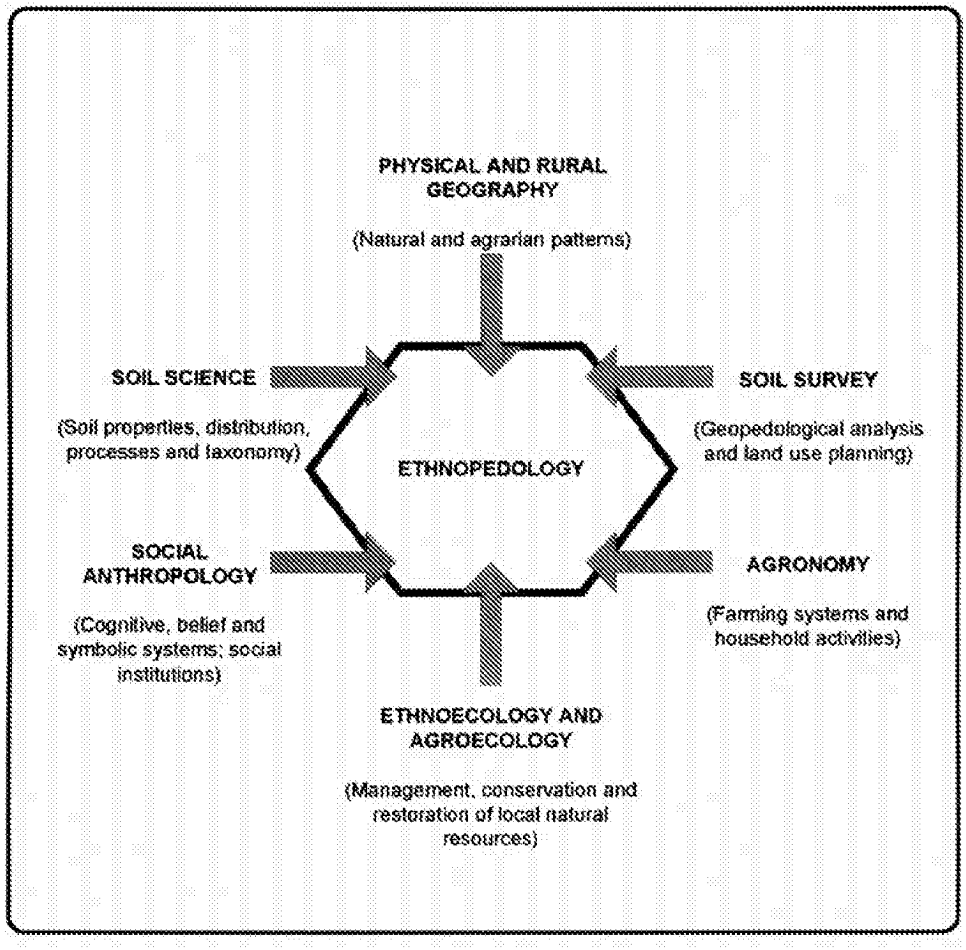

Figure 1. Ethnopedology as hybrid discipline (from Barrera-Bassols and Zinck, 2000).

In the last decade, ethnopedologic studies are starting to fulfill a more utilitarian role (e.g., Brouwers, 1993; Barrios, 1996; Barrios and Trejo, 2003; Niemeijer and Mazzucato, 2003). A variety of research has shown the practical utility of integrating local soil knowledge in development projects and/or soil survey efforts (Östberg and Reij, 1998; Sillitoe, 1998; Talawar and Rhoades, 1998; Sillitoe et al., 2002; Payton et al., 2003). This type of research continues to grow and will be valuable to a wide range of researchers and practitioners if attention is paid to the following four issues (Sandor and Furbee, 1996; WinklerPrins, 1999). First, a greater effort needs to be made to understand the link between soil knowledge and the political and socio-economic context in which it is used. Second, further attempts to expand soil knowledge studies to include the broader landscape processes need to be pursued. Third, there is a need to think creatively about ways in which local and scientific knowledge can inform each other and possibly be fused so as to make local soil knowledge an effective tool in sustainable land management strategies. Fourth, sustained attention to the cosmology (i.e., the kosmos) of local people is needed. This latter issue has been a highly neglected aspect of ethnopedologic research.

Why Latin America?

Latin America is an important place in terms of the study of ethnopedology. In a worldwide review of ethnopedology, Barrera-Bassols and Zinck found that a quarter of all published ethnopedological studies in a worldwide perspective came from Latin America (Barrera-Bassols and Zinck, 2000: 25, 2003a). About 30% come from Africa, and 20% from Asia and the rest elsewhere in the world. The studies in Latin America were concentrated in three agroecological zones within the continent: the cold and dry highlands, the arid and semi-arid lowlands, and the humid tropical lowlands. These three zones correlate well with zones of high agro-, bio-, and linguistic diversity. This overlap is not coincidental because these zones

- are complex physiographic and cultural areas;
- contain major civilization cores with centers of plant domestication;

- consist of complex agricultural systems (e.g., irrigation and fertility management through terraces and raised fields; agroforestry systems such as managed swiddens, anthropogenic forests, etc.); and
- include subsistence systems that have an horticultural emphasis due to the lack of large fauna in the Neotropics.

Additionally, in Latin America there are significant areas where traditional agriculture and knowledge has survived, especially in areas that are marginal and less attractive to commercial enterprises (Denevan, 1980). This traditional agriculture has evolved and fused with "modern" agriculture, but many of the processes that guided traditional practices have persisted and can be observed today (Wilken, 1987; Toledo, 1992b; Rist and San Martín, 1993; Faust, 1998).

We discuss three core areas with exemplary ethnopedologic studies in this paper. These three are located within the above-mentioned agro-ecological zones, which are considered critical and fragile from an ecological perspective. They are Middle America (primarily Mexico and Guatemala), the Andean region (primarily Peru and Bolivia), and Amazonia (primarily Brazil). This does not mean that examples of ethnopedology do not exist in other areas, but simply that these three regions provide excellent illustrations of the points we wish to make in this paper.

The complexity of the cultural and physical landscapes has resulted in long-term anthropogenic transformations of the landscape in these regions concomitant with broad knowledge of the land and the way it behaves (i.e., its dynamism). Local knowledge of the land and its management is rich and deeply cultural, and not easily accessible to outsiders. Therefore, it has taken many years for Western scientists to "discover" the extensive local soil knowledge and management systems that exist in the region, and to contemplate the implications and applications of those knowledge and management systems. Additionally, a complex cosmovision surrounding the land and its centrality (e.g., "the land is the mother") to life is only slowly becoming apparent to, understood, and appreciated by outsiders.

Middle America

In Middle America, prehispanic people had a profound knowledge of the land around them. They understood the nature of the soil, how to create it, manage it, and sustain it for productive agriculture. This is demonstrated quite clearly in graphic form by pictorial representations and the glyphs that form part of the Códices.[2] Barbara Williams, in her analysis of glyphs, has clearly shown that Nahua people possessed extensive knowledge of the soil (Williams, 1975, 1980, 1994). Barrera-Bassols (2003) built on this work by integrating the ethnohistorical work done by Williams with the kosmos of prehispanic Middle Americans. Pictorial representations and glyphs demonstrate the linkages between, for example, the Nahua kosmos, especially the oppositional qualities of deities and the human world linking the "above" world and the "underground" world as represented by the Holy Tree (Figure 2).

Middle Americans demonstrate their corpus of soil knowledge through elaborate pictographs, which show soil layers and local soil taxonomies (Figure 3).

The praxis of soil knowledge is expressed in the form of complex pictographs of people using the soil (Figure 4). Figure 4 shows the intimate relations and dominance of feminine and masculine deities over maize performance in different ecological settings, according to 16th century Aztec codices. Pictorial representation at the left shows Tonatiuh, the Sun God, influencing male maize performance under drought conditions. Tonatiuh represented descendent dry and red sunrays' dominant forces evoking drought, pests, plagues, and diseases. Of note is that the soil is represented as dry-layered and "sick." Pictorial representation on the right shows Tlaloc, the Rain god/goddess, influencing female maize performance under good weather conditions. Tlaloc represented female and humid ascendant dominant forces and substances, evoking the rainy season, abundance, and fertility. The soil body is soft, puffy, and humid (represented by dots). Female and male pictographic representations may be interpreted as fertile and unfertile conditions.

There are also toponyms with embedded soil information that clearly demonstrate that locals possessed substantial soil knowledge (Figure 5). Often, Nahuatl toponyms were used as descriptors of cultural landscapes, including soil and land resources information, reflecting the social perception and appropriation of natural resources, according to cosmological views and environmental and productive qualities of the landscapes. Thus, toponyms as linguistic descriptors and pictographic representations can be analyzed to understand social knowledge about nature and cultural adaptation to the environment. For example ***Acamalcingo***, or "on the cropland or *milpa*," shows a yellowish-black flat soil glyph, with a straight maize plant in green, its flowers in red and a maize cob in yellow. Also, ***Actopan***, or "on the fertile land," shows a straight flowering maize plant with two cobs, the latter referring to the high productivity abundance of an *Atoctli* soil type, assessed as a humid and fertile soil.

