An Overview of the Landscape Sciences Program in The National Exposure Research Laboratory - EPA

W.G. Kepner
US EPA
Las Vegas, NV

RESEARCH OBJECTIVES

- Develop landscape assessment approaches/simple models to assist in the identification and prioritization of watersheds/ water bodies vulnerable to non-point source pollution (regional scale down)
- Initial focus on nutrients, sediments, fecal coliforms, and surface runoff
- Develop new remote sensing approaches to improve assessments of watersheds/water bodies at risk to non-point source pollution
- Conduct regional and national assessments (historic/current/alternative futures) of watersheds/water bodies vulnerable to non-point source pollution
- Develop tools to aid environmental decision makers in evaluating vulnerability of watersheds/water bodies to non-point source pollution

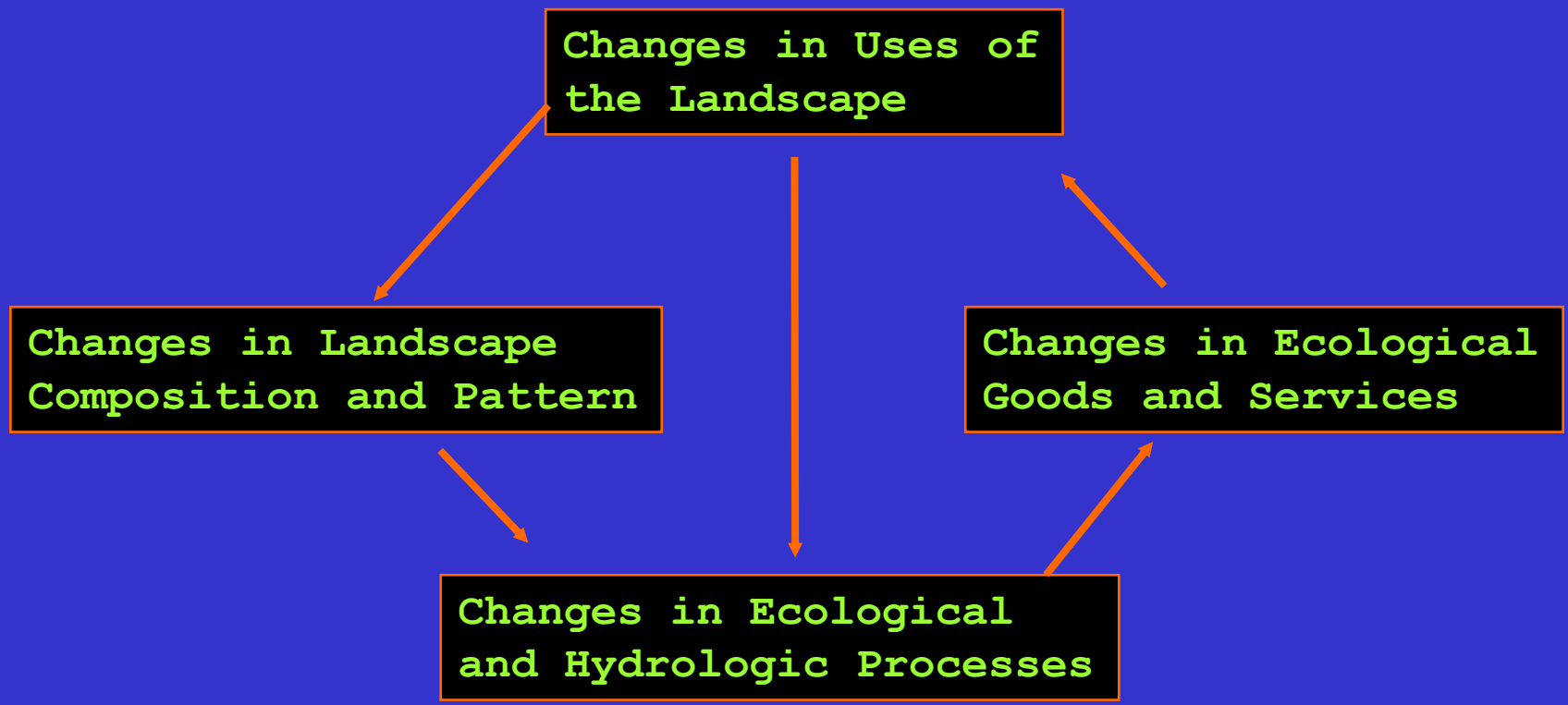
KEY RESEARCH AREAS

- Data enhancement/improved accuracy
- Detecting landscape features/pattern with new sensors
- Detecting landscape features/pattern using new analysis techniques
- Change detection
- Landscape indicator/model development
- Statistical approaches to improve interpretations/assessments

EPA Landscapes Staff

- 28 Scientists/3 Administrative Staff
- 1 US COE Scientist Co-located (Regional GAP)
- Three Locations
  - Las Vegas (20)
  - Reston (National USGS Headquarters) (8)
  - RTP (3)
- Numerous Scientific Disciplines
  - Landscape Ecology, Hydrology, Physiological Ecology, Aquatic Biology, Remote Sensing, GIS, Statistics, Terrestrial Biology and Ecology, Environmental Chemistry, Molecular Biology, and Wildlife Biology

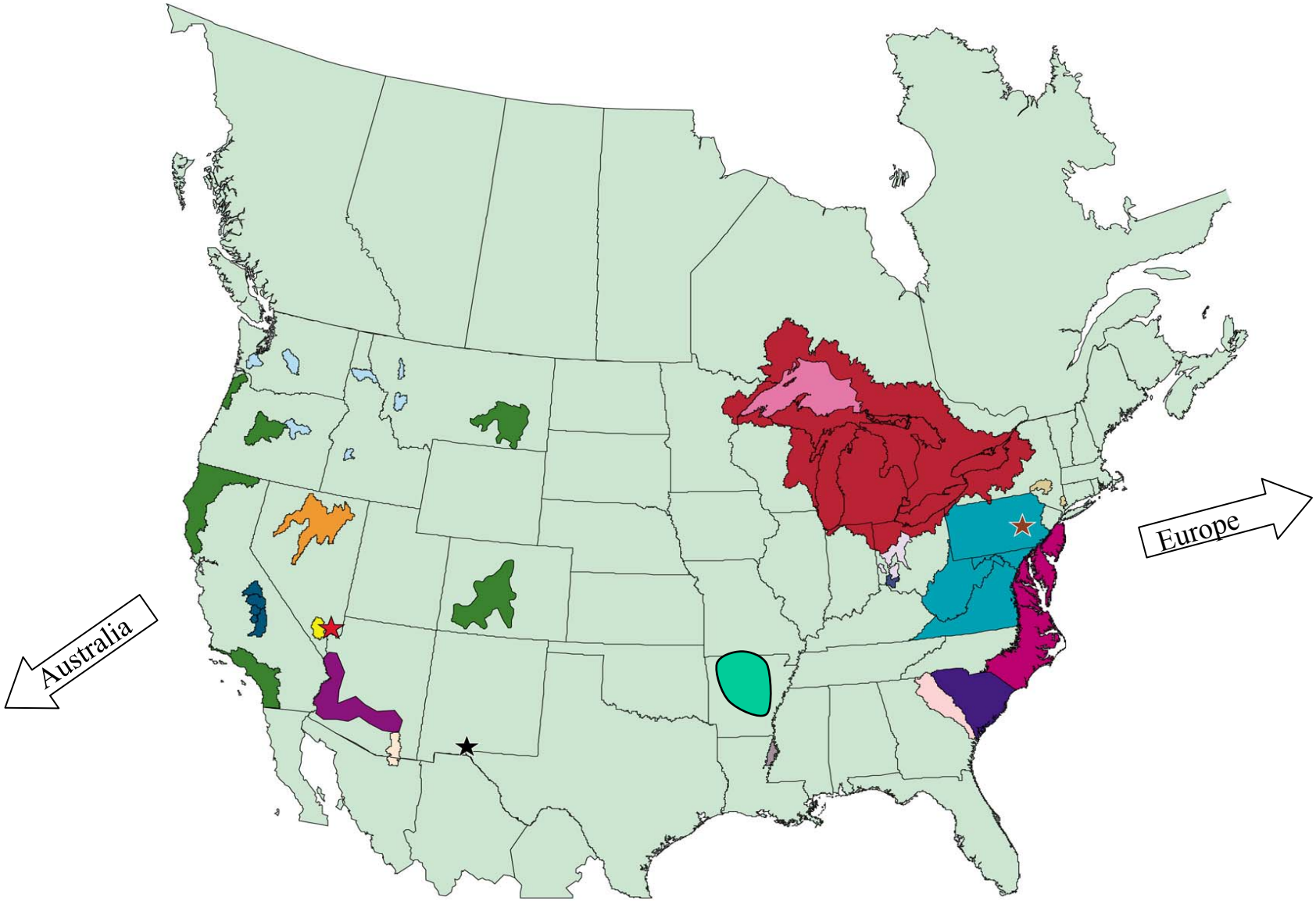
Simple Landscape Model



Elements for Landscape Change and Forecast Analysis

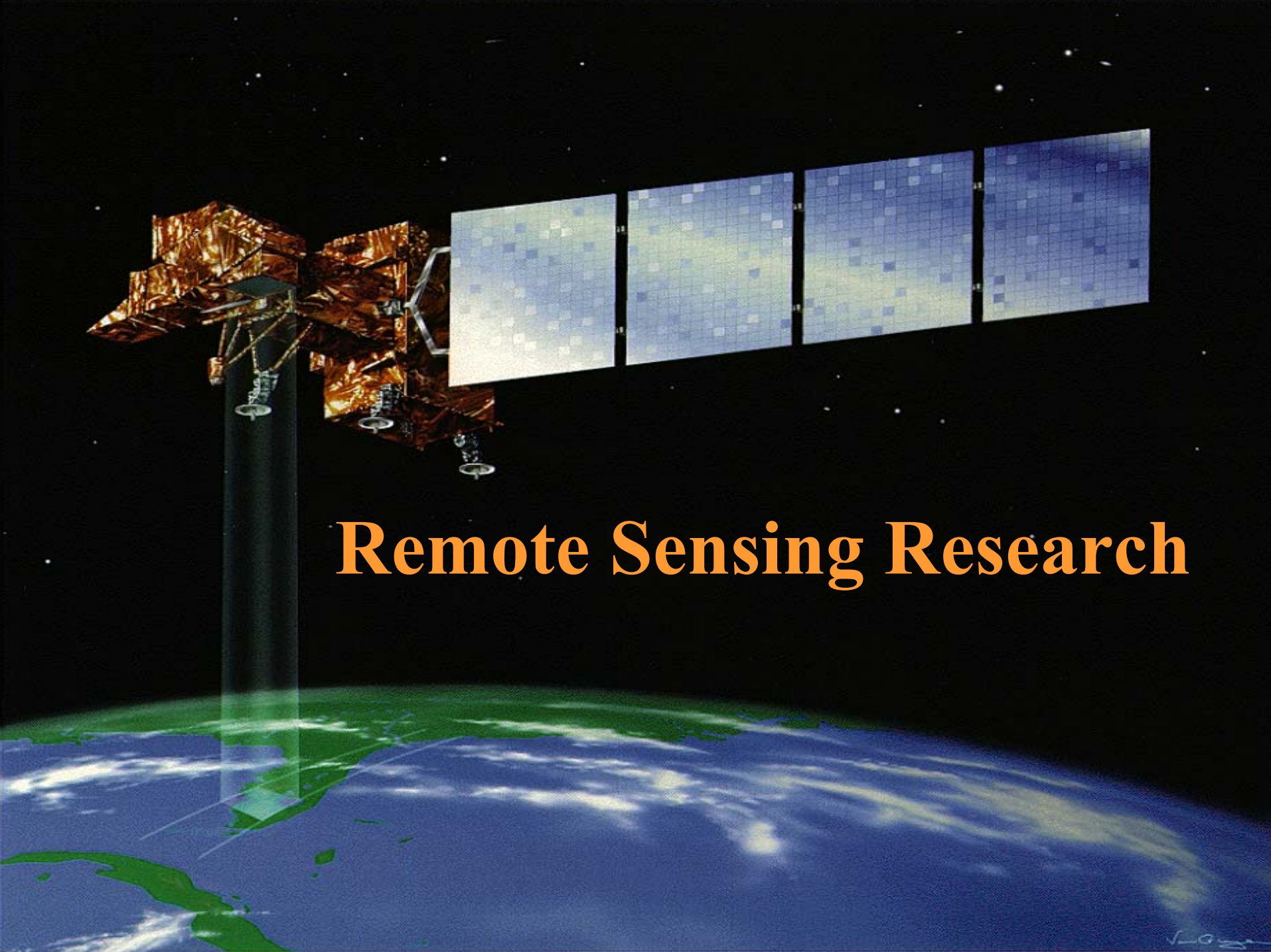
1. Description (landscape characterization)
2. Quantification of change
3. Place into context of process-based models that input landscape change (why is change important)
4. Forecast landscape change, ecosystem response, and the consequences of choice related to anthropogenic events
5. Communicate results in an understandable medium with easy public access

PROJECT LOCATIONS



Research Area Examples

1. Remote Sensing research applications (landscape characterization, multiple sensors)
2. Data Acquisition
3. Landscape metrics and indicator development
4. Integrated Assessments/Regional vulnerability analysis
5. Tool development
6. Change Detection


