

Automated Geospatial Watershed Assessment (AGWA): A GIS-Based Hydrologic Modeling Tool for Watershed Assessments



Project Background & Acknowledgements

- **Long-Term Research Project**
 - EPA Landscape Ecology Branch
 - EPA Office of Water
 - 10 years
- **Interdisciplinary**
 - Watershed management
 - Landscape ecology
 - Remote sensing
 - GIS
- **Multi-Agency**
 - USDA – ARS
 - US – EPA
 - University of Arizona
 - University of Wyoming

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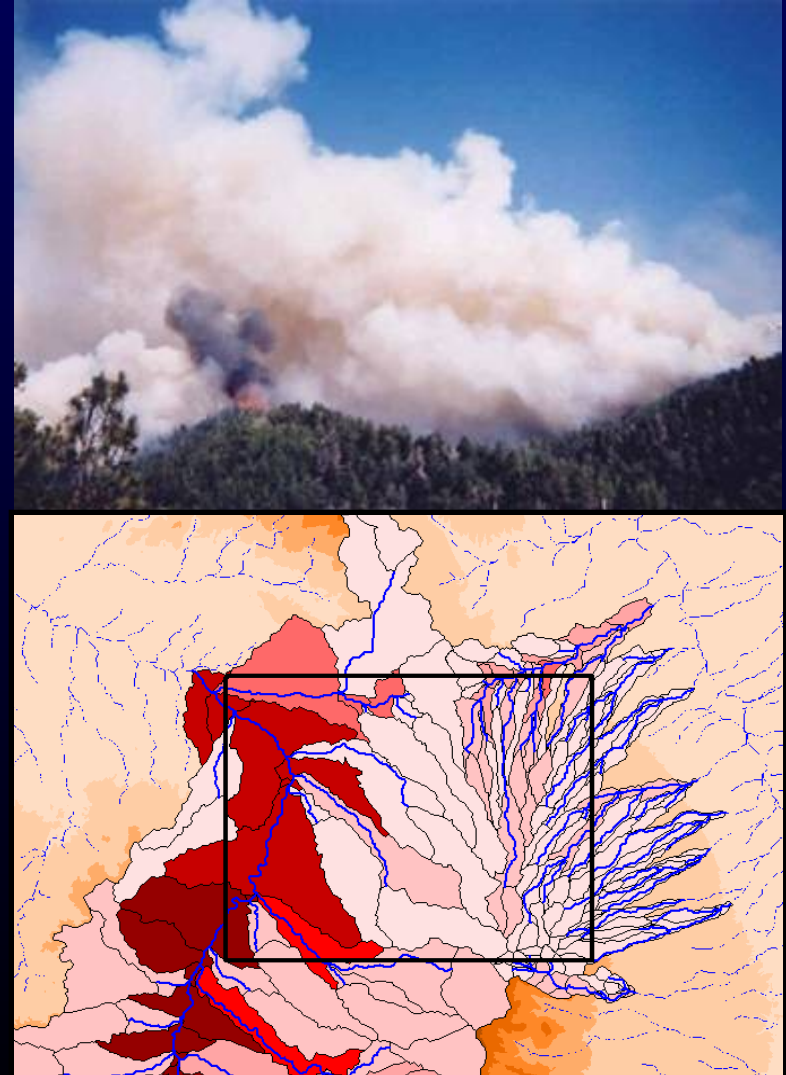
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Ginger Paige



OVERVIEW

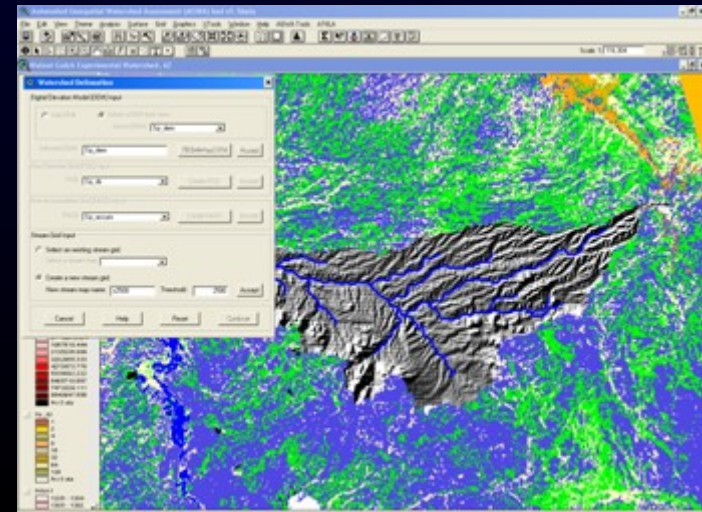


- **AGWA Background**
- **System Features with emphasis on new functionality of the just released AGWA 1.5**
- **Selected case studies**
- **Future Directions**



Objectives of the AGWA tool

- PC-based GIS tool for watershed modeling
 - Can accommodate multiple hydrological models (*modular*)
- Investigate the impacts of land cover change, and management practices, on runoff, erosion, water quality
- Targeted for use by scientists, management specialists, and engineers
 - Ease of use
 - Widely applicable

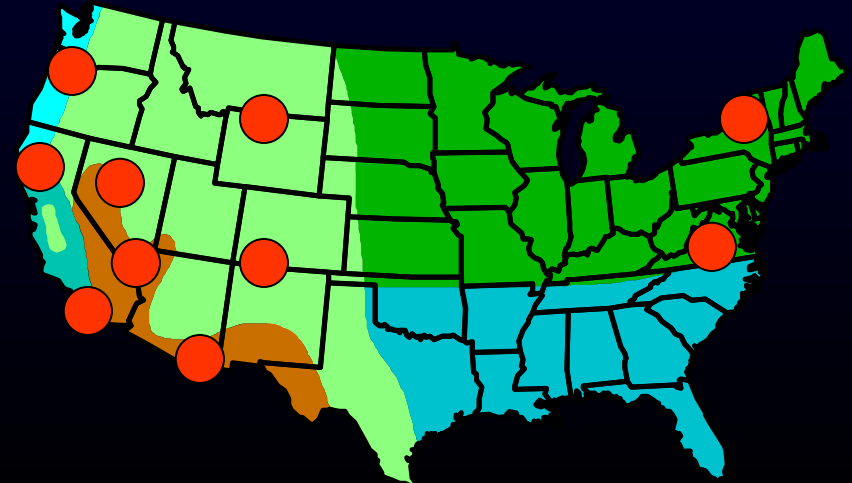


Objectives of the AGWA tool

- Simple, direct method for model parameterization
- Provide realistic, repeatable results
- Require basic, attainable GIS data
 - 30m USGS DEM (free, US coverage)
 - STATSGO, SURRGO, FAO soil data (US and global coverage)
 - US-EPA NALC, MRLC, and GAP landscape data
- Useful for scenario development, alternative futures simulation work, and watershed assessments
 - Provide relative change when validation data is insufficient

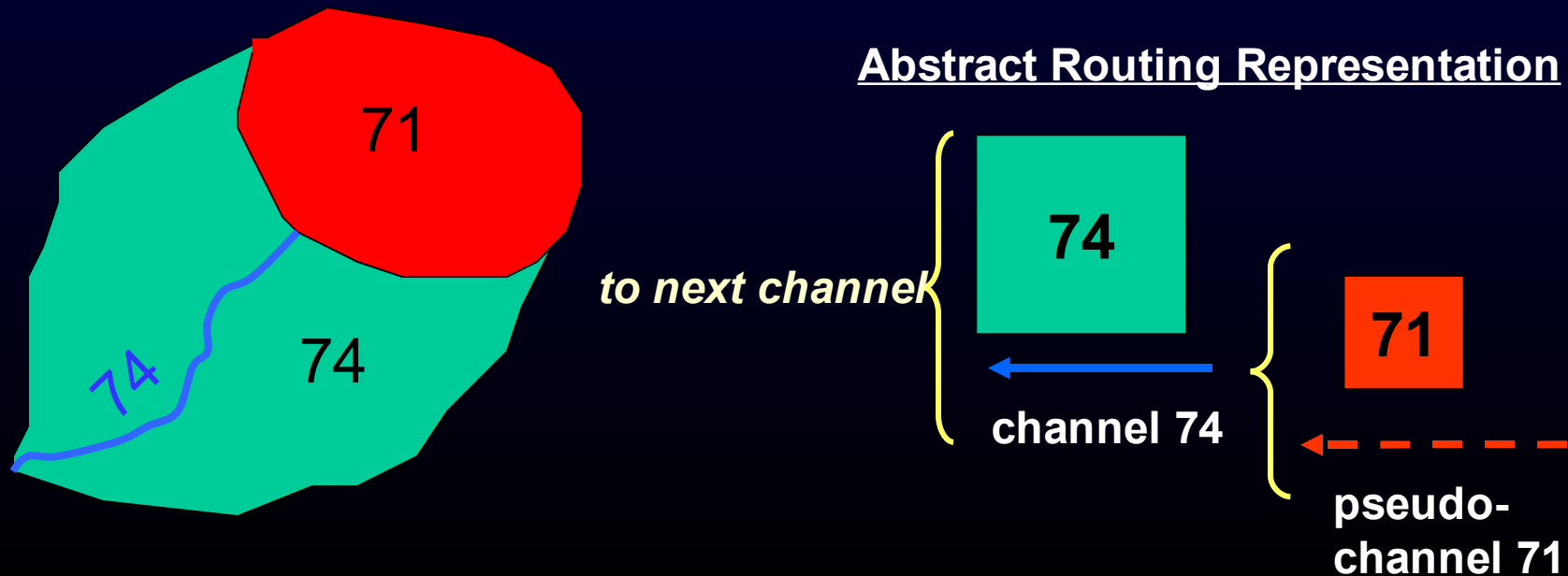
Modeling the Impacts of Land Cover Change and Best Management Practices