Three examples of contrasting soil-relief relationships are ***Xalapam***, ***Xaltepec***, and ***Xalatlaco***. All three

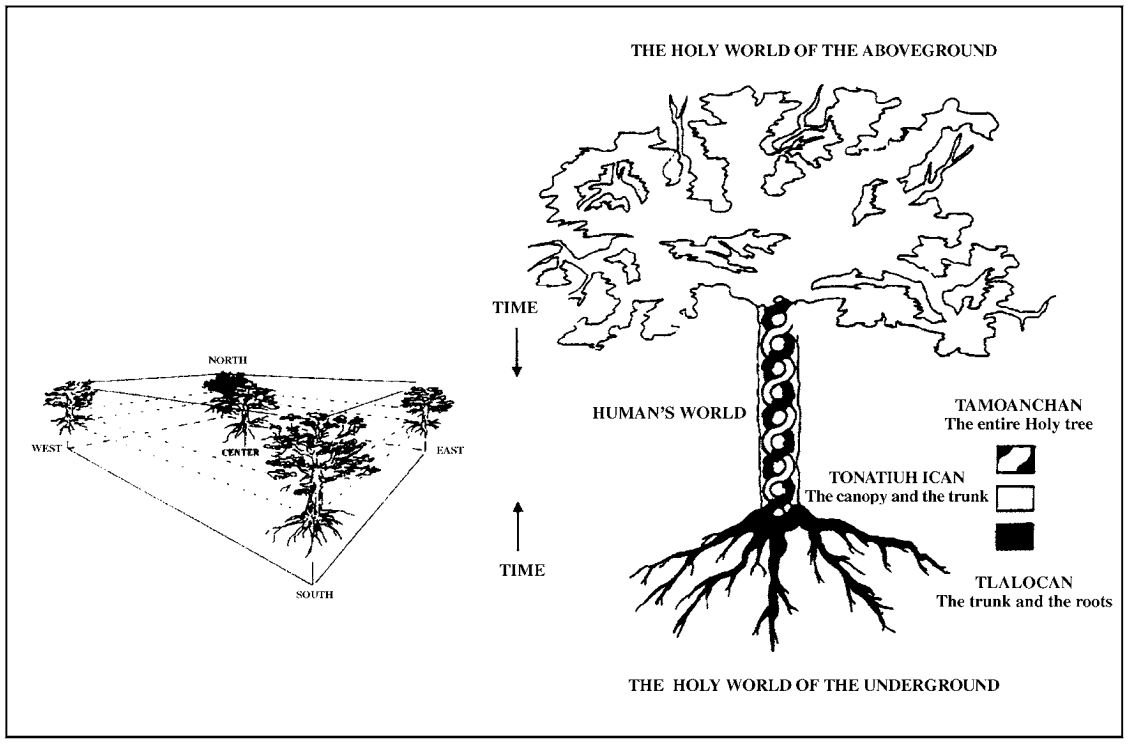

Figure 2. Middle American worldview: The Holy Tree (after López-Austin, 1994).

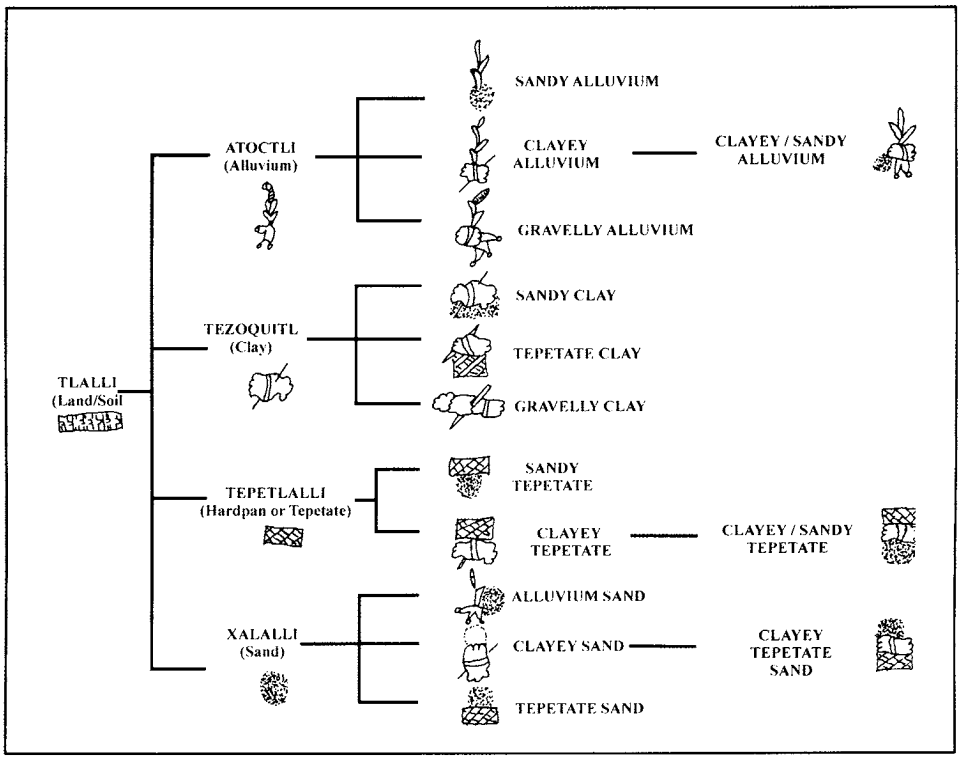

Figure 3. Nahua soil taxonomy (after Williams, 1994).

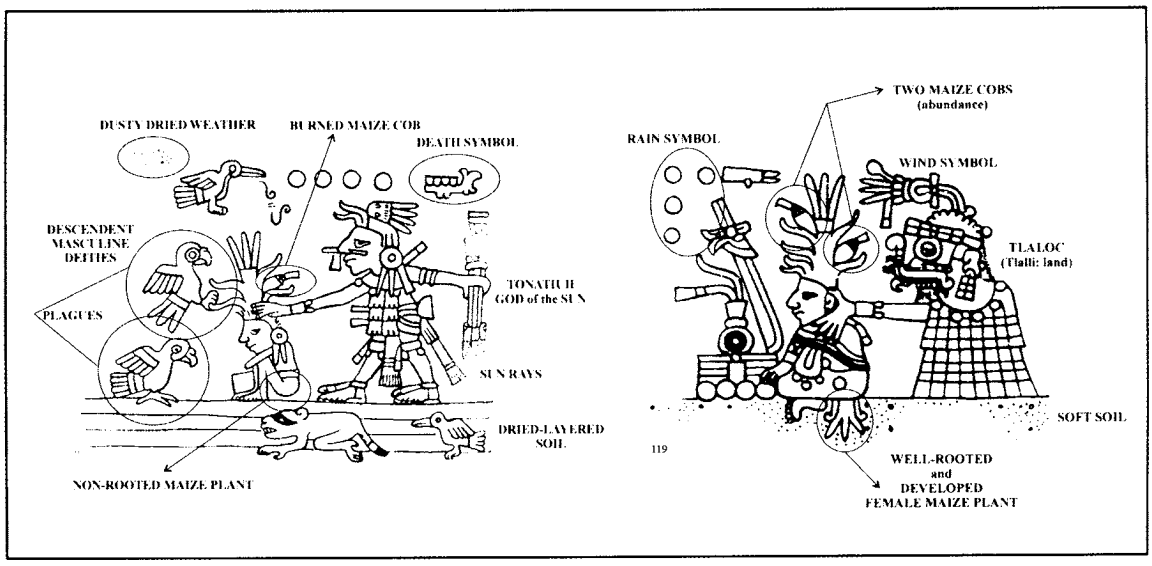

Figure 4. Middle American pictorial representations (after Anonymous, 1964–1967).

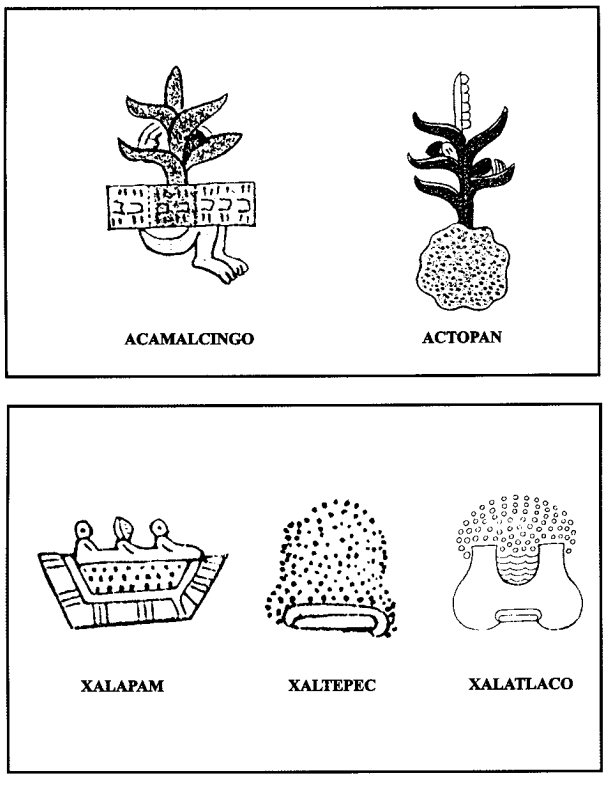

Figure 5. Middle American toponyms (after Peñafiel, 1885).

toponyms and pictorial representations refer to the same soil type, *Xalli* or sandy soil in different landscape positions. Sandy soils are located in (a) a humid valley with water springs, as is the case of ***Xalapam***; (b) in a hilly land, as is the case of ***Xaltepec***, and (c) in a gully or *barranco*, as is the case of ***Xalatlaco***.

An excellent example of ethnopedological praxis in Mexico are the Chinampas (also known as *floating gardens*), a type of raised field originally found in the Valley of Mexico (Coe, 1964; Moriarity, 1968; Barrera-Bassols, 2003). Soil management to create highly productive agricultural planting surfaces was extensive and involved the creation of a soil that could be sustained over time. Specific components of earth material were layered upon each other deliberately (e.g., organic material, gravel, sub-soil materials) to create a functioning agricultural soil. This was held in place by a mesh of stalks and the prudent planting of willow trees along the banks. Both of these measures helped to keep the erosive forces under control (Crossley, 2004) (Figure 6).

Remarkable examples of contemporary local soil knowledge in Mexico, Belize, and Guatemala show their historical persistence in an area where rural modernization had drastically reshaped the landscape (Williams and Ortíz-Solorio, 1981; Toledo, 1992b; Barrera-Bassols, 1988, 2003; Pulido and Bocco, 2003). Syncretic local soil knowledge systems, still based on maize milpa cropping, demonstrate the resistance of indigenous peoples and Mestizo small farmers to dismantling their traditional and hybrid land management techniques under drastically changing social conditions. Examples of contemporary Middle American ethnopedologies cover 12 ethnic groups, including Mestizo small farmers, located in a variety of landscapes, and reflect the potential for integrating external and local experts in search for sustainable land use and management (Dunning, 1990).

