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Using conservation auctions informed by environmental performance models to reduce agricultural nutrient flows into Lake Erie

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ABSTRACT

Cost-effectively mitigating agricultural nutrient export requires an understanding of the biophysical characteristics of cropland as well as the behavioral and economic factors that drive land management decisions. Conservation auctions informed by models that simulate environmental outcomes have the potential to allocate conservation payments cost-effectively by funding practices that provide high predicted environmental benefits per dollar spent. This research tested two forms of conservation auctions. First, experimental auctions were used to analyze farmer preferences for different types of financial incentives for voluntary conservation, including direct payments, insurance, tax credits, and stewardship certification benefits. Second, conservation auctions were conducted in two Ohio counties to evaluate performance under real-world conditions. Supporting both types of auctions, the Soil and Water Assessment Tool (SWAT) predicted reductions in phosphorus exported as a function of the type of conservation practice and farm location. Results of the experimental auctions showed direct payments and tax credits to be the most cost-effective incentives to mitigate phosphorus export. The real auctions yielded two important lessons: 1) participation was very low, due to perceived transaction costs of participation—especially on rented fields and for group bids, and 2) the cost-effectiveness ranking of bids was highly sensitive to the parameters for soluble reactive phosphorus concentrations in the SWAT model. Future socio-economic research into payment for environmental services programs should seek cost-effective mechanisms with lower transaction costs for participants. Future biophysical research should strengthen our understanding of the factors governing soluble reactive phosphorus movement, so that models like SWAT can be more reliably parameterized.

Introduction

In the Great Lakes region, agricultural nutrient loss via surface runoff and subsurface drainage is threatening aquatic ecosystems. In 2011, a harmful algal bloom (HAB) (*Microcystis* sp.) of unprecedented size and severity occurred in the Western Lake Erie Basin (WLEB) (Michalak et al., 2013). In 2014, another HAB in the WLEB contaminated water supplies for nearly half a million people living in and around Toledo, OH (Wynne et al., 2015). As a result of this and other coastal and freshwater re-eutrophication problems, significant effort is being dedicated to identify strategies that reduce nutrient loss from land in high-priority watersheds (US EPA, 2014, 2010).

In the United States, farmers generally hold the property rights to manage their land as they choose; therefore, most agri-environmental programs are voluntary and many involve payments for ecosystem services (PES) to create incentives to adopt conservation practices (Kroeger and Casey, 2007; Norris et al., 2008). However, payments must come from budgets, and budgets are constrained. Spending on federally funded conservation programs is projected to be over $5.5 billion annually during the 5-year life of the 2014 Farm Bill (Lubben and Pease, 2014). In order to make best use of these funds, there is growing interest in designing more cost-effective programs in order to generate greater benefits with a limited conservation budget. Researchers and practitioners have called for programs that "pay for performance," which refers to the desire to pay for environmental outcomes rather than paying for practices or inputs without considering the resulting impact on the environment (Sowa et al., 2016–in this issue; Weinberg and Claassen, 2006; Winsten and Hunter, 2011).

In order to obtain the greatest environmental impact from limited funds, two kinds of information are essential: 1) a reliable prediction of environmental benefits from using a best management practice (BMP) on a specific field, and 2) knowledge concerning the least costly incentive that a farmer would be willing to accept in order to adopt that

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BMP. Biophysical models have been developed to predict changes in ecosystem services (ES) that result from alternative farming practices. While these models are not perfect predictors of ES changes, they provide a scientifically validated basis for paying for environmental performance in PES programs. In practice, they can be used to predict environmental improvements (e.g., reduced nutrient export) in order to allocate payments to projects that will provide the greatest benefit per dollar spent.

On the cost side, the challenge is to identify the minimum payment amount that farmers would be willing to accept in order to adopt a BMP. That amount is based on direct costs, opportunity costs, risks, and personal benefits that are specific to each farmer but not known accurately by policy makers. One increasingly popular mechanism for allocating scarce conservation funding is the conservation auction (also called a procurement auction or reverse auction), because it can induce farmers to reveal the minimum payment that they are willing to accept in order to implement a BMP (Hellerstein et al., 2015). Conservation auctions create a competitive environment in which land managers compete for payments to fund BMPs.

Early auction-type mechanisms, like those used to enroll land in previous versions of the Conservation Reserve Program (CRP), evaluated bids based on cost alone in order to maximize the number of acres enrolled (Reichelderfer and Boggess, 1988). The CRP has evolved over the last 30 years to include a more complex bidding mechanism in which land is scored and ranked using the Environmental Benefits Index (EBI) that considers the ES provided by the land and the cost (e.g., the per-acre rental rate) to enroll the land in the program (Jacobs et al., 2014). The bidding system used in the CRP differs from the reverse auctions that we describe in this paper in two key ways. First, acreage enrolled in the CRP is removed from production whereas we describe an auction mechanism for working lands that will continue to be used for crop production. Second, the EBI provides a scoring system for CRP applications, but environmental benefits on submitted acres are not predicted using biophysical models as in the auctions described in this study.

