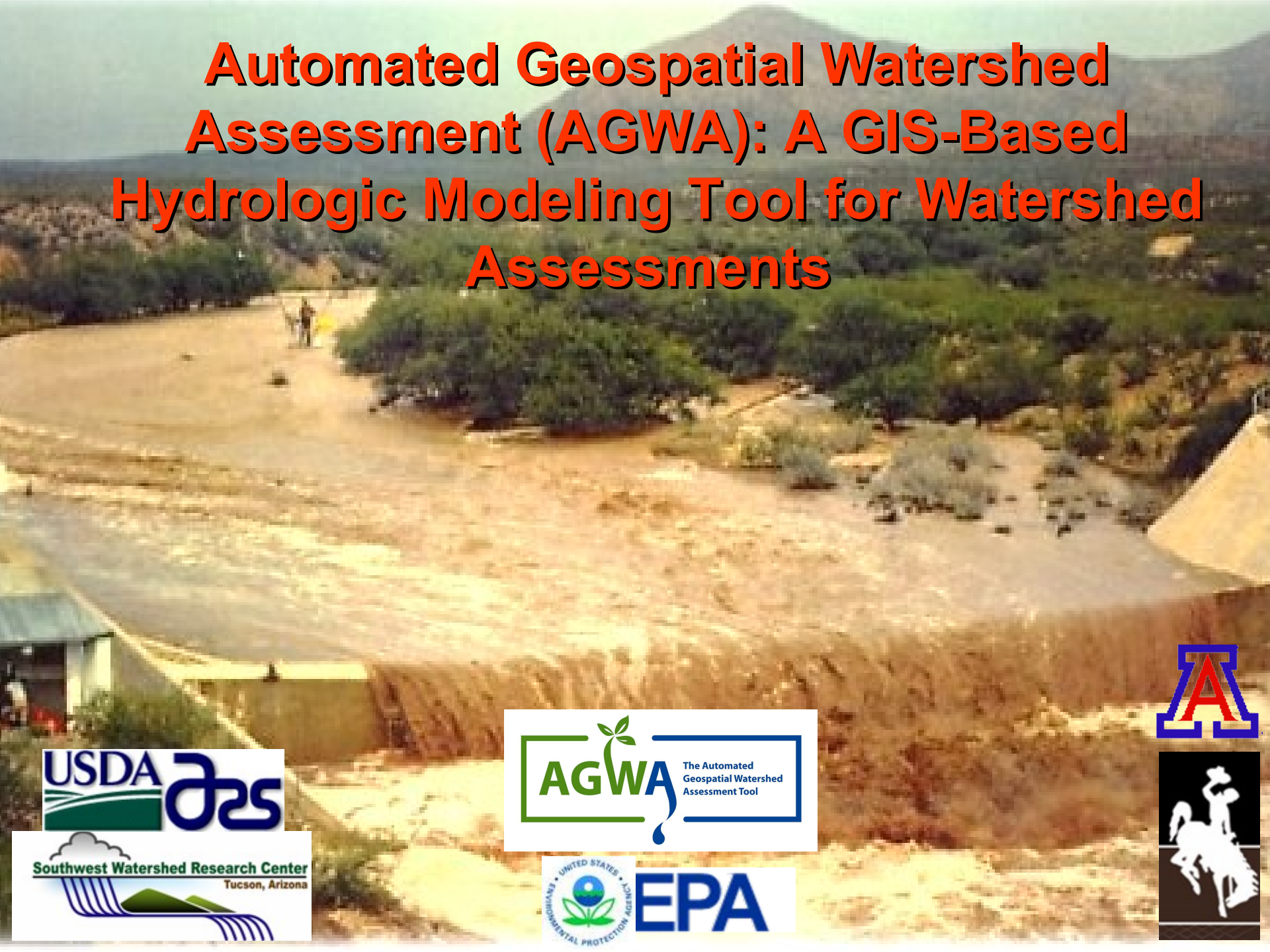
Automated Geospatial Watershed Assessment (AGWA): A GIS-Based Hydrologic Modeling Tool for Watershed Assessments



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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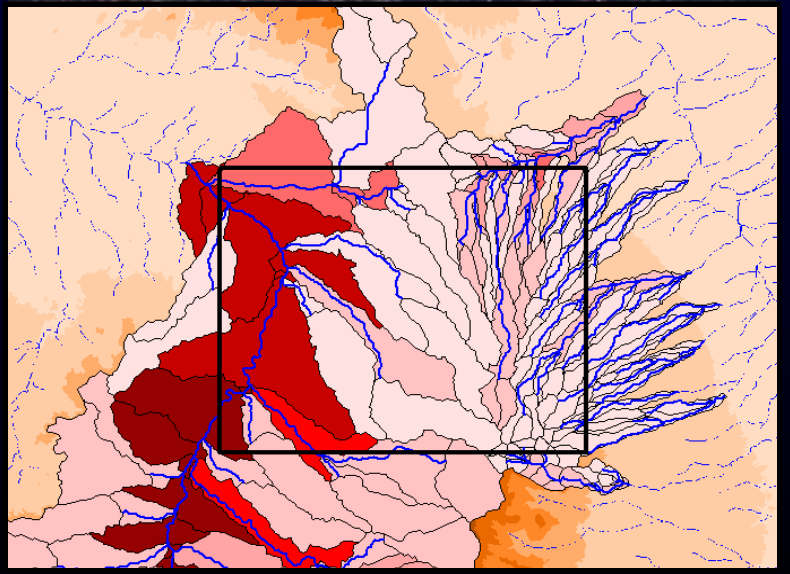
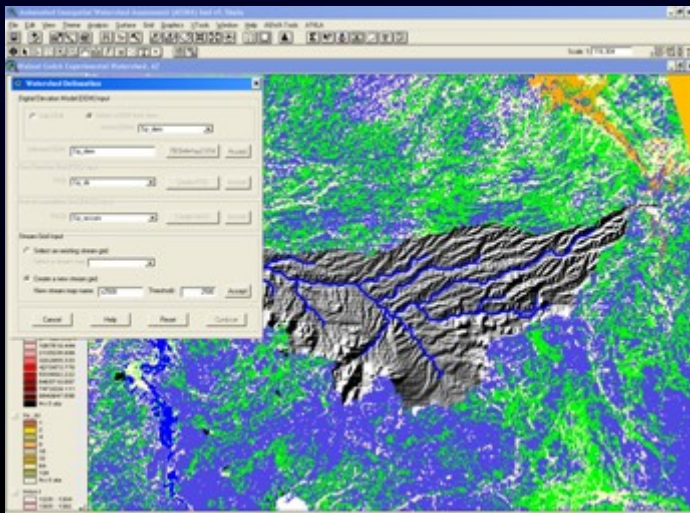
OVERVIEW

- 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**

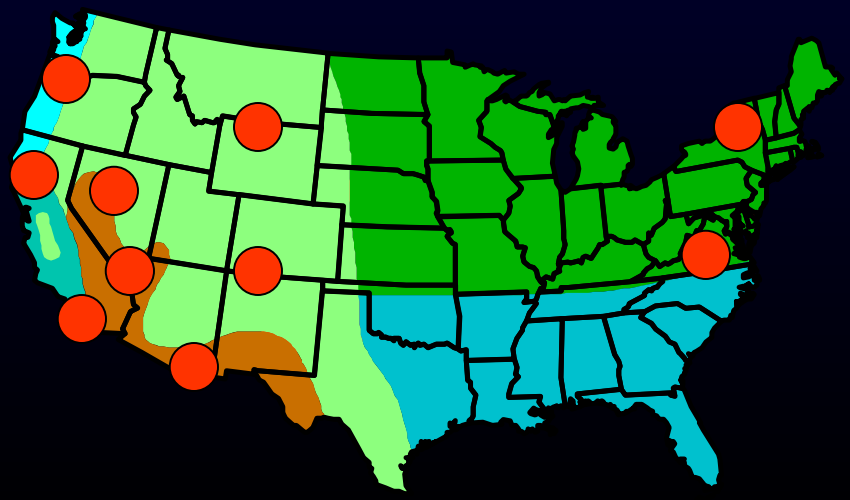


Objectives of the AGWA tool

- **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

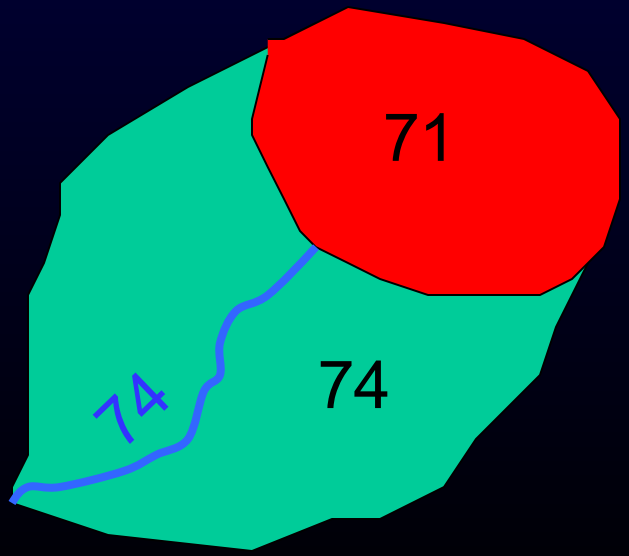
- Two models utilized to account for a range of space and time scales
  - KINEROS (smaller basins, events – design storms)
  - SWAT (Large basins – daily/annual)
- AGWA used for assessing flooding, water supply, and water quality
- Has been applied across a range of landscape, precipitation regimes

