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Amazonian Dark Earths

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LEGACIES IN THE SOIL: A REVIEW ESSAY

These volumes [1], consisting of sixty-six chapters in about 1,223 pages, constitute a monumental contribution to research on anthropogenic soils of the Amazon basin. Contribution is rendered here in the singular out of deference to the fact that each of the three volumes exhibits the same title, the differences of content, or at least as it is perceived by the editors, who vary somewhat from volume to volume, being indicated only by distinctive subtitles. This contribution refutes, in essence, the adaptationist view of Amazonian indigenous societies, of intrinsic importance to *Tipití* readers, though such an intention was probably far from the thinking of most of the authors at the time they wrote their chapters. It is intriguing that this refutation takes place in light of what constitutes less than 1% of the forested part of the region's surface soils (Woods and Denevan 3.1:1). That small fraction, nevertheless, like the difference in DNA between humans and chimpanzees, takes on profound significance in terms of understanding not only agriculture, population, and settlement in the prehistory of the region, but also the potential applications of Amazonian anthropogenic soils to carbon sequestration, climate change, protection of diversity, and human welfare more generally on planet Earth, present and future.

The adaptationist view of Amazonian archaeology and ethnology had placed Amazonian soils, especially those of the tropical forest, long ago within a framework of environmental limitation. For the most part, Amazonian soils, as with tropical soils in general, are fragile and depauperate of nutrients. A perhaps typical statement on the soils of the tropical forest, and their relationship to indigenous society, made by the founder of cultural ecology, reads at mid-twentieth century as follows: "Soil exhaustion periodically required that it [i.e., the village] be moved to the site of a new plantation" (Steward 1963:699). The key term here is the verb "required." The adaptationist view is now perhaps more commonly called the standard model (Viveiros de Castro 1996; Stahl 2002); it refers to the environmental determinism of egalitarian societies in Greater Amazonia and the Atlantic Coastal Forest.

It may seem interesting that the standard model has been partly laid to rest by soil scientists, beginning with the late Wim Sombroek, to whom each of the three volumes is dedicated, three separate times. If studied closely, soil scientists perhaps have more in common with archaeologists than they do with other students of the land, such as geologists, since they deal with the often anthropogenic A and B horizons; in contrast, geologists obviously may examine strata having no human-mediated disturbance at all (such as volcanic interiors and levels inside the Earth's mantle). In this regard, editor William Woods' distinction between soils and sediments (1.1) is a good place to begin the entire discussion. Although Sombroek was not the first to identify the charcoal-black *terra preta* soils, which always contain potsherds from pre-Columbian peoples, and which he called "kitchen middens," as anthropogenic, he was the first to distinguish these operationally from *terra mulata*, which are grayish-brown soils on the Belterra Plateau near Santarém, of which he wrote: "It seems likely that this soil has obtained its specific properties from long-lasting cultivation. The gardens around the former Indian villages were probably situated here" (Sombroek 1966:175). These soils typically lack ceramics. The idea is that they represent a sort of compost, taken from within the village to the fields, to support what has since been called semi-intensive cultivation (Denevan 2.10; Denevan 2006).

Anthropogenic soils are swathed in a plethora of acronyms (see Table 1). The authors generally agree on calling them Amazonian Dark Earths (the term from Woods and McCann 1999), which cover a broad variety, in fact, of soils. There is a basic distinction, first recognized by Sombroek (1966:175-176), between his kitchen midden black soils, the *terra preta* or TP, with its potsherds, and the grayish-brown soils lacking in ceramics, the *terra mulata* or TM. The TM has since been found

