Evaluation of Best Management Practices under Net Cost Risk

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INTRODUCTION

As environment awareness increases, management of animal waste has become a crucial issue in northwest Arkansas. Federal and state water quality policy standards have been proposed to reduce pollution from sediments, nutrients and pesticides runoff (U.S. EPA, 2008). Fortunately, there are several best management practices (BMPs) that when used alone or in combination, may help producers to minimize runoff from their fields.

However, producers are reluctant to voluntarily implement expensive practices that diminish their net returns (NR), even if they are effective in improving water quality (Intarapapong et al., 2005). Consequently, before settling on a particular BMP that might improve water quality, policymakers need to know what impacts each BMP could have on producer's income (Westra et al., 2002).

The Arkansas Department of Environmental Quality (ADEQ) has reported the Illinois River in the Clean Water Act 303(d) list as an impaired water body in the state of Arkansas. Total phosphorous (TP) is recognized as the nutrient of concern in this watershed (ADEQ, 2008). Although several studies have provided evidence of the effectiveness of BMPs in reducing sediments, nutrients and pesticides runoff in Arkansas (Chaubey et al., 1995; Maringanti et al., 2009; Moore and Edwards, 2005; Rodriguez et al., 2007), an economic evaluation of management alternatives that includes producers' attitudes when implementing BMPs to control water pollution in nutrient surplus areas is scarce.

OBJECTIVE

To develop a procedure to economically and environmentally evaluate a range of BMP alternatives under uncertain production conditions using stochastic dominance techniques. This study compares different scenarios (i.e., BMP combinations) in terms of net return risk (NRR) reduction for bermuda grass-hay producers in the Lincoln Lake watershed. It was expected that producers' water conservation decisions (TP reduction) change based on environmental or economic goals.

RESEARCH METHODS

To assess the cost-effectiveness of BMPs to reduce TP runoff, stochastic dominance with respect to a function (SDRF) was employed to analyze risky scenarios. This analysis requires a system approach combining a number of different models covering hydrologic, economic and risk analysis components of a bermuda grass-hay production system.

Fifty-nine scenarios were created using combinations of BMPs. Practices were grouped into pasture management (no grazing and optimum grazing); buffer zones (0 and 15 meters wide) and poultry litter. Poultry litter practices were defined by three factors: 1) poultry litter application rates (0, 2.47, 3.71, 4.94, 6.18 and 7.41 tons/ha), 2) litter characteristics (non-amended litter and alum amended) and 3) application timing (spring, summer or fall).

The Soil Water and Assessment Tool (SWAT) was run to generate TP loading and bermuda grass yield data. An economic model used yield data to calculate NR. Outcomes from these models were input to the risk model. This last model was employed to evaluate the impact of decision-makers' risk attitudes on scenario preferences.

Each scenario was ranked in terms of TP runoff and NR reduction and compared with a baseline (scenario 41). Then, the top-ten scenarios of each ranking (i.e., TP and NR) were evaluated assuming that decision makers were risk neutral and risk averse regarding their environmental and economical attitudes, respectively.

