Model Development and Applications at the USDA-ARS National Soil Erosion Research Laboratory

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"The NSERL – to provide the knowledge and technology needed by land users to conserve soil and water for future generations."

Building dedicated 1/15/1982

Co-Authors

- **Chi-hua Huang, Research Soil Scientist, NSERL Research Leader (erosion mechanics, soil surface/subsurface hydrology impacts)**
- **Doug Smith, Research Soil Scientist (nutrient dynamics, water quality, conservation effects assessment, model applications)**
- **Gary Heathman, Research Soil Scientist (hydrology, soil moisture, remote sensing, model development and application)**

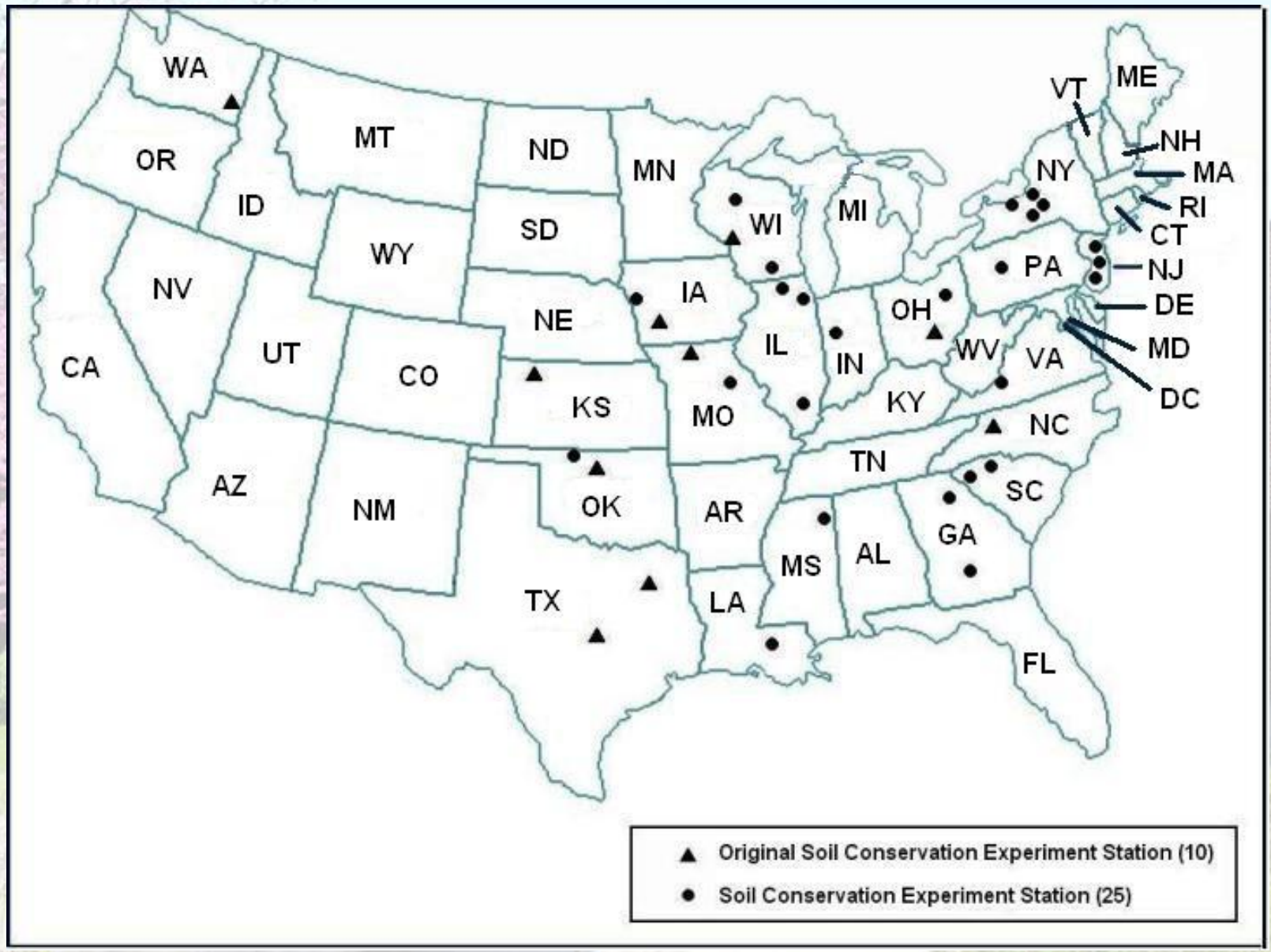
Presentation Outline

- Erosion Prediction History and the NSERL
- Current Erosion Modeling Products
- Model Development Efforts
- Model Applications
- Summary

Soil Conservation Experiment Stations

Some erosion plots at Guthrie, Oklahoma experiment station, circa 1940. SCS Chief Hugh H. Bennett shown.

