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Aquatic metabolism as an indicator of the ecological effects of hydrologic pulsing in flow-through wetlands

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ABSTRACT

Water column metabolism is a major component in the functioning of wetland ecosystems and can be used as an indicator of ecosystem health. The effect of hydrologic pulsing on water column metabolism was studied with 2 year's field data and a validated model for two 1-ha created riparian wetlands in Columbus, OH, USA. Aquatic gross primary productivity (GPP) was measured during hydrologic pulses the first week of April, May and June of 2004 and compared to GPP during steady flow-conditions in April, May and June 2005. Pulses reduced diurnal variation of water temperature, pH and dissolved oxygen, and negatively affected GPP rates. Mean GPP measured during hydrologic flood pulses was 5.4 ± 2.6 kcal m^{-2} day^{-1}, significantly lower than that measured for comparable months with steady-flow hydrology (10.8 ± 3.3 kcal m^{-2} day^{-1}). Solar-normalized productivity values of 0.08 ± 0.01% of solar energy during pulses and 0.2 ± 0.02% for steady-flow conditions were also significantly different. Different hyperbolic curves of optimum productivity with water temperature were seen for pulsing and steady-flow conditions. A simulation model with hydrology, metabolism, and dissolved oxygen sub models was calibrated with 2005 steady-flow year data and validated with 2004 pulse year data. Results from both the field study and model simulations suggest that there was a threshold hydraulic inflow rate between 30 and 50 cm day^{-1} where aquatic metabolism became negatively affected by flow.

1. Introduction

Aquatic metabolism – the productivity and respiration of the shallow water column – provides a useful composite indicator of ecosystem function in wetlands. Hydrologic pulsing due to rivers can either positively or negatively affect this metabolism. Increased flow rates stimulate aquatic metabolism by accelerating nutrient uptake, photosynthesis, respiration and reproduction rates of aquatic producers (Stevenson, 1996). Positive effects of current on aquatic production generally increase with increased nutrient concentrations. Where river inflow is a significant source of nutrients, higher flow rates can support higher aquatic productivity as demonstrated by Cronk and Mitsch (1994) in created riparian wetlands. Increased current also acts to ameliorate the negative effects of biomass density in established algal mats by transporting nutrients through the mat and washing away senescent cells (Peterson, 1996; Stevenson, 1996). Aquatic production can be stimulated by periodic pulses that suppress predators, flush toxins and waste materials from the system, and create new substrate space for colonization (Mosisch and Bunn, 1997). In addition, seasonal flood pulses may indirectly contribute to long-term positive effects for the aquatic community by reducing macrophyte abundance and releasing nutrients previously

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stored in vegetation biomass (Goldsorough and Robinson, 1996).

Increased water velocity as a result of hydrologic pulsing negatively affects aquatic productivity by increasing drag forces on cells creating san environmental stress, and causing export of biomass from the system. In extreme instances, abrupt increases in current velocity due to high amplitude flood pulses result in a complete denudation of the producer community (Peterson, 1996; Stevenson, 1996; Mosisch and Bunn, 1997). However, when algal mats and senescent vegetation are removed, productivity may be stimulated following the disturbance due to increased light availability and water temperatures (Peterson, 1996). Maximum rates of aquatic primary productivity likely occur at intermediate current velocities, where benefits of higher flow stimulate growth, but do not exert enough drag to be considered an environmental stress (Stevenson, 1996).

The goal of this study was to examine the influence of seasonal hydrologic pulsing on aquatic metabolism in two created flow-through riparian wetlands. The following objectives were established to determine this relationship:

(1) investigate the impact of seasonal hydrologic pulsing on spatially explicit patterns of dissolved oxygen and aquatic productivity and respiration; and
(2) develop, calibrate and validate an ecosystem model that describes the observed effect of hydrologic pulsing on dissolved oxygen aquatic metabolism dynamics.

