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Economic Implications of Biomass Production from High Energy Sorghum in the Tres-Palacios River Watershed of Texas[1]

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This briefing paper presents estimates of unintended consequences to water quality associated with High Energy Sorghum (HES) biomass feedstock production. A hypothetical shift from current pasture to HES production in the Tres-Palacios River watershed of Texas was evaluated by applying the SWAT model (Soil Water Assessment Tool) (Arnold et. al. 1998) and estimating annual changes in Phosphorus (TP), Nitrogen (TN), and sediment runoff. The results estimated at the watershed outlet indicate that HES production increases nutrient and sediment loadings. The goal of this research was to estimate the economic implications of mitigating the water pollution externalities associated with the land use change.

Cover crop (CC) and filter strips (FS) were selected as the Best Management Practices (BMPs) to mitigate or reduce the increased level of runoff of TP, TN, and sediment resulting from shifting to HES production from pasture. The results indicate that the selected BMPs when implemented individually failed to produce reduction levels that meet the status-quo loadings, i.e., nutrient and sediment loadings prior to shifting from pasture to HES. The mitigation considerations in the current analysis through adoption of BMPs are related to the results from Lee, Narasimhan, and Srinivasan (2011b) and Rister et al. (2009), where a portfolio of similar and additional BMPs achieved the 35 percent reduction goal for TP in the Cedar Creek reservoir located near Kaufman, Texas. However, the mitigation goal of 100 percent runoff reduction in the current study combined with a limited set of feasible alternatives warrants a different approach to evaluating the BMPs than suggested in Rister et al. (2009). Two BMPs (CC and FS) combined in different ways resulted in nine sets of possible solutions (Table 1). The combination BMPs implemented produced improved reduction levels relative to the individual BMPs, but still fell short of the 100 percent mitigation goal, mainly with respect to TP and TN. The sub-par results for the combination BMPs suggest need for evaluation of other potential BMPs such as wetland creation (e.g., construction of a dike around the field). However, it has to be noted that such BMPs can be expensive (Rister et al. 2009).

The results from the SWAT analyses provide a basis for economic analyses, which consists of estimating Annuity Equivalent Values (AEV), i.e., calculated annual payments over life of project of all costs of individual and combination BMPs. These AEV estimates are used to evaluate the relative cost-effectiveness across the alternative BMPs with the goal to reduce nutrient and sediment runoff, i.e., to get the most "Bang for the Buck."

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[1] This is one of three essays that comprise the dissertation of Dr. Adusumilli (2012).

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Table 1. Financial annuity equivalent value of costs per unit for TP, TN, and Sediments associated with each BMPs, desired mitigation levels, and effectiveness of individual and combination BMPs measured at the watershed outlet, Tres-Palacios river watershed, Texas

BMP Description	Annuity Equivalent Value of all Costs ($/year)	Desired Mitigation Levels[a]			Annuity Equivalent Cost per English Ton Reduction ($/Ton/year)[c]		
		TP (ET[b])	TN (ET)	Sediment (ET)			
		216	410	8,762			
		Mitigation (% of Desired) Achieved Through BMP Adoption					
		TP	TN	Sediment	TP	TN	Sediment
FS (20:1)[d]	$ 563,862	69.3%	70.8%	73.5%	$ 3,763	$ 1,942	$ 83
FS(15:1)[d]	751,816	71.5%	73.7%	77.1%	4,863	2,487	111
FS(10:1)[d]	1,127,723	74.1%	77.1%	81.9%	7,040	3,563	157
FS(5:1)[d]	2,255,447	77.3%	81.7%	87.4%	13,493	6,732	295
Cover Crop (CC)[e]	13,185,077	48.3%	55.7%	66.7%	126,188	57,728	2,255
CC[e]+ FS(20:1)[d]	13,748,938	88.2%	97.0%	102.6%	72,059	34,554	1,529
CC[e]+ FS(15:1)[d]	13,939,893	89.3%	98.4%	104.1%	72,196	34,530	1,528
CC[e]+ FS(10:1)[d]	14,312,800	90.4%	100.1%	106.1%	73,166	34,867	1,539
CC[e]+ FS(5:1)[d]	15,440,524	91.7%	102.0%	108.3%	77,853	36,895	1,627

