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Exploring farm pond dynamics in low-order agricultural watersheds: A synthetic analysis and process-based modeling

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Farm ponds, which are sometimes numerous and widely distributed in agricultural regions, have faced widespread degradation in recent decades. Although relevant conservation strategies have gradually increased, detailed assessments on their roles in regional biogeochemistry and ecology are lacking. We concluded that farm ponds provided hydrologic, biogeochemical, and socioeconomic benefits to southern China for thousands of years, but they are facing contemporary threats and management challenges, including (1) inadequate planning in terms of construction and conservation regulations; (2) rural nonpoint source and mini-point source pollution; (3) climate change-induced abnormalities in the hydroperiod and disturbance to wildlife; (4) invasive species; and (5) inadequate social and political capacity to consider ecological conservation. As farm ponds function as wetland complexes that are embedded within or integral to larger ecosystems, we recommend multi-disciplinary efforts over scales ranging from within-pond to regional for their assessment and conservation.

Excessive nitrogen (N) discharge from agriculture is a major factor of widespread problems in aquatic ecosystems. Knowledge of spatiotemporal patterns and source attribution of N pollution in these small, scattered ponds is a critical first step for nutrient management and ecosystem health in low-order agricultural watersheds. We applied the process-based HSPF model for ponds, ditches, and downstream waters in a 4.8 km^2 test watershed in southern China. The results exhibited distinctive spatial-seasonal variations with an overall seriousness rank for the three indicators: total nitrogen (TN) > nitrate/nitrite nitrogen (NO_x^--N) > ammonia nitrogen (NH_3-N). TN pollution was severe for the entire watershed, while NO_x^--N pollution was significant for ponds and

ditches far from the village, and the NH_3-N concentrations were acceptable except for the ponds near the village in summer. Although food and cash crop production accounted for the largest source of N loads, we discovered that mini-point pollution sources, including animal feeding operations, rural residential sewage, and waste, together contributed as high as 47% of the TN and NH_3-N loads in ponds and ditches.

Our synthetic analysis and process-based modeling studies focused on farm ponds in an agriculturally dominated developing country (China), but similar small, scattered wetlands and their degradation trends are observed worldwide (e.g., vernal pools and prairie potholes in North American, farm ponds in Western and Central Europe, and chain of natural pond system in Australia). Nature-based solutions are becoming increasingly recognized as important for addressing the complex challenges in hydrology, ecology, and biodiversity under anthropogenic and climatic pressures. Apart from proposed conservation policies, including public awareness building, top-down regulations and bottom-up engagement, and sustainable management and utilization, we are also trying techniques that involve interconnected smart sensors and integrated modeling methods to better understand pond hydrological processes. We believe that such solutions can provide a basis for the numerical assessments on their ecosystem services and associated conservation cost analyses.