The Maya are probably the most well studied ethnic group of the Middle American tropical humid lowlands (e.g., Wilken, 1987; Sanabria, 1986; Terán and Rasmussen, 1994). Linked to agroforestry management, homegardening, and swidden agricul-

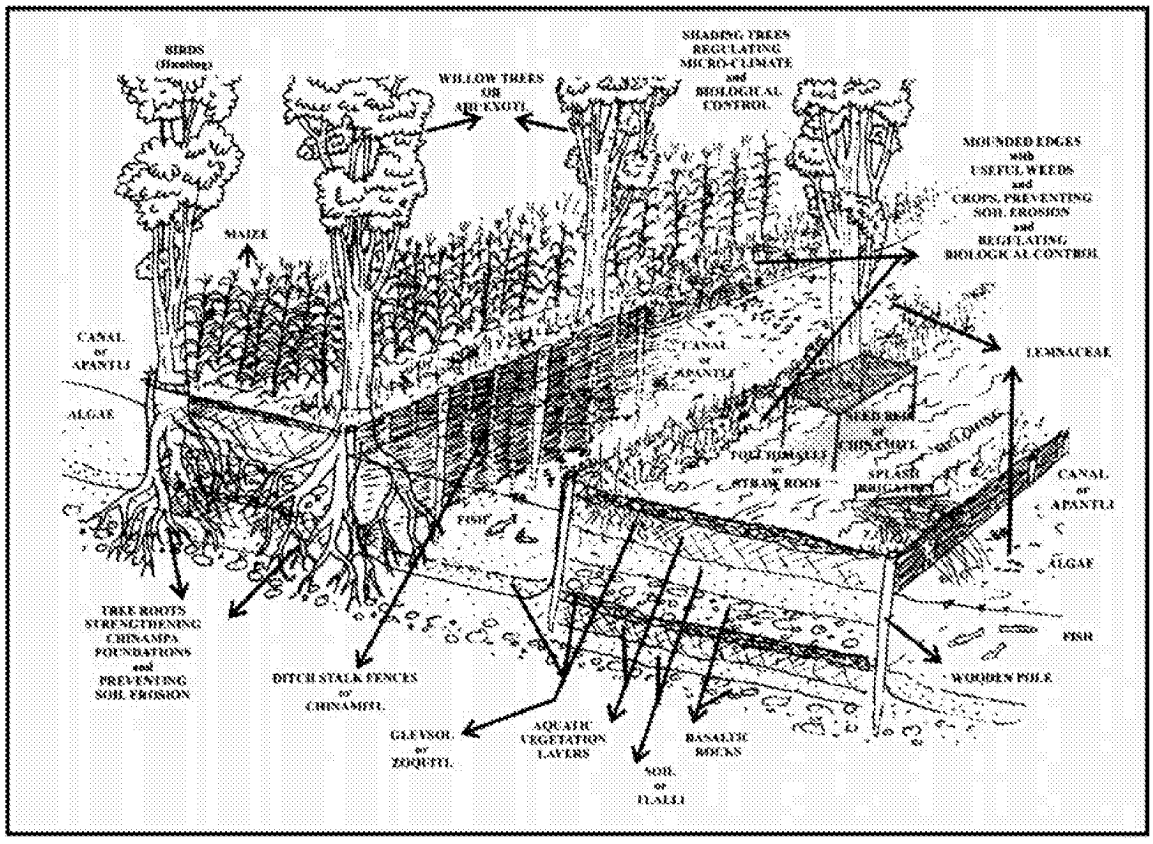

Figure 6. Chinampas (after Coe, 1964).

ture, Maya soil knowledge shows inextricable links between k-c-p in modern days (Gómez-Pompa and Kaus, 1990; Faust, 1998). For example, the Chinantec and Mixe soil knowledge systems reveal a complex understanding of soil and land resources enabling the management of diverse ecological fringes in the mountainous tropical humid landscapes of Mexico (Martin, 1993). The Huave of San Mateo del Mar in Oaxaca evolved sophisticated local soil knowledge based on the recognition and micro-management of several agro-habitats in marginal coastal lands of the tropical sub-humid landscapes (Zizumbo and Colunga, 1982). The Otomi of the Mezquital Valley in Hidalgo have a complex understanding of the soil profile, allowing the construction of diverse types of terraces in the semiarid highlands of central Mexico. Agricultural land assessment is done according to soil fertility and salinity ranking.

The Purhépecha of San Francisco Pichátaro in Michoacán, a village located on the temperate sub-humid highlands of central Mexico, possess a hierarchical soil classification based on soil-relief-microclimate relations, allowing the cultivation of 14 maize varieties with respect to a complex land suitability assessment (Barrera-Bassols and Zinck, 2003b). Technological adoption of HYV maize landraces cropping on the most fertile bottom-level lands complements the traditional maize varieties cropping on the local sloping lands (Barrera-Bassols, 2003; Barrera-Bassols and Zinck, 2003b). Mestizo small farmers from Chiapas, Mexico have also made a technological choice that combines milpa cultivation for market with subsistence production (Bellón, 1995).

Contemporary Middle American soil knowledge systems are still based on maize cultivation but are framed by a common cosmovision that evolved as a syncretic Catholicism, which maintains underlying Middle American beliefs, symbolic representations, and fertility rituals. The overlapping climatic, agricultural, and religious calendars in San Francisco Pichátaro, demonstrate that religious festivities, rituals, and ceremonial offerings are given at the beginning or at the end of most important agricultural activities, which correspond to seasonal climatic change. In regard to soils, the Purhépecha farmers of San Francisco Pichátaro also conceptualize the soil body as possessing its own agency, which is not perceived to be merely an inert raw material to be used toward human ends. The active participation of the land is assessed in many ways, resembling explanations of human agency, health, and illness. Land talks, behaves, moves, becomes thirsty, sweats,

requires to be fed, gets sick, needs to rest and recover. Soil "strength" is balanced through periods of "weakness" and "recovery." The land "works," thus requiring "resting" when it is "tired;" it needs to be fed when "hungry" and needs to "drink" when thirsty to recuperate its strength. A fertile soil may become unfertile after "working" for several years and then needs to be left to "rest" (fallow) as any other living being. Local explanations of soil health show that nature and human agency are connected through the food chain. Human health depends on plant and soil health, and soil health requires the active participation of healthy humans. Interconnectedness and mimicry stand as factors explaining all living beings. Soil health in San Francisco Pichátaro appears to merge views about nature, the human body, and health-disease causation. In principle, the soil body is thought to be impure and highly prone to get ill; thus it is conceived as a fragile living being. Soil diseases are contagious, affecting animals, plants, and humans. Therefore, the soil requires care and nurturing to maintain its own and its keepers' health. Its bodily constitution resembles a womb where opposite substances and forces intercourse, producing plants, animals, and humans (Barrera-Bassols and Zinck, 2003b).

In some areas, local soil knowledge is shared among farmers from different communities as region-wide ethnopedologic systems. Naming, characterization and land use and management of soil classes are relatively homogeneous over thousands of square kilometers. Mapping indigenous and Mestizo soil units at plot, local, and regional scales contributed to strengthen ethnopedological techniques for land use planning over the last fifteen years (Ortíz-Solorio et al., 1989; Licona Vargas et al., 1992; Ortíz-Solorio, 2001).

Remnants of past systems of agriculture and associated knowledge continue to exist in Latin America, especially in the more marginal locations. These systems have hybridized with more modern systems of agriculture to form what Zimmerer has labeled neotraditional agriculture (Zimmerer, 1994a). Contemporary examples of local systems of soil knowledge also exist in the form of other types of terraces and raised beds throughout Middle America (Wilken, 1987).

Andes

The Andean region, like Middle America, has an extensive recorded prehistory, primarily of the Quechua and Aymara peoples. Although the pictographic record, such as the codices that exist in Middle America, have not been analyzed with an eye to soil knowledge and management, the landscape itself is a palimpsest and can be used to reconstruct what were systems of soil manipulation in the past. Past uses of the land are inscribed in the physical landscape today and can be "read" using a variety of technologies and having an open frame of mind to a range of the possibilities (Erickson, 1999). Present day uses and manipulations of the land appear to be similar, though not as extensive as in the past.

In the Andean region, the work by Denevan (1970), Erickson (1989, 1993, 1999), Sandor (1991, 1995, 1996) and their colleagues, as well as others (e.g., Rist and San Martín, 1993), clearly demonstrates that human manipulations of the landscape, in the past and at present, is long-term, specifically in the form of terracing and raised fields. Both systems involved manipulation of the land to create favorable physical conditions to maintain continual and productive agricultural systems. People had and have a deep and complex understanding of the processes of soil formation, profoundly linked to their spiritual beliefs, their kosmos (Treacy, 1989; Rist et al., 1996).

For Andean people, the material life (Pachamama) is intimately linked with the spiritual life (Pachakamak) and social life (Pachankama chana). An individual is at the intersection of those three realms, and cannot be disconnected from them (Figure 7). Pachamama is considered the Earth Mother, residing in the land and tending to the well-being of nature. As farming is considered to be an extension of nature, she attends to farming as well, especially controlling climate and soil fertility. In order for these to operate properly, the Earth Mother needs to be constantly thanked through ritualistic tribute (Zimmerer, 1996). Therefore, maintenance of the soil resource in terraces and other structures is a profoundly spiritual experience as it pleases the Earth Mother, who will repay the farmers with adequate climate conditions and soil fertility and abundant harvest.

