

**2014 Esri International User Conference**

July 14–18, 2014 | San Diego, California



# 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



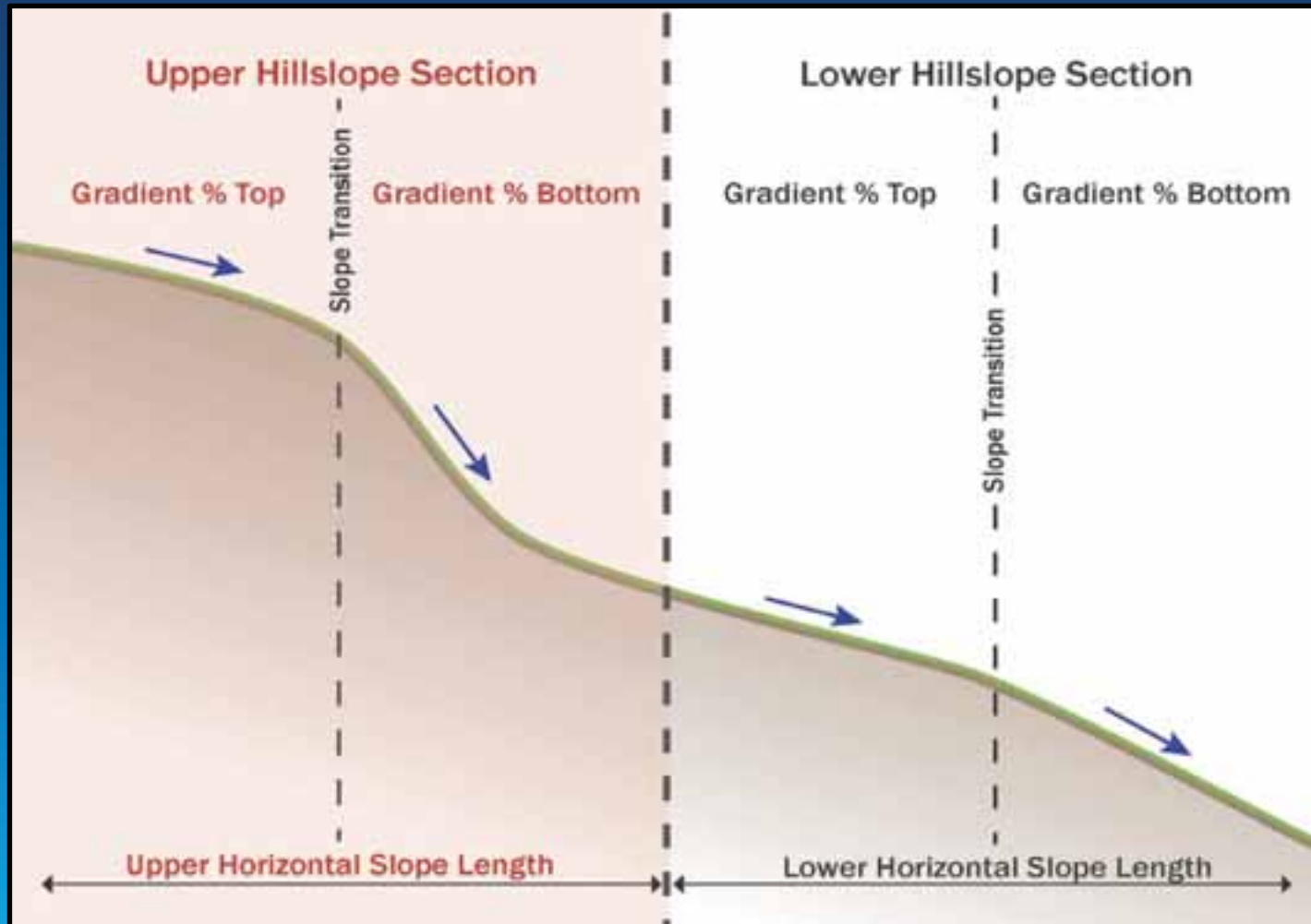
More than just  
muddy water....

Values are at risk!

JUL 12 2006



# Hillslope Erosion and Sediment Models



# Disturbed Water Erosion Prediction Project (WEPP)

Run description:  Years to simulate:

Climate	Element	Treatment / Vegetation	Gradient (%)	Horizontal Length (ft)	Cover (%)	Rock (%)
BIRMINGHAM WB AP AL CHARLESTON KAN AP WV DENVER WB AP CO FLAGSTAFF WB AP AZ MOSCOW U OF I ID MOUNT SHASTA CA SEXTON SUMMIT WB OR Custom Climate    closest	Upper	Mature forest	<input type="text" value="0"/>	<input type="text" value="50"/>	<input type="text" value="100"/>	<input type="text" value="20"/>
		Thin or young forest				
		Shrubs				
	Lower	Good grass	<input type="text" value="30"/>	<input type="text" value="50"/>	<input type="text" value="100"/>	<input type="text" value="20"/>
		Poor grass				
		Low severity fire	<input type="text" value="5"/>			
Soil Texture clay loam silt loam sandy loam loam	Upper	Mature forest	<input type="text" value="30"/>	<input type="text" value="50"/>	<input type="text" value="100"/>	<input type="text" value="20"/>
		Thin or young forest				
		Shrubs				
	Lower	Good grass	<input type="text" value="5"/>	<input type="text" value="50"/>	<input type="text" value="100"/>	<input type="text" value="20"/>
		Poor grass				
		Low severity fire				

