Hillslope Toolbox to Support Post-Wildfire Erosion and Sediment Models

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Project Background

All photos courtesy of Pete Robichaud, Rocky Mountain Research Station
Post-Fire Soil Erosion and Sedimentation

- Increase in number and severity of wildfires in recent decades
- Results:
  - Increased soil erosion
  - Negative water impacts
  - Catastrophic damage from floods and debris
More than just muddy water....

Values are at risk!
Hillslope Erosion and Sediment Models

[Diagram showing the upper and lower hillslope section with gradient % Top and Gradient % Bottom, and the upper and lower horizontal slope length.]
Disturbed Water Erosion Prediction Project (WEPP)
Erosion Risk Management Tool (ERMiT)
Model Inputs and Existing Methods

- Models rely on hillslope data
- Hillslopes modeled individually, delineated by hand
- GeoWEPP interface
- Excel batch-processing tools
Hillslope Delineation Toolbox
Hillslope Delineation Toolbox Objectives

• Toolbox goals:
  - Generate hillslope data for models
  - Step-by-step interface
  - Transparent output

• Toolbox not designed to:
  - Eliminate need for desktop GIS or data collection
Hillslope Toolbox Requirements

- ArcGIS v9.3 or v10.0
- Spatial Analyst extension
- Batch ERMIIT and WEPP spreadsheets

Data:
- Elevation grid
- Treatment polygons
- Soil polygons
- BARC burn severity raster (ERMIIT only)
Hillslope Delineation Toolbox Overview

Step 1: Hydrology Processing

Step 2: Stream and Watershed Delineation

Step 3A: Disturbed WEPP Treatment Area Processing

Step 3B1: ERMiT Treatment Area Processing

Step 3B2: ERMiT Burn Severity Processing

Step 4: Representative Slope Profile Extraction

Step 5: Process Representative Slope Profile

Step 6: Export Hillslope Data
Step 1: Hydrology Processing

Tool Output

Step 1: Hydrology Processing

Completes the hydrology preprocessing steps required to generate the grid inputs for the next steps in this toolbox.
Step 2: Stream and Watershed Delineation

Tool Output

Stream and Watershed Delineation Tool Output

- Input Flow Accumulation Grid
- Input Flow Direction Grid
- Stream Threshold
- Conditional
  - Con
  - Pick
  - SetNull
  - Math
  - Abs

SetNull("%Input Flow Accumulation Grid%" < 500, "%Input Flow Accumulation Grid%")

Output Stream Network:
K:\Projects\Y2010\Toolbox\stream_network_centerlines_step2.shp

Output Watershed Grid Name:
grid_wshed

Output Hillslope Polygons:
K:\Projects\Y2010\Toolbox\hillslope_polygons.shp
Step 2: Stream and Watershed Delineation

Stream networks and hillslopes are very sensitive to grid resolution and contributing drainage area!

100 pixels (0.01 km²)  500 pixels (0.05 km²)  1000 pixels (0.1 km²)  USGS Stream Delineation
Step 3A: Disturbed WEPP Treatment Area Processing

Tool Output
Step 3B: ERMiT Treatment Area Processing
Step 4: Representative Slope Profile Extraction

Tool Output

Flow Length

Percent Slope
Step 5: Process Representative Slope Profile

- 3 representative slope profile algorithms reviewed
- Method chosen: linear averaging
- Assumes all gradients influence soil loss equally
Step 6: Export Hillslope Data

Tool Output

Table 1. Formatted hillslope output table fields.

