Rapid Post-Fire Watershed Assessment using the AGWA (Automated Geospatial Watershed Assessment) Tool

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OVERVIEW

- **AGWA Background**
- **Post-fire model parameters**
- **Pre- and Post-Fire Application**
- **Future Direction**

AGWA – Basics

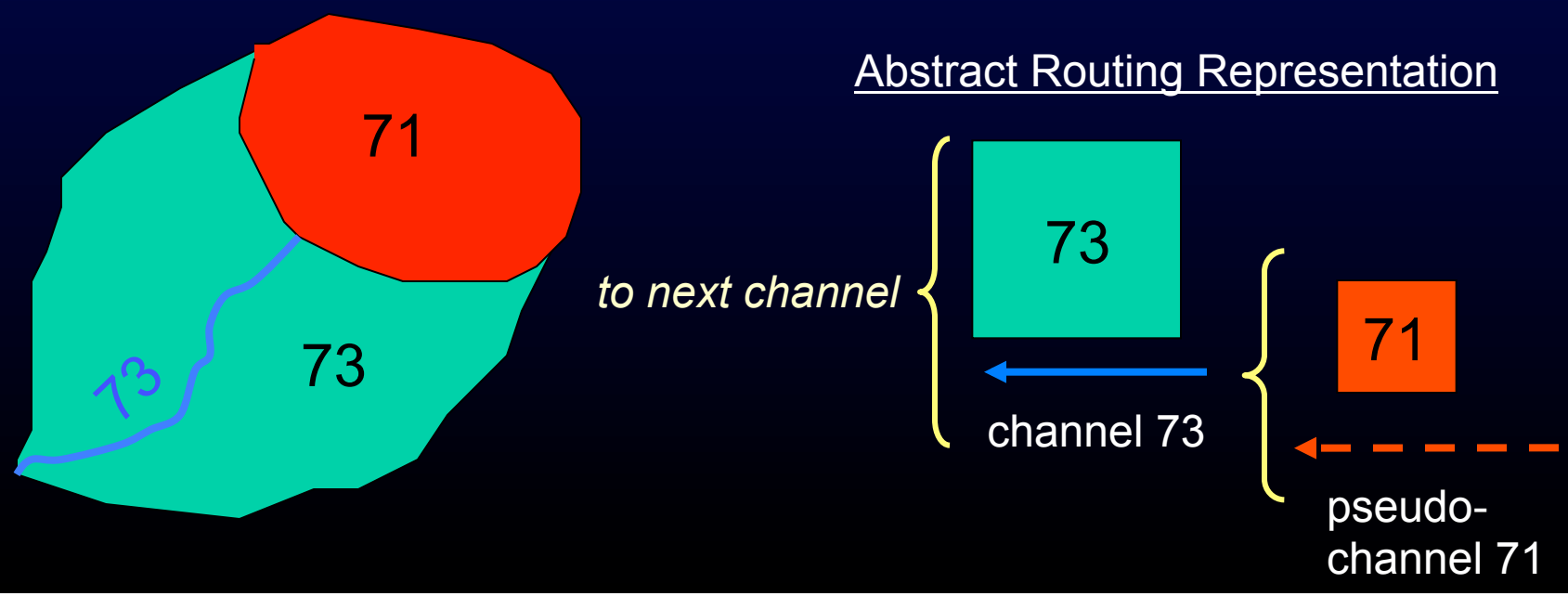
- A reliable, automated GIS interface for watershed modeling (hydrology, erosion, WQ) for resource managers
- Applicable to ungauged / gauged watersheds
- Operate with nationally available data (DEM, Soils, LULC)
- Freely available (currently in ArcView 3.x, ArcGIS 9.x/10.x)
- Investigate the impacts of land cover change
  - Historical and future
  - Identify sensitive, "at-risk" areas
  - Assess impacts of management (e.g. growth, fire, mulch)
- Provide repeatable results for relative change assessments
- Two established watershed models to address multiple scales
  - SWAT for large basins, daily time steps
  - KINEROS2 for small-medium basins, sub-hour time steps

SWAT | Soil & Water Assessment Tool

KINEROS2 A KINEMATIC RUNOFF AND EROSION MODEL

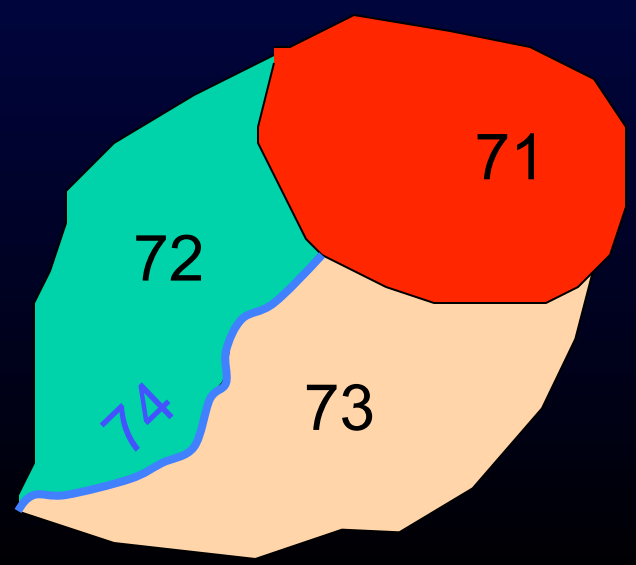
Soil Water and Assessment Tool (SWAT)

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

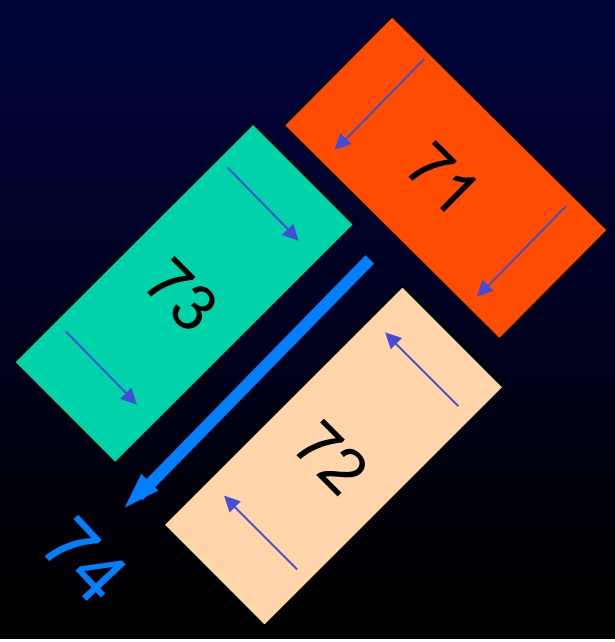


Kinematic Runoff and Erosion Model - KINEROS2

- Event-based (< minute time steps)
- Runoff: Volume, Qp, entire hydrograph and water balance for all model elements
- Erosion (Dynamic WEPP & RHEM)
- Distributed: physically-based model with dynamic routing, erosion, and sediment transport
- Small-Medium watersheds



Abstract Routing Representation



Conceptual Design of AGWA

PROCESS

Build GIS Database

Discretize Watershed
f (topography)