Research has shown that auctions are more cost-effective when bids are evaluated based on both the cost of BMP implementation and the predicted environmental benefits estimated by appropriate biological simulation models (Connor et al., 2008; Duke et al., 2013; Messer and Allen, 2010; Rabotyagov et al., 2014). Fig. 1 illustrates a bid selection process that accounts for both the payment required by a farmer and the predicted environmental benefits in allocating funds to the conservation projects that provide the most environmental benefit per dollar spent. Compared to uniform payment programs, conservation auctions have the potential to increase total environmental benefits procured with a limited budget (Selman et al., 2008). However, there is a need for additional field-testing in order to evaluate the feasibility of scaling up the conservation auction approach, particularly when the program targets working agricultural lands with heterogeneous production practices.

One important factor influencing the potential cost-effectiveness of reverse auctions is the incentive or payment mechanism offered. The norm up to now has been offering a direct payment to the farmer. Previous research has focused on programs that offer cost-share or annual stewardship payments (Claassen et al., 2008), but little is known about farmer willingness to adopt BMPs in exchange for other incentives such as tax credits, specialized insurance products, and benefits associated with stewardship certification (e.g., price premiums, market access, reputational benefits).

In this study, we explored alternative payment incentives and the feasibility of scaling up reverse auctions in the Maumee River basin to promote adoption of BMPs that reduce phosphorus runoff to Lake Erie. In the first stage, we implemented four experimental reverse auctions across the Maumee basin to understand farmer preferences among different types of conservation incentives. In these experimental auctions, farmers received payment based on the budgeted performance of mock farms to which they were assigned in the economic experiment, but their auction bids did not affect BMPs implemented on their own real farms. In the second stage, we conducted two public conservation auctions in the Tiffin watershed, a subwatershed in the Maumee basin, in order to assess how the auctions could be implemented in the real world at farm field scale. Farmers were invited to submit bids to implement BMPs on their own farms, thus the level of participation in the bidding process was of particular interest.

For both sets of auctions, the Soil and Water Assessment Tool (SWAT) was employed to predict changes in agricultural phosphorus (P) watershed export (i.e., combined surface and subsurface delivery) that would result from implementing the BMPs. Between the two sets of auctions, the SWAT model was updated to a new version. It was also called upon to predict the reduction in phosphorus export from

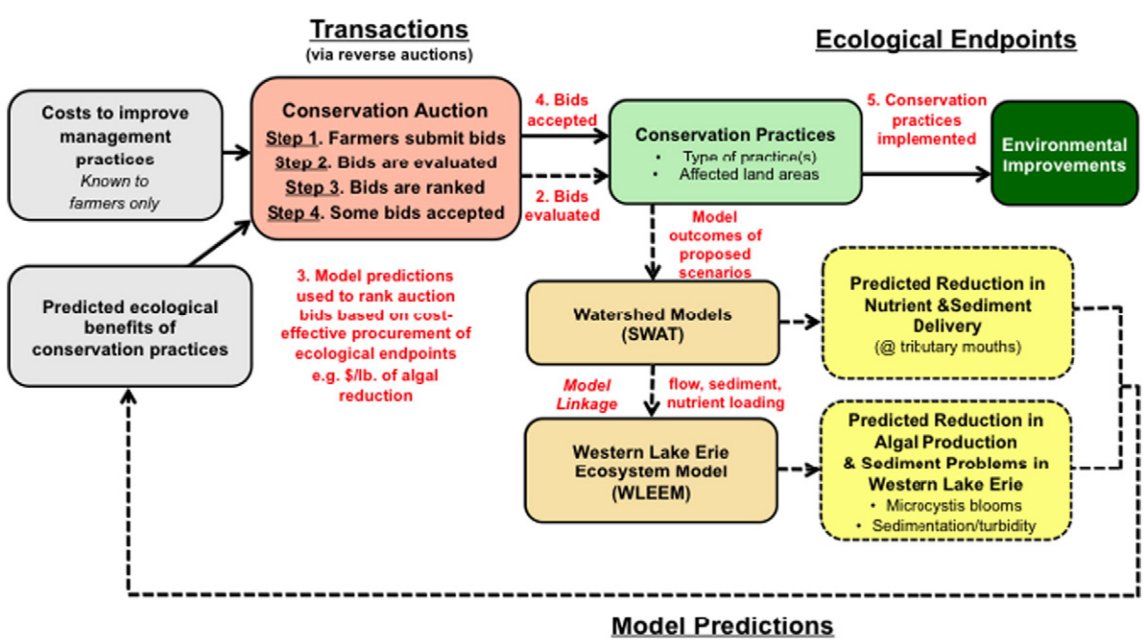

Fig. 1. Conceptual process model of this study. Farmers provide information about the cost of using conservation practices, while ecological models predict the benefits of these practices. Understanding the costs and benefits facilitates cost-effective transactions.