

DISCOVERY AND AWARENESS OF ANTHROPOGENIC AMAZONIAN DARK EARTHS (TERRA PRETA)

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“Somewhere, Something Incredible Is Waiting To Be Known”

Words of a brilliant and wise man, Carl Sagan. And indeed, some of the things we will be talking about over the next two days are incredible and have only recently become known. Amazonian dark earth is incredible for its own sake, but even more so because of its implications for sustained cultivation, energy generation, global warming, and forest survival. In the Brazilian Amazon these anthropogenic soils are called terra preta do indio, or black soil from the Indians, mostly created by them hundreds, even thousands, of years ago.

Our task is to review the history of the discovery, awareness, and early research on Amazonian dark earths. However given that I am the first presenter, I will begin with a brief introduction to what these soils are.

BACKGROUND

The major sources of energy in the world today are non-renewable fossil fuels which release pollutants and CO₂, creating major health hazards and global warming. These sources will be depleted in the near future. A cleaner and sustainable fuel can be derived from hydrogen, produced from waste biomass, of which there are vast quantities on the earth. A potential by-product of biomass fuel is black carbon from

charcoal, which we are beginning to realize can be applied to and stored or sequestered in soil as CO₂ sinks, and to improve crop productivity and long-term soil sustainability and in the process help subsidize the cost of producing bio-energy.

Awareness of the importance of carbon for soil fertility comes from different directions of research, but particularly influential, and what this first session is about, is iAmazonian dark earth, both terra preta proper which is black, and terra mulata which ii is lighter or brownish in color. These dark earths probably occupy at least 0.1-0.3 percent, or 6,300 to 18,900 square kilometers of forested lowland Amazonia according to Sombroek et al. (2003), but others estimate 1.0 percent or more. They occur in a variety of climatic, geologic, and topographic situations, with depths of up to about 2.0 meters.

The black terra preta is associated with long-enduring, Indian village sites, and is filled with ceramics, animal and fish bones, and other cultural debris. The brown terra mulata, on the other hand, is much more extensive, generally surrounds the black midden soils, contains few artifacts, and apparently is the result of semi-intensive cultivation over long periods. Both forms are much more fertile than the surrounding highly weathered reddish soil, mostly oxisol, and they have generally sustained this fertility to the present despite the tropical climate and despite frequent or periodic cultivation. This is probably because of high carbon content and an associated high microbial activity which is self-perpetuating.

The carbon in terra preta comes from kitchen fires and village refuse burning, and in terra mulata probably from in-field burning of organic debris (weeds, crop residues, thatch, branches from adjacent forest, etc.). Low intensity “cool” burning,

what has been called “slash and char,” resulting in incomplete combustion, can produce carbon in high quantity which can persist in soil for thousands of years. Dated carbon in terra preta is as old as 450 B.C. (Petersen et al, 2001:100). In contrast, slash and burn shifting cultivation fires today tend to be “hot” fires, set at the end of the dry season, which produce large releases of carbon dioxide to the atmosphere and more ash of brief persistence than charcoal.

As part of this story, I have argued that in pre-Columbian times the use of stone axes made long-fallow shifting cultivation very inefficient, and as result probably uncommon until the European introduction of metal axes (Denevan, 2001:116-119). Previously, soil fertility must have been maintained and improved by composting, mulching, and frequent in-field burning, making semi-permanent cultivation possible with only brief fallowing. Over time, these activities could have produced fertile, self-sustaining dark earth soils.

This has been a brief overview of current knowledge and thinking about Amazonian dark earths. More details will be provided in the presentations by Clark Erickson, Susanna Hecht, William Woods, Johannes Lehmann, and others in this symposium.

DISCOVERY AND AWARENESS

The significance of terra preta in Amazonia reached international awareness in 2001-2002. Geographers, archaeologists, and soil scientists from the U.S., Germany, Brazil, the Netherlands, and Colombia came together at three international conferences in Benicassim in Spain and in Rio de Janeiro and Manaus in Brazil. These meetings led

to books edited by Johannes Lehmann and colleagues in 2003 and by Bruno Glaser and William Woods in 2004; widely read articles in Science, The Atlantic Monthly, and Der Spiegel; the BBC/Horizon/Discovery video program on “The Secret of El Dorado” in 2002; a display at the British Museum Exhibition on “The Unknown Amazon” in 2001; and other scientific articles, media reports, and interviews.

