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Evidence for rapid and wide-spread root-induced soil structural changes in response to land use

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Soil structure - the arrangement of soil particles and voids - regulates hydrologic flow, solute and gas exchange, mineral and organic matter transformations, and microbial dynamics. The heterogeneous nature of soil structure can promote or restrict soil resources and thus is a key driver of ecosystem productivity and feedbacks to climate. Roots must adapt their architecture to exploit temporally and spatially variable resources, resulting in a reciprocal evolution where roots exhibit the capacity to influence soil structure and formation. However, large knowledge gaps remain in our understanding of root-driven changes in soil structure and the timescales of those changes. Recent research estimates globally-averaged rooting depths shallowing up to 59 cm this century which is driven by replacement of perennial systems with agriculture and tempered by root deepening with woody encroachment. **We hypothesize that because roots are important drivers of soil structure, modification of rooting abundances in deep soil prompts quantifiable structural changes.** Leveraging continental US soil surveys from the Pedogenic and Environmental DataSet, we investigate the relationship between soil structural metrics and rooting density. Using data from relatively deep horizons in reference forests, cropland, and secondary forests, we demonstrate that soil structural characteristics reflect the decline and regeneration of roots. Our efforts reveal significant correlations between total root density and mean ped size, angle, solidity, and grade, as well as soil texture. In three dominant soil orders, root-generated soil pores, ped grade, and angle exhibited declines as roots became less abundant. In Ultisols, root regrowth promoted rebounding of structural characteristics similar to reference forests; in contrast, in Mollisols and Alfisols, root regrowth did not result in a reversion to reference forest structural state. **The data suggest removed roots impose structural changes deep within the soil and whether root regrowth can reimpose those conditions depends on the degree of soil development.** We suggest that changes to root abundances, such as those accelerating in the Anthropocene, are an important agent of structural changes in the subsurface that have meaningful implications for contemporary and future ecosystem feedbacks to climate.