Table 1. Meaning of Acronyms of Anthropogenic Soils Employed in the *Amazonian Dark Earths* Volumes

acronym	term	synonyms	comment
ADE	Amazon Dark Earth	Relic anthrosols (Lehman et al. 2.8)	includes all anthrosols of Amazonia
ABE	Archaeological Black Earth (e.g., Woods and Glaser 2.1; Ruivo et al. 2.7)	same as above	same
TP	*terra preta* or *terra preta do índio*	“kitchen midden”(Sombroek 1966); cultic archaeo anthrosol (Neves et al. 1.3); *tierra negra* in Colombia (Mora 1.11)	charcoal black A horizon soils with potsherds and lots of soil organic matter
TM	*terra mulata*	gray-brown garden soil (Sombroek 1966); also archaeo anthrosol (Neves et al. 1.3 ; *Tropische Plaggenböden* (Kämpf et al. 1.5); *tierra parda* in Colombia (Kern et al. 1.4)	“transitional” soils (Kern et al. 1.4) ; i.e., some authors see these as transitional between TP and TC (*terra comum*) [not an anthrosol]
TPN	*terra preta nova*	“New Black Earth” experimental anthrosol	made from biochar=pyrogenic carbon=charcoal

outside the Belterra Plateau, such as in the Central Amazon (Neves et al. 1.3), so Sombroek’s initial discovery was not isolated, and it has led to a revolutionary new debate about origins and management, if any, of these soils. Debate essentially hinges on intentionality (German 2003; Kämpf et al. 1.5; Myers 2.6; Erickson 1.23): did people purposefully make dark earths for agricultural purposes or not? The evidence is tantalizingly inconclusive, or perhaps it is empirically too rich, to answer the question simply one way or the other.

Some of the chapters in volumes one and especially three are exceedingly technical. It would certainly help one to have a PhD degree in organic chemistry to understand them—add to that advanced training in GIS, nuclear magnetic resonance, plant genetics, DNA fingerprinting using clone libraries, fluorescence microscopy, and somewhat more than cursory acquaintance with current trends in the more mundane fields of experimental field biology, electromagnetics, and molecular and soil biology, and one will have reasonably good background for comprehension of several chapters. Even so, it is perhaps not overly taxing for most anthropologists, even social and cultural ones like the present reviewer, to recognize that soils can indicate human activity on the landscape, or as Lehmann et al. (1.6) call it, the soilscape. Anthrosols in Amazonia, or Amazon Dark Earths (ADE) [Woods and McCann 1999], which are soils made consciously or not by human activity, are simply good ground for agriculture.

Compared to primeval soils around and under them, ADE are sandy loams, high in nutrients, low in acidity, and more or less dark to charcoal-black in color. The key indicator of human activity, when looking at the ground, is elevated levels of phosphorus (P), which has been known as an indicator-element of human activity since at least the early twentieth century (Woods 1.1), and which is found in ADE mostly in its compound form as phosphate [P_2 O_5] (Kern et al. 1.4, Kern et al. 2.3, Van Hofwegen et al. 3.22, German 2.4, Coomes 2.5, Lehmann et al. 2.8, Falcão et al. 3.11). Some but not all the writers think this P derives from bone, specifically human bone from burial inside ancient houses; others think most of the P is coming from ceramics (see below). ADE also show high levels of carbon (C), nitrogen (N), and calcium (Ca) (Woods 1.1, Kern et al. 1.4, 2.3, Falcão et al. 3.11, Sombroek et al. 1.7). Also found in high levels are Magnesium (Mg) (Kern et al. 1.4, Kern et al. 2.3), Manganese (Mn) (Kern et al. 1.4, Kämpf et al. 1.5, Kern et al. 2.3), and Zinc (Zn) (Kern et al. 1.4, Kern et al. 2.3). These elements taken together form part of what is called SOM (soil organic matter). In addition, ADE have the electromagnetic property of high CEC (cation exchange capacity) meaning that they retain nutrients well, which is another way of saying that they do not tend to be leached easily, and therefore tend to remain productive, in an agricultural sense, over long stretches of time. ADE are less acid (have a higher pH—Woods 1.1) than surrounding primeval soils; pH correlates negatively with aluminum (Al^{3+}) content (Falcão et al. 1.14), and positively with organic carbon (OC) and P levels (Ruivo et al. 2.7, Arroyo-Kalin 3.3) in the soil.