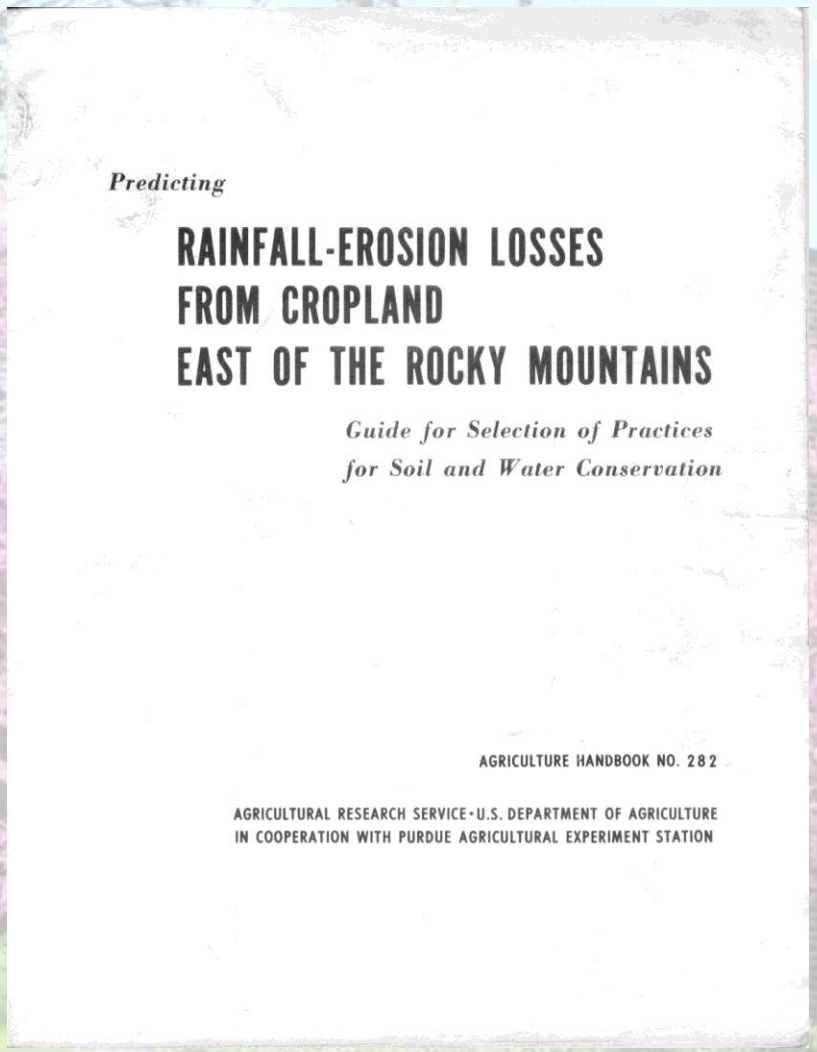
Soil Conservation Experiment Stations

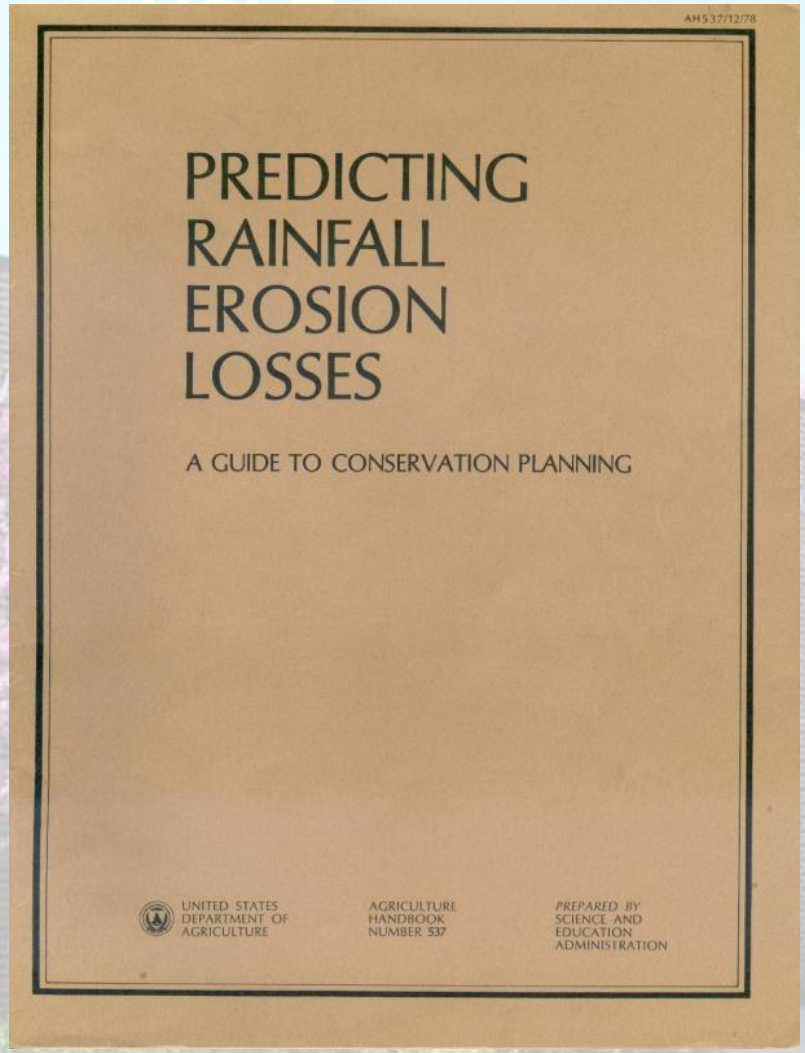


The USDA-ARS National Runoff and Soil Loss Data Center (NRSLDC)

- **The USDA – Agricultural Research Service's NRSLDC was created at Purdue University in 1954.**
- **The Research Leader was Mr. Walt Wischmeier, a statistician transferred from Missouri. He had formerly been a Soil Conservation Service employee. Other original scientists in the unit were Don Meyer, Don McCune, and Tam Olson.**
- **The main focus of the unit originally was to house and use all of the data collected at the SCES locations. Data was transferred to computer punch cards, and then statistical analyses run using Purdue's new computing capabilities.**
- **Work at the NRSLDC resulted in the development of the Universal Soil Loss Equation (USLE), published in 1965.**

Data transfer from handwritten logs to computer punch cards.



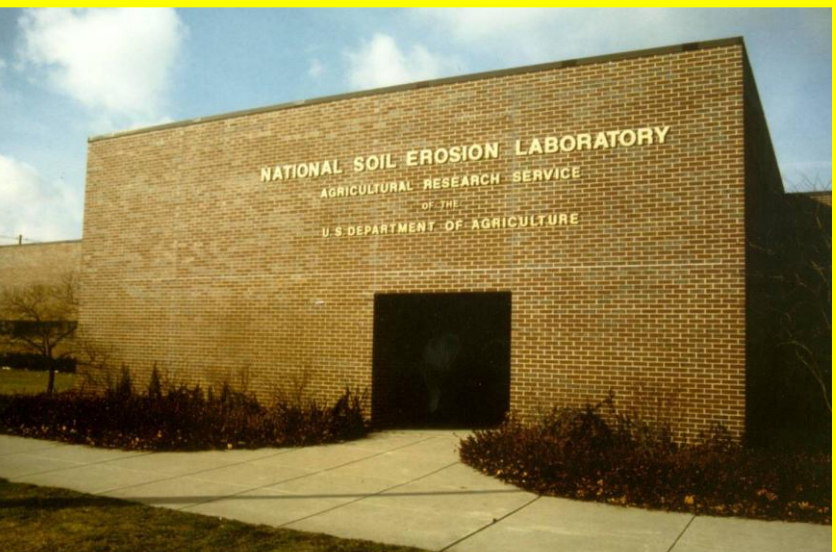


Milestones of USLE technology development:

Agriculture Handbook 282 (1965), and 537 (1978).

