

The Terra Preta Revolution

New Look at Ancient Soil Management Technique

ACRES U.S.A. interview with *Charles C. Mann*



*A consummate journalist with a deep personal interest in the prehistory of the Americas, Charles C. Mann brings together in **1491: New Revelations of the Americas Before Columbus** astounding insights by a host of heretofore unpublicized experts, who talk about a different America before the arrival of Columbus, an America that was heavily populated, with architecture and agriculture much more sophisticated than that of Europeans in the same period. The Americas were a far more urban, populated, and technologically advanced region than generally assumed, and the natives, rather than living in static harmony with nature, radically engineered the landscape across the continents: to the point that even natural features such as the Amazon rainforest and the Eastern woodlands can be seen as products of human intervention—literally managed "parks" or orchards.*

Most astonishingly, recent discoveries reveal an ancient soil management technique in the Amazon (Magic Soil of the Lost Amazon, Feb. 2007). Thousands of years before Europeans arrived, civilizations there had buried charcoal and pottery sherds in tropical soils to make them productive. Terra preta, or "black earth," still remains bountiful 500 years later. Charcoal acts like a coral reef for soil organisms and fungi, creating a rich micro-ecosystem where organic carbon is bound to minerals to form rich soil.

ACRES U.S.A.: *Terra preta* soils were first reported to universities in the United States around the time of the Civil War and yet no one paid attention to it academically until recently. Right now there seems to be a *terra preta* information explosion. What's that about?

CHARLES C. MANN: Highly fertile areas in the Amazon have been known for a very long time, but it's fair to say that their significance was not appreciated until quite recently, and it's rapidly spawned an international movement to understand how and when it was made and what potential impact it could have around the world. There's a large collaboration called *Terra Preta Nova* that was largely established by the late Wim Sombroek—quite an amazing guy. He was a soil scientist from the Netherlands who established an outfit called ISRIC—the International Soil Research and Information Center. It's a think tank about soil, the world's first—and for all I know—the only one that attempts to collect together all the information scientists know about soil around the world, how it's made, etc. I'm sure readers of **ACRES U.S.A.** can appreciate what an important thing such a repository of information is and can also probably imagine how radical a suggestion something like this was in 1960 or thereabouts, when he put his ideas into action.

ACRES U.S.A.: How did he get so excited about soils?

MANN: He traveled all over Brazil and sampled soils, tried to understand how they worked there, and at that point he came across *terra preta* and got very excited. He couldn't get anybody else interested in it, though, and he went on to do other things like large studies about soil degradation around the world—almost all of the statistics on this topic come from ISRIC. Anyway, he was the director, and late in life after he retired, he went back to *terra preta* and began trying to interest people in it again. Through ISRIC, he gathered together Brazilian researchers, many of them from the Amazon region, and a number of archaeologists who had independently been investigating this and some geographers and some soil scientists. The soil scientists were, by and large, from Germany or Austria,

the Brazilians were from various research agencies, and the archaeologists were largely a group called the Central Amazon Project, which was led mainly by three researchers, one Brazilian, Eduardo Goes Neves; the late James Petersen, who is from the University of Vermont; and Michael Heckenberger, who is from the University of Florida. They started finding these *terra preta* archaeological digs using carbon-dating data and the result of all this sort of independent work came to fruition with a series of scientific meetings and publications. Almost all of them quickly came to believe that *terra preta* was not a natural phenomenon, instead it was what they call "anthropogenic" (manmade), deliberately created by people. They began to map its extent, a process that's still underway, and to understand how it was created.

ACRES U.S.A.: *Terra preta* quality varies from site to site, apparently made with different materials and techniques.

MANN: There are two types of *terra preta*—*terra preta proper* and *terra mulatta*. The bulk of it seems to be *terra mulatta*. The *terra preta* is this very rich, black earth, and the *terra mulatta* is a slightly less rich, browner earth. *Terra preta* is probably even more fertile than the *terra mulatta*. They're both made in the same way, but it looks like *terra preta* was closer to people's houses and probably has much more a mixture of household garbage in it—that may explain the difference between them. They also sometimes call them Amazonian Dark Earths (ADE).

ACRES U.S.A.: Is *terra preta*'s higher quality due to compost?

MANN: In these societies, the areas right around the houses and cooking areas, all the melon rinds and that kind of stuff gets mixed in with the soil when it falls down, as opposed to the sort of deliberate composting that will spread it more thinly.