Black carbon, which is the same as charcoal, pyrogenic carbon, and biochar, is believed to be the principal source of the color of the Amazon Dark Earths as well as the reason for retention of nutrients. Microbial activity (Tsai et al. 3.15) leads to increased carbon sequestration (Glaser et al. 1.8; Sombroek et al. 1.7). That is what makes ADEs of interest in research on climate change. The higher and more diverse the microbial activity, the better the soil (Tsai et al. 3.15), and ADE is richer and more diverse in microbes than surrounding soils, even though millions of these species remain to be identified precisely and literally *a million separate taxa can be contained in only 10 grams of soil* (Tsai et al. 3.15). A significant proportion of the microbes in ADE are different from the microbes in the surrounding primeval soils (Thies and Suzuki 1.16; specifically, they are less likely to have Acidobacteria perhaps because of higher pH—Tsai et al. 3.15). This difference suggests, in my reading, an anthropogenic contribution to microbial diversity in the Amazon, a remarkably intriguing and still living, even evolving legacy of the pre-Columbian Dark Earth people.

Charcoal is produced by incomplete combustion (sometimes called a "cool burn") of organic material and it is what is responsible for retaining SOM at high levels in ADE (Glaser et al. 1.8., German 1.10, Teixeira and Martins 1.15), which cannot result from slash-and-burn cultivation, a "hot burn." Charcoal is wood that is not completely burned up into the atmosphere. Partly for that reason, several authors believe that charcoal was added (or amended) to otherwise impoverished Amazon soils to make them more or less continuously productive in a system of semi-intensive cultivation (the term from Denevan 2.10, Denevan 2006) and that this would have preceded slash-and-burn cultivation in Amazonia. It would have been semi-intensive, not intensive, because a short-fallow period would have obviated weed problems (see below).

Such a belief had been already logically enabled by Denevan's (1992) insightful note concerning the rarity of stone, the complete lack of iron (unlike Africa—Fairhead and Leach 3.13), and hence the unlikelihood of prehistoric Amazonian agriculture based on a swidden system, as documented by ethnographers of the twentieth century, who witnessed, for the most part, indigenous societies using steel, not stone axes, to fell trees in making their small and temporary agricultural clearings, the steel, of course, not having been manufactured by themselves. An explanation was needed to account for kilometers-long, linear bluff villages that were "densely inhabited" by thousands of people and "thickly covered" with hundreds of dwellings (Myers et al 1.2:15), as reported in Carvajal's account of the Orellana 1541-42 descent of the Amazon River. For if people did not have swidden agriculture, they likely had some form of food production, including reliance on alluvial soils as well as soils behind the floodplain (e.g., Herrera et al. 1992, Neves and Petersen 2006, Rebellato et al. 3.2), that could guarantee long term settlement. We now know in the Central Amazon and elsewhere along Orellana's descent of the existence of Amazon Dark Earths (e.g., Neves et al. 1.3, Myers 2.6). Perhaps these soils guaranteed settlement stability there and in other places, such as Araraquara, an ADE site on the Caquetá River in Colombia (Herrera et al. 1992; Mora 1.11).

All ADE have charcoal content and it is responsible for more than just color. That is the one part of the ADE equation that Sombroek did not understand in 1966, nor did anyone else for that matter, but which he later grasped thoroughly when proposing TPN (*terra preta nova*), the creation of a new agricultural soil based on ancient technology, a vision still being worked on in applied soil science, which could be used to improve tropical soils. Charcoal contributes not only to coloration of ADE but also to nutrient retention, productivity, CEC, and stability of SOM, believed by many authors to be at the physical and chemical center of the anthrosols. Anthrosols are also sweet in smell; their aromatic structure is due to the charcoal (Glaser et al. 2.2, Steiner et al. 2.14, Cunha et al. 3.20).

