Historical Changes in Sediment and Phosphorus Loading to the Upper Mississippi River:

Mass-Balance Reconstructions from the Sediments of Lake Pepin

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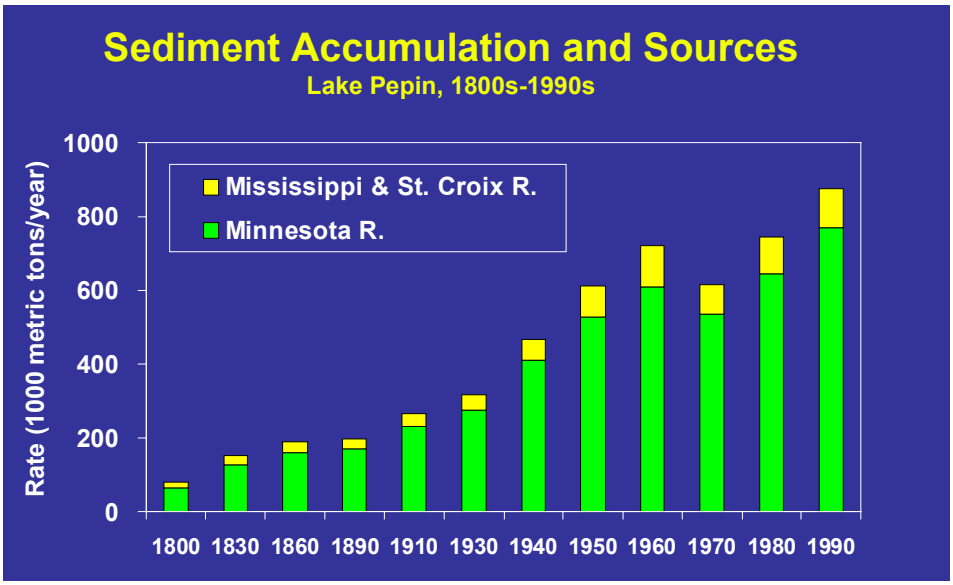
ABSTRACT

Long-term changes in sediment and phosphorus loading to the upper Mississippi River were quantified from an array of 25 sediment cores from Lake Pepin, a large natural impoundment downstream of the Twin Cities metropolitan area. Cores were dated and stratigraphically correlated using ^{210}Pb, ^{137}Cs, ^{14}C, magnetic susceptibility, pollen analysis, and loss-on-ignition. All cores show a dramatic increase in sediment accumulation beginning with European settlement in 1830. Accumulation rates are highest and show the greatest post-settlement increases in the upper end of the lake. Present-day sediment-phosphorus concentrations are roughly twice those of pre-settlement times, and the Fe/Al-bound fraction makes up a greater portion of the total. Diatom assemblages record a marked increase in nutrient availability over the last 200 years, changing from clear-water benthic forms and mesotrophic planktonic taxa in pre-settlement times to exclusively planktonic assemblages characteristic of highly eutrophic conditions today. Lake-water total-phosphorus concentrations (total-P), estimated by weighted averaging regression and calibration, increased from 50 to 200 $\mu g\ l^{-1}$ during this period.



Sediment loading to Lake Pepin from the Mississippi River has increased by an order of magnitude since 1830. Modern fluxes are about 900,000 metric tons annually, and are more than 80% detrital mineral matter. About 17% of the lake's volume in 1830 has been replaced by sediment, and at current accumulation rates the remainder will be filled in another 340 years. Phosphorus accumulation in Lake Pepin sediments has increased 15-fold since 1830, rising from 60 to 900 metric tons annually. This rise represents a seven-fold increase in phosphorus loading from the Mississippi River coupled with more efficient retention of phosphorus inflows by bottom sediments. More efficient trapping of phosphorus in Lake Pepin over the last century resulted from higher rates of sediment burial. The most dramatic changes in nutrient and sediment inputs to Lake Pepin have occurred since 1940, although gradual increases began shortly following European settlement. Sediment accumulation rates rose sharply between 1940 and 1970 and then leveled off, while phosphorus inflows record their largest increases after 1970.