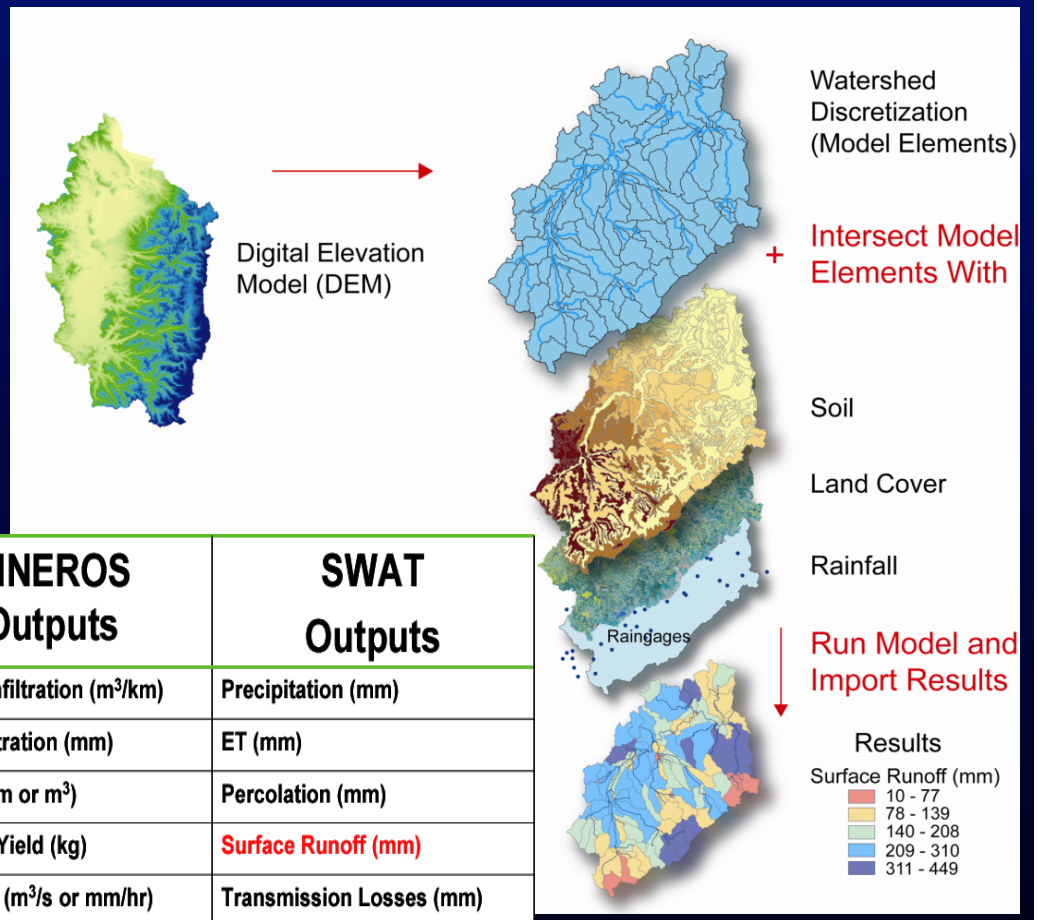
Characterize Model Elements
f (land cover, topography, soils)

Derive Secondary Parameters
look-up tables from Exp./Res.

Build Model Input Files

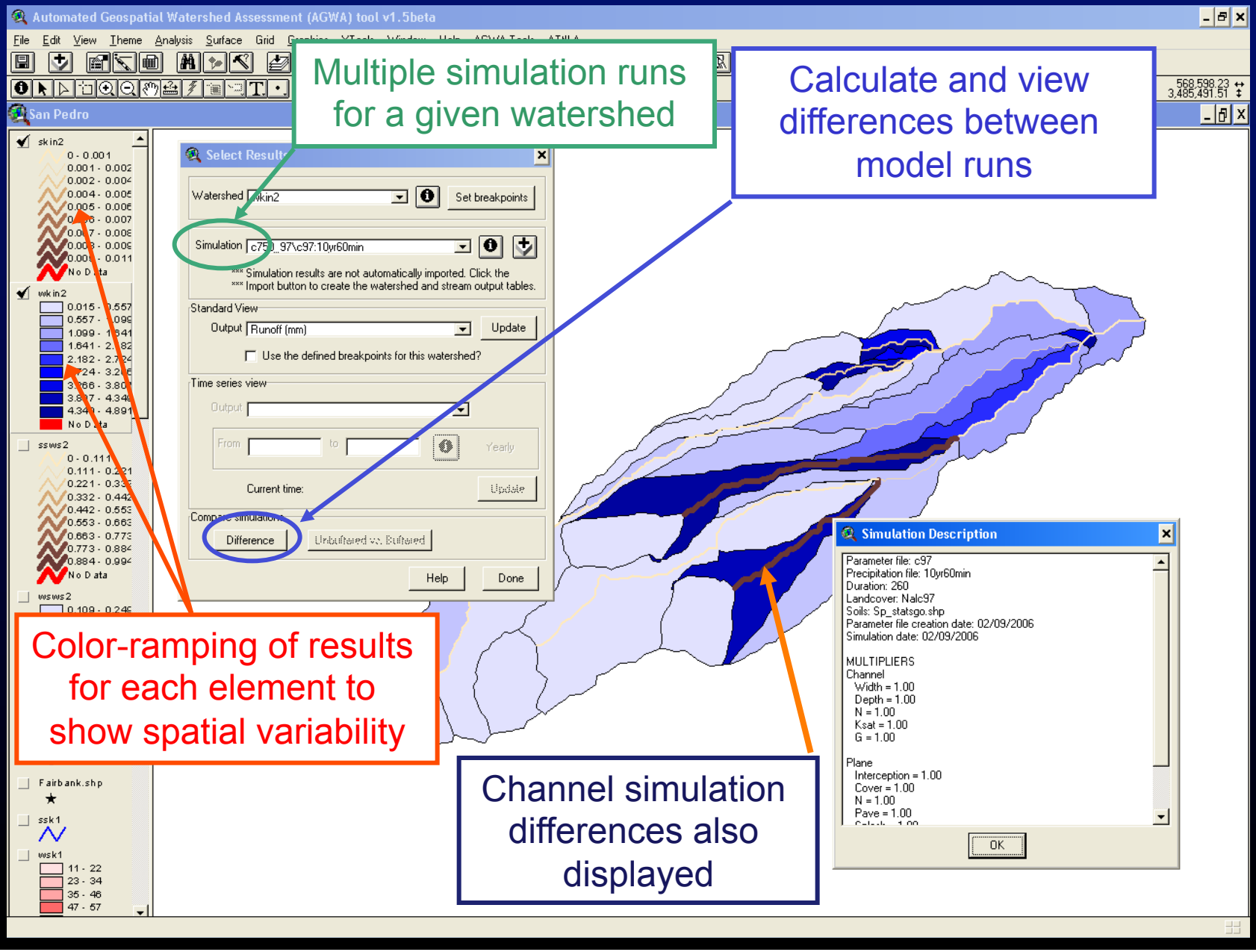
View Model Results
link model to GIS

INPUTS & OUTPUTS



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)	Surface Runoff (mm)
Peak Flow (m^3/s or mm/hr)	Transmission Losses (mm)
Channel Scour (mm)	Water Yield (mm)
Sediment Discharge (kg/s)	Sediment Yield (t/ha)
	Nitrate in Surface Runoff (kg N/ha)
	Phosphorous in Surface Runoff (kg P/ha)

