Incorporating Process-Based Understanding into Watershed Management

International Symposium on Erosion And Landscape Evolution
Anchorage, AK
Sept. 18-21, 2011

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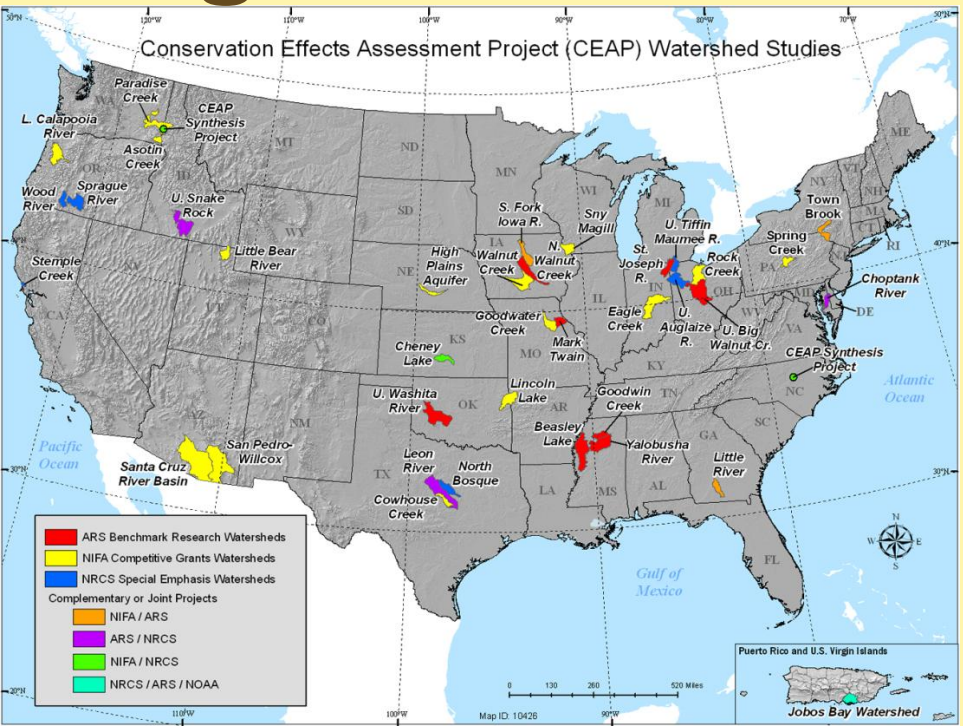
Outline

- 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)

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

USDA United States Department of Agriculture
National Institute of Food and Agriculture

“Building Understanding”

In the scientific research community

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

In the applied science community

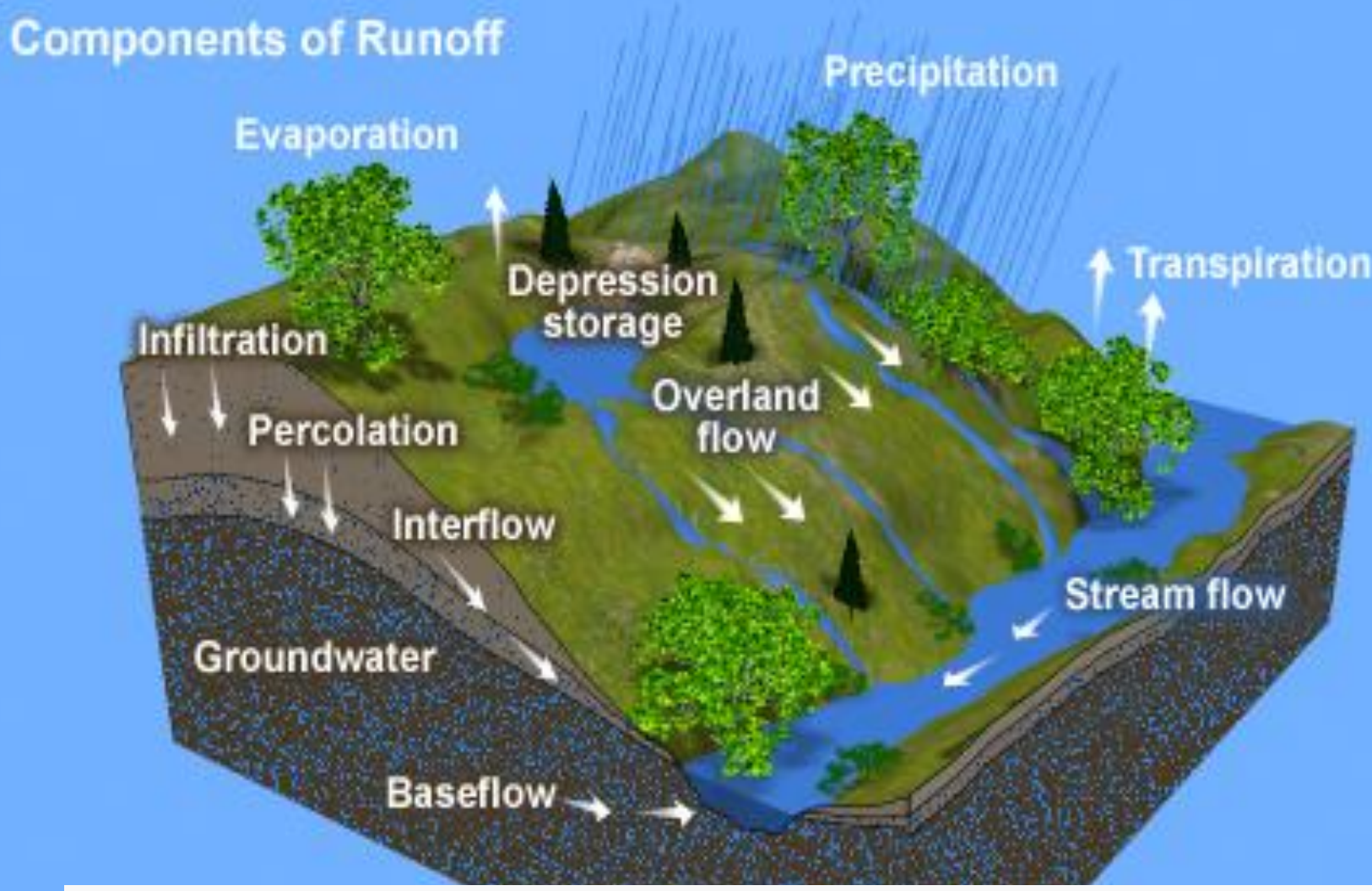
Building Understanding → **Simple decision support tools**

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.