ACRES U.S.A.: Some people have suggested that the higher quality of *terra preta* is due to the incorporation of humanure in the soils. Do you know if this was a practice?

MANN: Very probably. Certainly in *terra preta* there is some of it and, so far as I know, in *terra mulatta*. They had outhouses

of a sort, and whether the night soil from outhouses was mixed up and became part of *terra preta* or whether it was deliberately put into the terra mulatta, which was under most of the agricultural usage, is not well established. We just don't know.

ACRES U.S.A.: We've heard figures that indicate as much as 30 percent of the Amazon Basin is composed of manmade soils.

MANN: A lot of people would say that the area of soils that have been affected by human beings is something on that order, possibly even higher—but it's certainly not that high for *terra preta*. The Amazon Basin is so big, even 10 percent of it is the size of France, so 30 percent would be something like the size of a good chunk of Western Europe. The figure is probably somewhere between 1 and 10% for *terra preta* and terra mulatta. Nobody really knows, though—we keep finding more of the stuff. Whatever the exact figure might be, by the time you're getting to 1%, you're talking about *thousands of square kilometers*—an enormous area—enough to feed an enormous number of people. Population estimates of the Amazon Basin are on the order of 5 to 10 million at the time of Columbus, so you only needed enough *terra preta* to feed that population, and a few percent of the Amazon Basin is *plenty*. In terms of acreage, it's much, much more than, say, Yucatan, where a much smaller area fed a much larger population of Maya.

ACRES U.S.A.: Is anyone trying to determine the full extent of this ancient technology?

MANN: There's a project at the University of Kansas to do this, but they haven't even started yet. Their idea is to find some kind of signature of *terra preta* in the vegetation, some kind of mineral or something that is taken up by the vegetation and gives off a particular wavelength of light, which could then indicate locations of *terra preta* in satellite photos. The search has barely begun, but it seems likely that they will find something and ultimately that will be how we know the true extent of *terra preta*. Right now we know it's all over the half of the Amazon, up and down the river, up and down the major tributaries. This summer, the Central Amazon Project with Dr. Eduardo Neves is going to begin excavating in western Amazonia on the Madeira River, which is far up the Amazon Basin, and they believe there are some *terra preta* deposits there that are thousands of years old.

ACRES U.S.A.: We've heard some dating for *terra preta* soils that are rather confusing. We've heard it said that some soils are 700 years old and that others might be 2,000 years old. Why is this?

MANN: Scientists are still trying to figure it out. I can give you some answers, but bear in mind, they're not definitive. On the basis of the fragmentary data we have, the oldest deposits of *terra preta*, up by the Bolivian border and on the Peruvian border with Brazil, far up the Amazon Basin, look like they started somewhere around 1500 or 2000 B.C., *Terra preta* contains lots of charcoal, which can be carbon dated. The reason it gets to be tricky is that if you're in zero A.D. and you cut down a 500-year-old tree and make it into charcoal, the carbon in the tree will be older than your fire, right?

ACRES U.S.A.: So in this case, science can date raw materials but not human actions?

MANN: Right. So you need studies on various samples to try and eliminate this problem, and we simply haven't done enough yet. Anyway, the fragmentary data that we do have seems to suggest that the oldest stuff is from the west—it probably dates

back to 1500 or 2000 B.C.—and it looks like the technology spread from west to east, very slowly, so that by about 1000 A.D., it was right up on the Atlantic Coast and along the coastal areas.

ACRES U.S.A.: Was *terra preta* technology associated with any particular group of people?

MANN: Nothing definitive, but the directional movement of *terra preta* development seems to follow a migration of Arawak-speaking people from west to east—displacing Tupi-Guarani-speaking people—at roughly the same time and the same pace.

ACRES U.S.A.: Can you talk more about how these people actually created *terra preta*?

