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Water Quality Trading: A Framework for Incorporating Modelling Uncertainties into Quantification of Trading Ratios

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Abstract: Quantifying the water quality benefits of conservation practices (BMPs) is prone to different types of uncertainties, a big portion of which stem from application of models. These uncertainties result in biased decisions when developing water quality trading programs. While trading ratios are currently applied mainly to account for the natural variability of nonpoint sources, they are rather applied as random safety factors without considering estimates of modelling uncertainties. A Bayesian total uncertainty analysis framework is presented to assess the model estimates of the effectiveness of BMPs in reducing nonpoint source pollution. The framework entails a two-stage procedure. First, various sources of modelling uncertainties are characterized during the period before implementing BMPs. Second, the effectiveness of BMPs are probabilistically quantified during the post-BMP period. The framework was used to assess the uncertainties in effectiveness of two BMPs in reducing daily total nitrogen (TN) loads in a 54 ha agricultural watershed in North Carolina using the SWAT model. The results indicated that the modelling uncertainties in quantifying the effectiveness of selected BMPs were relatively large. Assessment of measured data uncertainty revealed that higher errors were observed in simulating TN loads during high flow events. The results were used to develop bands of uncertainty around BMP efficiencies. Trading ratios were then determined using the cumulative probability distribution functions of TN loads from the nonpoint and point sources. The results of this study have important implications for decision-making under uncertainty when models are used for water quality simulation.

***Keywords**:* Watershed management; BMP effectiveness; Water quality conservation; Watershed modelling; Bayesian uncertainty analysis; SWAT