Remote Sensing Research

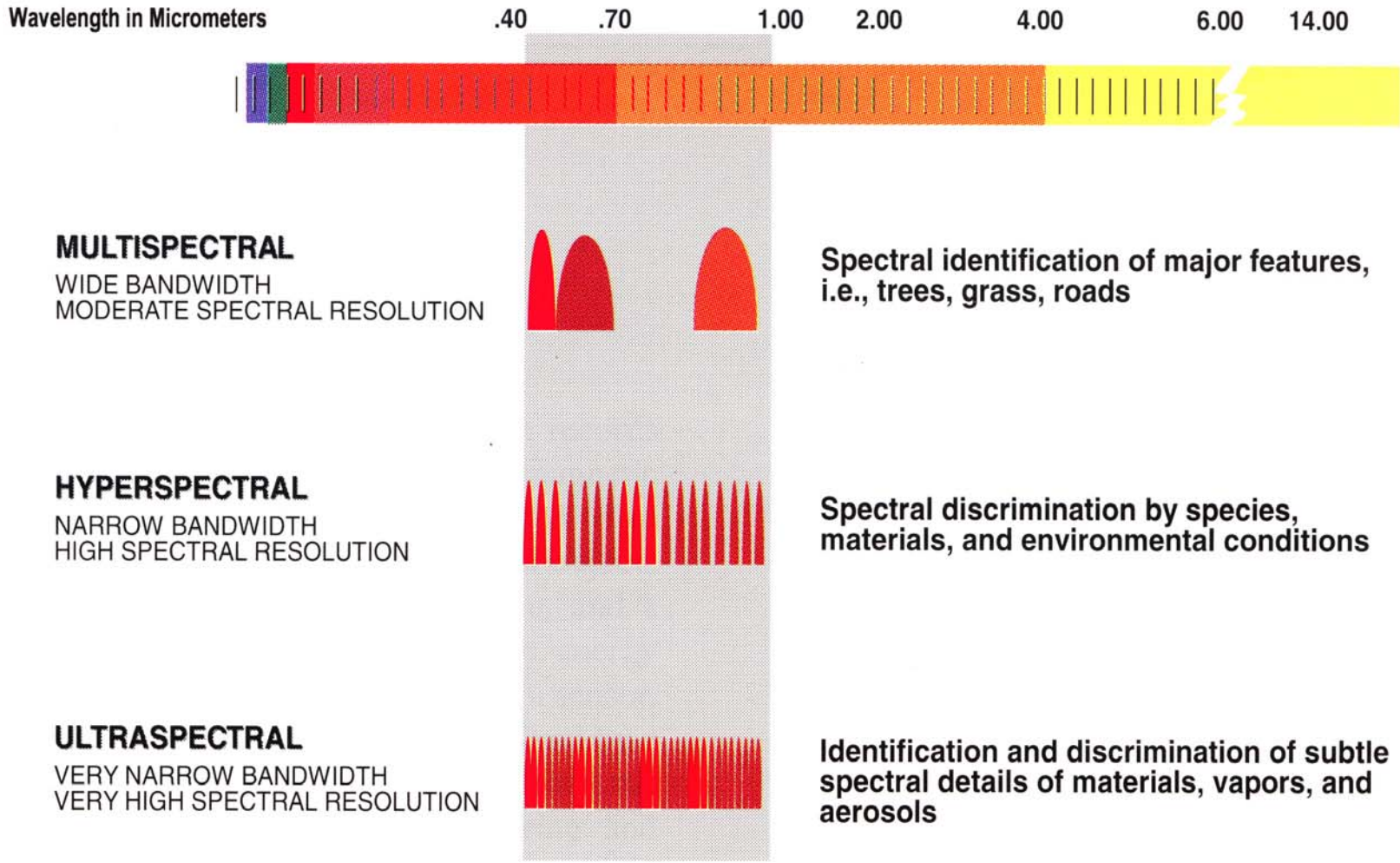
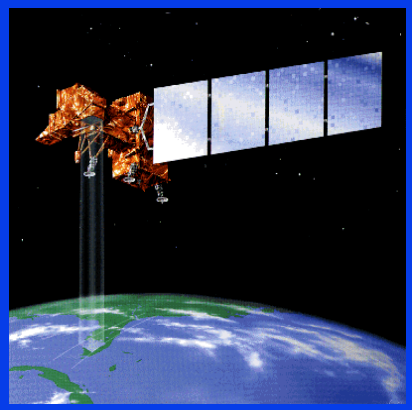
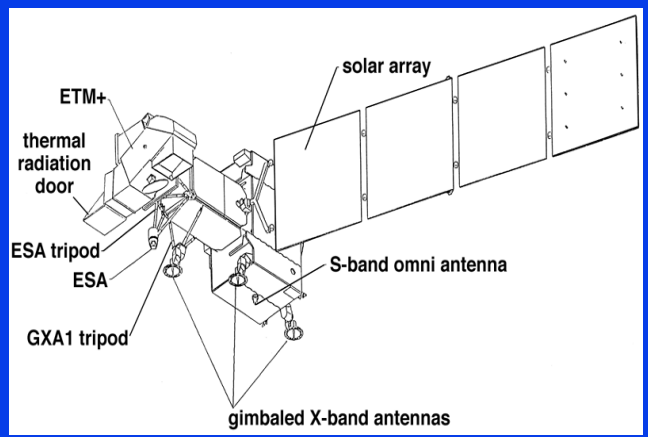


Figure 1-3 Types of Spectral Imaging

Landsat 7 ETM+ Instrument Characteristics



Band Number	Spectral Range (micrometers)	Ground Resolution (m)
1	.450 to .515	30
2	.525 to .605	30
3	.630 to .690	30
4	.750 to .900	30
5	1.55 to 1.75	30
6	10.40 to 12.5	60
7	2.09 to 2.35	30
Pan	.520 to .900	15



Swath Width: 185 km
Repeat Coverage Interval: 16 days (233 orbits)
Altitude: 705 km
Quantization: Best 8 of 9 bits
On-board data storage: ~375Gb (solid state)
Inclination: Sun-synchronous, 98.2°
Equatorial Crossing: Descending, 10:00am +/- 15 min.
Launch vehicle: Delta II
Launch Date: April 15, 1998

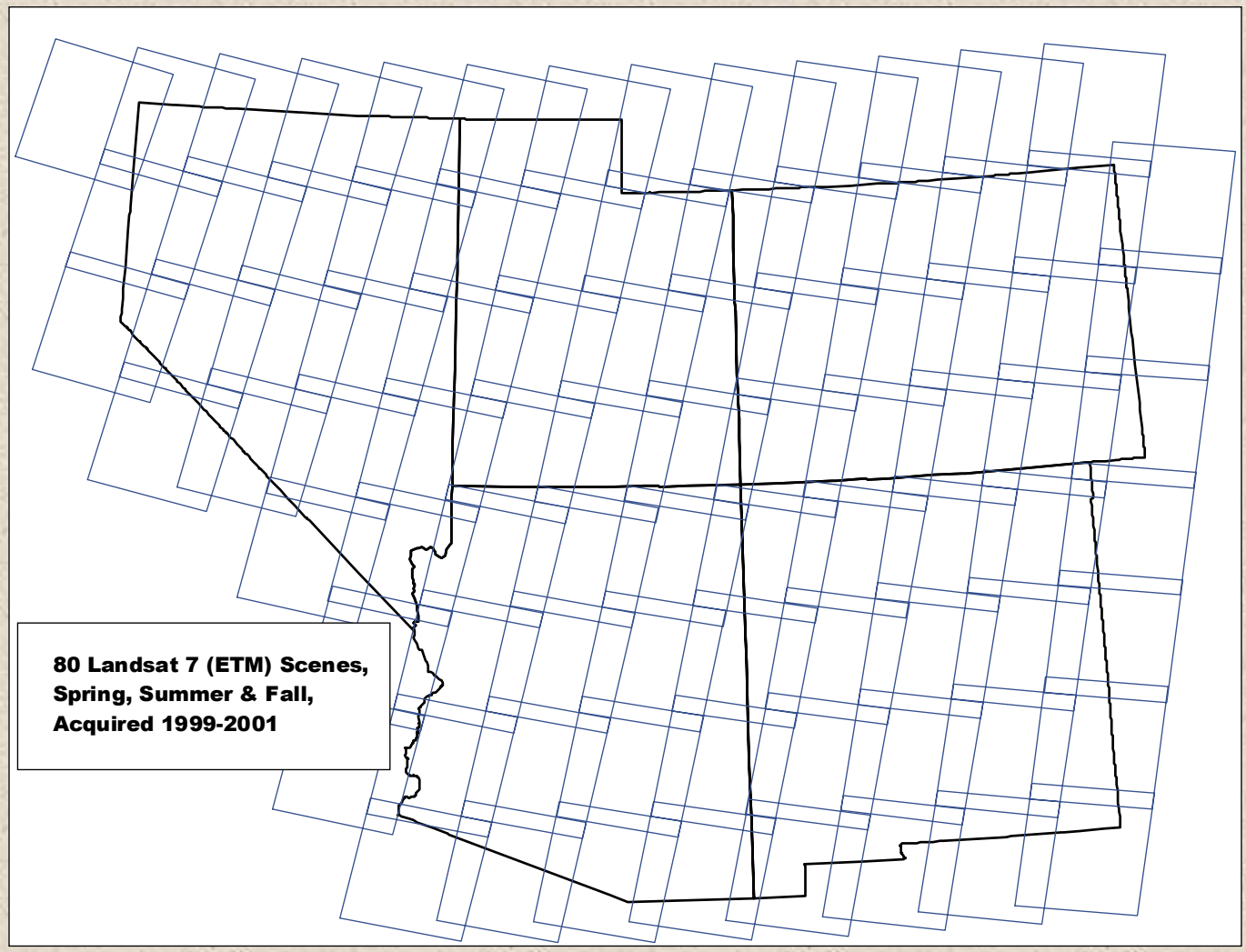
Southwest Regional GAP Analysis Project.

The 5-state region covers approximately 560,000 square miles.

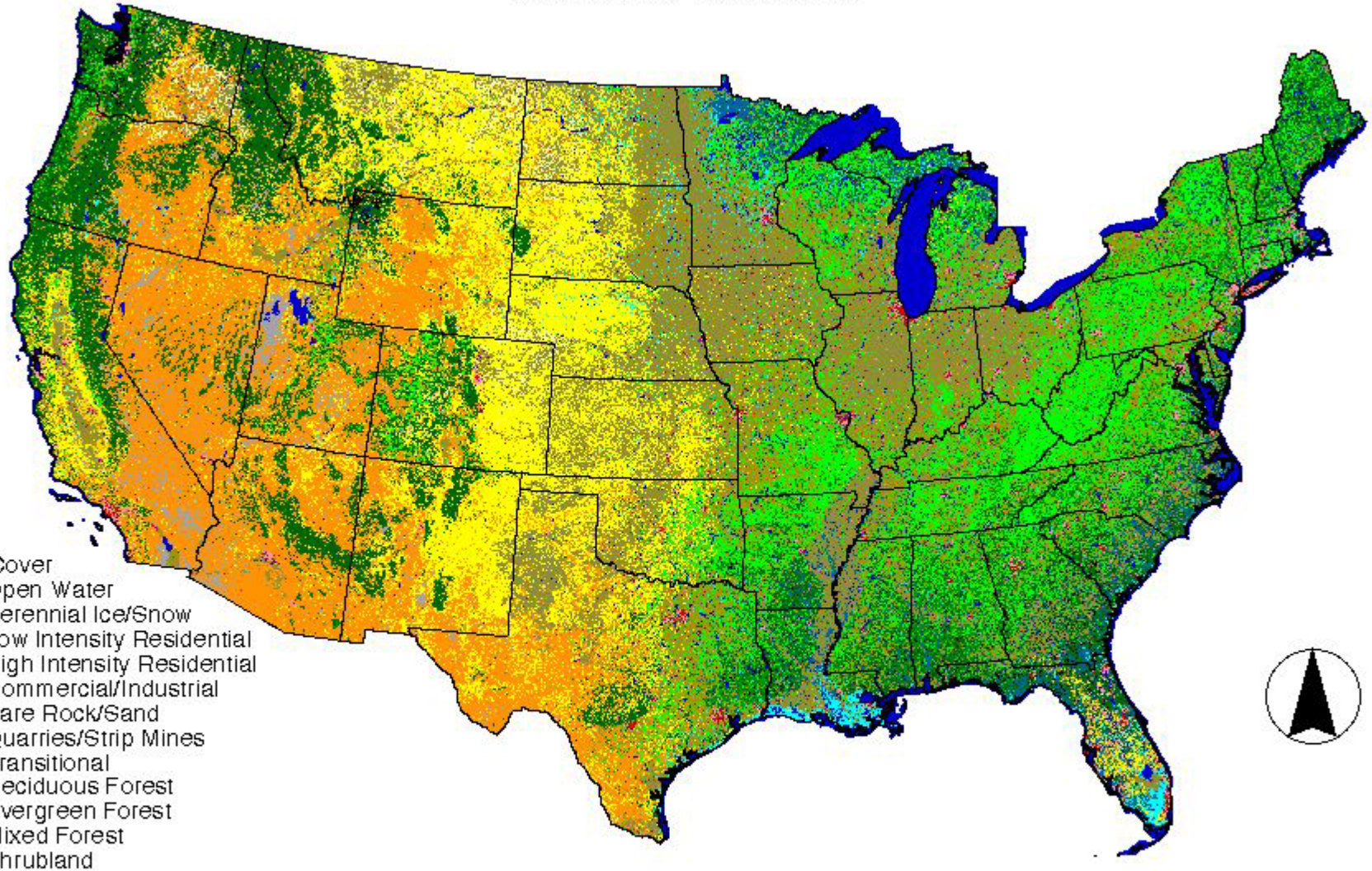
Conservation mapping for biodiversity.