2. Methods

2.1. Site description

This study was carried out at the Wilma H. Schiermeier Olentangy River Wetland Research Park, a 12-ha wetland research facility located on the campus of The Ohio State University in Columbus, Ohio, USA. The two 1-ha experimental wetlands used for this research (Fig. 1) were created in

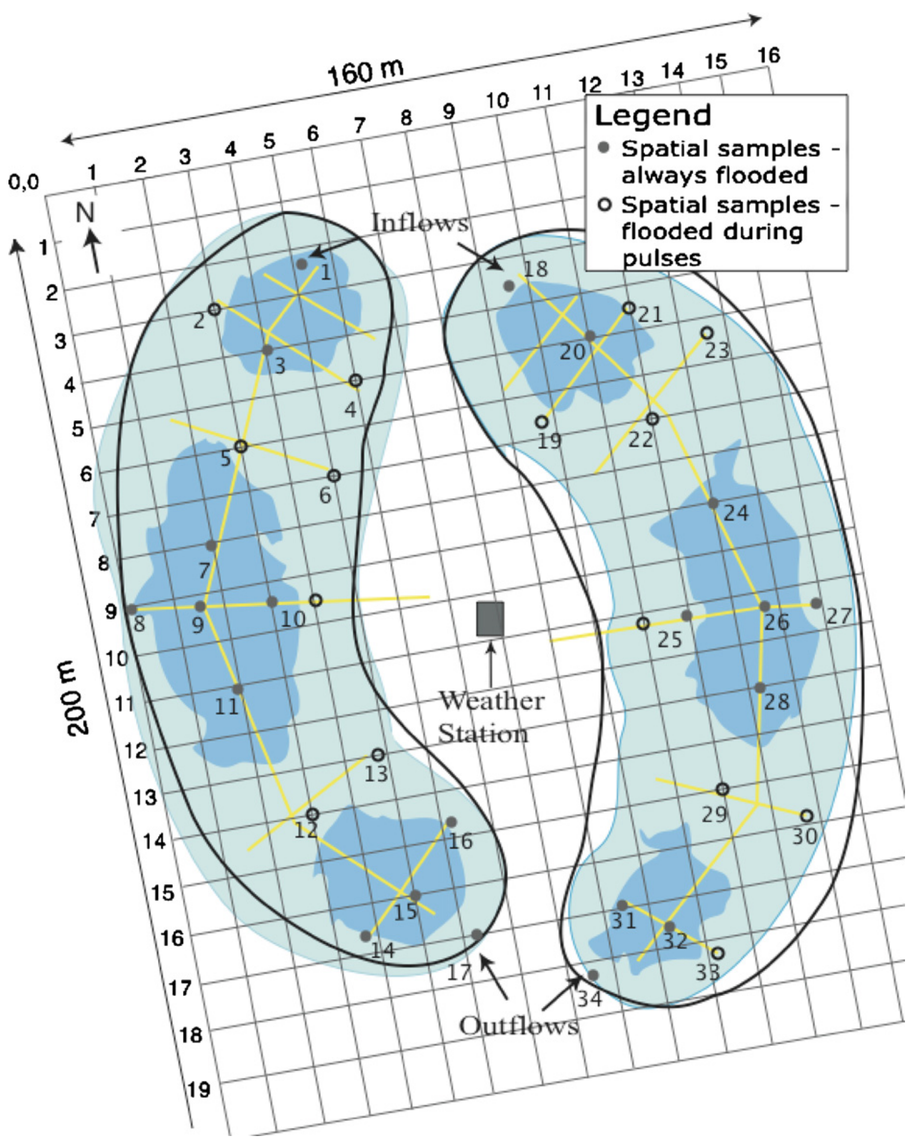

Fig. 1 – Sample sites established in the experimental wetlands at the Olentangy River Wetland Research Park in Columbus USA for spatial sampling of water quality parameters, chlorophyll-*a* and aquatic vegetation biomass.