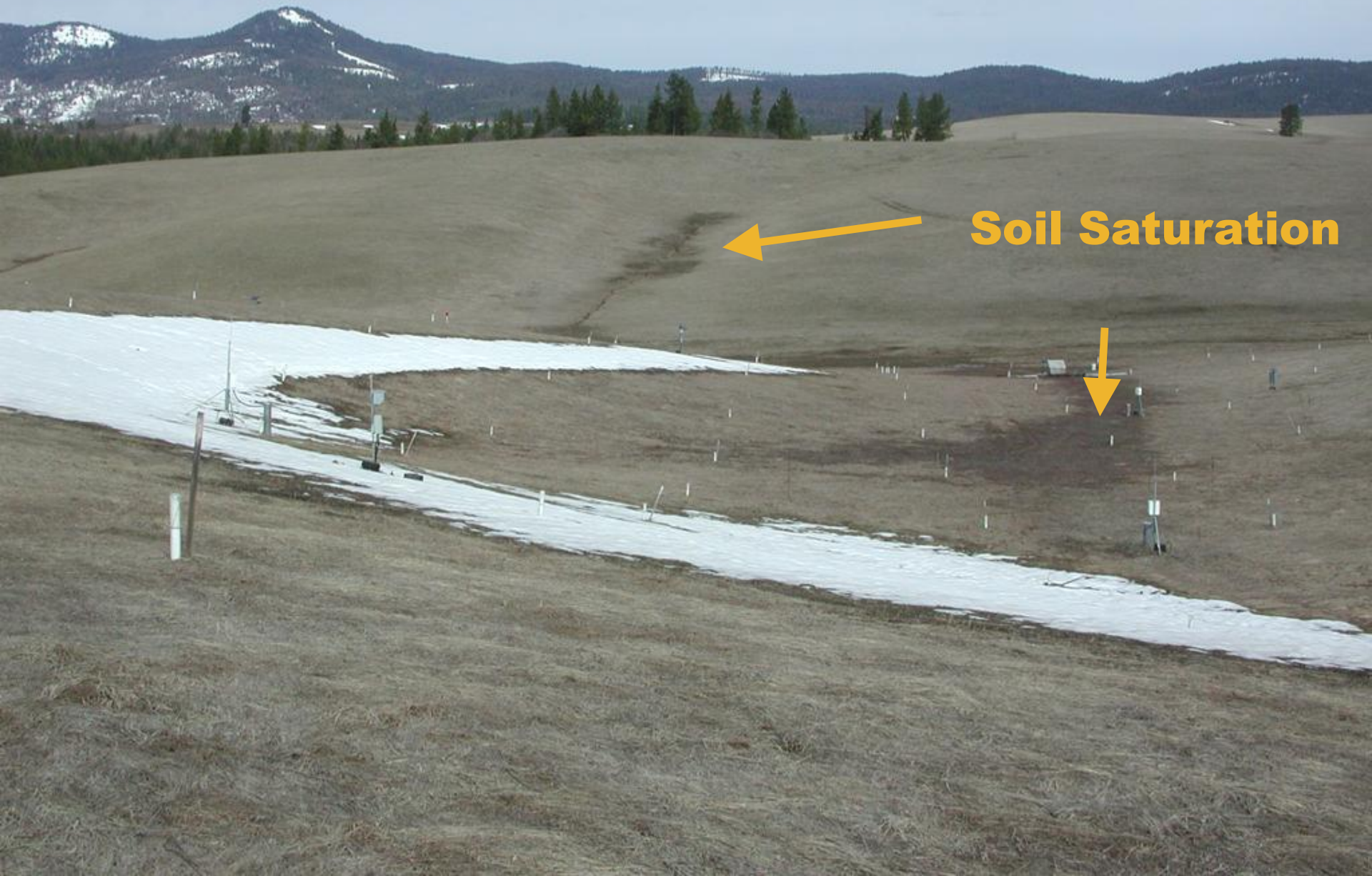
Importance of flow paths

- 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

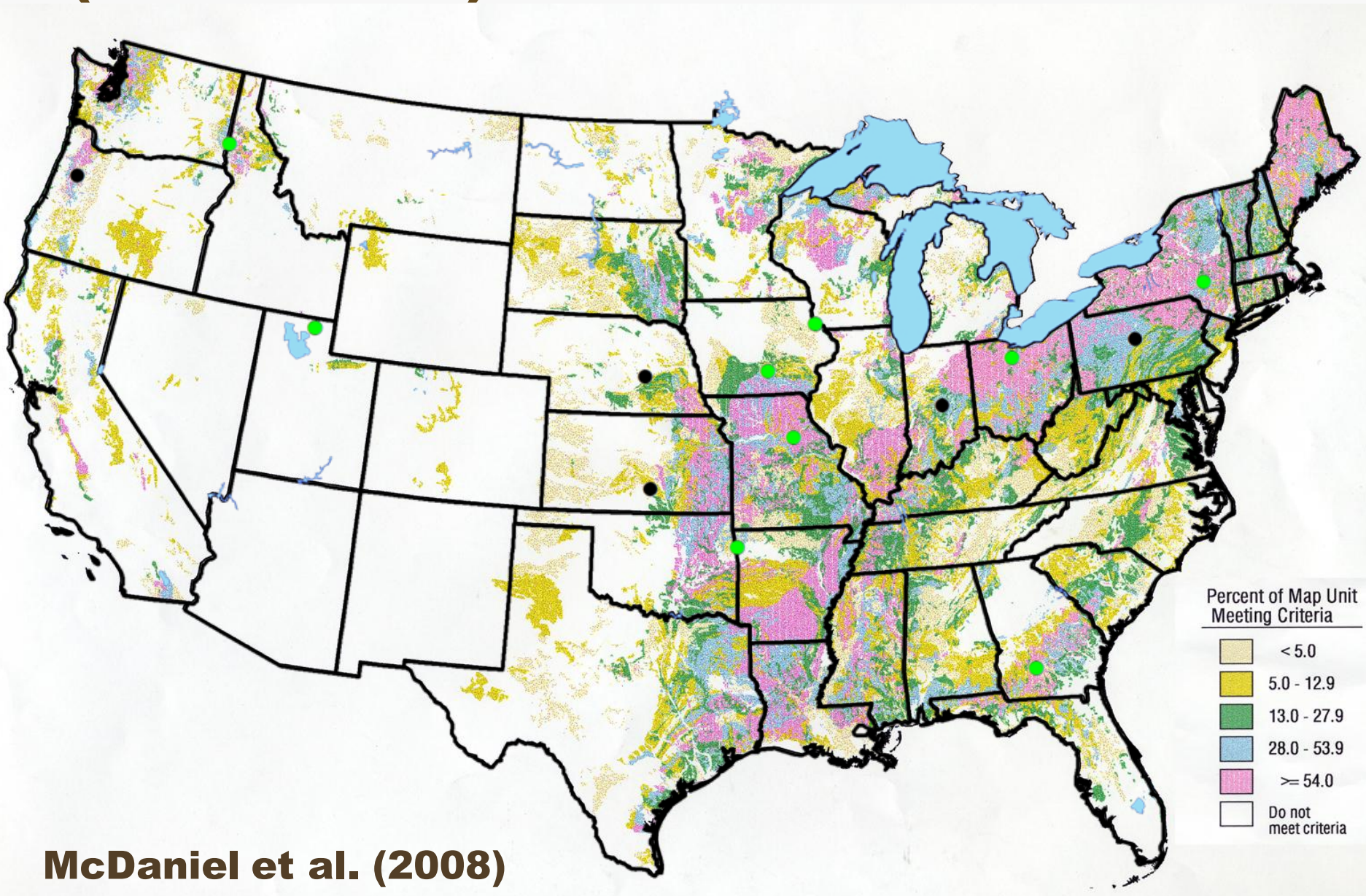
Courtesy of Paul McDaniel

Surface saturation patterns driven by converging subsurface lateral flow