EPA

Landsat 7- 1999-2001; Spring, Summer & Fall Imagery



MRLC Land Cover of the Conterminous United States



Land Cover
- Open Water
- Perennial Ice/Snow
- Low Intensity Residential
- High Intensity Residential
- Commercial/Industrial
- Bare Rock/Sand
- Quarries/Strip Mines
- Transitional
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Orchards/Vineyards
- Grasslands/Herbaceous
- Pasture/Hay
- Row Crops
- Small Grains
- Fallow
- Urban Grasses
- Woody Wetlands
- Herbaceous Wetlands

300 0 300 600 900

Kilometers

USGS

EPA

Data Acquisition

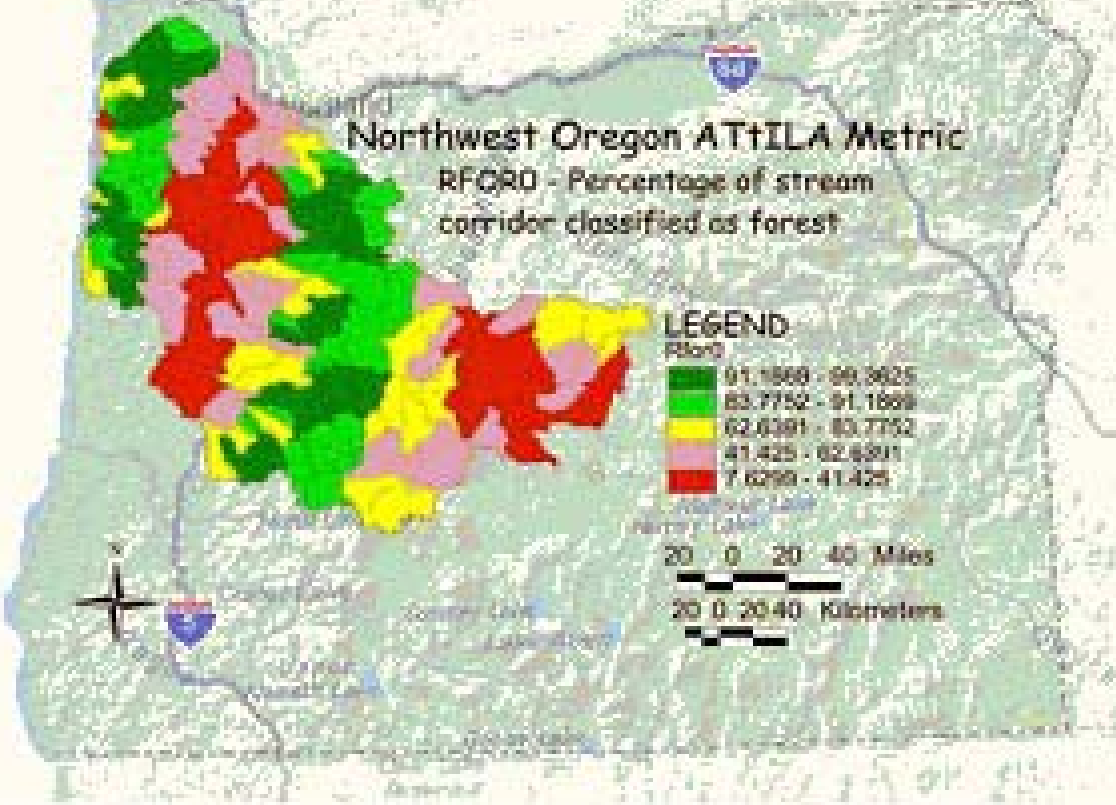
EPA United States Environmental Protection Agency

NORTHWEST OREGON
EMAP - WEST
PILOT STUDY AREA

ABSTRACT | GEODATA | MAP SERVER | METRIC MAPS | HELP

Northwest Oregon Metric Maps

Select Northwest Oregon Metric Maps From Drop Down Menu



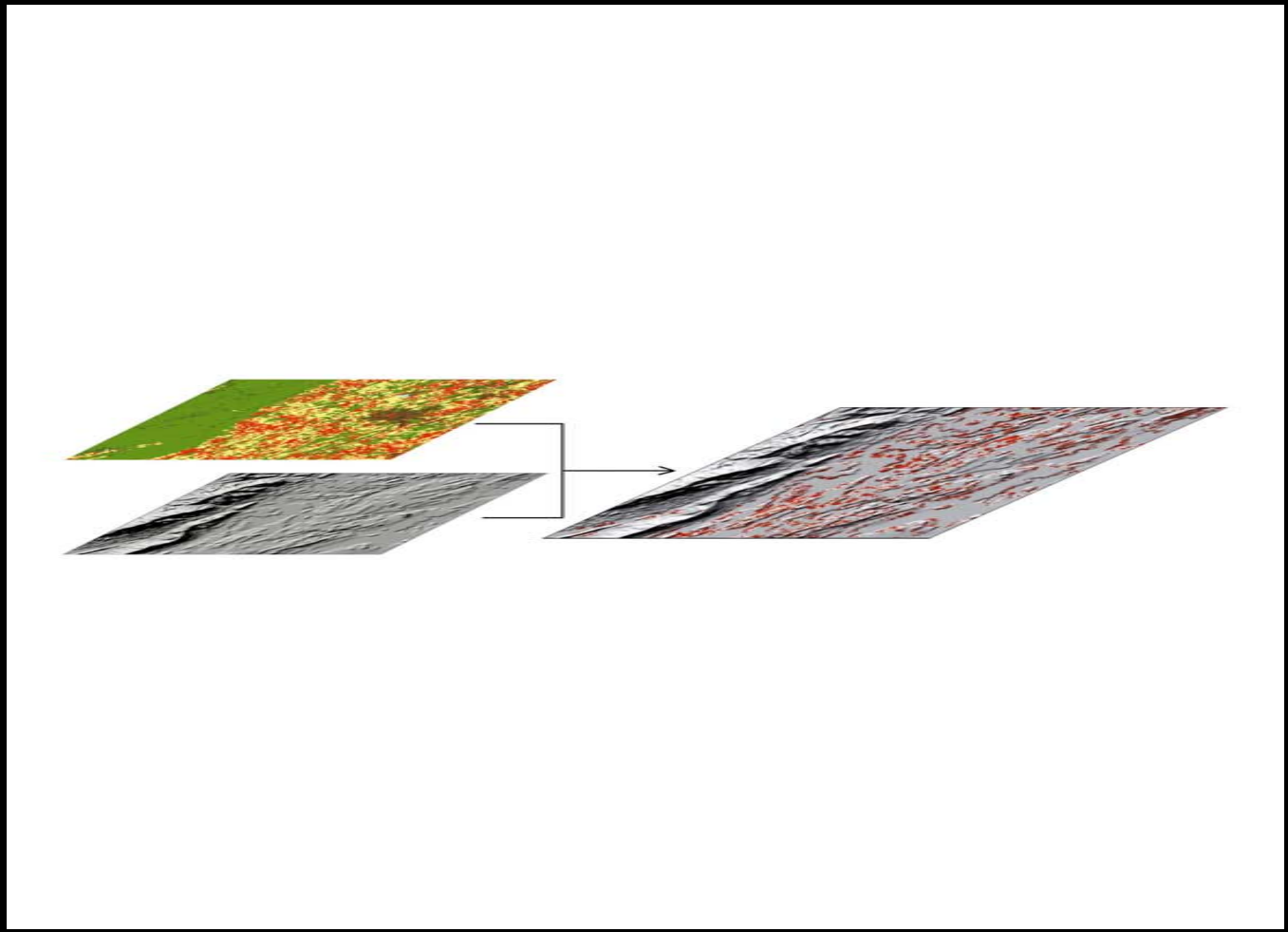
METRIC INFO

ENLARGE IMAGE

ATTILA INFO

DOWNLOAD METRICS

Landscape metrics and indicator development

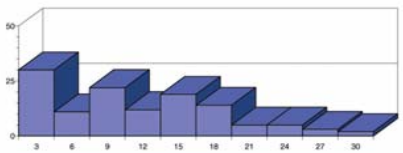


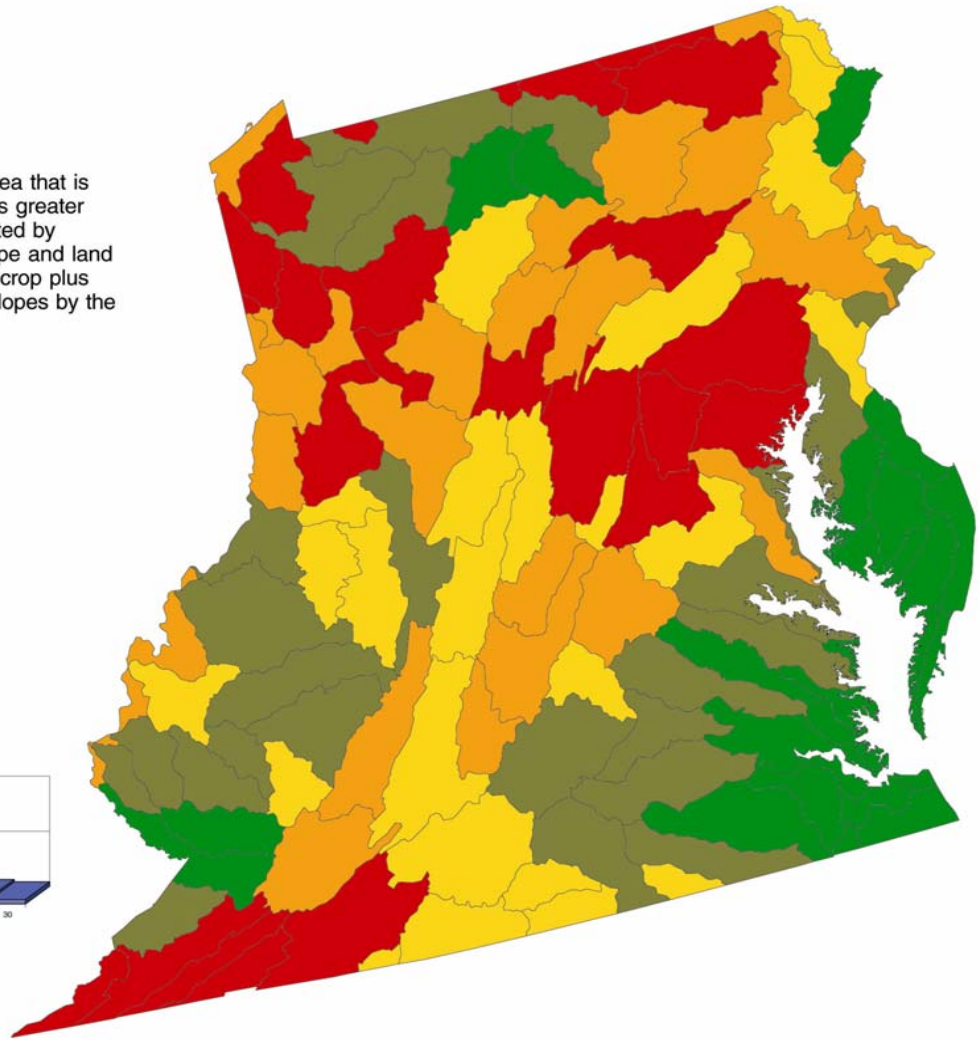
Landscape Metrics

Mean Riparian agriculture
Riparian forest
Forest fragmentation
Road density
Forest land cover
Agricultural land cover
Agricultural land cover
on steep slopes
Nitrate deposition
Potential soil loss
Roads near streams
Slope gradient
Slope gradient range
Slope gradient variance
Urban land cover
Wetland land cover
Barren land cover

The proportion of watershed area that is agriculture land cover on slopes greater than three percent was calculated by overlaying maps of percent slope and land cover, and dividing the area of crop plus pasture land covers on steep slopes by the total area of the watershed.

Quintile	Data Range (Percent)
1	< 2.4
2	2.4 - 6.7
3	6.7 - 11.4
4	11.4 - 15.6
5	>15.6





Integrated Assessments

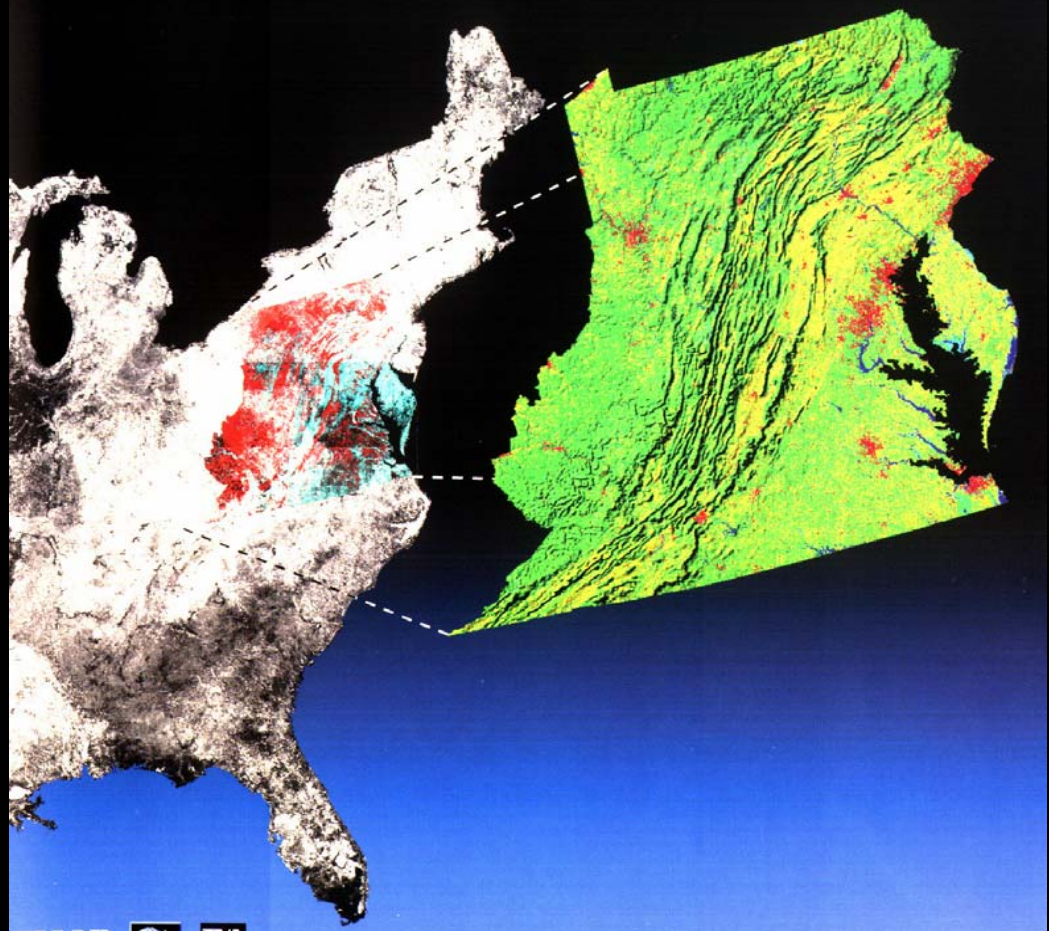
United States
Environmental Protection
Agency

