Arizona NEMO: GIS Applications and AGWA Modeling for Integrated Watershed Management

Kristine Uhlman, RG
D. Phil Guertin
University of Arizona

Components of the Watershed-Based Plans

GIS-based Land Use and Land Cover Analyses:

- ~ Physical
- ~ Biological
- ~ Social
- ~ Economic

Watershed Classification / Prioritization for Susceptibility to Water Quality Problems:

- ~ Metals
- ~ Sediment
- ~ Organics
- ~ Selenium

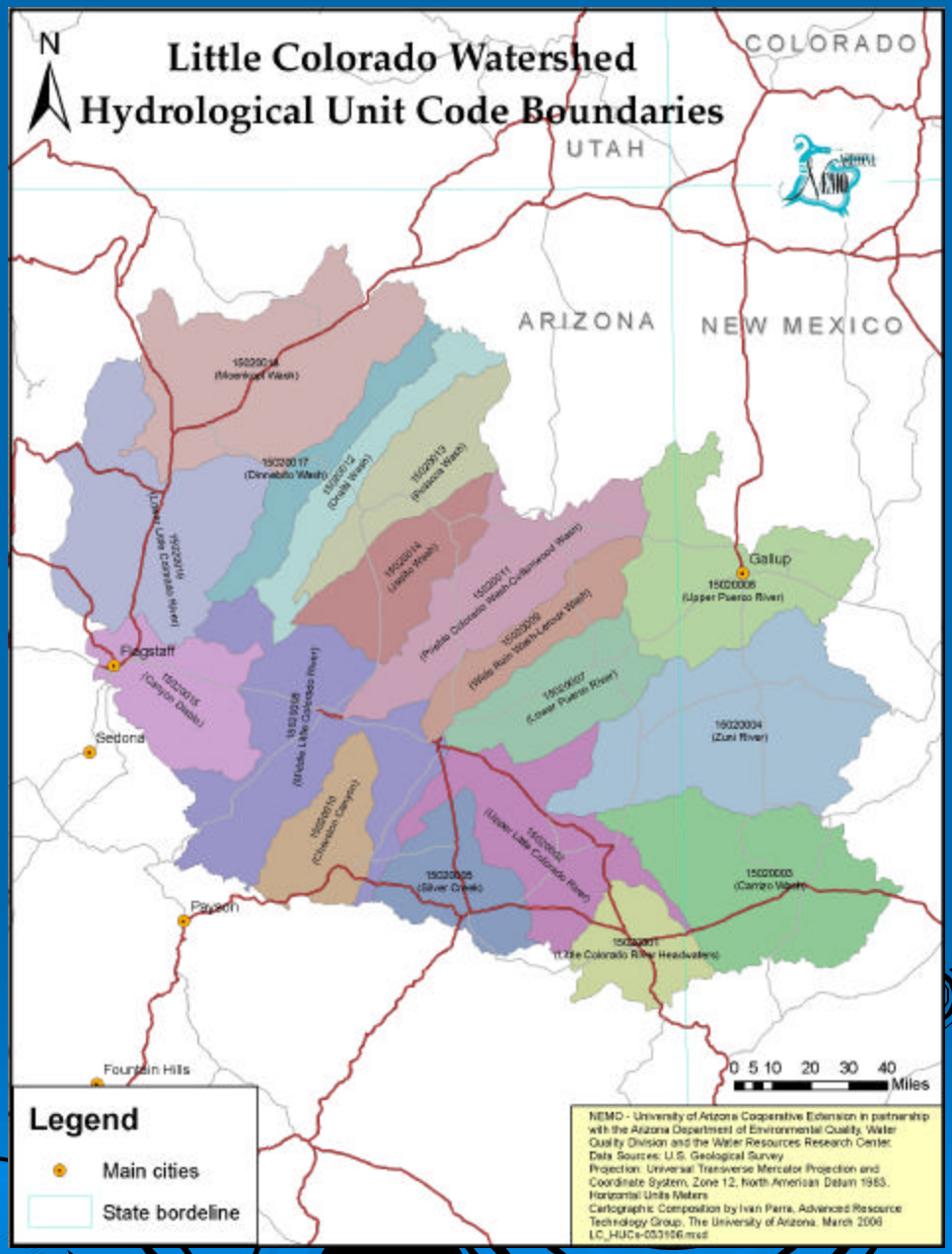
Watershed-Based Plans

Bill Williams
Verde
Little Colorado
Upper Gila
Agua Fria (Middle Gila)
San Pedro

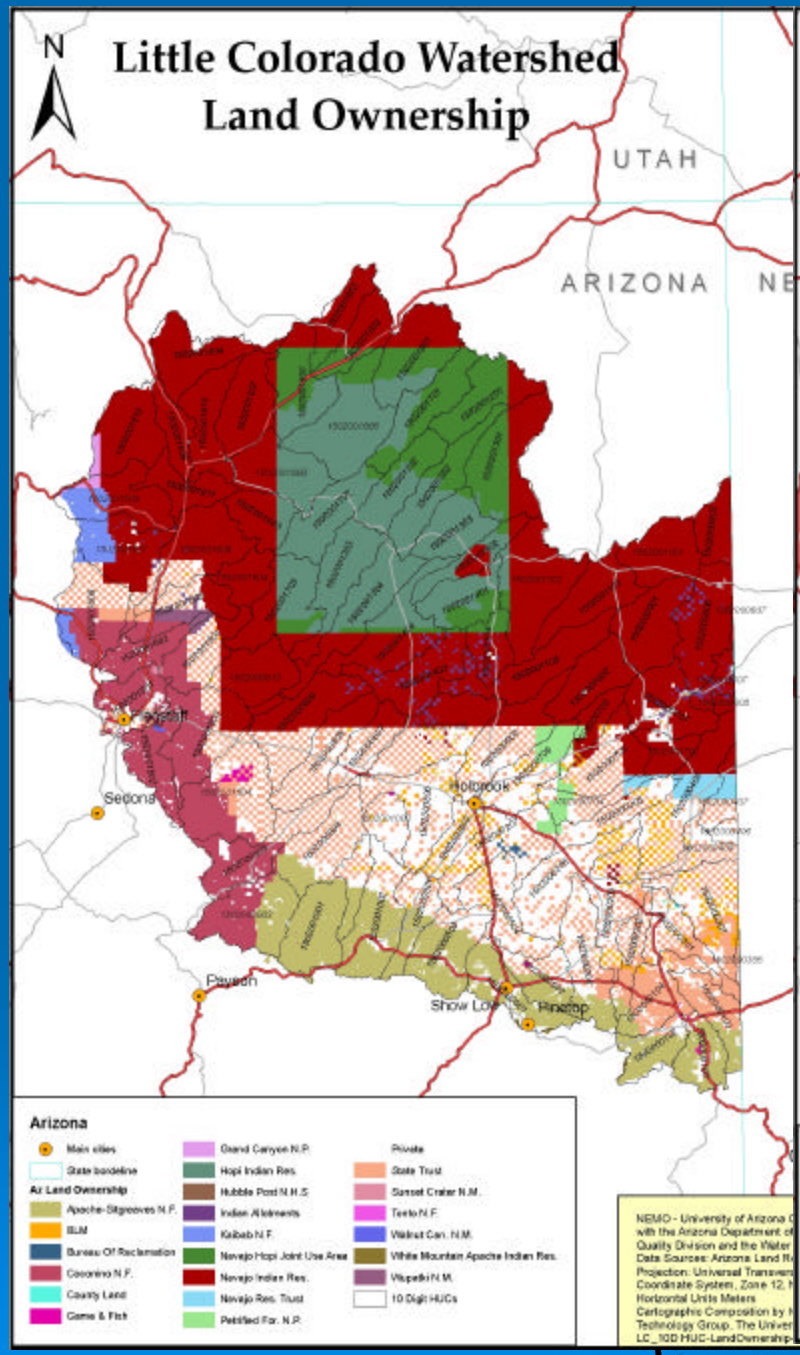
2007 / 2008:
Santa Cruz
Middle Gila
Salt

The Little Colorado River Watershed area is approximately 27,051 square miles, covering a little over 19% of the state of Arizona.