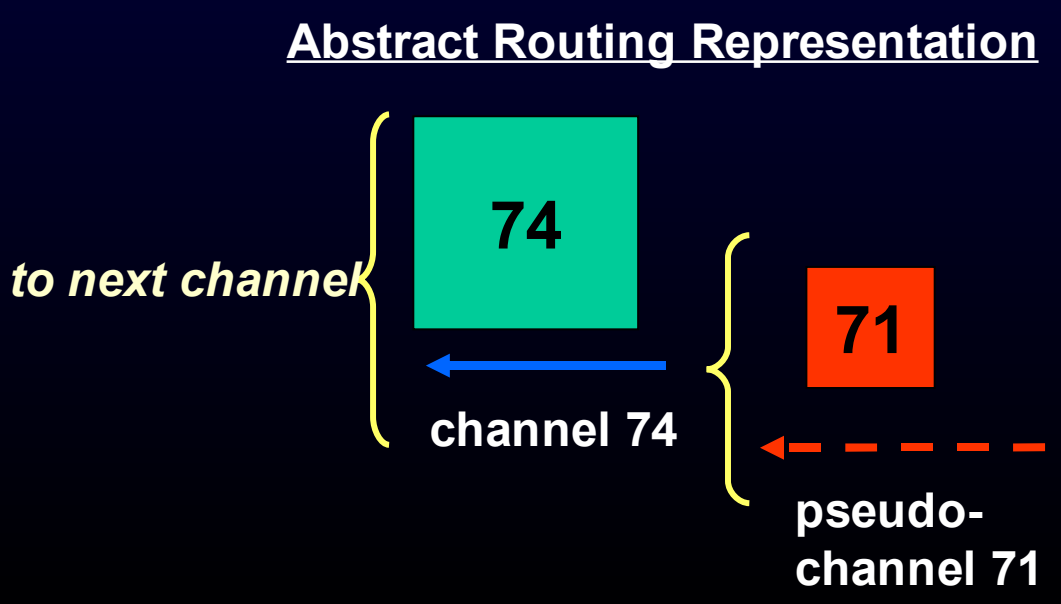


AGWA

Soil Water and Assessment Tool (SWAT)

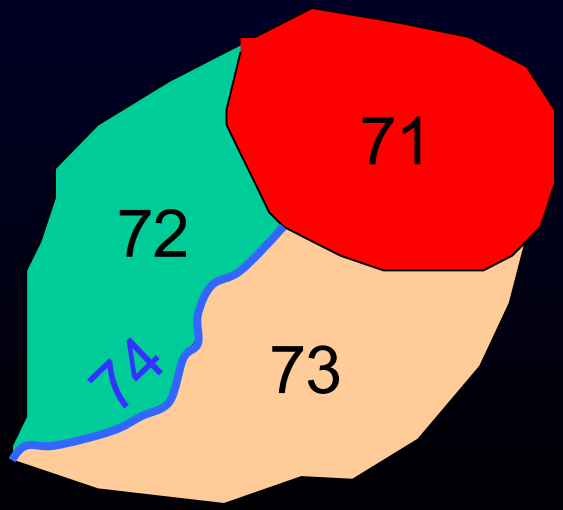
- Daily time step
- Distributed: empirical and physically-based model
- Curve-number based infiltration
- Hydrology, sediment, nutrient, and pesticide yields
- Larger watersheds (> 1,000 km^2)

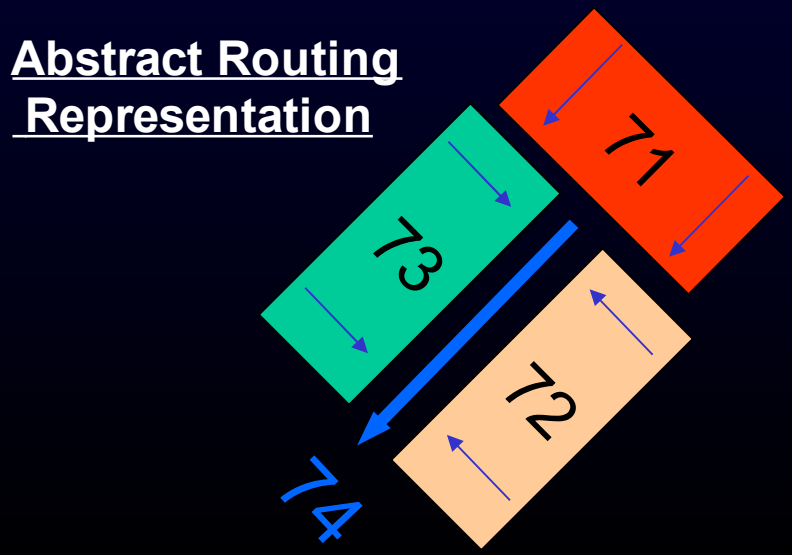




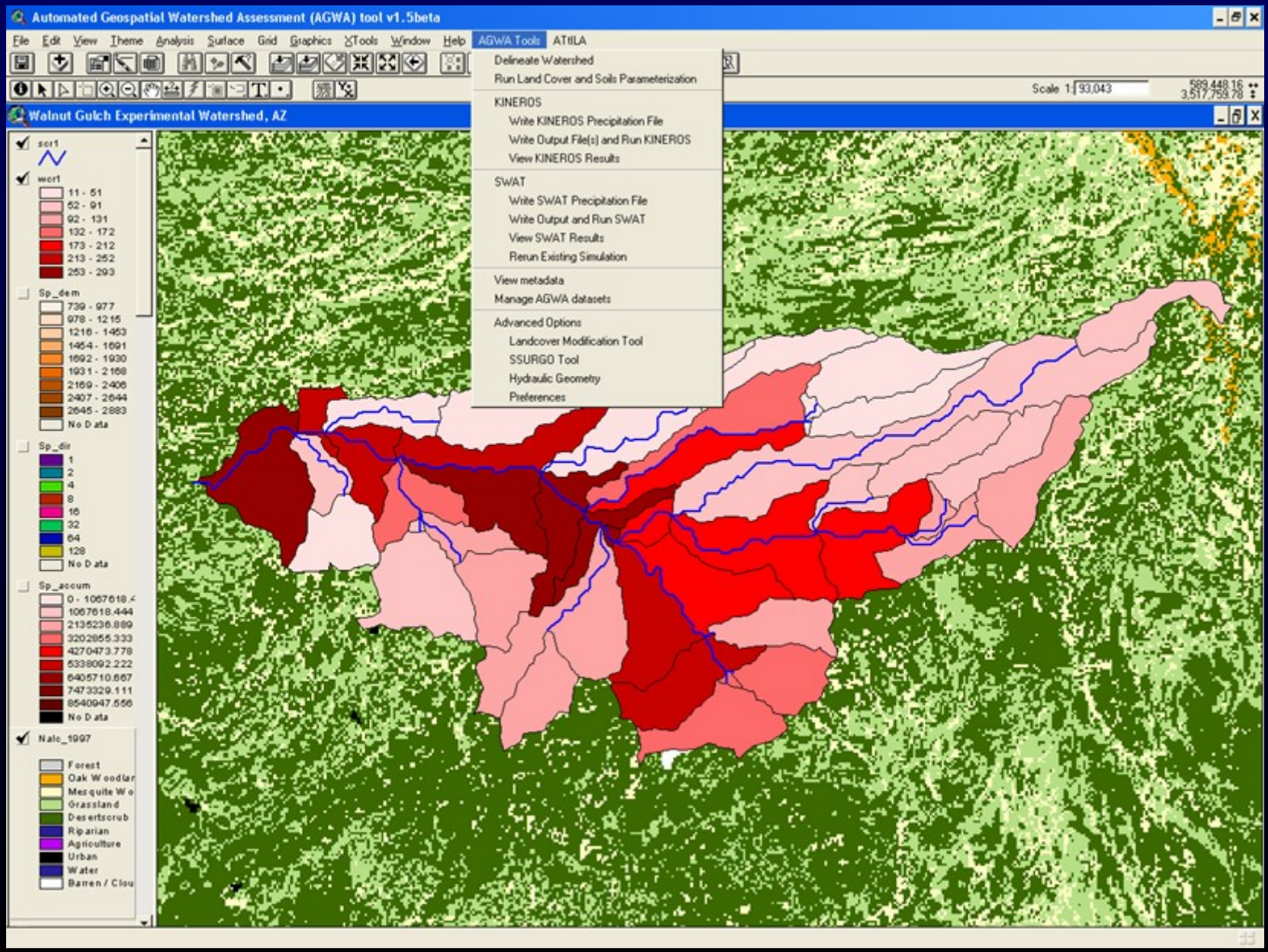
Kinematic Runoff and Erosion Model (KINEROS2)