- Two models utilized to account for a range of space and time scales
 - KINEROS (smaller basins, events – design storms)
 - SWAT (Large basins – daily/annual)
- AGWA used for assessing flooding, water supply, and water quality
- Has been applied across a range of landscape, precipitation regimes



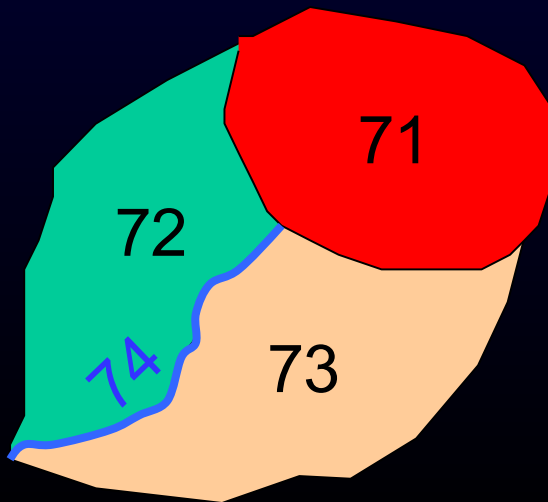
Soil Water and Assessment Tool (SWAT)

- Daily time step
- Distributed: empirical and physically-based model
- Curve-number based infiltration
- Hydrology, sediment, nutrient, and pesticide yields
- Larger watersheds ($> 1,000 \text{ km}^2$)

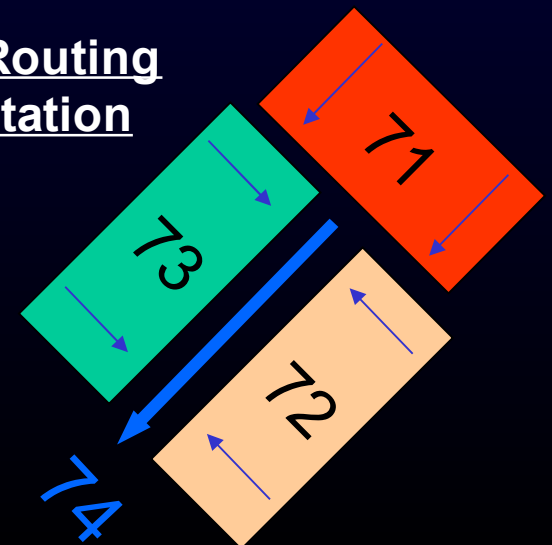


Kinematic Runoff and Erosion Model (KINEROS2)

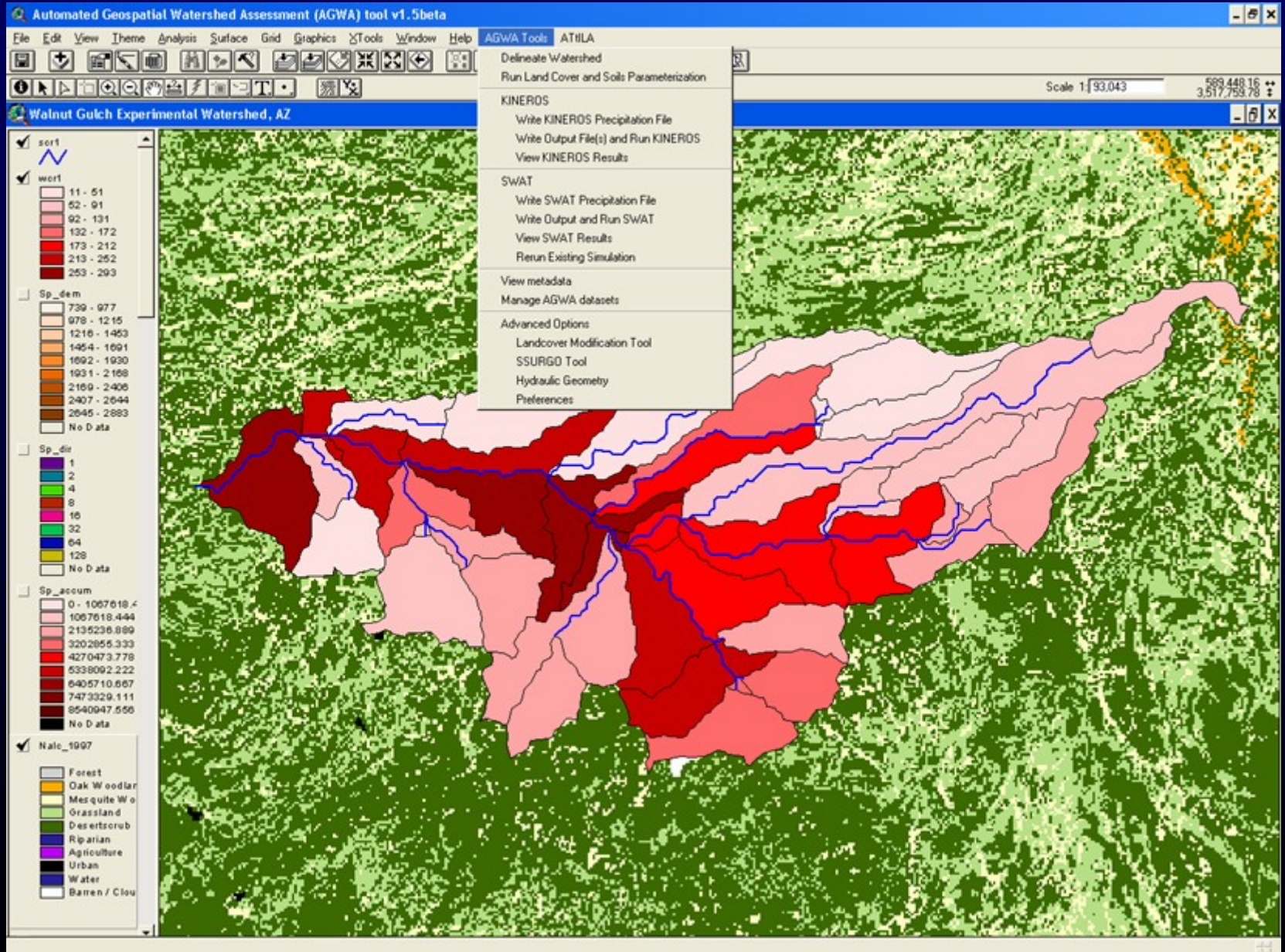
- Event-based (< minute time steps)
- Distributed: physically-based model with dynamic routing
- Hydrology, erosion, sediment transport
- Typically applied to smaller watersheds (100-200 km²)
- Enable direct tracking of BMPs / land use on downstream impacts



Abstract Routing Representation

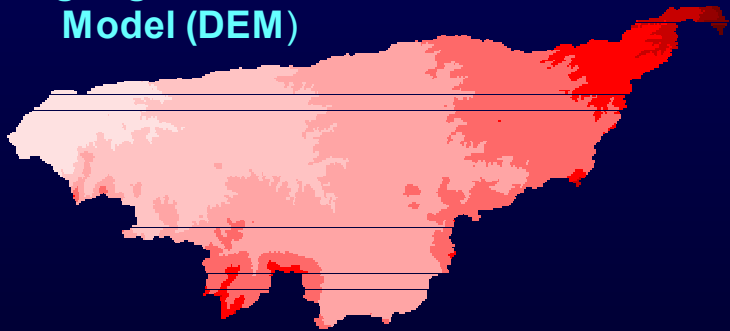


AGWA 1.5 ArcView Interface

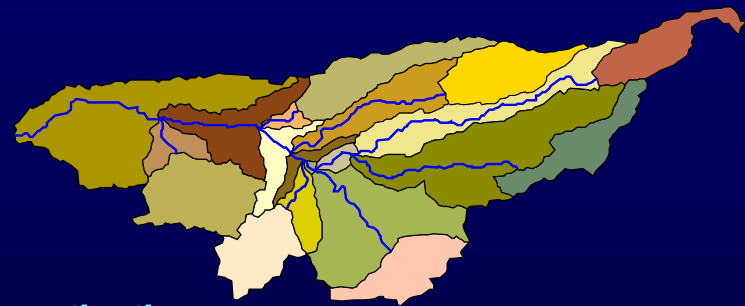


AGWA Conceptual Design: Inputs and Outputs

Watershed Delineation
using Digital Elevation
Model (DEM)