All these issues come together in the question of soil color. The darkness of ADE is directly influenced by the presence of charcoal content (Falcão et al. 1.14). Several authors employ the Munsell color chart to classify this color, which to *Tipití* readers may sound familiar from classic research on nomenclature and classification of color cross-culturally in cognitive anthropology (Berlin and Kay 1991). In ADE research, the use of Munsell color charts and color classification is related to understanding how color can index physical and chemical properties of soils, such as texture, P, and age (Rebellato et al. 3.2) and has nothing to do with local perception (cf. German 1.10). In addition, CEC, nutrients, and microbes are functionally interconnected by electric charges on the surface that affect nutrient cycling and retention (Woods and Glaser 2.1), all of which is reflected in soil color (Thies and Suzuki 1.16). The Munsell color chart can be used to distinguish "black ebonic" (a tag for TP) from "dark grayish" (a tag for TM) (Kämpf et al. 1.5), even though in practice, according to critics of ADE classification schemes to date, perhaps because color is a continuous not a digital phenomenon, it has been difficult to draw a hard and fast line between where TP ends and TM begins on this basis alone (Erickson 1.23, Madari et al. 1.21, Ruivo et al. 1.13). One thing is fairly obvious though: TP has higher mean values of OC, P, Ca, Mg, pH, and CEC than TM, and both are higher in these values than surrounding TC, which is to say, primeval soils.

Less clear are the duration and intensity of settlement involved in the original formation of ADE, a problem first addressed by Nigel Smith

(1980), who suggested that ADE had accumulated at 1 cm every 10 years in prehistory. Neves et al. (2.9; also Neves and Petersen 2006) counter that by suggesting it may have developed at a much faster rate than in the Central Amazon, in the context of semi-intensive cultivation and TM (Denevan 2.10). Denevan (2.10) is careful to point out that the evidence of permanent settlements in late prehistory is inferential. This care is evidently taken in recognition of the catastrophic and rapid loss of population due to introduced disease suffered by the Dark Earth people after 1541, and the absolute paucity of ethnohistorical observations on ADE. [2] If semi-intensive cultivation existed, which would have supported permanent settlement, a "relaxation" of intensification took place with the collapse of population following 1541 (Myers et al. 1.2: 20). Early depopulation is, in fact, a confound as to ADE use in the past (Neves et al. 1.3). Therefore, one has to be more reliant on ethnographic analogy than ethnohistory to understand its formation (Silva 1.19, Fraser et al. 3.12, Hiraoka et al. 1.20, WinklerPrins 3.10).

It would be good to see more on sociopolitical organization. Earthworks and networks of all sorts in prehistory evince complexity the likes of which are unknown in the ethnographic record of the twentieth century. Roads, as Myers et al. (1.2:16) well point out, "exist only among friends and allies" and roads, we know, in 1541-42 were found leading away from the Amazon River to points unknown in the interior. Nimuendaju spoke of roads 1.5 m wide that linked ADE sites to each other on the Santarém Plateau (Kern et al. 2.3). Prehistoric raised fields, causeways, mounds, and ring-plaza (now being called ring-ditch) settlements (Erickson 1.23) are also found in Bolivia, Acre, Rondônia and elsewhere. These sites are typically associated with ADE. It is not clear exactly how people made these sites.

Although we do not know exactly how the Dark Earth people lived, we have some indications of the arrangements of settlements along the main stem of the Amazon River. They were long, linear, bluff settlements with economies based in agriculture and aquatic resources and they would have cultivated alluvial as well as *terra firme* ground (Denevan 1996). The sizes of ADE patches vary from a few hectares to several square kilometers (Schmidt and Heckenberger 3.8). The areas behind contemporary houses, and behind the plazas of ancient settlements tend to be higher in P than front yards and plazas themselves (Neves et al. 1.3). It is true settlements vary in time, and vary ethnographically in space (Myers 2.6). An argument for intentionality of composting of ADE is explicitly put forth by Myers (2.6: 92) as "purposeful spread of compost over abandoned habitation areas." These would be Sombroek's garden soils or TM regardless of the exact color. So far, the discussion has largely been horizontal; Rebellato et al. (3.2) are seeking to develop methods to understand the verticality of ADE. Arroyo-Kalin (3.3) clearly makes the point humans do not make vertical deposits in nature randomly. They dig pits (like graves for tombs, holes for houseposts, and compartments for hordes of goods) which interrupt natural stratigraphy, or what obtains from the random shufflings about of the animals that burrow into and disturb the terrain. But "bioturbation" which involves mixing of A and B horizons (the uppermost layers of the soil) of ADE has not yet shown conclusively intentionality, despite the coherence of its objective. Even so, as one knows from historical ecology, the landscape changes along with historic and economic dynamics over time (Fraser et al. 3.12), and people no doubt recognized this, even in their own lifetimes.

