# Applying Online WEPP to Assess Forest Watershed Hydrology

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# Introduction

- The US Army Corps of Engineers and the Great Lakes Commission are developing predictive tools to aid in watershed management with an ultimate goal of improving and preserving the water quality in the Great Lakes Basin
- A new version of the online Water Erosion Prediction Project (WEPP) GIS interface has been developed for evaluating sediment sources associated with forests and forest management within the Basin

# The Online WEPP GIS Interface

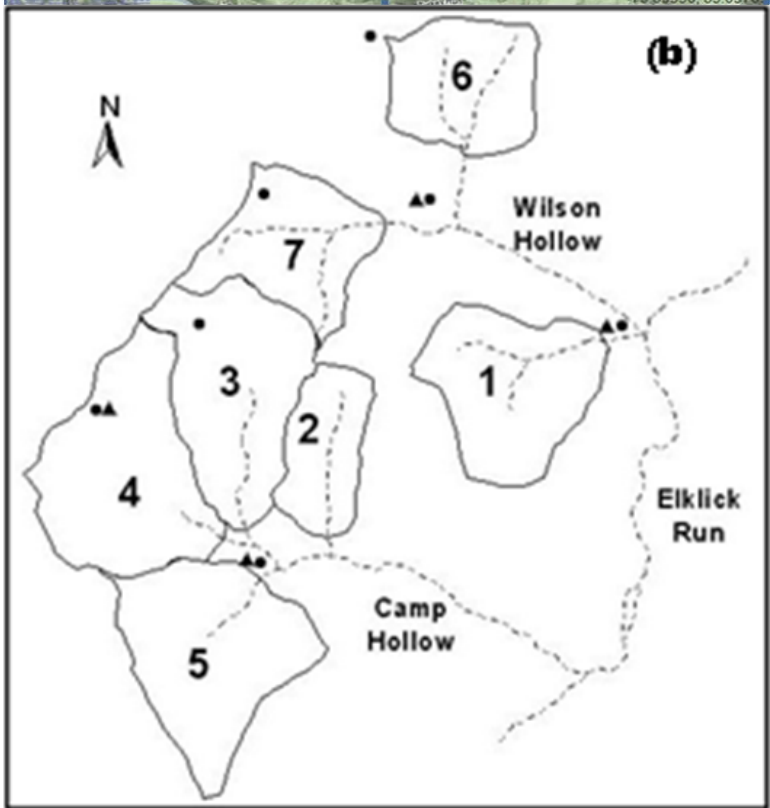
- Uses the OpenLayers, MapServer, and Google images
- The following WEPP inputs are automatically retrieved from web servers
  - Digital elevation data: USGS 30-m National Elevation Data
  - Landuse and management: USGS land cover maps
  - Soils: NRCS SSURGO soil database
- Land management and soils can be customized to reflect the site-specific conditions
- Climate inputs are generated using CLIGEN based on the long-term climate statistical parameters of the nearest weather station
- Statistical climate parameters can be adjusted by using the 800-m grid PRISM data to account for locations distant from the CLIGEN stations

# Objective

- To examine model performance of the new Online WEPP GIS Interface by applying it to forested watersheds in the vicinity of the Great Lakes Basin

# Study Site

- Two monitored watersheds (WS1 and WS4) at the Fernow Experimental Forest
- The Fernow Experimental Forest is located in Tucker County, W. Virginia, 1.3 km south of Parsons, in the Allegheny Mountain section of the Appalachian Plateau

# Hydrological Settings

- Unglaciated, humid-mountainous topography
- Weathered and fractured sedimentary bedrock with low dip angle (5–10° to the southeast)
- Loam and silt loam soils with an average depth of 1 m, originated from the bedrock
- Mean annual precipitation 1,470 mm, distributed evenly throughout the year
- Mixed hardwood forest with an annual average ET of 640 mm