MANN: The technique itself is really quite interesting. The first thing you should note is that these *terra preta* deposits are incredibly stable. Part of the reason that tropical soils are so poor, as you probably know, is that they're physically battered by the rain. The rain comes down very hard and washes away whatever is on top and turns it into kind of a slurry. Then the sun comes out and bakes it, eventually turning soil into something that resembles brick—what ecologists call a "wet desert." That's the reason there's justified concern about cutting down the forest—you'll ruin the land by doing that. *Terra preta*, however, despite going through these same punishing physical conditions, is extremely stable and fertile for a very long time. This soil has been fertile for literally thousands of years in some cases, and that's quite remarkable. Much of that stability seems due to its charcoal content. Japanese researcher Ogawa tested to see how long it takes for charcoal to release carbon into the air, and typical time periods were 50,000 years. So charcoal retains its physical characteristics—it's really durable stuff—for a very, very long time. That's why Amazon farmers today can find *terra preta* deposits that were laid down thousands of years ago and haven't been used for hundreds of years. At those locations, you can literally rip up the soil and immediately start planting.

ACRES U.S.A.: As you know, specimens of *terra preta* are not legally available to lay researchers here in the United States. We've never even actually seen the stuff, so there are lots of questions. One would be: is this truly an indestructible soil?

MANN: It's not supernatural—you *can* exhaust it, but properly taken care of, it's really great stuff. The technology seems to be relatively simple, although we are still far from understanding all the details. In basic terms, the first step is to convert ground cover into charcoal. That's not hard to do, you just have a low fire rather than a hot fire. It's a charring, smoldering fire, a low-temperature burn—a "cool burn," as it's sometimes called—which, interestingly enough, produces relatively little carbon emissions. A hot fire, by contrast, emits most of the carbon in the form of carbon monoxide and carbon dioxide. In low-intensity flames, charcoal can keep up to 85 or 90 percent of its carbon content, which from a global warming perspective is pretty interesting—if you cut down the same trees and just let them rot, a very large percentage of that carbon would be lost to the atmosphere. Next you crush the charcoal and you stir it into the soil, along with, in many cases, unfired pottery, smashed pieces of plates, etc. It appears that putting the pottery in there promotes circulation—water and nutrients can keep circulating around—and it prevents the soil from contracting into something like brick, as we were discussing. The third element—and this is the least understood at the moment—appears to be a special set of biota, of microorganisms.

ACRES U.S.A.: The secret ingredient, so to speak?

MANN: We know so little about the micro-world, about the ecology of soil. We can't even grow most of the organisms found in the soil—we can grow 1 or 2 percent of all those organisms. It appears that there are certain characteristic species of microorganisms—bacteria, fungi and so forth—that are in *terra preta*, and some researchers believe although this is very speculative—that when these people made a new batch of *terra preta*, they would take some soil from an older batch and put it into the new batch—a little like sourdough starter. In this way these microorganisms could be transported all the way across the Amazon Basin.

ACRES U.S.A.: Is it possible that pre-Columbian Indians who made *terra preta* inoculated their fields with microbial cultures?

MANN: Well, if you saw the same microorganisms in many, many different places in the Amazon, you would start to wonder how that happened. Variation in microorganisms in the Amazon, just as anywhere else, is pretty high—species that are at the mouth of the Amazon aren't necessarily upriver. Thus, when we find these cultures again and again over such a wide geographical area, there are two possibilities—one is the use of a "mother culture" inoculation, the other is that the combination of charcoal and ceramics inevitably produces these microorganisms because they're the only ones that can survive in that environment.

ACRES U.S.A.: Have any *terra preta* researchers published papers on microbial scenarios that produce soils of this quality?

MANN: Research into the biology of these soils is very much ongoing. It will take a number of years to work out because there are microbiologists, fungi specialists, bacteriologists, biologists, all kinds of them, investigating the soil and what grows there, then looking at multiple generations—it's a long and complex process.

ACRES U.S.A.: Have you heard of *terra preta nova*, a movement to create *terra preta* soils without using inputs from the archaeological *terra preta*?

MANN: Yes—Johannes Lehmann, leader of the Cornell group, has been exploring this with Christoph Steiner. They basically said, let's take a batch of this *terra preta*, and then take some patches of earth and add charcoal and see if anything happens. They were surprised to find that the simplest things had big impacts. This wasn't even the full *terra preta*—it was, "let's stick some charcoal in there; now let's add some charcoal and put a little fertilizer on it, just to see what happens." They found dramatic differences in yields. In some experiments, they found something like 800 percent yields—just amazing.

ACRES U.S.A.: Are studies done on the chemical makeup of *terra preta* charcoal? Is there a possibility that a particular type of charcoal from a particular type of tree is necessary?