Regardless of whether contemporary peasant societies claim ADE to be "natural" (German 1.10) soil [3] and not anthropogenic, that does not mean that the Dark Earth people of prehistory were not consciously making it. To risk a shopworn phrase, the technology is not rocket science, and because of the weediness that often goes with ADE (Myers et al. 1.2, Clement et al. 1.9, Thayn et al. 3.14, Falcão et al. 3.11), there could have been reasons why people preferring mobility rather than permanence of settlement might not have wanted to make and invest time in ADE, if there were such people coexisting with the Dark Earth people. If the Dark Earth people could have understood English, though, they probably would have readily taken the point of Shakespeare's Hamlet when he told his mother in Act III, Scene IV:

> "Confess yourself to heaven,
> Repent what's past, avoid what is to come,
> And do not spread the compost on the weeds
> To make them ranker" (RS 1974:1169).

Weediness is a condition of these soils. Weeds are pre-adapted to human activity (Clement et al. 1.9). It is difficult to point to specific indicator species of ADE, however, as apart from human-mediated sites in general (Clement et al. 1.9). In any event, weediness on ADE in the present can be a reason for why these soils are not more extensively used, or why in some cases they are misused or not used at all (German 1.10, Major et al. 1.22, Thayn et al. 3.14). People who have ADE work harder, perhaps, than people who don't have them. Interestingly, some invasive species on ADE of the Central Amazon are actually useful, cultivated species elsewhere where ADE does not occur. This is the case with arrow cane, called *limorana* (or "false lime tree") in the Upper Amazon, where it is an aggressive weed on ADE plots (Fraser et al. 3.12); to the Ka'apor in the Eastern Amazon, the same species of grass (*Gynerium sagittatum*) is not a weed. Rather, it is the cultivated source of their arrow shafts (Balée 1994:56). One man's invasive species may be another's tool for getting the *pièce de resistance* out of the forest and onto the table, so to speak. Arrow cane is not, incidentally, an introduced invasive species, for it is native to South America.

If one takes a Boserupian viewpoint, namely, that people are by nature lazy and don't work harder unless they absolutely have to, this suggests that the use of ADE, specifically TM, would have been intentional since it would have involved additional work. It certainly seems to have involved longer settlement duration. Myers states the productivity of TP can last hundreds even "thousands of years" and that "it is self-regenerating" (2.6: 67). Teixeira and Martins (1.15: 284) have experimental evidence of continuous cultivation of ADE at Iranduba (near Manaus) since 1974, where it has been cultivated for at least forty years, and is "still very productive." According to Mora (1.11), the ADE at Araraquara on the Caquetá River is what guaranteed settlement stability over time. As to the intentionality of ADE, the questions have been posed most articulately, in my view, by Laura German (2003:312) as follows:

> As cultural acts, settlements are 'intentional,' as are agricultural practices, waste treatment and other activities carried out within settlements. Yet even though the many processes that have been claimed to contribute to Black Earth formation are each intentional cultural acts, does this mean that Black Earth as an *outcome* of these processes is also intentional?