# Field Observations

- Within the Elklick Run watershed, seven small sub-watersheds under different forest managements have been instrumented since 1951
- Observed data include daily climate, streamflows, and stream water chemistry
- WS1 and WS4 have collection areas of 30 ha and 34 ha, respectively; both have been completely covered with mature forest for the last two decades

# WEPP Simulations

- The Online WEPP GIS Interface was applied to WS1 and WS4 for 20-yr (1987–2007) simulations
  - Management inputs for mature-forest were used
  - Soil inputs generated by the Online WEPP Interface from SSURGO were refined to reflect the site-specific hydrological conditions of the two watersheds
  - Statistical parameters of the nearest NOAA weather station (Rowlesburg 1, WV, 20 mi to the north) were adjusted with PRISM and were used to generate daily climate inputs

# WEPP Simulations cont'd

- The saturated hydraulic conductivity, $K_{sat}$, of the restrictive bedrock layer was calibrated using the desktop version of WEPP for adequately simulating deep percolations and reproducing the observed streamflows
  - Calibration of $K_{sat}$ required the use of observed climatic data, an option yet to be included in the Online WEPP GIS
  - Same WEPP inputs except climatic inputs were used in $K_{sat}$ calibration

# WEPP ET Simulation

- WEPP includes both the Penman equation and the FAO Penman-Monteith method for estimating ET, and the latter was used in this study
- Crop coefficient for middle growth season was set to 0.71 to reproduce the observed ET (640 mm) from the hardwood forests of the region

# Site-specific Soil Inputs

- Soil inputs were generated by combining the SSURGO soil texture profile with the hydraulic and erosion parameters from the forest loam soil file in the WEPP database
- The soil file was further adjusted by including the anisotropy ratio of the soil hydraulic conductivity and the bedrock hydraulic conductivity

# Major Soil Inputs

| Surface soil parameters | Effective hydraulic conductivity mm $hr^{-1}$ | Interrill erodibility kg s $m^{-4}$ | Rill erodibility s $m^{-1}$ | Critical shear stress Pa |
|---|---|---|---|---|
| | 35 | 1e+5 | 1e-5 | 1 |

| Soil texture profile | | | | | |
|---|---|---|---|---|---|
| Depth mm | Sand % | Clay % | Organic matter % | CEC Meq/100g soil | Rock fragments % |
| 130 | 29.1 | 17.5 | 6.6 | 14 | 10 |
| 790 | 22.4 | 22.5 | 0.26 | 16 | 12 |
| 1190 | 22.4 | 22.5 | 0.18 | 13 | 13 |

| Other parameters | Anisotropy ratio | Restrictive layer $K_{sat}$ mm $hr^{-1}$ | |
|---|---|---|---|
| | | Watershed #1 | Watershed #4 |
| | 25 | 0.036 | 0.008 |

# Model Performance Evaluation

- Simulated runoff and sediment yield using observed climate data were compared with observed runoff and sediment yield
- Runoff and sediment yield for the events with return period of 2, 5, and 10 yr in the simulated series from both WEPP runs were compared with those of the observed values

$$T = (N + 1) / m$$

*T*: return period
*N*: number of simulation years
*m*: rank of the annual maximum events in descending order