The National Soil Erosion Research Lab

- The large success of the USLE and the accomplishments by the scientists at the NRSLDC provided the impetus to secure Congressional funding in 1977 for construction of a physical facility at Purdue University for continuing soil erosion research and prediction technology development.
- Construction began in 1979 and was completed in 1981.
- The NSERL building was dedicated on January 15, 1982.
- First research leader was Dr. Bill Moldenhauer. Scientists when the lab opened were Dr. George Foster, Dr. Joe Bradford, and Dr. Darrell Norton.



Erosion Modeling at NSERL

- CREAMS/GLEAMS model erosion component
- RUSLE model
- Water Erosion Prediction Project (WEPP) model

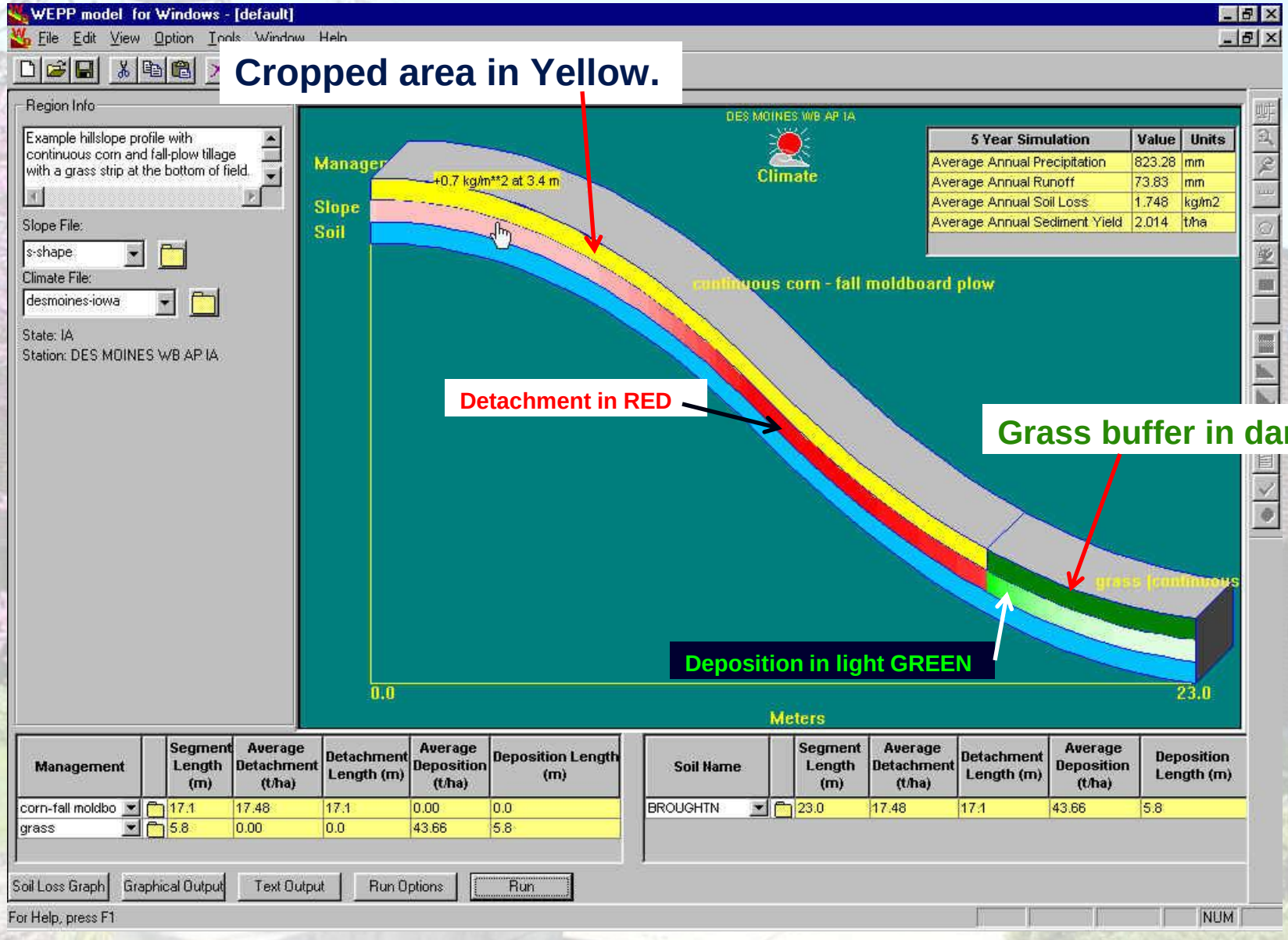
The WEPP Model

- Physical process based
- Distributed parameter
- Continuous simulation (as well as single storm simulations)
- Implemented on personal computers
- User-friendly interfaces, and nationwide databases