- Event-based (< minute time steps)
- Distributed: physically-based model with dynamic routing
- Hydrology, erosion, sediment transport
- Typically applied to smaller watersheds (100-200 km^2)
- Enable direct tracking of BMPs / land use on downstream impacts

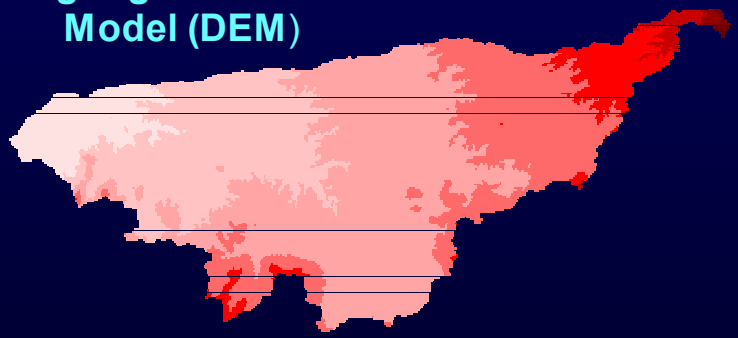




AGWA 1.5 ArcView Interface

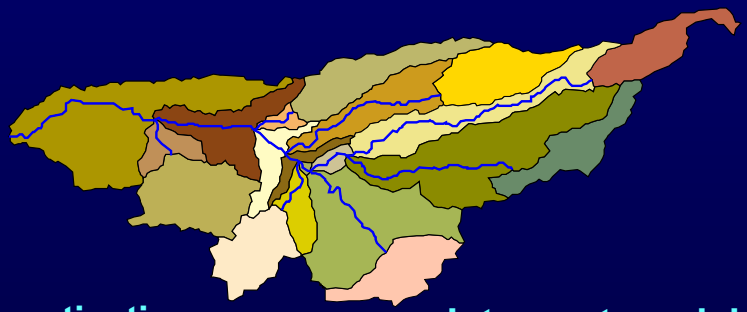


AGWA Conceptual Design: Inputs and Outputs

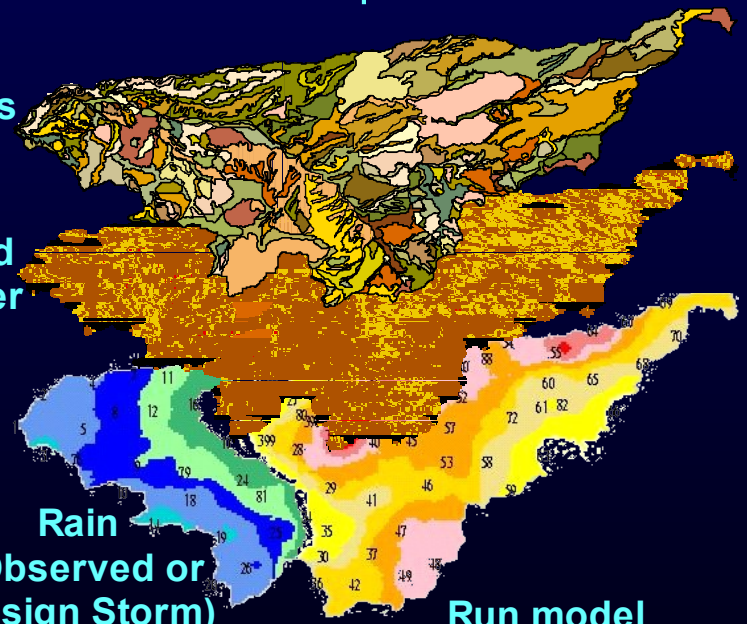


Watershed Delineation using Digital Elevation Model (DEM)

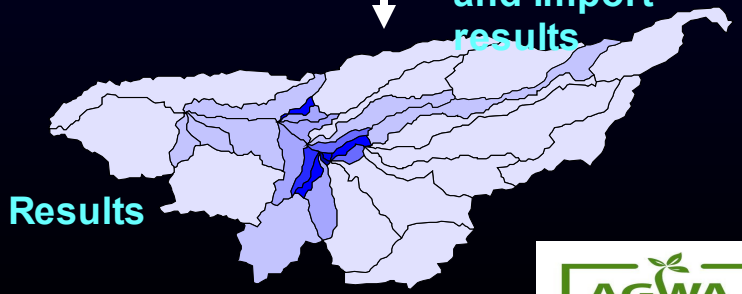
Watershed Discretization (model elements)



Intersect model elements with



Run model and import results

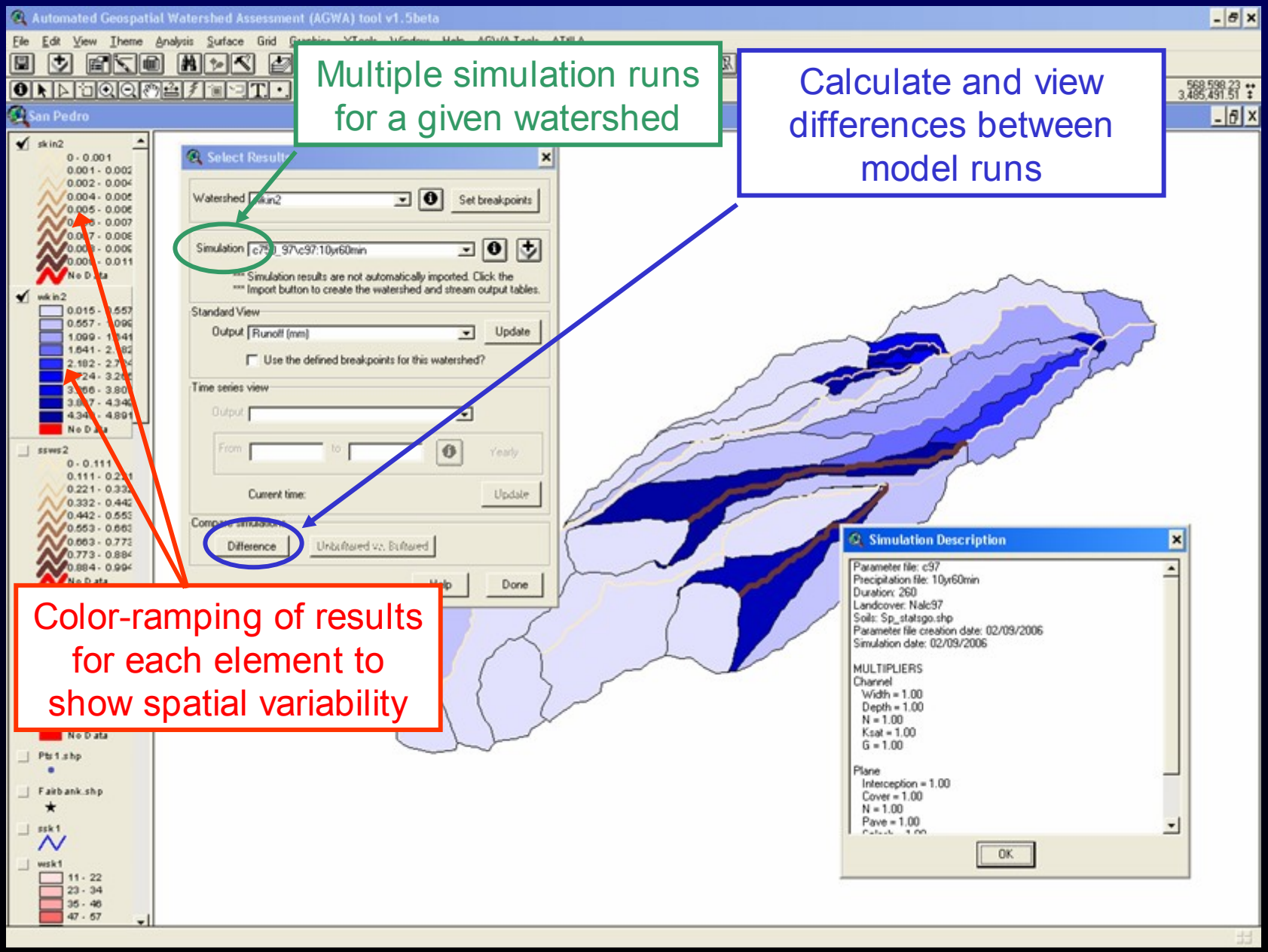


Output results that can be displayed in AGWA

KINEROS Outputs	*SWAT Outputs*
Channel Infiltration (m^3/km)	Precipitation (mm)
Plane Infiltration (mm)	ET (mm)
Runoff (mm or m^3)	Percolation (mm)
Sediment yield (kg)	Channel Disch. (m^3/day)
Peak flow (m^3/s or mm/hr)	Transmission loss (mm)
Channel Scour (mm)	Water yield (mm)
Sediment discharge (kg/s)	Sediment yield (t/ha)