The corpus of soil knowledge of Andean people, generally speaking, is reflected in their complex soil classification systems (e.g., Zimmerer, 1994b; Sandor and Furbee, 1996). Soils are identified according to texture (sand, silt, clay) as well as color, and to a much lesser degree by other properties (edibility; dusty; clods; hardpan). The categorization of soil names and careful differentiation reflects a profound experiential knowledge of the soil resource (Figure 8).

Terracing is an example of ethnopedological praxis in the Andean environment. The work of Jon Sandor and colleagues (1991, 1995, 1996) and Treacy (1989, 1994) demonstrates how local people create and manage soils to their advantage over the long-term. The result of continual and careful attention to feeding the soil has created soils with very rich and friable A horizons that have been sustained for many centuries.

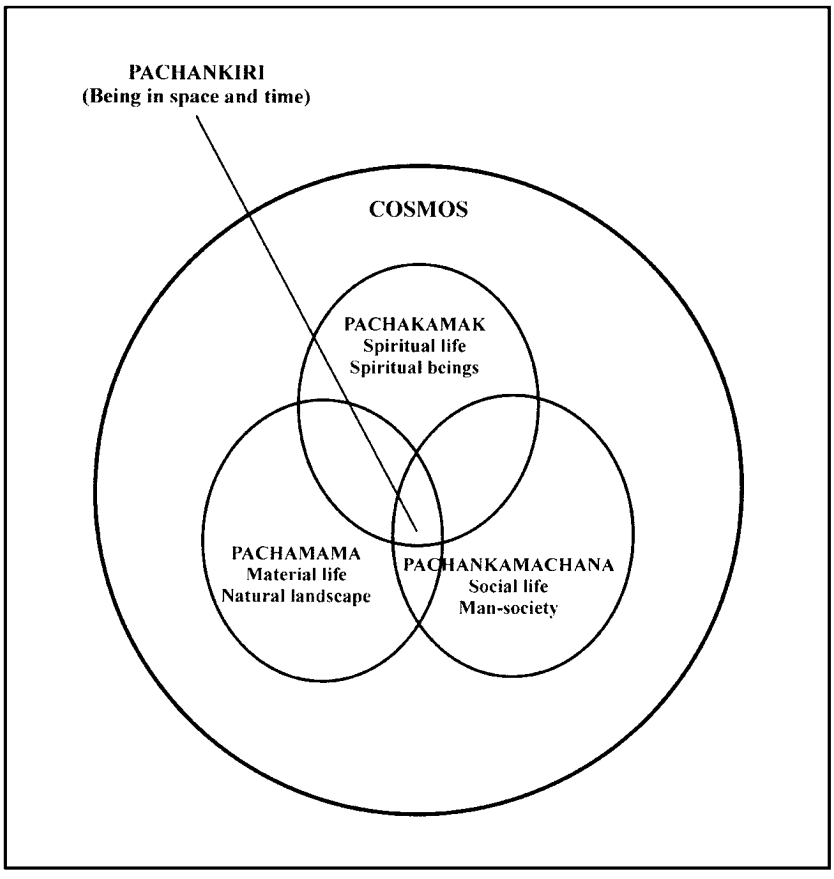

Figure 7. Andean k-c-p (after Rist et al., 1996).

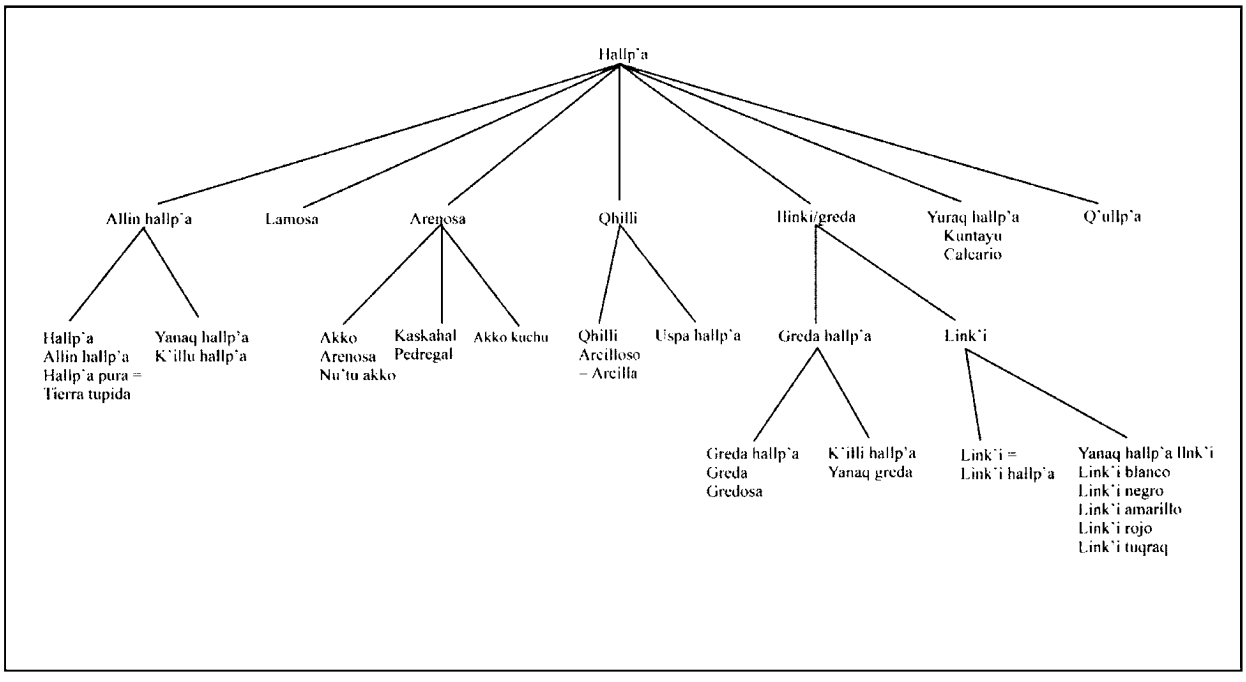

Figure 8. Andean soil taxonomy (after Sandor and Furbee, 1996).

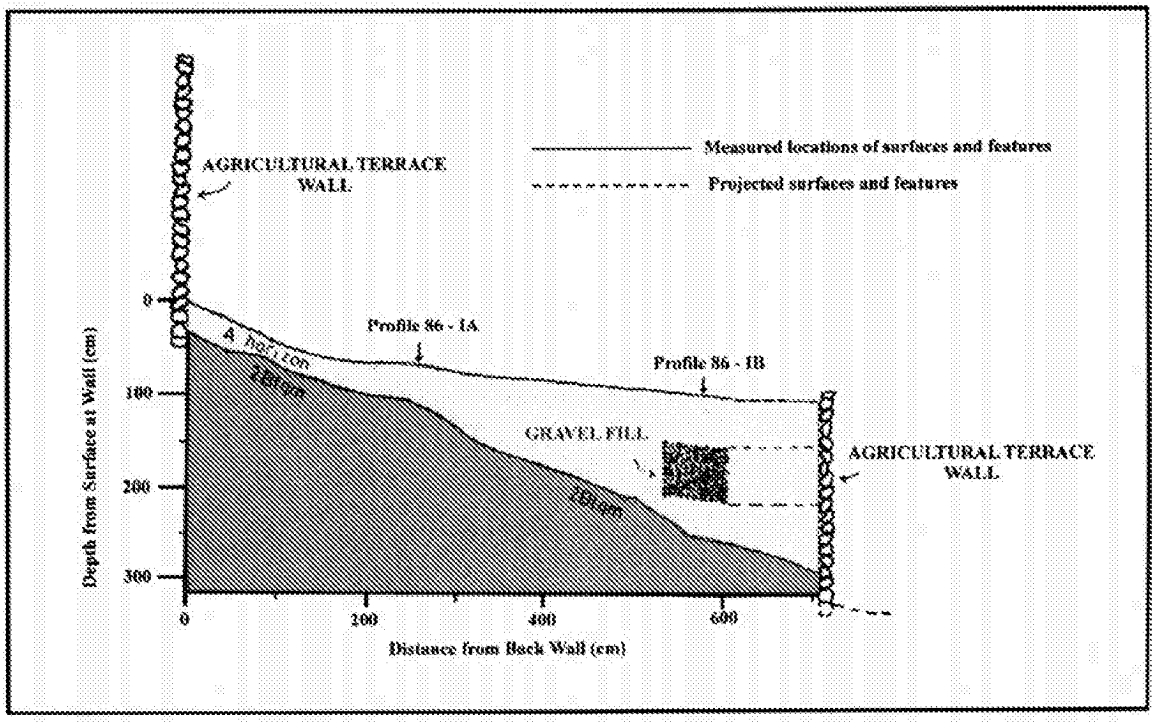

Figure 9. Andean agricultural terrace (after Sandor and Eash, 1995).

Relative to non-manipulated soils in the same region, the terraced soils offer a more productive medium for agriculture (Sandor and Eash, 1991). The praxis of continued fertilization, by the incorporation of manure and hearth ashes, has thickened the topsoil to maintain the fertility and tilth of soils under this type of agricultural system (Figure 9).

Planting practices demonstrate knowledge of the soil as a three-dimensional entity. Specifically, the fronts of terraces are chosen for planting since this is where the soil is deepest and the depth to duripan (hardpan that limits roots growth) the furthest.

A conscientious effort has been made to improve soil quality through the application of specific materials (manure, ash) by linking a profound religious and spiritual feeling toward the soil, the earth, and land stewardship (Treacy, 1989; Sandor and Furbee, 1996; Rist et al., 1996). It should be noted, however, that the linkages between cultural system and landscape modifications is critical for long-term sustainability and cannot be separated (Treacy, 1989). There is currently a strong international interest in local knowledge of the region that has focused on native solutions to land use problems, probably more so now that before. At the same time, there is increasing local consciousness to solve local problems with local solutions and not to rely on outsiders (Gade, 1999). The source of knowledge for these local solutions resides in the knowledge systems of indigenous farmers in combination with information from the outside.

