Development of a GIS Interface for WEPP Model Application to Great Lakes Forested Watersheds

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WEPP Model Background

- The Water Erosion Prediction Project (WEPP) model predicts soil erosion and runoff from hillslopes and small watersheds.

- Process based model includes climate and crop growth, channel processes, soil hydrology. No fertilizers, pesticides.

- Released in 1995. Major recent improvements for bedrock restrictive layer, detailed winter freeze/thaw by Shuhui Dun.

- US Forest Service has developed online web tools for roads, disturbed lands using hillslope WEPP.
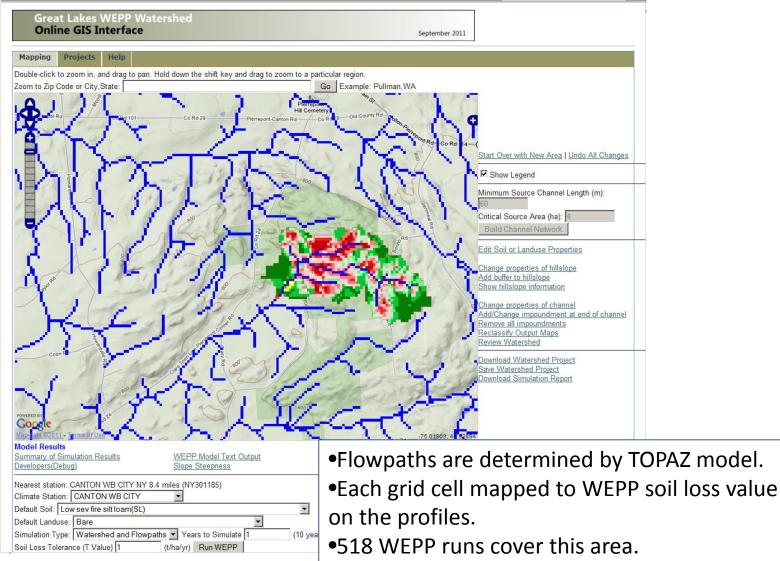
WEPP GIS Options

- Desktop GeoWEPP, based on ArcGIS is used to run WEPP watershed applications. GeoWEPP is used by the Forest Service to evaluate remediation after fires.

- GeoWEPP requires ArcGIS expertise to prepare the data layers.

- The WEPP online interface for Great Lakes forested watersheds provides an alternative to GeoWEPP. More detailed followup simulations can be done with GeoWEPP.

- Focused on Forest Service applications, but can be used for other land uses and for areas outside the Great Lakes.

Objectives of Online GIS WEPP

- Allow users to easily run WEPP watershed simulations from standard web browsers.

- Customize online WEPP soils and land use databases for forest simulations.

- Develop methods to efficiently run the WEPP watershed simulations on servers.

- Allow GIS data from other sites to be used, such as USGS land use and NRCS soils data.

- Make the server setup configurable so it can be deployed on mirror sites.

Flowpath Erosion Output Map

- Flowpaths are determined by TOPAZ model.
- Each grid cell mapped to WEPP soil loss value on the profiles.
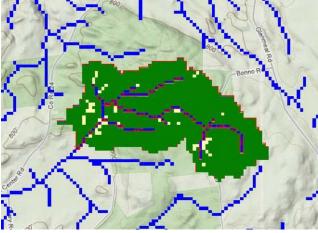- 518 WEPP runs cover this area.

WEPP GIS Operations

- Change land use and/or soil for a subcatchment.

- Add a buffer to the end of a subcatchment.

- Change USGS land use association with a WEPP input.

- Add an impoundment to the end of a channel.

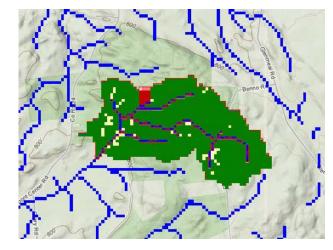- Select a different set of channel properties.

WEPP GIS Operations

- Override soil or land use maps to evaluate potential impacts.

- Reclassify outputs to different soil loss thresholds.

- Apply PRISM climate adjustments to account for elevation changes from a base climate station.

