Cost and benefits of using best management practices to control non-point sources of pollution under environmental and economic uncertainty

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Selection of Best Management Practices to Control Non-Point Sources of Pollution under Environmental and Economic Uncertainty

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INTRODUCTION

The economy of northwest Arkansas (NWA), including the Lincoln Lake watershed (a subwatershed of the Illinois River), relies greatly upon livestock and poultry production. Although animal waste can be used beneficially on farms to fertilize crops, in excessive amounts it can cause water quality degradation. In NWA animal production is concentrated in small areas producing more manure than adjacent pasture fields require. Consequently, manure handling and disposal problems receive attention as the effects of these problems reach to others in nearby communities.

Best management practices (BMPs) can be adopted to prevent or reduce pollution from nonpoint sources. Livestock producers face costs for developing and implementing BMPs, thus economic pressures can create disincentives for producers to include water conservation practices in their management plans. In fact, producers may be reluctant to voluntarily implement expensive practices that diminish their net returns (NR), even if the practices are effective in improving water quality (Intarapapong, Hite, and Isik 2005). In light of the recent economic crisis, methodologies that help producers to evaluate the environmental and economic impacts of several practices before implementing them may be a cost-effective means of increasing BMP adoption.

OBJECTIVE

To generate rankings that could be useful to producers and watershed managers in selecting BMPs to reduce total P (TP) losses from runoff. Specifically, this study compares scenarios in terms of net return (NR) risk reduction for bermudagrass hay producers in the Lincoln Lake watershed.

RESEARCH METHODS

Stochastic dominance with respect to a function (SDRF) is used to compare the effects of, and tradeoffs between, economic and environmental goals. This analysis requires a systems approach combining hydrologic, economic and risk analyses. Ten BMP combinations were created using pasture, buffer and poultry litter factors. Table 1 displays the ten BMP scenarios analyzed and, the baseline as well as their associated total costs. Each combination was ranked in terms of TP reduction and NR variability when compared to a baseline. Producers' risk attitudes regarding combinations that resulted in higher TP reductions with less NR variability were evaluated.

The Soil Water and Assessment Tool (SWAT) was run to generate TP loading and bermuda grass yield data for each sub-basin in the watershed (69 pasture sub-basins). An economic model used yield and price 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. TP losses reduction and NR variability were estimated as percentage change from the baseline for each scenario. Each BMP scenario was ranked at the sub-basin level and then an overall ranking was estimated at the watershed level. Scenarios were evaluated assuming that decision makers were risk neutral and risk averse regarding their environmental and economical attitudes, respectively. Subbasin 63 was used as an example to illustrate the results of this analysis. This subbasin was chosen because it represented 4.4 % of the total pasture area in the watershed. Cumulative distributions functions (CDFs) for each scenario were estimated.

Table 1. Best management practice combinations and associated total cost

BMP Scenario [a]	Buffer Width (m)	Poultry Litter: Time	Poultry Litter: Amount (Mg/ha)	Poultry Litter: Alum	Total Cost: % Change [b]
S1	15	Spring	2.47	yes	12.76
S2	15	Spring	4.94	yes	44.59
S3	15	Spring	2.47	No	-4.49
S4	15	Spring	4.94	No	10.09
S5	15	Summer	2.47	yes	12.76
S6	15	Summer	4.94	yes	44.59
S7	15	Summer	2.47	No	-4.49
S8	15	Summer	4.94	No	10.09
S9	15	Fall	4.94	yes	44.59
S10	15	Fall	4.94	No	10.09
Baseline	No	Fall	4.94	No	0.00

[a] All pastures were optimally grazed
[b] Percentage change from baseline; a positive number means increase in total costs; a negative number means a reduction in total costs when compared to the baseline scenario. The units of analysis were kg of TP/ha and $/ ha.

Table 2. Scenario rankings based on total phosphorous and net returns

BMP Scenario	Total Phosphorous Losses Reduction: CV [a]	Ranking [b]	% Change [c]	Net Returns: CV [a]	Ranking [b]	% Change [d]
S1	77.2	2	83.6	70.5	4	1.6
S2	77.9	7	80.9	68.8	5	-2.2
S3	74.6	1	84.4	68.7	2	21.6
S4	80.5	5	81.4	57.2	1	38.9
S5	84.6	4	81.9	47.0	8	-18.9
S6	86.4	10	78.9	86.0	9	-30.4
S7	83.5	3	82.6	99.9	6	-1.6
S8	84.5	8	80.7	71.1	3	6.4
S9	87.6	9	79.4	65.5	10	-41.7
S10	85.3	6	81.2	119.7	7	-3.2

[a] Coefficient of Variation (%)
[b] Overall rankings across 69 pasture subbasins
[c] Percentage change from baseline scenario. A positive number means decrease in TP losses.
[d] Percentage change from baseline scenario. A positive number means a higher NR than for the baseline scenario. A negative number means a lower NR than for the baseline scenario.