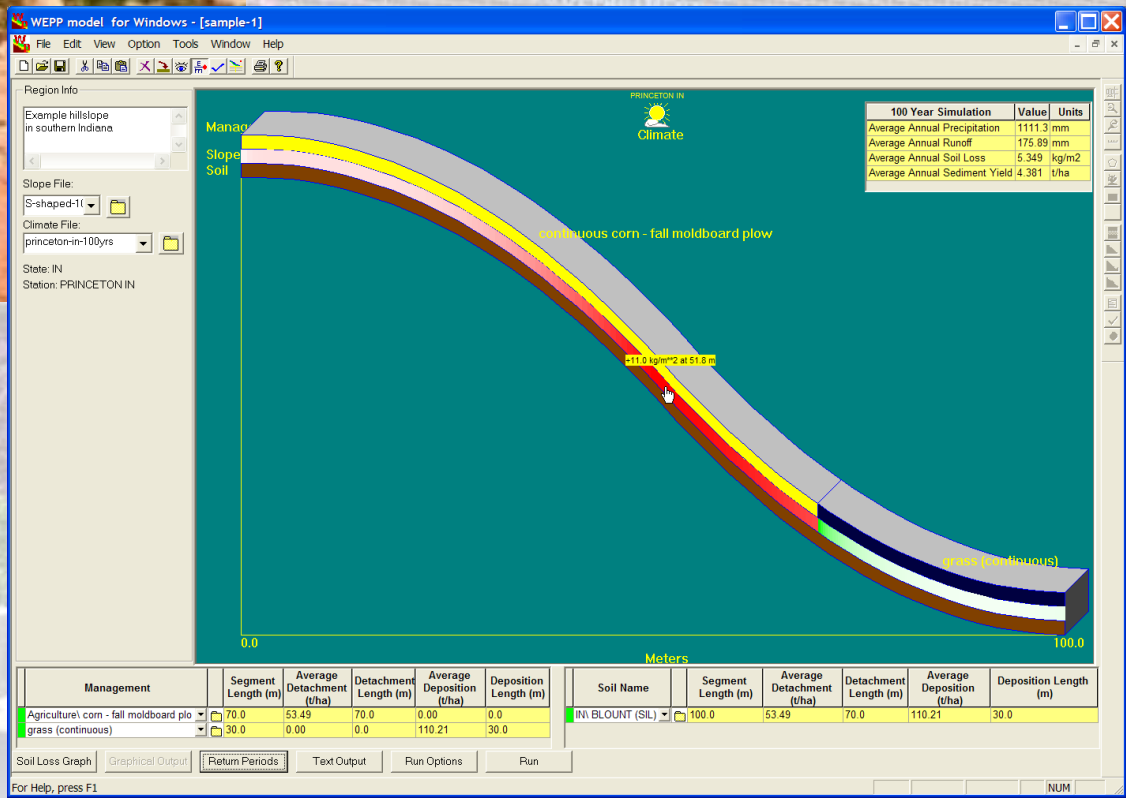
WEPP Model Background

- WEPP modeling effort initiated in 1985.
- Core Team of ARS, SCS, FS, BLM scientists
- Field experiments for model parameterization in 1987-88 on cropland and rangeland soils
- FORTRAN model code mainly developed from 1985-1995
- Validated WEPP hillslope and watershed model released in 1995, with full documentation and a DOS interface
- Updated model releases every 1-2 yrs since

