Amazonian Dark Earths: Wim Sombroek's Vision

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Logo on back cover: Symbol of the Terra Preta Nova group designed by Wim Sombroek.
Picture on front cover: Wim examining a house garden on the Rio Negro, July 2002.

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Dr Wim G. Sombroek

He had a passion for land as we know
Fueled by the Amazon where jungles grow
A flame that didn't flicker or even go out
His last endeavour Terra Preta still to shout[1]

Wim Sombroek joined the International Soil Museum in Wageningen as a Director in 1978. Long before that, we knew him as a respected soil scientist, who obtained a Ph.D. in Wageningen for his thesis on the Amazon soils, and had carried out extensive soil surveys in Kenya. These illustrated his enthusiasm for field work and for building upon these primary data – the basis for the establishment of the International Soil Museum as a link with the Soil Map of the World project carried out at FAO in Rome.

We remember his many new ideas to make our institution more widely known under the new banner of International Soil Reference and Information Centre (ISRIC). He had an enormous drive to implement new projects. It was a wise decision to accept the task of Secretary-General of the then International Soil Science Society (ISSS), now International Union of Soil Sciences (IUSS). Through this combination of functions over twelve years, he was able to carry out innovative ISSS activities at ISRIC, and play a prominent role internationally, in particular directed to the needs of developing countries.

Wim initiated activities in the further development of a world soil classification system, which finally resulted in the *World Reference Base for Soil Resources* (WRB); the Laboratory Exchange project (LABEX) to improve the performance of soil laboratories in developing countries, in which more than 100 labs participated; the *National Soil Reference Collection* (NASREC) project to develop national soil profile collections in more than 30 countries; and not least the *Soil and Terrain digital database program* (SOTER), which started in 1986 and has carried the initiative of the FAO-Unesco Soil Map of the World through to the twenty-first century,

[1] Excerpt from a poem entitled "Thanks, Wim!" by Richard W. Arnold.

and the framework of the *World Inventory of potential Soil Emissions* (WISE) a unique soil data set that is still used by many researchers.

Wim left ISRIC to become Director of the Land and Water Development Division of FAO, where he was also active in land use issues related to climate change in the framework of the International Panel of Climate Change. His ties with ISRIC were not severed and, after his tenure in Rome, he returned to the Amazon where his heart was, but one foot in an office at ISRIC. He worked on the economic zoning of the Brazilian Amazon, to safeguard parts of this huge but threatened forested region as protected reserves, and develop economical viable systems of sustainable land use.

Thirty years after his thesis, in which he discussed the importance of the *Terra Preta*, he showed the relevance of this pre-Colombian agricultural technique for the development of enhanced carbon sequestration in agricultural land – the *Terra Preta Nova*.

The Terra Preta network has developed enormously in recent years, and includes more than 100 scientists. Two books on the Terra Preta have been published in the meantime, and a symposium on these soils during the 18th World Congress of Soil Science in 2006 was dedicated to his memory.

We, at ISRIC and within the IUSS, are proud that Dr. Wim G. Sombroek has been our Director and friend, and that the work he initiated continues and develops – in the field, in laboratories, institutes and museums, carried out by dedicated researchers in so many disciplines.

On behalf of retired and present ISRIC staff members,

Hans van Baren

Thanks, Wim!

Each of us has a story to tell this day
Of meeting Wim Sombroek along the way
He touched our lives in ways oft untold
And helped us become ‘champions with gold’

He had a passion for land as we know
Fueled by the Amazon where jungles grow
A flame that didn’t flicker or even go out
His last endeavour Terra Preta still to shout

What made this man a man to remember?
Dedication from January to December?
Ready zeal to impart his vast knowledge
To those who never had seen a college?

Perhaps it was the breath of his interests keen
Archaeology nearby, within, without – to be seen
And wild orchids gardened in an exotic place
In his green house always finding space

Was it not the pillars there at home?
Wife Willemijn and four girls that led him roam
Whose constancy supported his very being
Welcomed his return late in the evening?

