The Potential of GIS and Hydraulic Modeling for Nonpoint Source Pollution Reductions in Arkansas Delta Agriculture

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Abstract

Soil erosion initiated by water runoff from agricultural areas contributes to nonpoint source pollution of surface waters. Through mutual uses of remotely sensed data, GIS and hydraulic modeling technologies, a study was conducted to develop a process for evaluating sediment reduction using Water Erosion Prediction Project (WEPP) model simulations as an assessment tool. Field monitoring was not conducted, therefore all results reflect model sensitivity. WEPP parameter inputs were partially derived from data layers in ArcView software. Cotton and soybean field boundaries were individually selected along the St. Francis River in NE Arkansas to determine amounts of surface water runoff and soil erosion from selected databases. Best Management Practices (BMPs) commonly used in Arkansas row crop agriculture were evaluated in each of 40 fields as eight statistical treatments. WEPP runoff simulations from cotton BMPs ranged from 100,488 to 132,391 m^3 yr^{-1}. Simulations for runoff from soybean BMPs ranged higher from 181,535 to 278,042 m^3 yr^{-1}. Runoff was significantly reduced in cotton and soybean systems using continuous cover con-tillage and continuous cover no-tillage with filter strips, respectively. WEPP soil loss simulations from continuous cover con-tillage cotton were reduced by 91.7 to 92.1% as compared to conventional tillage. Simulations of soil loss from continuous cover no-till soybeans were reduced 61.5 to 62.7 % as compared to conventional tillage methods. Results of this study showed WEPP was sufficiently robust to detect differences in field variability as well as BMP differences between the two cropping systems. GIS technologies and available remote sensed databases provided detailed measurements for appropriate characterization of the St. Francis watershed study areas. The linking of remote sensed data and hydraulic models offers a rapid assessment for environmental planning of sensitive areas to meet compliance of nonpoint source sediment control.

The Arkansas Delta is typical of ~1% slope, variable soil series and predominately commercial agriculture.

Producers are currently faced with fewer pesticide alternatives, more pest resistance and increased water quality issues.

On relatively flat fields, soil erosion and runoff still occur with minimum protected soils.

In order for land managers and stakeholders to comply with the CWA of 1972, a comprehensive assessment of the surface water and ground water must be completed to determine the health of those systems. Required evaluation of large areas can be very expensive and time consuming.

A solution....

Combining the technologies of computer assisted programs of remote sensed imagery and hydraulic models can provide decision makers with rapid cost-effective assessment tools for compliance.

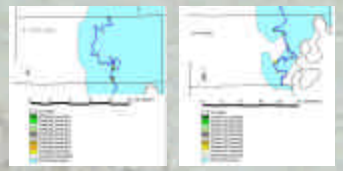
Research Objectives

1. Investigate the potential use of remotely sensed data sources for application in GIS as a method of obtaining watershed parameters of sections of the St. Francis River Basin.
2. Investigate the WEPP model to determine if it is sufficiently robust to detect differences in selected conservational land management practices as applied for sediment reduction from commercial agricultural production within the St. Francis River Basin.

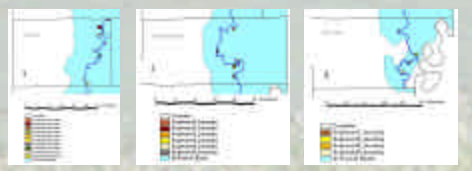
Methods

- Construct and uniformly configure databases.
- Compile data layers into ArcView 3.2a.
- Identify and select forty actual cotton and soybean production fields.
- Ground truth selected fields.
- Include database information as hydraulic model input parameters.
- Apply BMP scenarios to each field.
- Eight BMPs consisted of tillage combinations and crop rotation scenarios.
- WEPP simulations were ran for 50-year annual averages.
- Surface water runoff and soil loss data for each BMP were predicted.
- Simulation results were statistically analyzed using ANOVA and linear regression techniques.

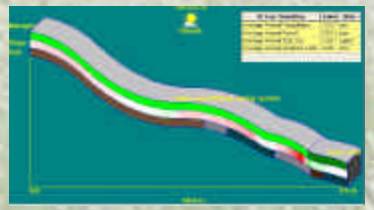
Location and study area of St. Francis River Watershed



Cotton field locations along St. Francis River

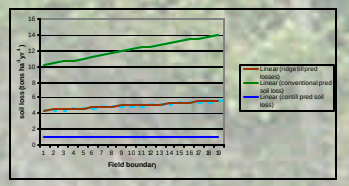


Soybean field locations along St. Francis River

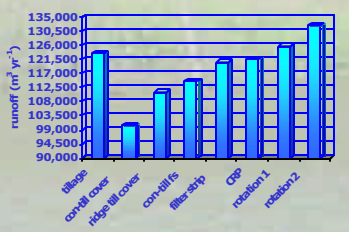


WEPP 3D slope profile displaying field topography, land management, soil deposition and soil variation of flowpath.

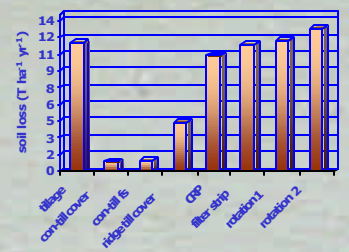
Cotton Results



Linear regression of cotton BMPs showing WEPP sensitivity.



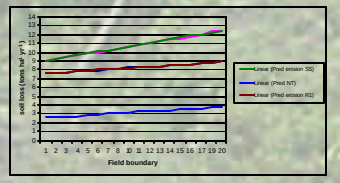
Simulated runoff for cotton BMPs.



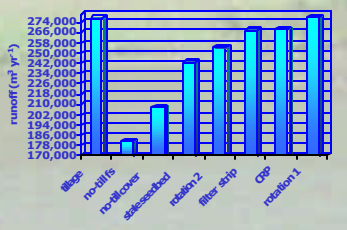
Simulated soil loss for cotton BMPs.

Each horizontal line of the bar charts represents statistical significance. All data shown reflects 95% confidence.

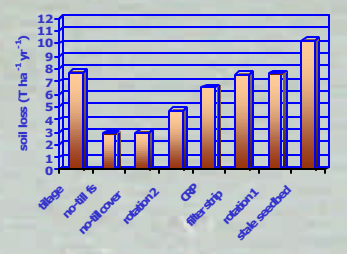
Soybean Results



Linear regression of soybean BMPs showing WEPP sensitivity.



Simulated runoff for soybean BMPs.



Simulated soil loss for soybean BMPs.

Conclusion

In most situations, it is impractical to physically monitor each farm or land parcel that is suspect of contributing nonpoint source pollution. This, however, is approachable through application of remote sensed data toward environmental planning of sensitive areas. Precision and specific features of remote sensed data are considered comparable to actual field measurements. This study demonstrated that use of GIS technologies and available remote sensed databases provided detailed measurements for characterization of the St. Francis watershed study areas. This information was then used as direct parameter inputs into the hydraulic model, WEPP. Subwatershed evaluations were then accomplished through the linking of GIS and hydraulic models.

This study also demonstrated that WEPP was sufficiently robust to show differences between BMP effects among varying row crop production fields and land management practices. WEPP simulations consisted of runoff and erosion from field responses and BMP selections for cotton and soybean cropping systems. Reliability of the simulations generated was validated from detailed literature documentation. Statistical significance of BMP responses showed the model's sensitivity in determining definitive conservation suggestions.

The prevalence of field variability emphasizes the need for accurate descriptions of input parameters. Applications of appropriate BMPs allows the user to specifically plan land use for potential environmental compliance of nonpoint source sediment control.

***Contributing Author**

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