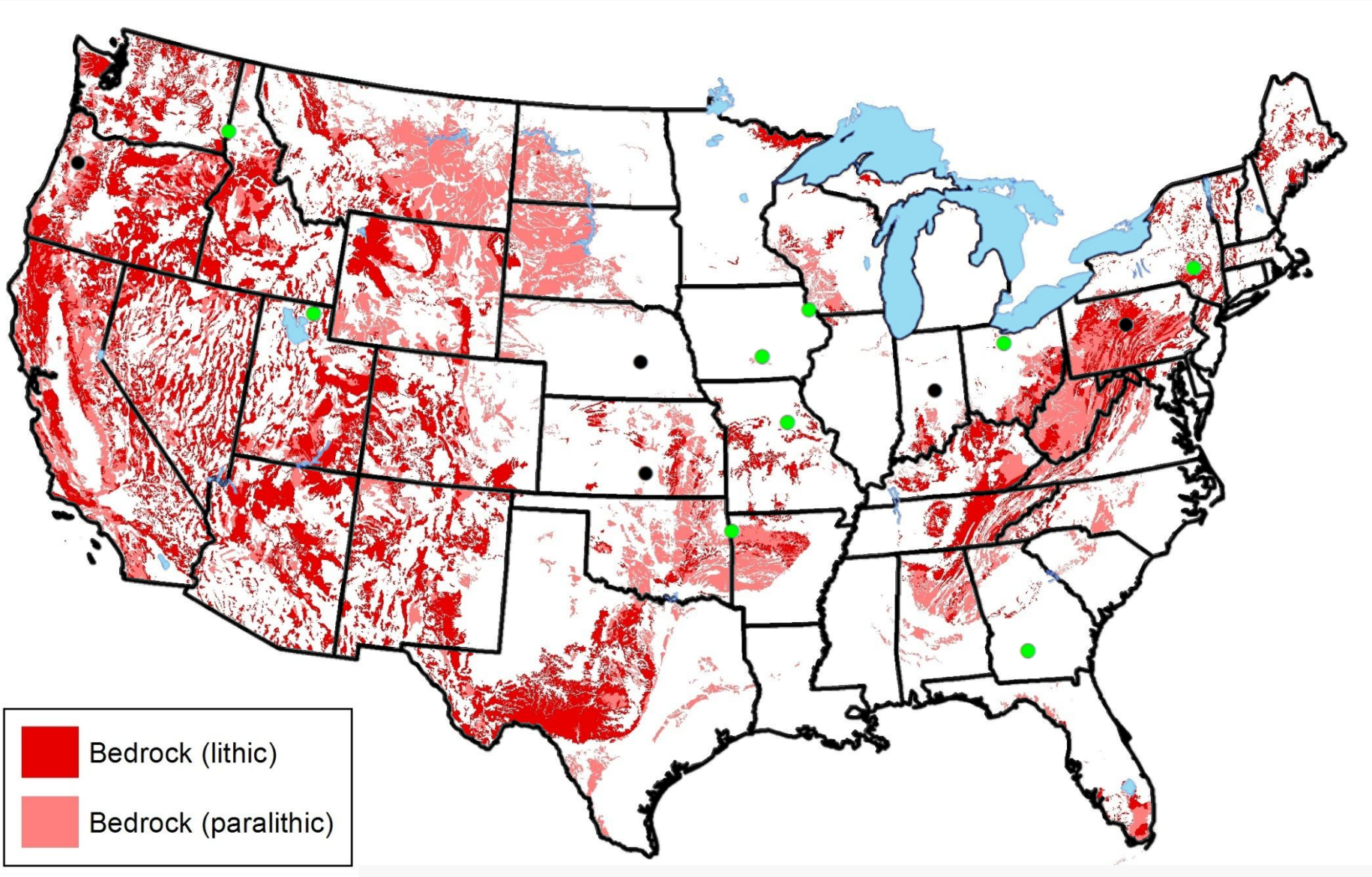
Critical shear ~5x smaller in seepage zones Nouwakpo and Huang (2011)!

Perched Water Tables (STATSGO)

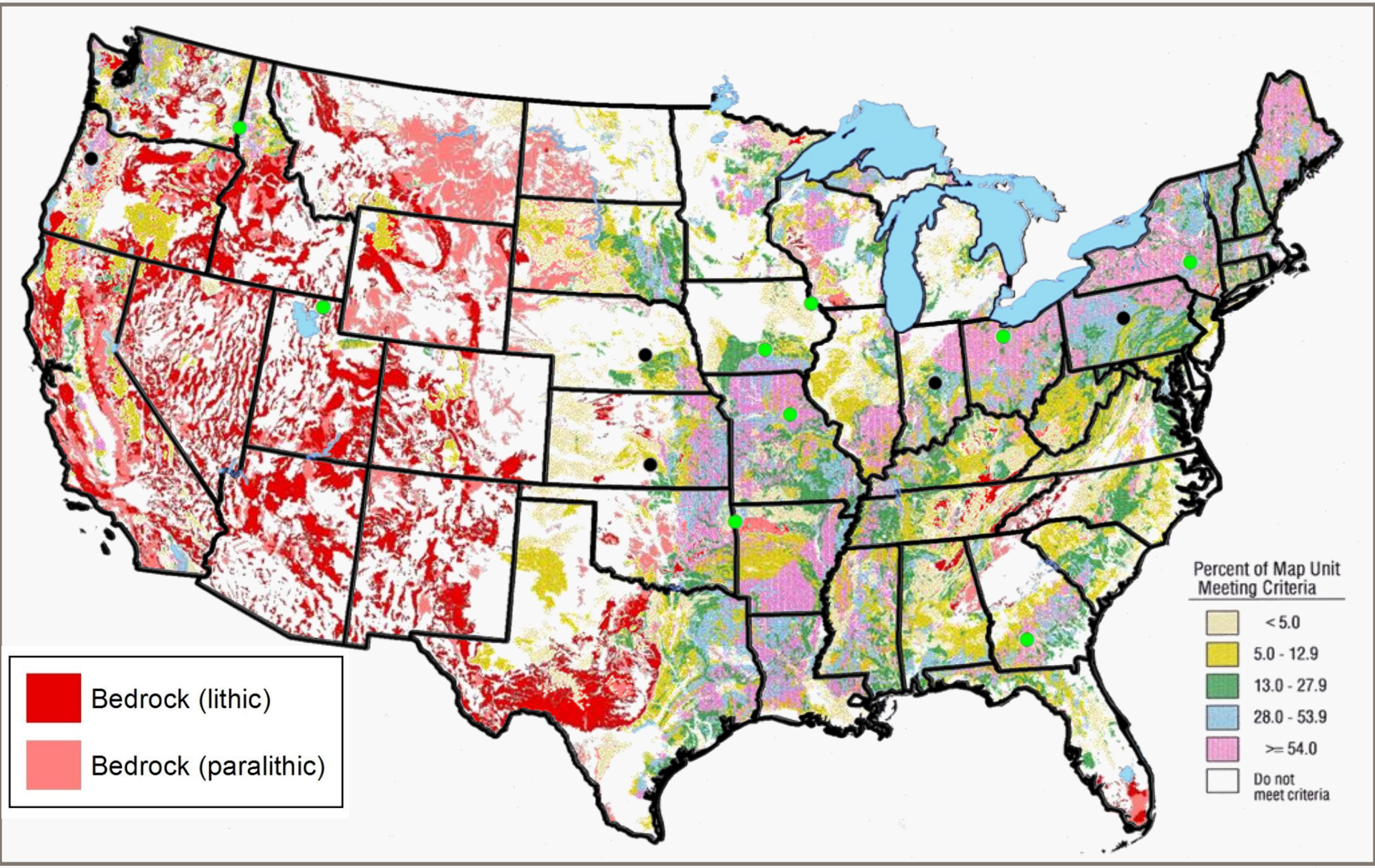


McDaniel et al. (2008)