<table>
<thead>
<tr>
<th>Field Description</th>
<th>Field Name</th>
<th>Field Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hillslope Unique ID</td>
<td>HS_ID</td>
<td>Long</td>
</tr>
<tr>
<td>Unit ID Number</td>
<td>UNIT_ID</td>
<td>Text</td>
</tr>
<tr>
<td>Land Type Code</td>
<td>LAND_TYPE</td>
<td>Text</td>
</tr>
<tr>
<td>Area (Acres)</td>
<td>AREA</td>
<td>Double</td>
</tr>
<tr>
<td>Upper Treatment Area Type</td>
<td>UTREAT</td>
<td>Text</td>
</tr>
<tr>
<td>Upper Hillslope Slope Profile Length</td>
<td>USLP_lng</td>
<td>Double</td>
</tr>
<tr>
<td>Upper Hillslope Top Slope (Percent)</td>
<td>UGRD_TP</td>
<td>Double</td>
</tr>
<tr>
<td>Upper Hillslope Bottom Slope (Percent)</td>
<td>UGRD_BTM</td>
<td>Double</td>
</tr>
<tr>
<td>Lower Treatment Area Type</td>
<td>LTREAT</td>
<td>Text</td>
</tr>
<tr>
<td>Lower Hillslope Slope Profile Length</td>
<td>LSLP_lng</td>
<td>Double</td>
</tr>
<tr>
<td>Lower Hillslope Top Slope (Percent)</td>
<td>LGRD_TP</td>
<td>Double</td>
</tr>
<tr>
<td>Lower Hillslope Bottom Slope (Percent)</td>
<td>LGRD_BTM</td>
<td>Double</td>
</tr>
<tr>
<td>Adjacent Stream Name</td>
<td>ADJ_STRM</td>
<td>Text</td>
</tr>
<tr>
<td>Stream Tributary</td>
<td>TRIB_TO</td>
<td>Text</td>
</tr>
<tr>
<td>ERMIT Top Slope (Percent)</td>
<td>ERM_TSLP</td>
<td>Double</td>
</tr>
<tr>
<td>ERMIT Middle Slope (Percent)</td>
<td>EM_MSLP</td>
<td>Double</td>
</tr>
<tr>
<td>ERMIT Bottom Slope (Percent)</td>
<td>ERM_BSLP</td>
<td>Double</td>
</tr>
<tr>
<td>ERMIT Burn Severity</td>
<td>BURNSEV</td>
<td>Double</td>
</tr>
</tbody>
</table>
Disturbed WEPP and ERMiT Batch Models

- Excel-based batch tools for WEPP and ERMiT
- Run using GIS hillslope output
Disturbed WEPP and ERMiT Batch Models

USFS ERMiT Batch Program - Year 1 Results By Hillslope

Select the hillslope code to view the year 1 sediment delivery results. Select the desired probability % by clicking on the percentage column headers in row 13.

Select Hillslope Code

<table>
<thead>
<tr>
<th>Year 1 Sediment Delivery (tons/acre)</th>
<th>Probability %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30%</td>
</tr>
<tr>
<td>Untreated</td>
<td>12.22</td>
</tr>
<tr>
<td>Seeding</td>
<td>12.22</td>
</tr>
<tr>
<td>Mulch (0.5 tons/acre)</td>
<td>1.54</td>
</tr>
<tr>
<td>Mulch (1 tons/acre)</td>
<td>0.46</td>
</tr>
<tr>
<td>Mulch (1.5 tons/acre)</td>
<td>0.45</td>
</tr>
<tr>
<td>Mulch (2 tons/acre)</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Year 1 is defined as the first summer after the fire.
Challenges and Lessons Learned
Toolbox Limitations

- Desktop GIS and Spatial Analyst required
- Users have to collect and process their own data
- Easy to make bad resolution decisions
- Step-by-step does not equal intuitive!
Project Challenges

- Specific to each version of ArcGIS
- Not every desktop process is easy to make repeatable
- Organic development
- Model Builder vs. Python
- Budget constraints
Proposed Improvements

• Web-based platform
• Develop video user tutorials
• More in-tool help options
• Automate importing WEPP and ERMiT model output into GIS
• Toolbox and documentation available for download at: http://forest.moscowfsl.wsu.edu/fswepp/batch/HillslopeDelineationToolbox.html

• Thank you to the USDA Forest Service Rocky Mountain Research Station, specifically Pete Robichaud, William J. Elliot, David Hall, and Sue Miller, and Mary Larkin and David Yu of Herrera Environmental Consultants.

Questions?
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