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Summary: Conversion of the natural prairie-forested landscape in U.S. Midwestern states to a corn-soybean crop rotation has altered the runoff condition and stream hydrology throughout the region by creating more dynamic surface water flow regimes and increasing the likelihood of severe floods. Flooding and the associated water quality issues in the region adversely affect crop yields, downstream ecosystem health, and water availability. In response to these concerns, Midwestern agricultural producers have adopted Best Management Practices (BMPs) to increase runoff retention and reduce sediment delivery. Common BMPs in the region are Grassed Waterways (GWWs), which have been found to effectively reduce runoff/sediment conveyance by slowing water flow and increasing infiltration rates. This study examined the storm event-based efficiency of GWWs at reducing runoff within an agricultural watershed of the U.S. Midwest using the Water Erosion Prediction Project (WEPP). Reductions in runoff volume in a representative field increased by 9 times as the length of the GWW increased. GWW efficiency was governed by the hydrology, expressed as Qpeak. The GWWs were more efficient during events with smaller Qpeak values, while the efficiency decreased during larger events. Building on these simulations for a single hillslope, a standardized hydrologic analysis was conducted in the watershed using established hydrologic modeling techniques (i.e., WIN TR-20) to quantify and mitigate potential flooding impacts for the entire watershed. The outcome of this study was to identify and quantify the management practices (e.g., conversion to grass or no-till) needed to mitigate large flood events in the watershed. The results suggested that the landscape changes are best used as secondary efforts. A high level of land use conversion was needed to produce significant runoff reductions. Average reductions in runoff volumes of about 12% were observed for a 25% conversion of agricultural land to grasslands, with an average 15% reduction for a 50% conversion. However, these land conversions will likely decrease sediment and contaminant loads in the streams, which has other significant benefits.

Methodology:

Step 1: Determine the efficiency of GWWs at reducing runoff for single storm events in representative test fields of the Clear Creek watershed. Different GWWs were examined with different dimensions (e.g., length) for different magnitude events, as represented with the peak runoff rate (Qpeak).

The Watershed Erosion Prediction Project (WEPP) model was used to simulate runoff for 3 storm events (4 events for calibration and 4 events for validation). Runoff was primarily controlled by the hydraulic conductivity. See table below.

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Rainfall (mm)</th>
<th>Runoff (mm)</th>
<th>Qpeak (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>6/22/07</td>
<td>74</td>
<td>55</td>
<td>5.02</td>
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<tr>
<td>2a</td>
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<td>24</td>
<td>2</td>
<td>0.56</td>
</tr>
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<td>4</td>
<td>7/7/08</td>
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<td>5</td>
<td>1.52</td>
</tr>
<tr>
<td>5*</td>
<td>7/12/08</td>
<td>13</td>
<td>2</td>
<td>0.46</td>
</tr>
<tr>
<td>6a*</td>
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<td>43</td>
<td>16</td>
<td>2.28</td>
</tr>
<tr>
<td>6b</td>
<td>7/19/08</td>
<td>30</td>
<td>16</td>
<td>1.12</td>
</tr>
<tr>
<td>6c*</td>
<td>7/21/08</td>
<td>19</td>
<td>13</td>
<td>1.06</td>
</tr>
<tr>
<td>8</td>
<td>9/12/08</td>
<td>62</td>
<td>30</td>
<td>3.19</td>
</tr>
</tbody>
</table>

Model simulations:

(i) Assess the effects of GWW length on reducing runoff, altering GWW length between 100 m - 600 m and planting the corn remaining the same.
(ii) Examine the effects of the gradient of the contributing hillslope area on GWW efficiency by changing the hillslope gradient between 0.5 – 6.0%.

Step 2: Quantify runoff volumes in Clear Creek sub-watersheds for large storm events where excess runoff is produced. Storm events selected from the 2-year, 24-hour (83 mm) to the 100-year, 24-hour Natural Resources Conservation Service (NRCS) design storm (171 mm). Calculate reduction in runoff volume by implementing GWWs.

The Win TR-20 is a Windows-based version of the NRCS Technical Release-20 and was used to calculate runoff volumes and peak flow rates (NRCS, 2004a).

Runoff reduction (\%):

\[ S = \frac{1000}{CN} - 10 \]

where \( S \) is the percent reduction in water surface runoff, \( CN \) is the curve number, \( P \) is the rainfall (in), \( I \) is the infiltration (in), and \( Q \) is the peak runoff (cfs).

The predominant agricultural sub-watersheds had the highest average CN, while the grassland-forest central sub-watersheds had the lowest average CN.

Results:

Runoff reductions from the contributing hills increased with the length of the GWW. The reduction increases about 9 times by increasing the length from 328 ft. to 1969 ft. The GWW’s ability to reduce runoff decreased dramatically at higher Qpeak (see left); thus, GWWs are more efficient at lower events. See Derensis et al. (2010) for more discussion.

Runoff volumes were strongly related to the percentage of agricultural land in each sub-watershed, which is due to the agricultural land use having a relatively high CN and covering considerable area in each sub-watershed. The highest runoff volumes are in the western agricultural sub-watersheds, with the lowest in the grassland-forest watersheds.

Different percentages (from 1% to 100%) of agricultural land in each sub-watershed were converted to grassland by lowering the CN. A 1% conversion would simulate the addition of approximately 20 GWWs, while a 100% conversion would simulate return to native prairie conditions.

The graph above shows an example of the runoff reductions for different levels of grassland conversion for a predominantly agriculture sub-watershed. A conversion of 25% of the agricultural lands to grasslands would only produce a runoff reduction of ~5 to 12% depending on the event size. These results correspond to the results of the WEPP simulations, which showed higher runoff reductions for smaller events.

Runoff reductions throughout the watershed ranged up to 15%. Thus, for large events, additional measures are needed for substantial runoff reductions.

Goal: To determine the types of landscape-based Best Management Practices and the degree of their implementation needed to limit excess runoff in agriculture watersheds.

Excess runoff is defined as the volume that cannot be carried within channel boundaries.

Study Site:
Clear Creek, IA (260 km²) is located in the rolling hills of the southeastern Iowa.

Average annual precipitation is ~ 900 mm/yr. The average gradient is ~ 4%. Soils are mostly silty clay loam and have moderate infiltration rates (i.e., consist of moderately to well drained soils. Land use transitions from predominantly agriculture in the western sub-watersheds to grasslands and forests in the central sub-watersheds to an urban environment on the eastern most edge of Clear Creek.

References:

We service the following counties:

- Black Hawk
- Boone
- Buchanan
- Cedar
- Clinton
- Delaware
- Dubuque
- Grundy
- Iowa
- Johnson
- Jones
- Linn
- Muscatine
- Scott
- Tama
- Winneshiek

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MODEL NUMBERS

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>Hydrologic Soil Group (HSG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forests</td>
<td>65</td>
</tr>
<tr>
<td>Row Crops</td>
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</tr>
<tr>
<td>Industrial</td>
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<td>Roads</td>
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<tr>
<td>Pastures</td>
<td>66</td>
</tr>
<tr>
<td>Soils</td>
<td>50</td>
</tr>
<tr>
<td>Forests</td>
<td>66</td>
</tr>
</tbody>
</table>

The predominantly agriculture western sub-watersheds had the highest average CN, while the grassland-forest central sub-watersheds had the lowest average CN.