

PYROGENIC CARBON IN AMAZON FOREST SOILS

Amazon pyrogenic carbon: the deep store soil surveys miss

Amazon forest soils hold far more fire-derived carbon than global budgets assume, and most of it lies below the depth that soil carbon accounts measure.

Photo: Amauri Barradas

Pyrogenic carbon, the charcoal-like residue of burning, forms about 3% of the carbon in the top 30 cm of Amazon forest soils, three times the 1% assumed in global carbon budgets, and 11% over the top 2 m. Across the basin this adds up to about 2.8 billion tonnes in the top metre of soil. It is one of the most persistent forms of soil carbon, yet half of it lies deeper than surveys usually reach.

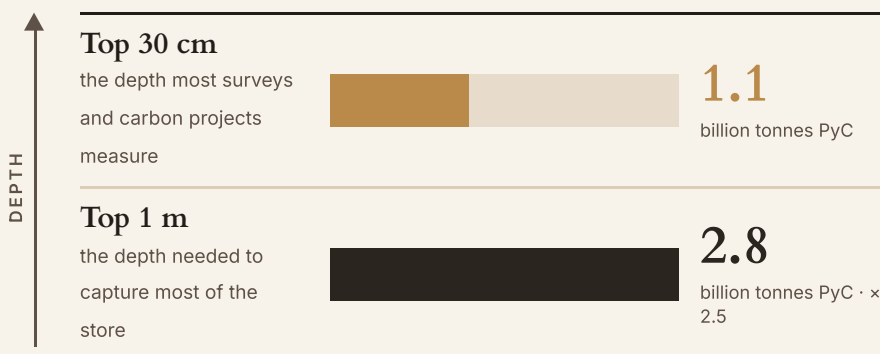
The evidence comes from 37 one-hectare forest plots across the Amazon Basin, chosen because they had no known history of recent fire or human disturbance. Soils were sampled to 2 m and analysed by hydrogen pyrolysis.

KEY MESSAGES

- Amazon forest soils hold about **2.8 billion tonnes** of pyrogenic carbon in the top metre.
- That is **about three times** the share assumed in global budgets.
- Pyrogenic carbon is present in **every soil sampled**, even in forest with no known fire.
- **Half of it lies below about 58 cm**, deeper than most surveys sample.
- It persists for **centuries to millennia**.

01 · HOW MUCH THE SAMPLING DEPTH CHANGES THE ANSWER

Stop at 30 cm and you miss most of the store



≈ 10 Gt CO₂

The pyrogenic carbon in the top metre of Amazon forest soils is equivalent to about **10 billion tonnes of CO₂**, more than a quarter of a year of global fossil-fuel emissions.

Pyrogenic carbon stocks of Amazon Basin forest soils, excluding Amazonian Dark Earths (terra preta). The top 30 cm holds only about 40% of the stock in the top metre.

02 · DEEP AND DURABLE

The deeper the soil, the larger the fire-derived share

11%

of soil organic carbon to 2 m depth is pyrogenic

58 cm

average depth below which half the pyrogenic carbon lies

71 / 127 cm

depth needed to capture half / three quarters of it

3 samples

per hectare are enough to capture the variation within a plot

The pyrogenic share of soil carbon rises with depth. Deep pyrogenic carbon is protected by clay and by iron and aluminium minerals, and by low oxygen, so it is older and more stable than the carbon near the surface. Ferralsols, the most widespread Amazon forest soils, hold the most: about 0.65 billion tonnes in the top metre.

03 · WHY THE ACCOUNTS MISS IT

Budgets assume too little. Global pyrogenic carbon budgets assigned humid tropical forest soils a nominal 1% share in the top 30 cm and little or none below. Across the basin the measured share averages about 3%, three times that, and pyrogenic carbon was present in every soil.

Inventories stop too shallow. National inventories, IPCC default methods and most carbon-credit methodologies measure soil carbon to 30 cm, or treat soil as an optional pool. Below that depth lies most of the pyrogenic carbon, the part of soil carbon most likely to stay put for centuries. Clearing and repeated fire expose it to loss; protecting forest keeps it.

KEY TERMS

Pyrogenic carbon (PyC).

Charcoal-like carbon left by incomplete burning. It resists decay for centuries to millennia.

Hydrogen pyrolysis. A laboratory method that isolates the most stable, condensed part of pyrogenic carbon.

Ferralsol. Deep, old, iron-rich red and yellow soils that cover most of the Amazon Basin.

04 · RECOMMENDATIONS: COUNT THE DEEP, DURABLE CARBON

1

INVENTORY AGENCIES AND PROJECT DEVELOPERS

Sample soil carbon to at least 1 m

Three samples per hectare are enough; stopping at 30 cm misses most of the pyrogenic store.

2

CARBON STANDARDS AND THE IPCC

Measure the pyrogenic fraction, not a default

A fixed 1% understates it about three-fold, more at depth; measured pyrogenic carbon is direct evidence of permanence.

3

EARTH-SYSTEM AND SOIL CARBON MODELLERS

Treat pyrogenic carbon as its own slow pool

Represent it to depth, with turnover over millennia, so that budgets and fire scenarios reflect what is in the soil.

Reference. Koele, N., Bird, M., Haig, J., Marimon, B.H., Marimon, B.S., Phillips, O.L., de Oliveira, E.A., Quesada, C.A. & Feldpausch, T.R. (2017) Amazon Basin forest pyrogenic carbon stocks: first estimate of deep storage. *Geoderma* 306: 237–243. doi.org/10.1016/j.geoderma.2017.07.029

Notes on the numbers. Basin stocks combine measured pyrogenic shares with total soil carbon stocks from Batjes & Dijkshoorn (1999) *Geoderma* 89: 273–286. CO₂ = carbon × 44/12. Global fossil-fuel and industry emissions were 9.9 Gt C (36 Gt CO₂) in 2015 (Le Quééré et al. 2016, *Earth System Science Data* 8: 605–649). Basin share: 1.10 Pg PyC ÷ 36.1 Pg soil C to 30 cm.

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