Run WEPP

# Erosion Risk Management Tool (ERMiT)

<p>(- *) <b>Climate</b> (+)</p> <ul style="list-style-type: none"> <li>*Gerona, Spain ++</li> <li>*Sweet Fire +</li> <li>*STEVENSVILLE MT</li> <li>*Kalamata, Greece ++</li> <li>*CHEESMAN CO</li> <li>*Kalamata, Greece ++</li> <li>*ALBUQUERQUE WB AP NM</li> </ul> <p>Custom Climate</p>		<p><b>Soil Texture</b> ?</p> <ul style="list-style-type: none"> <li>clay loam</li> <li>silt loam</li> <li>sandy loam</li> <li>loam</li> </ul> <p><b>Rock content</b> ?</p> <p>20 %</p>										
<p><b>Vegetation type</b> ?</p> <ul style="list-style-type: none"> <li>Forest</li> <li>Range</li> <li>Chaparral</li> </ul>	<p><b>Hillslope gradient</b> ?</p> <table border="1"> <tr> <td>Top</td> <td>20</td> <td>%</td> </tr> <tr> <td>Middle</td> <td>40</td> <td>%</td> </tr> <tr> <td>Toe</td> <td>60</td> <td>%</td> </tr> </table>	Top	20	%	Middle	40	%	Toe	60	%	<p><b>Hillslope horizontal length</b> ?</p> <p>1000 ft</p>	<p><b>Soil burn severity class</b> ?</p> <p><input checked="" type="radio"/> High</p> <p><input type="radio"/> Moderate</p> <p><input type="radio"/> Low</p>
Top	20	%										
Middle	40	%										
Toe	60	%										
<p><b>Range/chaparral pre-fire community description</b> ?</p> <table border="1"> <tr> <td>% shrub</td> <td>% grass</td> <td>% bare</td> </tr> </table>			% shrub	% grass	% bare							
% shrub	% grass	% bare										
<p>Running ERMiT...</p>												

# Model Inputs and Existing Methods

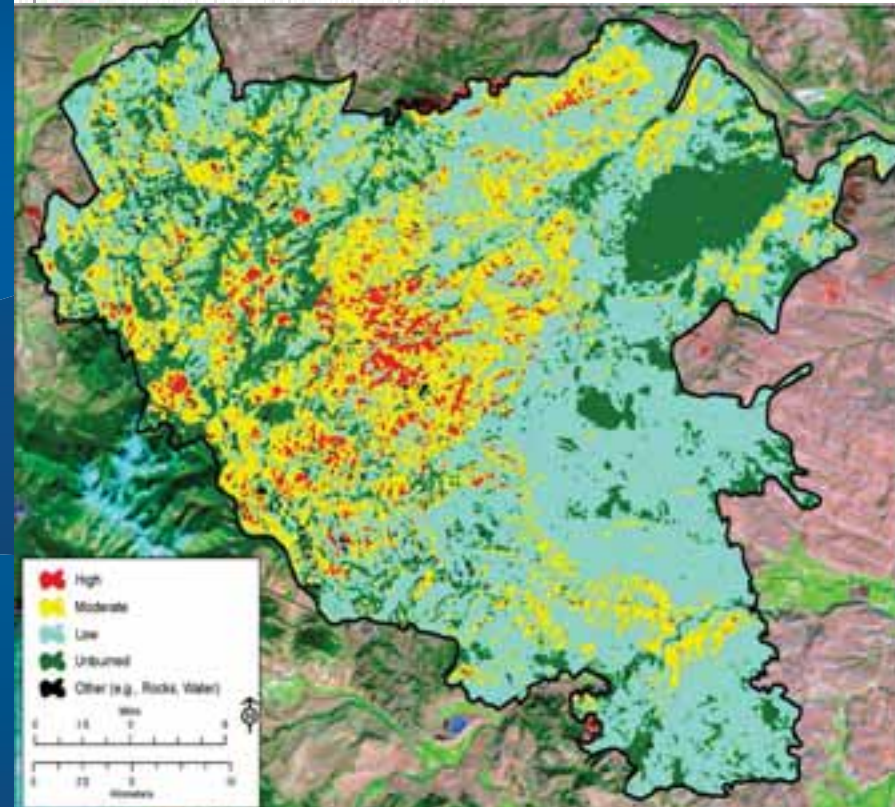
- **Models rely on hillslope data**
- **Hillslopes modeled individually, delineated by hand**
- **GeoWEPP interface**
- **Excel batch-processing tools**





# Hillslope Delineation Toolbox

- [-] Hillslope Delineation Tools
  - 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
- [+] Linear Referencing Tools