Bedrock Map



Perched Water Tables & Bedrock



Hydrologic Characterization Tool

Incorporating Process-Based Understanding into Watershed Planning

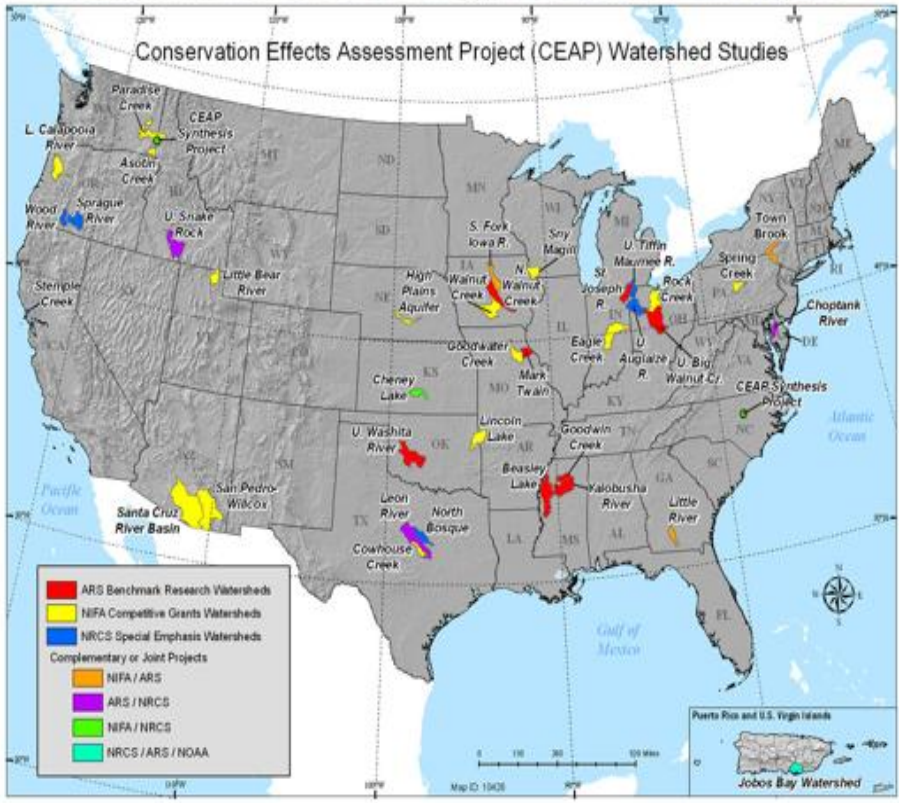
Select Region:

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

Start

Background on Tool Development

Comments?



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This interface funded jointly by USDA-NIFA and USDA-NRCS through the Conservation Effects Assessment Project Synthesis Program.
CONTRACT/GRANT/AGREEMENT NO: 2007-51130-03992

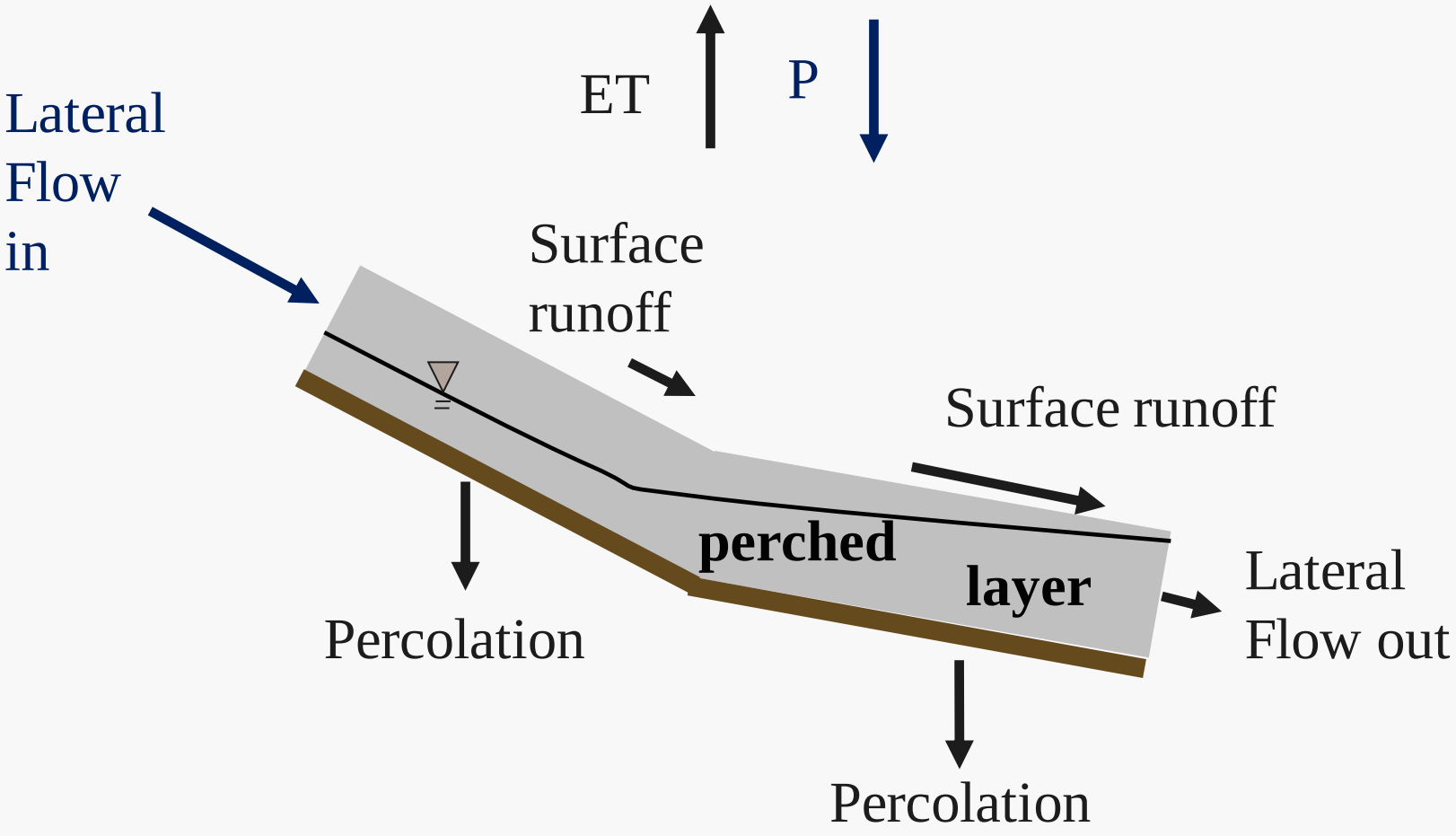
Key Management Questions

- 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

Hillslope Scale



Select Data Files

Paradise Creek ID

Select State for climate: Idaho Select

Select climate file: Moscow ID

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)