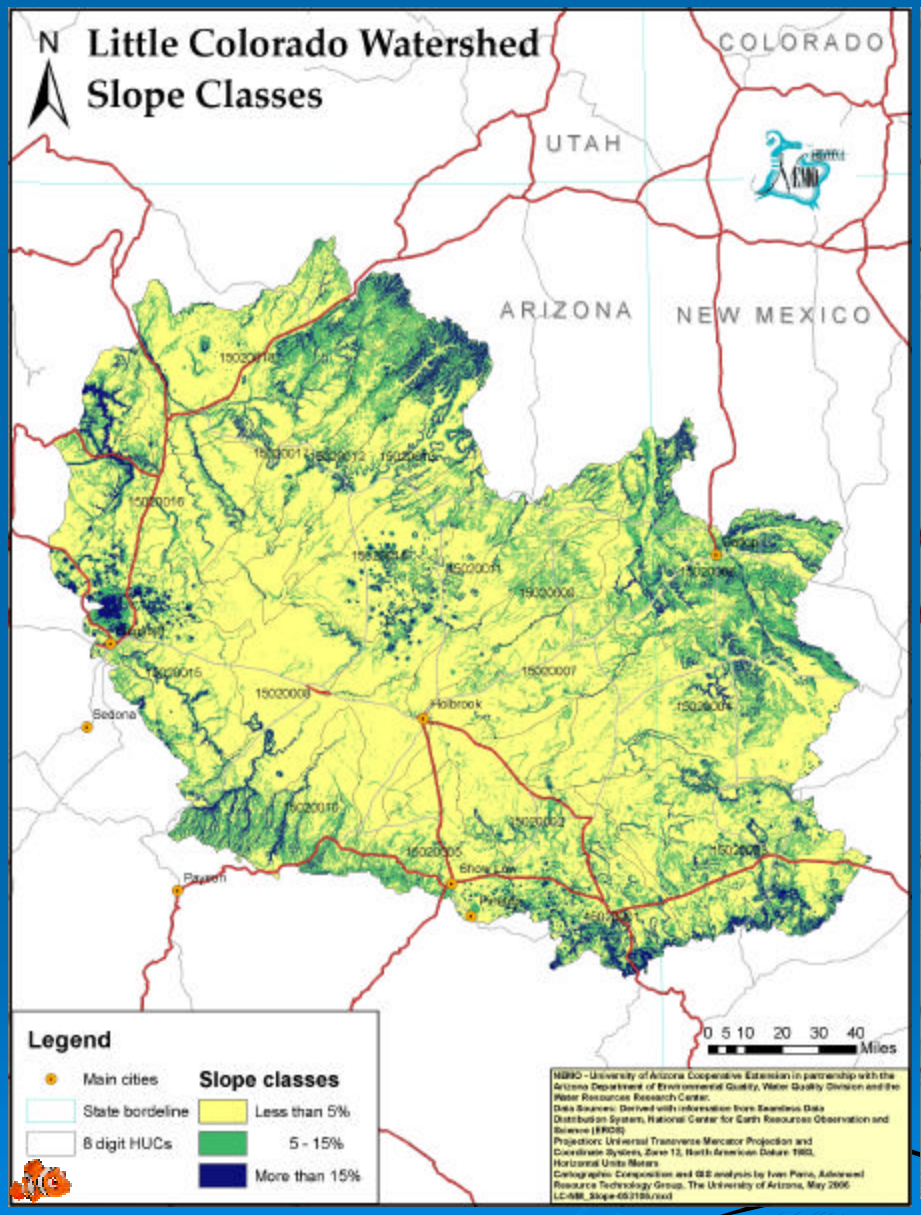
6-digit HUC = 150200

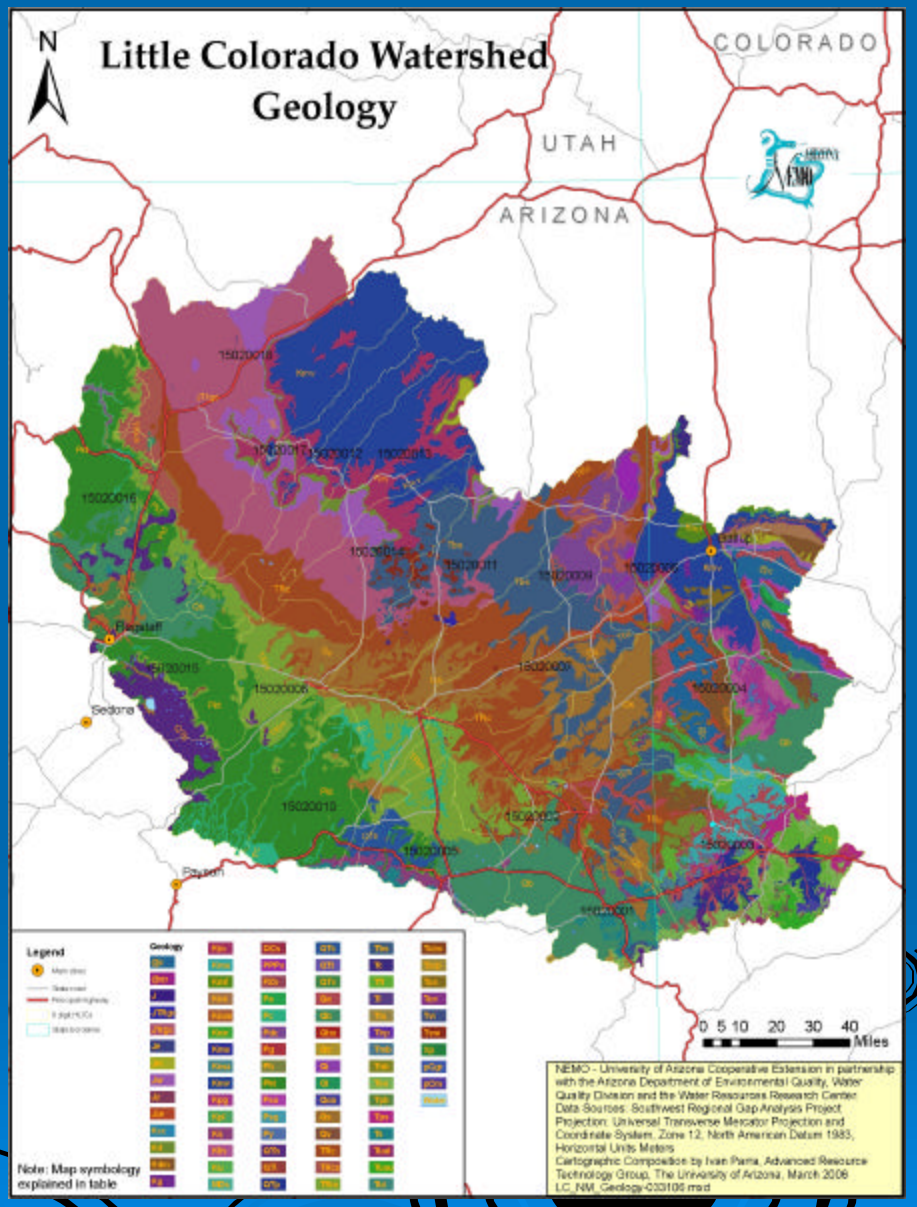


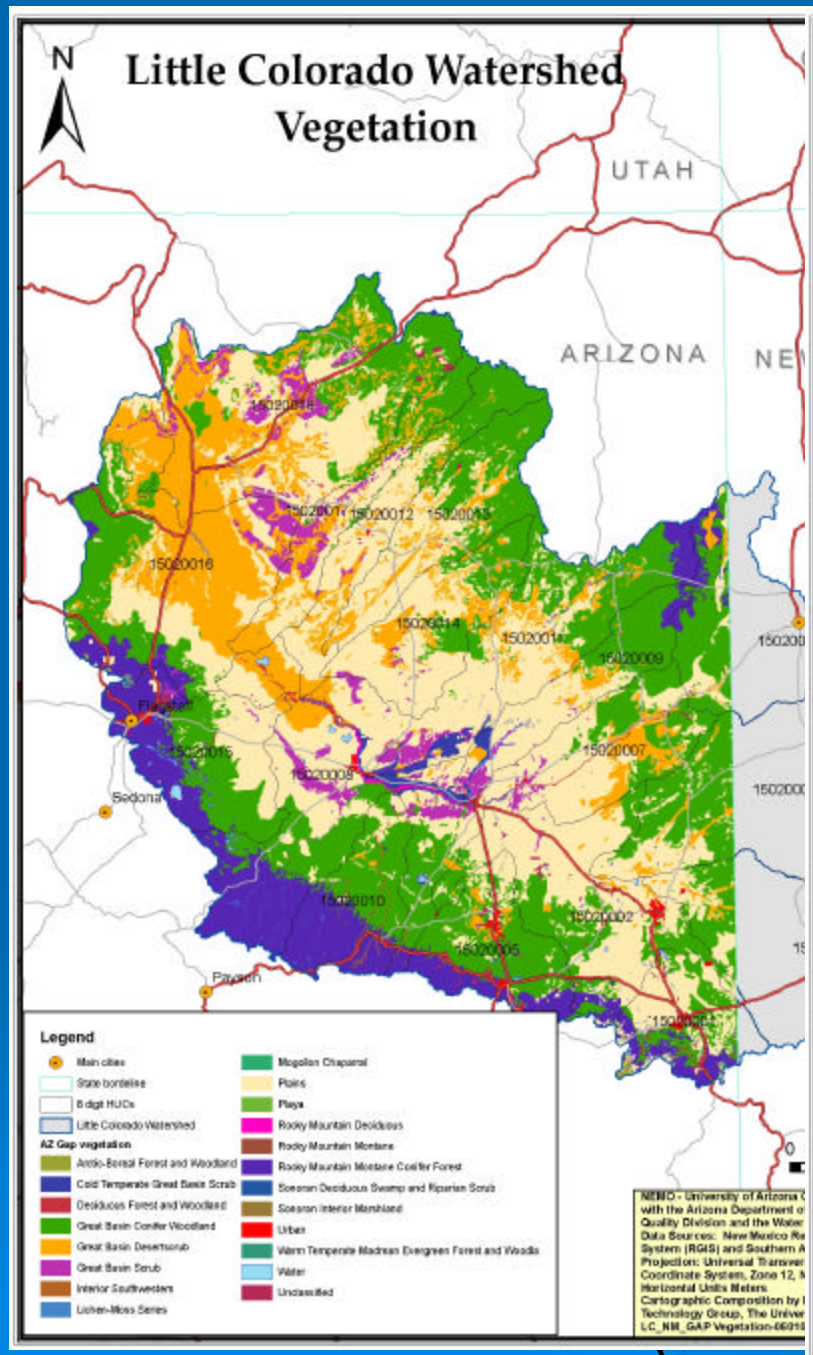
18 8-digit HUCs, 92 10-digit HUCs

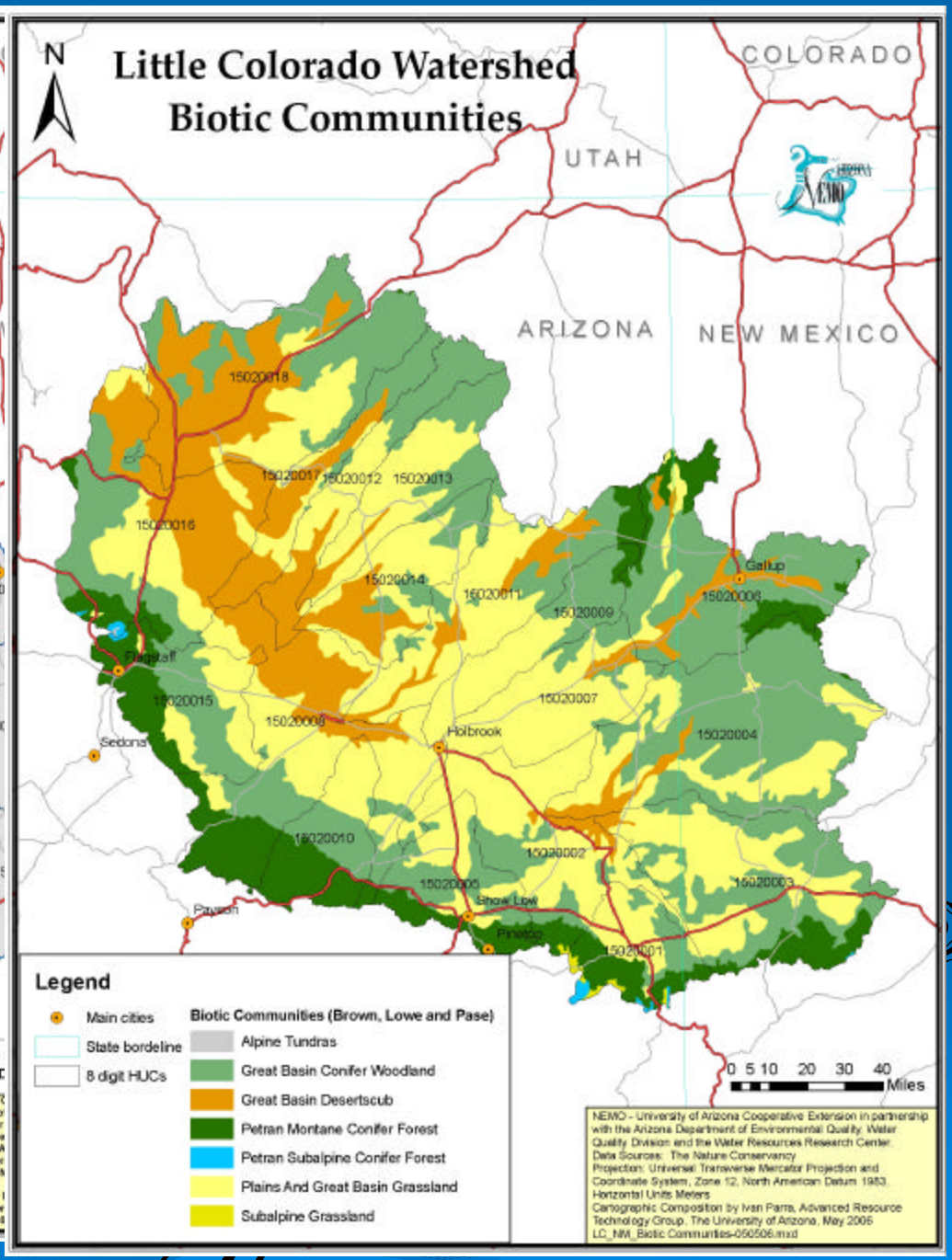

Little Colorado Watershed
Land Ownership
N
UTAH
ARIZONA
Flagstaff
Sedona
Holbrook
Pinetop
Show Low
Payson
Arizona
Main cities
State borderline
Air Land Ownership
Apache-Sitgreaves N.F.
BLM
Bureau Of Reclamation
Coconino N.F.
County Land
Game & Fish
Grand Canyon N.P.
Hopi Indian Res.
Hubble Post N.H.S.
Indian Allotments
Kaibab N.F.
Navajo Hopi Joint Use Area
Navajo Indian Res.
Navajo Res. Trust
Petrified For. N.P.
Private
State Trust
Sunset Crater N.M.
Tonto N.F.
Walnut Can. N.M.
White Mountain Apache Indian Res.
Wupatki N.M.
10 Digit HUCs

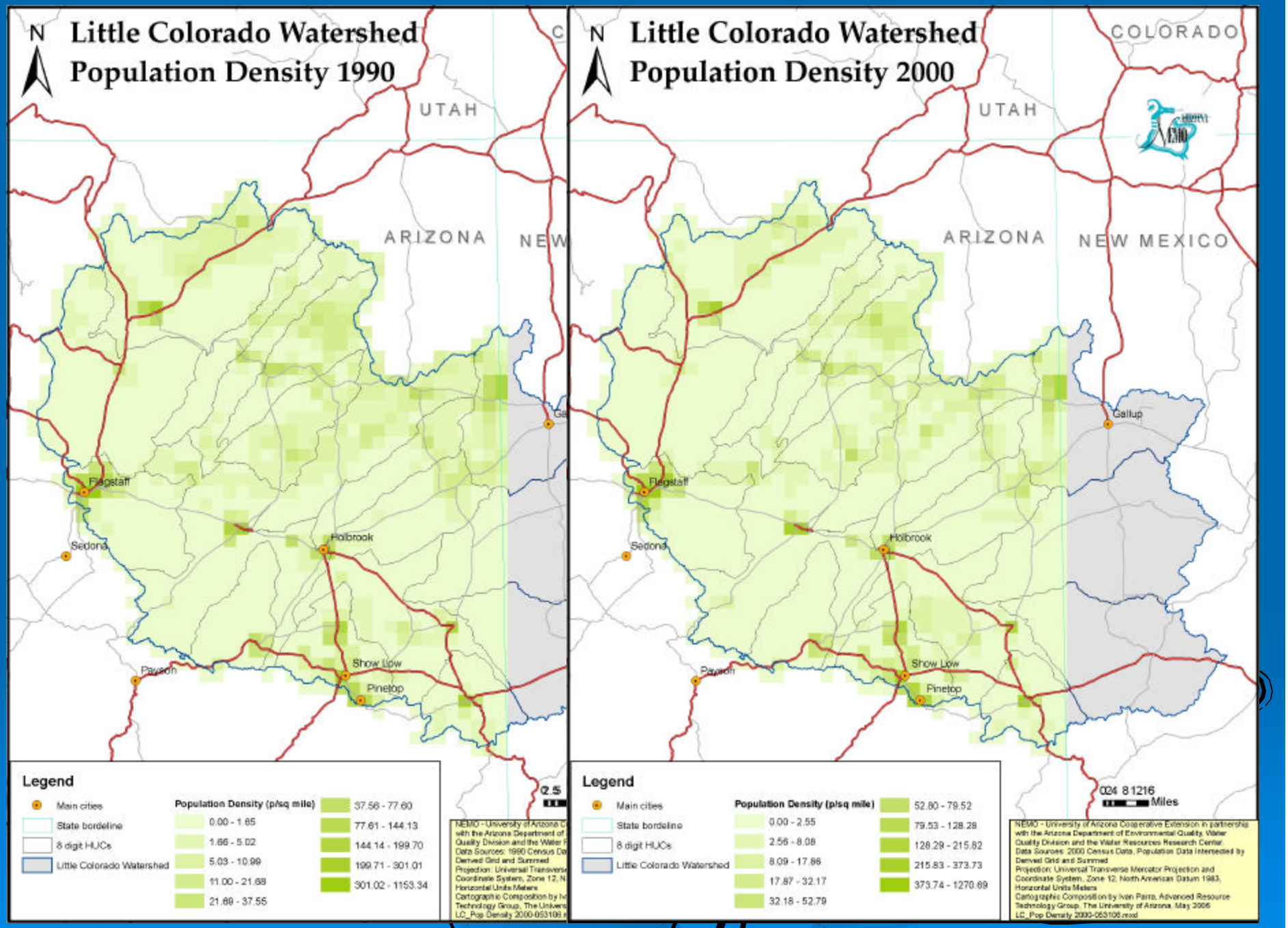

Little Colorado Watershed
Topography
N
COLORADO
UTAH
ARIZONA
NEW MEXICO
15020018
15020017
15020012
15020013
15020016
15020014
15020011
15020009
15020006
Gallup
Flagstaff
15020015
15020008
15020007
15020004
Sedona
15020010
15020002
15020005
15020003
Payson
15020001
Legend
Main cities
State bordeline
8 digit HUCs
Altitude