One might have expected that the widespread and still cultivated dark earths in Amazonia had previously been well studied and were well known outside the region, but such was not so. The first published mention of dark earth in Amazonia, “black and very fertile,” was in 1870 by the American geologist and explorer James Orton, a professor at Vassar, in his book The Andes and the Amazon, dedicated to Charles Darwin who had corresponded with Orton. By 1879 there were additional published reports of this soil by Canadian geologist Charles Hartt (1874), his assistant Herbert Smith (1879), and by the British geologists Brown and Lidstone (1878:270-271)). The black earth accounts of all of these people are primarily for the Santarém region of the lower Amazon. They all knew one other and interacted. But why in the 1870s?

One influence was the famous Louis Agassiz Expedition to the Amazon in 1865-66, on which Hartt was a member. More important was the establishment in the Santarém area of settlements of former Confederate Civil War soldiers and their families starting in 1867. These Confederados learned about the black soils from local farmers and established highly productive crops of sugar cane and tobacco on them. The English-speaking travelers just mentioned naturally visited the English-speaking colonists and observed their soils and fields.

One of the most detailed descriptions is from Herbert Smith (1879:144-145, 168-169, 238, 271, 308), who wrote that this was “the best [soil] on the Amazons... a fine, dark loam, a foot, and often two feet, thick..[which] owes its richness to the refuse of a thousand kitchens for maybe a thousand years... [in one stretch] it forms almost a continuous line...thirty miles long... and strewn over it everywhere we find fragments of Indian pottery so abundant in some places they almost cover the ground...like shells on a surf-washed beach.” So Smith, and also Hartt and Brown/ Lidstone, clearly recognized the anthropogenic origin of these soils.

The first chemical description of terra preta was not for another 25 years, in 1903 by the German Friedrich Katzer, also a geologist, who identified the high organic matter content in the soil, the fine carbon particles giving the black color, and suggested a cultural origin. He estimated that there were 50,000 hectares of terra preta on the Belterra plateau south of Santarém.

From the 1920s into the 1970s, various soil scientists and others noted and commented on these soils; however more attention was given to debating whether terra preta was natural or anthropogenic than to soil analysis. Included were North American anthropologist William Farabee in 1921, the Brazilian agronomist Felisberto Camargo in 1941, the French geographer Pierre Gourou in 1949, and Brazilian pedologist Italo Falesi in 1967 (also 1974). One argument, now rejected, was that terra preta was formed by the accumulation of organic material in former lakes and ponds and that these sites attracted Indian settlement, thus accounting for the cultural debris present.

The first mapping of terra preta site locations was by the German-Brazilian

anthropologist Curt Nimuendajú (1952) from 1923 to 1926 - 65 sites east and west of Santarém, almost all being along bluffs where large linear sectors of the soil occur.

Wim Sombroek from The Netherlands published his important book Amazon Soils in 1966. Only a few pages are given to terra preta; however he made a distinction between black terra preta derived from village middens and brownish terra mulata, a term he introduced to the literature, which he believed, “obtained its specific properties from long-lasting cultivation.” He was the first to suggest this as far as we know. In 1966 he questioned whether it was “economically justifiable,” in his words, to create and cultivate such soil today; however more recently he changed his mind. He mapped the distribution of terra preta and terra mulata along a bluff of the lower Rio Tapajós (Sombroek, 1966:175). More recently he promoted the idea of developing new dark earth as carbon stores and sinks and for intensive cultivation, what he called “Terra Preta Nova” (Sombroek et al., 2003).

Sadly, Sombroek passed away last year. Both of the recent Dark Earth books are dedicated to him, “The Godfather of Amazonian Dark Earths.” He would have wanted to have been here at this conference, full of contagious enthusiasm and ideas.