Office of Research and
Development
Washington DC 20460

EPA/600/R-97/130
November 1997

EPA

An Ecological Assessment of the United States Mid-Atlantic Region



EMAP TVA

Tool Development

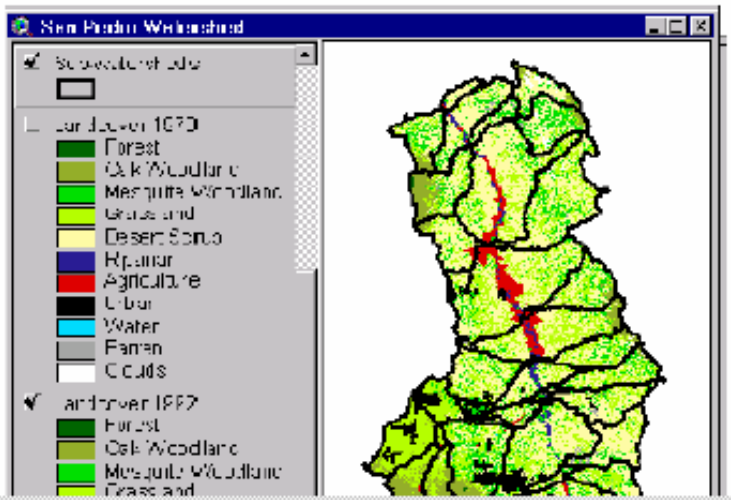
Acrobat Reader - [attila.pdf]

File Edit Document View Window Help

ATtILA

Analytical Tools Interface for Landscape Assessments

Environmental management practices are trending away from simple, local-scale assessments toward complex, multiple-stressor regional assessments. Landscape ecology provides the theory behind these assessments while geographic information systems (GIS) supply the tools to implement them. A common application of GIS is the generation of landscape metrics, which are quantitative measurements of the environmental condition or vulnerability of an area (e.g., ecological region or watershed). The generation of these metrics can be a complex, lengthy undertaking, requiring substantial GIS expertise.



The Landscape Ecology Branch in cooperation with U.S. EPA Region 4 and TVA are developing a user friendly interface to facilitate this process. ATtILA is an easy to use ArcView extension that calculates many commonly used landscape metrics. By

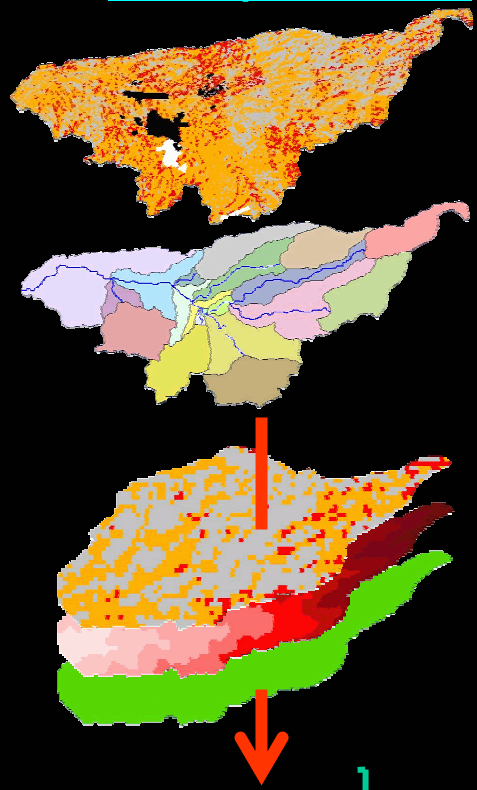
124% 1 of 2 8.5 x 11 in

Conceptual Design of AGWA

Processes

- Build GIS Database
- Discretize Watershed
  f (topography)
- Characterize Model Elements
  f (landcover, topography, soils)
- Derive Secondary Parameters
  look-up tables
- Build Model Input Files
- View Model Results
  link model to GIS

Components

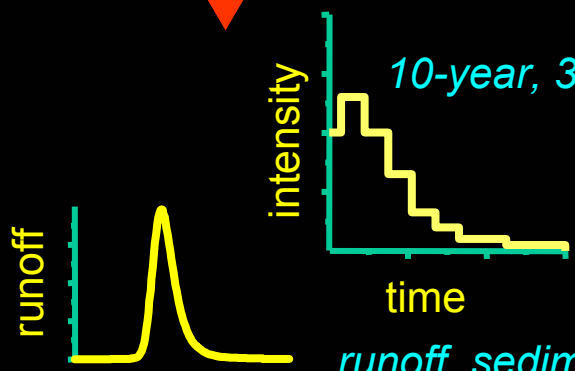


STATSGO
NALC, MRLC
USGS 7.5' DEM

Contributing
Source Area

Gravelly loam Soil

- Ks = 9.8 mm/hr
- G = 127 mm
- Por. = 0.453



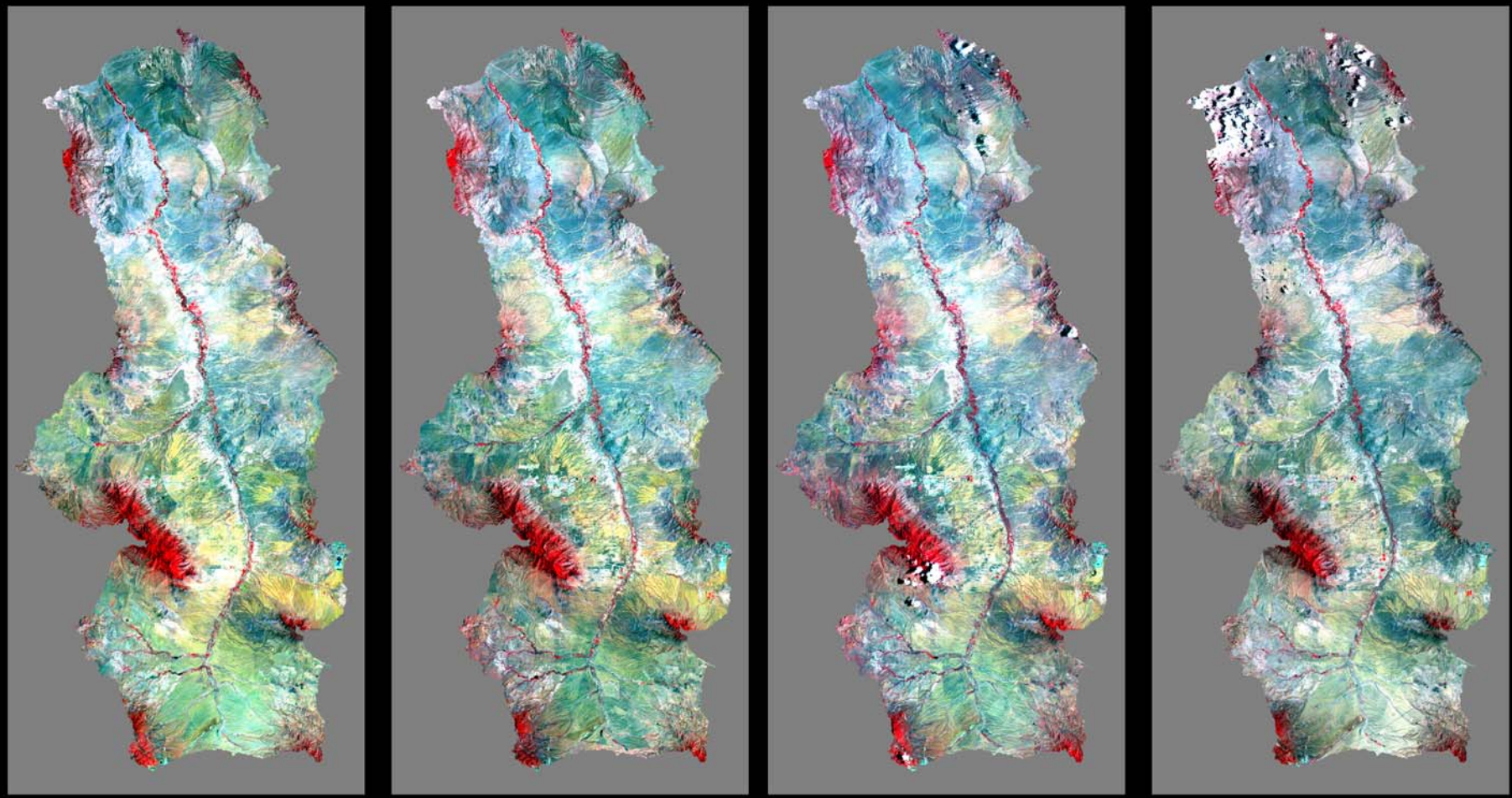
10-year, 30-minute event

runoff, sediment hydrograph

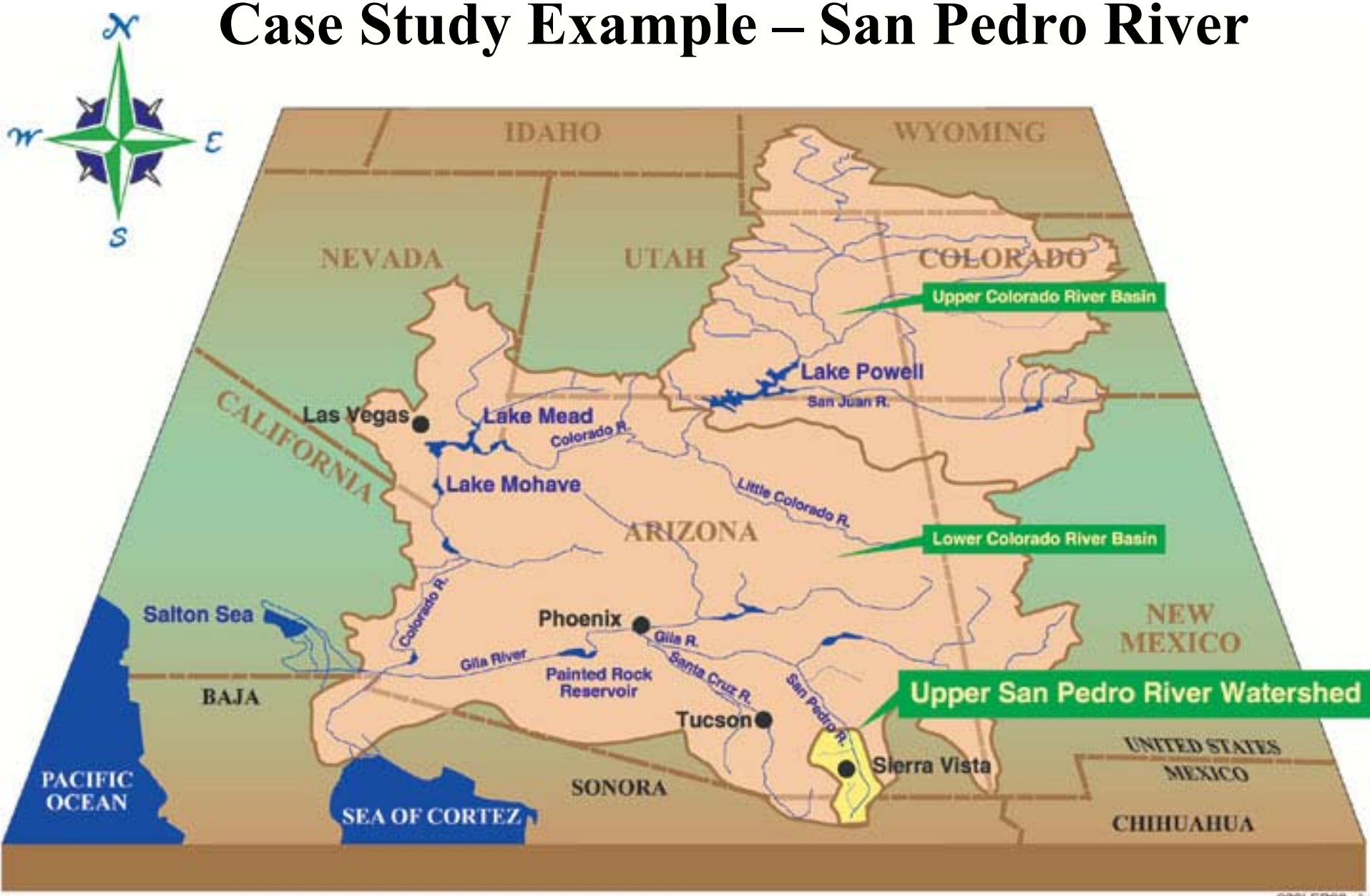
Change Detection

Upper San Pedro Watershed (Arizona/Sonora)

Satellite Imagery



Case Study Example – San Pedro River



Upper San Pedro Watershed

(Arizona/Sonora)