- Vary the run type, all flowpaths (detailed) or representative hillslope (watershed channels).
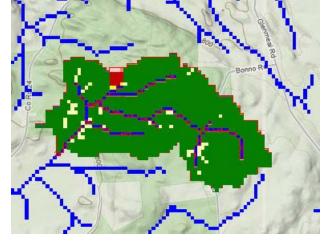
Modifying Land Use Areas

•Original Forested Area

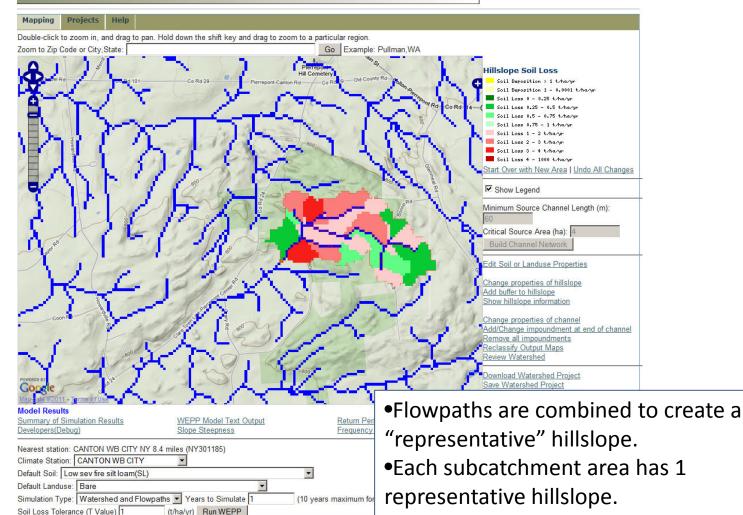•Burned area generates more erosion
•Sediment to channel 11.1 t/yr

•Area with buffer next to channel.
•Yellow cells indicates deposition.
•Sediment to channel 6.8 t/yr

Hillslope Erosion Output Map
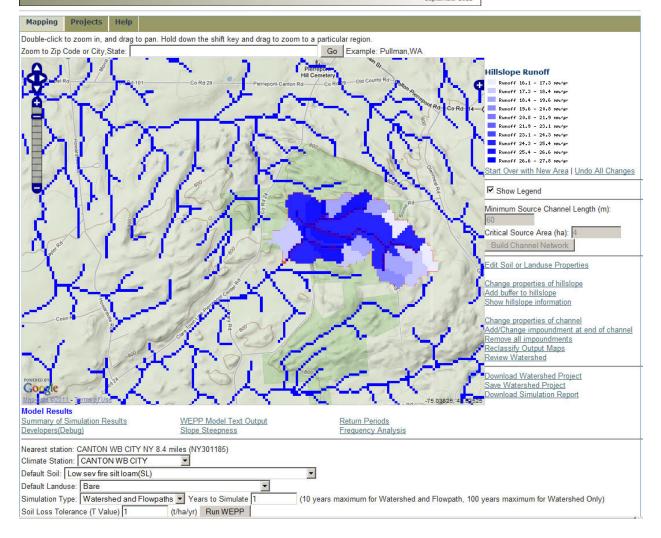
- Flowpaths are combined to create a "representative" hillslope.
- Each subcatchment area has 1 representative hillslope.
- 35 WEPP runs to cover the area

Runoff Output Map

Major Software Pieces
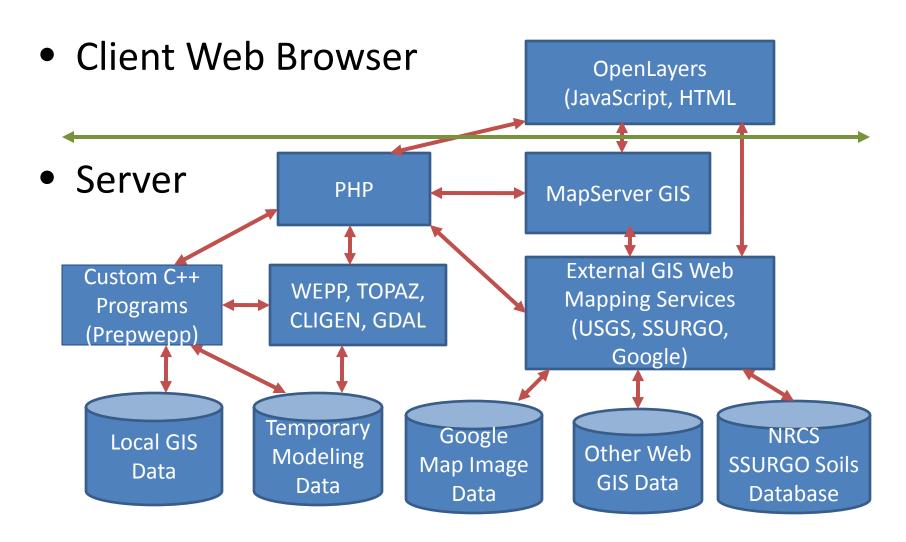
- **OpenLayers+Google Images+MapServer** – Allows user to locate area of interest, assemble grids, visualize outputs.

