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Geochemical mass balance approach to quantify long-term impacts of agricultural conversion of forest on the elemental losses and gains in soils

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The impacts of agricultural conversion of forests on soil properties and processes have been documented widely. However, little is known about the degree that such land use change alters elemental budgets in soils over decade to century time scales, a critical information in assessing the role of agriculture in local, regional, and global biogeochemical budgets. Here, we focus on comparing the time-integrated losses and gains of nutrient elements (Ca, P, and K) and environmental trace metals (Pb, Cad, and Ni) in two adjacent soils in crop lands and protected forests in the Coastal Plain in Delaware, USA. The two soils share virtually identical soil forming factors except the land use during the past century. Geochemical mass balance approach - which has been successful in quantifying the fluxes of various elements during soil formation - is newly applied to this issue. Within the limitations of (1) unknown land use history beyond a century and (2) heterogeneity of stream sediment parent material, our results strongly suggest that agricultural liming and fertilizer inputs have not only refurbished the losses of Ca and P via dissolution and leaching via the pre-agricultural soil formation but also have added extras such that agricultural soils are enriched in Ca and P relative to their parent materials. The analyses further show that environmental trace metals such as Pb and Cd are significantly enriched in the agricultural soil relative to the pre-agricultural forest soil, indicating that these elemental inputs through fertilizer, amendments, and farm machinery, when quantified over decades to century time scales, are significant. This study also indicates the potential to use geochemical mass balance model in quantitatively coupling lake sedimentary cores to land use history in the adjacent basins.