Grassed Waterway Planning Model Evaluated for Agricultural Fields in the Western Coal Field Physiographic Region of Kentucky

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Project Background

The environmental benefits of grassed waterways (GWWs) including erosion control and sediment reduction in runoff are well documented. The USDA-NRCS provides funding to producers for the establishment and maintenance of approved waterways in these areas if a field has sufficient erosion resulting from concentrated water flow. The first step in successfully establishing a grassed waterway is for an NRCS conservationist to make a site assessment to determine if sufficient erosion exists to warrant mitigation. This involves traversing fields to locate physical evidence of prior erosion which can be a time consuming and expensive process.

Precision agriculture technologies such as global positioning systems (GPS) and geographic information systems (GIS) may improve the efficiency of locating areas for GWWs per NRCS guidelines. In a previous study, a model was developed with considerable predictive capacity that identified where erosion resulting from concentrated water flow was likely to occur (Pike et al. 2009). The model was developed with data from five fields located in the Outer Bluegrass physiographic region of Kentucky, each containing extensive GWWs. For model input, they used a 4.0 by 4.0 meter grid of terrain attribute values (i.e., length-slope factor, topographic wetness index, and plan curvature) that corresponded to digital elevation model (DEM) grid points derived from real-time kinematic (RTK) GPS elevation measurements. Their validation analyses demonstrated that most of the eroded features requiring GWWs could be identified with this procedure and the erosion probability maps had excellent predictive capacity.

Project Objectives

The focus of this study was to test the logistic regression model developed by Pike et al. (2009) on agricultural fields located in a different physiographic region of Kentucky to better understand the limitations of this approach. The premise of this project was that the logistic regression model would be useful to planners if predictions matched with the locations of existing waterways, surface drains, or field observations of erosion associated with concentrated water flow.

Experimental Methods

The model was tested on four fields (two of which are highlighted here) in Hopkins County located in the Western Coal Fields physiographic region of Kentucky. These fields were selected because GWWs had previously been installed as delineated by an NRCS Conservationist and others installed by the producer without input from NRCS personnel. Field A (27 ha) contained several GWWs delineated by the producer. Field B (22.7 ha) contained multiple GWWs that were delineated by the NRCS Conservationist.

RTK GPS was used to collect elevation data for Field A in 2001 and Field B in 2008. The elevation data for both fields were pre-processed prior to calculating terrain attributes according to methods described by Pike et al. (2009). After successfully calculating the terrain attributes, the analysis proceeded with calculating the probability of erosion for each field.

Pike et al. (2009) presented a logistic regression model using three terrain attributes; length-slope factor (LS), topographic wetness index (WET), and plan curvature (PLAN) for calculating the probability of erosion. The probability of erosion was calculated as:

$$\textit{Probability of Erosion} = \frac{1}{1 + e^{-(-3.63 + 1.1(LS) + 0.217(WET) - 12.1(PLAN))}}$$

Areas of each field with a probability of erosion between 0.5 and 1.0 were plotted as overlays on the aerial photographs. Field boundaries and existing GWW boundaries were overlain on each map. During an April, 2009 site visit, areas where erosion channels had developed without existing GWWs for protection were observed. Photographs were taken in these areas and the locations were denoted on the aerial imagery with arrows indicating the viewpoint of the camera.

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Results and Discussion

In Field A (Fig. 1), the outline of the existing GWWs (yellow border) matched well with the probability of erosion model values that were greater than 0.5 (shown with semi-transparent red shading). The model suggested that erosion may have been better controlled if GWW had been added (e.g., locations 1-5) and extended (e.g., locations 6-8) to areas that included the shaded zones. During the 2009 field visit, evidence of erosion was observed in locations 1 through 8 (Fig 2). The existing GWWs in Field A were smaller than would have been required by the NRCS because they were installed by the producer. It is likely the producer would have been able to better control erosion in this field if there had been access to erosion probability maps when the waterway conservation features were designed.

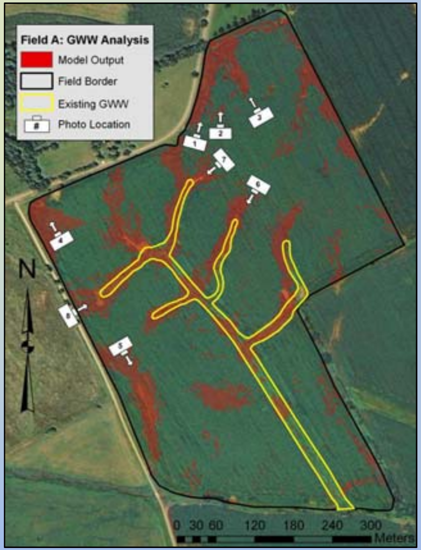

Fig. 1: Aerial photograph of Field A identifying probability of erosion model output (values > 0.5 are shown in red), existing GWWs, and locations of photographed eroded areas.