- **GDAL** – Geospatial Data Abstraction Library, GIS processing functions.

- **TOPAZ** – Performs DEM analysis, watershed delineation, subcatchments, flow direction, channel network.

- **Prepwepp** – Builds WEPP inputs from grids, runs WEPP model, produces output maps.

Software Architecture

- Client Web Browser

- Server
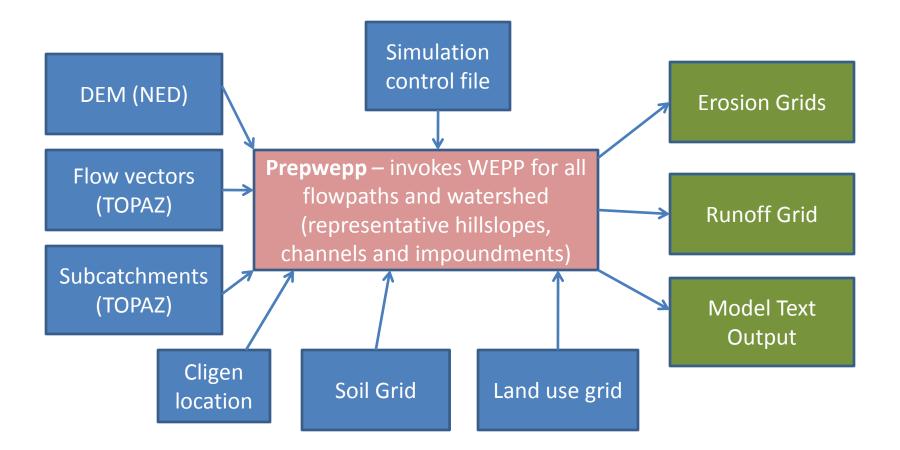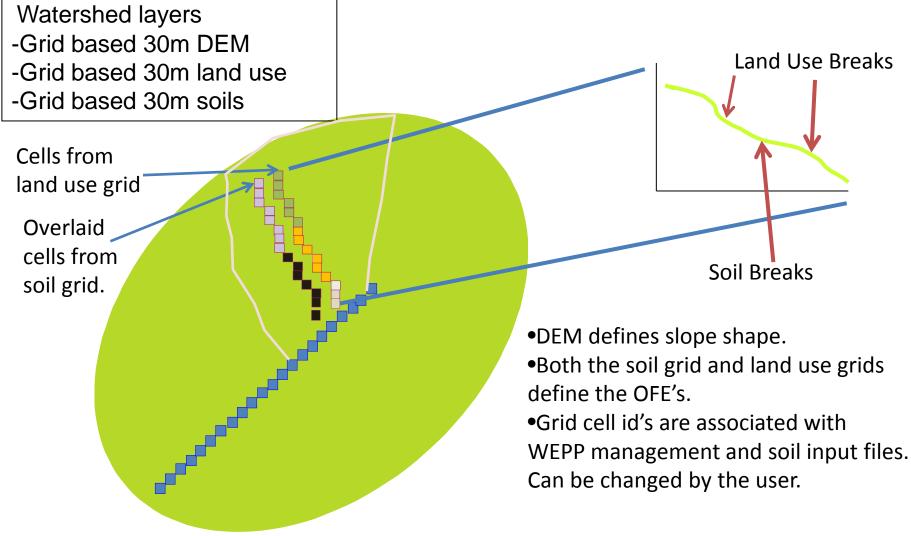
WEPP Watershed Inputs

- **Topography** – Derived from USGS 30 meter DEM using TOPAZ model.