High: 12,585 feet
Low: 2,733 feet
0 5 10 20 30 40
Miles


Little Colorado Watershed
Slope Classes
N
COLORADO
UTAH
ARIZONA
NEW MEXICO
Flagstaff
Sedona
Holbrook
Payson
Show Low
Legend
Main cities
State bordeline
8 digit HUCs
Slope classes
Less than 5%
5 - 15%
More than 15%
0 5 10 20 30 40
Miles


Little Colorado Watershed
Geology
N
COLORADO
UTAH
ARIZONA
Flagstaff
Sedona
Payson
Legend
Note: Map symbology explained in table
0 5 10 20 30 40
Miles

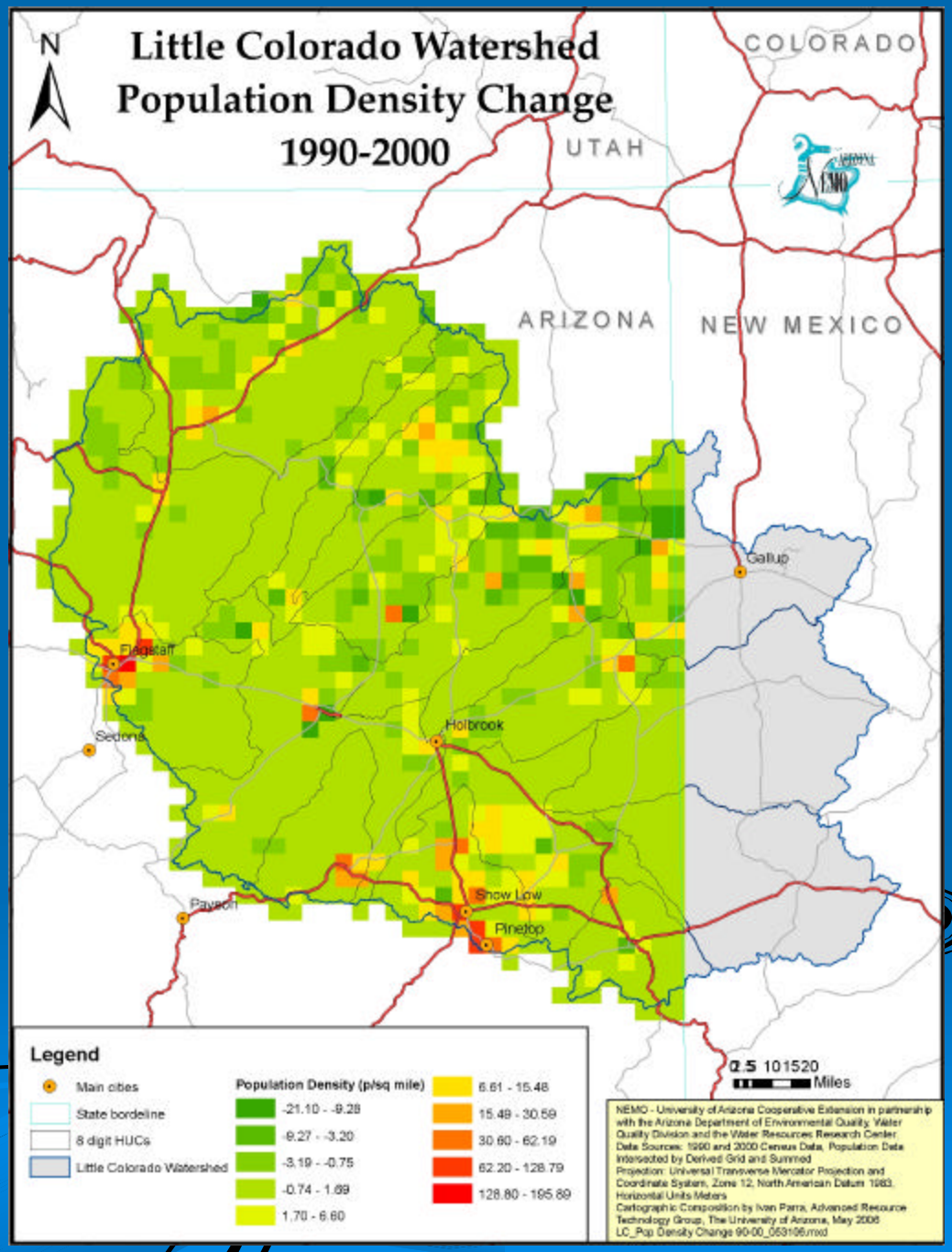

Little Colorado Watershed
Vegetation
N
UTAH
ARIZONA
Flagstaff
Sedona
Payson
Legend
Main cities
State borderline
8 digit HUCs
Little Colorado Watershed
AZ Gap vegetation
Arctic-Boreal Forest and Woodland
Cold Temperate Great Basin Scrub
Deciduous Forest and Woodland
Great Basin Conifer Woodland
Great Basin Desertscrub
Great Basin Scrub
Interior Southwestern
Lichen-Moss Series
Mogollon Chaparral
Plains
Playa
Rocky Mountain Deciduous
Rocky Mountain Montane
Rocky Mountain Montane Conifer Forest
Sonoran Deciduous Swamp and Riparian Scrub
Sonoran Interior Marshland
Urban
Warm Temperate Madrean Evergreen Forest and Woodla
Water
Unclassified