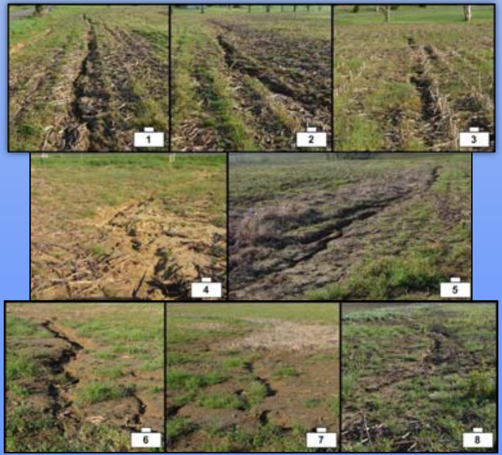

Fig. 2: Photographs of eroded areas in Field A (locations and viewpoint identified in Fig. 1).

For Field B (Fig. 3), the model suggested the need for extending existing GWWs (locations 3 and 4 in Fig. 3) where erosion was noted. Erosion was observed at locations 1 through 4 (Fig. 4) indicating that many of the model predictions outside the boundaries of the existing GWWs were valid for this field. It is important to note that the producer had regraded field locations 2 and 3 (Fig. 4) because of the severity of erosion. Observations from the April, 2009 field visit indicated that the model over-predicted along the eastern and southeastern boundaries of Field B (Fig. 3). Had the conservationist had access to the model predictions when the waterways were designed, some eroded ephemeral gullies (e.g., location 2 in Fig. 4) may not have been overlooked. In addition, the GWW between locations 3 and 4 (Fig. 3) may have been extended to better control erosion in this area.

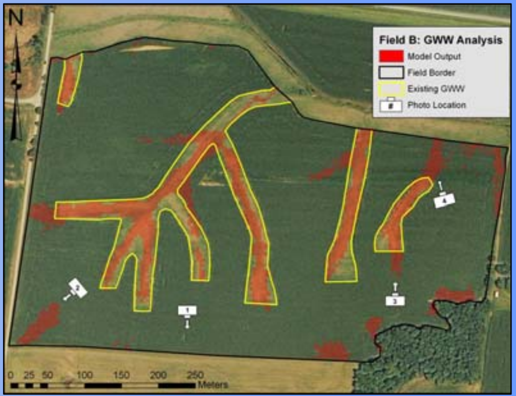

Fig. 3: Aerial photograph of Field B identifying probability of erosion model output (values > 0.5 are shown in red), existing GWWs, and locations of photographed eroded areas.

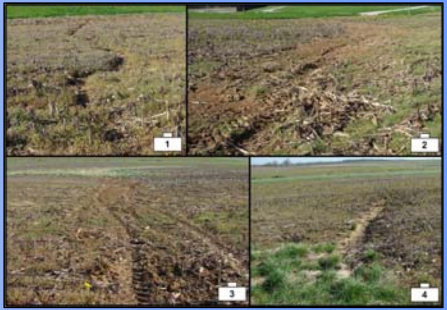

Fig. 4: Photographs of eroded areas in Field B (locations and viewpoint identified in Fig. 3).

Conclusions

Although the model was developed for Outer Bluegrass region of Kentucky, the model predicted erosion well at this location in the Western Coal Field physiographic region. This is remarkable considering the higher clay content soils present in the Outer Bluegrass region compared to these more silty soils in the Western Coal field region. Because silty soils tend to be more easily eroded than clayey soils, the predictive strength of the model was not expected to be as great in this physiographic region. These analyses suggest the erosion prediction approach, studied herein, creates models with large inference spaces and both producers and NRCS conservationists can improve waterway designs by considering erosion model predictions.

References

Pike, A.C., T.G. Mueller, A. Schorgendorfer, S.A. Shearer, and A.D. Karathanasis. Erosion indicies derived from terrain attributes using logistic regression and neural networks. *Agronomy J*. 101(5): 1068-1079.