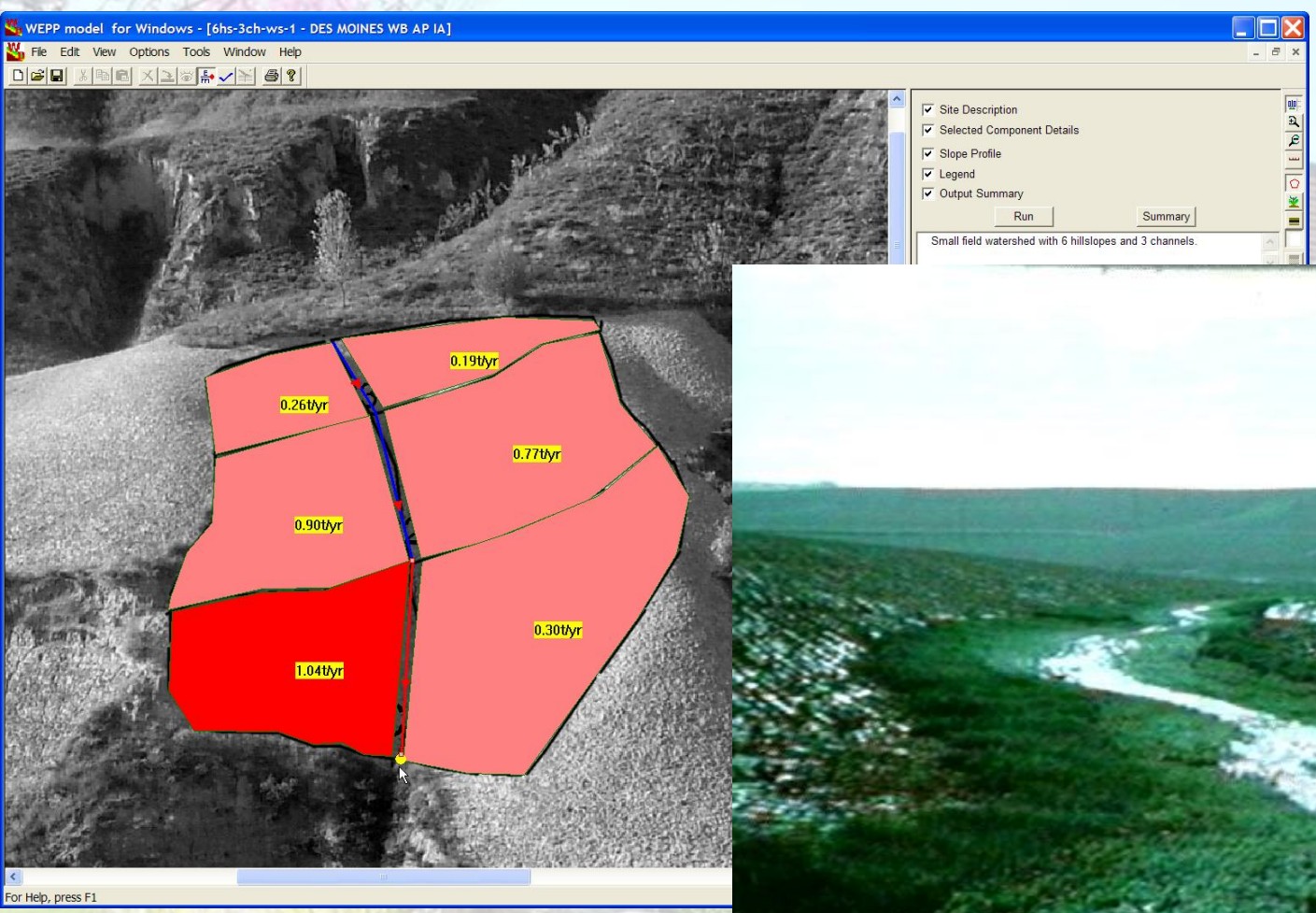
Example – WEPP Grass Buffer simulation



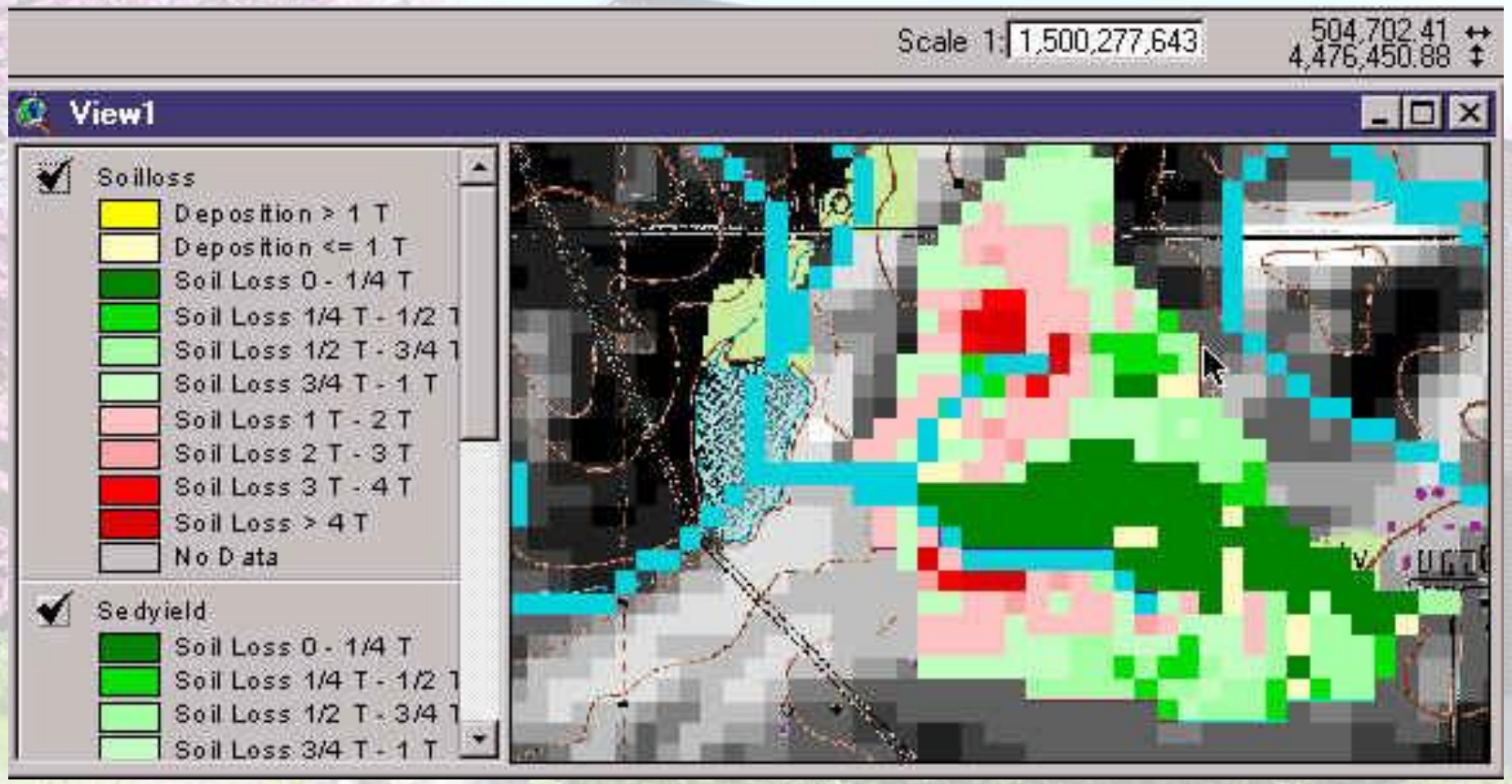
WEPP predicts soil loss and sediment delivery from hillslope profiles.



WEPP predicts erosion and sediment delivery from fields and small watersheds



GeoWEPP – Geo-spatial Interface for WEPP implemented as an extension in ArcView/ArcGIS.



Soil detachment or deposition depicted graphically on sub-basins within a small watershed.

WEPP Web Browser Interfaces

WEPP Model Interface - Netscape

File Edit View Go Communicator Help

Water Erosion Prediction Project | Databases | Help

WEPP Cropland | Cropland Worksheet | WEPP Rangeland | Rangeland Worksheet

State: Georgia

Climate Station: CORNELIA

Field Length (ft): 150
Field Width (ft): 60
Slope Shape: S-shaped
Steepness: 10% View

View Standard Slope Shapes

Soil: DUNBAR(SL)

Management: corn,soybean-fall mulch till
View Management

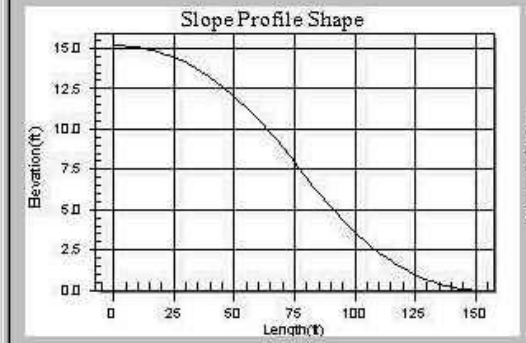
Simulation Years (1 to 30): 30
Detailed Graphics

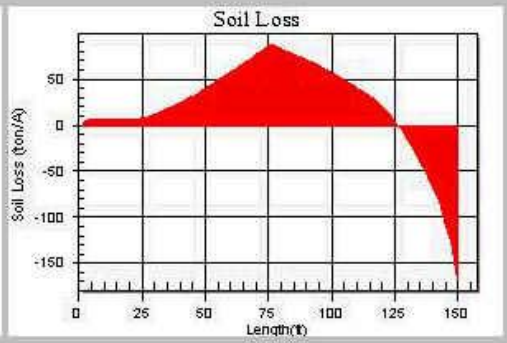
Calculate Soil Loss

WEPP Simulation Results (30 Years)

State:	Georgia
Climate Station:	CORNELIA
Management:	corn,soybean-fall mulch till
Soil:	DUNBAR(SL)
Slope Shape	S-shaped(10%)
Slope Length (ft):	150
Slope Width (ft):	60

Average Annual Precipitation (in/yr)	61.4
Average Annual Runoff (in/yr)	13.8
Average Annual Soil Loss (ton/A/yr)	39.2
Average Annual Sediment Yield (ton/A/yr)	22.0