Little Colorado Watershed
Biotic Communities
N
COLORADO
UTAH
ARIZONA
NEW MEXICO
Gallup
Flagstaff
Sedona
Holbrook
Show Low
Payson
Legend
Main cities
State borderline
8 digit HUCs
Biotic Communities (Brown, Lowe and Pase)
Alpine Tundras
Great Basin Conifer Woodland
Great Basin Desertscub
Petran Montane Conifer Forest
Petran Subalpine Conifer Forest
Plains And Great Basin Grassland
Subalpine Grassland
0 5 10 20 30 40
Miles

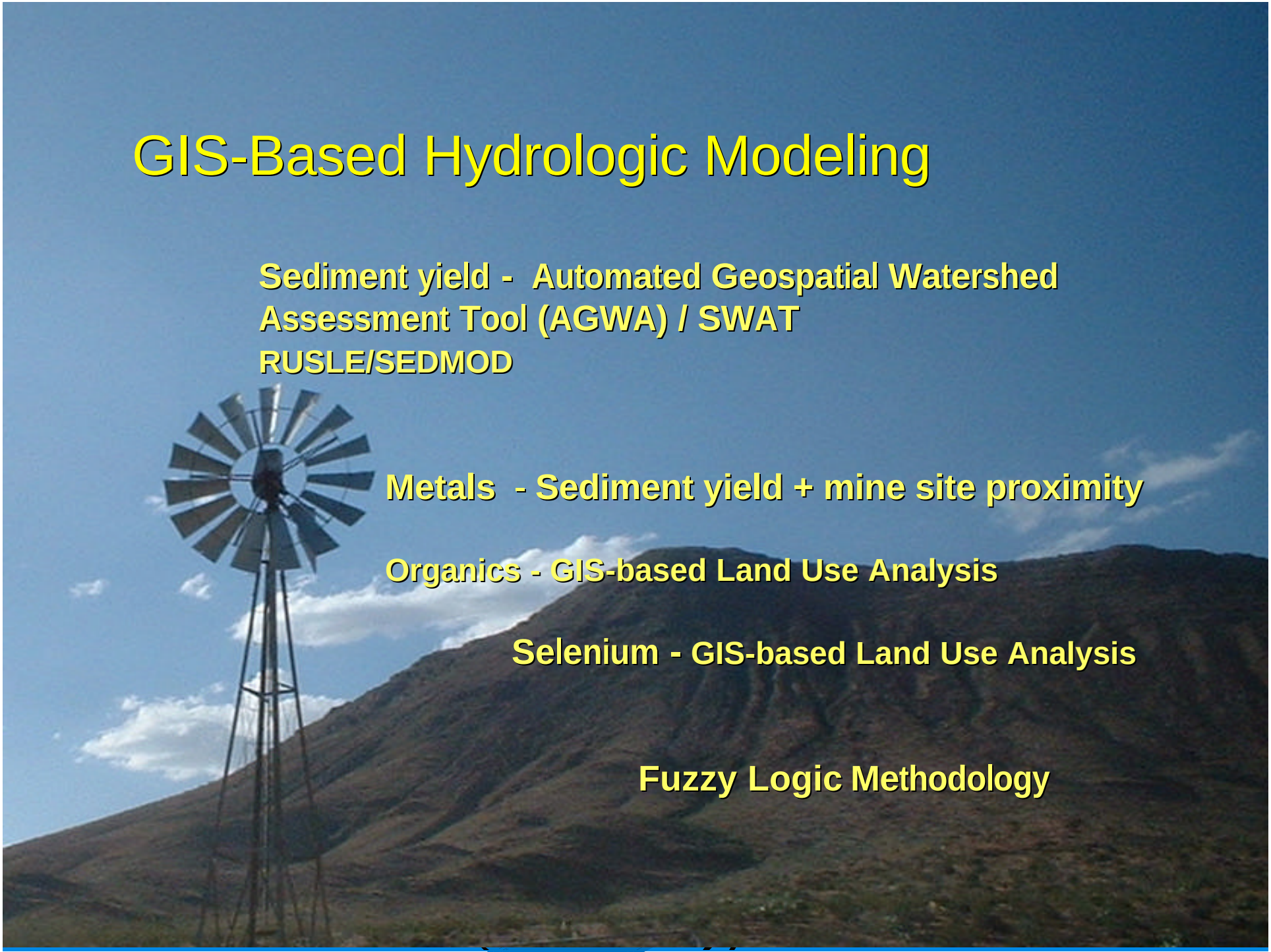

Little Colorado Watershed
Population Density 1990
UTAH
ARIZONA
Flagstaff
Sedona
Holbrook
Show Low
Payson
Pinetop
Legend
Main cities
State borderline
8 digit HUCs
Little Colorado Watershed
Population Density (p/sq mile)
0.00 - 1.65
1.66 - 5.02
5.03 - 10.99
11.00 - 21.68
21.69 - 37.55
37.56 - 77.60
77.61 - 144.13
144.14 - 199.70
199.71 - 301.01
301.02 - 1153.34
Little Colorado Watershed
Population Density 2000
COLORADO
UTAH
ARIZONA
NEW MEXICO
Gallup
Flagstaff
Sedona
Holbrook
Show Low
Payson
Pinetop
Legend
Main cities
State borderline
8 digit HUCs
Little Colorado Watershed
Population Density (p/sq mile)
0.00 - 2.55
2.56 - 8.08
8.09 - 17.86
17.87 - 32.17
32.18 - 52.79
52.80 - 79.52
79.53 - 128.28
128.29 - 215.82
215.83 - 373.73
373.74 - 1270.69
Miles

Population Change

ESRI 2006
"Best Analytical Presentation"



GIS-Based Hydrologic Modeling



Sediment yield - Automated Geospatial Watershed Assessment Tool (AGWA) / SWAT
RUSLE/SEDMOD

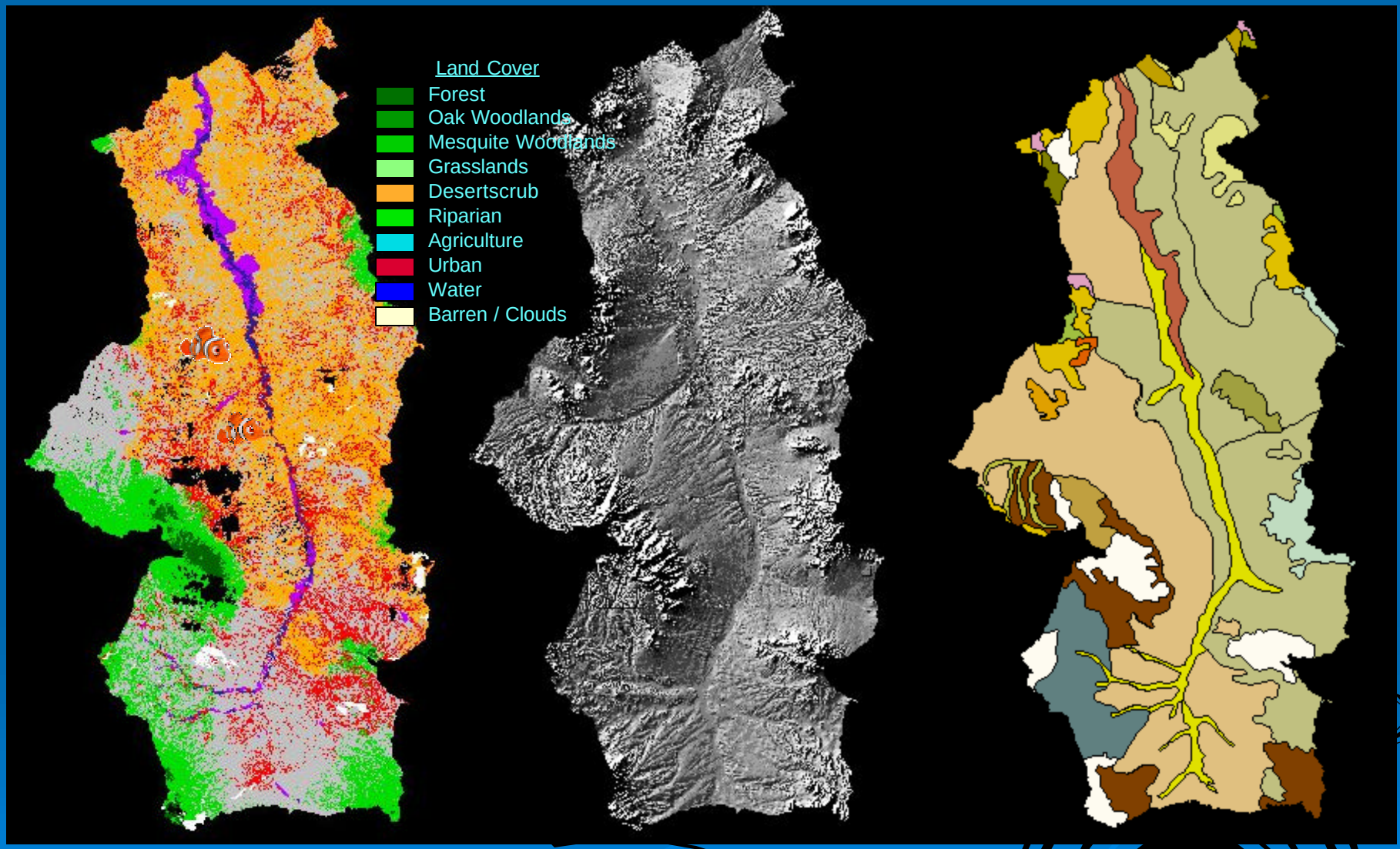
Metals - Sediment yield + mine site proximity