Amazonia

Amazonia is significantly different from Middle America and the Andean region in regard to ethnopedology. The legacy left by prehispanic populations in Amazonia is much more subtle and has only recently started to be investigated systematically. In contrast to the physical structures (raised beds, terraces) left behind by Middle Americans and Andean people, the "structures" left by Amerindians in Amazonia are the forest and land itself. Reading these landscapes is difficult for Western scientists because of preconceived notions of the landscape, the subtle nature of landscape modifications, and its perpetual change (Raffles, 2002).

The lack of physical structures is one of three reasons why it is easier to find examples of current ethnopedological knowledge in Amazonia rather than examples from the past. The second reason is that post-contact depopulation was severe in this region with the result that few remnant populations are practicing agriculture the way it was prehistorically (Denevan, 2001). Those that do exist have changed their practices considerably (through agricultural regression) to adjust to new post-contact demographic conditions (Balée, 1994). Therefore, today's practices do not necessarily reflect those of the past (Roosevelt, 1989). Third, archaeological research to date has been severely limited in this region relative to the size and importance of the area. The reasons for

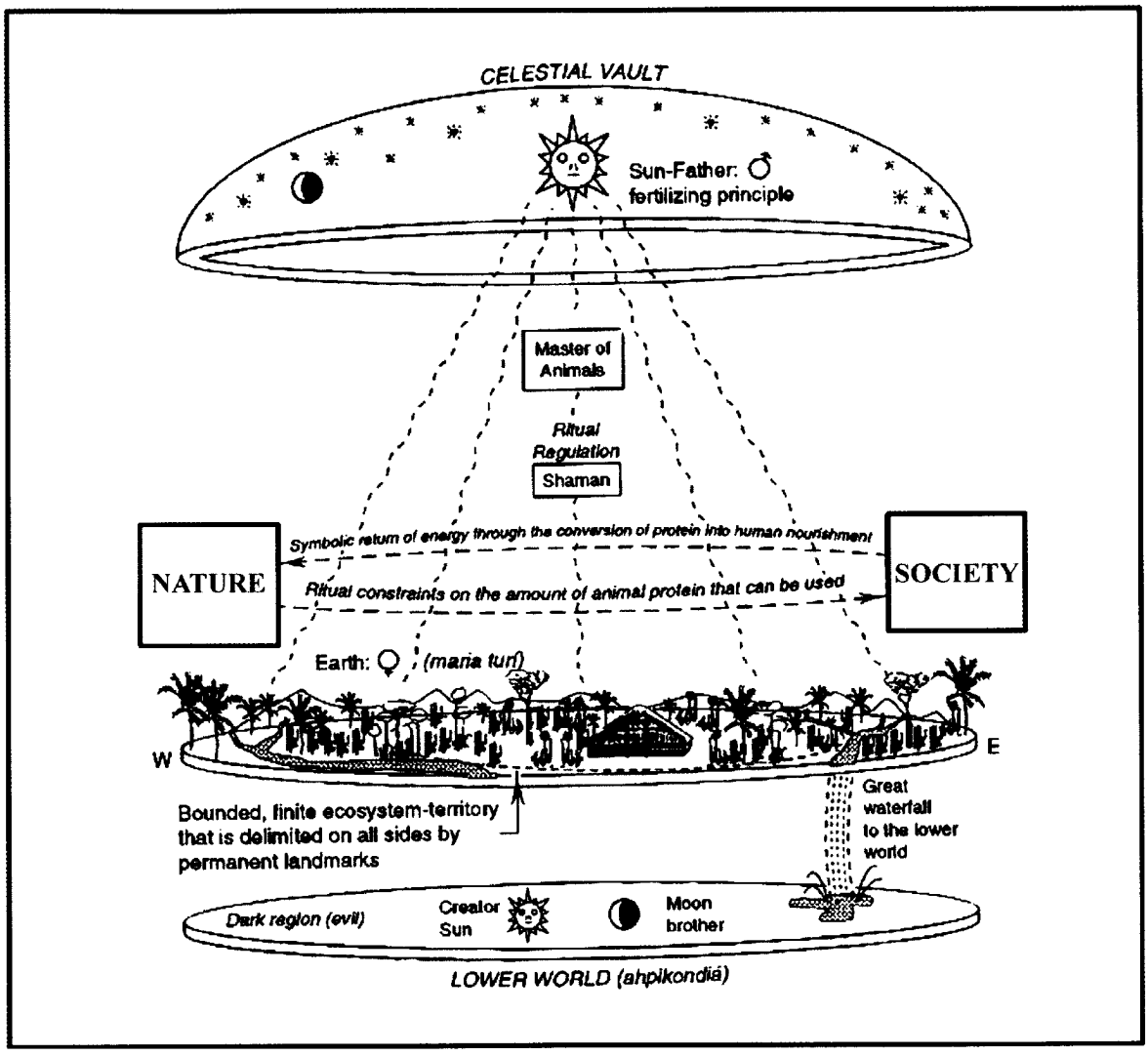

Figure 10. Amazonian k-c-p (after Reichel Dolmatoff, 1976).

this have been logistical and institutional, and will probably improve in the future. Recent work (e.g., Roosevelt et al., 1996; Heckenberger et al., 1999; McEwan et al., 2001) is clearly demonstrating that Amazonian prehistory is much more complex than heretofore acknowledged by the dominant forces in Amazonian archaeology (e.g., Meggers, 1996 [1971]).

The little that is known about indigenous ethnopedology in Amazonia comes from the ethnographic literature, e.g., the Desana (Tukano), Yukuna, and Tanimuka in Colombia (Reichel-Dolmatoff, 1976; Hammen van der, 1992) and the Canelos Quichua and Achuar in Ecuador (Whitten, 1978; Descola, 1994, 1996b), the Ka'apor from Eastern Amazonia (Balée 1994), and from extensive investigations of the ethnoecology of the Kayapó in the Brazilian Amazon by Posey (1985), Hecht and Posey (1989), Hecht (1989), and Parker (1992).

The Desana perceive the environment they inhabit as humanized, "transformed and structured in the past, not so much by any exploitative activities of their ancestors, but by having been imbued by [the Desana] with symbolic meaning" (Reichel-Dolmatoff, 1976: 309). The latter part of the quote is critical. It is the symbolic meaning (kosmos) and not praxis that humanizes the landscape. The environment is perceived as being bounded with finite and restricted resources (Figure 10). Environmental degradation is seen as depletion of game resources and walking distance, not soil exhaustion.

The Achuar have a "pragmatic and theoretical knowledge of the diversity of their inorganic environment" (Descola, 1994: 43), including the nature of soils. They judge soil quality by physical properties such as color, texture, and porosity. These properties are linked with relief and sediment characteristics to develop categories of soil types. This corpus of

INDIGENOUS NOMENCLATURE	DESCRIPTION
Pakui nunka Dirty earth	Dark hydromorpohus soil, characteristic of alluvial terraces and ***Aguajales***
Kanus nunka River earth	Alluvial soil over silt; dark and loamy
Shuwin nunka Black earth	Sandy black alluvial soil
Nayakim nunka Sandy earth	Compact lateritic soil made up predominantly of volcanic sandstone; brown and clayey
Kante nunka Dense earth	Lateritic soil made up of volcanic sandstone; brown and clayey
Keaku nunka Read earth	Compact red lateritic soil characteristic of hills; clay texture
Muraya nunka Hill earth	
Kapantin nunka Reddish-orange soil	Highly laterized soil
Nayakim Sand	Black sand characteristic of Pastaza beaches
Kaya Rock	The term denotes either the volcanic rocks (***pampa***) protruding from riverbeds or the pebbles that build up on the beaches (***kayan-matak***: pebble beach)
Nuwe	White clay used for pottery
Maajink	Small surface deposit of white clay with brown clay that likes its color from ferrous oxide (a coloring used for pottery)
Pushan	*Idem*, but yellow
Pura	*Idem*, but red
Namur, nantur	Flint chips used as magical charms

Figure 11. Current Achuar soil knowledge (after Descola, 1994).

knowledge is represented in a system of nomenclature that is not hierarchically organized because of non-exclusive categorization (Figure 11). Soil types are very important in the selection process of agricultural sites, but pragmatic considerations such as walking distance to garden site may overrule the higher agronomic potential of "better" soils.

The Kayapó manipulate soils before they create forest islands (*apêtê*) in the savanna environment in which they live in Brazil. The first step in forming these forest islands is the creation of an appropriate soil. They "create a new soil by making compost piles in the forest ... from sticks, leaves, and limbs" and by adding "hearth debris, ashes, organic matter, portions of termite hills, ant nests, slashed vegetation, and mulch from backyard gardens" (Parker, 1992: 408, 410). Into this created soil are planted seeds and seedlings that form the basis of a small forest (Figure 12).

These activities demonstrate that the Kayapó understand that the natural soil on the savannah is not fertile enough to support forest vegetation, and that organic materials need to be added to create a new soil base. This is anthropogenic soil genesis.

Another form of evidence of Amazonian knowledge of soil processes is the significant evidence of the anthropogenic nature of *terra preta* (Black Earth) soils. It is clear that continual enrichment of occupation sites through garbage and litter composting and burning has yielded enriched soils much more favorable to cropping (Balée, 1994; Glaser et al., 2001; Woods and McCann, 1999) and sought out for that purpose by today's native people and peasantry (German, 2003). This demonstrates that people indigenous to the region feel they have the ability to improve their soil resource, they are active agents in its formation and maintenance.

The cosmovision that guides much Amazonian praxis is one of unity with a symbolically infused forest. The origin myth of the Ka'apor recounts how people came from plants (Balée, 1994). This suggests a complex and profound relationship with these plants that are perpetually manipulated and managed. Similarly for the Kayapó, vegetation is the center of their cosmovision (Posey, 1985). People are part of the forest/savanna environment, actively working with nature to create a forest that is useful and a "home" to people. Soils are simply seen as part of the forest/savanna system and by extension receive similar treatment.