Add Custom Slope

Select Soil Type:

Soil Type	Depth to Restrict (cm)	Remove Soil
Paradise Creek ID---southwick	◉ 97	☐
southwick	Add Soil Type	

Add Custom Soil

Select Management Practice:

Management	Tillage Practice	Buffer (m)	Remove Management
Paradise Creek ID---ww_barley_pea	○ CT ◉ MT ○ NT	0	☐
ww_barley_pea	Add Management Practice		

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

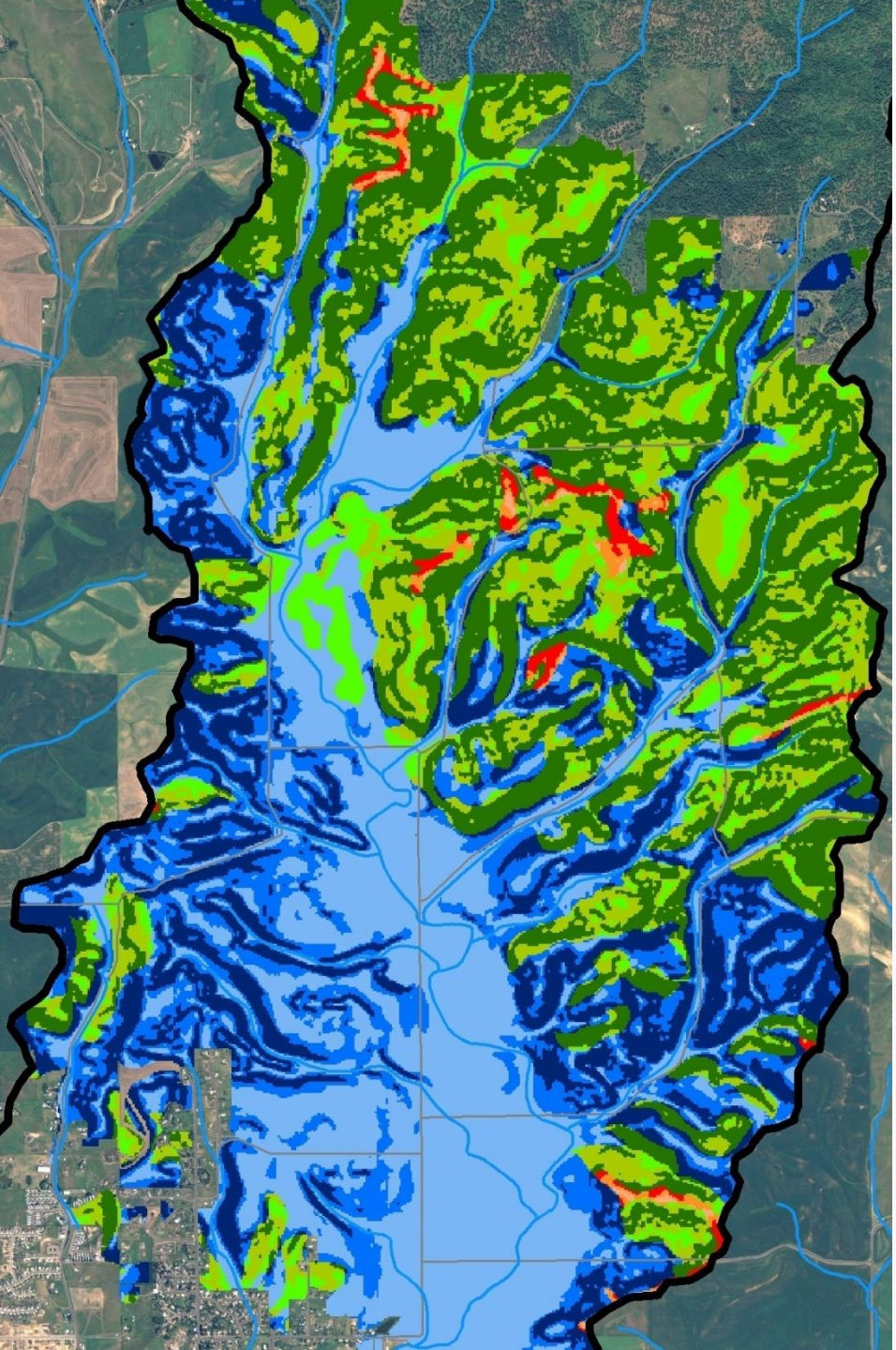
How many years would you like to simulate? 10

Select Files

Select:
- **Climate**
- **Slopes**
- **Soils**
- **Crop Rotation**
- **BMPs**

Keep it simple!

Land Type MAP



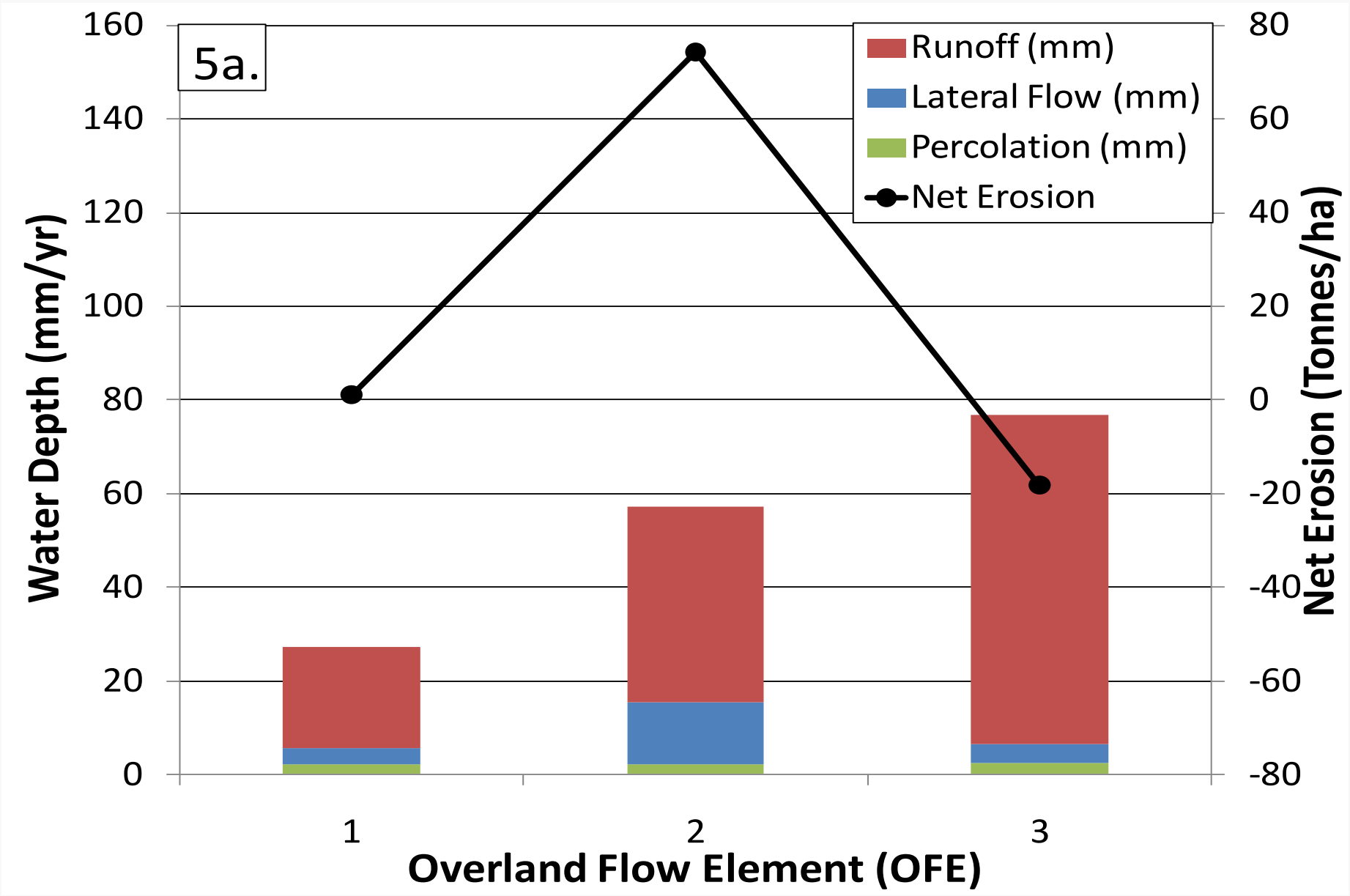
- Streams
- Watershed Bnd.
- Roads
- Steep Slope, Deep Soils
- Mod. Slope, Deep Soils
- Flat Slope, Deep Soils
- Steep Slope, Moderate Soils
- Mod. Slope, Moderate Soils
- Flat Slope, Moderate Soils
- Steep Slopes, Shallow Soils
- Mod. Slope, Shallow Soils
- Flat Slope, Shallow Soils