Organics - GIS-based Land Use Analysis

Selenium - GIS-based Land Use Analysis

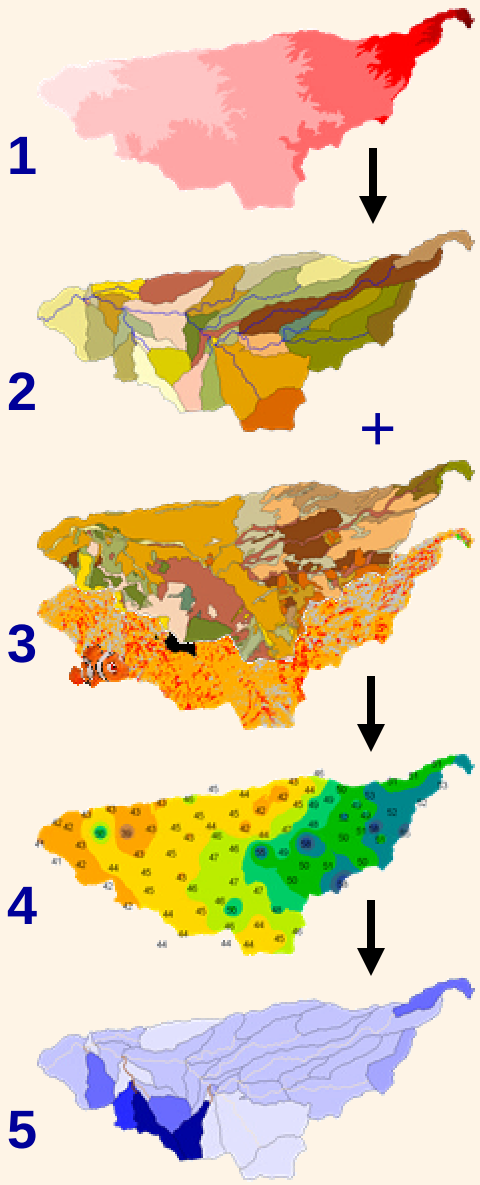
Fuzzy Logic Methodology

Automated Geospatial Watershed Assessment - AGWA



Advanced Resource Technology – ART Lab – GIS Watershed Modeling

Automated Geospatial Watershed Assessment Tool (AGWA)



Inputs: Digital Elevation Models (DEMs), flow direction and flow accumulation grids.

Delineate and discretize the watershed, using a user-specified outlet and contributing source area,

Parameterize the watershed for soils and land cover to determine model parameters.

Generate precipitation files

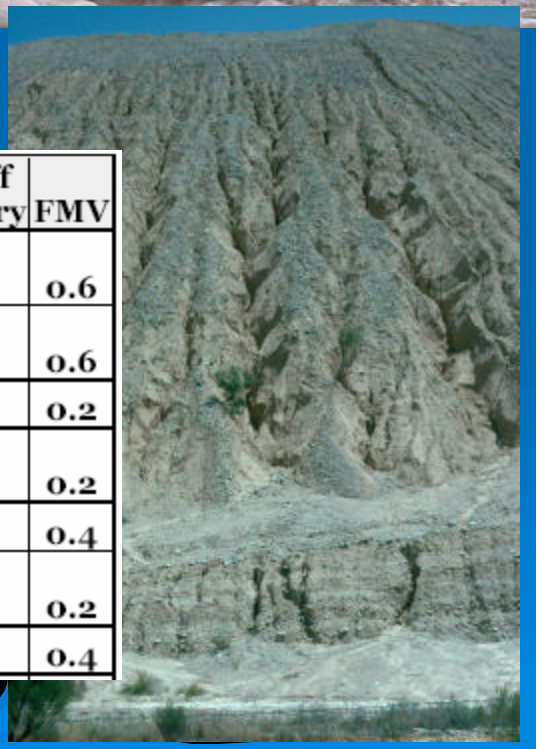
Run the model and view results.

- Extension for ArcView 3.x
- Runs two runoff/erosion models: KINEROS2 & SWAT
- Model simulations identify subwatershed areas vulnerable to increased sedimentation and erosion due to soil and slope conditions as well as land use practices across the watershed.

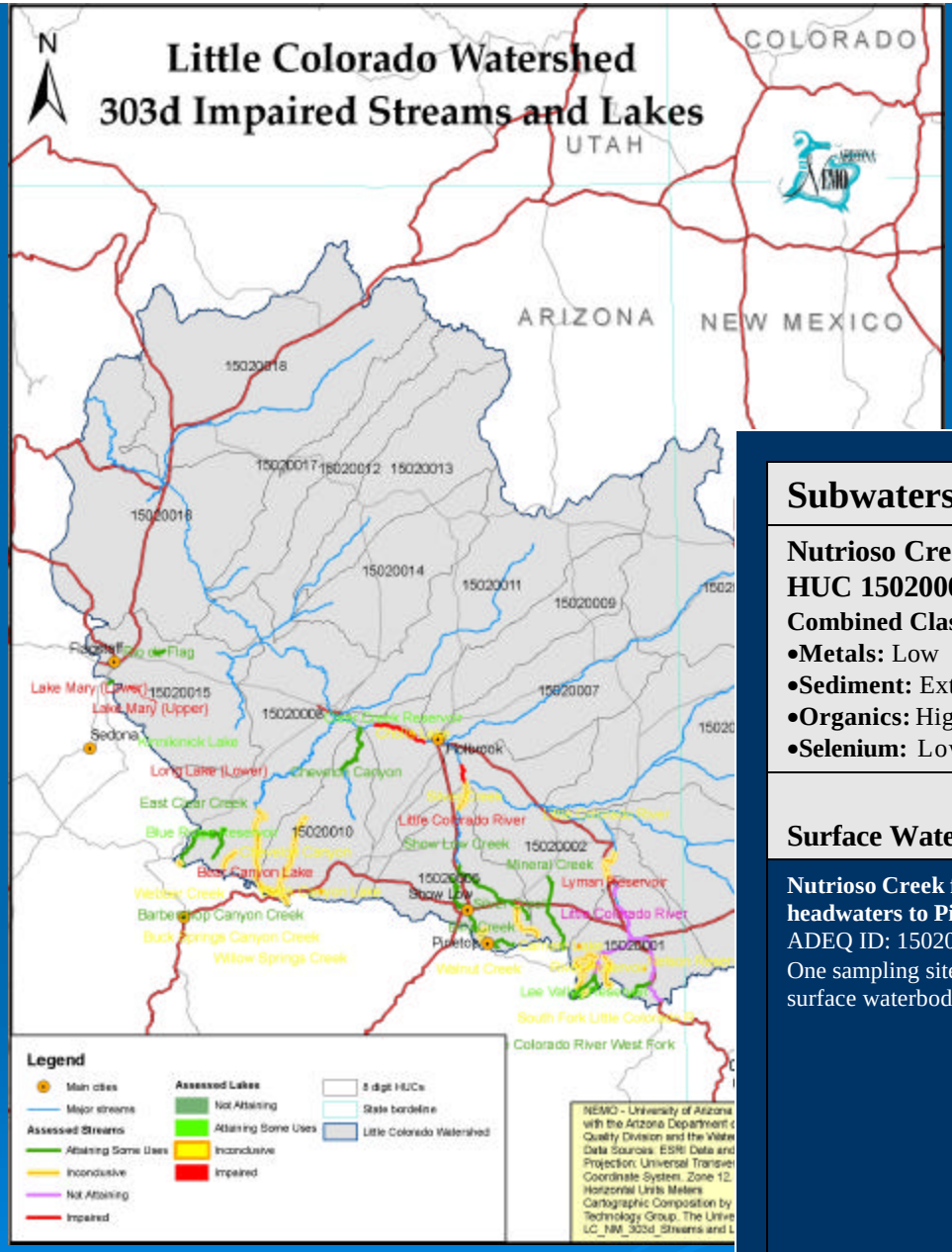
www.tucson.ars.ag.gov/agwa

Sediment

- ADEQ Sediment or Turbidity data
- GIS analysis for human use
  Urbanization
- GIS analysis of Land ownership
  FMV = 0 if (% State + private <= 10)
  FMV = (% State + private – 10) / 15
  FMV = 1 if (% State + private >= 25)
- Calc & Classify Runoff & Erosion
  - AGWA / SWAT
- Final ranking using Weighted Combination method of Fuzzy Logic for each subwatershed



Subwatershed	Runoff Category	FMV
Railroad Wash-Upper Gila River	3	0.6
Apache Creek-Upper Gila River	3	0.6
Animas Valley	1	0.2
Centerfire Creek-San Francisco River	1	0.2
Upper Blue River	2	0.4
Pueblo Creek-San Francisco River	1	0.2
Lower Blue River	2	0.4