Table 1. Top-ten scenario rankings, total phosphorous and net returns

BMP Scenario #	Pasture Land (Grazing)	Buffer Width (meters)	Poultry Litter[a] Amount (ton/ha)	Poultry Litter[a] Time (season)	Poultry Litter[a] Alum	Total Phosphorous Ranking	Percentage Change from Baseline	Net Returns Ranking	Percentage Change from Baseline[b]
Rankings Sorted in Terms of Total Phosphorous									
S20	No	15	0.00	N/A	No	1	94.52	43	-93.44
S24	No	15	2.47	Summer	No	2	92.67	28	-66.68
S33	No	15	2.47	Summer	Yes	3	92.15	56	-106.70
S21	No	15	2.47	Spring	No	4	92.13	26	-61.01
S30	No	15	2.47	Spring	Yes	5	91.58	53	-105.38
S25	No	15	3.71	Summer	No	6	91.48	21	-43.89
S22	No	15	3.71	Spring	No	7	91.20	19	-28.20
S34	No	15	3.71	Summer	Yes	8	90.70	52	-105.07
S27	No	15	4.94	Fall	No	9	90.44	16	-21.77
S26	No	15	4.94	Summer	No	10	90.42	14	-21.04
S41[a]	Optimal	0	4.94	Fall	No	59	0.00	10	0.00
Rankings Sorted in Terms of Net Returns									
S10	No	0	7.41	Fall	No	54	35.93	1	53.54
S4	No	0	4.94	Spring	No	49	44.82	2	28.98
S29	No	15	7.41	Fall	No	17	88.45	3	27.29
S9	No	0	6.18	Fall	No	50	41.51	4	25.38
S45	Optimal	15	4.94	Spring	No	30	81.48	5	14.99
S23	No	15	4.94	Spring	No	12	90.07	6	7.66
S50	Optimal	15	6.18	Fall	No	32	81.37	7	6.97
S28	No	15	6.18	Fall	No	13	89.45	8	1.74
S7	No	0	4.94	Summer	No	47	46.83	9	0.29

[a] baseline; [b] negative numbers indicate decrease from the baseline (%)

Figure 1. Total phosphorous vs. Net returns

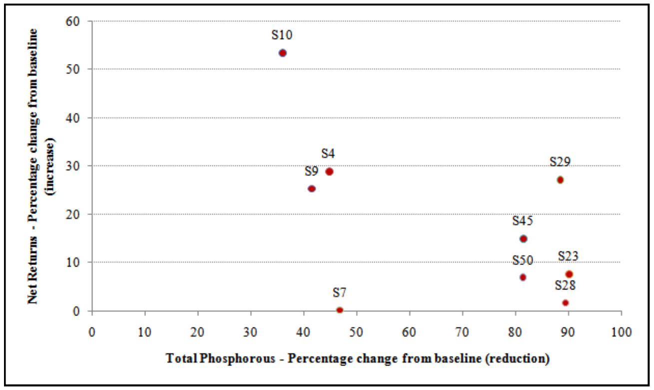
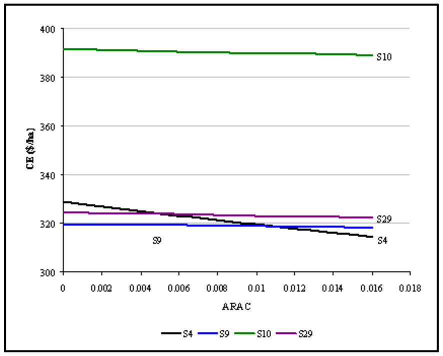


Figure 2. Certainty Equivalents vs. Risk Aversion Coefficients



RESULTS & DISCUSSION

Scenario selection differs when environmental and economic impacts are analyzed separately. Results show the most preferred scenarios to reduce TP runoff generate lower or even negative NR when compared to the common practice employed by producers in the watershed (table 1). In other words, results suggested that producers would not implement scenarios based only on their potential to reduce TP runoff.

When scenarios are ranked in terms of NR first, nine scenarios reduced TP runoff and increased NR simultaneously (figure 1). These results highlight the importance of evaluating the effectiveness of scenarios not only on their potential to reduce TP runoff but also in their positive or negative economic impact to producers.

Additionally, the model reveals that producers' risk preferences matter (figure 2). For instance, slightly risk averse producers would prefer S4 (ARAC < 0.006) while producers who were slightly more risk averse would prefer S29. Similarly, producers who were slightly more risk averse to very risk averse would prefer S9 over S4 (ARAC > 0.012). Since S29 had greater CEs than S9, it would be preferred over S9 regardless producers' risk preferences. Consequently, ignoring producers' risk preferences could lead to inappropriate policy choices.

CONCLUSIONS

Ranking BMPs solely in terms of their effectiveness to reduce nutrient runoff can lead to cost-prohibited recommendations since producers' risk aversion levels matter. These research results can be seen as policy choices that take into consideration environmental benefits and economic costs of various BMP alternatives. Consequently, producers could address nutrient pollution more effectively if water quality management practices are linked to producers' NR variability.

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