The Legacy of Intensively Managed Agricultural Landscapes Written in the Soil Organic Carbon of the Critical Zone

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Intensively managed agricultural landscapes (IML) cover nearly half of the Earth's land surface and are now essential for feeding our growing population. The critical zone (CZ), which extends from the lowest circulating groundwater to the top of the canopy, defines the environment that supports this agricultural activity. As sustainable agricultural intensification looks to balance the need to increase food production while sustaining important ecosystem services, a detailed understanding of the ecosystem's supporting CZ rate-limiting services, such as ground water recharge and soil formation, is essential. A CZ perspective views the ongoing ecological, geological, geochemical, and hydrological processes as an integrated and interconnected system that acts over broad spatial and temporal scales. A growing global network of CZ observatories (CZO) offers unique opportunities to study how climate, lithology, land use, biology, and topography control the structure and function of the CZ and support IML. Over the last century, intensive management (IM) has severely degraded the underlying soils of approximately 20% of the world's vegetated land, often leading to a decline in productivity and soil organic carbon (SOC). The most rapid loss or redistribution of SOC usually occurs immediately after natural ecosystems are put into IM, as was the case with the mollisol regions of North and South America and Northeast China. Other IML, like the eroded karst and loess regions of China, carry the legacy of multiple IM periods spread over millennia. We propose that as a result of human activities, all IML have, or will, pass a tipping point and shift from being a *transformer of material flux* with high SOC, water, and sediment storage to a *transporter of material flux* with low storage. We will examine herein how different CZOs address IM impacts on SOC and offer recommendations for comparative studies to isolate the main factors controlling SOC resilience and stabilization.