In 1980, Nigel Smith, a geographer at the University of Florida, published a landmark article summarizing what was known about terra preta, including from his own field work along the TransAmazon Highway. One thing that became clear from Smith’s research was that some sectors of terra preta were quite large, as much as 350 hectares or 3 and 1/2 square kilometers, both on bluffs and in the interior. Linear bluff sites are as long as 6 kilometers, lending support to the claims by the first Spanish

expeditions down the Amazon in 1542 and 1561 that some villages extended continuously for many leagues, suggesting that there were quite large villages supported by intensive cultivation. Much of the major Amazon River city of Santarém, site of the center of the Tapajos Chiefdom reported by the Spaniards, is apparently underlain by terra preta, possibly 500 hectares in all.

Nigel Smith's 1980 article is frequently cited, and it clearly has been influential. Until then, reports about terra preta generated little attention. After 1980 groups of terra preta researchers can be identified, particularly in Germany and Brazil, also in Colombia, and somewhat later, surprisingly, in the U.S., leading to significant articles in the late 1980s and the 1990s.

At Bayreuth University in Germany, soil scientist Wolfgang Zech and his students first published on Amazonian dark earths in 1979, an analysis of the distinctive characteristics of the soil. This was followed by several theses and then a flurry of articles starting in the late 1990s on black carbon, organic matter stability, micromorphology, chemical and mineralogical analysis, and microbiology. This German-initiated research has been continued under Bruno Glaser and others at Bayreuth (e.g. Glaser et al, 2001) and by Johannes Lehmann and his students at Cornell University.

In Brazil, Marcondes Lima da Costa, Nestor Kampf, and Dirse Kern have been working on terra preta soils since the late 1980s, and they are now leaders of a large group of Brazilians. Kern's 1996 dissertation under da Costa, and subsequent articles, on the geo-chemistry of black earth archaeological sites at Caxiuana in eastern Amazonia have been particularly influential.

In Colombia, major projects were initiated on terra preta and terra mulata sites at Araracuara along the middle Río Caquetá starting in 1977, involving archaeologists, soil scientists, and paleoecologists, particularly Leonor Herrera, Angela Andrade, Santiago Mora, and initially the late British geographer Michael Eden (e.g. Mora et al., 1991). Some Araracuara village sites were occupied almost continuously for over 800 years, highly unusual in the neotropics.

In the US these Amazonian dark earth studies elsewhere initially aroused little interest. I first learned about terra preta from the Brazilian-American geographer Hilgard Sternberg, who had examined such soil on Careiro Island near Manaus in 1950-1953 (Sternberg, 1998:107-110). I assigned Nigel Smith's 1980 article to my classes and seminars at Wisconsin, and I talked about these soils with colleagues, believing that this was an exciting phenomenon. Eventually this led to a small project in 1994 in the Santarém region involving geographers and anthropologists at Wisconsin and geographer-archaeologist-soil scientist William Woods. This was followed by dissertation research by geographer Joseph McCann (2004) and by soils field work and lab analyses by Woods (Woods and McCann, 1999; McCann, Woods and Meyer, 2001). Archaeologists Michael Heckenberger, James Petersen, and Eduardo Neves (2001) excavated large, long-lasting villages on dark earths in the Upper Xingu region and along the lower Rio Negro in the 1990s.

These groups, previously mostly working independently, coalesced and interacted at the three mentioned international conferences held in 2001-2002. The leadership of Woods, and also Lehmann, Glaser, and Kern, and the guidance and enthusiasm of Sombroek, were keys to the successful integration of diverse people at

these meetings and in the books that followed. In the Lehmann (2003) volume there are 55 authors and co-authors, and in the Glaser/Woods (2004) volume there are 27 authors and co-authors. Some chapters have as many as seven co-authors from four different countries and three different disciplines. This work represents an explosion of knowledge about Amazonian dark earths in less than ten years. However, there is still much more to be learned about these remarkable soils of human origin and their potential for today's world. This research is well underway, as evidenced by this conference.

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