- **Land Use** – From USGS Landcover map, general types are associated with WEPP management.

- **Soil** – Built from SSURGO spatial and tabular data for area of interest. Can also use local forest soils.

- **Climate** – Generated from CLIGEN, can be adjusted with PRISM grids to account for elevation differences.

- **Watershed channel structure** – Determined from TOPAZ.

WEPP Modeling

Processing Flowpaths

Watershed layers
-Grid based 30m DEM
-Grid based 30m land use
-Grid based 30m soils

Cells from
land use grid

Overlaid
cells from
soil grid.

Land Use Breaks

Soil Breaks

•DEM defines slope shape.
•Both the soil grid and land use grids define the OFE's.
•Grid cell id's are associated with WEPP management and soil input files. Can be changed by the user.
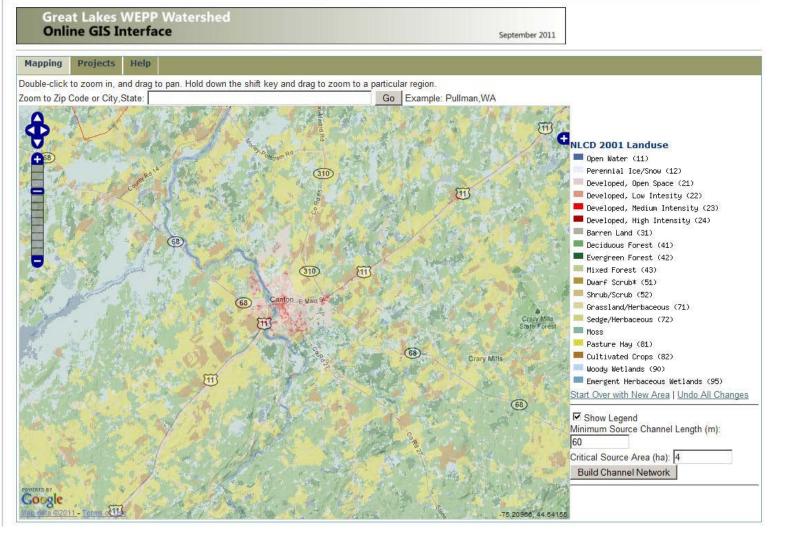
Land Use Choices

Shrubs ▼

Custom Managements
Forest
Mature forest
Thin or young forest
Shrubs
Good grass
Poor grass
Low severity fire
High severity fire
Prescribed fire
Bare
Mulch only
Mulch and till
Low traffic road
High traffic road
Agriculture
Barley, conventional tillage, Palouse
Barley, mulch tillage, Palouse
Barley, no till, Palouse
alfalfa with cuttings

Shrubs ▼

High traffic road
Agriculture
Barley, conventional tillage, Palouse
Barley, mulch tillage, Palouse
Barley, no till, Palouse
alfalfa with cuttings
corn,soybean,wheat,alfalfa(4yrs)- consv till
corn,soybean,wheat,alfalfa(4yrs)- conv till
corn,soybean,wheat,alfalfa(4yrs)- no till
corn,soybean-fall moldboard plow
corn,soybean-fall mulch till
corn,soybean-no till
corn,soybean-spring chisel plow
corn-fall moldboard plow
corn-fall mulch till
corn-no till
corn-spring chisel plow
fallow
fallow tilled
grass
soybean-fall moldboard plow