0.3 0.6 1.2 Kilometers

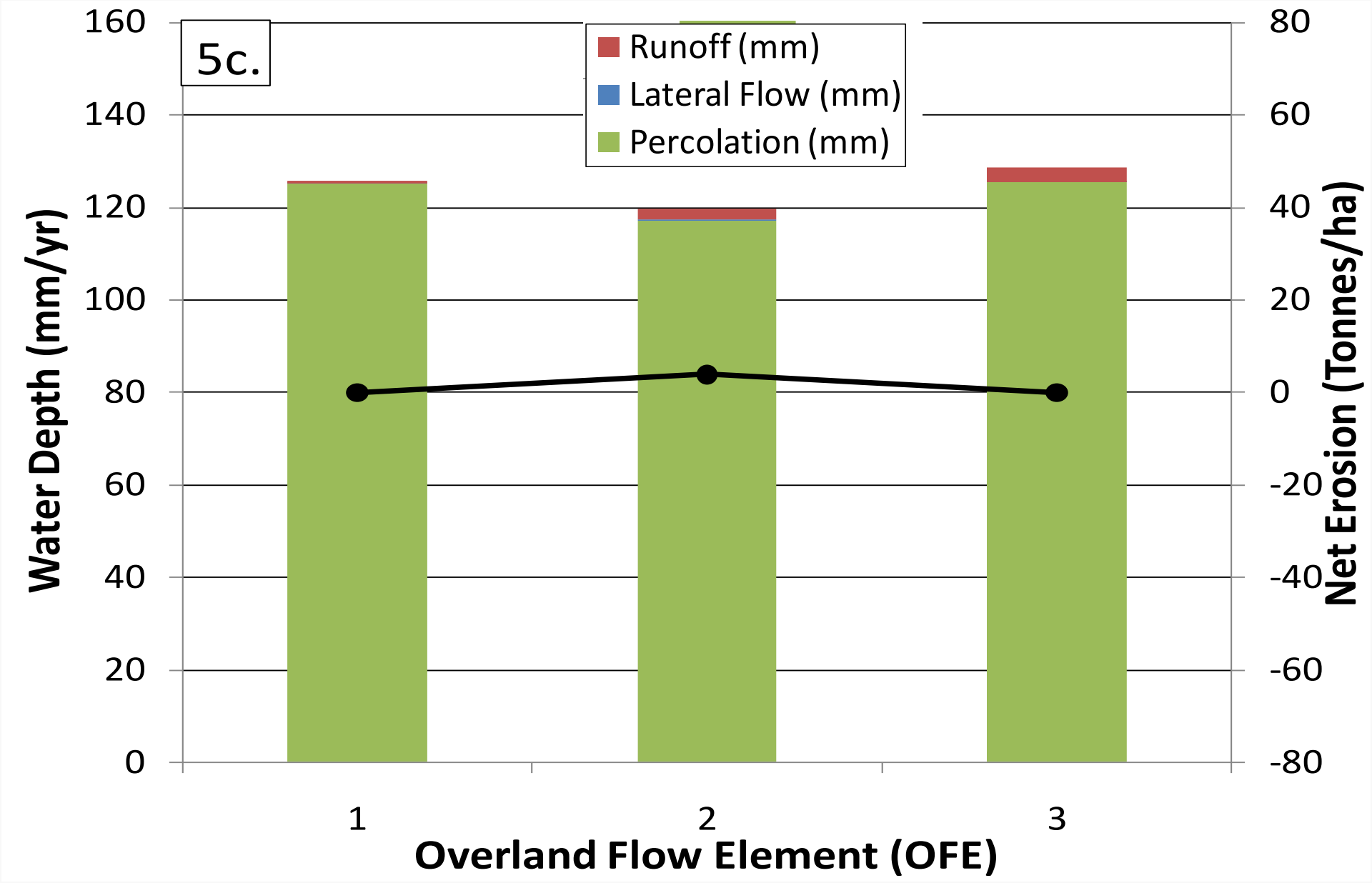
HCT Processing

- **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

