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"Competing pathways for equitable food systems transformation: Trade-offs and synergies"

Deep soil carbon loss offsets rapid aboveground growth after reforestation of the Atlantic forest, Brazil

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Abstract

Carbon (C) sequestration following land restoration is an efficient measure of climate change mitigation. However, most studies including the international '4 per 1000' initiative focus on topsoil C only. Due to absence of the deep soil pool on land restoration assessments, studies might fail to select the most appropriate approach when it comes to C sequestration. Here, we studied the response of deep soil C to different land restoration approaches. Samples were taken from rural sites in the Atlantic Forest Biome (Brazil), using a paired site design with triplicates of different 16-to-19-year-old restoration approaches of former arable land: reforestation, natural regeneration, and agroforestry systems. Adjacent arable land and a > 25-year old secondary forest served as references. We determined aboveground and belowground C pools, including deep soil until 3 m depth. The C stock in the aboveground living biomass in the reforestation site was 85±15 Mg ha^{-1}, significantly exceeding the respective aboveground C in natural regeneration (40±13 Mg ha^{-1}) and agroforestry system (25±5 Mg ha^{-1}), respectively. This order, however, was reversed in soil, where reforestation caused a loss of soil organic carbon (SOC) by 27 Mg ha^{-1} below 40 cm depth, whereas SOC stocks in the agroforestry system and natural regeneration site increased by 41 and 25 Mg C ha^{-1}, respectively, compared to arable land. When analysing the whole ecosystem carbon, we did not find statistical differences among the three restoration methods. We thus conclude that deep soil carbon losses can negate aboveground carbon accrual after land restoration. Not considering deep subsoil C combined with aboveground C would have led to a false ranking of the success of the land restoration practices.

Keywords: Agroforestry, carbon pools, carbon sequestration, deep soil carbon storage, land restoration, natural regeneration

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