What do you recall when you hear his name?
A towering presence with moustache and mane
Blue eyes twinkling through gold-rimmed glasses
A fat little notebook shock full of addresses

Or may be the pause as he ‘rolled’ his own
Smoke rising gently as softly it was blown
Or the patient way he slightly leaned over
Catching our phrases like blossoms of clover

I, too, have a special way to recall –
Several clusters of Dutch bulbs one fall
He planted along my garden maze
Now each spring he brightens my gaze

I hear his laughter, feel his handshake
I treasure the moments we dared to take
To dream our dreams, to vision the future
Returning to Pedology, our souls to nurture

Are we mourning – never; rejoicing – ah, yes, ever
Along with insights, strength, and wisdom so clever
There was gentleness, love, and tenderness, too
Wim Sombroek, our hearts give thanks to you.

Richard W. Arnold 1-15-04

A Few Words About Wim Sombroek

The first time I met Wim Sombroek was actually the second time I met him, though I didn't realize it till later. I also didn't realize that in both cases Wim was doing something he had been doing his whole life: trying to attract the world's attention to soil, and to soil science. I am a journalist, and both times I was introduced to Wim I had a notebook and pen in my hand and wanted to talk to him about his research on *terra preta do índio* – anomalously rich, charcoal-thick soils, created by native peoples in the Amazon Basin. Eventually we became friendly and I learned how many and various his interests were. But it was only after he passed away that I fully grasped what he was trying to accomplish. He wanted to change and expand the discipline of soil science itself, with *terra preta* as a hortatory example.

This second time when I met Wim (or, as I thought, the first time) was at a *terra preta* conference at a hotel in Manaus. Someone I was talking to pointed at a silver-haired man with an impressive moustache who was nursing a beer at a table in the lobby bar. "That's Wim Sombroek," I was told. "You ought to talk to him." I went over and introduced myself. One thing led to another, and many hours later we were drinking beer with a large group in another part of Manaus. I asked how long he had been interested in *terra preta*. "A few years," he said, or something to that effect. The amused glint in his blue eyes suggested to me that he was understating the case, an impression that was confirmed when he told me about the soils at his parents' home in the rural Netherlands.

He was ten years old during the Hongerwinter — the Dutch famine of 1944–45, in which more than 10,000 people died. Sombroek's family survived on the harvest from a tiny plot of *plaggen* soil: land enriched by generations of careful fertilization. His parents further improved their land, he told me, by scattering the ash and cinders from their home fireplaces. In the 1950s, Wim went to Brazil and encountered more charcoal-filled earth: *terra preta*. Naturally, it reminded him of the *plaggen* in his parents' yard, and he paid attention. His book, *Amazon Soils*, included the first sustained study of *terra preta* and a map of its distribution along the lower Rio Tapajós.[1]

[1] Sombroek WG (1966) Amazon Soils: A Reconnaissance of the Soils of the Brazilian Amazon Region. Wageningen, the Netherlands: Center for Agricultural Publications and Documentation (map on p. 175).

As Wim told this story I suddenly realized that I had met him almost a decade before, in the early 1990s. At that time two groups of researchers were embroiled in a lengthy fight over the extent and cost of soil degradation. One side, led by entomologist David Pimentel, of Cornell University, charged that "nearly one-third of the world's arable land has been lost by erosion" since the 1950s. Soil loss, Pimentel and his collaborators said in 1995, already cost the world "$400 billion per year, or more than $70 per person per year."[2] The other side, often identified with economist Pierre R. Crosson of the Washington environmental-research group Resources for the Future, responded that Pimentel's figures had "such thin underpinnings that [they] cannot be taken seriously." The annual toll of erosion-induced on-farm productivity losses in the United States was, in Crosson's estimation, no more than $600 million.[3] (Off-farm costs might well be higher, he said, but neither Pimentel nor he had tried to assess them.)[4] The debate spilled outside academia – Crosson, as I recall, once found himself on National Public Radio, trying to explain the Universal Soil Loss Equation to a bewildered interviewer.