AGWA

Visualization of Results

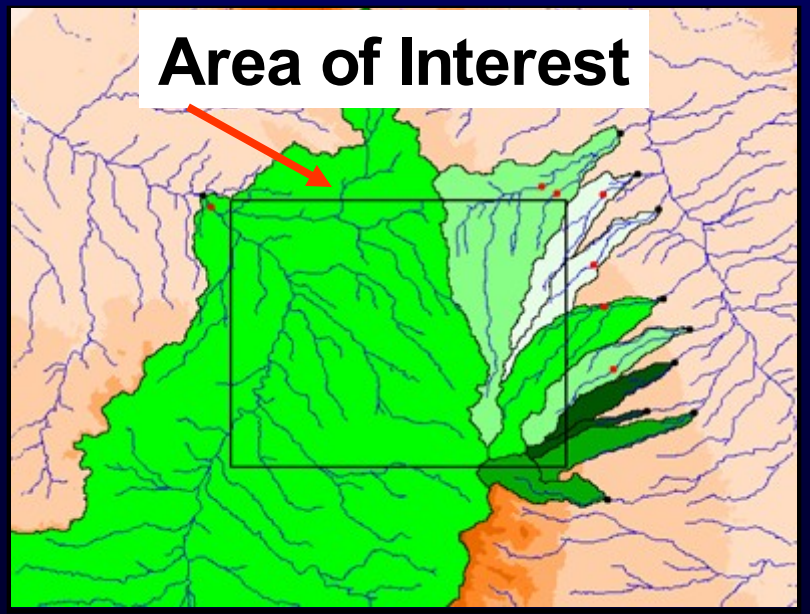


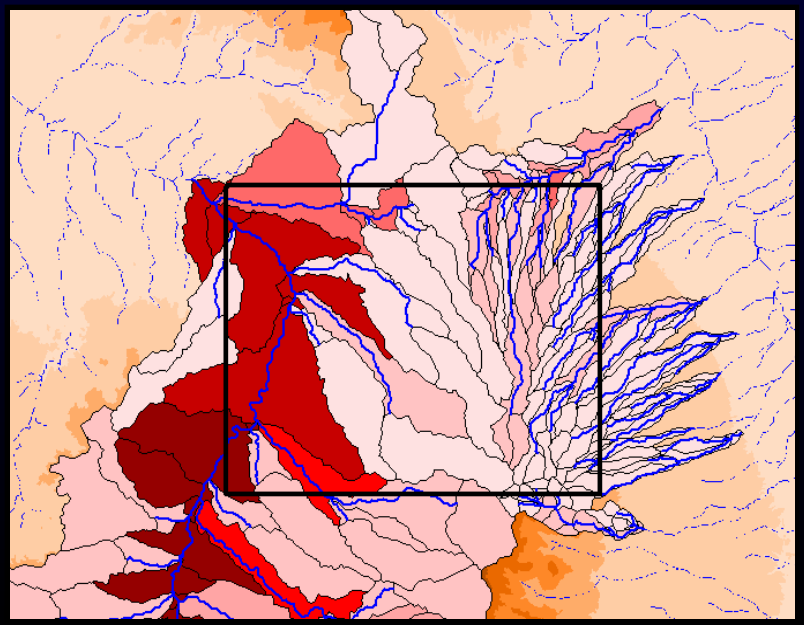
New Tools to be released in: AGWA 1.5 (ArcView) - Current AGWA 2.0 (ARCGIS and BASINS 4.0); and, DotAGWA (Internet) - 2007

- **"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





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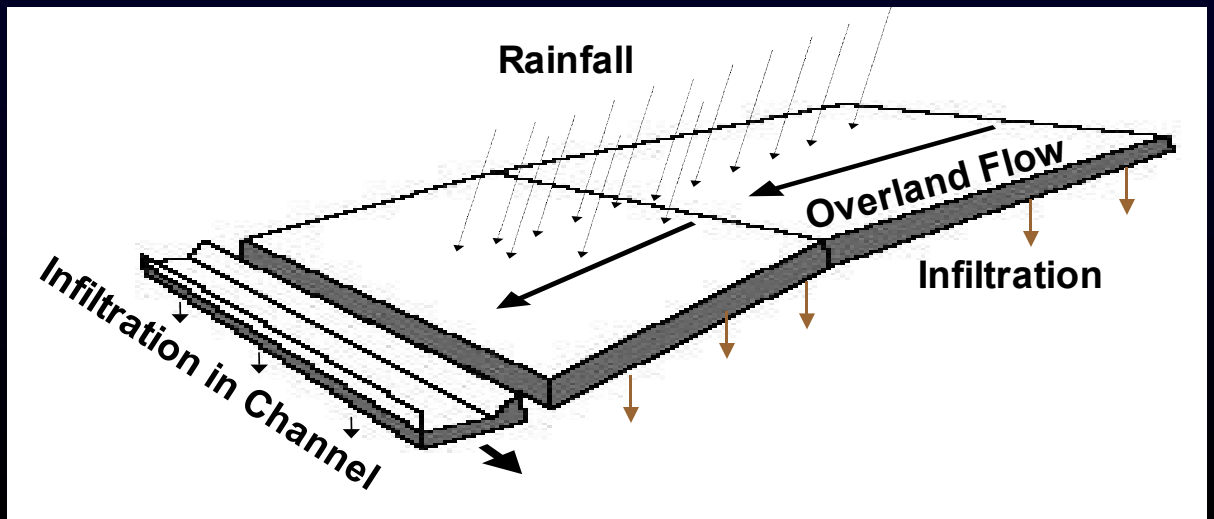
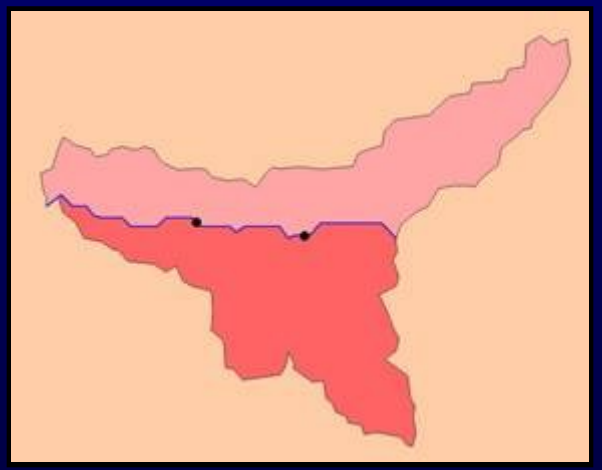
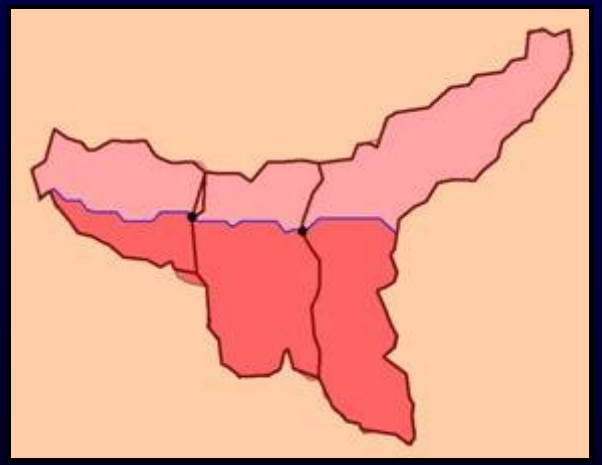
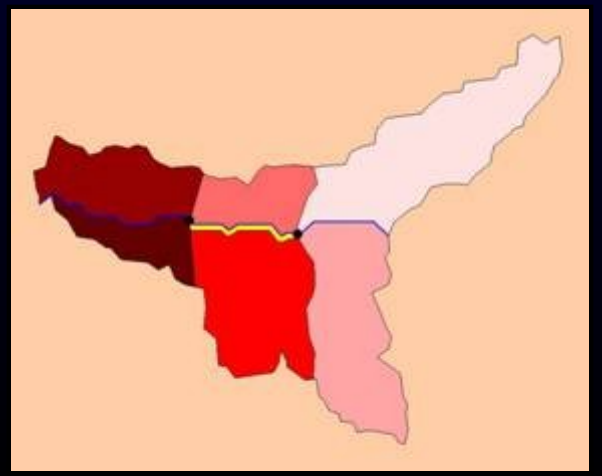
KINEROS Stream Buffer Tool

- 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







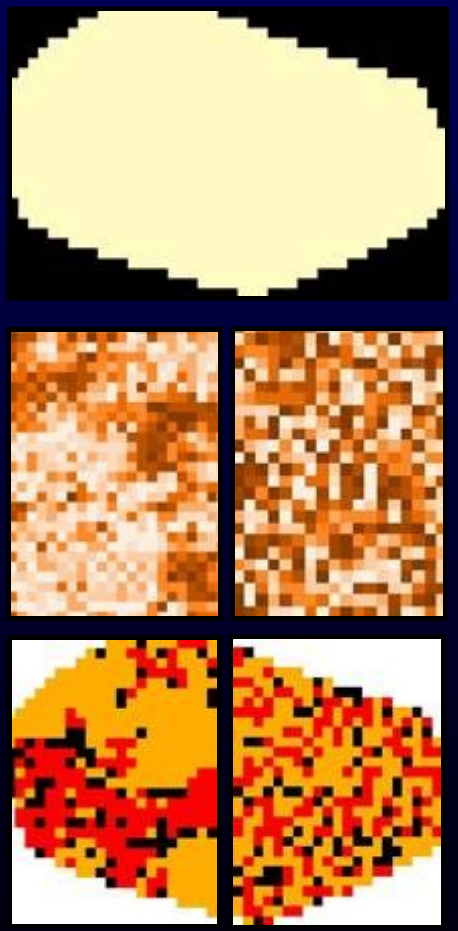


Land Cover Modification Tool

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



AGWA

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.