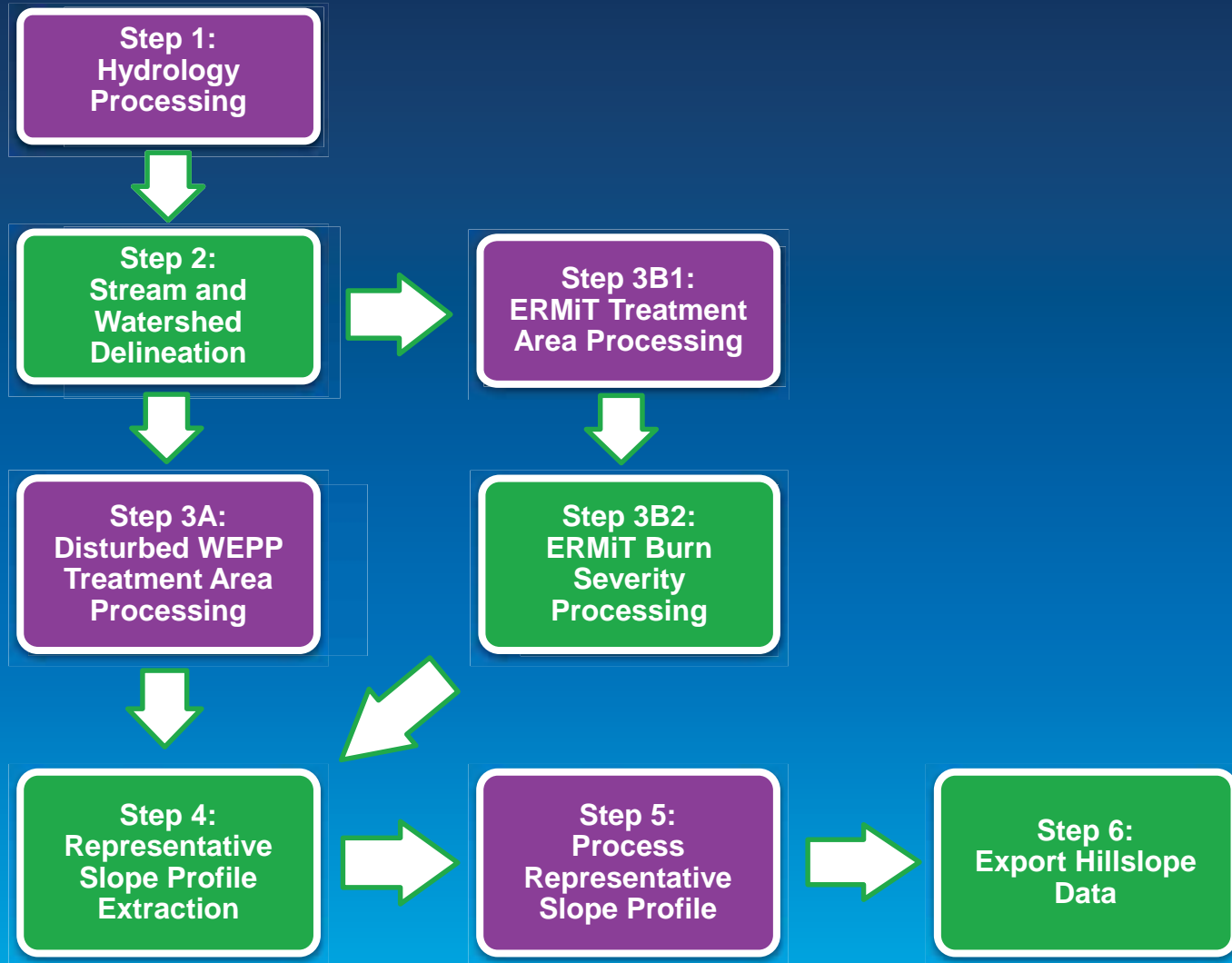
# Hillslope Delineation Toolbox Objectives