Visualization of Results



Multiple simulation runs for a given watershed

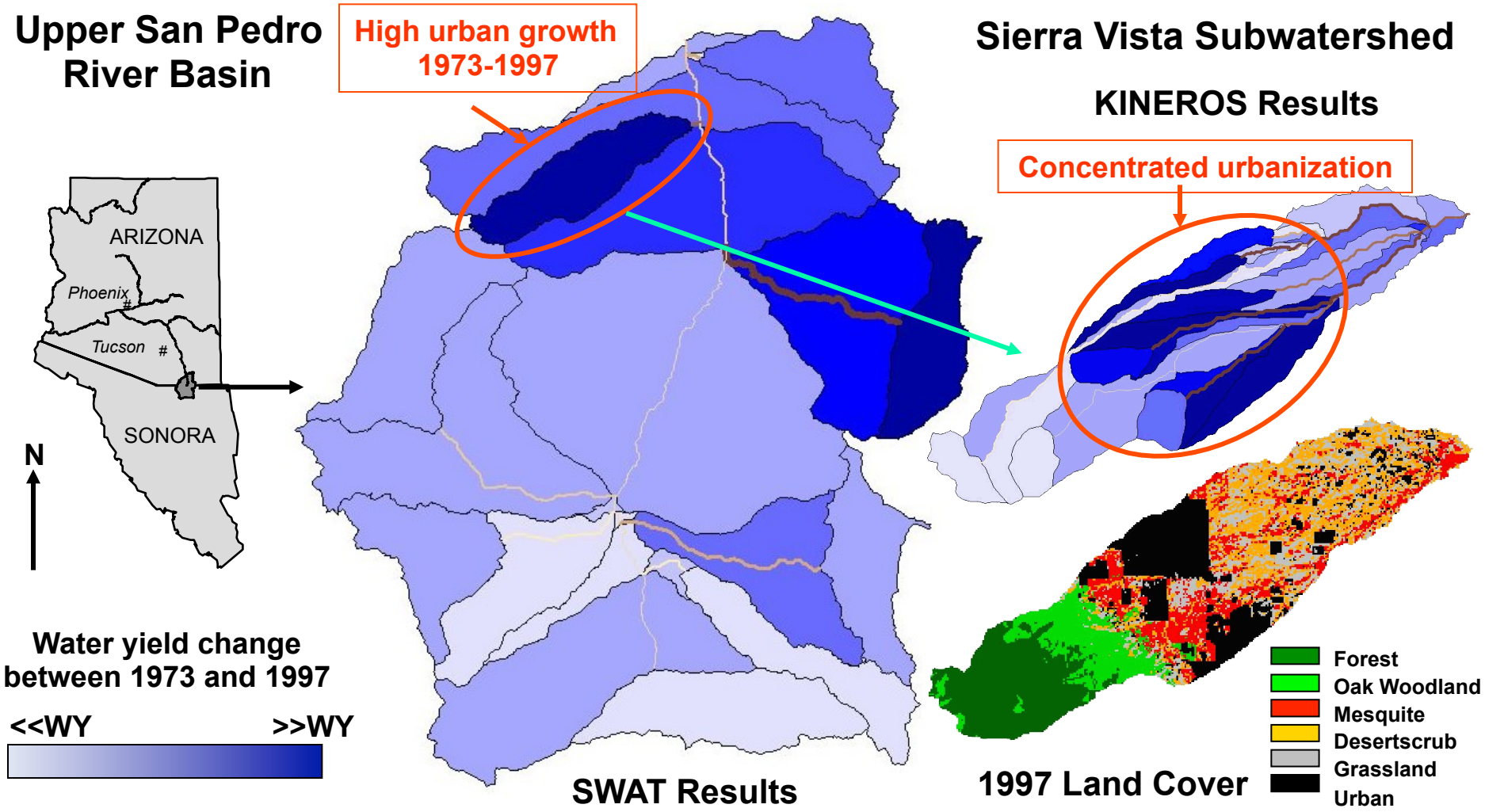
Calculate and view differences between model runs

Color-ramping of results for each element to show spatial variability

Channel simulation differences also displayed

Spatial and Temporal Scaling of Results

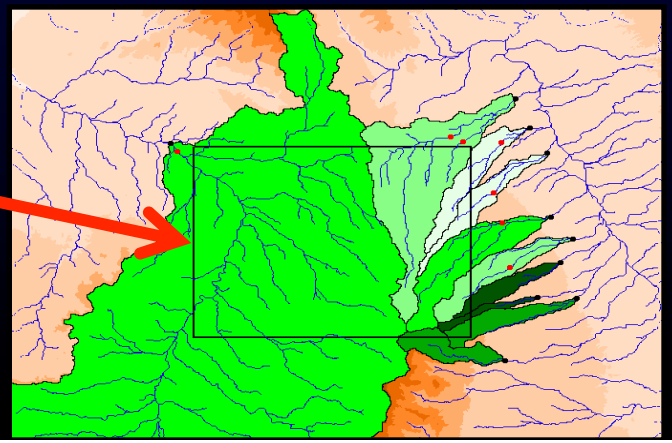
- Using SWAT and KINEROS for integrated watershed assessment
- Land cover change analysis and impact on hydrologic response

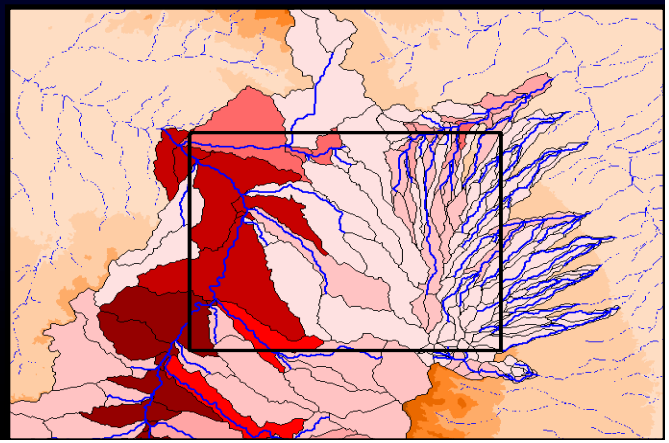


Management Tools Built into AGWA

- Land use and land cover modification tool
  - User-defined polygons to change land cover by class (uniform, patchy, fractal)
  - Apply post-fire mulch at specified tons/acre
  - Mimic fuel thinning using land fire data (in progress)
  - NRCS Ecological Site Descriptions (in progress)
- Buffer strips
- Designate multiple points of interest for model output
- Detention and retention ponds/reservoirs
- Multi-watershed analysis for political/park boundaries