Along the floodplain of the Amazon River an indigenous peasantry takes a slightly different approach (WinklerPrins, 2001). Here, it is the river that is imbued with meaning, as it is what "refreshes"

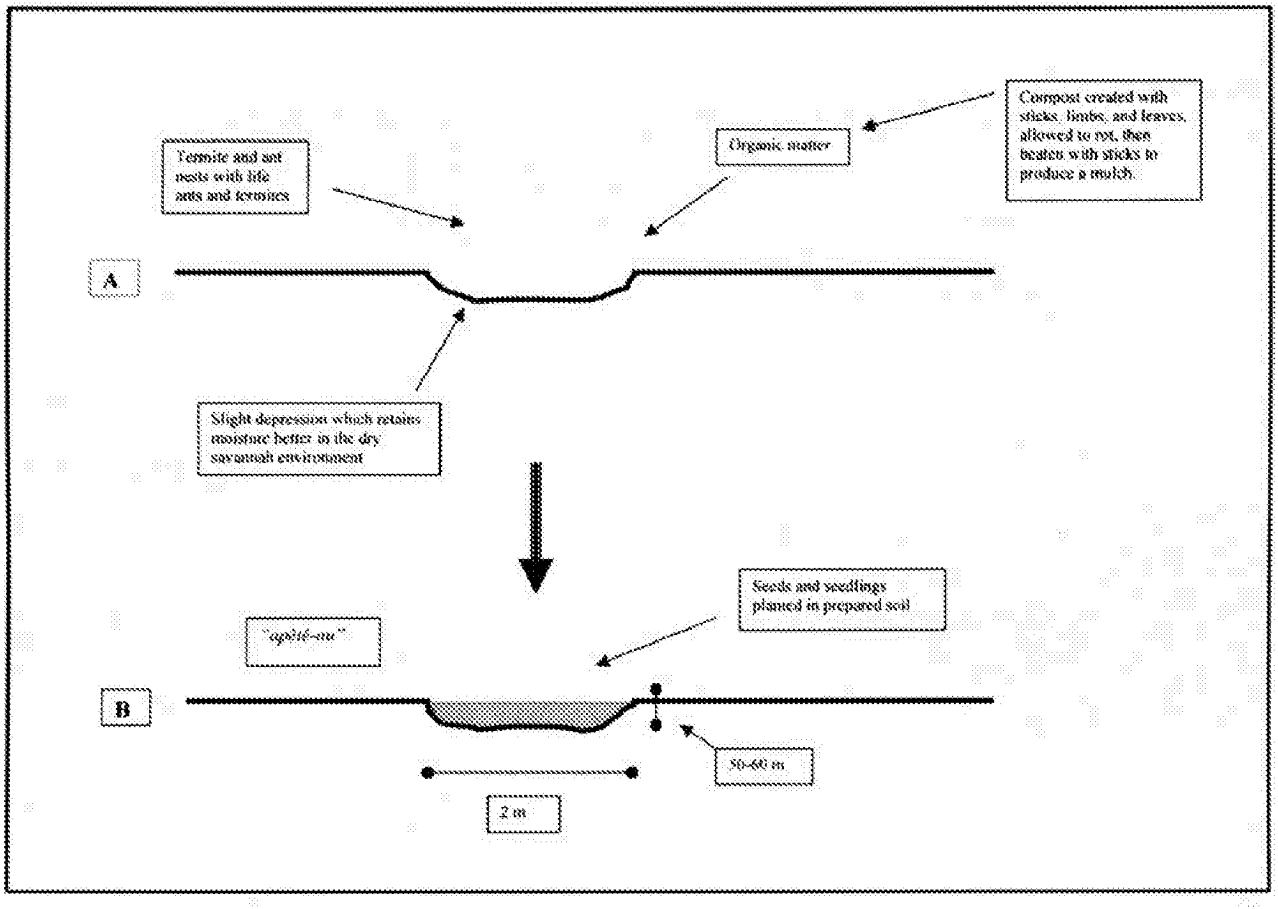

Figure 12. Apêtê soil formation (drawn using descriptions from Posey, 1985 and Parker, 1992).

a "tired" land. Similar to the conceptualizations of Middle Americans described above, the soil is conceived of as a body needing care. But most of that care comes from the river, over which locals feel they have no control. This much more fatalistic view of the environment as exhibited by a peasant people stands in contrast to the active agent approach seen to be taken by indigenous peoples on the uplands (Desana, Achuar, Ka'apor, and Kayapó). This may be the result of the Westernization of belief systems, but may also be the result of a different environment. Studies specifically addressing these issued are non-existent to date and require much further investigation.

Conclusions: The future of ethnopedology in Latin America

> For indigenous people, knowledge is viewed as emanating from a spiritual – not a unilineal scientific – base. Thus all creation is sacred, and the sacred and the secular are inseparable. Spirituality is the highest form of consciousness, and spiritual consciousness is the highest form of awareness. In this sense, traditional knowledge in not *local* knowledge at all, but rather an expression of *universal* knowledge as expressed through the local (Posey, 2002: 28).

What will happen to these complex systems of soil knowledge in the future? There are two potential pathways for the future of ethnopedology in Latin America. The first is that there be continued efforts to conduct research on and to use indigenous soil knowledge systems as a springboard for the development and maintenance of sustainable land-use systems, acknowledging the dynamism of local knowledge and the blended nature it often takes. The second pathway is more pessimistic, and assumes that modernist development projects and the processes of globalization and economic integration will destroy local knowledge systems.

The persistence of local knowledge to date is impressive, despite forces to the contrary, especially in conjunction with associated systems of agriculture and, therefore, the co-evolution of agriculture and knowledge. It is becoming increasingly clear

that for the preservation of biodiversity and especially agrodiversity, the people involved in maintaining these systems need to be present and be practicing successful agriculture in order to maintain the knowledge embedded in it (Zimmerer, 1996; Brookfield, 2001). Local soil knowledge forms part of broader local theories about nature, which constitute the bases for adaptive management systems. Soil fertility conservation and improvement constitutes, in most cases, the center of local and micro-local management of resilience, with ritual being the most sacred dimension of these management strategies.

But local people cannot be kept in museum-like settings, told to keep on with their traditional ways so that their systems of knowledge can be preserved. Local people are constantly adjusting and changing, and likewise their knowledge and practice will continue to change as well. In the Americas, adjustments were made at conquest, and they will be made continually in the future. As Sillitoe has eloquently stated, "local understanding is a blend of knowledge from various sources which is difficult to disentangle. It is syncretic. There is no repository of agreed knowledge; it is in a constant process of change, being continually influenced by outside ideas" (Sillitoe, 2002: 117). Therefore, it is critical that researchers and planners who are interested in sustainable land-use acknowledge that local soil knowledge is dynamic and that there will be knowledge "loss" as well as "gain" as local people experiment and adjust to new circumstances.

We do feel that the pendulum has swung in the direction of embracing local knowledge. As part of the post-modern deconstruction of monolithic modern knowledge systems, the gathering of local knowledge is now an accepted component of development work (e.g., Fujisaka, 1994; Sillitoe et al., 2002; Barrios and Trejo, 2003) and an accepted field of inquiry in social as well as soil and environmental sciences (Winkler-Prins and Sandor, 2003). The problem is that, although local knowledge is increasingly being gathered and acknowledged, researchers and practitioners are still not sure what to do with the "gathered" knowledge. In other words, the question of operationalizing local knowledge either directly or as a fusion with scientific knowledge is only in its infancy. This is an area of ethnopedological work that needs continued attention. In addition, issues of scale and generalization continue to hamper furthering the benefits of local knowledge (Payton et al., 2003).

The second, more pessimistic, pathway is still adhered to by those who espouse modernist pathways to agricultural development. Here, the removal of traditional knowledge is seen as a positive feature of modernization, and an inevitable step in the process of globalization in which we will all become the same, using efficient (by some definitions), industrial methods to produce food. This approach, though generally rejected by academics, is unfortunately still engrained in plentiful agricultural development and extension agencies worldwide. It will be slow to change and necessitates that those institutions that train development and extension workers, frequently Northern universities, and others in the agricultural business start accepting and incorporating the "soft side of the land" (Röling, 1997) and include local knowledge as an integral part of working with farmers (Birmingham, 1996).

Extension and development workers would do well to understand that all members of a community share local soil knowledge, with variations according to age, gender, and level of experience. It is transferred from generation to generation via practical demonstrations, informal conversations, and participatory meetings. It is also explained symbolically and/or logistically by recognizing cause and effect relationships, and it is conceptualized by formalizing practical experience into knowledge rules. Farmer theories about soil and land resources go beyond practical rules of thumb and include complex conceptualization about processes, such as soil health, behavior, erosion, and fertility. In this sense, they are similar to scientific theories of soil and land resources. The social theory of soil and land resources may be conceived as an *encyclopedia*, where soil and land nomenclatures constitute the *words* of soil knowledge, explanations about its bodily behavior may be conceived as the *sentences* of soil knowledge, and its practical and symbolic representations may be considered as the *grammar* of the soil knowledge. The constant adaptation of social theories about the soil and land resources according to the ever-changing circumstances also resembles an *open book* about the soil, open to all in the community to see (Barrera-Bassols and Zinck, 2003b; Niemeijer and Mazzucato, 2003). If those outsiders working at the local level on land-use issues can at least acknowledge and try to work within local concepts and constructs, then there is much more hope for the implementation of sustainable land-use systems.

Acknowledgments

The authors wish to thank ITC – International Institute for Geoinformation Science and Earth Observation for its institutional support that enabled us to work together. We also thank the many farmers with whom we have spent innumerable hours learning about their knowledge. Lastly, we thank Al Siemens and Andrew Sluyter for organizing the special session on native

ecologies at ICA 2000 where this paper was originally presented.