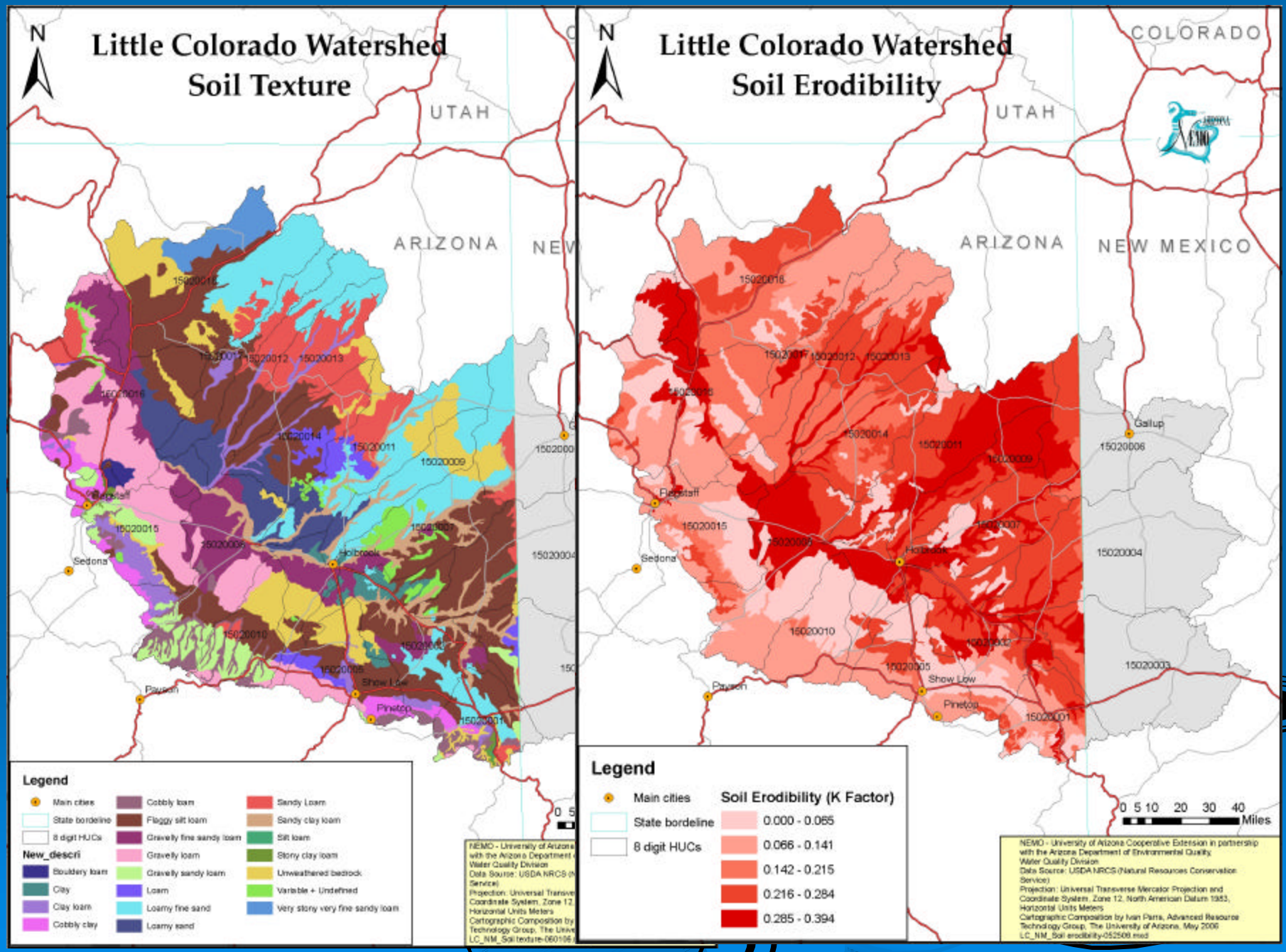


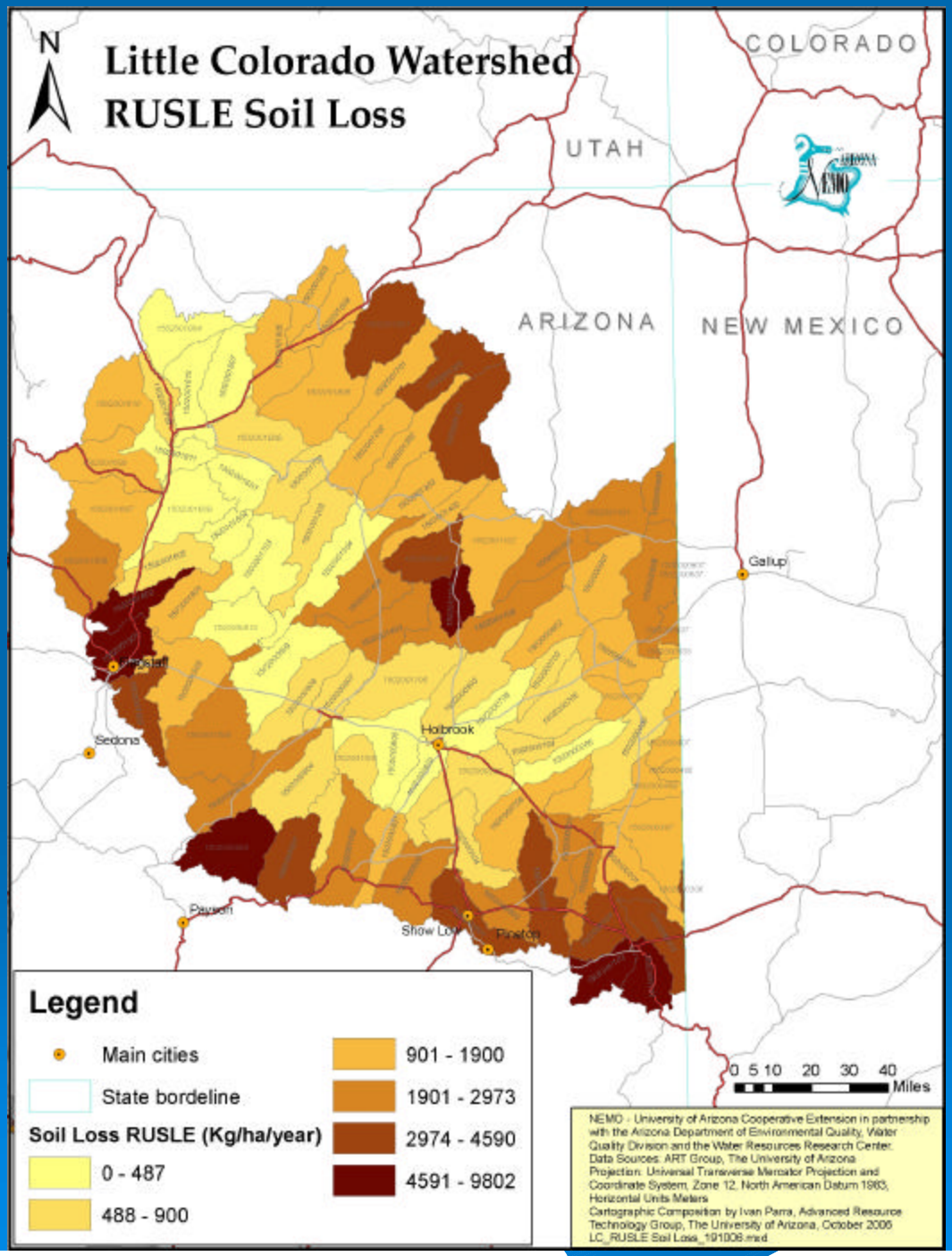
Appendix A: ADEQ Data

Subwatershed

Nutrioso Creek Subwatershed
HUC 1502000101
Combined Classification for Risk of Impairment:
- **Metals:** Low
- **Sediment:** Extreme due to exceedances at Nutrioso Creek;
- **Organics:** High due to insufficient data at McKay Reservoir
- **Selenium:** Low

Surface Waterbody	Water Quality Data: Sampling and Assessment Status [i], [ii], [iii]	
Nutrioso Creek from headwaters to Picnic Creek ADEQ ID: 15020001-017 One sampling site at this surface waterbody.	Sampling	•**Metals:** Arsenic (td4); barium (td4); beryllium (td4); thorium (td4); antimony (td4); mercury (td4); cadmium (td4); chromium (td4); copper (td4); lead (td4); nickel (td4); silver (td4); zinc (td4); magnesium (4t); fluoride(4); boron (4); •**Sediment:** Total dissolved solids (4) and turbidity (4) •**Organics:** *E. coli* (4); •**Selenium:** selenium (4);
	Status	Parameters exceeding standards: Turbidity (1/1). Currently assessed as "Impaired". Surface Waterbody risk classification: •**Metals:** Low •**Sediment:** Moderate due to insufficient data •**Organics:** Extreme due to exceedance •**Selenium:** Low


Little Colorado Watershed
Soil Texture
N
UTAH
ARIZONA
Flagstaff
Sedona
Holbrook
Payson
Show Low
Pinetop
Legend
Main cities
State bordeline
8 digit HUCs
New_descri
Bouldery loam
Clay
Clay loam
Cobbly clay
Cobbly loam
Flaggy silt loam
Gravelly fine sandy loam
Gravelly loam
Gravelly sandy loam
Loam
Loamy fine sand
Loamy sand
Sandy Loam
Sandy clay loam
Silt loam
Stony clay loam
Unweathered bedrock
Variable + Undefined
Very stony very fine sandy loam
Little Colorado Watershed
Soil Erodibility
N
COLORADO
UTAH
ARIZONA
NEW MEXICO
Gallup
Flagstaff
Sedona
Holbrook
Payson
Show Low
Pinetop
Legend
Main cities
State bordeline
8 digit HUCs
Soil Erodibility (K Factor)
0.000 - 0.065
0.066 - 0.141
0.142 - 0.215
0.216 - 0.284
0.285 - 0.394
0 5 10 20 30 40
Miles



RUSLE

Soil Loss

10-digit HUCS ranked

0.0 - 1.0

w/ Fuzzy Logic

Fuzzy Membership functions - transform vulnerability / impairment metrics into Fuzzy Membership Values (FMV)

Table 1 - Risk

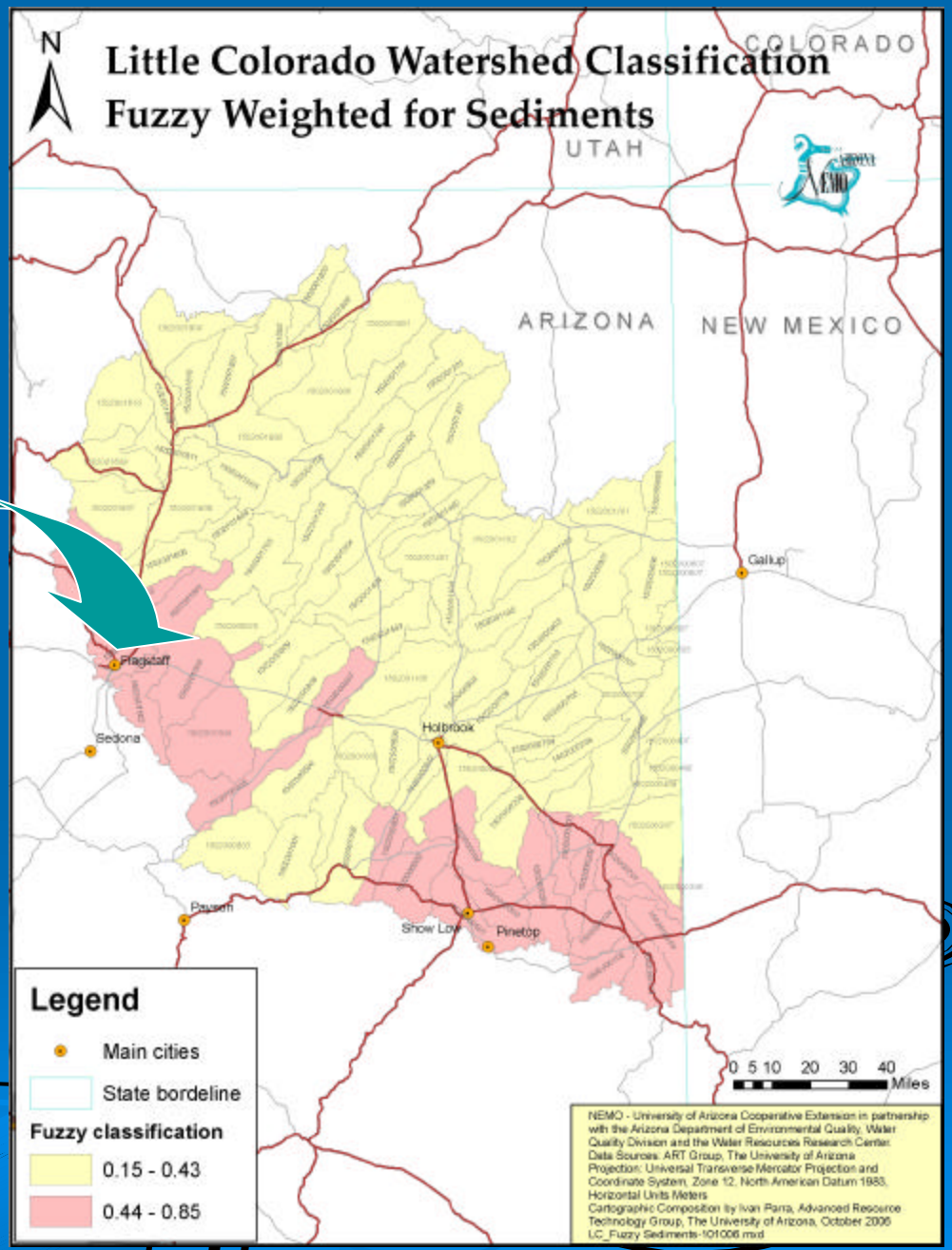
Reach Condition	Downstream WS Condition	FMV
Extreme	N/A	1.0
High	Extreme	1.0
High	High	0.8
High	Moderate /Low	0.7
Moderate	Extreme	0.7
Moderate	High	0.6
Moderate	Moderate	0.5
Moderate	Low	0.3
Low	N/A	0.0