Area of Interest





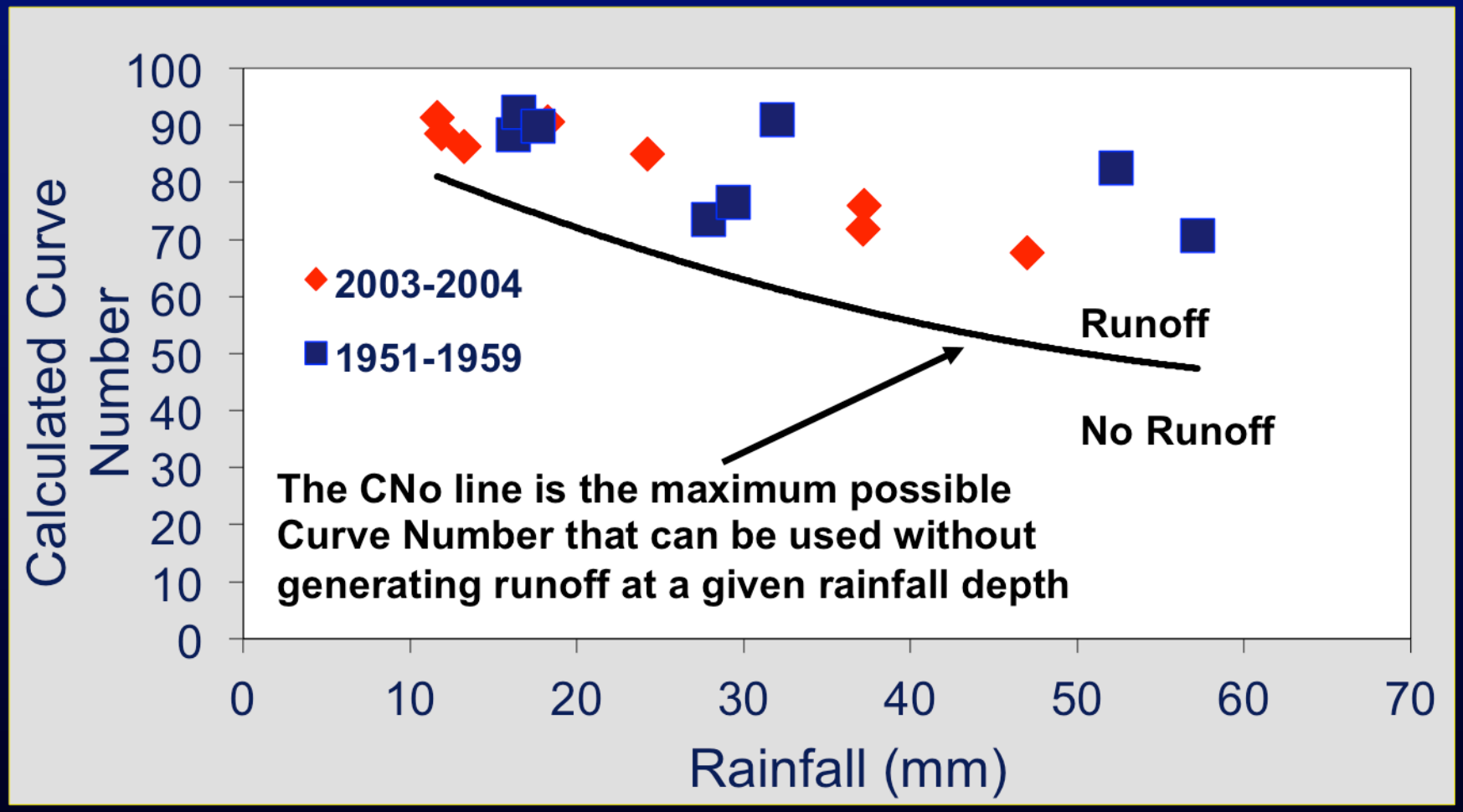
Post-Fire Model Parameterization

- **Select watersheds with relatively good rainfall and runoff observations pre-fire and post-fire**
- **Using this data compute post-fire model parameters as a function of burn severity and land cover type**
  - **Marshall Gulch, Aspen Fire, Arizona**
  - **Starmer Canyon, Cerro Grande Fire, New Mexico**
- **Also track recovery in roughness, CN, and Hyd. Cond. as a function of time and place sediment fences on Oracle Hill fire(results not presented)**

Canfield et al., 2005. Selection of parameter values to model post-fire runoff and sediment transport at the watershed scale in southwestern forests. Proc. ASCE Watershed Manage. Conf., July 19-22, Williamsburg, VA.

Goodrich et al., 2005. Rapid Post-Fire Hydrologic Watershed Assessment using the AGWA GIS-based Hydrologic Modeling Tool. Proc. ASCE Watershed Manage. Conf., July 19-22, Williamsburg, VA.

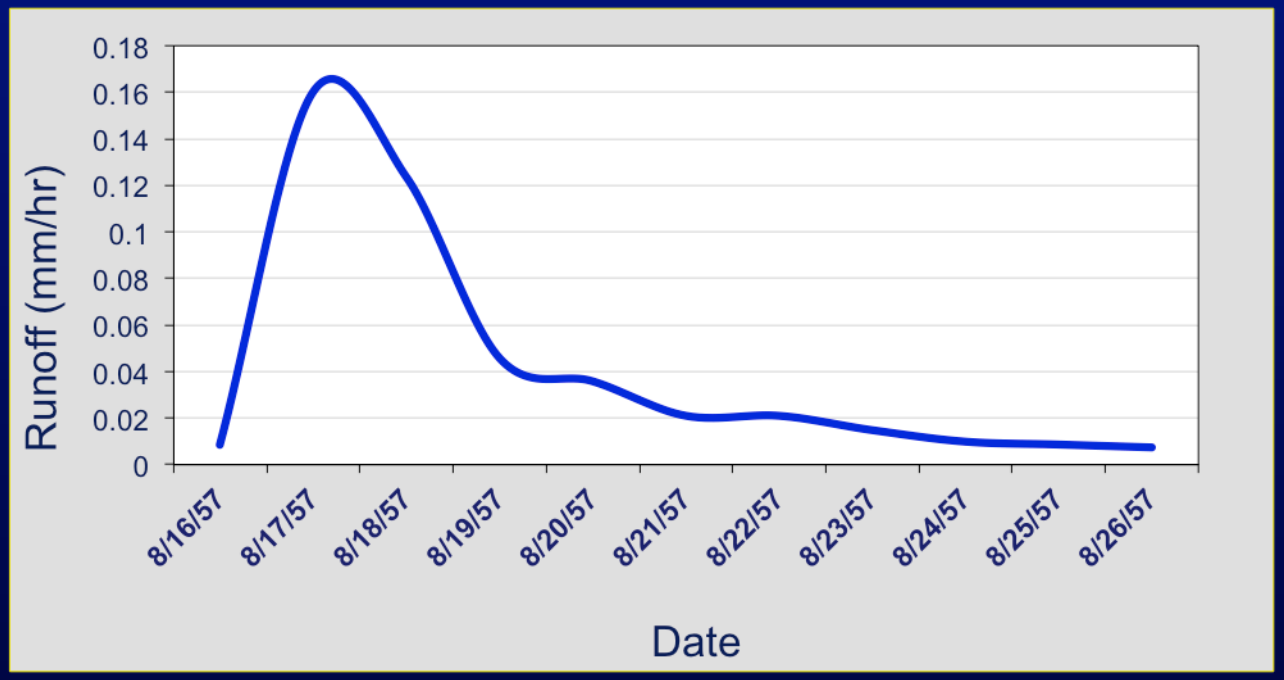
Calculated Curve Numbers for Before and After Aspen Fire



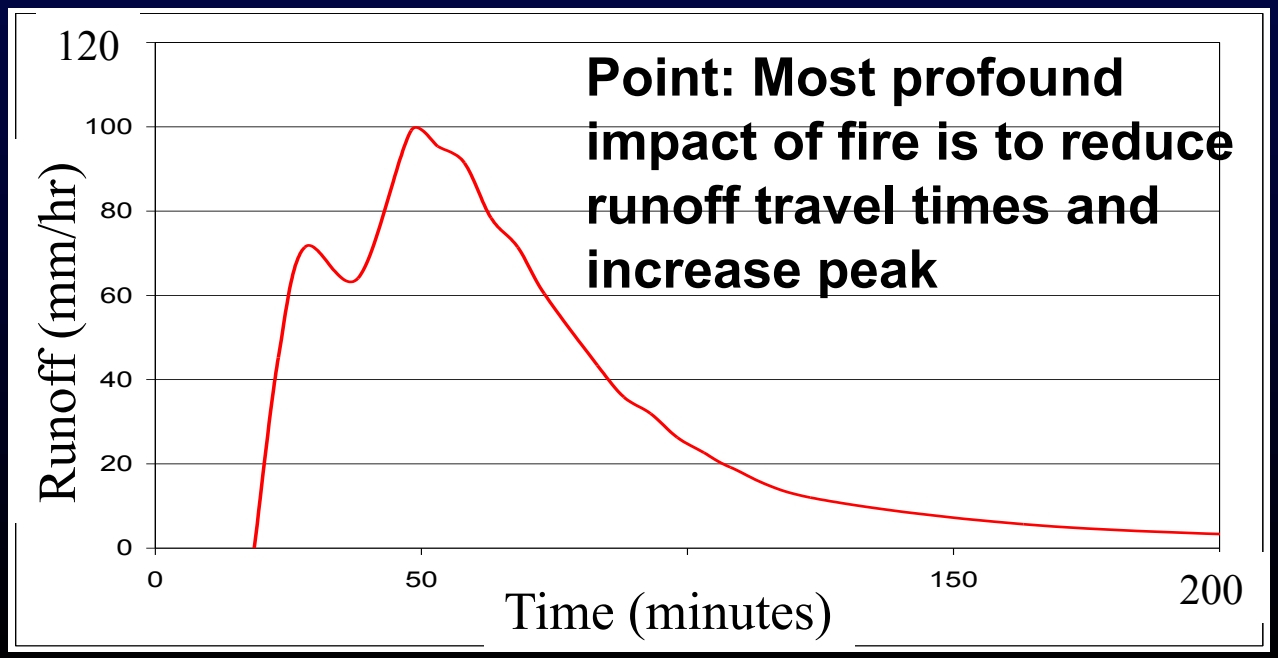
Point: The impact on runoff volume is relatively small. This result has been reported by other (Springer & Hawkins 2005; McLin et al. 2001).