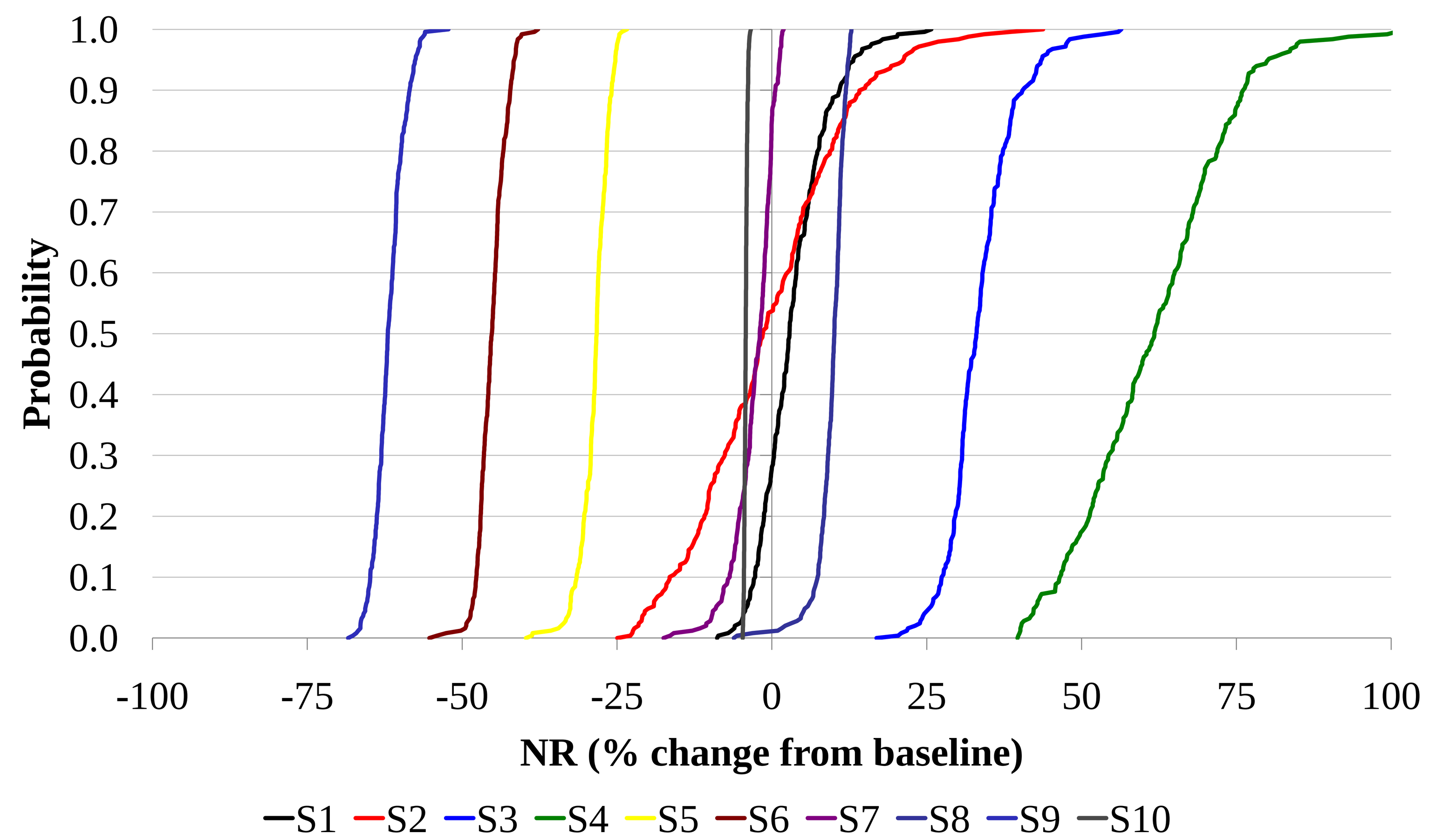

Figure 1. Cumulative distribution functions of net returns for sub-basin 63

RESULTS & DISCUSSION

All BMP scenarios analyzed were effective in reducing TP losses. Overall, four scenarios reduced TP and increased NR, indicating that environmental and economic goals may be complementary. However, six of them also decreased NR when compared to the baseline (table 2). This suggests that including BMPs in current production systems may lead to higher NR variability.

This analysis revealed that producers' risk preferences did not matter when selecting among the top-two BMP combinations but it could be a factor for other less preferred scenarios. Figure 1 described the probability that a NR outcome took on a value less, equal or greater than the baseline. Without additional incentives, producers will not likely implement BMP scenarios S5, S6, S9 and S10 regardless of their TP losses reduction benefits because they always generated lower NR than the baseline scenario. The same figure showed that the ranking of scenarios S1, S2, S7, S8 and S10 was inconclusive since their CDFs intersected each other at several points. Overall, slightly risk-averse producers will prefer different scenarios than very risk-averse producers. Consequently, ignoring producers' risk preferences could lead to inappropriate policy choices if these less desired practices are chosen.

CONCLUSIONS

Policy makers could see these research results as policy choices that take into consideration environmental benefits and economic fluctuations of various BMP alternatives. These results highlight the importance of evaluating the effectiveness of BMP scenarios not only on their potential to reduce TP losses but also in their economic impact to producers. Consequently, nutrient pollution could be addressed more effectively if water quality management practices are linked to producers' NR variability. Finally, although the results are watershed specific, the methodology itself is readily applicable to evaluate the selection of any set of BMP combinations desired by policy makers, watershed managers and producers.

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