Landcover Map

Soil Choices
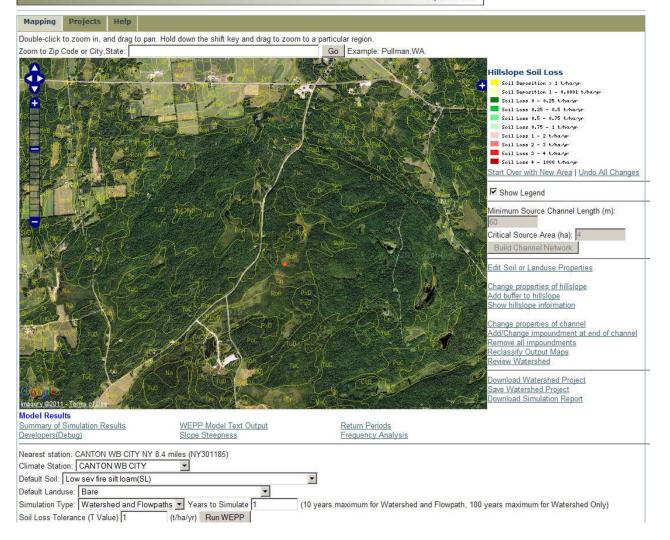
Shrub loam(SL) ▾

Custom Soils
SSURGO Soils
  Carbondale muck
  Potsdam-Tunbridge complex, 3 to 15 percent slopes, very bouldery
  Roundabout silt loam, 0 to 2 percent slopes
  Tunbridge-Lyman complex, 15 to 35 percent slopes, very rocky
  Tunbridge-Lyman-Dawson complex, rolling, very rocky
Forest Soils
  Bare Rock(SL)
  Bunch Grass clay loam(CL)
  Bunch Grass loam(SL)
  Bunch Grass sandy loam(S)
  Bunch Grass silt loam(SL)
  Forest clay loam(CL)
  Forest loam(SL)
  Forest sandy loam(S)
  Forest silt loam(SL)
  High sev fire clay loam(CL)
  High sev fire loam(L)
  High sev fire sandy loam(S)

Shrub loam(SL) ▾

Forest Soils
  Bare Rock(SL)
  Bunch Grass clay loam(CL)
  Bunch Grass loam(SL)
  Bunch Grass sandy loam(S)
  Bunch Grass silt loam(SL)
  Forest clay loam(CL)
  Forest loam(SL)
  Forest sandy loam(S)
  Forest silt loam(SL)
  High sev fire clay loam(CL)
  High sev fire loam(L)
  High sev fire sandy loam(S)
  High sev fire silt loam(SiL)

Shrub loam(SL) ▾

  Young forest sandy loam(S)
  Young forest silt loam(SL)
WEPP Database
  ADAMS(LFS)
  ADJIDAUMO(SICL)
  AGAWAM(FSL)
  ALBRIGHTS(SIL)
  ALDEN(SIL)
  ALLAGASH(FSL)
  ALLARD(SIL)
  ALLIS(SIL)
  ALTMAR(FSL)
  ALTON(GR-SL)
  AMBOY(VFSL)
  AMENIA(SIL)
  ANGOLA(SIL)
  APPLETON(L)
  AQUENTS(GR-LS)
  ARKPORT(VFSL)
  ARNOT(CN-SIL)

NRCS SSURGO Map

Server Implementation

- http://WEPPonlineGIS.puyallup.wsu.edu
- Server for Great Lakes WEPP watershed application
- Dell PowerEdge, 2-CPU Intel Quad cores, 8GB memory, 250GB drive
- Ubuntu Linux
- http://milford.nserl.purdue.edu/
- General WEPP server for NSERL, hillslope and watershed
- Custom built, 1-CPU Intel Quad core, 4GB memory, 150GB drive, 120GB SSD drive
- Gentoo Linux

Performance

- Larger watershed area, including number of flowpaths and number of representative hillslopes increases runtime.

- Multiple OFE runs take longer. The more land use and soil changes along a profile the longer the simulation. Roughly linear.

- Length of simulation, whether all flowpaths are simulated.

- Server setup, number+speed of CPU's, hard disk types, compiler used for WEPP.

Performance

- Run on NSERL server (Intel Quad core)
- 134 ha watershed, 35 hillslopes, 15 channels, 518 flowpaths, single soil and land use, 1 year run.

Concurrent Sessions	Simulation Time (secs)
1	9
4	17
5	20

- Representative hillslopes only - < 1 second for 5 concurrent users.

Open Source Software Used

- **GDAL Software** – Code to do GIS operations.

- **OpenLayers** – Frontend for multiple GIS layers.

- **MapServer** – online GIS, vector, grid data.

- **GnuPlot** – General graphing

- **TcPDF** – Create PDF documents from PHP

- **PostgreSQL** – Server database

- **Apache** – Web server

- **PHP** -   Server side scripting

Conclusions

- Web based approaches simplify WEPP watershed setup.

- Forest specific land use and soils can be merged with existing data sets.

- Performance is reasonable for small areas and limited run times.

- Detailed simulations still require desktop WEPP and GeoWEPP.