Marshall Gulch

Pre- Fire Hydrograph



Post - Fire Hydrograph



Point: Most profound impact of fire is to reduce runoff travel times and increase peak

Parameterization of SWAT

- CN is based on cover. Assume a reduction in cover of:
  15% - low severity
  32% - moderate severity
  50% - high severity

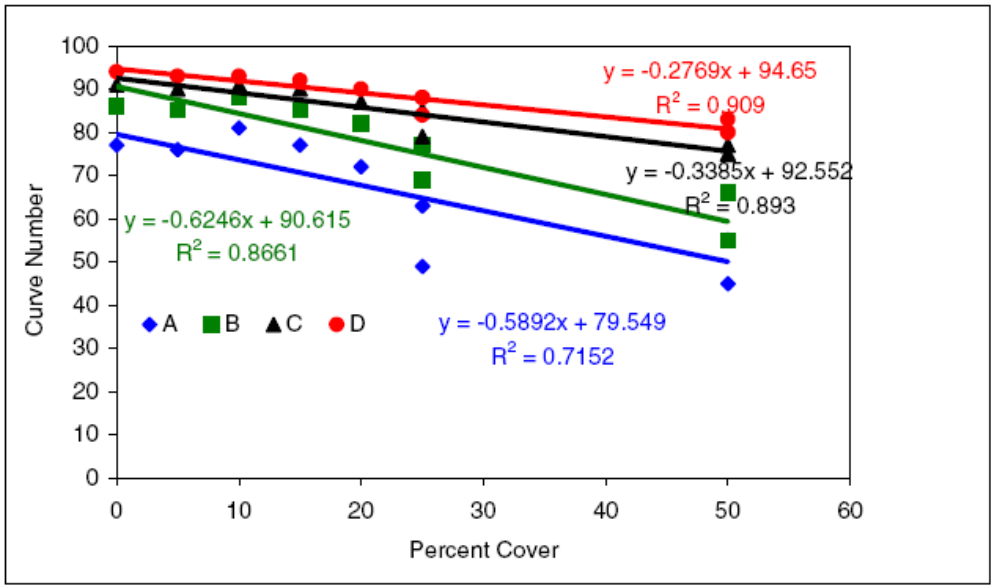


Figure 2 – Estimated Post-Fire Average Annual Runoff over a 10 Year Simulation Period (mm)

- CN values lower then typically used in BAER post-fire assessments
- Assume no change.

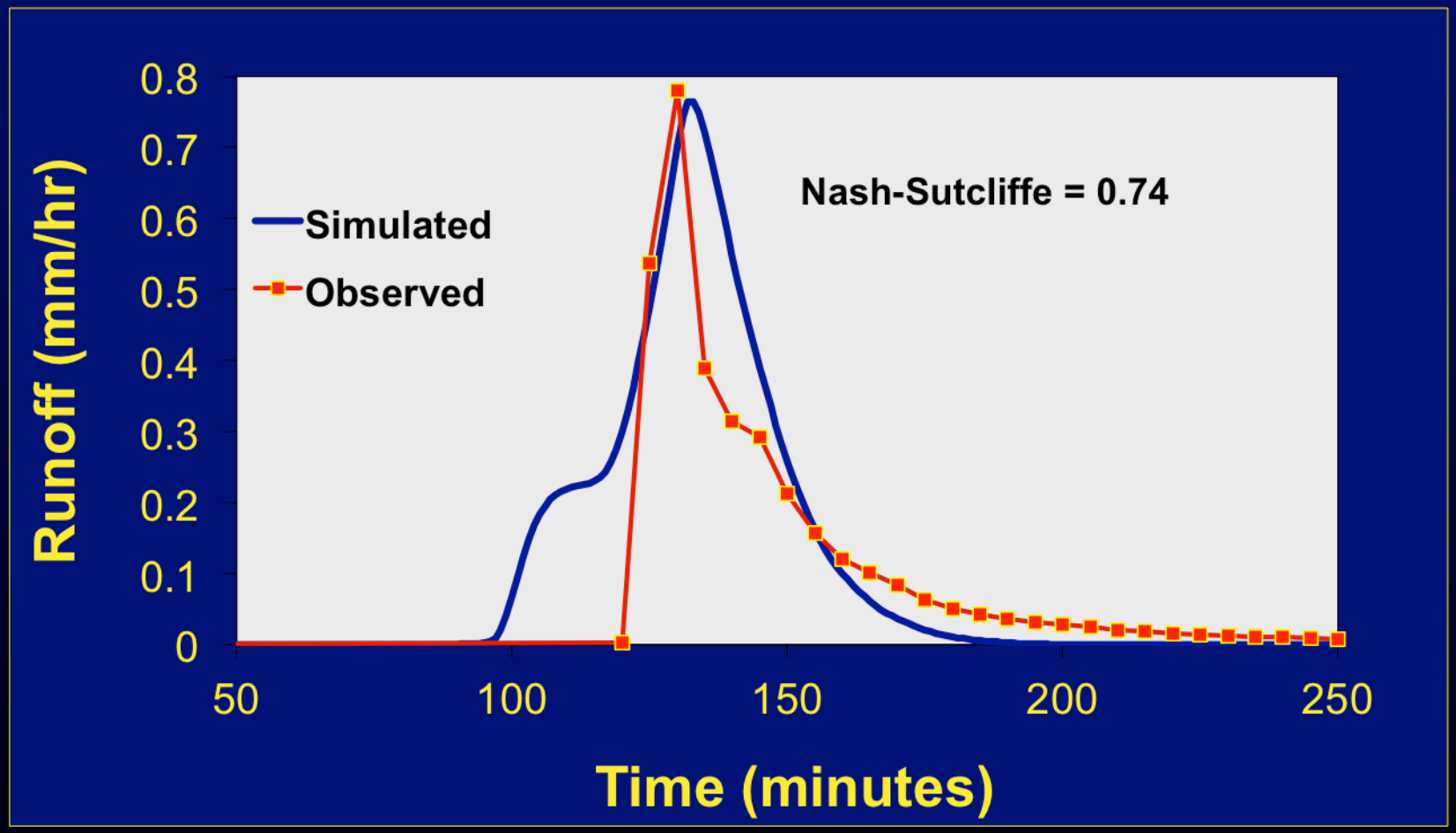
- Fix the roughness factor for overland flow to equal bare soil (n = 0.011). Selection of this value allows for more than an order of magnitude change in extremely rough environments, such as conifer forests.

Optimal Hillslope Roughness, Saturated Hydraulic Conductivity and Channel Roughness for KINEROS2 at Starmer Canyon following Cerro Grande Fire

Event	Rainfall Depth (mm)	Days Since Fire	Ks (mm/hr)	n Channnel	n Hillslope	Nash-Sutcliffe
6/28/2000	11.3	37	3.361	0.193	0.014	0.89
7/9/2000	14.3	48	0.390	0.013	0.213	0.74
10/22/2000a	14.1	154	1.183	0.151	0.430	0.85
10/22/2000b	12.3	154	0.866	0.150	0.087	0.85
8/9/2001	9.8	444	2.172	0.008	0.716	0.88
7/14/2002	9.8	783	3.312	0.041	1.175	0.95
8/11/2003	22.6	1176	7.540	0.117	1.053	0.90

Canfield, H.E., Goodrich, D.C., Burns, I.S. 2005. Selection of parameter values to model post-fire runoff and sediment transport at the watershed scale in southwestern forests. Proc. ASCE Watershed Manage. Conf., July 19-22, Williamsburg, VA.