Table 2 – Sediment FMV

Subwatershed Name	FMV	Justification
Railroad Wash-Upper Gila River	0.6	Classified as moderate risk, drains into Apache Creek subwatershed that is classified as high risk.
Apache Creek-Upper Gila River	0.8	Classified as high risk, drains into Yuma Wash subwatershed that is classified as high risk.
Animas Valley	0.5	Classified as moderate risk (no data), and is along the Arizona-New Mexico state line.
Centerfire Creek-San Francisco River	0.5	Classified as moderate risk (limited data), drains into New Mexico.
Upper Blue River	0.6	Classified as moderate risk, drains into Yuma Wash that is classified as high risk.
Pueblo Creek-San Francisco River	0.5	Classified as moderate risk (no data).

Sediments

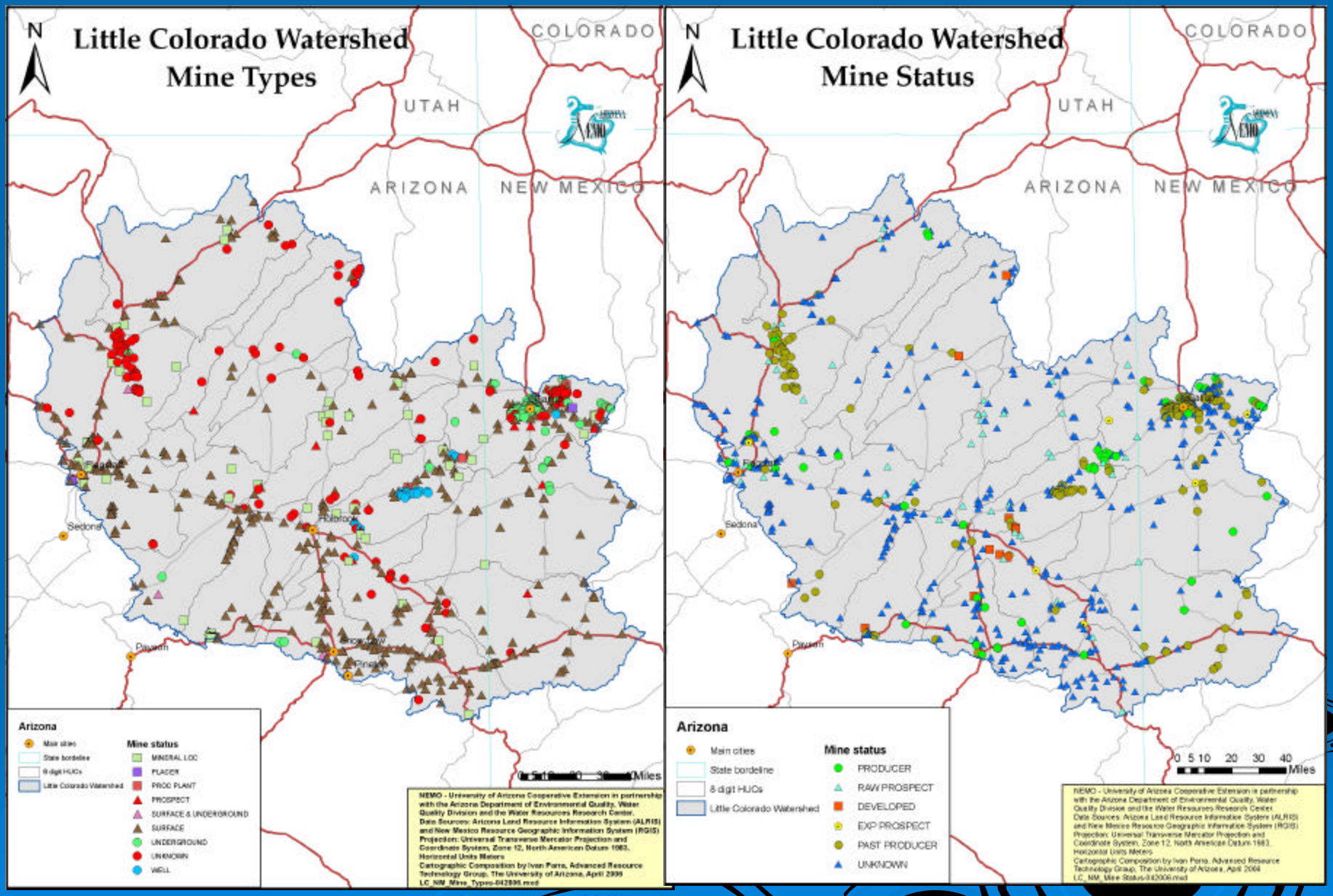
Rio De Flag Subwatershed, in the Flagstaff area, for sediment pollution derived from land use – increased urbanization

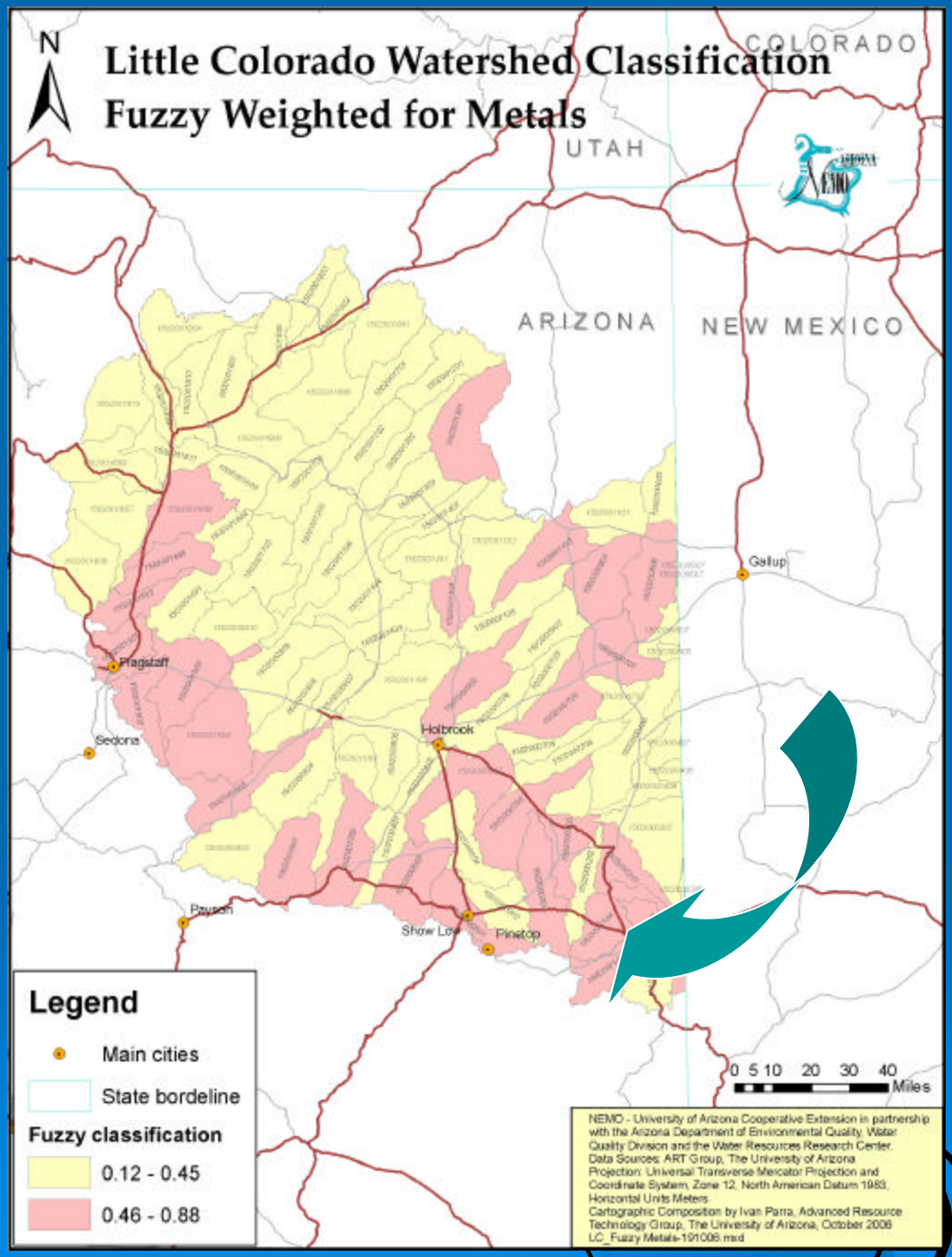


Metals

- Assume sediment from abandoned mine sites contains elevated levels of heavy metals
- Calculate & Classify Sediment Yield
  - RUSLE / SEDMOD
    - ArcInfo Workstation
- ADEQ Water Quality Data
- GIS analysis to rank subwatershed based on number of mines in subwatershed & near streams
- Final ranking using Weighted Combination method of Fuzzy Logic for each subwatershed