- **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**

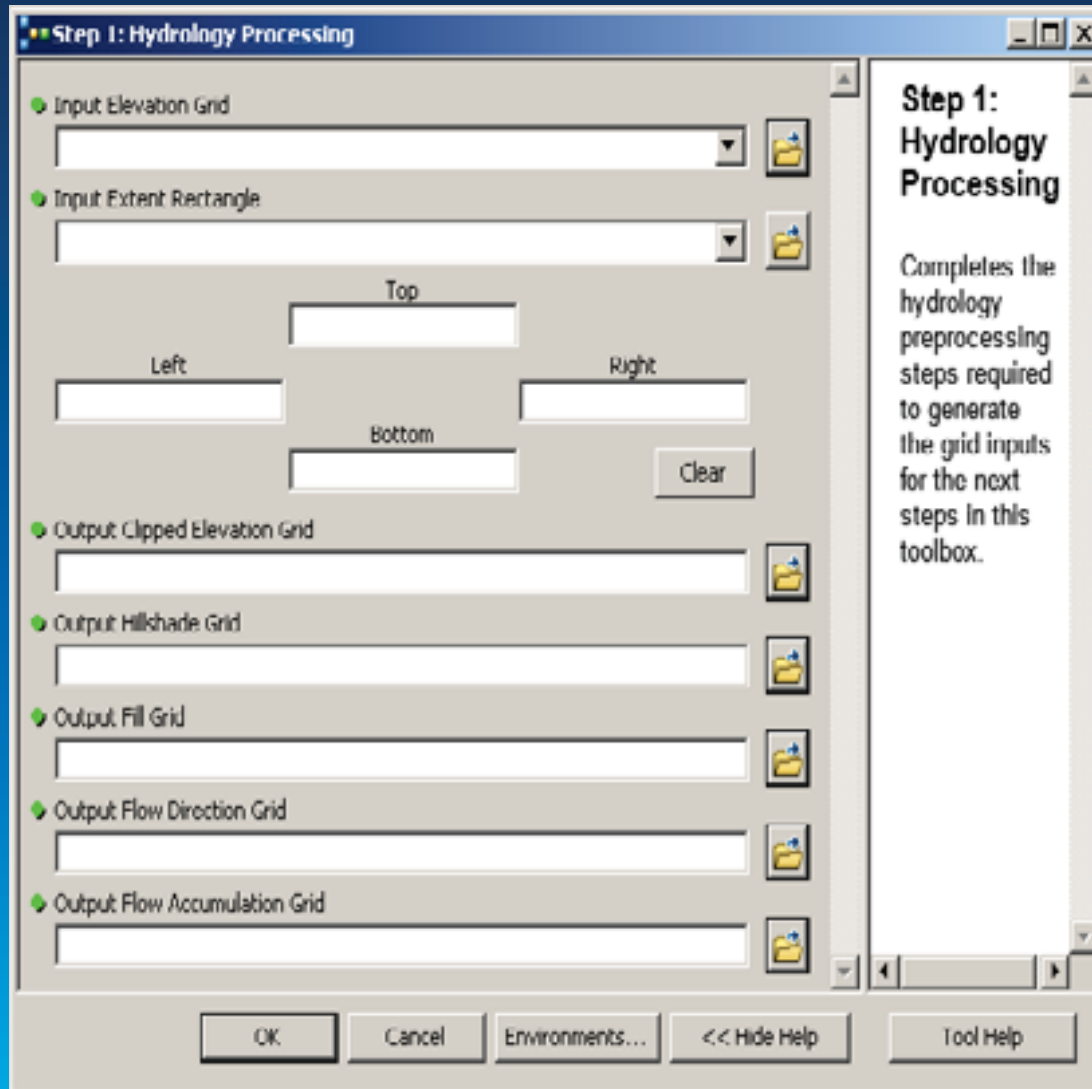
# Hillslope Toolbox Requirements

- **ArcGIS v9.3 or v10.0**
- **Spatial Analyst extension**
- **Batch ERMiT and WEPP spreadsheets**
- **Data:**
  - **Elevation grid**
  - **Treatment polygons**
  - **Soil polygons**
  - **BARC burn severity raster (ERMiT only)**

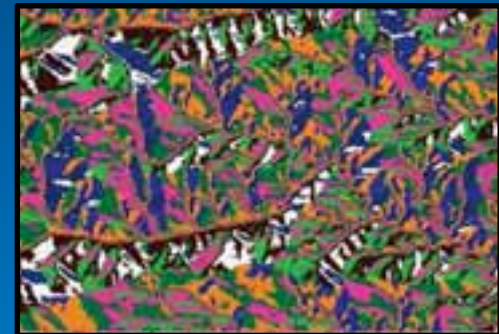
# Hillslope Delineation Toolbox Overview