For a long time, one of the more striking features of the debate was the near-absence of soil scientists themselves from the discussion. Indeed, almost 20 years passed between the time soil-degradation fears first stirred alarm and the first published estimates of global soil degradation. In 1990, the International Soil Reference and Information Center (ISRIC) in Wageningen, the Netherlands, finally filled the gap, releasing the Global Assessment of Soil Degradation. This major effort was undertaken at the initiative of Wim Sombroek, then ISRIC's director (and, simultaneously, Secretary General of the International Society of Soil Science).[5]

When I learned about GLASOD, as the assessment was called, I contacted Wim. We met when he came to the United States for, I believe, a meeting in Washington, D.C. GLASOD, he told me, was a first step toward answering an urgent question in soil science — the size, location and character of degraded soils around the world. But the assessment also had a second purpose. All soil scientists know that, as Will Durant said, "Ultimately every civilization is based upon the soil."[6] But all

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[2] See, e.g., Pimentel D et al. (1976) Land degradation: effects on food and energy resources. Science 194:149–55. Pimentel D et al. (1995) Environmental and economic costs of soil erosion and conservation benefits. Science 262:1117–1123 (quotes on 1117, 1120)

[3] See, e.g., Crosson PR (1986) Soil erosion and policy issues. In: Phipps TT, Crosson P and Price KA (eds) Agriculture and the Environment. Washington, DC: Resources for the Future.,pp. 35–73; Crosson PR (1995) Soil erosion estimates and costs. Science 269:461–64 (quote on 461)

[4] Crosson PR (2003) The Economics of Soil Erosion and Maintaining Soil Biodiversity. Discussion paper for OECD Expert Meeting on Soil Erosion and Soil Biodiversity Indicators, Rome (unpublished manuscript)

[5] Sombroek WG (1985) Establishment of an International Soil and Land Resources Information Base. Discussion Paper for the ISSS Working Group on Digital Mapping of Global Soil Resources. Wageningen: ISRIC (unpublished manuscript); Oldeman LR, Hakkeling RTA and Sombroek WG (1990) World Map of the Status of Human-Induced Soil Degradation. Wageningen: ISRIC/UNEP

[6] Quoted in Preston RJ (1939) Soil erosion. The significance of the problem and its attempted control. Journal of Geography 38:308. See also the widely cited Howard A 1940. An Agricultural Testament. London: Oxford

too often, Wim said, they act as handmaidens to agronomy and crop science, rather than environmental scientists who should use their specialized knowledge about a critically important resource to work with ecologists, economists, and political scientists to help humankind through these ecologically parlous times.[7] GLASOD was an attempt to show "policy-makers and decision-makers" how soil science could inform the fight against "declining food productivity by conserving and restoring our natural resources."[8]

Ultimately, Wim told me in Washington, he had been disappointed by GLASOD's lack of larger impact, as well as ISRIC's failure to improve on it.[9] But even as he was finishing GLASOD he was turning his attention to another means of elevating the profile of soil science: *terra preta* — or Amazonian Dark Earth,[10] as it has been renamed. Found in patches along almost all of the major rivers in the Amazon basin, Amazonian Dark Earth is, unlike typical tropical soils, rich with phosphorus, nitrogen, zinc, and magnesium. More important, it is full of carbon – as much as 70 times the level of neighboring soils—in the form of "bio-char," a charcoal-like residue created when organic matter is burned at a low temperature.[11]

As far back as the 1960s, Wim had wondered whether scientists could reconstruct the techniques by which Indians had made *terra preta* in the past. If so, he now argued, contemporary tropical farmers might create their own *terra preta — terra preta nova*, as he dubbed it — to help forestall soil degradation. Because soil degradation is an enormous limiting factor in tropical agriculture, *terra preta nova* could not only boost yields but also reduce the amount of tropical forest that had to be cleared for farms. Much as the Green Revolution dramatically improved the developing world's crops, resilient *terra preta nova* could unleash a "black revolution" for the developing world's soil.[12]

In addition, Wim argued, manufacturing large swathes of Amazonian dark earth would require so much biochar that these regions would act as enormous carbon

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[7] This is not a new complaint. See, e.g., Kellogg CE (1961) A challenge to American soil scientists: On the occasion of the 25th anniversary of the soil science society of America. Soil Science Society of America Proceedings 25:419–23

[8] Oldeman LR, Hakkeling RTA, Sombroek WG (1991) World Map of the Status of Human-Induced Soil Degradation: An Explanatory Note. Den Haag: CIP-Gegevens Koninklijke Bibliotheek, 2nd ed.: 21

[9] GLASOD is not even mentioned in Pimentel et al. (1995), a widely publicized study in a major journal that appeared just 5 years afterward

[10] This term was coined by Woods and McCann to encompass the wide range of variability of dark anthropogenic soils in Amazonia [Woods WI, McCann JM (1999) The anthropogenic origin and persistence of Amazonian dark earths. The Yearbook of the Conference of Latin American Geographers 25:7–14]

[11] Lehmann, J, Kern DC, Glaser B, Woods WI (eds). 2003. Amazonian Dark Earths: Origin, Properties, Management. Dordrecht: Kluwer; Glaser, B, and Woods WI (eds) 2004. Amazonian Dark Earths: Explorations in Space and Time. Berlin: Springer.

