Lake sediments record the changes in phosphorus loading and cycling accompanying the transition from agricultural to urban land use in a watershed in the Greater Toronto Area

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Agricultural intensification and urbanization alter biogeochemical cycling and substantially increase the export of nutrients, including phosphorus (P), to downstream lake ecosystems. Here, we reconstruct the post-1920 trajectories of external P loading and in-lake P recycling in Lake Wilcox (Ontario, Canada) that accompanied changes in land use/land cover (LULC) of the watershed using a dated sediment core. The progressive conversion of the initially forested watershed to farmland was followed by agricultural intensification after World War II and by rapid urbanization during the 21st century. The watershed's agricultural expansion from 1950 to 1970 was accompanied by a 2.5-times increase in the bulk sedimentation rate. Since the early 1980s, however, the sedimentation rate has dropped to values below those observed before 1940 because of spreading impervious land cover, better soil conservation, and, beginning in the late 1990s, effective stormwater management upstream of the lake. Although significant up-core increases of the concentration of total P (TP) and the fraction of organic P (Porg) in the sediments occurred during the period of urbanization, the TP burial rate decreased by around 60% from its maximum value at the end of the intensive agricultural period. The chlorophyll-a accumulation rate also peaked during the agricultural period and decreased as the watershed became more urbanized, indicating that the agricultural period was the period when the lake was in its most eutrophic state as a result of the highest external TP loads. Post-2000 water quality monitoring data further implies that the expansion of anoxic conditions in the hypolimnion is not caused by increasing watershed P loading but rather by rapid salinization that strengthens the lake's summer stratification. Longer periods of summer anoxia, in turn, enhance internal P loading from the sediments which, in recent years, represents about 13% of the total (external plus internal) TP loading to the water column. Reconstructed TP budgets for Lake Wilcox highlight the shifts in the lake's P cycle driven by LULC changes.