Abstract

A freshwater marsh, created about one hundred years ago by artificially draining a 105-ha shallow lake (Rice Lake), is a suspected source of phosphorus (P) to the Detroit Lake watershed, a major recreational destination for northwestern Minnesota. P loadings to the main drainage canal increase during the summer months, when the water table typically declines. On the assumption that increased aeration causes P release through mineralization of organic matter, local authorities have proposed that the water level in the marsh be maintained at a higher level. To test this assumption, and to examine the impacts of water table control on greenhouse gas emissions, intact soil cores from 2 sites in the wetland were subjected in the laboratory to three water table levels and incubated for 6 - 23 wk. Dissolved reactive P, reduced Fe, pH, dissolved organic carbon (DOC), and oxidation-reduction potential (Eh) were monitored in the pore water. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) fluxes were determined from headspace gas samples. Gas fluxes were converted to global warming potentials in CO_2 equivalents. DRP dynamics differed between sites. One site displayed high DRP flux from the highest water table treatment, while the other site showed only trace levels of porewater DRP, with no significant differences among treatments. Additionally, the effect of transition from low to high water table yielded significantly higher mean DRP under flooded conditions than during the drained conditions, but did not show different mean DRP than continuously flooded conditions. DRP release in wetland soil was attributed largely to reduction and dissolution of P bound to Fe hydroxides, but P mineralization may play an important role in slower organic-inorganic P transformations. Field porewater monitoring and soil sampling supported hypothesis that DRP solubility is controlled by Fe. Greenhouse gas fluxes were similar at both sites, and significant differences were observed among treatments. At both sites, the highest water table treatment displayed lower cumulative N_2O flux ($p < 0.05$) and higher cumulative CH_4 flux ($p < 0.001$) than the lowest water table treatment. Cumulative

CO_2 equivalent data suggests that the highest water table treatment has the greatest global warming potential (significant at $p < 0.06$). Thus, the proposal to increase water levels has the potential to increase both P release and total greenhouse gas emissions, although issues related to process variability across the wetland were difficult to assess.