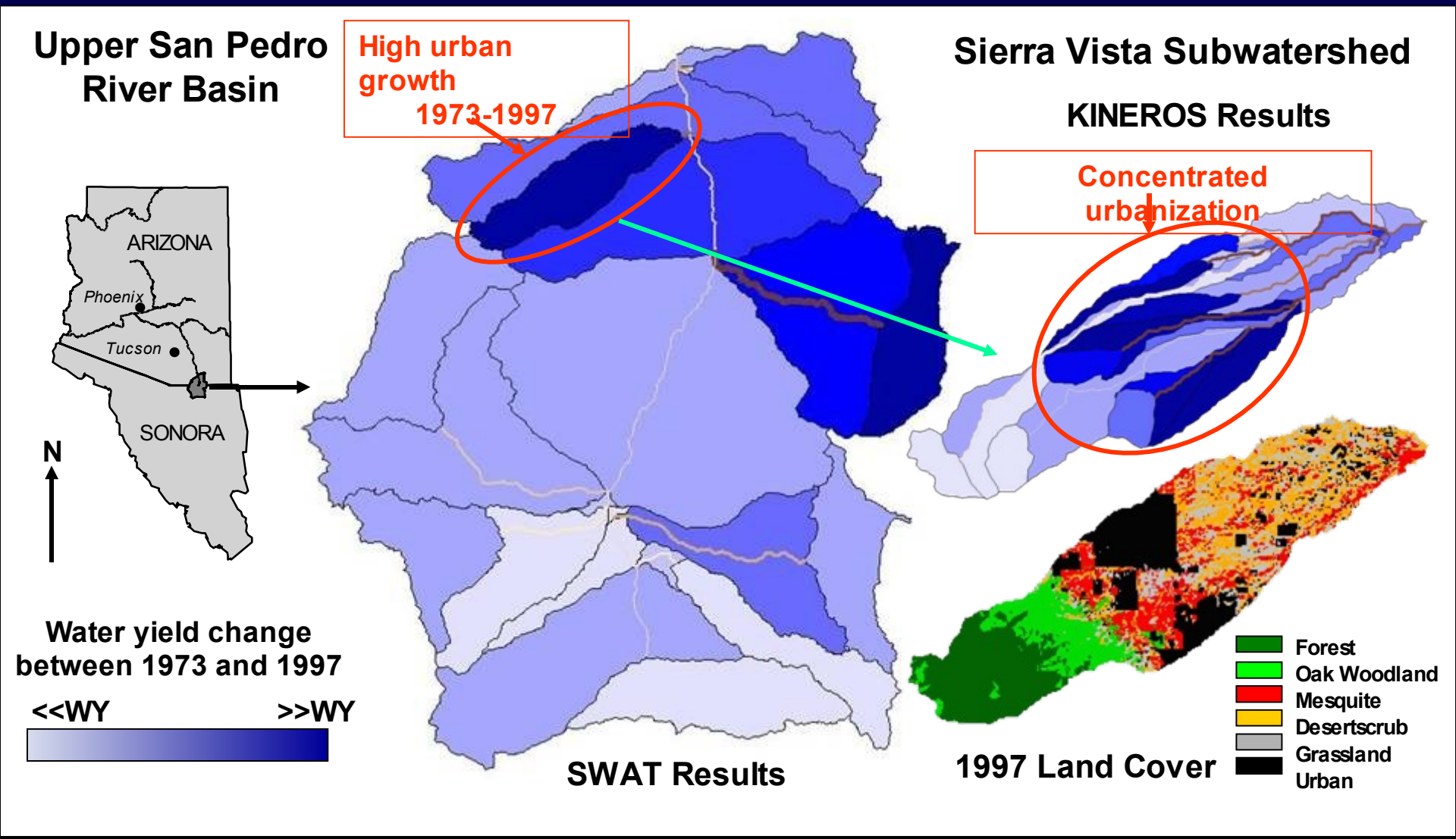
- ***Nutrient modeling*** provides estimates for nitrogen and phosphorus loading from subwatershed elements and in the channels
- Requires no additional inputs
- Management scenarios can be simulated by changing the default land cover parameters

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

AGWA

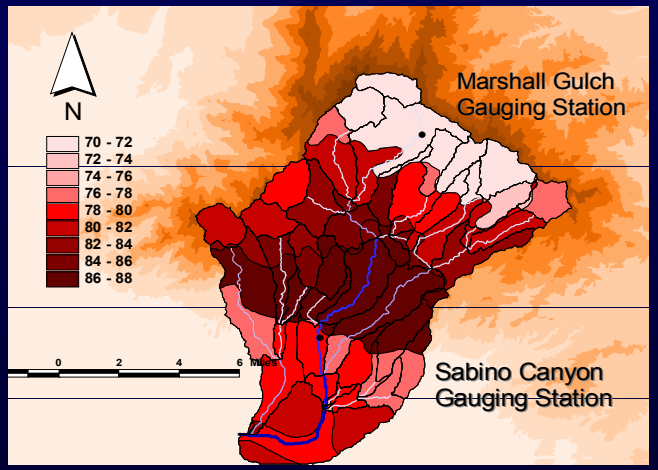
Urbanization – Multi-Scale Application

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

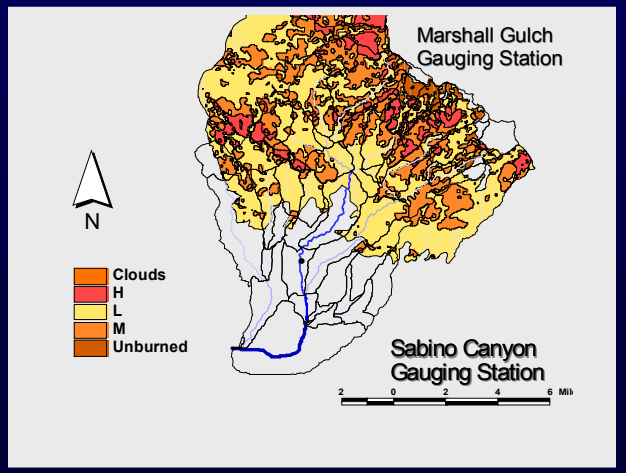


AGWA-SWAT Aspen Post-Fire Assessment

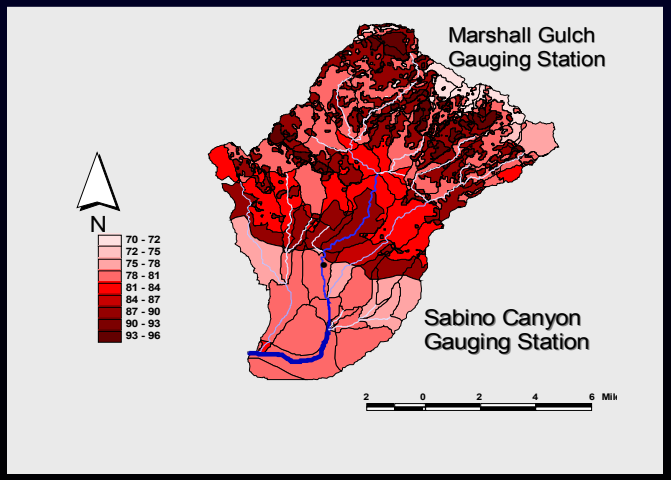
Pre-fire Est. Curve Numbers f(Hydro. Soils Group, Cover Type)