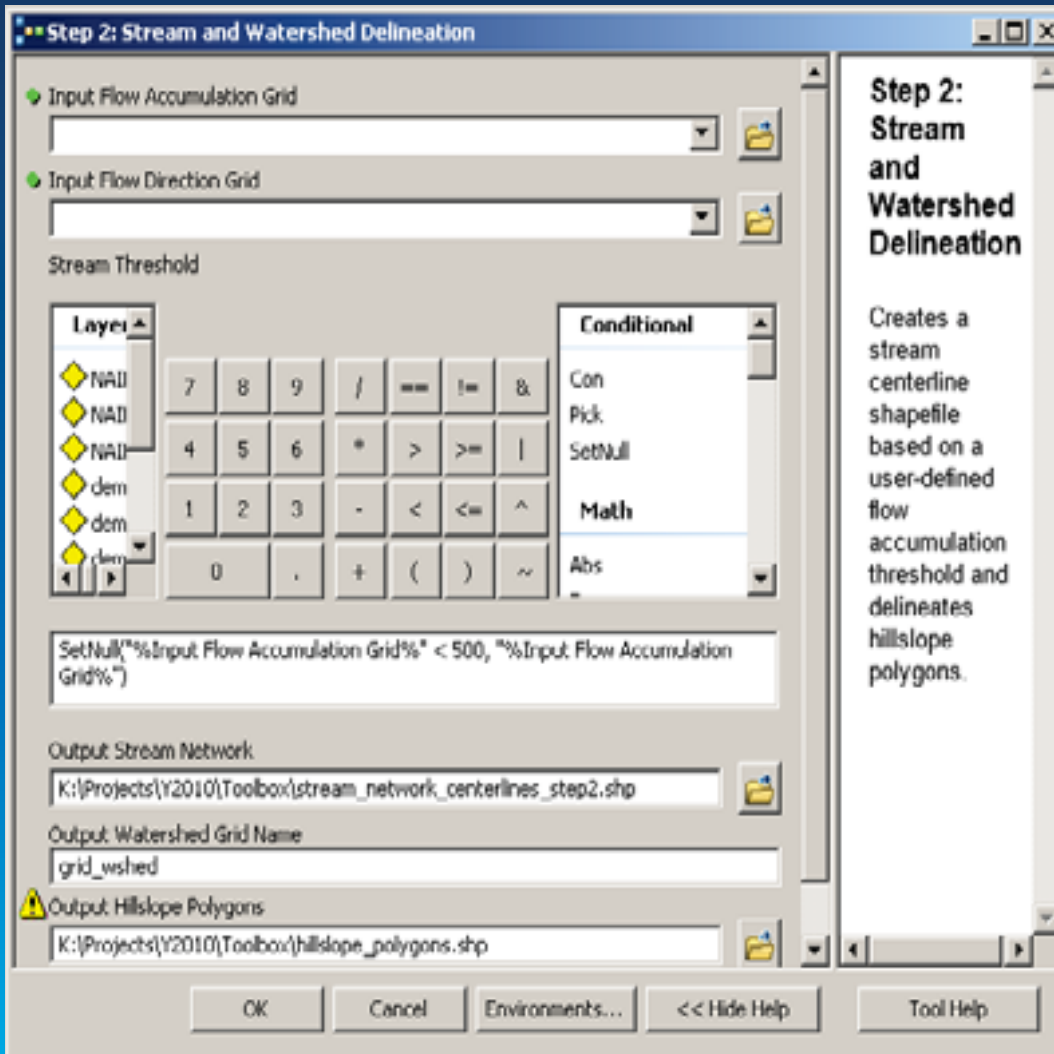
# Step 1: Hydrology Processing



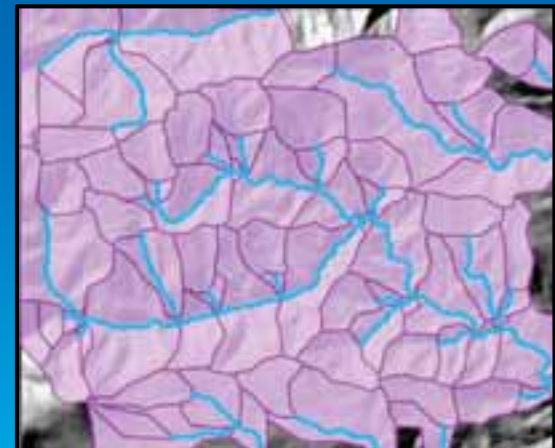
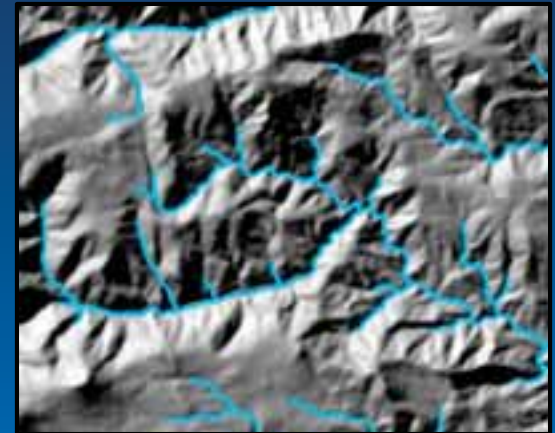
Tool Output



# Step 2: Stream and Watershed Delineation



Tool Output



# Step 2: Stream and Watershed Delineation

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



100 pixels (0.01 km<sup>2</sup>)



500 pixels (0.05 km<sup>2</sup>)

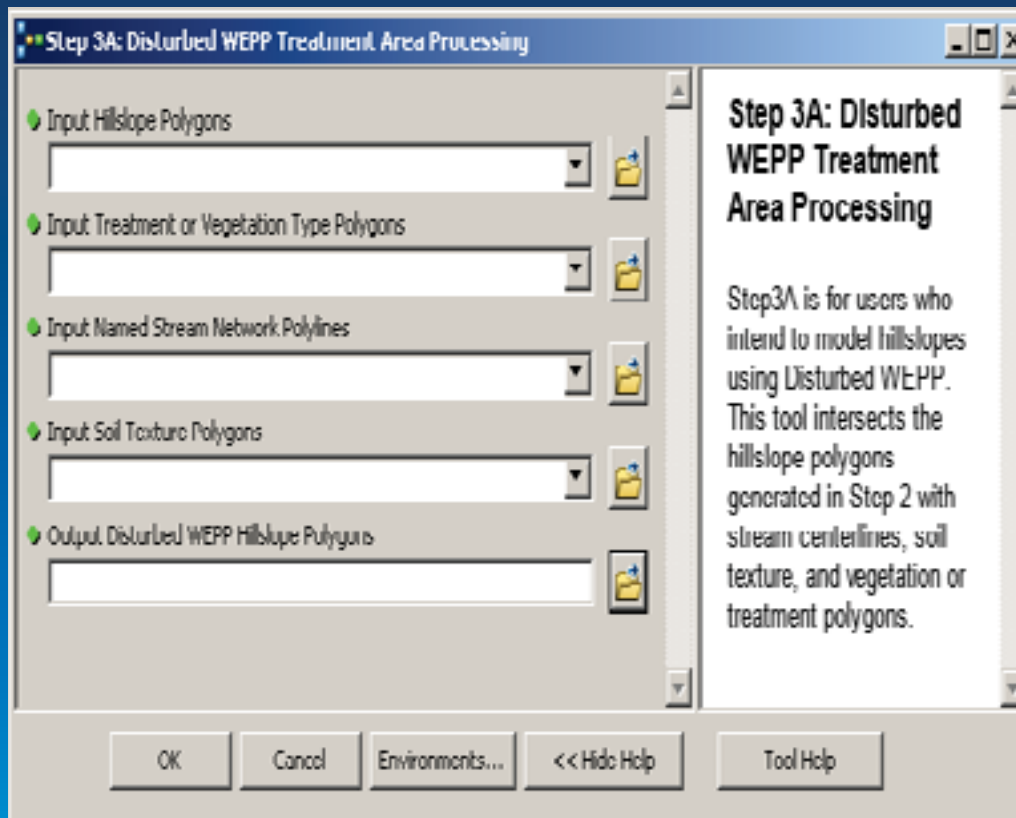


1000 pixels (0.1 km<sup>2</sup>)