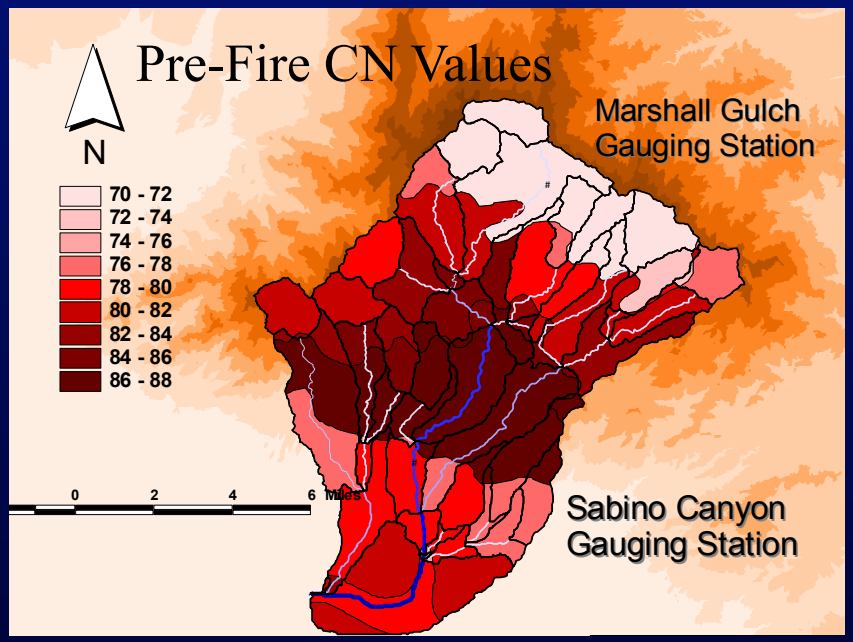
Calibrated Hydrograph for Most-poorly Fit Event

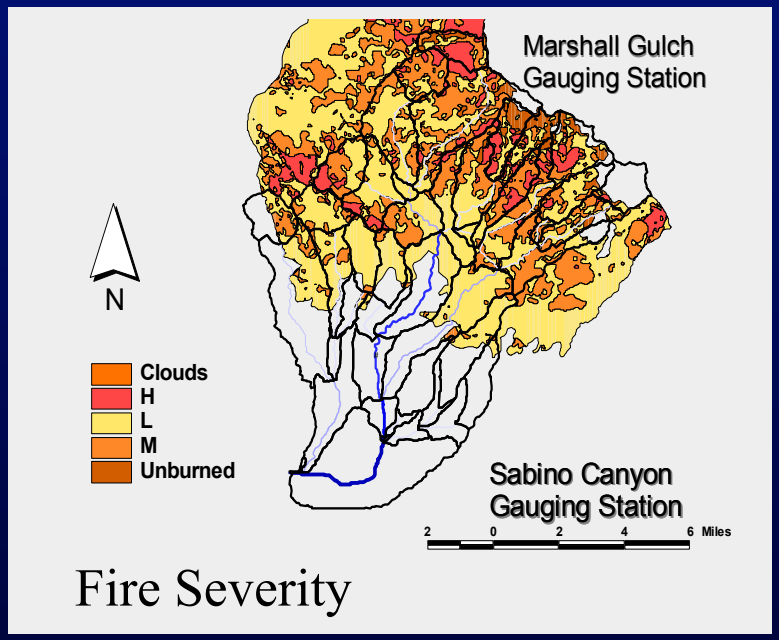


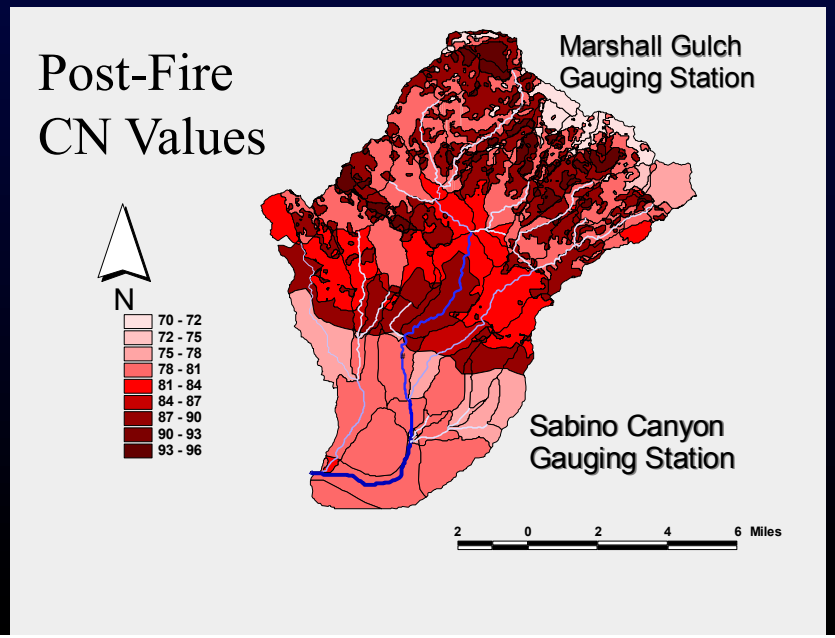
Post-Fire Assessments

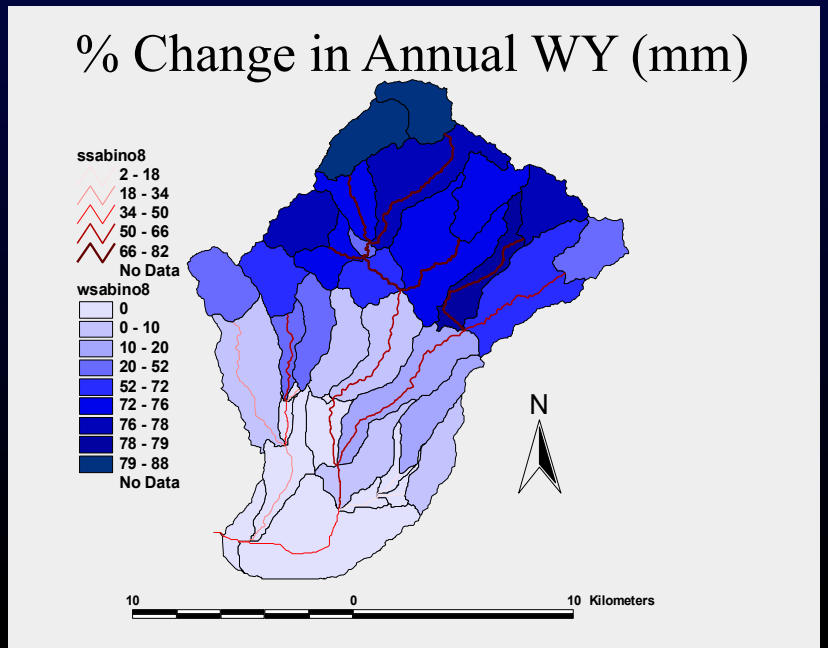
- Define look-up table for pre- and post- model parameters as a function of land cover type and burn severity
  - SWAT (CN, roughness)
  - KINEROS2 (roughness, Interc., cover, Sat. Hydraulic Cond.)
- Pre-fire data and simulations can be done for any given watershed at any time in a non-crisis environment
- 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 recognition of watershed areas most prone to post-fire impacts so mitigation and remediation can be targeted