MANN: There are lots of questions about how you make the charcoal, how big the chunks should be, etc. All these kinds of things have to be examined, where you take ten plots and add big chunks of charcoal and ten plots where you add little. Researchers explore variants—"let's try it now in different soils." "What happens in temperate soils?" That kind of thing. A critical mass of research is forming, and we will soon know much more than we do today.

ACRES U.S.A.: Is this research being published?

MANN: Yes, and it's ongoing. A couple of books have come

out, both of them edited by prominent *terra preta* researchers. *Amazonian Dark Earths: Origin, Properties, Management* was edited by Johannes Lehmann, Dirse C. Kern, Bruno Glaser and William Woods, and *Amazonian Dark Earths: Explorations in Space and Time* was edited by Glaser and Woods. There's also a third book coming out, maybe in the next year or two, and there are whole conferences exploring this topic.

ACRES U.S.A.: Given the pre-iron technologies of the era that created *terra preta*, do archeologists have any idea of how the charcoal was worked into the earth?

MANN: That's an excellent question. Could they have dug it in somehow? The exact procedure they don't know. Just a couple hours north of Manaus, they have discovered a group of 100 Amazonian Indians still making it. They're using shovels and digging it right in, but we don't really know how they would have done it in the past—it may have been as simple as residue from agricultural practices. When they cut down trees to clear fields, they would girdle them and burn the trees slowly in these mounds of dirt. Maybe over time as they were preparing fields, this stuff was simply incorporated into the soil. We still don't know the answer, as far as I know.

ACRES U.S.A.: Does it have to be dug in? Is it possible it was just put on the soil surface and became incorporated over time?

MANN: You want to dig it in, dig fairly deep. In some cases they're amazed to discover charcoal extending 8 feet deep.

ACRES U.S.A.: This was done with wooden tools?

MANN: Yes; it's really amazing. That's a significant amount of work, done over a significant amount of time.

ACRES U.S.A.: Natives who currently make *terra preta*, how much of their original culture do they retain? They're making *terra preta*, but they also wear sunglasses and ride motorbikes?

MANN: No, sort of in between. They're very poor people by modern Western standards, who live semi-traditional lives and aren't terribly dependent on the Western market, but you can spot Western influences easily—they wear T-shirts and so on.

ACRES U.S.A.: Do you have any information on how these modern people are making the charcoal for *terra preta*?

MANN: Susanna Hecht, a geographer at UCLA observed and lived with the Kayaps back in the 1980s. She didn't understand that she was watching them make *terra preta*, because she didn't know the concept, but that's what they were doing. Hecht said that to live with them is to live in "a landscape that smolders." They're constantly making these low fires everywhere, and there are many, many religious practices that involve planting and so forth. I don't know if she said anything specifically about rituals involving *terra preta*, but since there was so much of this in every other aspect of planting and agriculture, it seems likely that it would apply to *terra preta*, as well.

ACRES U.S.A.: In *terra preta* discussions, corn culture often comes up, but I get the impression from your book the original cultures weren't into annual plants like corn, but grew them in patches while they waited for nut and fruit trees to start bearing.

MANN: By and large, what they seem to have been doing was agri-forestry, and the idea would be that you'd slowly cut down these trees. It's an enormous number of trees, and it was very, very arduous to cut them down with stone axes. Thus, they would gradually cut down little areas of forest and bring down trees, turn them into charcoal, stir them into soil, and probably plant annual crops for a little while. The primary concern,

however, was with managing the succession. Tree species had the advantage of multiple years, they also had the advantage of preserving the canopy, and some of these species were just fantastic. One of them was peach palm (*Bactris gasipaes*), which has many different common names. This tree was supposedly to their culture what the buffalo was to the Plains Indians. Every aspect of the tree is useful—you can actually make wine from the sap, they have tremendous heart of palm, the fruits are full of very good palm oil and also chock full of proteins, the bark is very tough and can be used for tools, and the list goes on and on. This is a species originally from the western Amazon that people propagated all over the Amazon.

ACRES U.S.A.: Was that transitional period; the period when annuals were planted and orchard trees had not yet come of size, similar to today's slash-and-burn farming?

MANN: If you just leave land bare, you'll soon be choked out by weeds, and weeds in the Amazon are very aggressive. So they would plant manioc or other crop, but what they'd really be concerned with were the shoots they were planting of the peach palm or the ice cream bean or acai palm and all these other wonderful, useful species—in effect, creating a new, artificial forest that was more useful to humans, filled with food trees—papaya and all those species. They'd also get a couple years of manioc. So it wasn't slash-and-burn in the way we think of it.