[a] The "Desired Mitigation Levels" are the difference in runoff loadings between the pre-HES (pasture) levels and the post-biofuel levels. These desired levels indicate the amount of reduction in runoff that needs to be achieved to attain pre-HES runoff loadings.
[b] English Ton; One English Ton = 2,000 lbs.
[c] Estimated as AEV of all costs divided by the product of marginal reduction achieved and desired mitigation levels; for TP and FS (20:1): 563,862/ (69.3*216) = $3,763 per ET.
[d] FS refers to filter strip BMP and (20:1) refers to the ratio of crop acres to filter strip acres.
[e] CC refers to cover crop BMP acres and is assumed to be planted on all land in the rotation that is not planted to HES.

Table 1 presents the SWAT and AEV results of the analysis. The AEV of cost per ET (English Ton equal 2,000 pounds) of reduction in TP through Filter Strip (FS) of one acre per 20 acres of cropland (20:1) BMP was $3,763 (Table 1), which is relatively lower than the $4,752, the AEV of cost per ET of TP reduction estimated by Lee et al. (2010) for the Cedar Creek Watershed. However, the AEV of cost per ET of reduction in TP using a cover crop BMP was relatively higher in the current analysis compared to Lee et al. (2010) (i.e., $126,188 compared to $53,307). The differences in the AEV of BMPs between two studies are primarily attributed to the differences in mitigation levels achieved, which are dependent on topography of the land, rainfall events during the project period, nature of the crop used for the BMPs, history of fertilizer application, and other factors.

Although the FS (20:1) BMP was substantially less expensive than the CC BMP, and due to the less than 100 percent mitigation achieved through the individual BMPs, other relevant BMPs that could provide the remaining mitigation and their associated costs are evaluated. As a result, higher intensity

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BMPs, i.e., filter strips of intensity FS (15:1), FS (10:1), and FS (5:1) are implemented. These BMPs produced slight improvements in runoff mitigation at marked relatively higher costs (i.e., $13,493 per ET of reduction in TP). A similar trend is observed with the combination BMPs, where the AEV of cost per ET of reduction in TP by CC+FS (5:1) was $77,853, substantially higher than filter strips BMPs (as a result of the higher costs of CC BMP). These results provide interesting insights into the potential of combination BMPS in providing runoff mitigation and their cost-effectiveness.

Considering and accepting all of the assumptions developed in the course of applying SWAT and BMPEconomics (i.e., the economic model developed to estimate mitigation costs), a 100 percent reduction in TP runoff for the case study defined in this research is not achievable. Reference conditions (i.e., pre-HES runoff information) are useful for comparison to the current water conditions (i.e., post-HES with and without BMPs) and to identify the extent of management required restoring the quality of the resource. An issue to determine is to what extent of improvement is demanded. For example, Rister et al. (2009) identified the portfolio of BMPs for Cedar Creek watershed in Texas to achieve 35 percent reduction in annual TP inflows to achieve a local watershed goal. This assumption emphasizes the importance of realistic water management goals and assumptions relative to geographical location. Hence, a more realistic assumption of requisite runoff mitigation levels for the Tres-Palacios River watershed could help identify cost-efficient BMPs and consequently a cost-efficient water quality management plan.

Policies designed around adoption of BMPs to mitigate water quality deterioration are an attempt to make the responsible parties accountable for the costs imposed by their activities (agricultural production in this case). In this study, the evaluation of the potential BMPs to achieve status-quo runoff levels (i.e., runoff levels of pre-HES production) indicates substantial investment and operation costs. Although achieving status-quo water quality is justified from a societal standpoint, the BMPs selected and their associated costs suggest relatively low levels of mitigation for inexpensive BMPs and substantial investment, operation, and maintenance costs for BMPs that offer higher levels of mitigation. Hence, further investigation of other potential BMPs and reevaluation of the desired mitigation levels are warranted, along with evaluation of other economic policy instruments to internalize the water pollution externality. This analysis suggests that decision makers have the responsibility of determining the level of tradeoff between mitigation and costs.