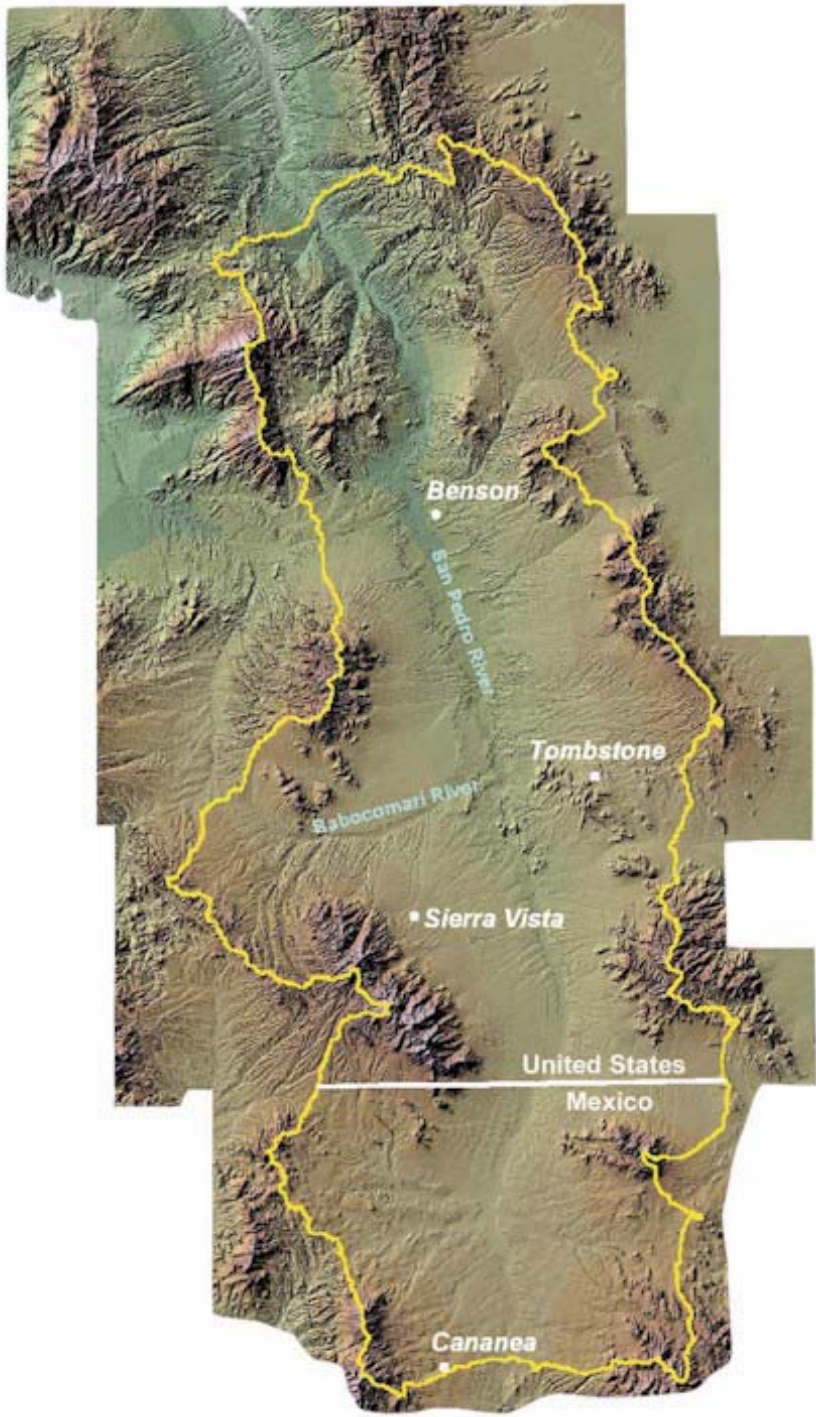
7,600 km^2

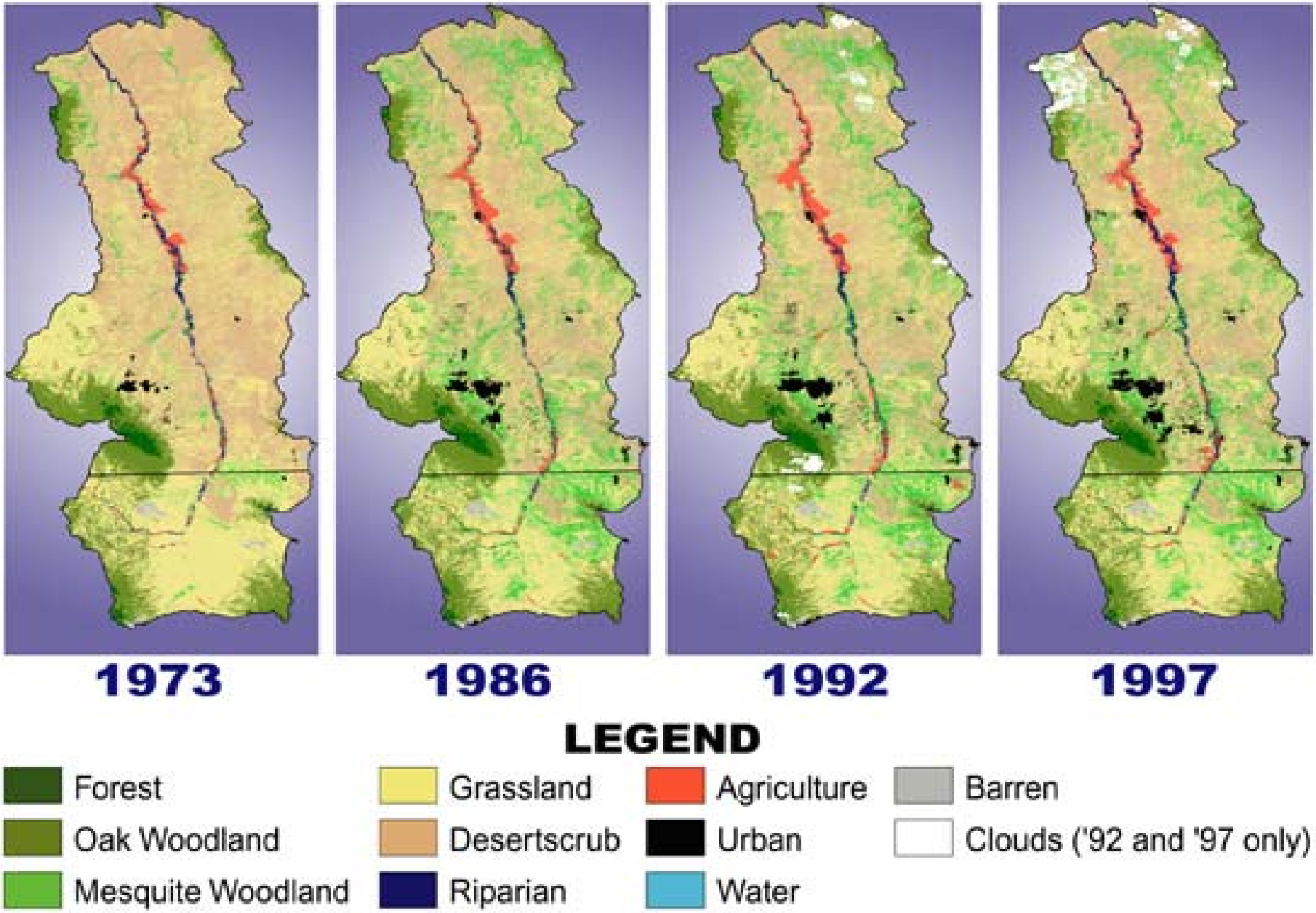
5,800 km^2 Arizona/ 1,800 km^2 Sonora

Elevation 900 – 2,900 m

Annual ppt. 30 – 75 cm

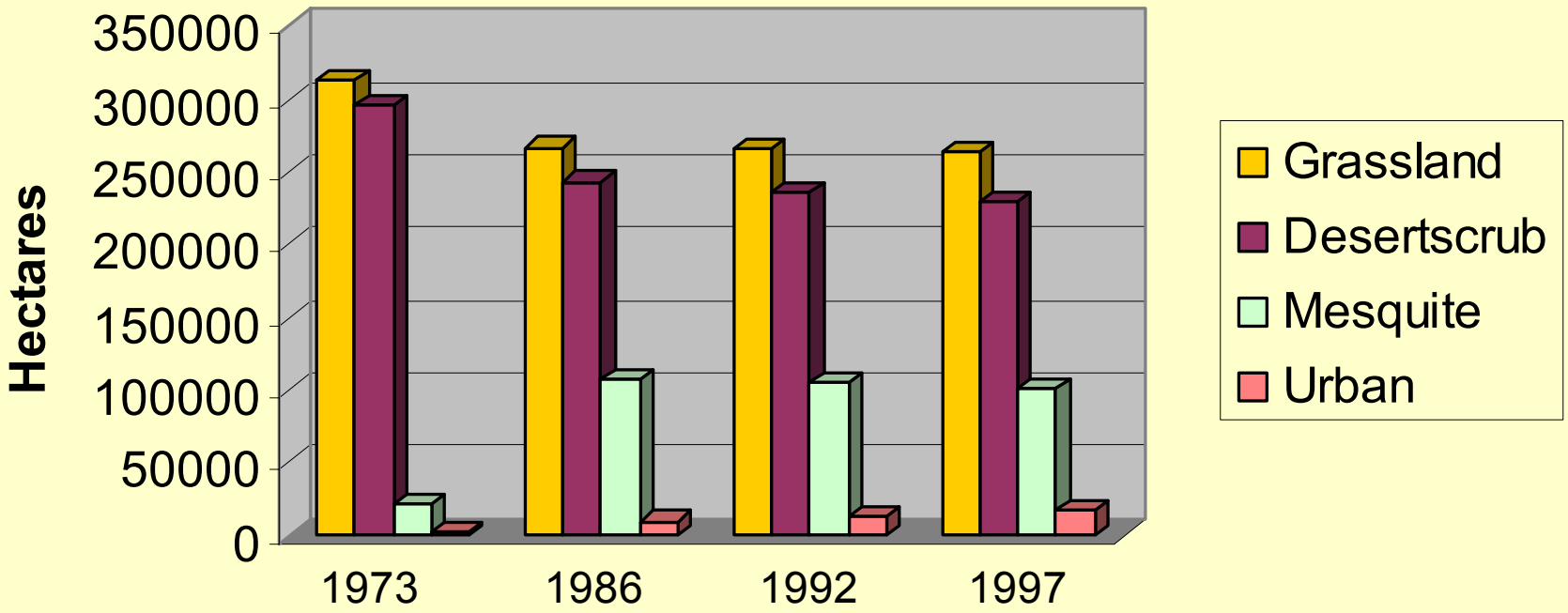
Sonoran/Chihuahuan Transition Zone





Kepner et al., EPA-NERL/ESD http://www.epa.gov/nerl1/land-sci/san-pedro.htm

Change in Land Cover Extent



Landscape Change Statistics

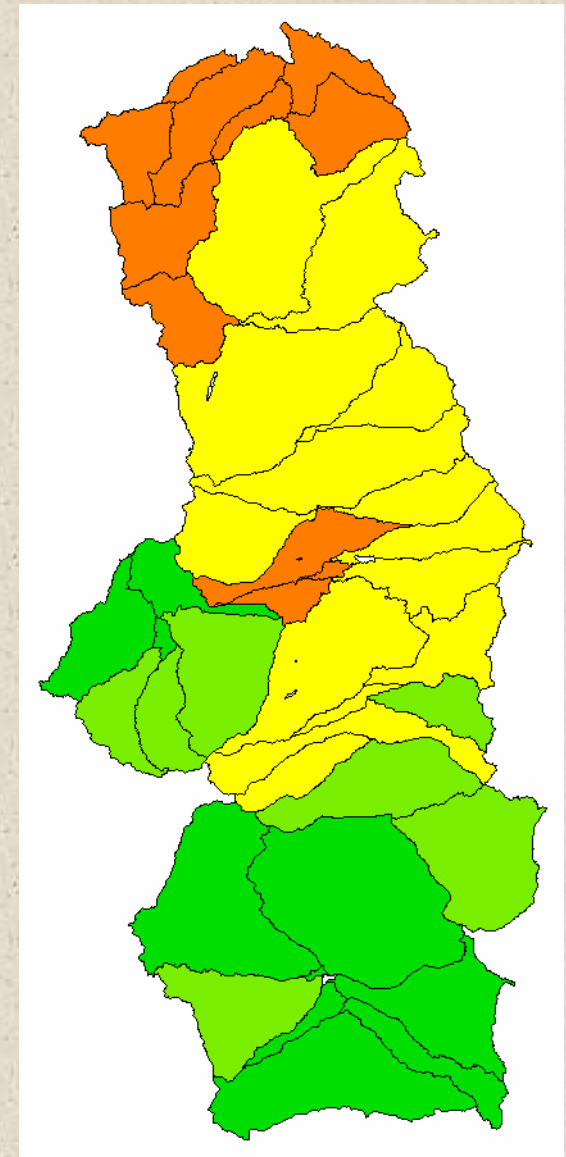
	GRASSLAND			DESERTSCRUB		
	1973	1997	% Rel. Change	1973	1997	% Rel. Change
AREA (ha)	312,850	263,432	-15.8	296,330	229,953	-22.4
% COVER	41.4	34.8	-15.8	39.2	30.4	-22.4
# OF PATCHES	50,715	58,142	+14.6	26,260	39,991	+52.3
LARGEST PATCH (ha)	126,258	53,173	-57.9	201,165	37,361	-81.4
AVE PATCH SIZE (ha)	6.18	4.54	-26.5	11.3	5.76	-49.0
CONNECTIVITY	0.62	0.56	-9.7	0.66	0.55	-16.7