# Simulated vs Observed

| Water year | Watershed #1 | | | | | Watershed #4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Observed | | | WEPP-simulated | | Observed | | | WEPP-simulated | |
| | Precip. mm | Runoff mm | Sed. yield t ha$^{-1}$ | Runoff mm | Sed. yield t ha$^{-1}$ | Precip. mm | Runoff mm | Sed. yield t ha$^{-1}$ | Runoff mm | Sed. yield t ha$^{-1}$ |
| 1987–1988 | 1324 | 460 | 0.22 | 428 | 0.18 | 1257 | 480 | 0.12 | 467 | 0.19 |
| 1989–1990 | 1548 | 632 | 0.36 | 582 | 0.16 | 1484 | 670 | 0.18 | 692 | 0.13 |
| 1991–1992 | 1376 | 466 | 0.31 | 452 | 0.09 | 1266 | 489 | 0.13 | 501 | 0.04 |
| 1993–1994 | 1943 | 966 | 0.40 | 991 | 0.37 | 1894 | 1038 | 0.25 | 1135 | 0.24 |
| 1995–1996 | 2082 | 970 | 0.46 | 1018 | 0.41 | 2023 | 1069 | 0.28 | 1128 | 0.38 |
| 1997–1998 | 1604 | 723 | 0.29 | 708 | 0.17 | 1562 | 803 | 0.19 | 864 | 0.12 |
| 1999–2000 | 1441 | 464 | 0.19 | 490 | 0.14 | 1393 | 504 | 0.13 | 519 | 0.07 |
| 2001–2002 | 1334 | 444 | 0.19 | 439 | 0.11 | 1229 | 502 | 0.13 | 426 | 0.05 |
| 2003–2004 | 1820 | 844 | 0.35 | 885 | 0.21 | 1699 | 907 | 0.22 | 964 | 0.15 |
| 2005–2006 | 1630 | 644 | 0.25 | 655 | 0.20 | 1533 | 625 | 0.15 | 666 | 0.15 |
| Average | 1517 | 610 | 0.28 | 599 | 0.17 | 1440 | 659 | 0.17 | 661 | 0.12 |

# Frequency Analysis

| | | Observed | | | WEPP-Simulated using observed climate data | | Simulated using online WEPP GIS interface | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Precip. mm | Runoff mm | Sed. Yield T ha$^{-1}$ | Runoff mm | Sed. Yield T ha$^{-1}$ | Precip. mm | Runoff mm | Sed. Yield T ha$^{-1}$ |
| Watershed #1 | | | | | | | | | |
| Return | 10 | 88.4 | 52.7 | 0.0078 | 52.8 | 0.084 | 103.4 | 54.0 | 0.12 |
| period | 5 | 80.5 | 37.4 | 0.0075 | 51.3 | 0.072 | 76.6 | 49.5 | 0.066 |
| yr | 2 | 63.5 | 24.1 | 0.0041 | 33.6 | 0.033 | 60.7 | 37.7 | 0.042 |
| Mean | | 64.0 | 28.5 | 0.0048 | 34.6 | 0.043 | 65.8 | 37.6 | 0.048 |
| Standard deviation | | 16.4 | 13.9 | 0.0026 | 12.9 | 0.027 | 22.7 | 14.7 | 0.034 |
| Watershed #4 | | | | | | | | | |
| Return | 10 | 90.2 | 55.4 | 0.0050 | 56.4 | 0.084 | 103.1 | 57.7 | 0.11 |
| period | 5 | 73.7 | 36.5 | 0.0046 | 46.6 | 0.054 | 76.4 | 52.0 | 0.079 |
| yr | 2 | 65.0 | 24.9 | 0.0026 | 34.5 | 0.034 | 60.5 | 41.0 | 0.036 |
| Mean | | 62.6 | 28.1 | 0.0030 | 34.8 | 0.035 | 65.5 | 42.3 | 0.044 |
| Standard deviation | | 16.8 | 14.9 | 0.0012 | 13.2 | 0.026 | 22.8 | 16.0 | 0.034 |

Note: means and std. dev. are for the annual maximum series

# Summary

- Two mature-forest watersheds at the Fernow Experimental Forest were selected for testing the Online WEPP GIS Interface
- With calibrated $K_{sat}$ for each watershed, the WEPP model successfully simulated the differences in the hydrological conditions of the watersheds
- WEPP simulated annual maximum series for runoff and sediment yield are not significantly different from those of the observations
- Ongoing efforts are devoted to examining the performance of the Online WEPP Interface under other hydrologic, landuse, and management conditions

Thank You!