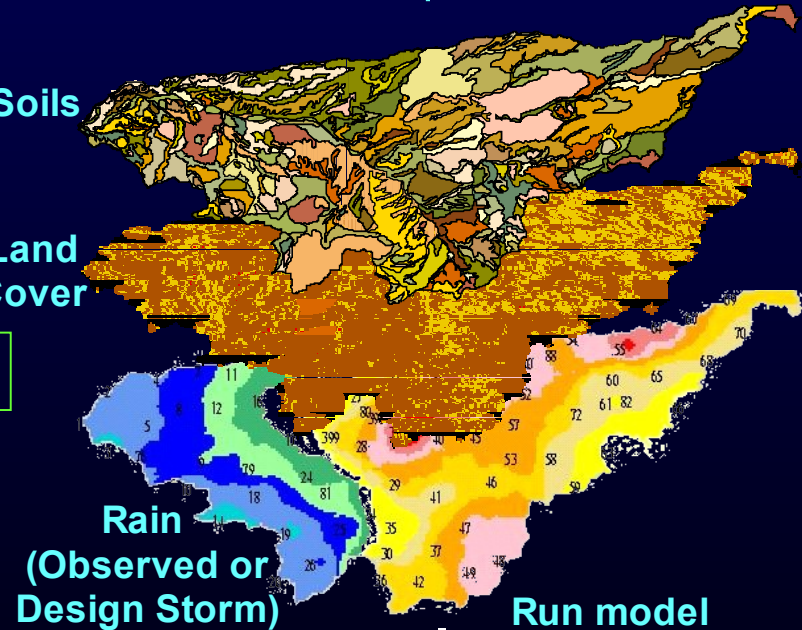
Watershed Discretization
(model elements)



Intersect model
elements with

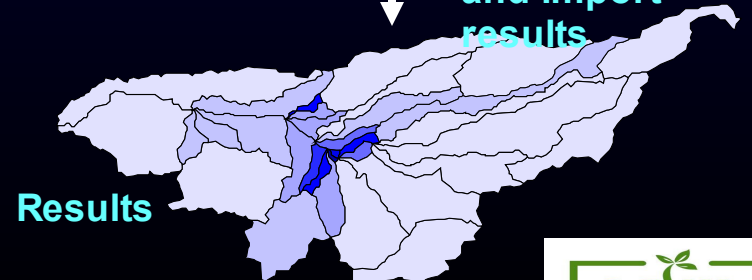
Soils

Land
Cover



Rain
(Observed or
Design Storm)

Run model
and import
results



Output results that can be displayed in AGWA

KINEROS Outputs

Channel Infiltration (m³/km)

Plane Infiltration (mm)

Runoff (mm or m³)

Sediment yield (kg)

Peak flow (m³/s or mm/hr)

Channel Scour (mm)

Sediment discharge (kg/s)

SWAT Outputs

Precipitation (mm)

ET (mm)

Percolation (mm)

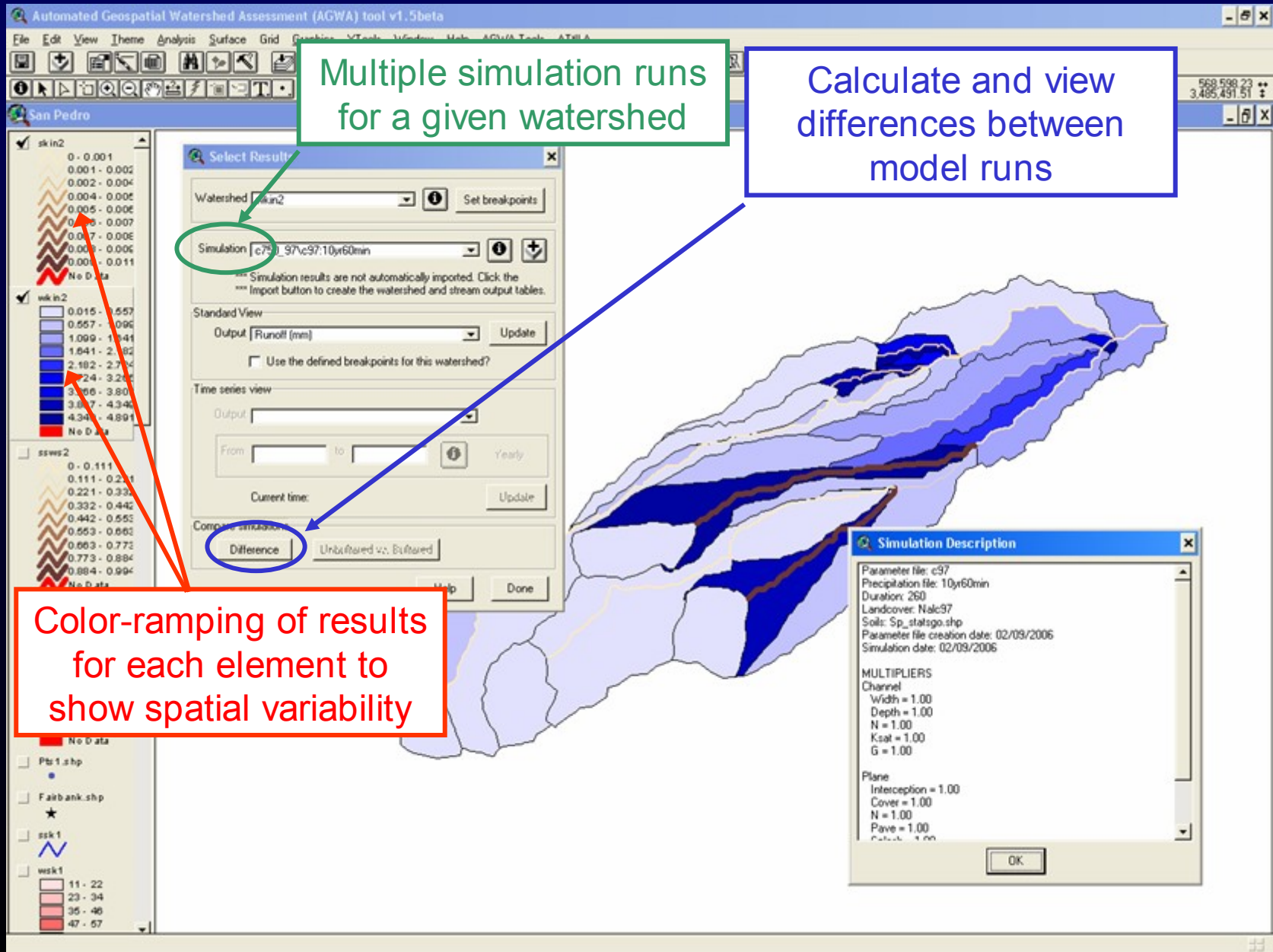
Channel Disch. (m³/day)

Transmission loss (mm)

Water yield (mm)

Sediment yield (t/ha)

Visualization of Results



The screenshot displays the AGWA tool interface with several key components:

- Left Panel:** A legend for simulation results, showing color-coded ranges for variables like 'sk in2', 'wk in2', and 'ssws2'. The 'sk in2' legend uses a red-to-white gradient, while 'wk in2' uses a blue-to-white gradient.
- Center Panel:** A 'Select Results' dialog box. It includes a 'Watershed' dropdown set to 'sk in2', a 'Simulation' dropdown set to 'c97_97\c97:10yr60min', and an 'Output' dropdown set to 'Runoff (mm)'. The 'Difference' radio button is selected under the 'Compare simulation' section.
- Right Panel:** A 'Simulation Description' dialog box showing parameters such as 'Parameter file: c97', 'Precipitation file: 10yr60min', 'Duration: 260', and 'Simulation date: 02/09/2006'. It also lists 'MULTIPLIERS' for Channel, Plane, and other factors.
- Main Map:** A map of a watershed area with a color ramp overlay representing simulation results. The colors range from light blue to dark blue, indicating spatial variability in runoff.