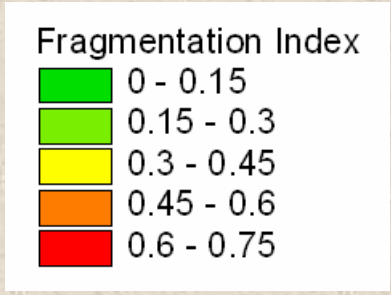
Landscape Change Statistics

	MESQUITE WOODLAND			URBAN		
	1973	1997	% Rel. Change	1973	1997	% Rel. Change
AREA (ha)	20,821	101,602	+388.0	3,205	16,494	+414.6
% COVER	2.8	13.4	+388.0	0.4	2.2	+414.6
# OF PATCHES	15,558	53,310	+242.7	418	3,010	+620.1
LARGEST PATCH (ha)	462	3,574	+674.3	982	4,938	+402.8
AVE PATCH SIZE (ha)	1.34	1.91	+42.5	7.86	5.55	-29.4
CONNECTIVITY	0.31	0.37	+19.4	0.74	0.69	-6.8

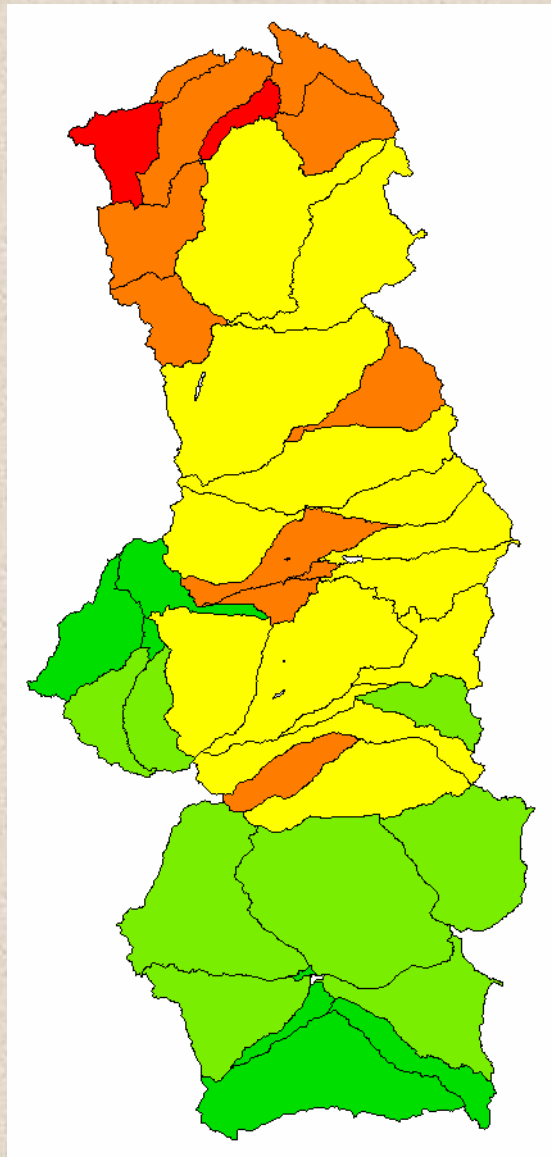
Grassland

1973

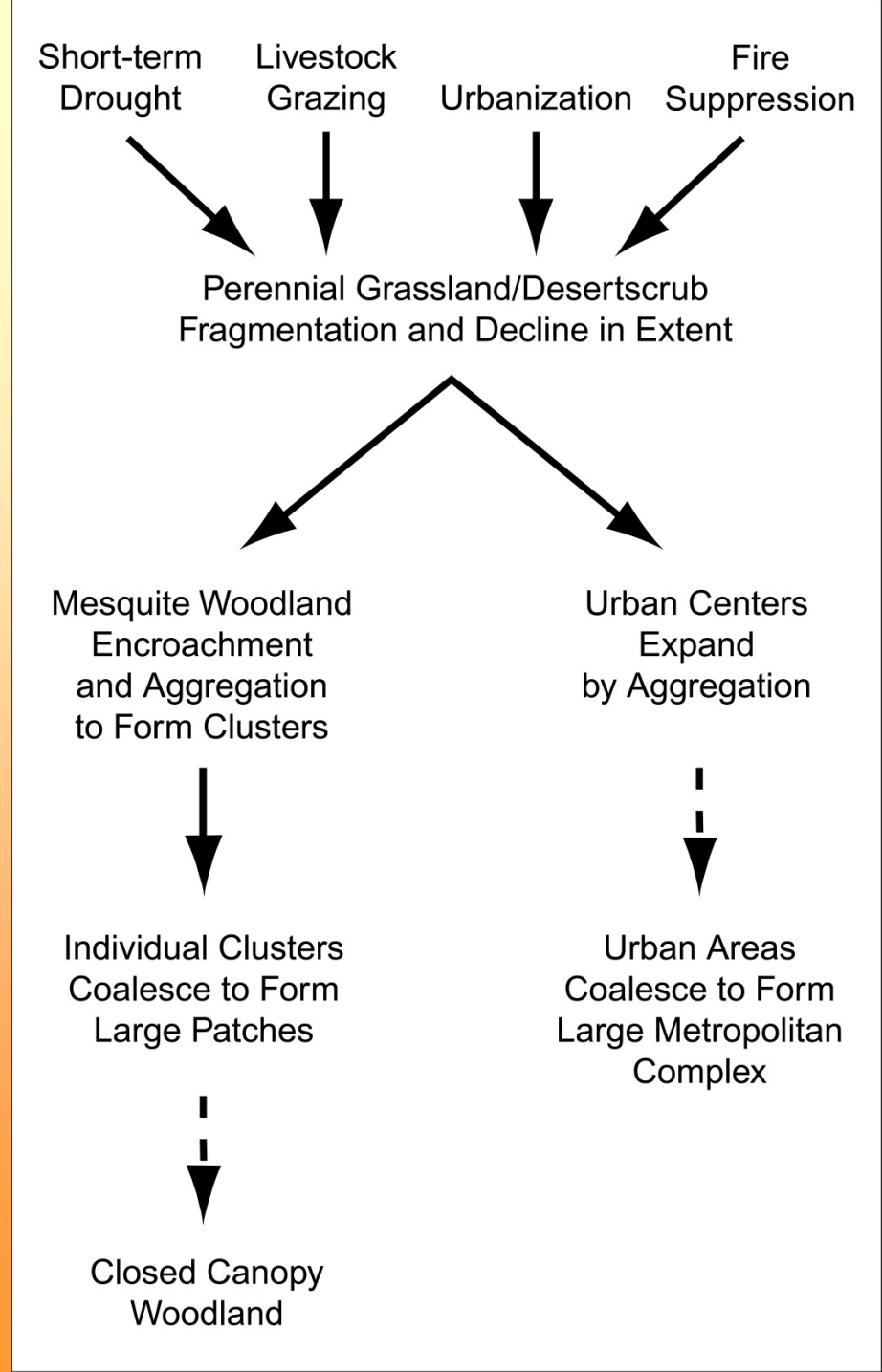




1997

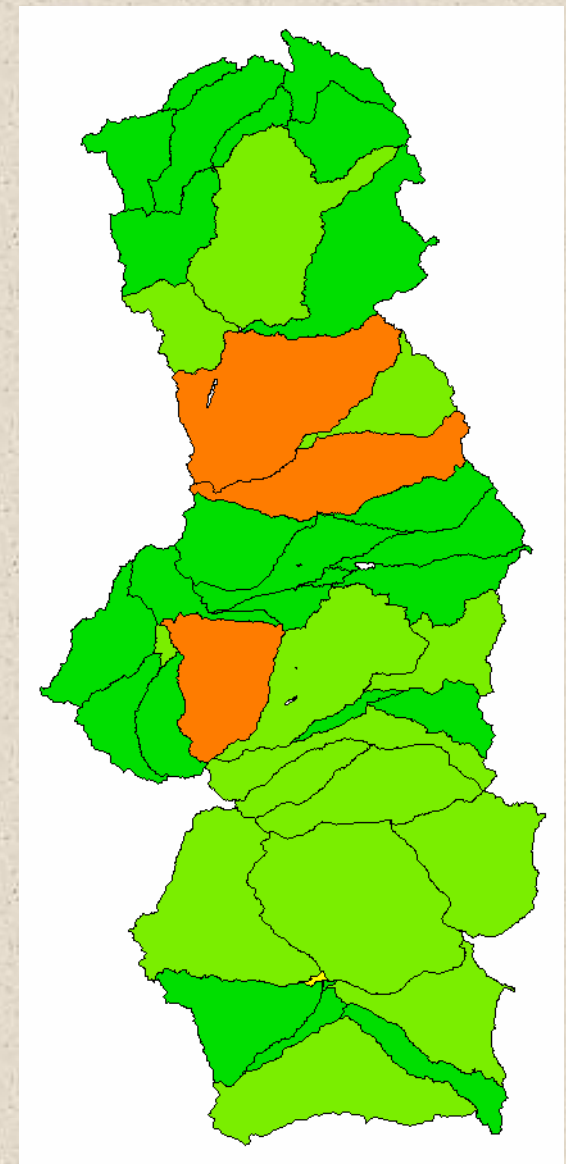


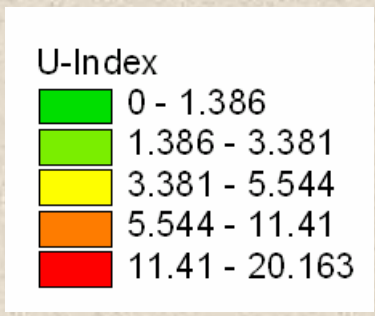
Conceptual Model of Vegetation Phase Transitions in a Semi-arid Watershed