If commitment to biofuels production continues, numerous agricultural producers have sufficient incentives to apply greater amounts of fertilizers, cultivate marginal lands, etc., showing little or no regard to environmental consequences. Although BMPs could reduce some of the potential negative impacts, these practices involve substantial costs and can quickly erode the profits of the producers or warrant funding from external sources. Any such policy options can affect the economics of biofuels production and thus require further investigation.

This analysis is useful to researchers from a cost-benefit standpoint, i.e., the AEV costs of BMPs can be used to compare against the benefits of protecting water quality. The study emphasizes the need for the

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U.S. to assess the broader environmental issues of biofuels, not limited to greenhouse gases, to make biofuels a sustainable option and to meet the energy demands of the country.

Limitations

The evaluation of the BMPs to identify a cost-efficient watershed protection strategy for the Tres-Palacios River watershed in Texas highlights the important issues that warrant thorough investigation to further improve the analysis. Some of the issues include:

- Water quality modeling requires extensive calibration of nutrient and other runoff data. Calibration of nutrient and sediments was not rigorous in the study due to the unavailability of data at the USGS gauge stations in the watershed region.
- Only two individual BMPs (i.e., cover crop and filter strips) were considered for evaluation in the study. Evaluation of other potential BMPs has the potential for identifying a lower cost solution related to reducing externalities.
- Some existing level of BMPs adoption suited to the current operations is expected in any production enterprise (Rister et al. 2009). However, due to lack of sufficient information to corroborate any such adoption levels in the Tres-Palacios River watershed, a zero current adoption level for the BMPs is assumed.
- It is also appropriate to recognize and include secondary impacts resulting from implementation of the BMPs. For example, the invasive nature of the crops used for cover crop or filter strips could require additional costs to control their spread to other parts of the watershed. These additional costs could change the portfolio of the BMPs. Due to the associated uncertainty of the secondary consequences; however, these concerns are not included in this study.
- Watersheds are vastly different in terms of soil and land characteristics, thus making the results of this research less generalized and not directly applicable to other watersheds across the U.S.
- Thoughtful consideration should be given to the incentive payments that determine/encourage participation in water quality mitigation activities such as BMPs adoption (e.g., Rister et al. 2009). No such payments were accounted for in the analyses of this research and it was assumed that financial incentives do not play a role in the decision making process of BMPs adoption. Failure to account for such incentive payments most probably underestimates the cost of water quality mitigation, which suggests that the true cost of water quality mitigation can be much higher than what is reported in this research.

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References

Adusumilli, Naveen. 2012. "Economic Policy and Resource Implications of Biofuel Feedstock Production," PhD dissertation, Department of Agricultural Economics, Texas A&M University, College Station, Texas.

Arnold, J.G., R. Srinivasan, R.S. Muttiah, and J.R. Williams. 1998. "Large Area Hydrologic Modeling and Assessment Part I: Model Development." *Journal of American Water Resources Association* 34(1): 73-89.0

Lee, T., B. Narasimhan, and R. Srinivasan. 2011b. *Eagle Mountain Watershed: Calibration, Validation, and Best Management.* Texas Water Resources Institute Technical Report No 408. College Station, TX.

Lee, T., M.E. Rister, B. Narashimhan, R. Srinivasan, D. Andrew, and M.R. Ernst. 2010. "Evaluation and Spatially Distributed Analyses of Proposed Cost-Effective BMPs for Reducing Phosphorous Level in Cedar Creek Reservoir, Texas." *American Society of Agricultural and Biological Engineers* 53(5): 1619-27.

McLaughlin, W.A. 2011. "The Economic and Financial Implications of Supplying a Bioenergy Conversion Facility with Cellulosic Biomass Feedstocks." Master of Science Thesis, Department of Agricultural Economics, Texas A&M University, College Station, TX.

Rister, E. M., R. D. Lacewell, A. W. Sturdivant, T. Lee, R. Srinivasan, B. Narashimhan, C. Wolfe, D. Waidler, D. Andrew, M. Ernst, J. Owens, B. Lesikar, L. F. Gregory, A. Jones, B. L. Harris, E. K. Seawright, and S. R. Yow. 2009. *NCTXWQ Project: Evaluating the Economics of Best Management Practices for Tarrant Regional Water District's Cedar Creek Reservoir.* Texas Water Resources Institute. TR-357. College Station, TX.

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