Notes

1. We use the terms "soil" and "land" interchangeably.
2. Códice is the pre-Hispanic Middle American written document or sacred book with pictorial representations and glyphs, explaining mythical, historical, and religious events, or offering botanical, zoological, geographic, cadastral, tribute, mathematical, or astronomical information. The Códice was elaborated with bark paper, vegetal fibers, or animal skin and painted with vegetal colors, oil (*chapopote*) and earth materials. Its use was confined to the religious nobility and the ruling class and was also used by Catholic priests as a Colonial document explaining the history of the Spanish conquest and the Middle American scientific knowledge and cosmovision.

References

Anonymous. Codex Fejérváry-Mayer (1964–1967). In *Antigüedades de México. Lord Kingsborough comp* (pp. 185–276). Mexico: Secretaría de Hacienda y Crédito Público.

Balée, W. (1994). *Footprints of the Forest: Ka'apor Ethnobotany – the Historical Ecology of Plant Utilization by an Amazonian People*. New York: Columbia University Press.

Barrera-Bassols, N. (1988). "Etnoedafología Purhépecha." *México Indígena* VI(24): 47–52.

Barrera-Bassols, N. (2003). *Symbolism, Knowledge and Management of Soil and Land Resources in Indigenous Communities: Ethnopedology at Global, Regional and Local Scales*. Ghent: University of Ghent Press.

Barrera-Bassols, N. and J. A. Zinck (2000). *Ethnopedology in a Worldwide Perspective: An Annotated Bibliography*. Enschede, The Netherlands: ITC. ITC Publication Number 77.

Barrera-Bassols, N. and J. A. Zinck (2003a). "Ethnopedology: A worldwide view on the soil knowledge of local people." *Geoderma* 111(3-4): 171–195.

Barrera-Bassols, N. and J. A. Zinck (2003b). "Soil moves and behaves: Indigenous discourse on sustainable land management in Pichátaro, Pátzcuaro Basin, Mexico." *Geografiska Annaler-A* 85(3–4): 229–245.

Barrios, E. (1996). "Managing nutrients in the Orinoco floodplain." *Nature and Resources* 32(4): 15–19.

Barrios, E. and M. T. Trejo (2003). "Implications of local soil knowledge for integrated soil management in Latin America." *Geoderma* 111(3–4): 217–231.

Bellón, M. R. (1995). "Farmers' knowledge and sustainable agroecosystem management: An operational definition and an example from Chiapas, Mexico." *Human Organization* 54(3): 263–272.

Berkes, F. (1999). *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*. Philadelphia, Pennsylvania: Taylor and Francis Publishers.

Berkes, F., J. Colding, and C. Folke (2000). "Rediscovery of traditional ecological knowledge as adaptive management." *Ecological Applications* 10: 1251–1262.

Birmingham, D. M. (1996). "Learning local knowledge of soils: Improving linkages between land users and extension personnel." *Journal of International Agricultural and Extension Education* 3(1): 43–51.

Bocco, G. (1991). "Traditional knowledge for soil conservation in central Mexico." *Journal of Soil and Water Conservation* 46(5): 346–348.

Brouwers, J. H. A. M. (1993). "Rural people's response to soil fertility decline: The Adja case (Benin)." *Wageningen Agricultural University Papers* (93–94): 157.

Brookfield, H. (2001). *Exploring Agrodiversity: Issues, Cases, and Methods in Biodiversity Conservation*. New York: Columbia University Press.

Buol, S. W., F. D. Hole, R. J, McCracken, and R. J. Southard (1997). *Soil Genesis and Classification*. Ames: Iowa State University Press.

Coe, M. D. (1964). "The Chinampas of Mexico." *Scientific American* (211): 90–98.

Crossley, P. (2004). "Sub-irrigation in wetland agriculture: Evidence from the Chinampas of Mexico." *Agriculture and Human Values* 21(2): 87–101.

Denevan, W. M. (1970). "Aboriginal drained-field cultivation in the Americas." *Science* 169(3946): 647–654.

Denevan, W. M. (1980). "Latin America." In G. A. Klee (ed.), *World Systems of Traditional Resource Management* (pp. 217–244). New York: John Wiley and Sons.

Denevan, W. M. (2001). *Cultivated Landscapes of Native Amazonia and the Andes*. Oxford: Oxford University Press.

Descola, P. (1994). *In the Society of Nature: A Native Ecology in Amazonia*. Cambridge: Cambridge University Press.

Descola, P. (1996a). "Constructing natures: Symbolic ecology and social practice. Anthropological perspectives." In P. Descola and G. Pàlsson (eds.), *Nature and Society* (pp. 82–102). London: Routledge.

Descola, P. (1996b). *The Spears of Twilight: Life and Death in the Amazon Jungle*. London: Flamingo (HarperCollins).

Donkin, R. A. (1979). *Agricultural Terracing in Aboriginal New World*. Tucson: The University of Arizona Press, Volume 56.

Duchaufour, P. (1998). *Handbook of Pedology: Soils, Vegetation and Environment*. Rotterdam, The Netherlands: A. A. Balkema.

Dunning, N. P. (1990). "The implication of folk soil taxonomies for agricultural change in Middle America." *Conference of Latin Americanist Geographers* (17/18): 243–247.

Erickson, C. L. (1993). "The social organization of prehispanic raised field agriculture in the Lake Titicaca Basin." In V. L. Scarborough and B. L. Isaac (eds.), *Economic Aspects of Water Management in the Prehispanic World* (pp. 369–426). Greenwich: JAI Press.

Erickson, C. L. (1999). "Neo-environmental determinism and agrarian 'collapse' in Andean prehistory." *Antiquity* 73: 634–642.

Erickson, C. L. and K. L. Candler (1989). "Raised fields and sustainable agriculture in the Lake Titicaca Basin of

Peru." In J. O. Browder (ed.), *Fragile Lands of Latin America: Strategies for Sustainable Development* (pp. 230–248). Boulder, Colorado: Westview Press.

Faust, B. B. (1998). *Mexican Rural Development and the Plumed Serpent. Technology and Maya Cosmology in the Tropical Forest of Campeche, Mexico.* Westport, Connecticut: Bergin and Garvey.

Fujisaka, S. (1994). "Incorporating farmers' knowledge in international rice research." In D. M. Warren, L. J. Slikkerveer, and D. W. Brokensha (eds.), *The Cultural Dimension of Development: Indigenous Knowledge Systems* (pp. 124–139). IT Studies in Indigenous Knowledge and Development. London: Intermediate Technology Publications.

Gadgil, M., F. Berkes, and C. Folke (1993). "Indigenous knowledge for biodiversity conservation." *Ambio* 22(2–3): 151–156.

Gade, D. A. (1999). *Nature and Culture in the Andes.* Madison: University of Wisconsin Press.

German, L. (2003). "Historical contingencies in the coevolution of environment and livelihood: Contributions to the debate on Black Earth." *Geoderma* 111(3–4): 307–332.

Glaser, B., L. Haumaier, G. Guggenberger, and W. Zech (2001). "The 'Terra Preta' phenomenon: A model for sustainable agriculture in the humid tropics." *Naturwissenschaften* 88: 37–41.

Gómez-Pompa, A. and A. Kaus (1990). "Traditional management of tropical forests in Mexico." In A. B. Anderson (ed.), *Alternatives to Deforestation: Steps toward Sustainable Use of the Amazon Rain Forest* (pp. 45–64). New York: Columbia University Press.

Grossman, J. (2003). "Exploring farmer knowledge of soil processes in organic coffee systems of Chiapas, Mexico." *Geoderma* 111(3–4): 267–287.

Hammen van der, M. C. (1992). *Managing the World: Nature and Society by the Yukuna of the Colombian Amazonia.* Estudios de la Amazonia Colombiana (4). Bogotá: Tropenbos.

Haverkort, B. and D. Millar (1994). "Constructing diversity: The active role of rural people in maintaining and enhancing biodiversity." *Etnoecólogica* 2(3): 51–64.

Heckenberger, M. J., J. B. Petersen, and E. G. Neves (1999). "Village size and permanence in Amazonia: Two archaeological examples from Brazil." *Latin American Antiquity* 10(4): 353–376.

Hecht, S. B. (1989). "Indigenous soil management in the Amazon Basin: Some implications for development." In J. O. Browder (ed.), *Fragile Lands of Latin America: Strategies for Sustainable Development* (pp. 166–181). Boulder, Colorado: Westview Press.

Hecht, S. B. and D. A. Posey (1989). "Preliminary results on soil management techniques of the Kayapó Indians." *Advances in Economic Botany* 7: 174–188.

Licona Vargas, A. L., C. A. Ortiz-Solorio, D. Pájaro-Huertas, and R. Ortega Packza (1992). "Metodología para el levantamiento de tierras campesinas a nivel regional en ejidos del centro de Veracruz, México." *Agrociencia. Serie Agua-Suelo-Clima* 3(4): 91–105.

López-Austin, A. (1994). *Tamoanchan y Tlalocan.* Mexico City: Fondo de Cultura Económica, Sección de Obras de Antropología.

McEwan, C., C. Barreto, and E. Neves (eds.) (2001). *Unknown Amazon: Culture in Nature in Ancient Brazil.* London: British Museum Press.

Meggers, B. J. (1996 [1971]). *Amazonia: Man and Culture in a Counterfeit Paradise.* Washington, DC: Smithsonian Institution Press.

Martin, G. J. (1993). "Ecological classification among the Chinantec and Mixe of Oaxaca, Mexico." *Etnoecológica* 1(2): 17–33.

Moriarity, J. R. (1968). "Floating gardens (Chinampas): Agriculture in the old lakes of Mexico." *América Indígena* 28(2): 461–484.

Nazarea, V. G. (ed.) (1999). *Ethnoecology. Situated Knowledge/Located Lives.* Tucson: The University of Arizona Press.

Niemeijer, D. and V. Mazzucato (2003). "Moving beyond indigenous soil taxonomies: Local theories of soils for sustainable development." *Geoderma* 111(3–4): 403–424.