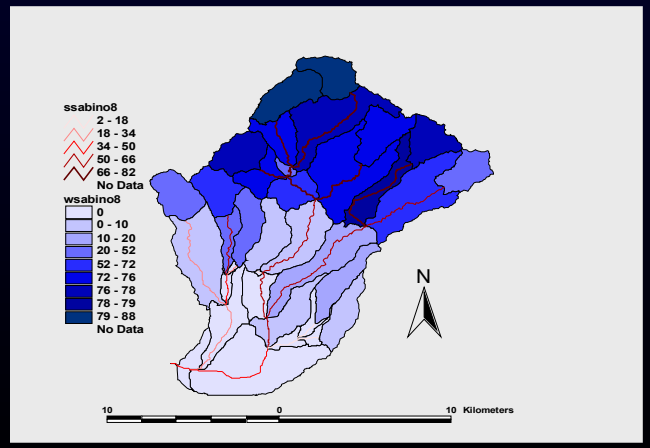
Overlay Burn Severity Map



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



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

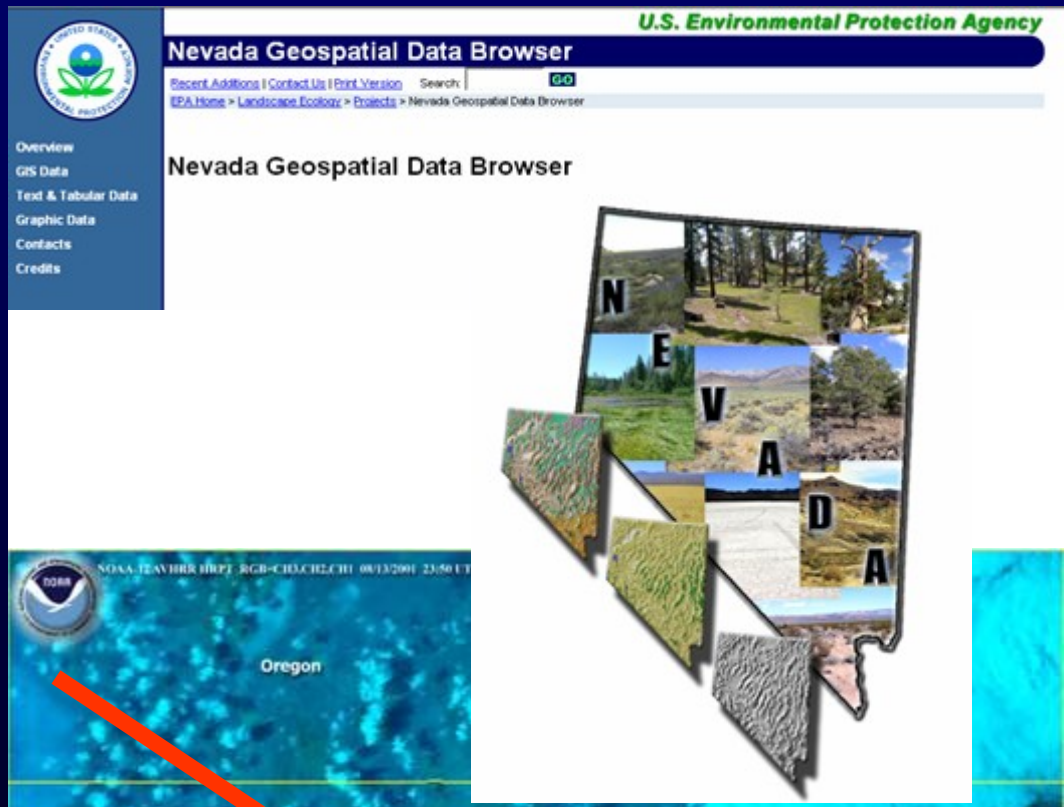


Future Directions

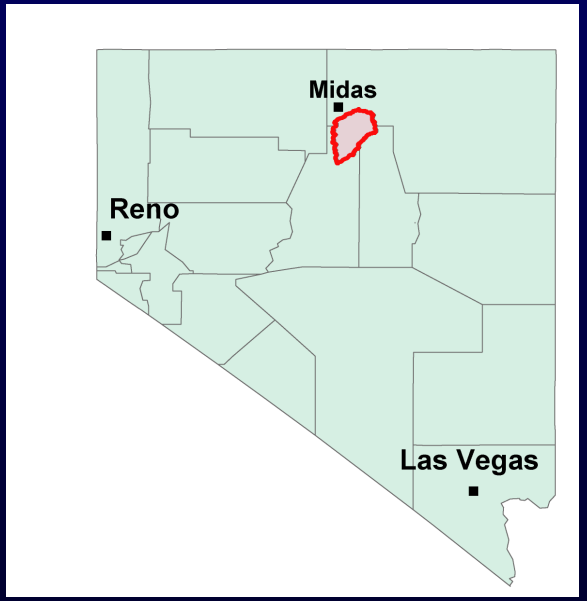
- 1-D Dynamic geomorphic model – channel erosion / deposition
- Enhanced ground-water parameterization for SWAT
- Mult. hydraulic-geometry relations for channel characterization
- Incorporation of WEPP erosion relations in KINEROS
- KINER-OPUS Coupling underway
  - OPUS simulation model for transport 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 Assessent 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



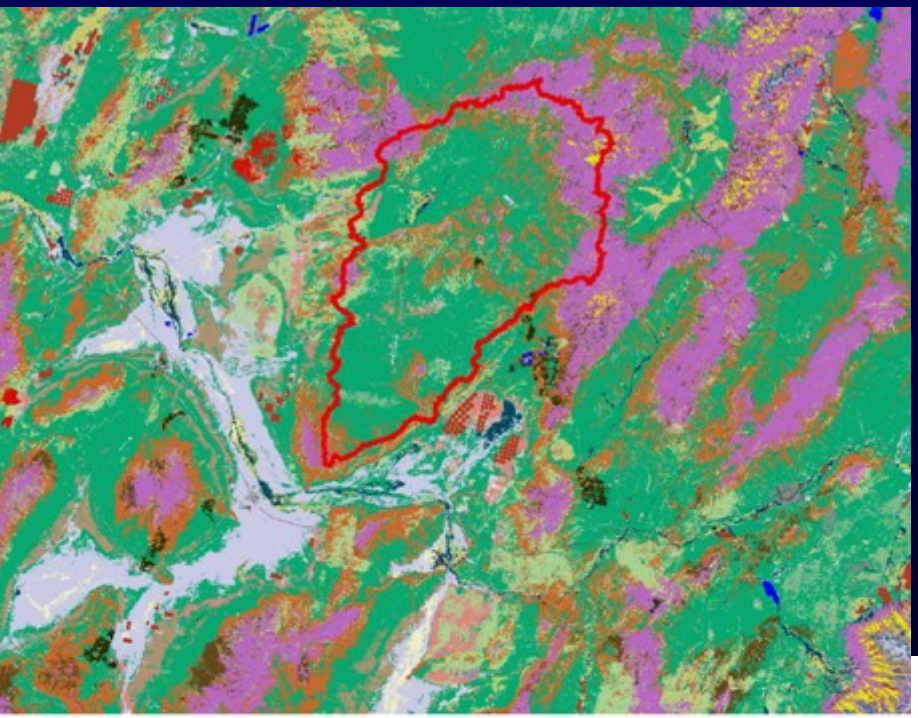
ACQUIRED SPATIAL DATA



- 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

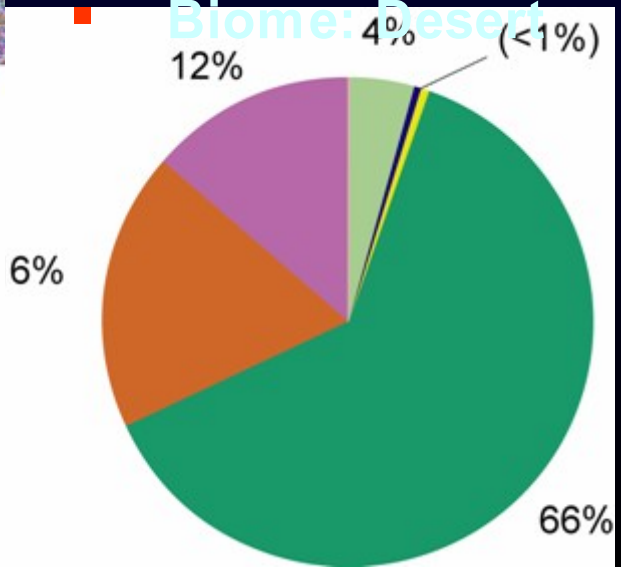
ROCK RIVER BASIN: LAND COVER (GAP) '99-'01



- Relief: 1863 m
- Basin Area: 2,237 km^2
- Mean daily discharge: 1.10 m^3/s
- Mean annual Precip.: 320 mm
- Mean air temperature: 9.4 ^{o}C
- Biome: Desert