Subwatershed	WQA[1]	#Mines/ Subwatershed	#Mines/ Riparian	Erosion Category	FMV Weighted
Railroad Wash-Upper Gila River	0.6	1.000	1.000	0.200	0.640
Apache Creek-Upper Gila River	0.8	1.000	1.000	0.200	0.700
Animas Valley	0.5	0.000	0.000	0.000	0.150
Centerfire Creek-San Francisco River	0.5	0.000	0.000	0.200	0.210
Upper Blue River	0.6	0.250	0.400	0.200	0.385
Pueblo Creek-San Francisco River	0.5	0.000	0.000	0.000	0.150
Lower Blue River	0.6	0.500	0.400	0.200	0.410


Little Colorado Watershed
Mine Types
N
COLORADO
UTAH
ARIZONA
NEW MEXICO
Sedona
Payson
Arizona
Main cities
State borderline
8 digit HUCs
Little Colorado Watershed
Mine status
MINERAL LOC
PLACER
PROC PLANT
PROSPECT
SURFACE & UNDERGROUND
SURFACE
UNDERGROUND
UNKNOWN
WELL
Miles
NEMO - University of Arizona Cooperative Extension in partnership with the Arizona Department of Environmental Quality, Water Quality Division and the Water Resources Research Center.
Data Sources: Arizona Land Resource Information System (ALRIS) and New Mexico Resource Geographic Information System (RGIS)
Projection: Universal Transverse Mercator Projection and Coordinate System, Zone 12, North American Datum 1983.
Horizontal Units Meters
Cartographic Composition by Ivan Parra, Advanced Resource Technology Group, The University of Arizona, April 2000
LC_NM_Mine_Types-042806.mxd
Little Colorado Watershed
Mine Status
N
COLORADO
UTAH
ARIZONA
NEW MEXICO
Sedona
Payson
Arizona
Main cities
State borderline
8 digit HUCs
Little Colorado Watershed
Mine status
PRODUCER
RAW PROSPECT
DEVELOPED
EXP PROSPECT
PAST PRODUCER
UNKNOWN
0 5 10 20 30 40
Miles
NEMO - University of Arizona Cooperative Extension in partnership with the Arizona Department of Environmental Quality, Water Quality Division and the Water Resources Research Center.
Data Sources: Arizona Land Resource Information System (ALRIS) and New Mexico Resource Geographic Information System (RGIS)
Projection: Universal Transverse Mercator Projection and Coordinate System, Zone 12, North American Datum 1983.
Horizontal Units Meters
Cartographic Composition by Ivan Parra, Advanced Resource Technology Group, The University of Arizona, April 2000
LC_NM_Mine Status-042006.mxd

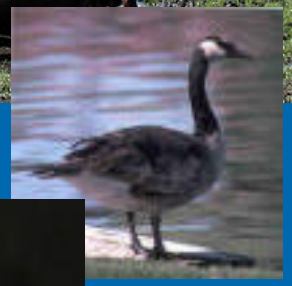


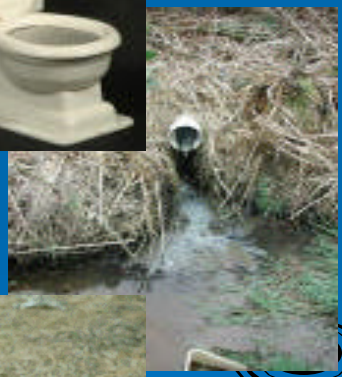
Metals

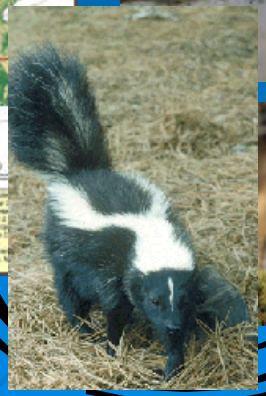
Carnero Creek Subwatershed – Little Colorado River Headwaters Subwatershed,
for metals pollution.

Organics

- ADEQ Water Quality Data for Nitrogen, pH, *E. coli,* DO
- GIS Analysis of Land Use
  - Grazing
- GIS Analysis of Human Use
  - Subwatershed and near riparian area
- Final ranking using Weighted Combination method of Fuzzy Logic for each subwatershed

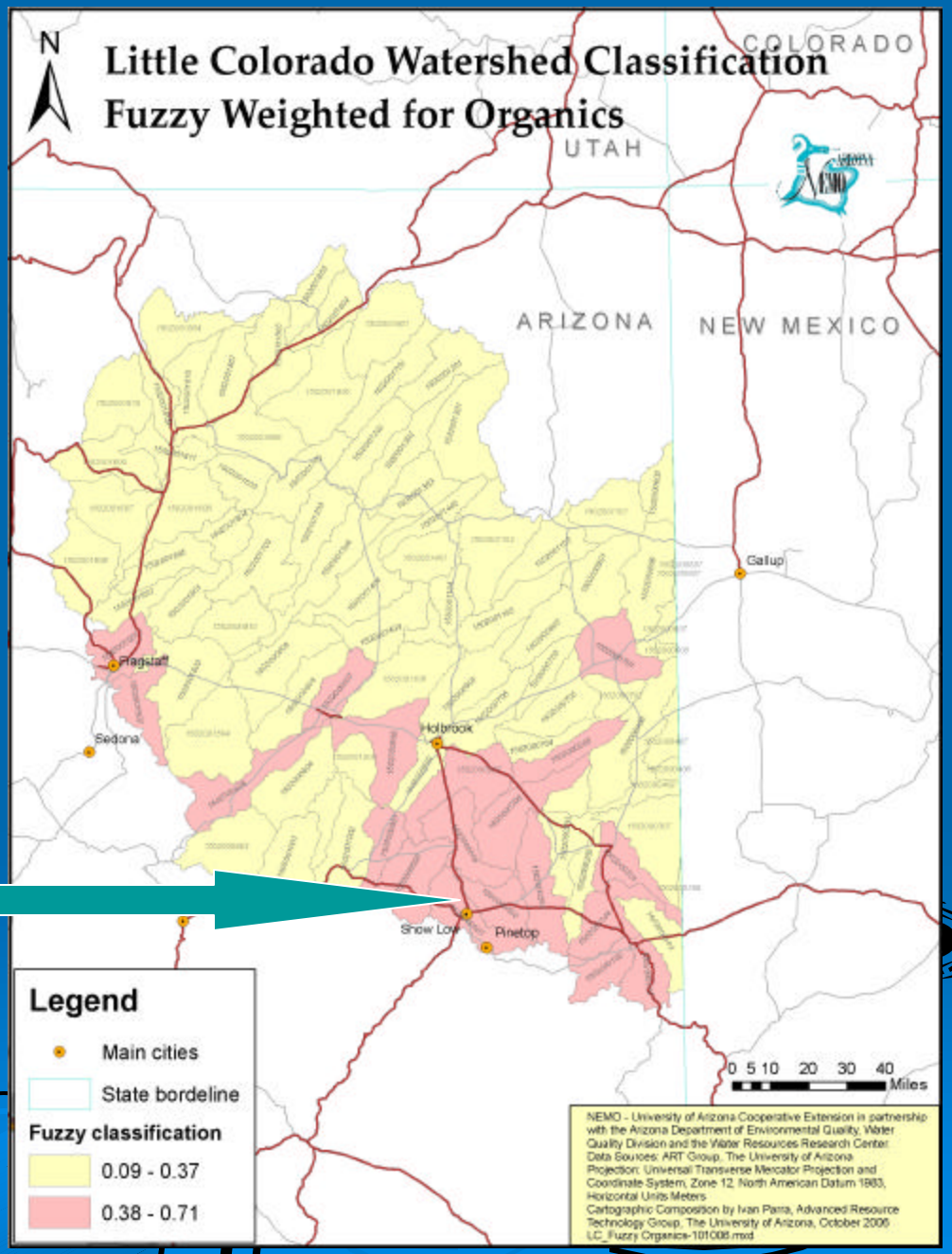






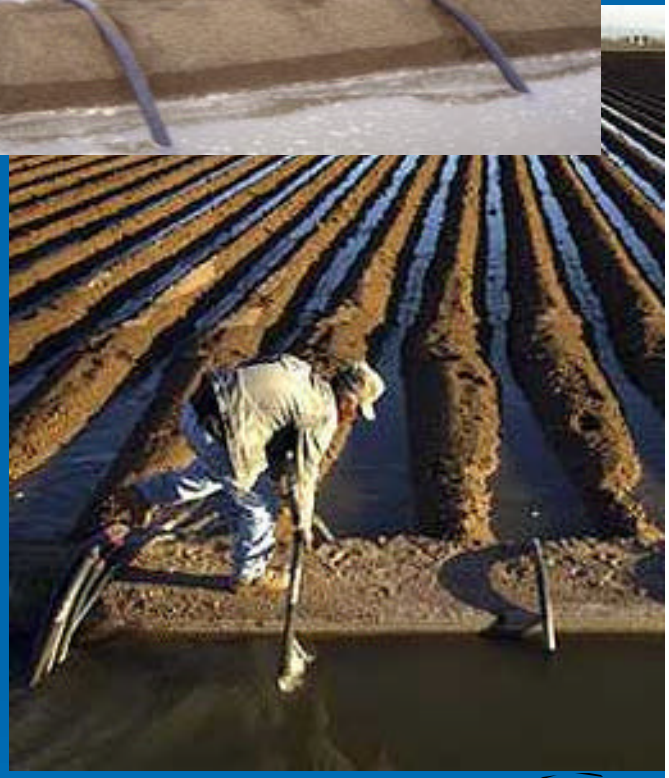
Organics, and Nutrients!

Lower Silver Creek Subwatershed, for organics pollution due to failing septic systems, lawn amendments, and livestock grazing.



Selenium

- ADEQ Water Quality Data
- GIS Analysis of Land Use
  - Agriculture
- Final ranking using Weighted Combination method of Fuzzy Logic for each subwatershed



Subwatershed Name	WQA[1]	FMV for Agricultural Lands	FMV Weighted
Railroad Wash-Upper Gila River	1.0	0.354	0.677
Apache Creek-Upper Gila River	1.0	0.059	0.530
Animas Valley	0.5	0.000	0.250
Centerfire Creek-San Francisco River	0.5	0.186	0.343
Upper Blue River	0.5	0.001	0.250
Pueblo Creek-San Francisco River	0.5	0.000	0.250
Lower Blue River	0.3	0.000	0.150

Selenium

Tonahakaad Wash Subwatershed Lower Little Colorado River – Subwatershed, for selenium due to elevated naturally occurring selenium.

….not a land use concern.