Ortíz Solorio, C. A., D. Pájaro-Huertas, and V. M. Ordaz-Chaparro (1989). "Manual para la Cartografía de Clases de Tierras Campesinas." *Cuadernos de Edafología* (15): 62.

Ortíz Solorio, C. A. and M. C. Gutierrez-Castorena (2001). "Mexican ethnopedology: The experience of soil mapping." In *Science and tradition: roots and wings for development* (pp. 89–106). Brussels: UNESCO/Académie Royale des Sciences d'Outre-Mer, Belgium.

Östberg, W. and C. Reij (1998). "Culture and local knowledge: Their roles in soil and water conservation." In H. P. Blume, H. Eger, E. Fleischhauer, A. Hebel, C. Reij, and K. G. Steiner (eds.), *Towards Sustainable Land Use: Furthering Cooperation between People and Institutions* (pp. 1349–1358). Advances in GeoEcology 31, Vol. 1. Reiskirchen: CATENA Verlag/ISSS.

Parker, E. (1992). "Forest islands and Kayapó resource management in Amazonia: A reappraisal of the *Apêtê*." *American Anthropologist* 94: 406–428.

Payton, R. W., J. J. F. Barr, A. Martin, P. Sillitoe, J. F. Deckers, J. W. Gowing, N. Habtibu, S. B. Naseem, M. Tenywa, and M. I. Zuberi (2003). "Contrasting approaches to integrating indigenous knowledge about soils and scientific soil survey in East Africa and Bangladesh." *Geoderma* 111(3–4): 355–386.

Peñafiel, E. (1885). *Nombres Geográficos de México.* Mexico City: Sociedad Mexicana de Geografía y Estadística.

Posey, D. A. (1985). "Indigenous management of tropical forest ecosystems: The case of the Kayapó Indians of the Brazilian Amazon." *Agroforestry Systems* 3: 139–158.

Posey, D. A. (2002). "Upsetting the sacred balance: Can the study of indigenous knowledge reflect connectedness?" In P. Sillitoe, A. Bicker, and J. Pottier (eds.), *Participating in Development: Approaches to Indigenous Knowledge* (pp. 24–42). London/New York: Routledge.

Pulido, J. S. and G. Bocco (2003). "The Traditional farming system of a Mexican indigenous community: The case of Nuevo San Juan de Parangaricutiro, Michoacán, Mexico." *Geoderma* 111(3–4): 249–265.

Raffles, H. (2002). *In Amazonia: A Natural History.* Princeton, New Jersey: Princeton University Press.

Reichel-Dolmatoff (1976). "Cosmology as ecological analysis: A view from the rain forest." *Man (N.S.)* II: 307–318.

Rist, S. and J. San Martin (1993). "Agroecología y

saber campesino en la conservación de suelos." *Agroecología*. Vol. 1: Cochabamba: Universidad Mayor de San Simon/AGRUCO.

Rist, S., J. San Martin, and N. Tapia (1996). "Andean concept of life and cosmovision." In B. Haverkort, W. Hiemstra, D. Millar, and S. Rist (eds.), *Compas: Platform for Intercultural Dialogue on Cosmovision and Agri-Culture* (pp. 13–19). Leusden, The Netherlands: ETC.

Röling, N. (1997). "The soft side of land: Socio-economic sustainability of land use systems." *ITC Journal* 1997 (3/4).

Roosevelt, A. C. (1989). "Resource management in Amazonia before the conquest: Beyond ethnographic projection." *Advances in Economic Botany* 7: 30–62.

Roosevelt, A. C., M. Lima da Costa, C. Lopes Machado, M. Michab, N. Mercier, H. Valladas, J. Feathers, W. Barnett, M. Imazio da Silveira, A. Henderson, J. Sliva, B. Chernoff, D. S. Reese, J. A. Holman, N. Toth, and K. Schick (1996). "Paleoindian Cave dwellers in the Amazon: The peopling of the Americas." *Science* 272: 373–384.

Sanabria, O. L. (1986). "El uso y manejo forestal en la comunidad de Xul, en el sur de Yucatán." *Etnoflora Yucatanense*. Vol. 2. Mexico: INIREB.

Sandor, J. A. and N. S. Eash (1991). "Significance of ancient agricultural soils for long-term agronomic studies and sustainable agriculture research." *Agronomy Journal* 83: 29–37.

Sandor, J. A. and N. S. Eash (1995). "Ancient agricultural soils in the Andes of Southern Peru." *Soil Science Society of America Journal* 59(1): 170–179.

Sandor, J. A. and L. Furbee (1996). "Indigenous knowledge and classification of soils in the Andes of Southern Peru." *Soil Science Society of America Journal* 60(5): 1502–1512.

Siemens, A. H. (1989). *Tierra configurada: investigaciones de los vestigios de agricultura precolombina en tierras inundables costeras, México*. Mexico City: CNCA.

Sillitoe, P. (1996). *A Place against Time: Land and Environment in the Papua New Guinea Highlands*. Amsterdam: Hardwood Academic.

Sillitoe, P. (1998). "Knowing the land: Soil and land resource evaluation and indigenous knowledge." *Soil Use and Management* 14: 188–193.

Sillitoe, P. (2002). "Globalizing indigenous knowledge." In P. Sillitoe, A. Bicker, and J. Pottier (eds.), *Participating in Development: Approaches to Indigenous Knowledge* (pp. 108–138). London and New York: Routledge.

Sillitoe, P., A. Bicker, and J. Pottier (eds.) (2002). *Participating in Development: Approaches to Indigenous Knowledge*. London/New York: Routledge.

Talawar, S. and R. E. Rhoades (1998). "Scientific and local classification and management of soils." *Agriculture and Human Values* (15): 3–14.

Terán, S. and C. Rasmussen (1994). *La Milpa de los Mayas: La Agricultura de los Mayas Prehispánicos y Actuales en el Noroeste de Yucatán*. Merida: DANIDA.

Toledo, V. M. (1992a). "What is ethnoecology? Origins, scope and implications of a rising discipline." *Etnoecológica* 1(1): 5–21.

Toledo, V. M. (1992b). "Pátzcuaro's lesson: Nature, production and culture in an indigenous region of Mexico." In M. E. Oldfield and J. Alcorn (eds,), *Biodiversity, Culture and Ecodevelopment* (pp. 147–171). Boulder, Colorado: Westview Press.

Toledo, V. M. (2002). "Ethnoecology: A conceptual framework for the study of indigenous knowledge on nature." In J. R. Stepp, F. S. Wyndham, and R. Zarger (eds.), *Ethnobiology and Biocultural Diversity: Proceedings of the Seventh International Congress of Ethnobiology* (pp. 511–522). Athens: University of Georgia Press.

Treacy, J. M. (1989). "Agricultural terraces in Peru's Colca Valley: Promises and problems of ancient technology." In J. O. Browder (ed.), *Fragile Lands of Latin America: Strategies for Sustainable Development* (pp. 209–229). Boulder, Colorado: Westview Press.

Treacy, J. M. (1994). *Las Chacras de Coporaque: Andenería y Riego en el Valle del Colca*. Lima: Instituto de Estudios Peruanos.

Whitten, N. E. Jr. (1978). "Ecological imagery and cultural adaptability: The Canelos Quichua of Eastern Ecuador." *American Anthropologist* 80: 836–859.

Wilken, G. (1987). *Good Farmers*. Berkeley: University of California Press.

Williams, B. J. (1975). "Aztec soil science." *Boletín del Instituto de Geografía, UNAM* 7: 115–120.

Williams, B. J. (1980). "Pictorial representation of soils in the Valley of Mexico: Evidence of the Códice Vergara." *Geoscience and Man* XXI (March): 51–62.

Williams, B. J. (1994). "Sixteenth century Nahua soil classes and rural settlement in Tepetlaoztoc." *Proceedings of the 15th World Congress of Soil Science*, Acapulco, Mexico (6a) (pp. 359–366). Mexico: ISSS.

Williams, B. J. and C. A. Ortíz-Solorio (1981). "Middle American folk soil taxonomy." *Annals of the Association of American Geographers* 71(3): 335–358.

WinklerPrins, A. M. G. A. (1999). "Local soil knowledge: A tool for sustainable land management." *Society and Natural Resources* 12(2): 151–161.

WinklerPrins, A. M. G. A. (2001). "Why context matters: Local soil knowledge and management among an indigenous peasantry on the Lower Amazon floodplain, Brazil." *Etnoecológica* 5(7): 6–20.

WinklerPrins, A. M. G. A. and J. Sandor (2003). "Preface to the Geoderma special issue on ethnopedology – 'local soil knowledge: Insights, applications, and challenges.' " *Geoderma* 111(3–4): 165–170.

Woods, W. I. and J. M. McCann (1999). "The anthropogenic origin and persistence of Amazonian Dark Earths." *Conference of Latin Americanist Geographers Yearbook* 25: 7–14.

Zimmerer, K. S. (1994a). "Transforming Colquepata wetlands: Landscapes of knowledge and practice in Andean agriculture." In W. P. Mitchell and D. Guillet (eds.), *Irrigation at High Altitudes: The Social Organization of Water Control Systems in the Andes* (pp. 115–140). Arlington, Virginia: American Anthropological Association.

Zimmerer, K. S. (1994b). "Local soil knowledge: Answering basic questions in highland Bolivia." *Journal of Soil and Water Conservation* 49(1): 29–34.

Zimmerer, K. S. (1996). *Changing Fortunes: Biodiversity and*

Peasant Livelihood in the Peruvian Andes. Berkeley: University of California Press.

Zizumbo, D. and P. Colunga (1982). *Los huaves: la apropiación de los recursos naturales*. Sociología *Rural*. Mexico City: UACH.

Address for correspondence: Antoinette M. G. A. Winkler-Prins, Department of Geography, 315 Natural Science Building, Michigan State University, East Lansing, MI 48824-1115, USA
Phone: +1-517-432-7163; Fax: +1-517-432-1671;
E-mail: antoinet@msu.edu