Annotations highlight specific features:

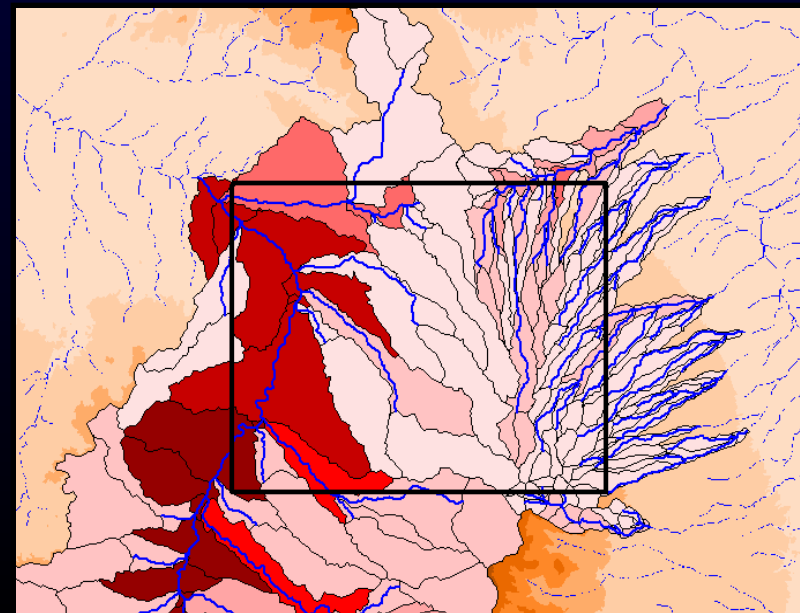
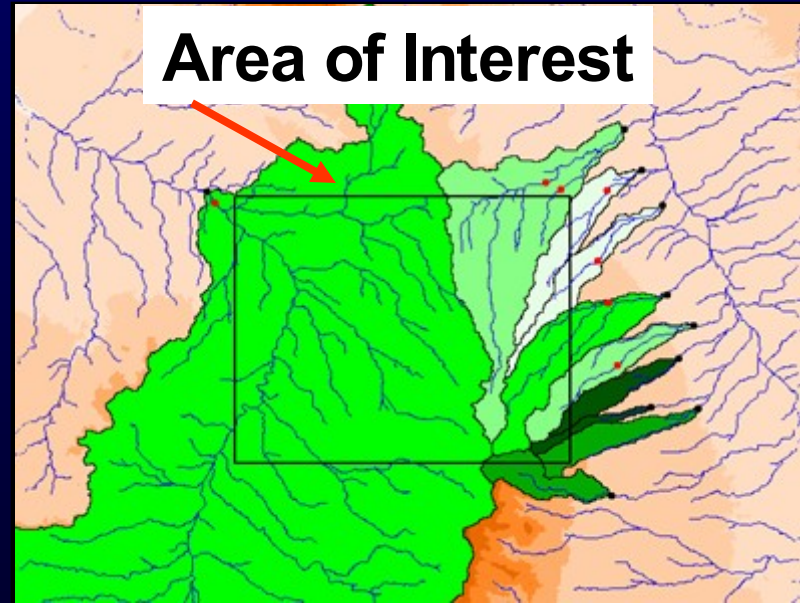
- Green box:** 'Multiple simulation runs for a given watershed' points to the 'Simulation' dropdown in the 'Select Results' dialog.
- Blue box:** 'Calculate and view differences between model runs' points to the 'Difference' radio button in the 'Compare simulation' section.
- Red box:** 'Color-ramping of results for each element to show spatial variability' points to the legend on the left side of the interface.

***New Tools to be released in:
AGWA 1.5 (ArcView) - Current
AGWA 2.0 (ARCGIS and BASINS 4.0); and,
DotAGWA (Internet) - 2007***

- **“Area of Interest” simultaneous multiple watershed analysis**
- **Multiple internal gauges**
- **KINEROS stream buffer strip tool**
- **2 new land-cover modification options**
- **Hydrologic Response Unit definition and Nutrient modeling for SWAT**
- **Post-fire watershed assessment**

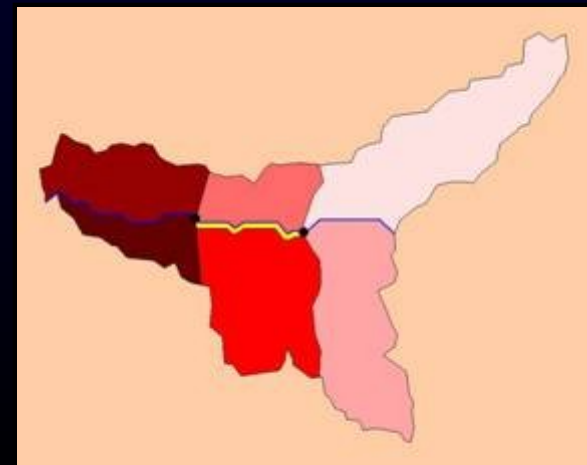
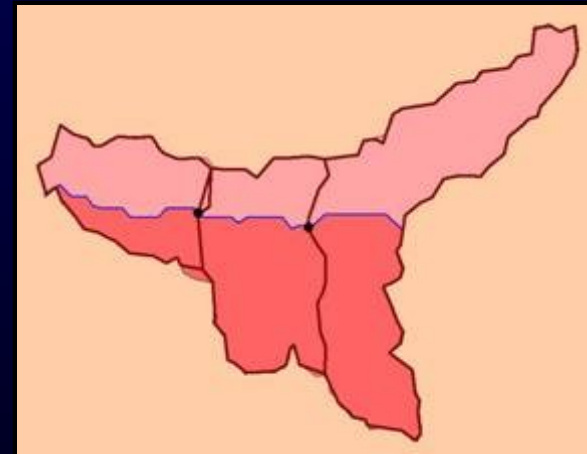
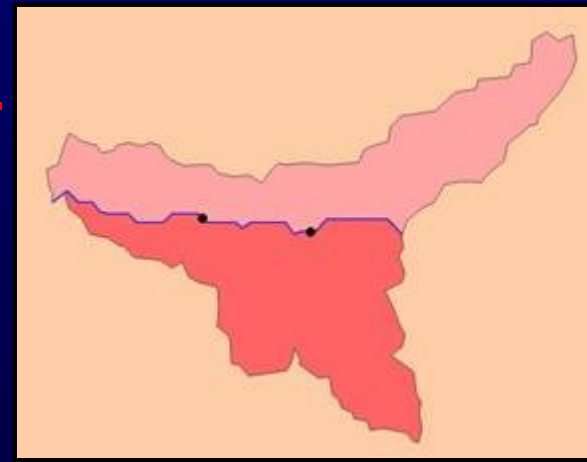
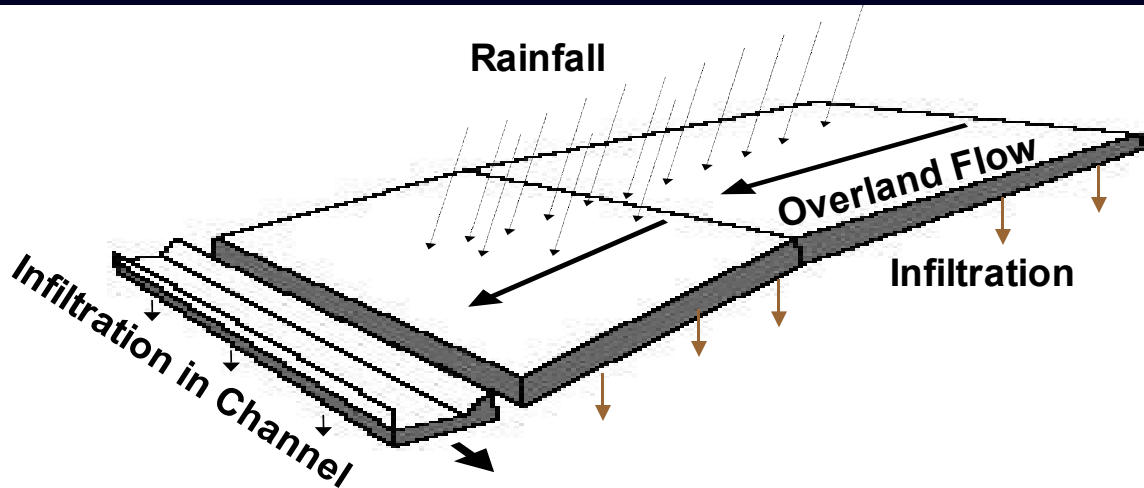
Area of Interest Multiple Watershed Analysis

- Interactively locates multiple watershed outlets
- Outlet ID uses the stream network & boundary polygons
 - Attempts to cover the area with the fewest, and smallest, watersheds necessary
- Discretized watersheds form a watershed group that is parameterized and simulated as one unit