USGS Stream Delineation

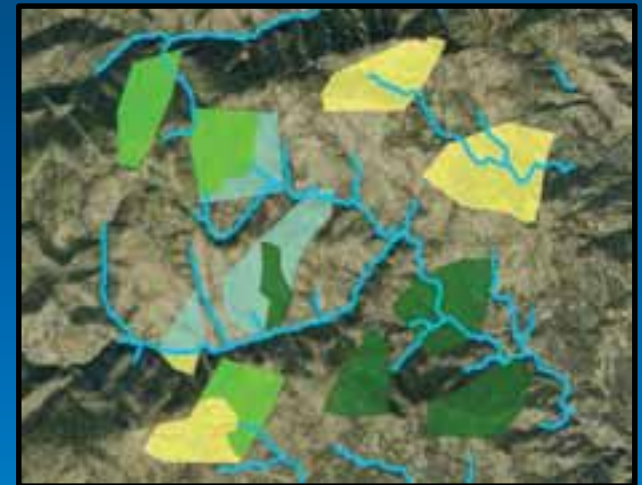
# Step 3A: Disturbed WEPP Treatment Area Processing



## Step 3A: Disturbed WEPP Treatment Area Processing

Step3A is for users who intend to model hillslopes using Disturbed WEPP. This tool intersects the hillslope polygons generated in Step 2 with stream centerlines, soil texture, and vegetation or treatment polygons.

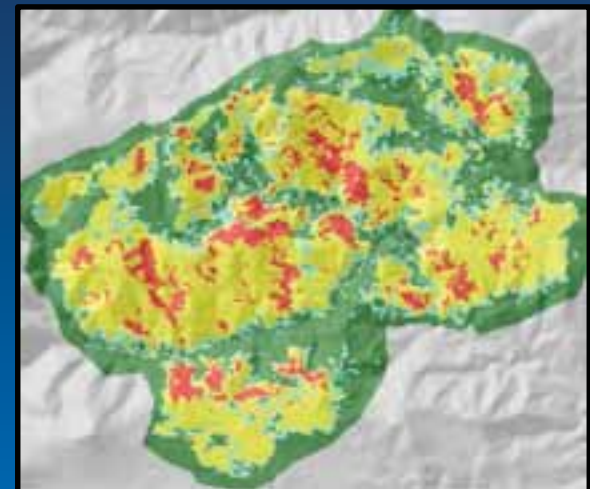
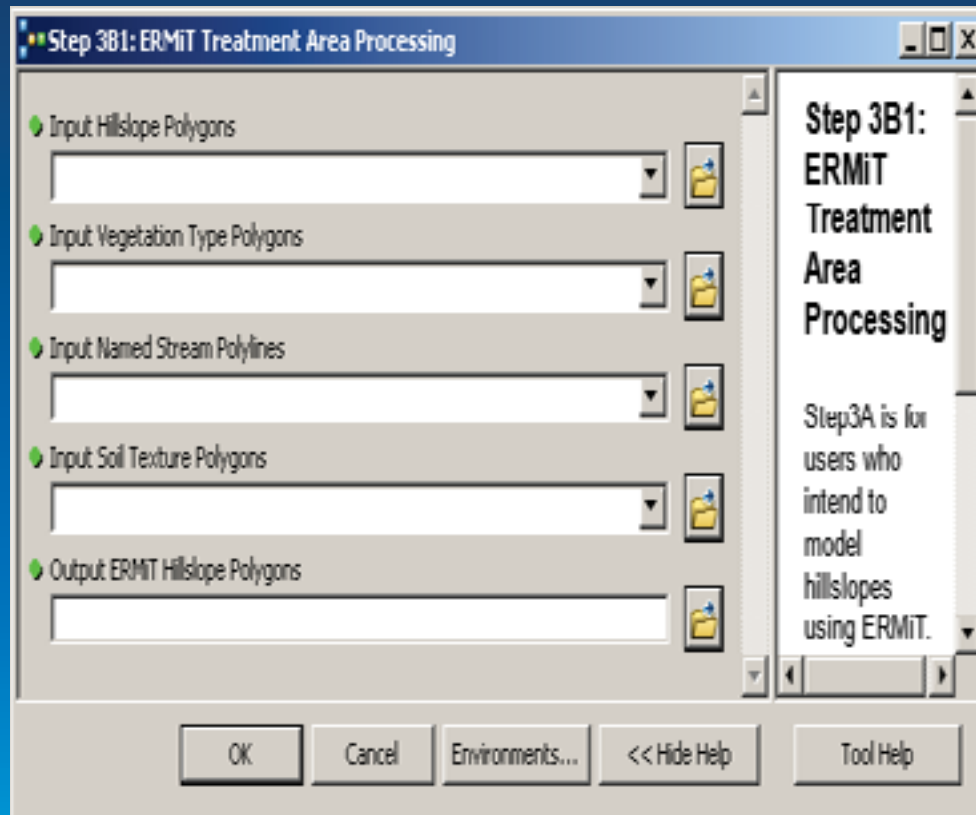
## Tool Output