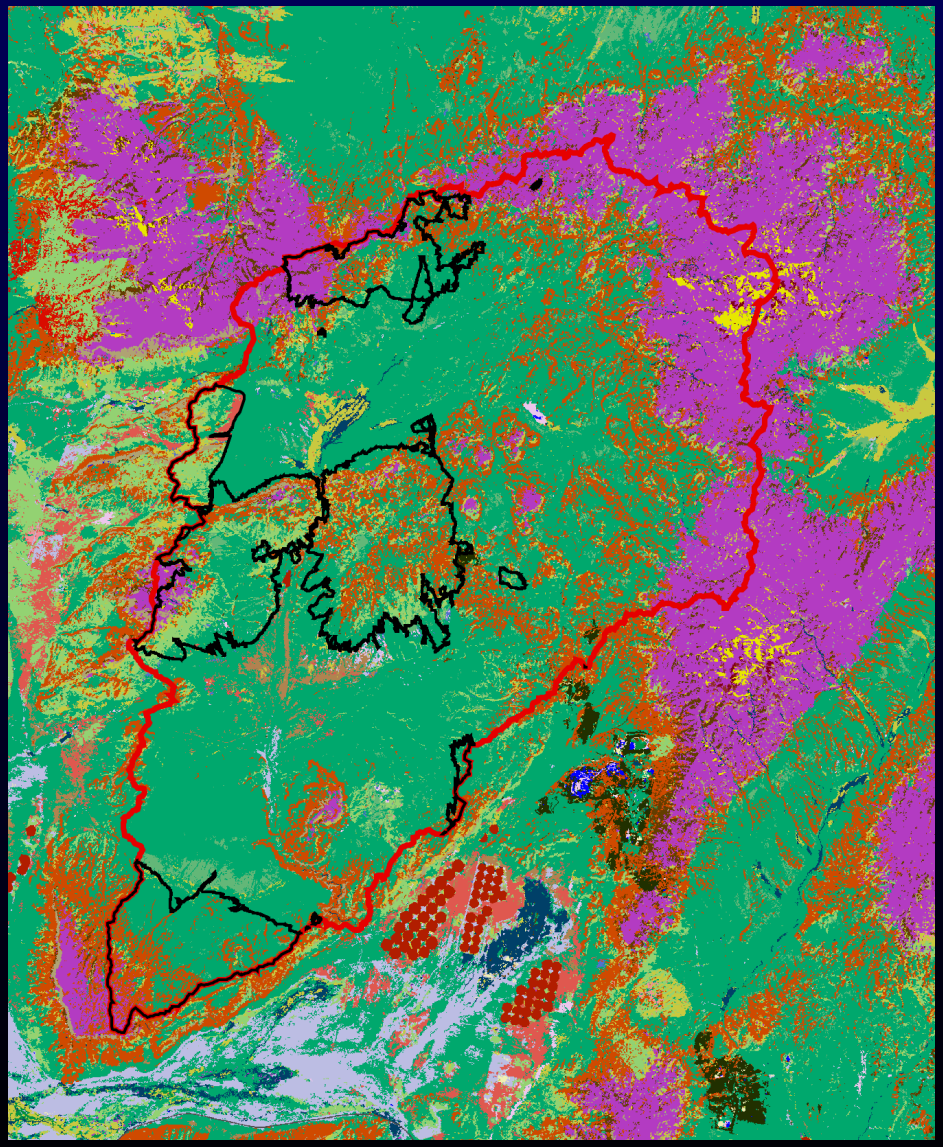
Legend

- 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



Land cover distribution

WILDFIRE BOUNDARIES



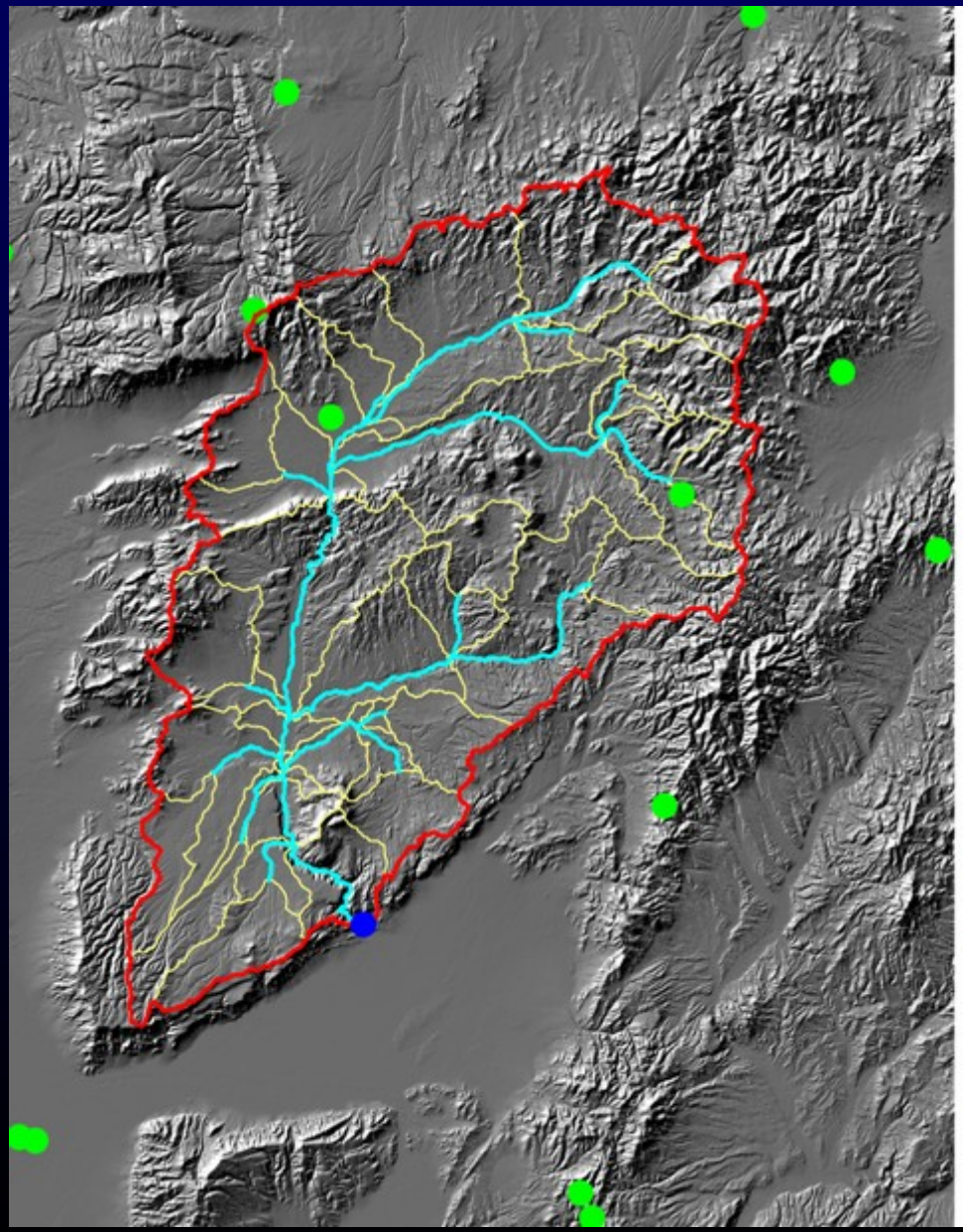
Date = Aug 14, 2001

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

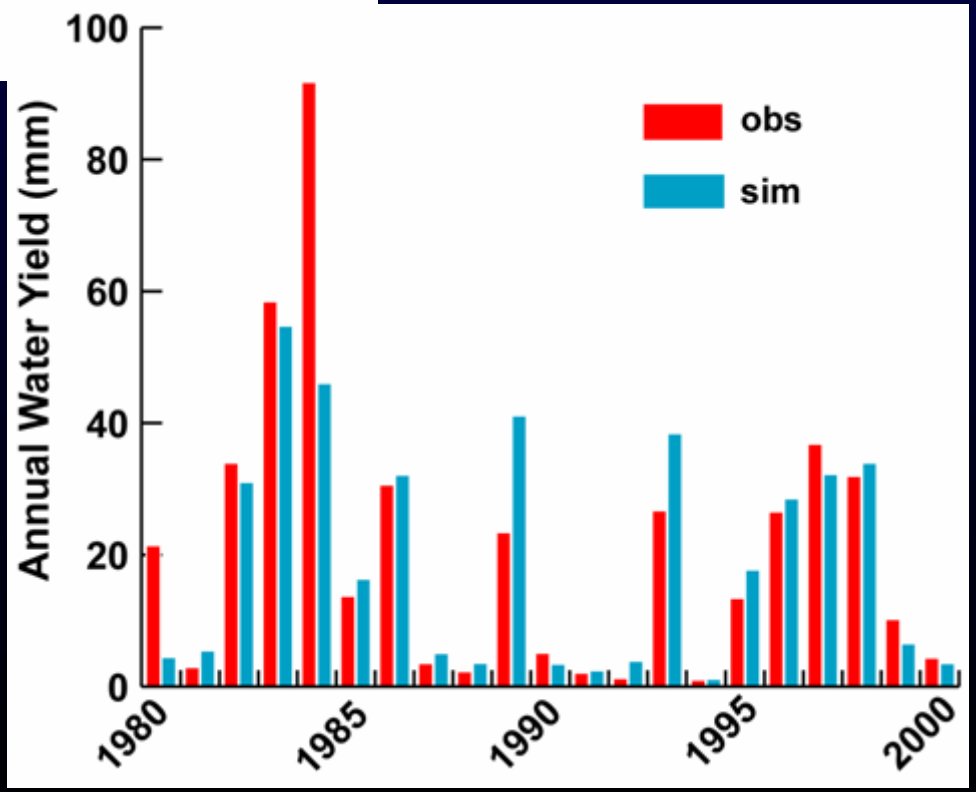
Watershed Boundary

Rock Creek

