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Earthworm impacts on organo-mineral interactions and soil carbon inventories in Fennoscandian boreal and sub-arctic landscapes

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Boreal and sub-arctic environments sustain some of the most pristine and fragile ecosystems in the world and house a disproportionate amount of the global soil carbon pool. Although the historical view of soil carbon turnover has focused on the intrinsic molecular structure of organic matter, recent work has highlighted the importance of stabilizing soil carbon on reactive mineral surfaces. However, the rates and mechanisms controlling these processes at high latitudes are poorly understood. Here we explored the biogeochemical impacts of deep-burrowing earthworm species on a range of Fennoscandian forest soils to investigate how earthworms impact soil carbon inventories and organo-mineral associations across boreal and sub-arctic landscapes. We sampled soils and earthworms at six sites spanning almost ten degrees latitude and encompassing a wide range of soil types and textures, permitting simultaneous consideration of how climate and mineralogy affect earthworm-mediated shifts in soil carbon dynamics. Across all sites, earthworms significantly decreased the carbon and nitrogen contents of the upper 10 cm, presumably through consumption of the humus layer and subsequent incorporation of the underlying mineral soil into upper organic horizons. Their mixing of humus and underlying soil also generally increased the proportion of mineral surface area occluded by organic matter, although the extent to which earthworms facilitate such organo-mineral interactions appears to be controlled by soil texture and mineralogy. This work indicates that quantitative measurements of mineral surface area and its extent of coverage by soil organic matter facilitate scaling up of molecular interactions between organic matter and minerals to the level of soil profiles and landscapes. Our preliminary data also strongly suggests that earthworms have profound effects on the fate of soil carbon and nitrogen in boreal and sub-arctic environments, highlighting the need for a better understanding of the joint ecological impacts of warming and indirect disturbances like earthworm introduction by humans to make sound predictions of future ecosystem change and carbon-climate feedbacks.