KINEROS Stream Buffer Tool

- User-defined geometry (length and width) for each buffer on the watershed
- Can be parameterized for pre- and post-treatment scenarios
 - Post-treatment scenario allows users to select a new landcover and slope for the buffer element
- Simulation models the runoff-runon process via interactive infiltration in KINEROS

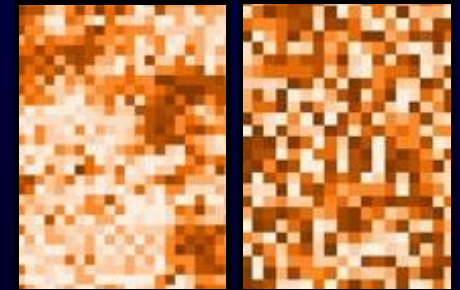
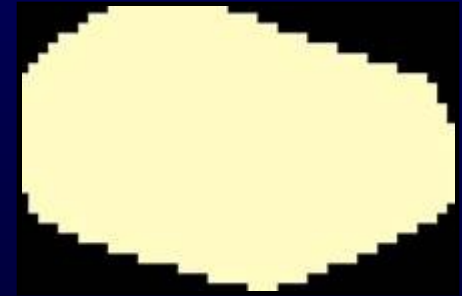


Land Cover Modification Tool

Allows users to examine the effects of different management practices on water quantity and quality at the watershed scale

Options

- **Uniform Change** – existing option: User-defined polygon change from one land cover class to another
- **For more realistic surface change a choice of two random surfaces is provided:**
 - Allows change of an area to a new landcover or landcovers
 - Randomly distributed landcover patches - Two-dimensional midpoint displacement multifractal surface
 - Completely spatially random surface



HRUs and Nutrient Modeling (SWAT)

- Characterizes **HRUs** in a subwatershed based on unique land cover attributes.
 - Users can define land cover and land use parameters for any land cover classification.
- **Nutrient modeling** provides estimates for nitrogen and phosphorus loading from subwatershed elements and in the channels
- Requires no additional inputs
- Management scenarios can be simulated by changing the default land cover parameters

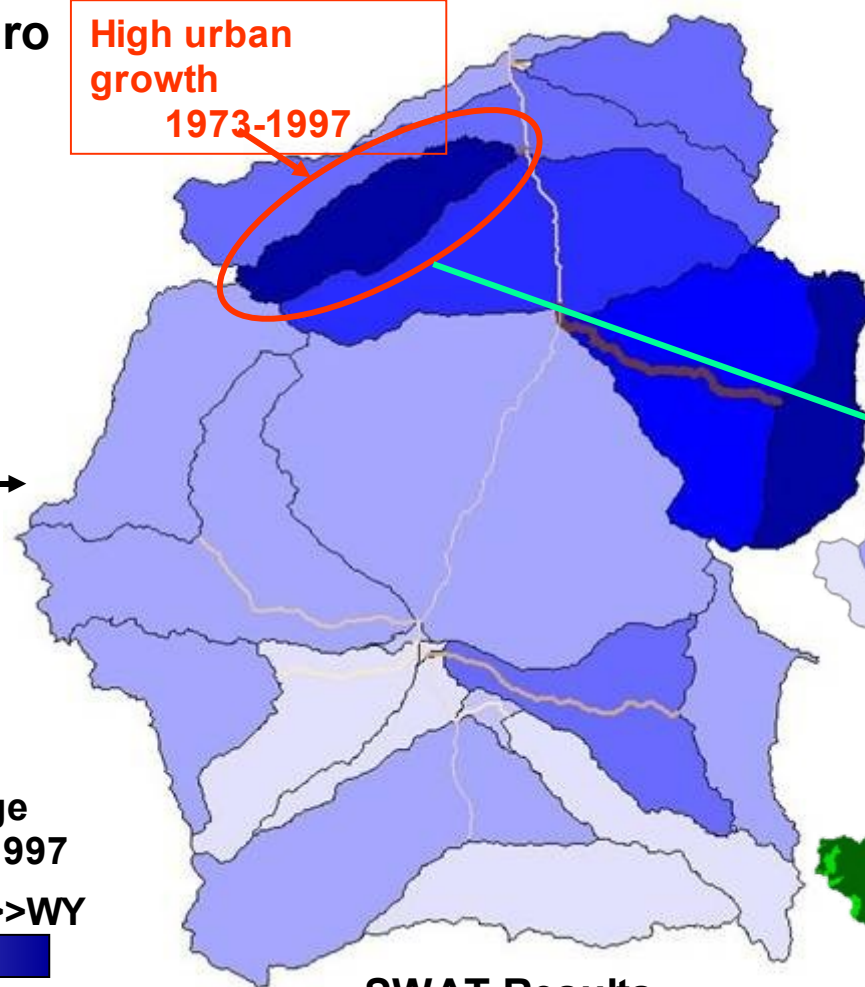
Outputs
Sediment Yield (t/ha)
Organic Nitrogen (kg)
Organic Phosphorus (kg)
Mineral Phosphorus (kg)
Nitrate/Nitrite Concentration (kg)

Urbanization – Multi-Scale Application

- Using SWAT and KINEROS for integrated watershed assessment
- Land cover change analysis and impact on hydrologic response