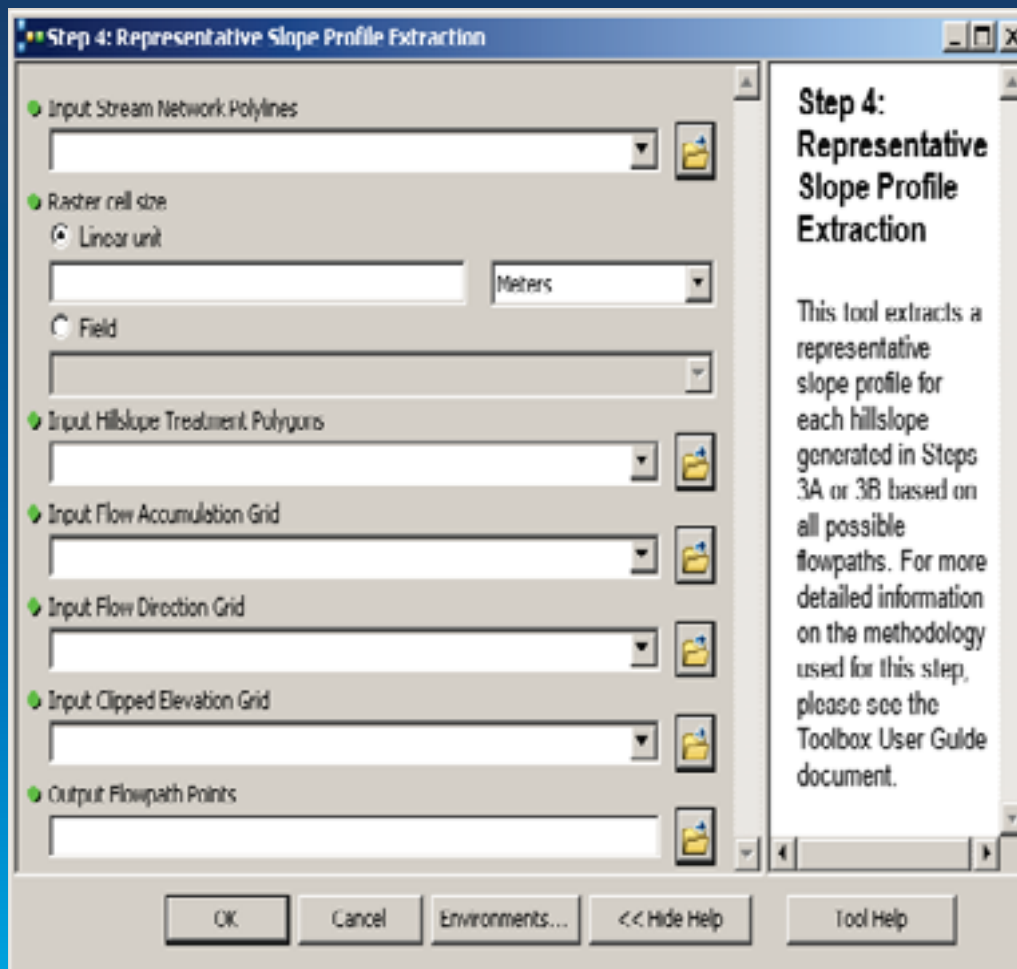
# Step 3B: ERMiT Treatment Area Processing