For German (2003), intentionality exists only where fertility enhancements occur that result in improved crop yields. One could get this with TM, for example. ADE, regardless of type, originates from many sources (Neves et al. 1.3). These include human bone, bones of fish and game, soot, ash, charcoal, hard carpels of fruits, nuts, seeds, ceramic vessels, human excrement, dyes, oils, fibers, and chelonian carapaces (Arroyo-Kalin 3.5; Balée 1989; Kern et al. 1.4; Neves et al. 1.3; Smith 1980). Some debate seems to ensue over the phosphate sources. Kern et al. (2.3) argue for human bone being the principal source due to ethnographic and archaeological evidence of urn burials inside habitation sites, but Lima da Costa et al. (1.17) suggest the phosphate in ADE derives from ceramic artifacts. Also Neves et al. (1.3: 46) point out that in some cases, potsherds constitute up to 10-25% of the volume of the soil itself in ADE sites. This accords well with a finding reported by the late Kenneth Lee that around 13% of the soil in a habitation mound in the eastern Bolivian Amazon, near the Ibibate mound complex of the Sirionó Indian habitat (Erickson and Balée 2006), was pure ceramics (as recounted in Balée 2000: 31), and it would not be surprising to me if much of the phosphate is indeed ceramic-derived. At the same time, these mounds are also burial mounds. It seems in these pages to be less debatable that the high levels of Ca in ADE are derivative of bone, probably much of it human (Kern et al. 1.4, Kern et al. 2.2, Falcão et al. 3.11). As to specifics, Erickson (1.23: 482) makes the cogent point that it is difficult to understand today exactly what went into the soil when past uses of the environment could have been quite different. Before the Europeans brought salt, for example, indigenous societies had to make their own, and this would have involved lots of burning up of organic matter, probably palm trunks. Also certain kinds of firewood were probably needed in firing the pottery that remains a significant constituent of these soils, even though in most ethnographic contexts people no longer make pottery, or little of it compared to pre-Columbian times.

Estimates of the age of ADE vary from as old as 8700 BP (Liang et al. 2006) [which ancient date is not reported in the three volumes incidentally] to 500 BP (Lehmann et al. 1.6) with clustering around 1500 BP (Kämpf et al. 1.5). Refinement of understanding of the age of ADE is probably in order as more dates come in because the extreme limits vary somewhat. Kämpf et al. (1.4) say the oldest dates of ADE are 4800 BP; Lehmann et al. (1.6) claim 2500 BP; Lima da Costa et al. (1.17) report ADE is not older than 2000 BP, which seems conservative. Woods and Denevan (3.1) indicate the oldest dated carbon at 2450 BP. I suspect from the evidence available thus far that what is likely is that the ADE was becoming more and more common in the time frame of 2500-2000 BP and that this rough period will become confirmed with more radiocarbon dates of more sites in the future. The archaeologists in the volumes tend to lean to Lathrap's original association of the Barrancoid tradition and a presumable "population explosion" and subsequent migration out of the Central Amazon, which would have coincided at about AD 200 with *terra preta* (Myers 2.6). The question remains, however, if they had ADE, and if it was so productive, which it is obviously is, why would they have needed to move?[4] Or were other people simply copying them? Lathrap had put his finger on something, and although he could not answer it completely, this something was not in keeping with the standard model.

The standard model was paradigmatic in the 1970s and early 1980s in American ecological anthropology; according to Hecht (3.7:145) in her masterful chapter, "Read today, these ethnographies are striking in their ahistoricism." After the 1970s, Sombroek's work in ADE, and the fact that no one with the relevant data could seem to confirm the environmental limitation hypotheses of the standard model, would begin to have an effect on understanding prehistory in the 1980s and 1990s, with the coming of the notion that people had affected Amazonian landscapes and biota of the past (Posey and Balée 1989; Balée 1989; Denevan 1992b), and the further refinement of understanding of the possibility of intentionality in the development of the ADE by geographers (Woods and McCann 1999). This work was foundational in the historical ecology of Amazonia (Erickson 1.23), even if not all the authors identified their work as such, or did not do so at the time.

ADE research before Sombroek did not involve disputes over the fertility of ADE, only its origins: one either considered it a case of geogenesis or anthropogenesis. Oddly enough, ADE was not discovered until the late nineteenth century; it was noted by American and German scientists, working independently of each other (Woods and Denevan 3.1). Into the mid-twentieth century, most authors thought its origins were natural, either deriving from volcanic activity or ancient lakebeds. Pioneers of ethnography, Nimuendaju and Farabee, actually reported independently in the early decades of the twentieth century on *terra preta* soils near Santarém, with Nimuendaju mapping them (Woods and Denevan 3.1). It was Sombroek who first clearly showed the indigenous origins of ADE with his discussion, however brief, of TM (Woods and Denevan 3.1), and that is one of the principal reasons these volumes were dedicated to him.

