Incorporating Process-Based Understanding into Watershed Management

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Outline

• Motivation
  – CEAP Synthesis Project
    • General observations

• Developing process-based management tools
  – Importance of understanding hydrologic flow paths

• “Hydrologic Characterization Tool”
Objectives of CEAP

Conservation Effects Assessment Program

- “Build understanding on how best to schedule and locate conservation efforts within a watershed in order to achieve locally defined water quality goals.”

(www.nrcs.usda.gov/technical/nri/ceap/watershed.html)
In the scientific research community

**Building Understanding** → More detail, finer scale, complex modeling

In the applied science community

**Building Understanding** → Simple decision support tools
BMP Selection

• Selecting and locating BMPs are widely based on the knowledge and experience of local managers
  – (NRCS, SWCD, Extension)
• Few complex, process-based models are used to target and select BMPs
  – Exceptions: Urban storm water and forestry
Current Needs

• Better tools are needed to identify these critical areas and improve them with appropriate BMPs. (Mulla et al., 2008)
  – Simple
  – Site specific
  – Pollutant specific
  – Minimal data requirements
  – Minimal calibration
Locating and selecting BMPs require a fundamental understanding of the dominant hydrologic flow paths.
Importance of flow paths

- Sediment
  - Infiltration excess vs Saturation excess runoff
    - Surface vs subsurface controls
- Nitrate
  - Shallow, saturated flow, carbon rich environments
  - Deep, water flow below rooting depths
- Particulate vs Soluble Phosphorus
  - Erosion-based or runoff-based BMPs
Importance of subsurface restrictive horizons
Surface saturation patterns driven by converging subsurface lateral flow
Critical shear ~5x smaller in seepage zones
Nouwakpo and Huang (2011)!
Perched Water Tables (STATSGO)

McDaniel et al. (2008)
Perched Water Tables & Bedrock

Bedrock (lithic)

Bedrock (paralithic)
Hydrologic Characterization Tool

Incorporating Process-Based Understanding into Watershed Planning

Select Region:

- All Regions
- Goodwater Creek MO
- Lake Tahoe Basin
- Lincoln Lake AR
- Little River CA
- Paradise Creek ID

Start

Background on Tool Development

Comments?

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CONTRACT/GRANT/AGREEMENT NO: 2007-51130-03992
Key Management Questions

– What is the dominant flow path?
– How much water moves through these flow paths?
– When does it move?
– Where on the slope does it occur?
– What are the controlling factors?
  • Infiltration-limited, soil storage limited
  • Surface vs subsurface restriction
WEPP Model

- Hillslope-scale
- Process-based
  - Saturation-excess and Infiltration excess runoff
  - Improved Subsurface lateral flow algorithms
  - Percolation
  - Soil detachment, delivery, and deposition
  - Crop growth, residue decay, and soil structural changes with time
Select Data Files

Paradise Creek ID

Select State for climate: [Idaho] Select

Select climate file: [MoscowID]

Select slope file:
- Flat (2_2_2)
- Mod Flat (2_5_2)
- Moderate (2_8_2)
- Mod Steep (5_12_5)
- Steep (5_35_5)

Keep it simple!

Select Soil Type:

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Depth to Restrict (cm)</th>
<th>Remove Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paradise Creek ID</td>
<td>97</td>
<td></td>
</tr>
</tbody>
</table>

Select Management Practice:

<table>
<thead>
<tr>
<th>Management</th>
<th>Tillage Practice</th>
<th>Buffer (m)</th>
<th>Remove Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paradise Creek ID</td>
<td>CT, MT, NT</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

* Tillage Practices: Conventional Till (CT), Mulch Till (MT), No Till (NT)

How many years would you like to simulate? 10

Select Files
HCT Processing

• **Pre-Processing**: Determines all possible combinations of treatments for each land type
• Feeds the input to WEPP
• **Post-Processing**:  
  – Monthly and Yearly output  
  – Upslope, mid-slope, toe slope positions  
  – Soil erosion, sediment yield, surface runoff, subsurface lateral flow, percolation  
  – All possible land types
Shallow Soil (20 cm)

Overland Flow Element (OFE)

- Runoff (mm)
- Lateral Flow (mm)
- Percolation (mm)
- Net Erosion

Water Depth (mm/yr)

Net Erosion (Tonnes/ha)
Deep Soil (no restriction)

5c.

Net Erosion (Tonnes/ha)

Water Depth (mm/yr)

Overland Flow Element (OFE)

Runoff (mm)
Lateral Flow (mm)
Percolation (mm)
Intermediate Soil (1 m deep)

5b.

Runoff (mm)
Lateral Flow (mm)
Percolation (mm)

Water Depth (mm/yr)
Overland Flow Element (OFE)
Net Erosion (Tonnes/ha)
Watershed Management

Why is it that conservation tillage more effective at reducing erosion in the Palouse than in Iowa?

http://photogallery.nrcs.usda.gov
Watershed Management

Why are riparian buffers so much more effective at reducing nitrate concentrations in Georgia than in Iowa???

http://photogallery.nrcs.usda.gov
Why is that Missouri is much more susceptible to erosion and atrazine transport than in Iowa despite having a very similar climate and topography?
Why are farmers in New York encouraged to apply their manure on steep ground rather than flat ground???

http://photogallery.nrcs.usda.gov
Summary

• There is a great need for management tools to incorporate process-based knowledge into management
  – “Learning tools” to identify:
    • Hydrologic flow paths within a hillslope
    • Key factors the control the response of a hillslope

• A platform for integrating multiple disciplines
Benefits of HCT

• Simple
• Flexible
• Useful for:
  – Targeting within a watershed
  – Identifying flow paths
  – Identifying hydrologic sensitive attributes
  – Relative comparison of BMP treatments
Comments and Questions?