Tool Output



# Step 4: Representative Slope Profile Extraction

## Tool Output



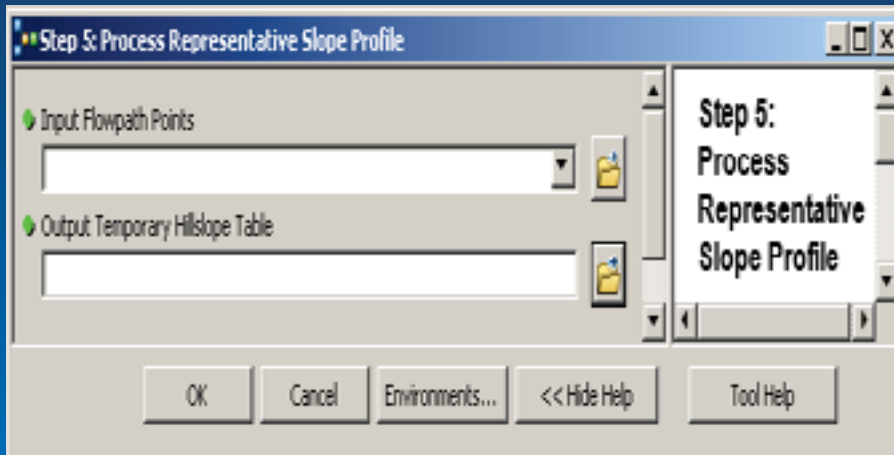
Flow Length



Percent Slope



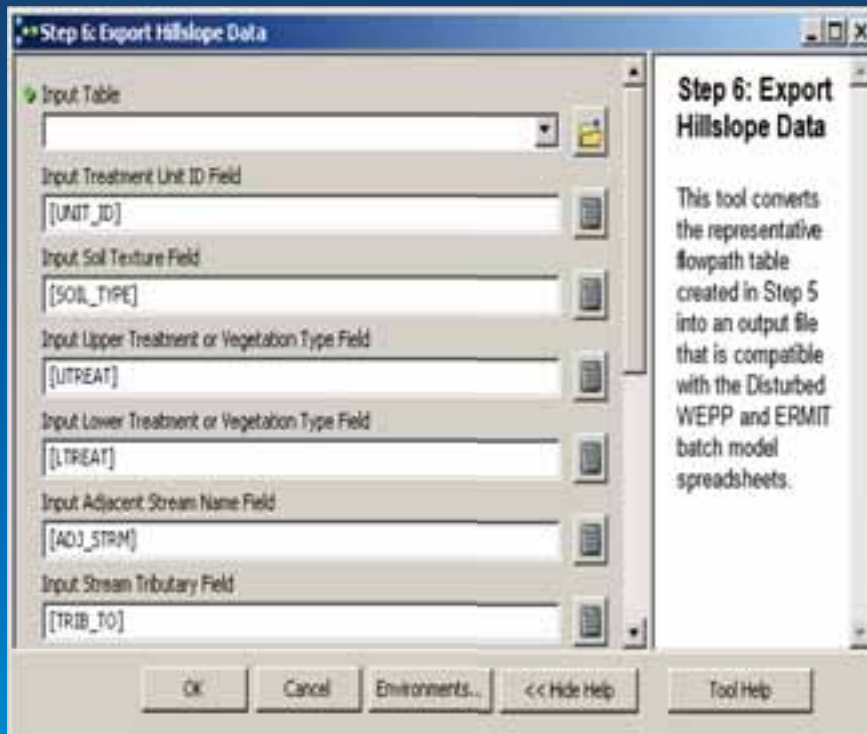
## Step 5: Process Representative Slope Profile



- 3 representative slope profile algorithms reviewed
- Method chosen: linear averaging
- Assumes all gradients influence soil loss equally

# Step 6: Export Hillslope Data

## Tool Output



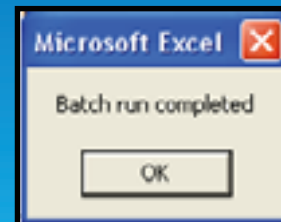
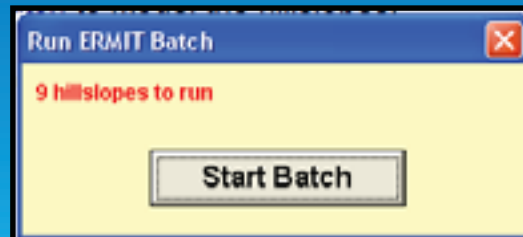
**Table 1. Formatted hillslope output table fields.**

Field Description	Field Name	Field Type
Hillslope Unique ID	HS_ID	Long
Unit ID Number	UNIT_ID	Text
Land Type Code	LAND_TYPE	Text
Area (Acres)	AREA	Double
Upper Treatment Area Type	UTREAT	Text
Upper Hillslope Slope Profile Length	USLP_LNG	Double
Upper Hillslope Top Slope (Percent)	UGRD_TP	Double
Upper Hillslope Bottom Slope (Percent)	UGRD_BTM	Double
Lower Treatment Area Type	LTREAT	Text
Lower Hillslope Slope Profile Length	LSLP_LNG	Double
Lower Hillslope Top Slope (Percent)	LGRD_TP	Double
Lower Hillslope Bottom Slope (Percent)	LGRD_BTM	Double
Adjacent Stream Name	ADJ_STRM	Text
Stream Tributary	TRIB_TO	Text
ERMIT Top Slope (Percent)	ERM_TSLP	Double
ERMIT Middle Slope (Percent)	EM_MSLP	Double
ERMIT Bottom Slope (Percent)	ERM_BSLP	Double
ERMIT Burn Severity	BURNSEV	Double

# Disturbed WEPP and ERMiT Batch Models

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

The screenshot shows the ERMiT Batch Model interface. At the top, there are three buttons: "Clear Hillslope Data", "Import GIS Hillslope File", and "Run ERMiT Batch". Below these are four dropdown menus: "Personality", "Units" (set to "English"), "Climate", and "Climate Option" (set to "Single Climate"). The "Climate" dropdown menu is open, showing a list of locations: "\* CHEESMAN CO", "\* STEVENSVILLE MT", "\* ALBUQUERQUE WB AP NM", "\* Kalamata, Greece ++", "\* Kalamata, Greece ++", "\* Kalamata, Greece ++", "\* Gerona, Spain ++", and "\* FORT COLLINS CO +". The "Hillslope G" field is partially visible at the bottom left, and the "e-fire community description" field is partially visible at the bottom right.



# 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

Year 1 Sediment Delivery (tons/acre)				
To change probability % for a column click on the probability cell and select the desired probability				
	Probability %			
	30%	40%	70%	50%
Untreated	12.22	5.02	0.14	3.05
Seeding	12.22	5.02	0.14	3.05
Mulch (0.5 tons/acre)	1.54	0.43	0	0.23
Mulch (1 tons/acre)	0.46	0.36	0	0.18
Mulch (1.5 tons/acre)	0.45	0.35	0	0.17
Mulch (2 tons/acre)	0.44	0.34	0	0.16

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.moscowfsi.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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