Aspen Fire: Post-Fire Assessment Using SWAT

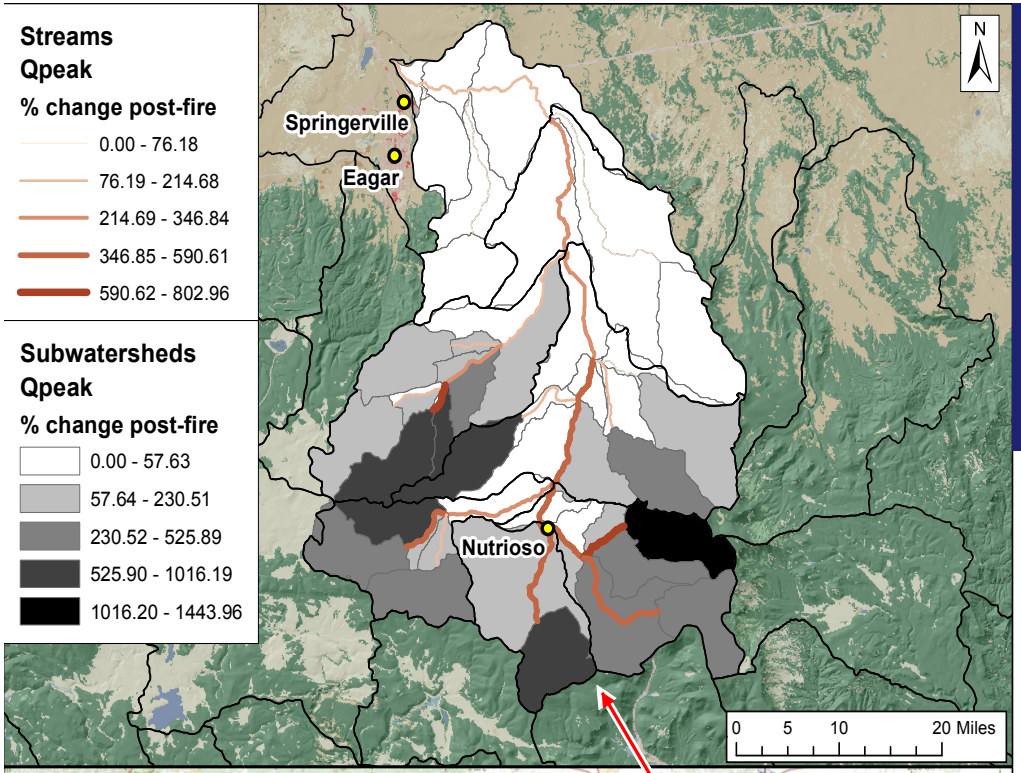


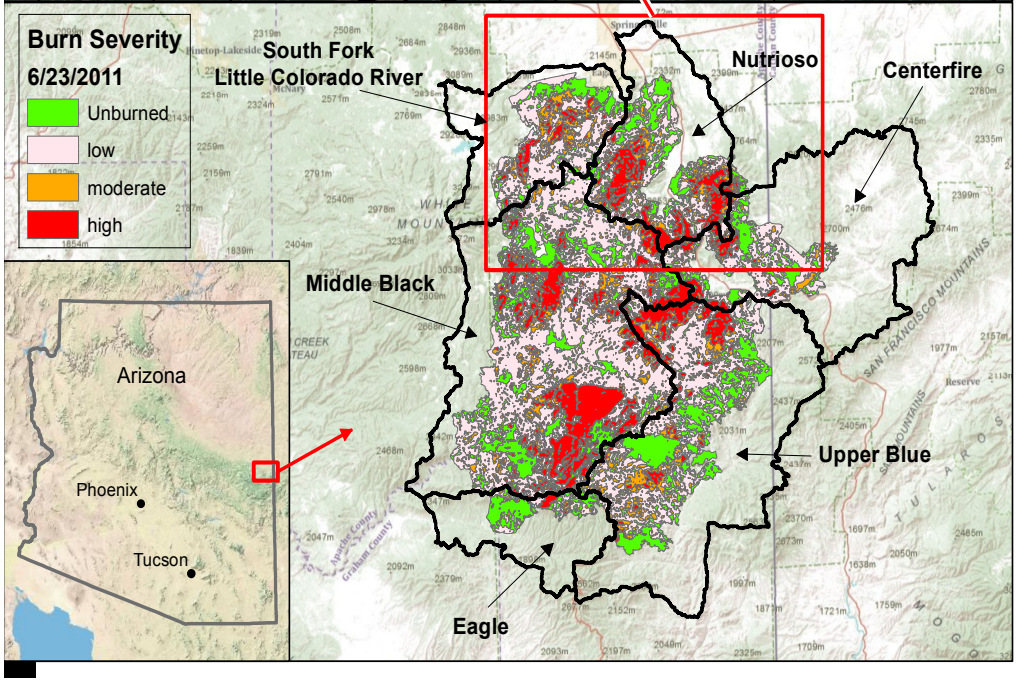




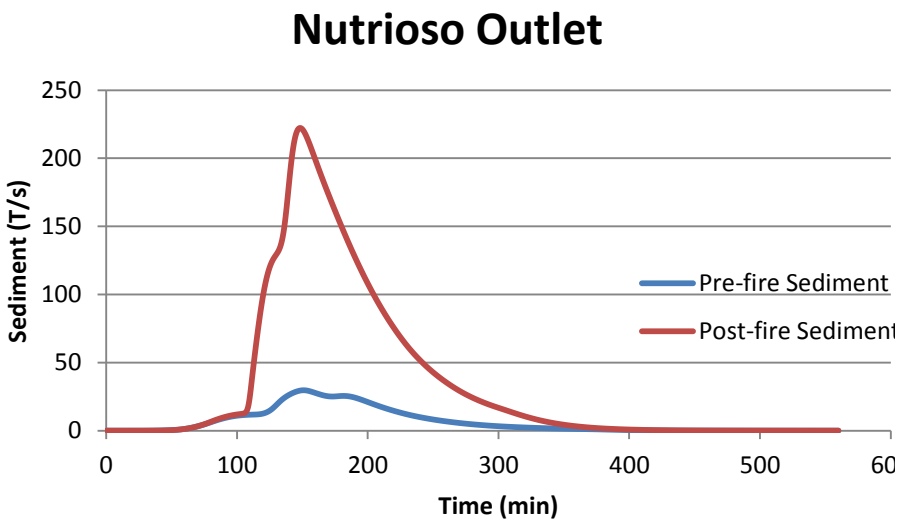


2011 Wallow Fire, AZ
Nutrioso Basin

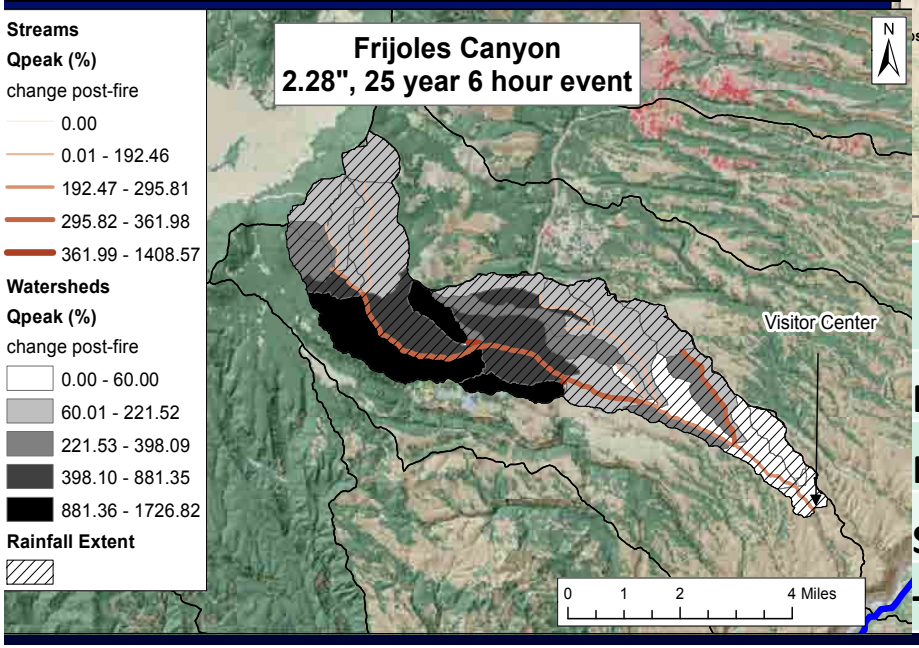


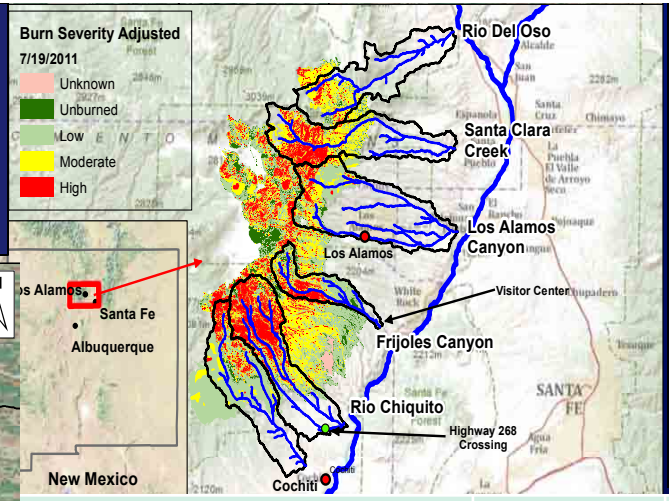


	Pre-fire	Post-fire	Percent Change
Runoff (ft3)	106889903.51	207317929.31	93.95
Peak Flow (cfs)	13100.65	35816.70	173.40
Sediment Yield (tons/ac)	1.94	10.67	449.80
Peak Sediment Flow (tons/s)	29.66	222.29	649.37
Total Sediment (tons)	213327.39	1172863.82	449.80