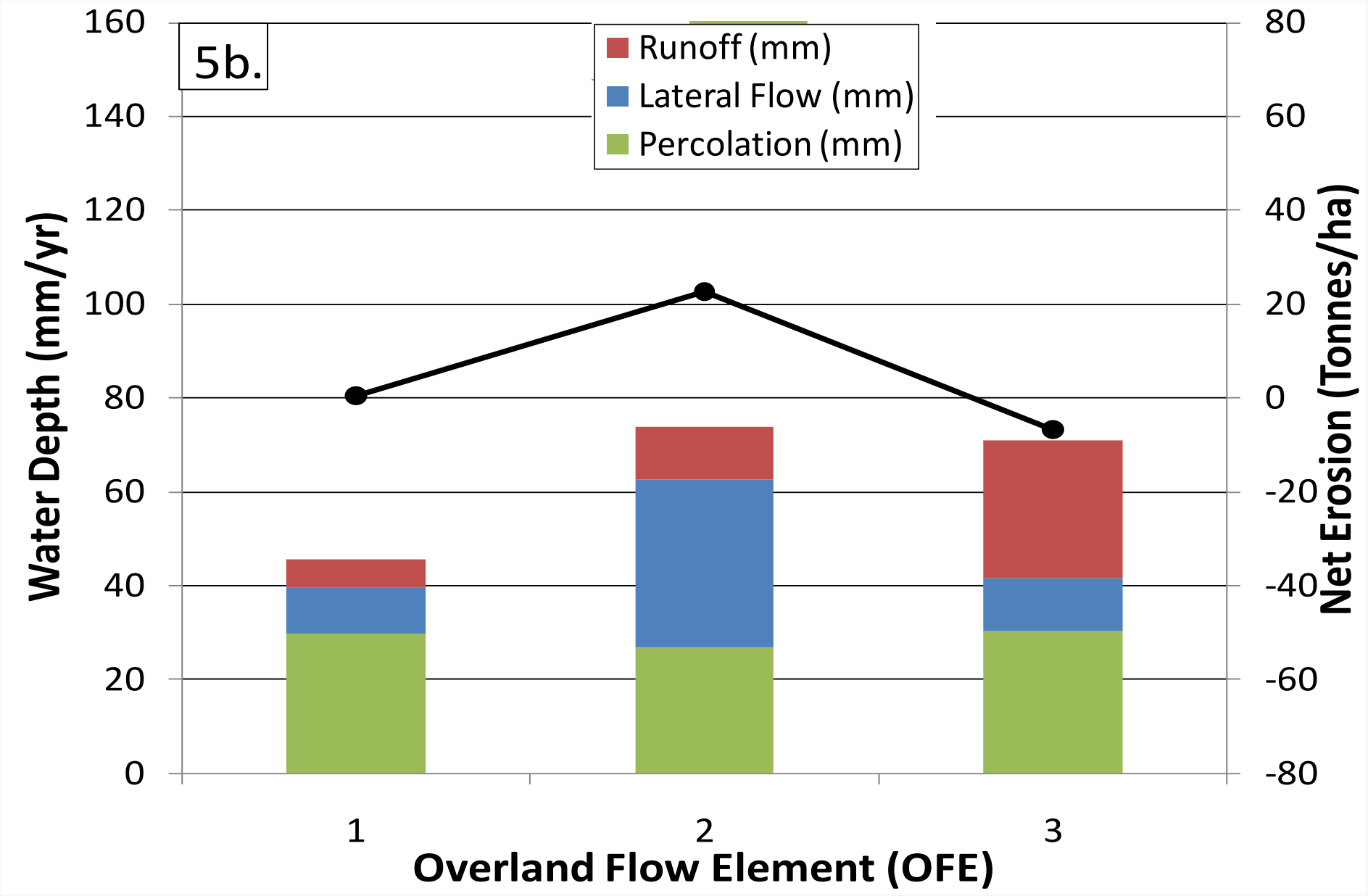
Shallow Soil (20 cm)



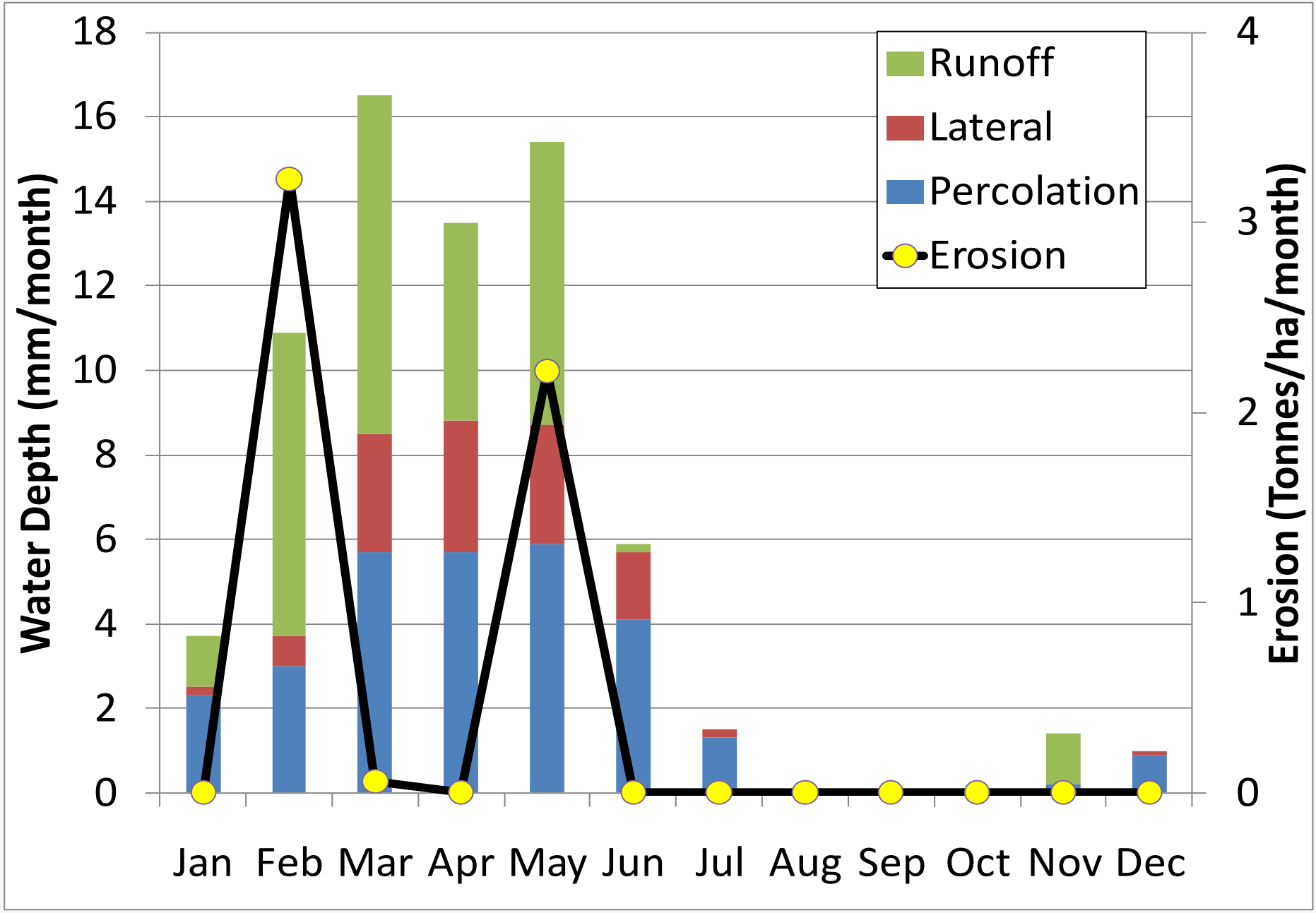
Deep Soil (no restriction)