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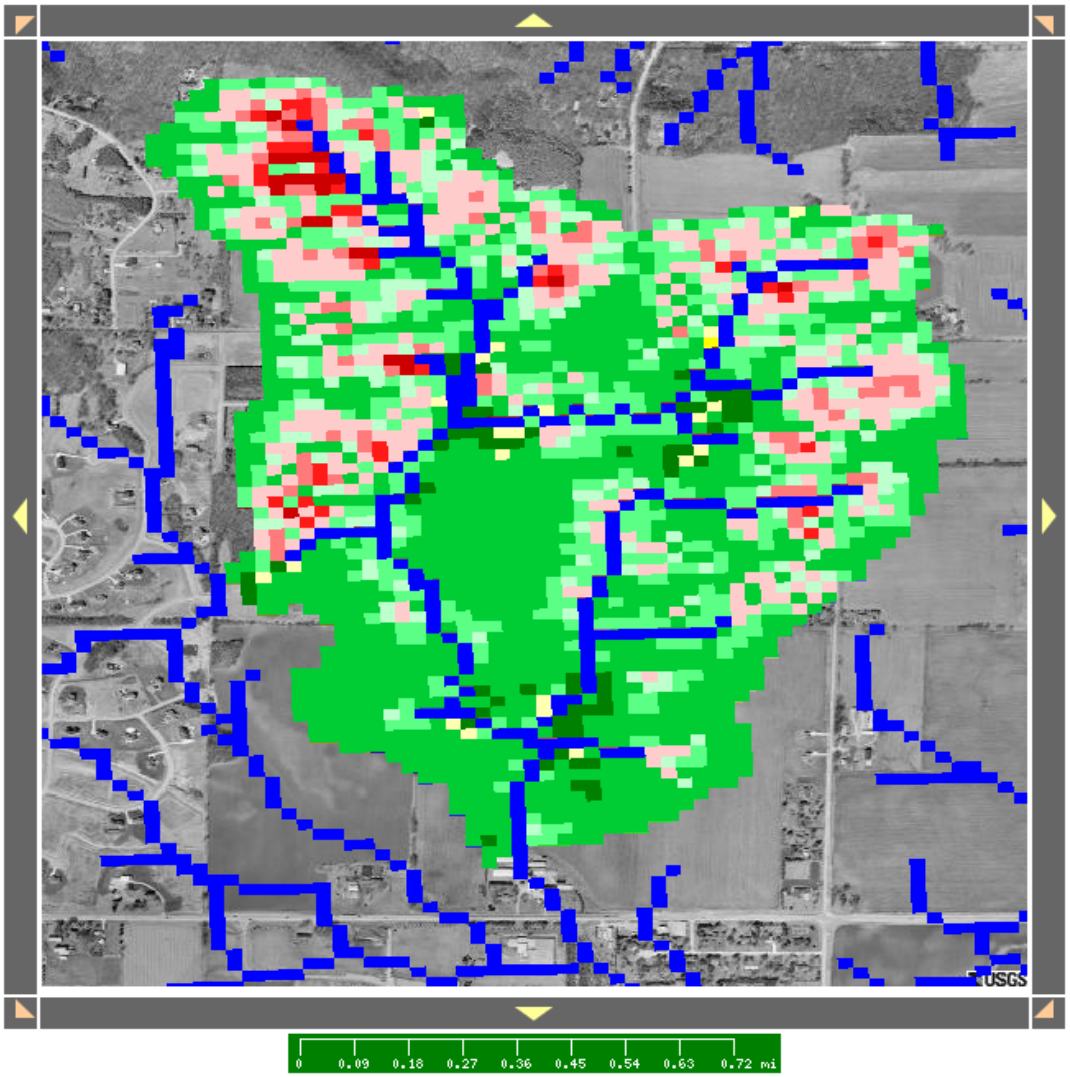
WEPP geospatial Web Watershed Results

5. WEPP Simulation Results The WEPP simulation results are displayed as soil loss maps. The flowpath results show soil loss from all flowpath runs by cell. The hillslope results show the average soil loss of each subcatchment from a WEPP watershed simulation. (NY_templatetopaz4.html)



Layers

- [ ] DRG Images (TerraServer)
- [ ] Landuse (USGS NLCD 1992)
- [x] Orthophotos (TerraServer)
- [ ] Roads
- [ ] Rivers
- [ ] Soils (STATSGO)
- [x] Channel Network
- [x] Subcatchments
- [ ] Boundary
- [x] Soil Loss - Flowpaths
- [ ] Soil Loss - Hillslopes

Redraw Map Full Extent

To change the landuse click on the Rerun WEPP Model to do another simulation on the same watershed.

Rerun WEPP Model

Reclassify Output Maps

Save Watershed Setup

New Watershed - Same General Area

New Watershed - Different Area

Text Summary of Simulation Results

- Soil Deposition > 5 t/ha/yr
- Soil Deposition 5 - 0.0001 t/ha/yr
- Soil Loss 0 - 1.25 t/ha/yr
- Soil Loss 1.25 - 2.5 t/ha/yr
- Soil Loss 2.5 - 3.75 t/ha/yr
- Soil Loss 3.75 - 5 t/ha/yr
- Soil Loss 5 - 10 t/ha/yr
- Soil Loss 10 - 15 t/ha/yr
- Soil Loss 15 - 20 t/ha/yr
- Soil Loss 20 - 1000 t/ha/yr

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Model Development

Testing/enhancement of WEPP science model

- Enhanced channel hydrology to allow application to larger watersheds. Cooperators at WSU have been incorporating new channel flow routines utilizing
  - Numerical kinematic wave
  - Muskingum-Cunge method
- Evaluation of tile drainage routines in cooperation with faculty at Ohio State University
- Utilizing results from other NSERL research into ephemeral gully formation and detachment, to improve these predictions in the model.