ACRES U.S.A.: Yet *terra preta* does involve burning forests.

MANN: But with slash-and-burn, you burn down the forest, you get this quick little pulse and grow crops for a few years, and then you get choked by weeds and cut something else down. Ancient Amazon agriculture is a much more sustainable idea—you're concerned about *creating a new forest*—that's the reason you thin and clear the old one. Instead of leaving an area open and will regenerate in 15 or 20 years, you actually create an area that you're going to harvest for the next 30 years.

ACRES U.S.A.: Was all charcoal-making done by burning logs where they lay, or was there other technology involved?

MANN: Yes, there are dome-like structures that operate much like the new wood-burning stoves—you can control them so they burn very, very clean and have relatively low oxygen inside. The ones I've seen are buried under earth rather carefully, with just enough oxygen holes to let wood smolder.

ACRES U.S.A.: Many people prefer to believe that *terra preta* was simply a byproduct of human habitation, not something intentionally created. How do you speak to this?

MANN: On some level this question is unanswerable, because we don't have direct access to those people. Most researchers with whom I talked believe it was made intentionally, simply because there was so much labor involved and it was done so consistently over such a long period and over such a large area.

ACRES U.S.A.: Why did the civilization that created *terra preta* disappear so completely? The Inca and Mayans left behind wondrous stone structures, but these people seem only to have left this wondrous high-humus soil.

MANN: They didn't have stone architecture, but they had lots of wood! You can do very clever things with wood. In fact, my wife, who is a professor of architecture, uses some Native American wooden structures as examples in her classes of how to do very clever things with very simple means. If you saw some of their structures done in glass and stone, you would think they were clever modernist masterpieces.

ACRES U.S.A.: Is it true Japanese government is supporting the use of *terra preta* technology in Japanese agriculture?"

MANN: Yes. The Japanese have been very interested in this for a very long period of time—and for kind of a strange reason. In the 1960s they said, "Wait a minute—we can't keep heating things with coal because of pollution. They set up a think tank to look at alternative uses for coal and, among other things, began researching what happens if you bury charcoal in the ground. They're basically trying to figure out energy alternatives so these people aren't thrown out of work by Kyoto protocols.

ACRES U.S.A.: In your book you discuss the incredible mound cultures that ranged from the Great Lakes to Florida. One thing was clear: these people were able to produce enough food with a few laborers to feed all the people that were working on very large structures. Did these people have some form of agriculture or did they live from the hunt?

MANN: They *did* have agriculture. What is interesting is that before corn and beans, the standard Native American cooking, an earlier type of agriculture called Eastern Agriculture Complex used a lot of species that are now regarded as weeds. I would like to see some of those crops tried today. I mentioned in my book that although corn had been around for a while, it just wasn't proved and adopted for hundreds of years—until about 1000 A.D. Then it started becoming popular and displaced this whole earlier kind of agriculture.

ACRES U.S.A.: Is there any truth to the story there is no archaeological record to account for the development of corn—that there is a lot of little corn in sites. And then *bam!* Ears of size of modern corn show up. There is no transition.

MANN: It's a little more complicated than that. There's much they don't understand about the development of the original corn. Even many of the varieties Indians were growing when the Europeans came were very small. But corn is incredibly diverse, so there are some giant varieties—it's a big puzzle as to how it all worked. It isn't just a simple gap, it's just that we don't really understand where all these different variables came in.

ACRES U.S.A.: Is it true natives in the Eastern U.S. routinely set forest fires to keep woods clear for the game they preferred?

MANN: Yes. It wasn't throughout the Eastern forest, but they did in many places—again, this wasn't forest-fire type burning but somewhat lower burns to clean up the landscape—killing off underbrush and new shoots and so forth—and creating these very park-like areas. This is a great practice for bringing in a lot of game—a lot of animal browsers, including buffalo.

ACRES U.S.A.: In closing, do you know of other manmade soils anywhere in the world that might compare to *terra preta*?

MANN: There's something called *plaggen* soils that are somewhat similar. They were used in Germany and Holland until the 19th century and involve the forced incorporation of large volumes of manure and straw and other bio-mass in the soil. The result is a dark soil with long-term fertility.

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For more information on *terra preta*:

www.css.comell.edu/faculty/lehmann/terra_prete/TerraPretahome.htm