Upper San Pedro River Basin

High urban growth
1973-1997

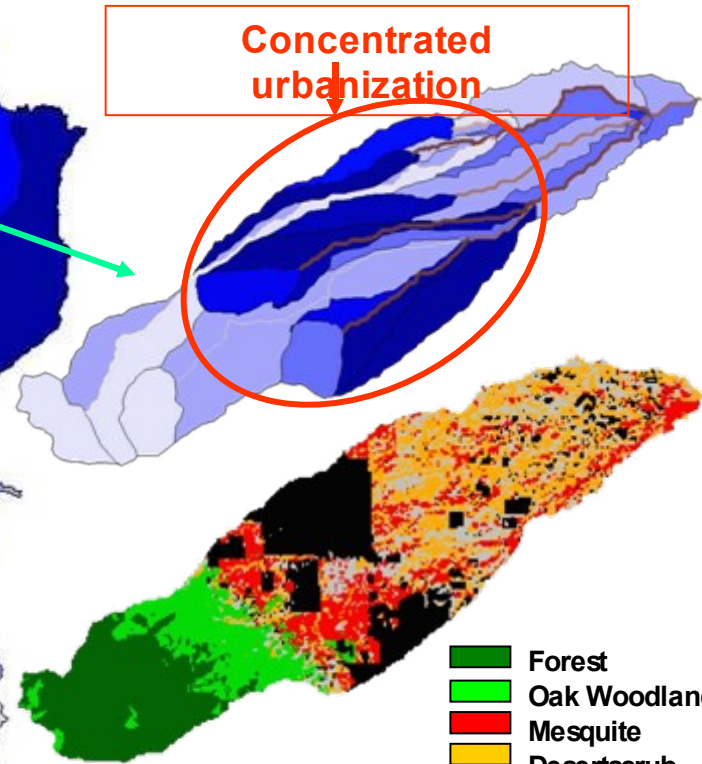


SWAT Results

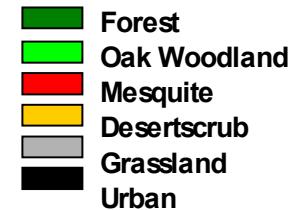
Sierra Vista Subwatershed

KINEROS Results

Concentrated urbanization



1997 Land Cover

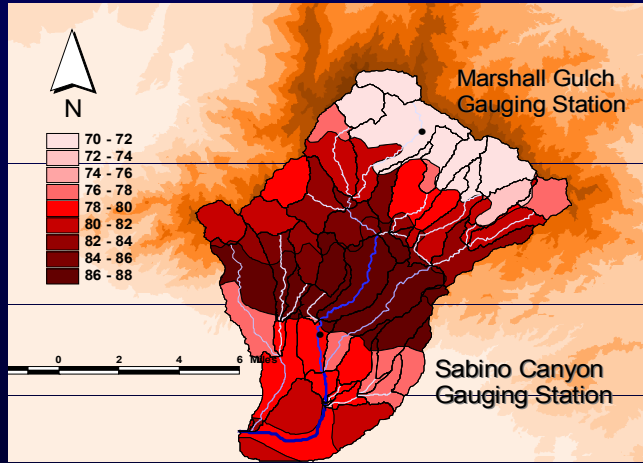


Water yield change
between 1973 and 1997

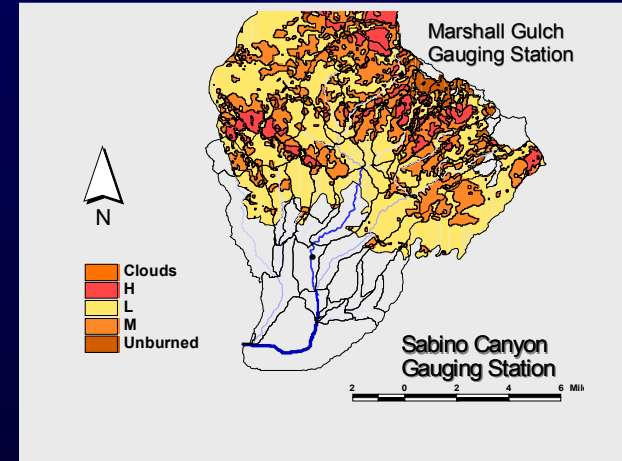


AGWA-SWAT Aspen Post-Fire Assessment

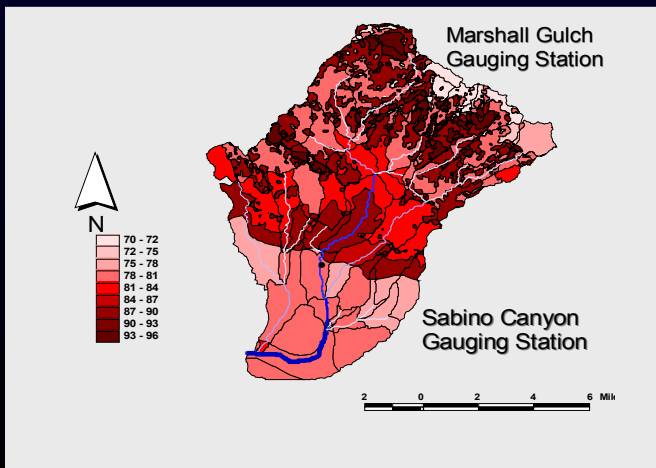
**Pre-fire Est. Curve Numbers
f(Hydro. Soils Group, Cover Type)**



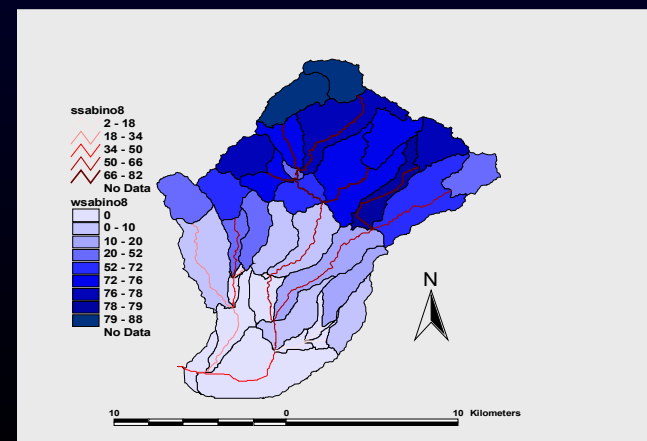
Overlay Burn Severity Map



**Post-Fire Curve Number Map
f(Hydro. Soils Group, Cover, Burn Severity)**



**Estimated Percent Change in
Water Yield in First Year
Following Aspen Fire**



Future Directions

- **1-D Dynamic geomorphic model – channel erosion / deposition**
- **Enhanced ground-water parameterization for SWAT**
- **Mult. hydraulic-geometry relations for channel characterization**
- **Incorporation of WEPP erosion relations in KINEROS**
- **KINER-OPUS Coupling underway**
 - **OPUS simulation model for transport of non-point source pollutants**
 - **Continuous, plant growth, nitrogen, phosphorus, carbon, snow, and management**
- **AGWA 2.0 (ARCGIS 9.1) incorporation into BASINS 4.0**
- **DotAGWA – Internet version - 2007**

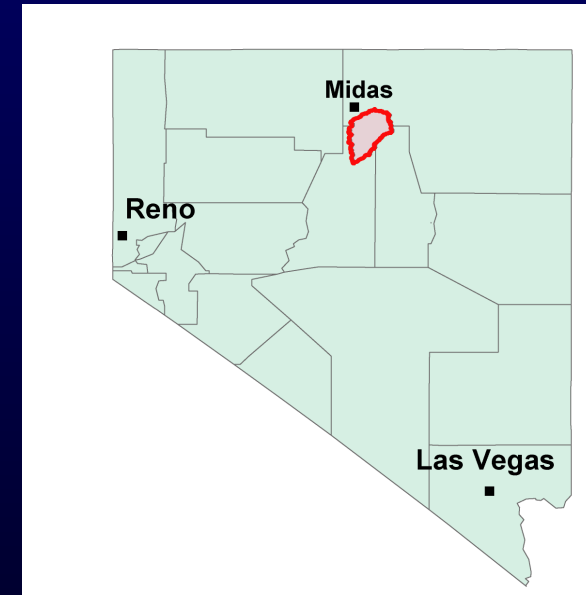
Pre- and Post-fire Watershed Assessment with SWReGAP Data

Evaluate the post – fire hydrologic response of the Hot Lakes & Buffalo wildfires (Aug. 2001) in northern Nevada using AWGA and SWReGAP land cover and additional datasets from the Nevada Data Browser

The image shows a screenshot of the Nevada Geospatial Data Browser interface. At the top right, the U.S. Environmental Protection Agency logo is visible. The browser title is "Nevada Geospatial Data Browser". Below the title, there are links for "Recent Additions", "Contact Us", and "Print Version", along with a search bar. The main content area displays a map of Nevada with a red box highlighting the Rock Creek Basin area. A red arrow points from the Rock Creek Basin area on the map to a larger, zoomed-in satellite image of the same area. The satellite image shows a landscape with a river and surrounding terrain. A red box highlights a specific area in the satellite image, with two yellow arrows pointing to features within that area. In the bottom left corner, there is a small map of Nevada with a red box highlighting the Rock Creek Basin area. The text "Rock Ck. Basin" is written below this map. The NOAA logo and "Oregon" are visible in the top left corner of the satellite image.

ACQUIRED SPATIAL DATA

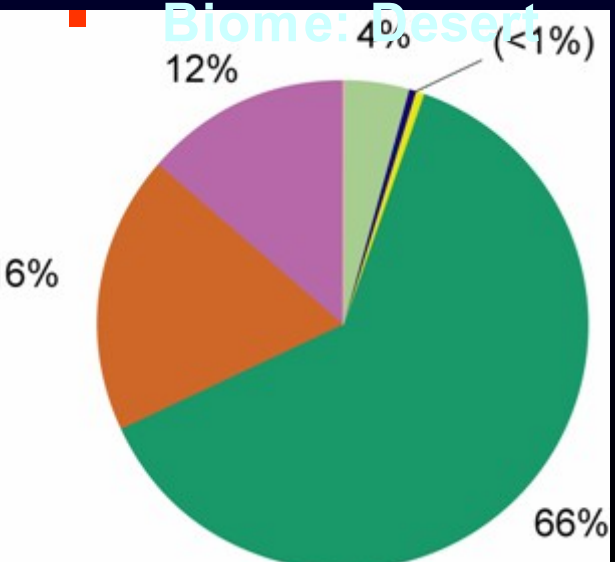
- **Fire History (1981-2002)**
- **National Elevation Dataset DEM**
- **Land Cover (GAP) 1999-2001**
- **STATSGO Soil Data**
- **Climate Data (Daily Total Precipitation)**
(NCDC, 15 gages, or PRISM derived daily Ppt on the Nevada Data Browser) 1980-2004
- **Daily Stream Flow Data (USGS 10324500 Rock CK NR Battle Mountain, NV) 1980-2004**