[12] I take the phrase "black revolution" from Marris, E 2006. Black is the new green. Nature 442:624–26.

sinks, counteracting global warming.[13] In theory, the potential for carbon storage is huge: according to a 2006 estimate in the journal *Mitigation and Adaptation Strategies for Global Change*, more carbon could be stored in *terra preta nova* every year than is released by the entire world's fossil-fuel use, at least at current levels of consumption.[14]

The possibilities of Amazonian dark earth obviously thrilled Wim. In Manaus, I was not the only person to be startled during the conference tour of *terra preta* sites when the former Secretary General of the International Society of Soil Science scrambled into archaeological trenches and began taking measurements with his soil-color chart. But what I only realized later, talking to Wim, is that he hoped that the *Terra Preta Nova* project would, even more than GLASOD, serve as an example of how soil science might reorient itself.

Between 1992 and 2004, enrollment in North American soil-science graduate programs fell by about 40%; Europe apparently experienced similar declines. The drop occurred despite "a continuous increase of the interest manifested by the scientific community in soils-related issues," at least as measured by scientific publications in the field.[15] Amazingly, it occurred despite the enormous global boom in organic farming, with its emphasis on protecting the soil. One common explanation for the decline is the tendency of soil-science schools to treat soil science, in isolation, as a vehicle to increase crop production, even though students increasingly view soil through the lenses of environmental and social sciences. To Wim's way of thinking, the *Terra Preta Nova* project was an example of the way to go.

Wim's hopes will not be easy to fulfill. It has become increasingly clear that much of the resilience in Amazonian dark earth derives from its ability to support soil ecosystems; the microbiota of *terra preta* are both more numerous and more diverse than that of surrounding areas.[16] Unfortunately, identifying precisely what is living in these soils will be difficult. As is well known, researchers can cultivate only a small fraction of rhizospheric species in petri dishes. Equally important, nobody knows how much carbon can be stored in soil. Preliminary studies suggest

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[13] Sombroek WG 1992. Biomass and carbon storage in the Amazon ecosystems. Interciência 17:269–72; Sombroek

WG, Ruivo ML, Fearnside PM, Glaser B, Lehmann J (2003) Amazonian Dark Earths as carbon stores and sinks. In: Lehmann, J, Kern DC, Glaser B, Woods WI (eds). 2003. Amazonian Dark Earths: Origin, Properties, Management. Dordrecht: Kluwer, pp 125–139

[14] Lehmann J, Gaunt J, and Rondon M (2006) Bio-char sequestration in terrestrial ecosystems: A review. Mitigation and Adaptation Strategies for Global Change 11:403-27. Lehmann, Gaunt and Rondon predicate their estimates on a sharp rise in biofuel use, with the biofuels being produced by processes that generate bio-char.

[15] Baveye P, et al. (2006) Whither goes soil science in the United States and Canada? Soil Science 171:501–18 (quote on 506).

[16] Ruivo ML, Cunha ES, Kern DC (2004) Organic matter in archaeological black earths and yellow latosol in the Caxiuanã, Amazônia, Brasil. In: Amazonian Dark Earth: Explorations in Space and Time. Berlin: Springer, pp. 95–108.

that at least in some soils' soil-carbon content may not increase linearly with carbon inputs but reach some limiting value.[17]

But in another sense Wim's dream has already been realized. The *Terra Preta Nova* project, with its vision of the soil as a key element in our common future, has attracted enormous public attention to soil science. On a professional level, the scientific collaboration links soil scientists, archaeologists, geographers, microbiologists, engineers, ecologists, economists, and atmospheric scientists around the world in a common project that promises to reveal much about the workings of soil, may have an enormous impact on agriculture and could even play a role in climate change. This book, and all it represents, is more than a tribute to Wim Sombroek's legacy—it is a way forward.

Charles C. Mann

[17] Stewart CE, et al. (2007) Soil carbon saturation: Concept, evidence and evaluation. Biogeochemistry 86:19–31.

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