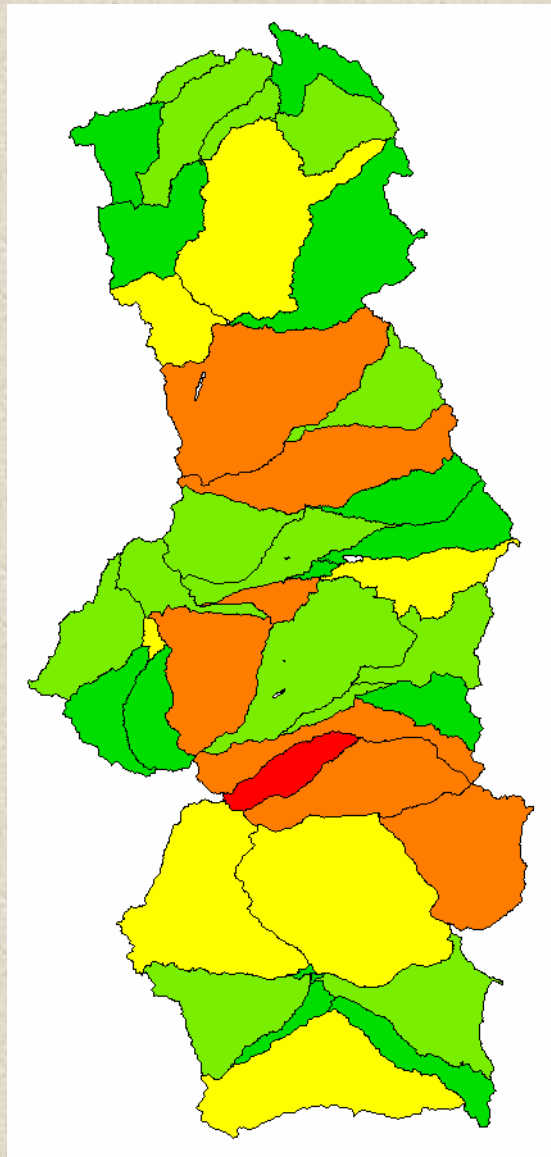
Human Use Index

1973



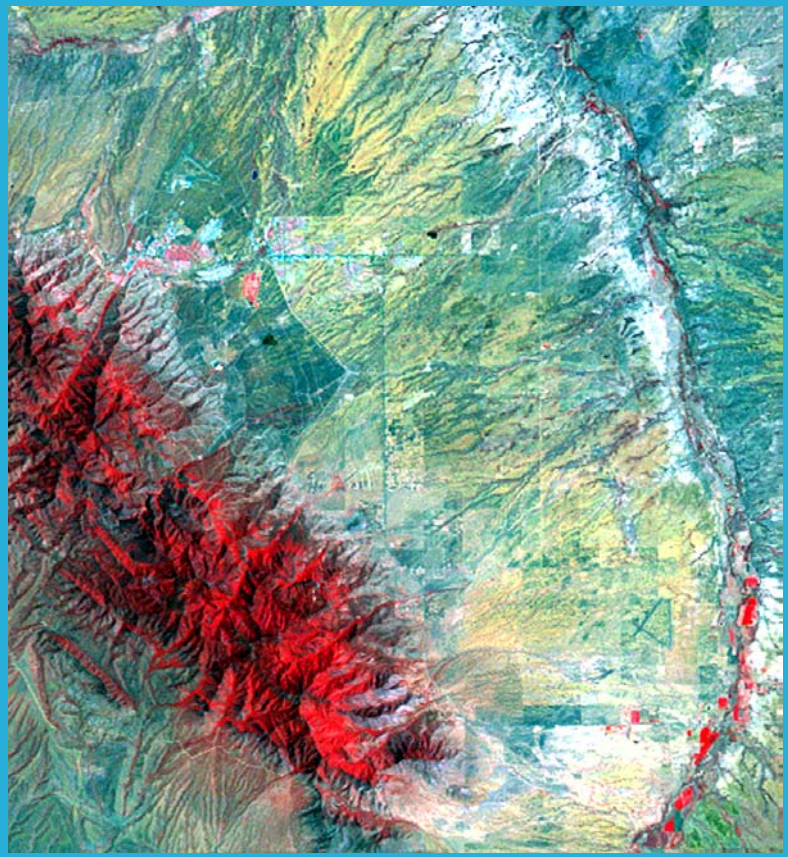


2000

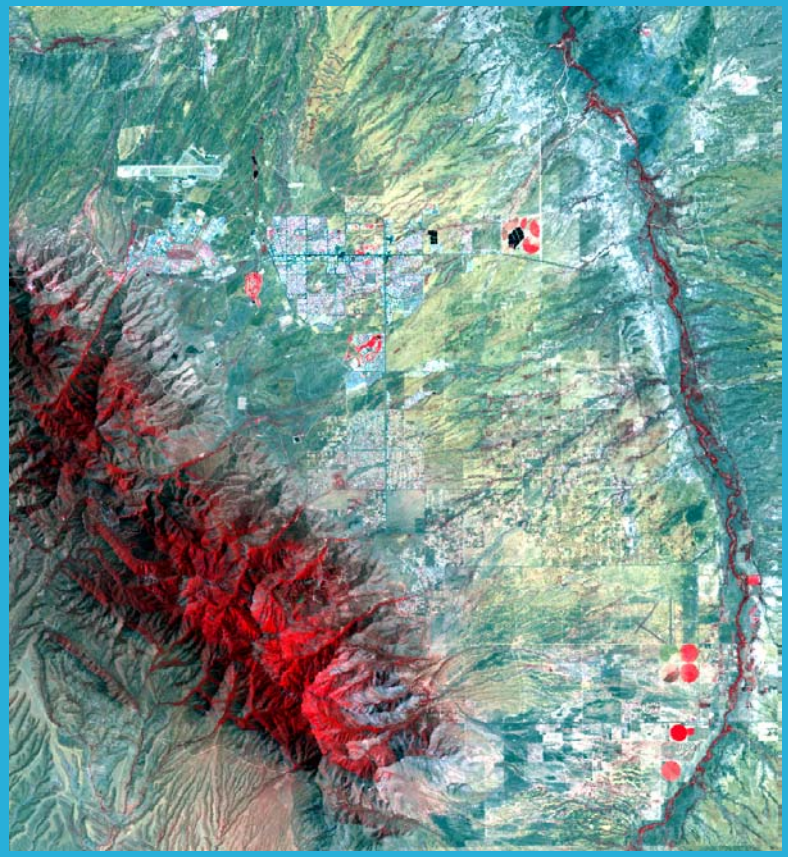


Sierra Vista Arizona Satellite Imagery

1973

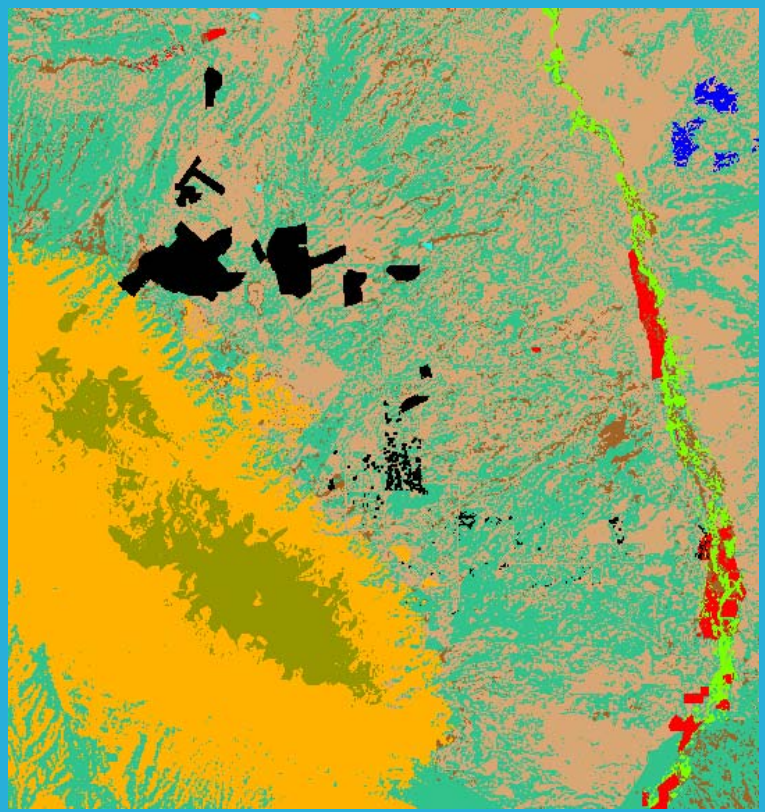


2000

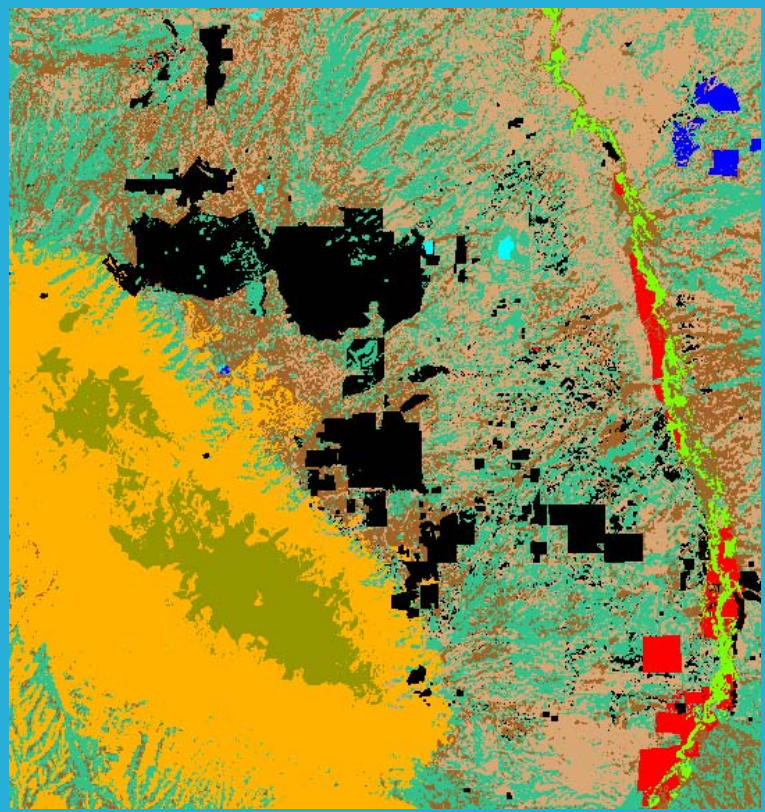


Sierra Vista Arizona Land Cover / Land Use

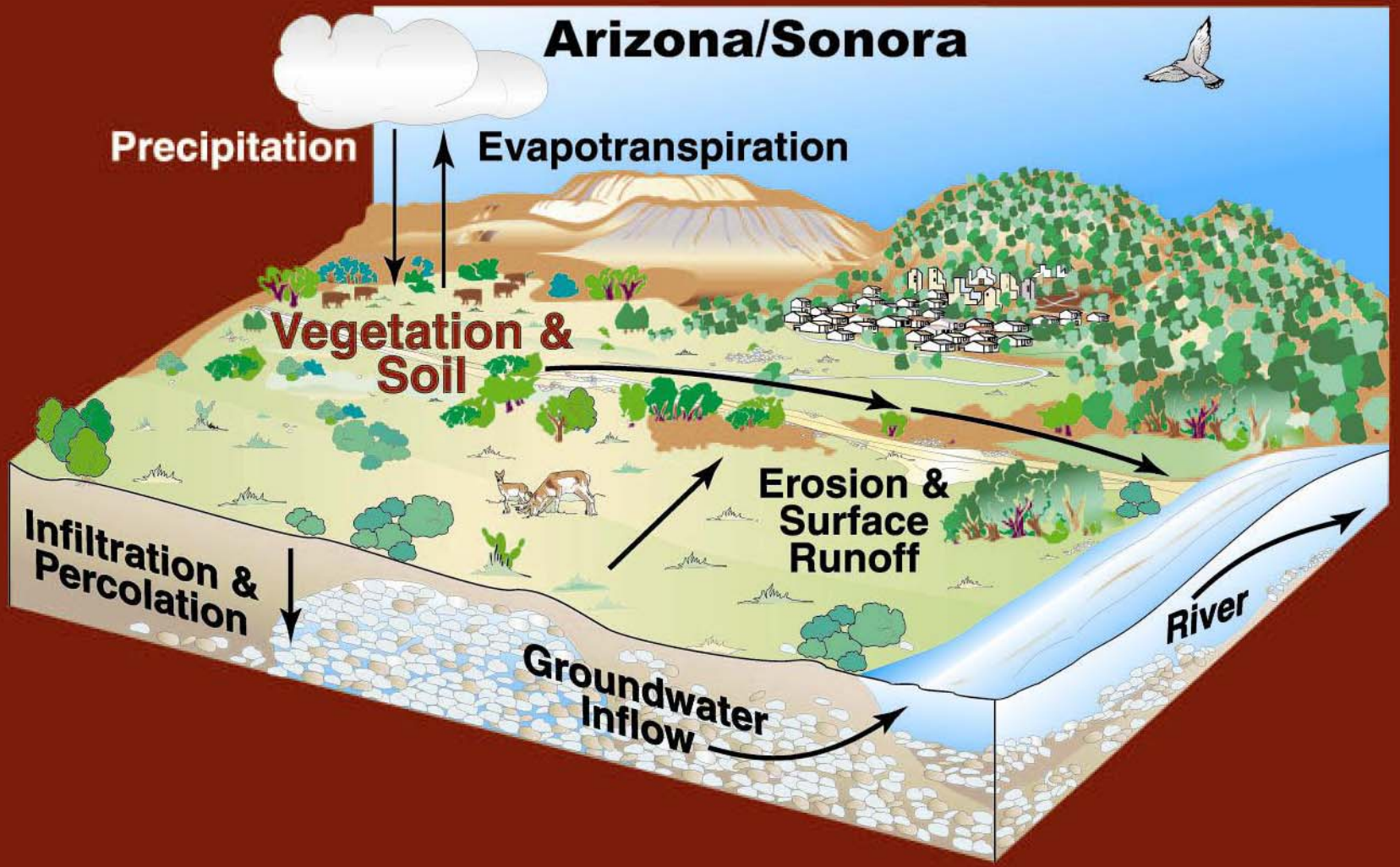
1973



2000



Watershed Response San Pedro River



Methods

1. Focus group meetings to determine user group preferences for alternative management options;
2. Acquire spatial data, e.g. land cover, DEM, & soils;
3. Model future land cover based on stakeholder input;
4. Watershed discretization and parameterization using Automated Geospatial Watershed Assessment tool;
5. Model execution for each alternative future;
6. Visualization and comparison of results with assessment of relative impacts for each alternative management option.

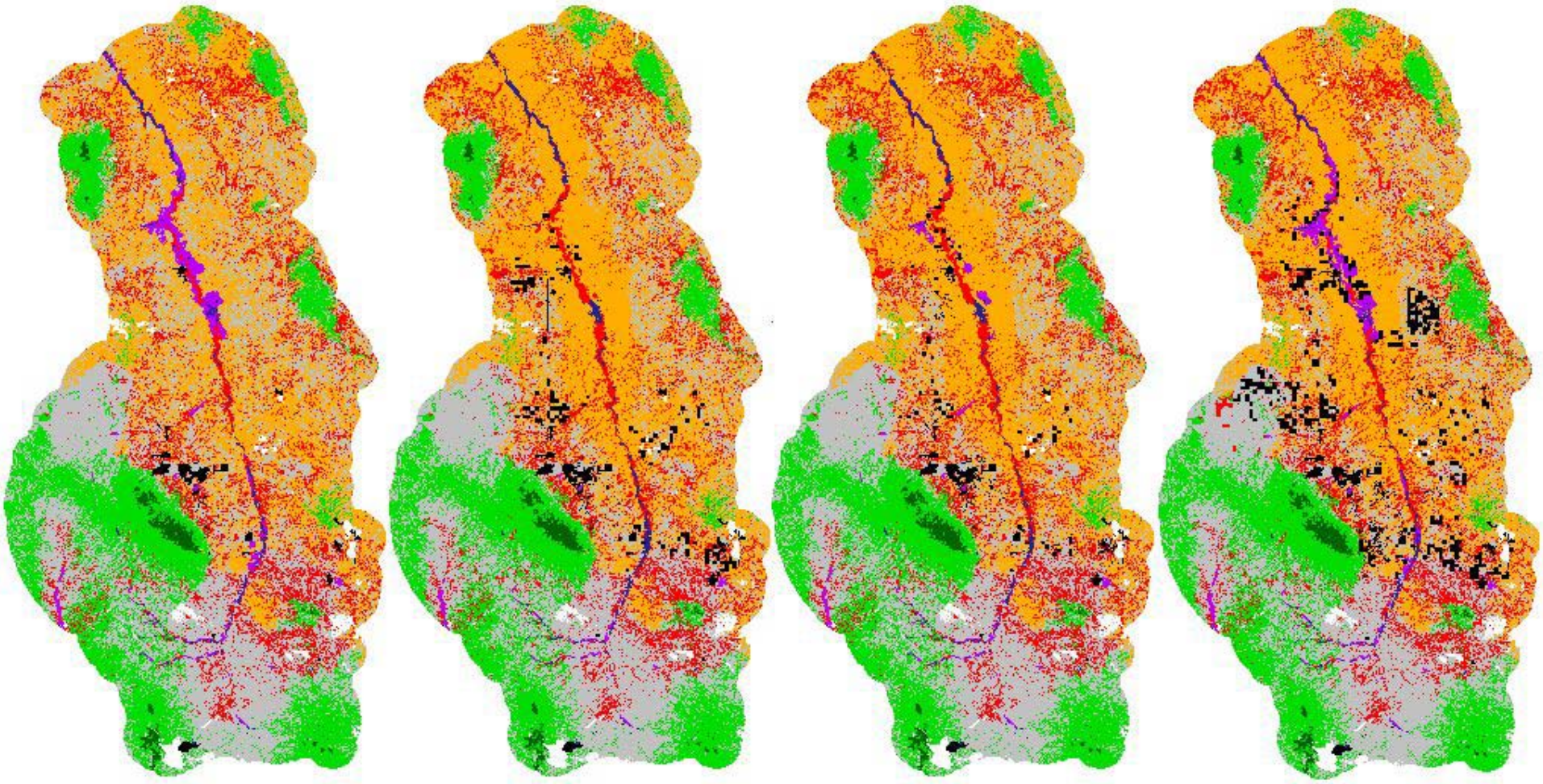
Base Change Scenarios

1. **CONSTRAINED** – Assumes population increase less than 2020 forecast (78,500). Development in existing areas, e.g. 90% urban.