ROCK RIVER BASIN: LAND COVER (GAP) '99-'01

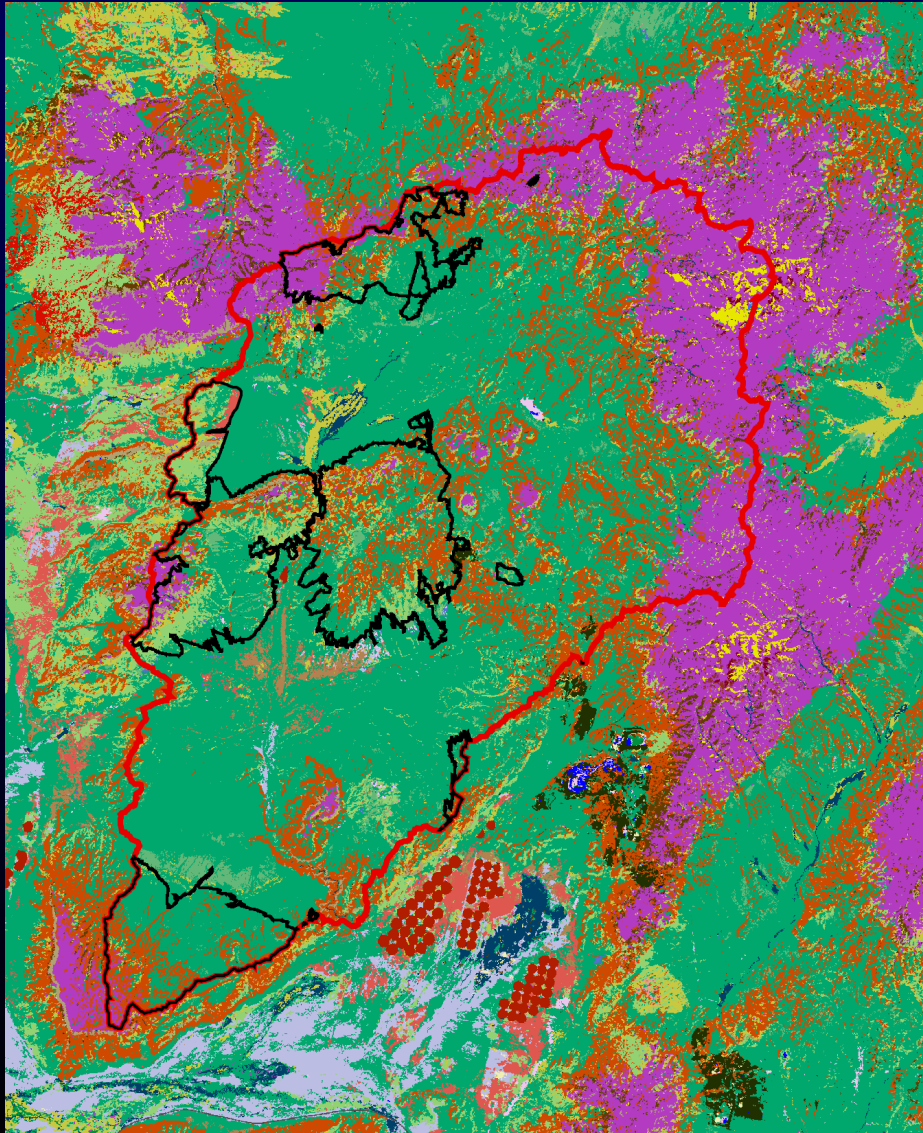


- Relief: 1863 m
- Basin Area: 2,237 km²
- Mean daily discharge: 1.10 m³/s
- Mean annual Precip.: 320 mm
- Mean air temperature: 9.4 °C



Land cover distribution

WILDFIRE BOUNDARIES



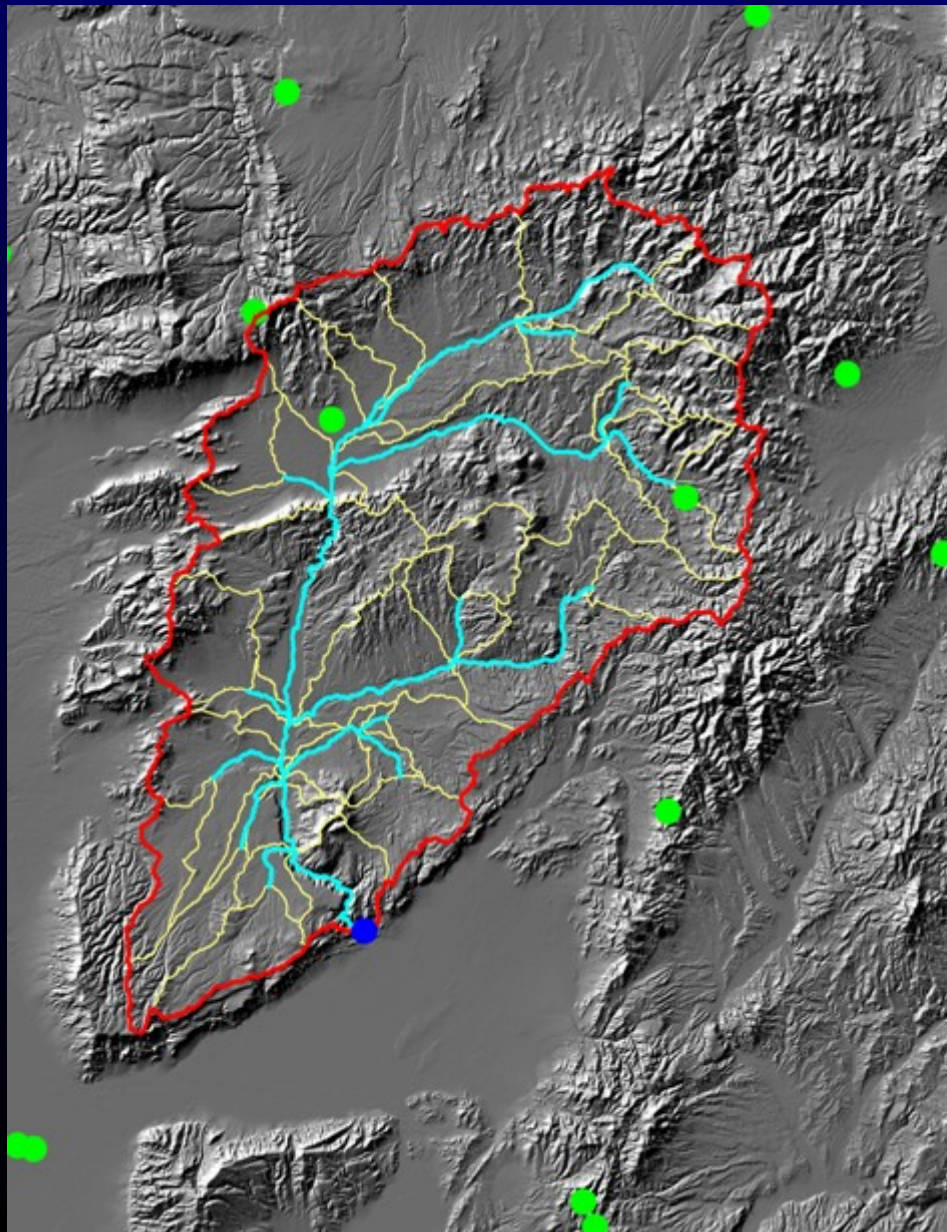
Date = Aug 14, 2001

Area = 236 km² (~10% of total drainage area)

Legend

-  Fire Area
-  Inter-Mountain Basins Big Sagebrush Shrubland
-  Inter-Mountain Basins Montane Sagebrush Steppe
-  Invasive Annual Grassland
-  Great Basin Xeric Mixed Sagebrush Shrubland
-  Invasive Annual and Biennial Forbland
-  Invasive Perennial Grassland
-  Rocky Mountain Aspen Forest and Woodland

WATERSHED DISCRETIZATION



Subwatersheds = 41
CSA = 45 km²

Legend

Elev (m.a.m.s.l.)