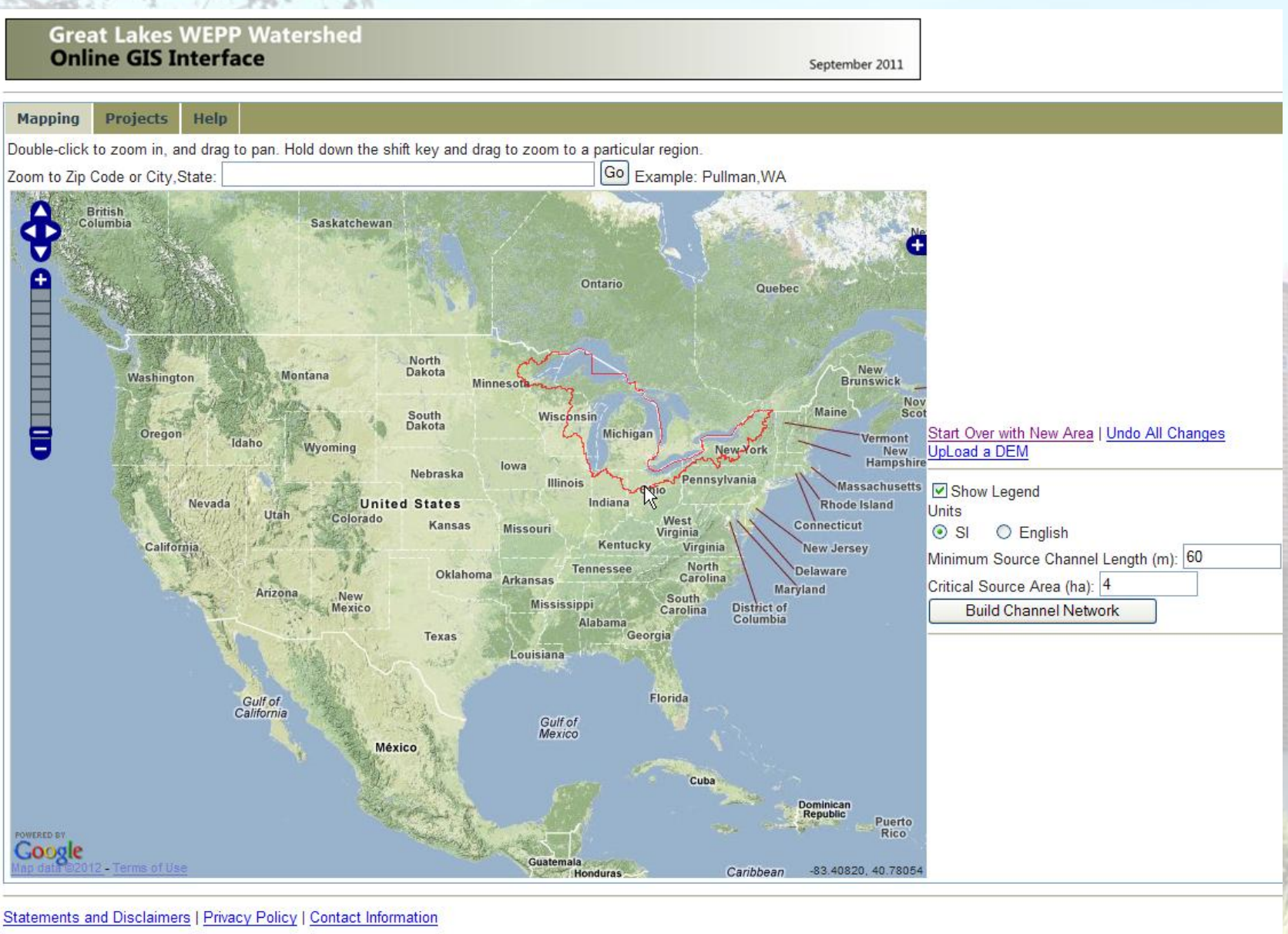
NSERL studies on ephemeral gully formation and erosion, as affected by subsurface hydrology, etc.

Model Development (cont.)

Enhancement/expansion of WEPP interfaces & databases

- Development of new default cropping/management example inputs
  - Minimum of 20 new sets per state
  - Examples contain most common crops, tillage operations, and management practices/dates as identified by NRCS agronomists
  - New WEPP sets are compared to similar RUSLE2 ones, and modified for conformity
- Development of internet-based GIS interfaces
  - Web-based hillslope and watershed interfaces
  - Web-based GIS watershed interfaces
    - Prototype on NSERL website
    - Targeted project for Great Lakes Forested watersheds (USACE)
    - Other potential projects (Lake Tahoe, Iowa Project, etc.)

WEPP watershed online GIS interfaces



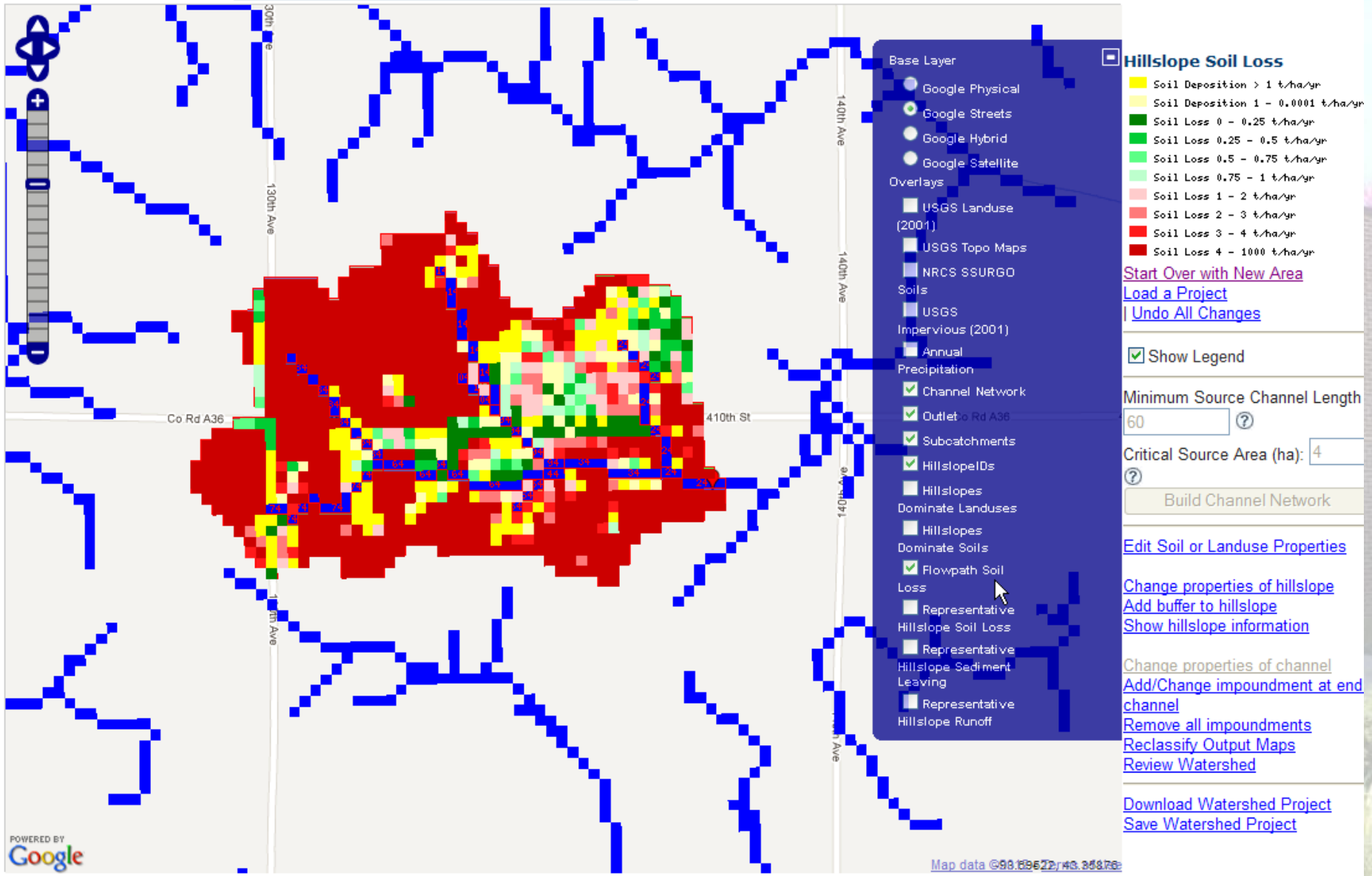
WEPP Watershed
Online GIS Interface

September 2011

Mapping | Projects | Help

Double-click to zoom in, and drag to pan. Hold down the shift key and drag to zoom to a particular region.