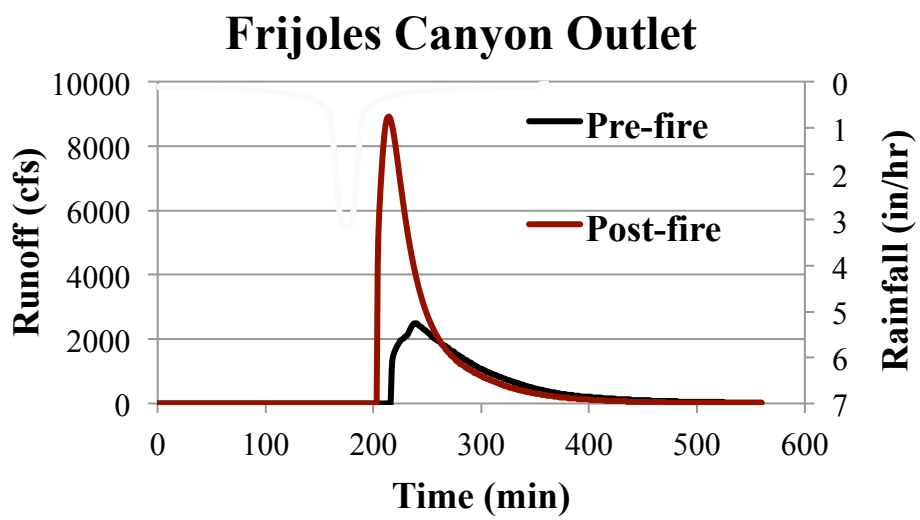
Las Conchas Fire - Frijoles Canyon Bandelier National Monument

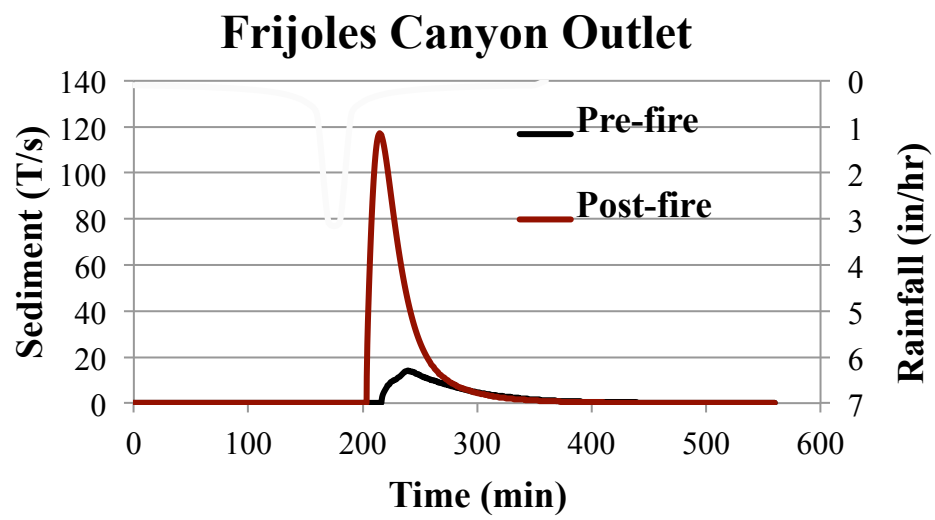




2.28", 25 year 6 hour design Storm

	Pre-fire Outlet	Post-fire Outlet	Percent Change
Peak Flow (cfs)	2490	8931	259
Peak Sediment (T/s)	13.98	117.07	737
Sediment Yield (tons/ac)	5.04	20.77	312
Total Sediment (tons)	59400	244829	312





Summary & Future Direction

- Changes in roughness can explain much of the post-fire hydrologic and erosion response.
- AGWA provides framework to quickly parameterize hydrologic/ erosion models and visualize the results.
- AGWA provides watershed scale assessments for both runoff and erosion/sediment transport at multiple points of potential risk and over all model elements
- With WEPP incorporated into AGWA all FS disturbed WEPP parameters can be employed
- IBAER team leader TJ Clifford noted high value of AGWA for rapid assessment in Wallow and Las Conchas fires
- Improve post-fire parameter estimates with additional fire data
- Working with NIFC to standardize pre-, post-fire AGWA modeling procedures and standardized reporting formats with coordinated training

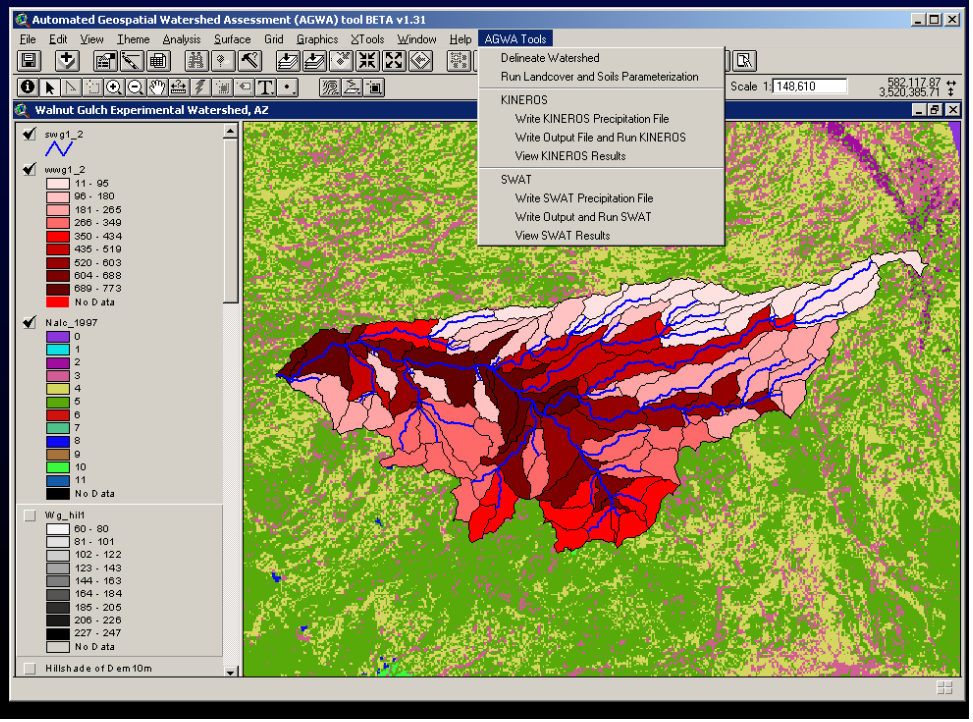
Information

AGWA
The Automated Geospatial Watershed Assessment Tool

AGWA Web Pages:

http://www.tucson.ars.ag.gov/agwa/

http://www.epa.gov/nerlesd1/land-sci/agwa/

Includes:

- Documentation
- Software
- Tutorials
- Pubs / Presentations