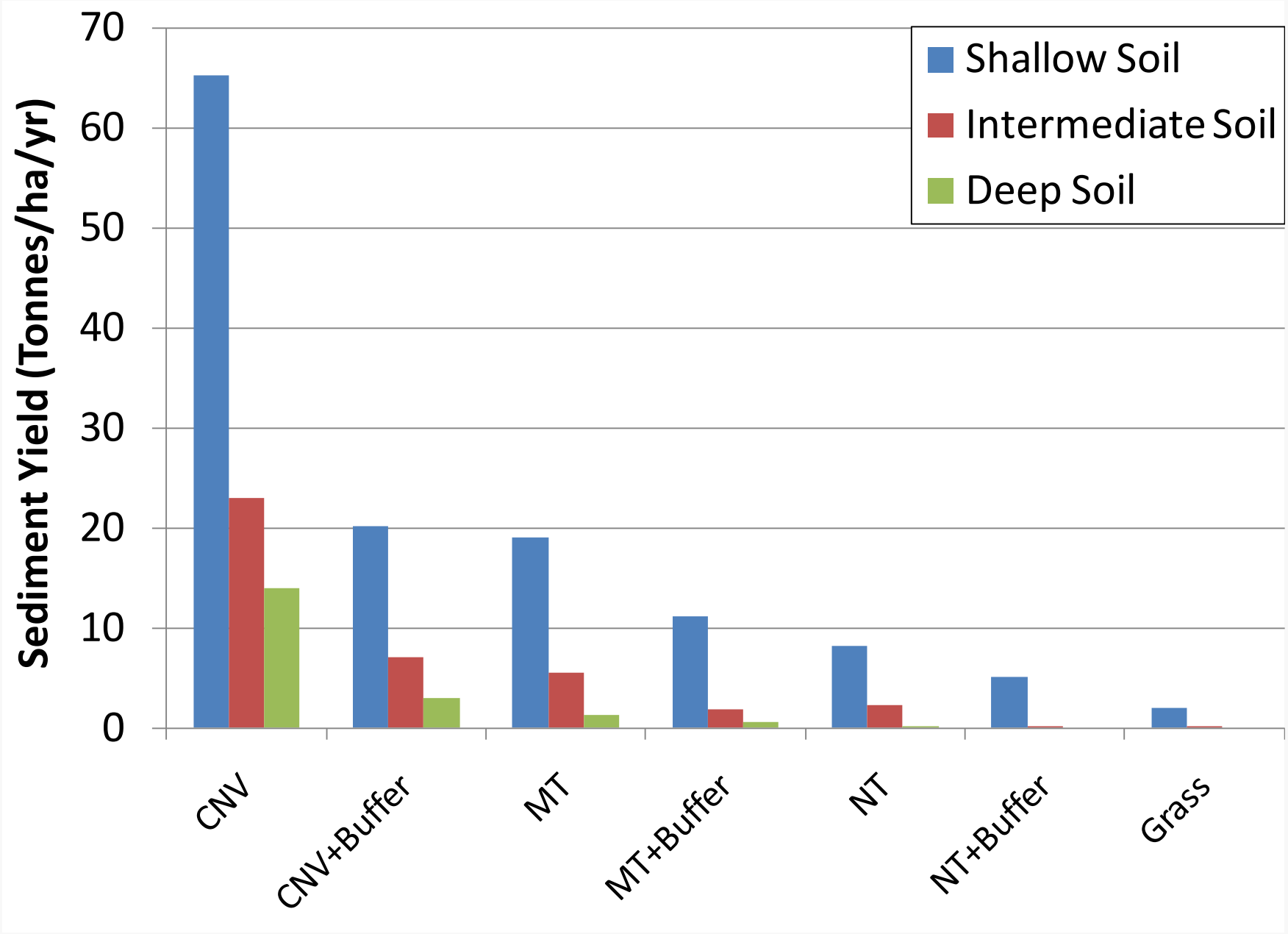
Intermediate Soil (1 m deep)



Monthly Output



Sediment Yield by Treatment



Deep Steep Mulch Till

Deep Mod. Mulch Till

Deep Flat Mulch Till

Mod. Steep Mulch Till

Mod. Mod. Mulch Till

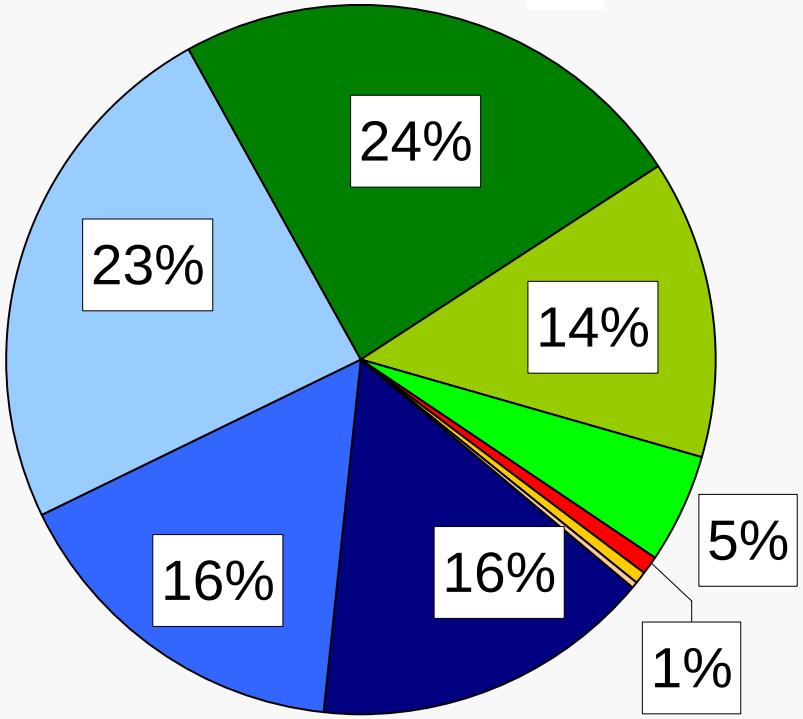
Mod. Flat Mulch Till

Shallow Steep Mulch Till

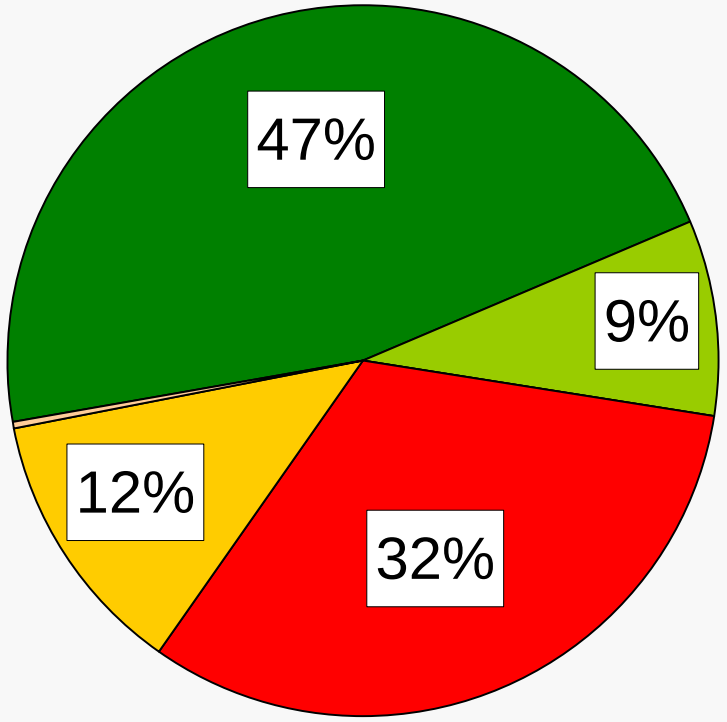
Shallow Mod. Mulch Till

Shallow Flat Mulch Till

Watershed Area



Sediment Yield



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

http://photogallery.nrcs.usda.gov

Watershed Management

Why is that Missouri is much more susceptible to erosion and atrazine transport than in Iowa despite having a very similar climate and topography??

http://photogallery.nrcs.usda.gov

Watershed Management

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?