High : 3185

Low : 1320

● Watershed Outlet

● Raingages

— Subwatershed Boundary

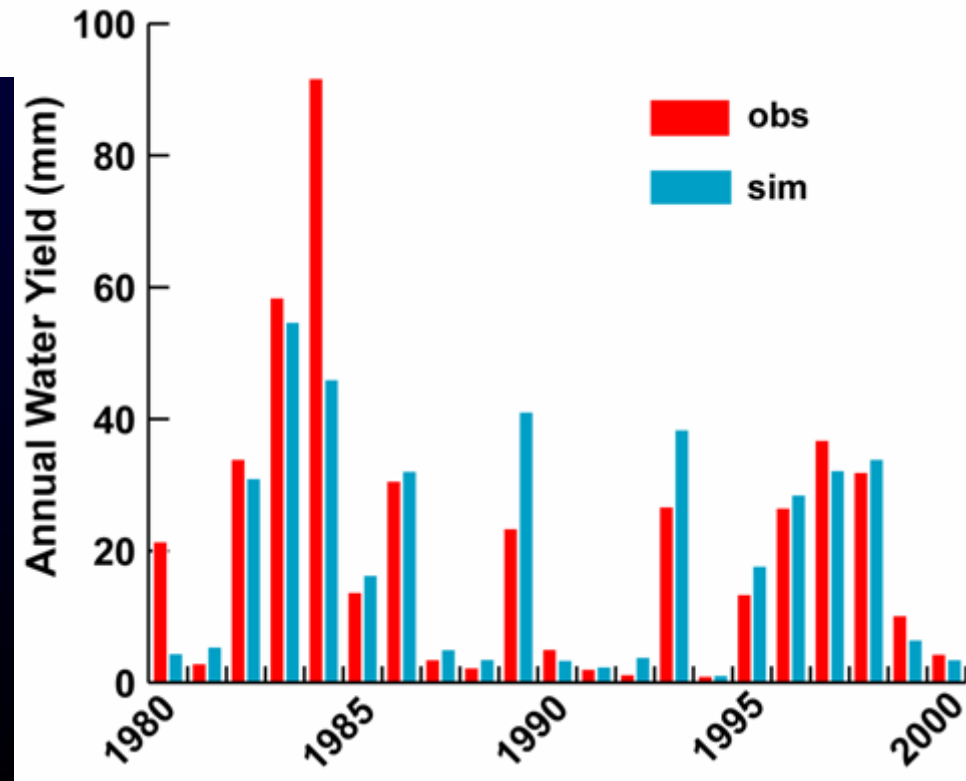
— Watershed Boundary

— Rock Creek

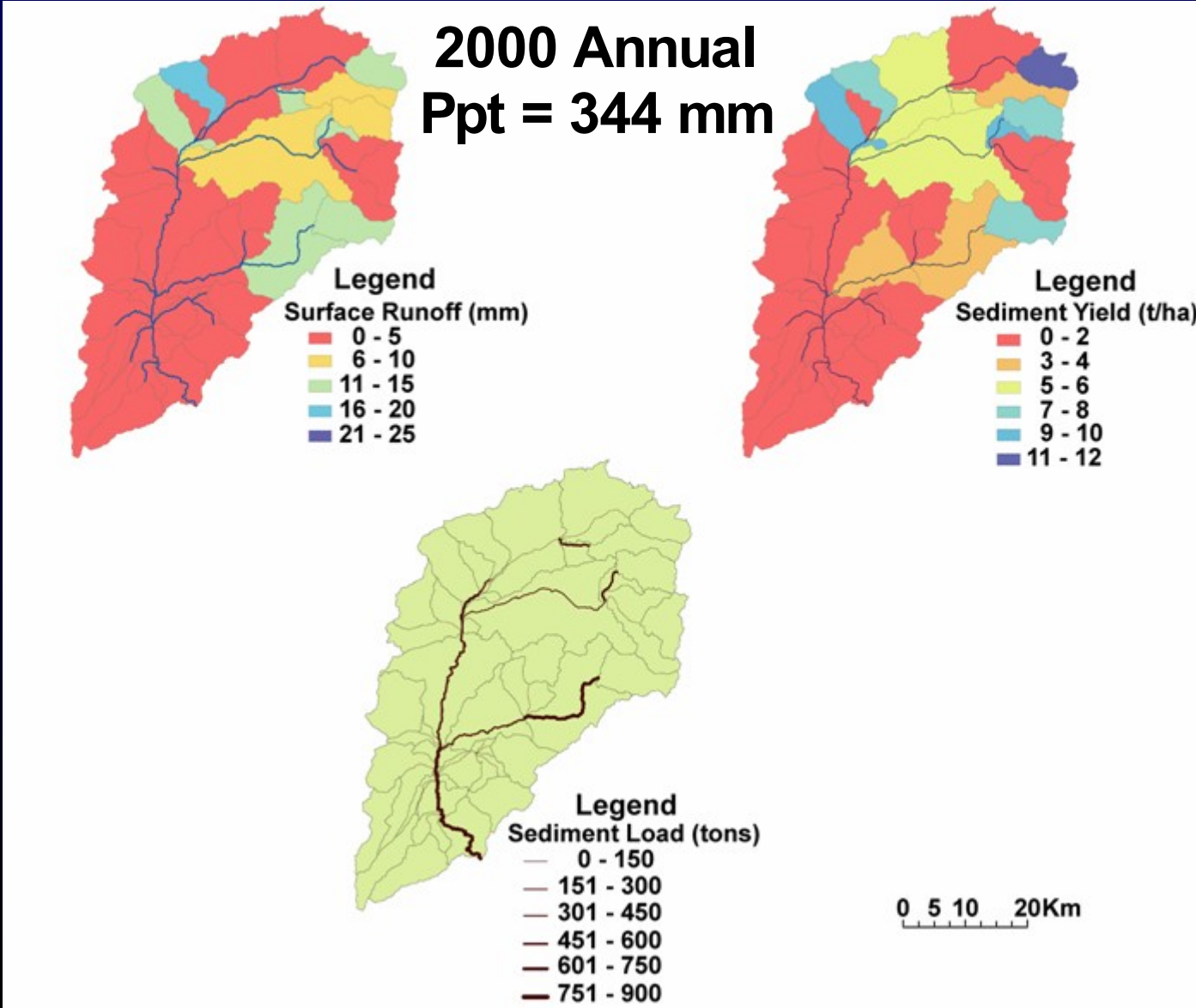
MODEL CALIBRATION RESULTS

Pre-Fire Simulation Period 1980-2000

Descriptive Statistics	Annual Water Yield		Annual Precipitation (mm)
	Obs (mm)	Sim (mm)	
Mean	21	19	347
Standard Dev.	22	17	101
Efficiency	0.70		

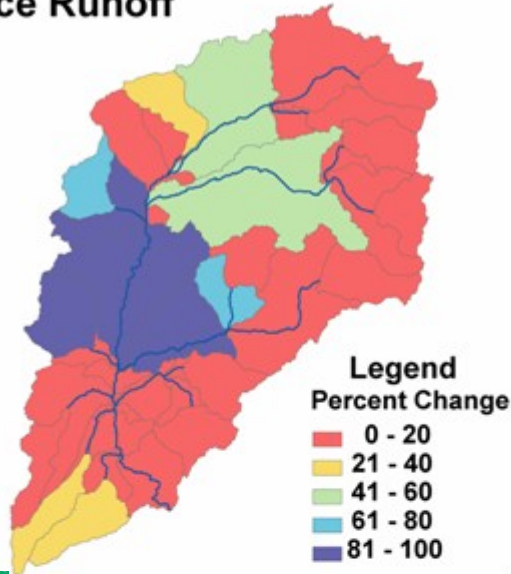


PRE-FIRE ANNUAL WATERSHED RESPONSE (Year 2000)

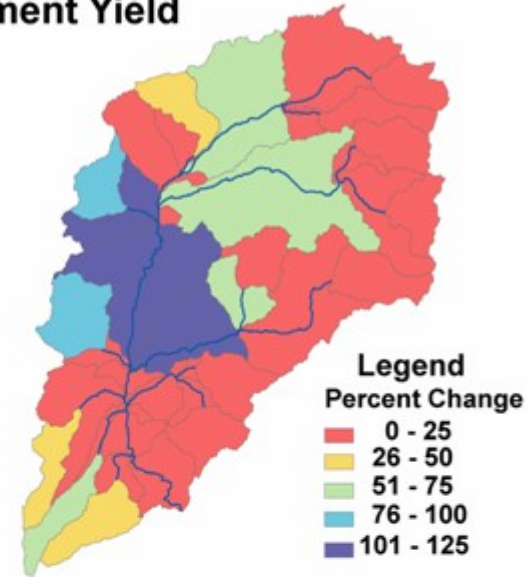


FIRST YEAR POST- FIRE WATERSHED RESPONSE PERCENT CHANGE

Surface Runoff



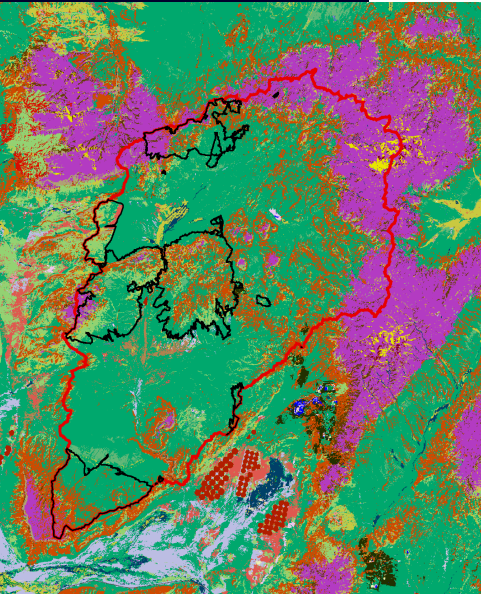
Sediment Yield



Sediment Load



WILDFIRE
BOUNDARIES



- Annual runoff volume in post-fire conditions can be up to 100% greater than pre-fire conditions
- Sediment yield / load can be up to 125% / 50% greater than pre-fire conditions, respectively

Post-Fire Assessments Conclusions

- **AGWA and GAP Land Cover data together can be used to evaluate the impact of wildfire on the hydrologic response of sagebrush shrubland-dominated rangelands**
- **Pre-fire data and simulations can be done for any given watershed at any time in a non-crisis environment**
- **Directly import post-fire burn severity map as a shape file**
- **Run model with same rainfall input as pre-fire simulation**
- **Difference post- and pre-fire simulations and spatially display results**
- **Allows rapid visual ID of watershed areas most prone to post-fire impacts so mitigation and remediation can be targeted**

