

## **NITRATE EXPORT FROM THE UPPER MISSISSIPPI BASIN: THE EFFECTS OF FLOOD TIMING AND SPATIAL DISTRIBUTION**

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We examined the spatial and temporal transport of nitrate + nitrite nitrogen (nitrate) in the Mississippi River during the period 1992-2001 with emphasis on two major floods (1993 and 2001) in the Upper Mississippi River basin (above the Missouri River confluence with the Mississippi River). We found significant influences of flood frequency (antecedent conditions), seasonal timing, and geographic distribution of flooding on nitrate transport. The results show that major floods dominate the movement of nitrate in this system and that the spatial and temporal distribution of flooding has substantial influence on nitrate transport. Of particular importance to the concentration of nitrate in flood waters is the level of discharge from the basin during the preceding 12 months and the character of flood waters delivered from the Upper Mississippi Basin to the Gulf of Mexico can be strongly influenced by dilutional flows from other basins in the Mississippi drainage (e.g., the Ohio River). The 1993 flood was record-setting in terms of nitrate and water flux, was preceded by a dry year, and was followed by the largest areal extent of hypoxia ever recorded in the northern Gulf of Mexico to that time. The 2001 flood had a much smaller total flux of water and nitrate, but also dry antecedent conditions and was asynchronous with the Ohio River Flood. As a result, the 2001 delivered to the Gulf of Mexico a higher concentration of nitrate, earlier in the season (May vs. July) than in 1993. The 2001 flood was followed by a hypoxic zone that exceeded in areal extent the one observed in 1993. Our results show that the size of the summer hypoxic zone, which varies in relation to discharge from the Upper Mississippi River, appears particularly sensitive to May discharge from the Upper Mississippi and appeared to respond more strongly to the early-season (April-May) flood in 2001.