The final and perhaps most important finding of Wim Sombroek's, which is his vision, is TPN, *terra preta nova*, which is the notion of applying pyrogenic carbon to improve existing tropical soils and crop yields (Madari et al. 2.13, Tsai et al. 3.15, Steiner et al. 2.14, Steiner et al. 2.15, Kern et al. 3.18). This is being carried out in the context of what is being called slash-and-char (making of charcoal and applying it to clearings) as opposed to slash-and-burn, in an effort to improve soils on selected experimental plots, where it is found that charcoal amendments are key to understanding the recalcitrance, or retention, of organic matter, and presumably, productivity (Steiner et al. 2.14, 2.15). It seems that TPN, in addition to getting amendments of pyrogenic carbon, also needs some mineral fertilization to be productive continuously, at least in some experiments (Birk et al. 3.16). Some of this work is highly experimental (e.g., Lehmann et al. 2.8, Steiner et al. 2.15, Steiner et al. 3.17, Birk et al. 3.16) and involves microbial responses to pyrogenic carbon amendments, and some of the long-term nutrient retention properties seem inconclusive. The work is ongoing, exciting, and perhaps representative of the future of applications. There is much potential here for ethnography as well, in the sense that more of it is needed, as Winkler Prins (3.10) points out in her illuminating chapter.

For the reader who has borne with me to this point, s/he has withstood perhaps the sticker shock of a bottom line of $717, exclusive of shipping and handling, for all three volumes. If I could only afford one of the three, it would be the third. It is the most substantial of the three. Volume two is the least substantial. Volume 1 is the first and in some ways holds pride of place for that reason, but it also was published six years before the third volume, and in that time, advances in the field took place and these are reflected in the third volume. The third volume is also less expensive than the first. On the other hand, the first volume does not have an online version. If I were to have an extra $100 or 125 dollars to spend, I might buy the first volume and purchase four pdfs from volume 3 online at the Springer website. The third volume contains 28 chapters sold by Springer + Business Media at $25 per chapter. If I had to recommend four chapters for purchase they would be as follows: 1) on history of research—Woods and Denevan (ch.1); 2) on formation of ADEs—Arroyo-Kalin (ch. 3); 3) on ADEs and refutation of the standard model—Hecht (ch. 7); and 4) on experiments and potential applications for increased agricultural productivity: Steiner et al. (ch. 17). In point of fact, however, I commend the complete set—all three volumes—to science and Latin American reference libraries, the latter herewith enjoined at least in part because of the significant archaeological, ethnographic, and historical contributions therein to be found.

The *Amazonian Dark Earths* volumes are of major importance and I applaud their publication, though not without noting some minor reservations. There are inconsistencies in terminologies and acronyms concerning the soils themselves, a point touched on by Erickson in his retrospective and somewhat critical summary of the first volume (1.23). These are rendered in various languages (English, German, Dutch, Portuguese, Spanish) but are not often readily glossed cross-linguistically. ABEs (archaeological black earths) were discussed at length in numerous chapters in volume 2, but appear to have fallen by the wayside by the time of volume 3 and were not mentioned at all in volume 1. Ferrasols (e.g. Kern et al. 1.4), which is the term for the old Latasol (e.g., Ruivo et al. 2.7) is elsewhere called Oxisols (Schmidt and Heckenberger 3.8:167) and that is because different authors are using different standardized terms, whether from FAO (Food and Agricultural Organization) or the Brazilian National soil classification system, or some other national soil science standard terminology, such as German or Dutch. I find this state of the science confusing and not conducive to interdisciplinary communication. Kämpf et al.'s (1.5) lengthy classification scheme of ADE seems overly complex and artificial, but to their credit, they ask readers for "critique" and input. The editors of the different volumes do not elaborate the theoretical framework of their books but leave this to individual chapters, such as Hecht (3.7) and Erickson (1.23). What seem to be missing are detailed overviews of all three volumes and synthetic summaries. In addition, with the exception of volume 3, the indexes are rather truncated and of little use, and there are no glossaries, which could have been useful for the uninitiated in any of the various sciences brought together under what is otherwise a fascinating topic.