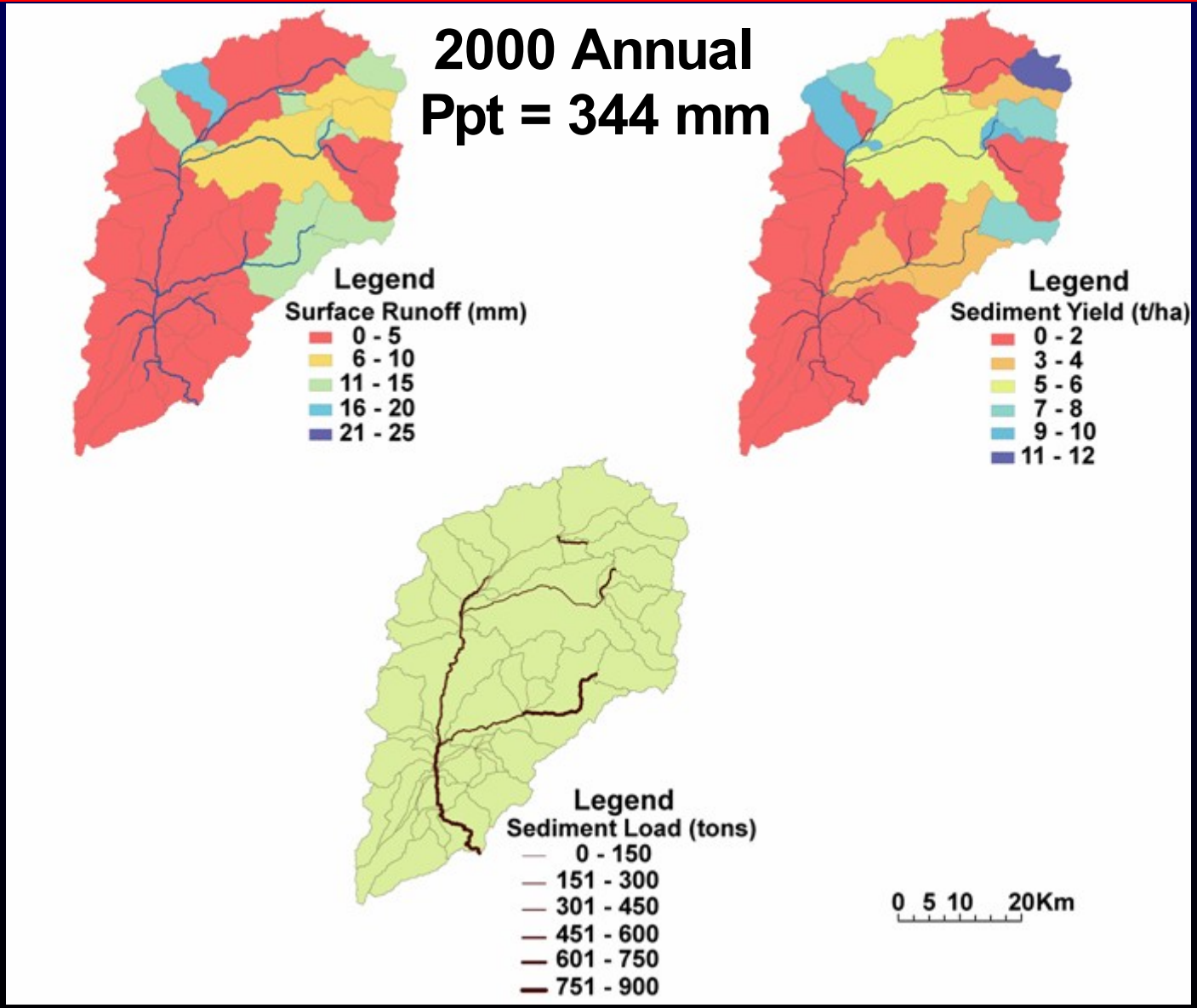
MODEL CALIBRATION RESULTS

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		

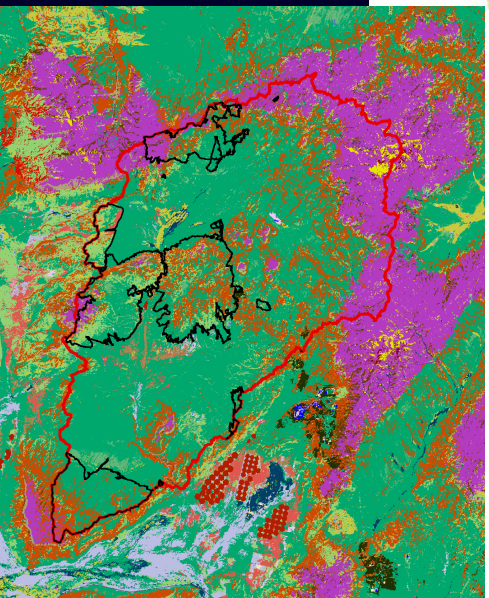


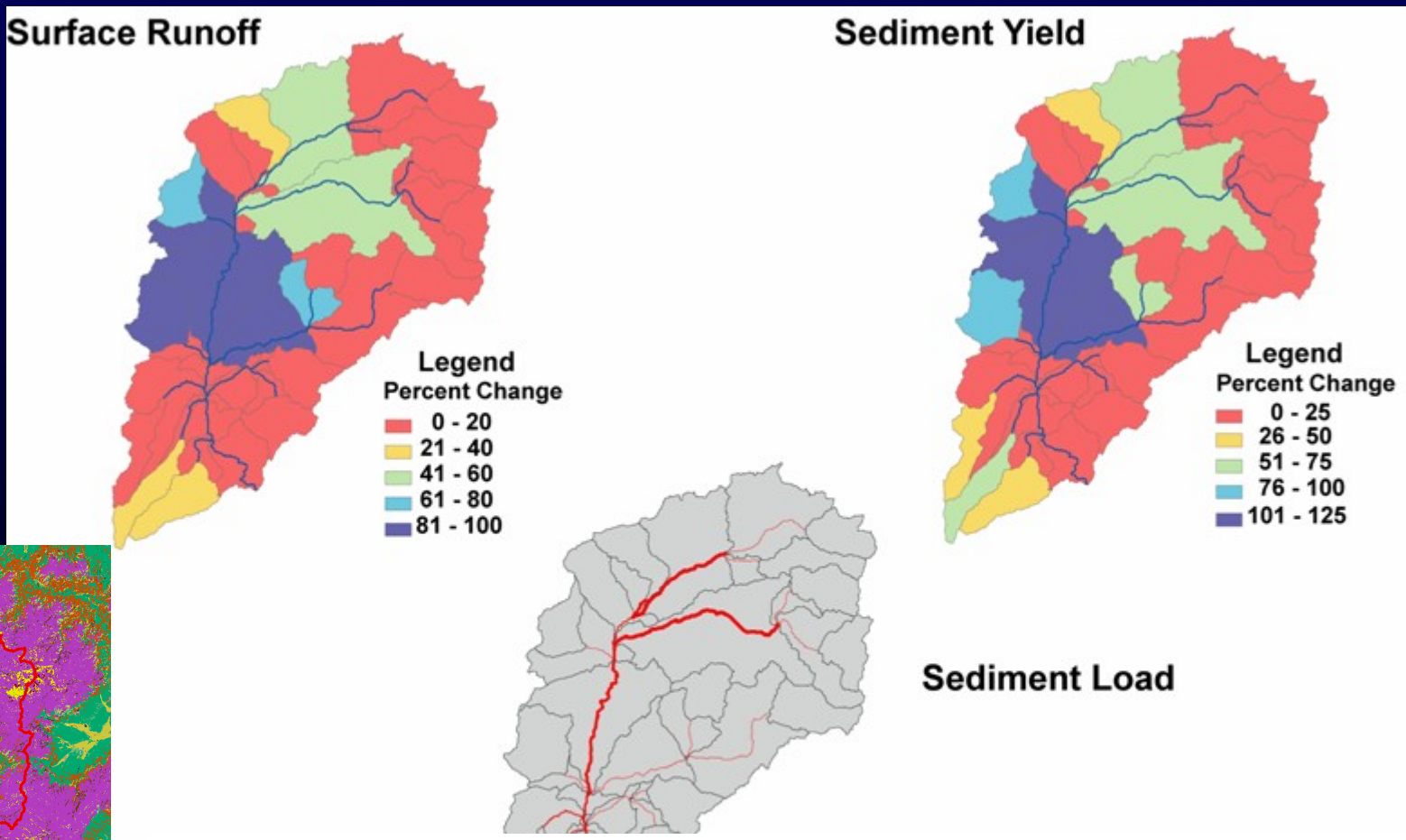
PRE-FIRE ANNUAL WATERSHED RESPONSE (Year 2000)



FIRST YEAR POST- FIRE WATERSHED RESPONSE PERCENT CHANGE

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