Zoom to Zip Code or City,State: Go Example: Pullman,WA



Start Over with New Area
Load a Project
| Undo All Changes

Show Legend

Minimum Source Channel Length
60

Critical Source Area (ha): 4

Build Channel Network

Edit Soil or Landuse Properties

Change properties of hillslope
Add buffer to hillslope
Show hillslope information

Change properties of channel
Add/Change impoundment at end channel
Remove all impoundments
Reclassify Output Maps
Review Watershed

Download Watershed Project
Save Watershed Project

Model Development (cont.)

- Creation of new combined models using WEPP
  - WWEM – Combined WEPP and WEPS model
  - WEPP-WQ – WEPP linked with SWAT wq routines to allow estimation of nutrient & pesticide losses.
  - WEPP-CO2 - simulate impact of increasing CO_2 levels in atmosphere on plant growth, along with impacts of more frequent and more intense rainfall on runoff and soil loss.
- Use of data assimilation techniques with SWAT model – Ensemble-Kalman filter. To allow insertion of observed soil moisture data, from field measurements or through remote sensing.

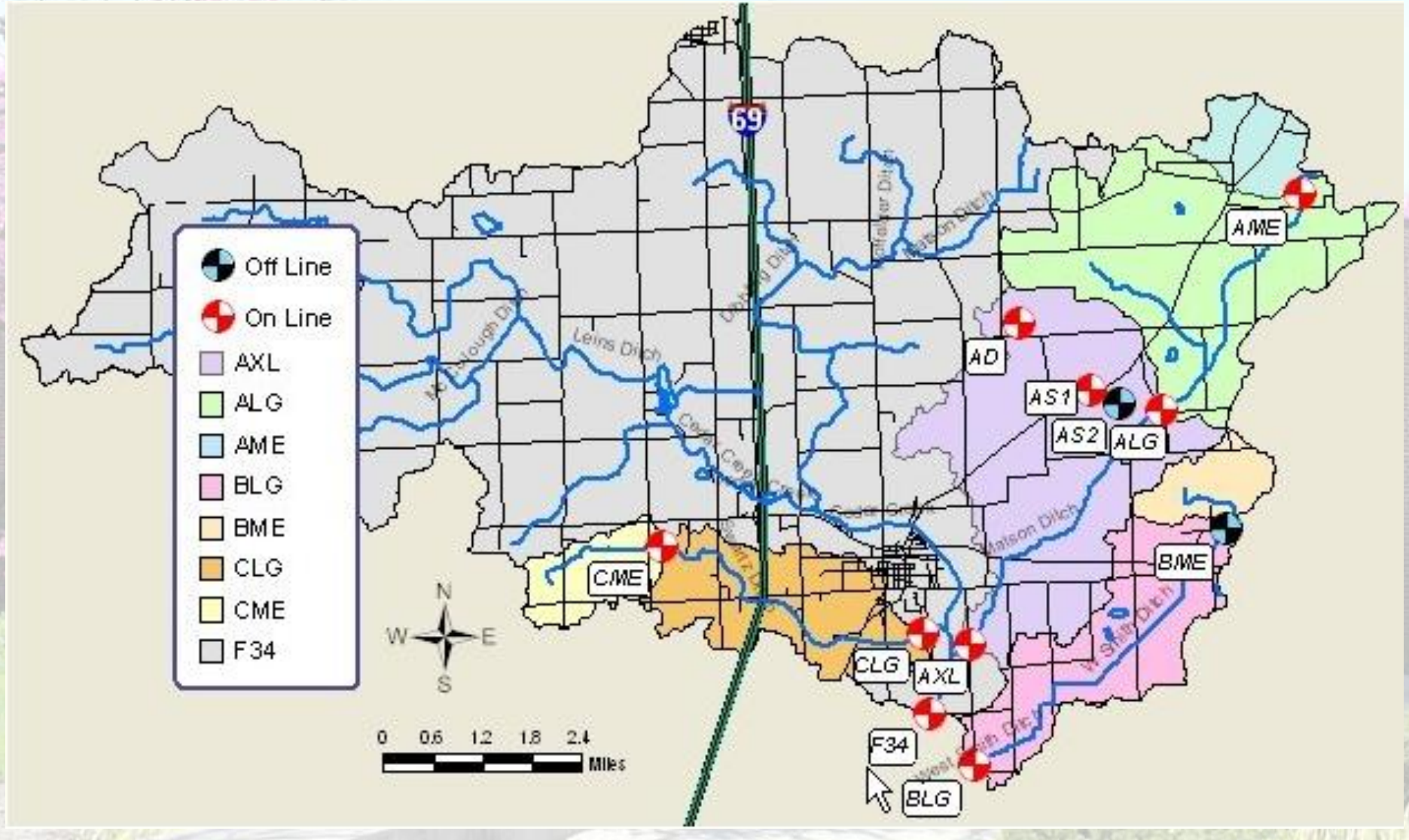
Wind and Water Erosion Model (WWEM)

- Have 2 working prototypes
  - WEPS model containing WEPP hydrology and WEPP water erosion components for single OFE hillslope simulations. Still undergoing testing and development.
  - Modular components and model within the Object Modeling System (OMS) at USDA in Ft. Collins, CO, with hydrology, water erosion, wind erosion components. Allows multiple OFE hillslope simulations, but does not contain all needed components (plant growth, etc.).
- Neither prototype allows for watershed simulations
- NRCS has not given clear direction on what they desire in WWEM, nor any staff or funding support to develop interfaces and databases.

Model Applications

- SWAT model – applied to St. Joseph River, Cedar Creek, and subwatersheds for flow, nutrient & pesticide prediction
- APEX model – applied to fields and small watersheds in the Upper Mississippi River basin.
- WEPP model applied to small field watersheds and medium-sized catchments in the Cedar Creek. Also intend to examine impacts of projected climate change.

Upper Cedar Creek and Subwatersheds with Sampling Sites



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Summary

- Long history of soil erosion prediction and modeling efforts at the NSERL
- New research project has components directly related to model development and modeling applications
- Major efforts in model development will involve testing and enhancement of WEPP
- Model applications will include use of WEPP, SWAT, and APEX models
- New research in other NSERL projects will provide additional understanding and ability to improve models' logic.

The End

Any Questions?