In summary, and despite these reservations, these volumes stand in the aggregate for the most important contribution to date on anthrosols of Amazonia. They are a tribute to the Dark Earth people of pre-Columbian times who can no longer speak for themselves obviously, but who have nevertheless left legacies in living soil now opened up for viewing and study by the world in the pages of these texts. These will be required reading for scholars in various fields with interests in tropical agriculture, tropical soils, Amazon archaeology, South American Indians, biological and landscape diversity, and historical ecology. This contribution is destined to become a classic benchmark in the field.

NOTES

1. I denote individual chapters by author(s), volume number, chapter number, and sometimes page number. For example, Fraser et al. (3.12: 230) or alternatively (Fraser et al. 3.12: 230) would refer to page 230 in the chapter by Fraser, Cardoso, Junqueira, Falcão, and Clement, which is number 12 of the third volume in the series (*Amazonian Dark Earths*, ed. by W.I. Woods et al., 2009).

2. Despite Orellana's plea to the Spanish crown in 1545 for authorization to make a second trip to ascend the Amazon River, that monarchy had little interest in such a venture because by the 1494 Treaty of Tordesillas, such lands already pertained to Portugal anyway, at least around the mouth of the Amazon. The Spanish explorers in Peru may have wanted to find El Dorado, which they thought was east of the Andes. Initially it must be said, their interest, and Columbus' interest in the New World was not in gold, but rather, like Marco Polo two hundred years before them, spices—and the Amazon was not an exception. In fact, before Orellana descended the Amazon River, he and Gonzalo Pizarro were looking for cinnamon "la canela" in the Land of Cinnamon, also called El Dorado, the land east of the Andes, not just gold (Medina 1988: 214). The Portuguese evidently had little interest in these lands at that time also, given the rewards they were reaping from the spice trade in Asia, having successfully rounded the Cape of Good Hope in 1497-98. They would not expel the French from Maranhão until 1615 and the Dutch, English, and French from the area of the mouth of the Amazon and extending up to the Xingu River until 1616, upon founding a fort at what would become the city of Belém (Edmunson 1903:649). At least in part for these reasons, the documentary record for Amazonia when

compared to the rich documents of the *cronistas* of coastal Brazil south of the mouth of the Amazon river, is decidedly impoverished regarding the early period (Porro 1996:7).

3. The Araweté Indians of the Xingu River basin traditionally grow maize in *terra preta*. They call *terra preta* by the term *ywy-howy-me'e* ("blue soil"). The forests growing on top of these *terra preta* sites, however, they refer to as primary forest (*ka'ã-hete*) and the potsherds found in these soils they claim to have been of divine, not human origin (Balée 1989:13 and n. 9). One could argue, of course, that divinities are ancestors, too, depending on perspective (see Viveiros de Castro 1992). In any event, nonhuman origins, or natural origins of anthrosols, however "nature" is understood locally, is not unique to caboclos, in the case of Laura German's interlocutors. It is probably not universal either, because as I have noted, the Ka'apor (who do not have *terra preta* in their habitat), distinguish between high forest (*ka'a-te*) and anthropogenic forest (*taper*) systematically (Balée 1994).

4. Perhaps one of the ironies of Lathrap's relatively premature death in 1990 at the age of 62 is that he did not live to see his basic ideas more or less vindicated. He was a precursor of Amazonian historical ecology (Balée 1995: 98), though he did not use that term, and he served as the mentor of two of its current practitioners, Clark L. Erickson and Peter W. Stahl. Betty Meggers, who trained few students fully and no PhDs to my knowledge, outlived Lathrap considerably, but her ideas have not.

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