2. **PLANS** – Assumes population increase as forecast for 2020 (95,000). Development in mostly existing areas, e.g. 80% urban and 15% suburban.

3. **OPEN** – Assumes population increase more than 2020 forecast (111,500). Most constraints on land development removed. Development occurs mostly into rural areas (60%) and less in existing urban areas (15%).

Baseline and Three Alternative Future Land Cover/Use Scenarios



2000 Baseline

2020 Constrained Scenario

2020 Plans Scenario

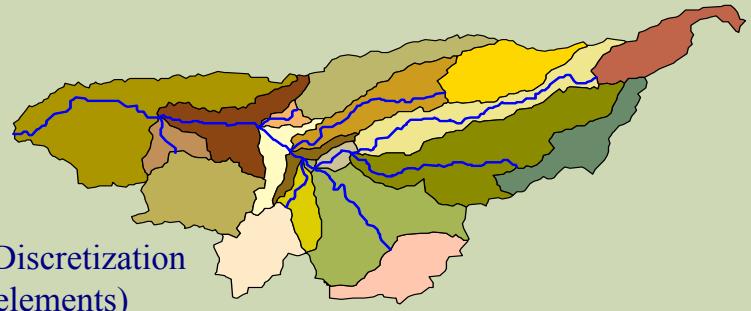
2020 Open Scenario

Key Questions

- What is the difference between the scenario that is most development/least conservation oriented, and the one that is least development/most conservation?

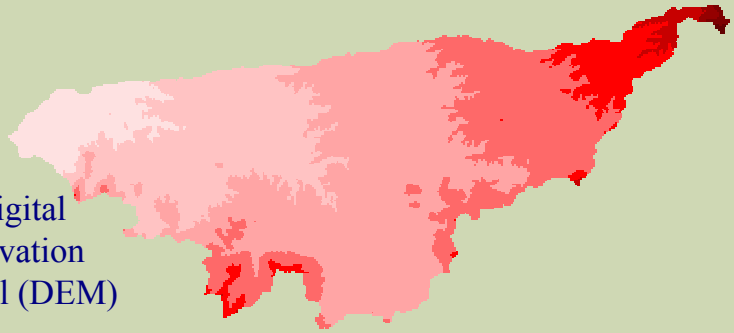
- Can growth patterns be managed to minimize hydrologic and environmental impacts?

AGWA Inputs and Outputs

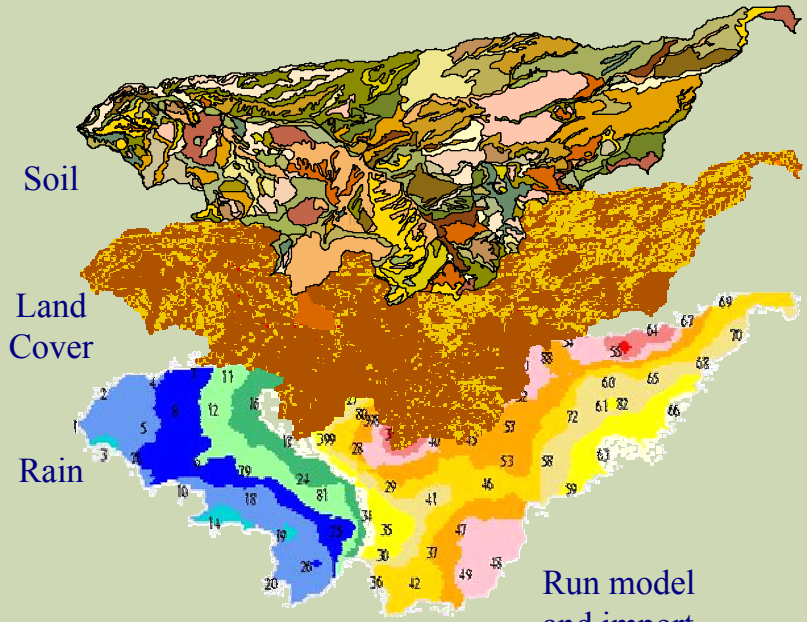


Watershed Discretization
(model elements)

Intersect model
elements with



Digital
Elevation
Model (DEM)

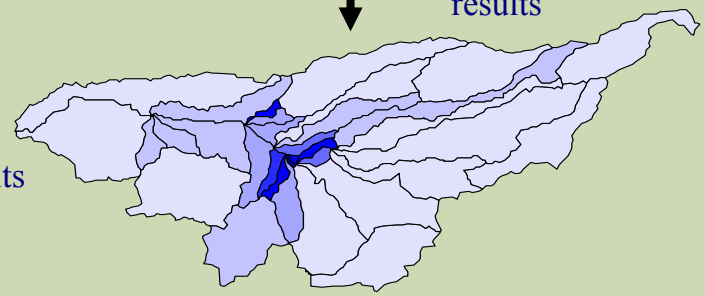


Soil

Land
Cover

Rain

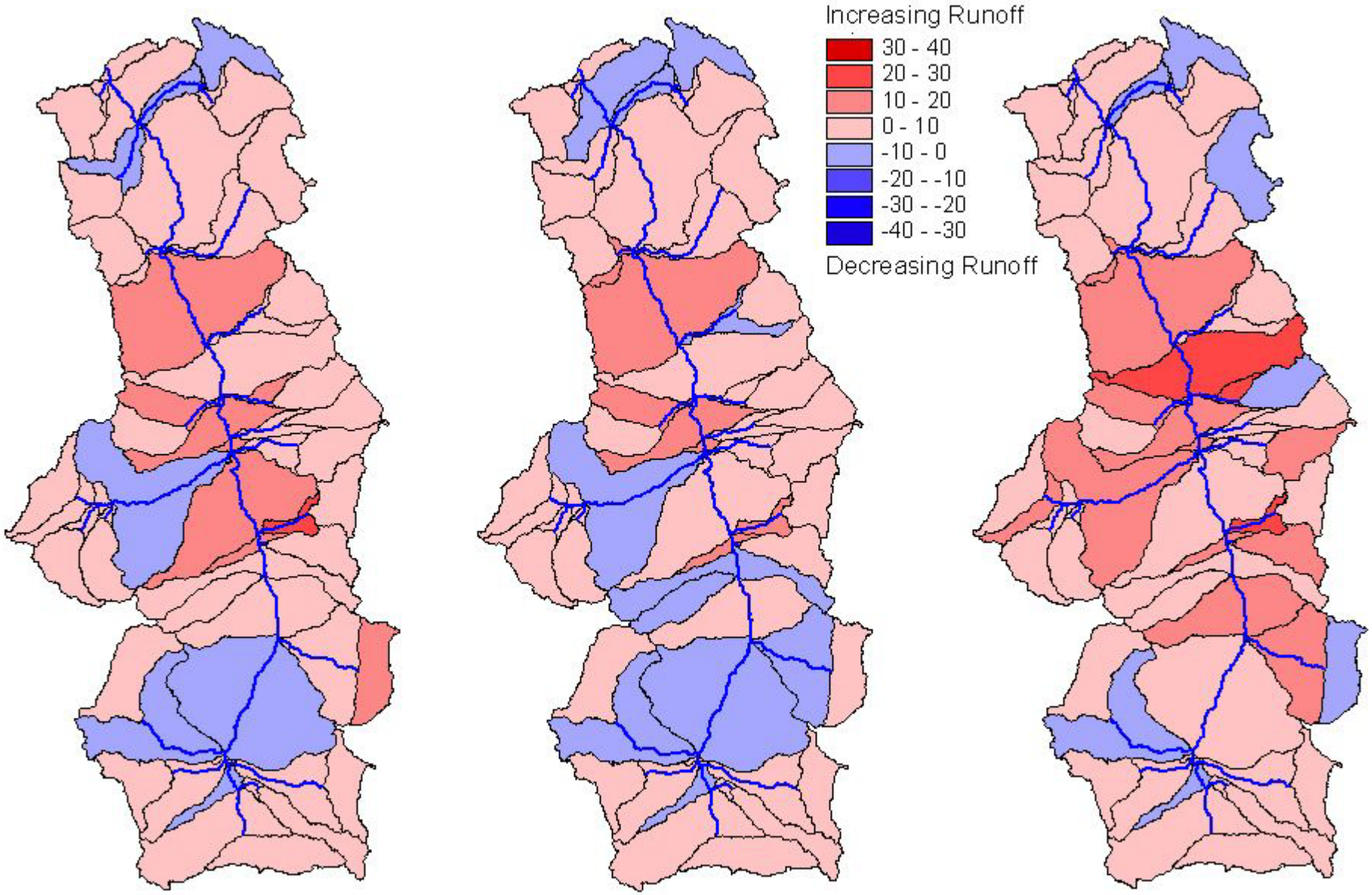
Run model
and import
results



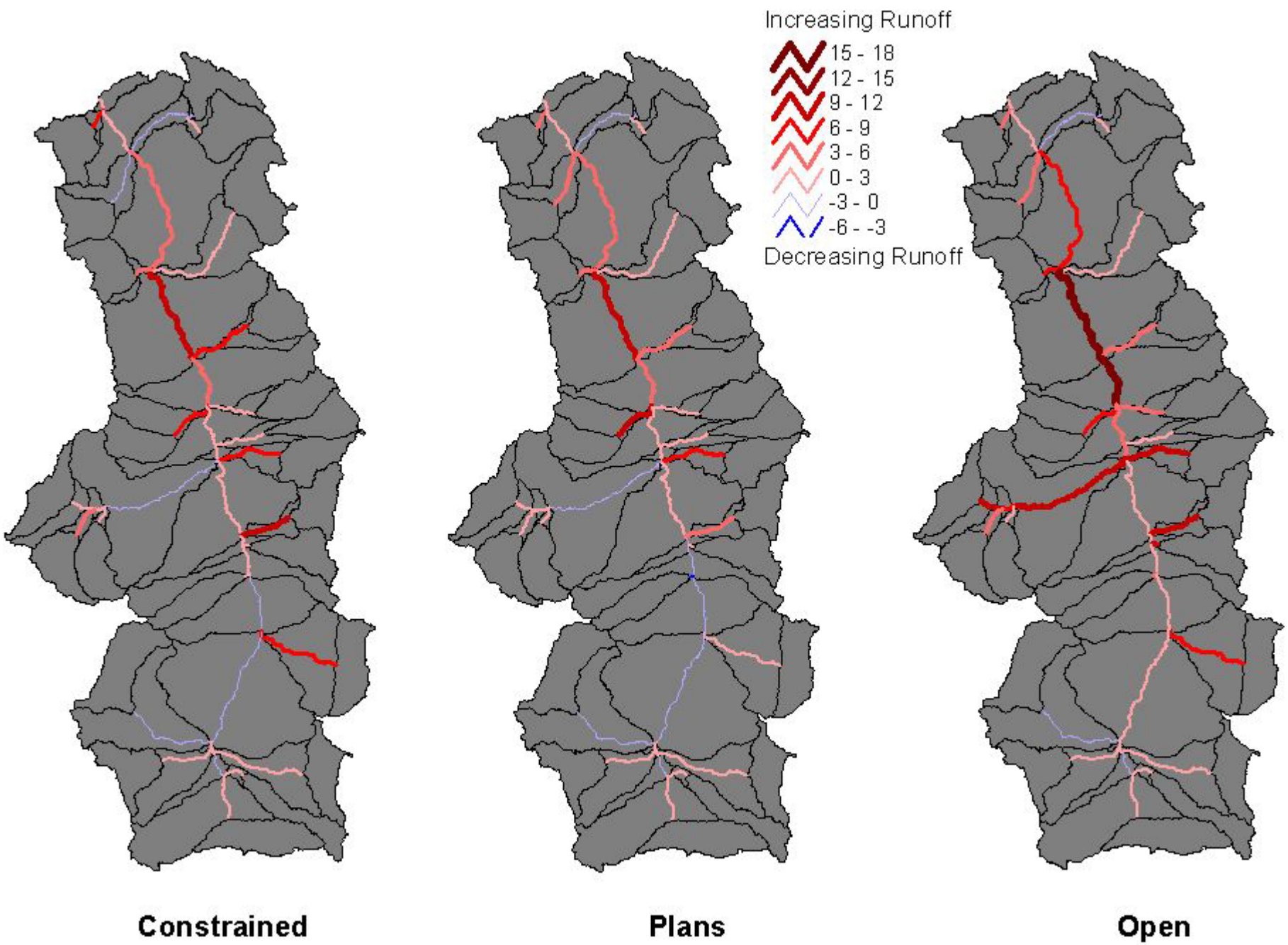
Results

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 loss (mm)
Channel Scour (mm)	Water yield (mm)
Sediment discharge (kg/s)	Sediment yield (t/ha)

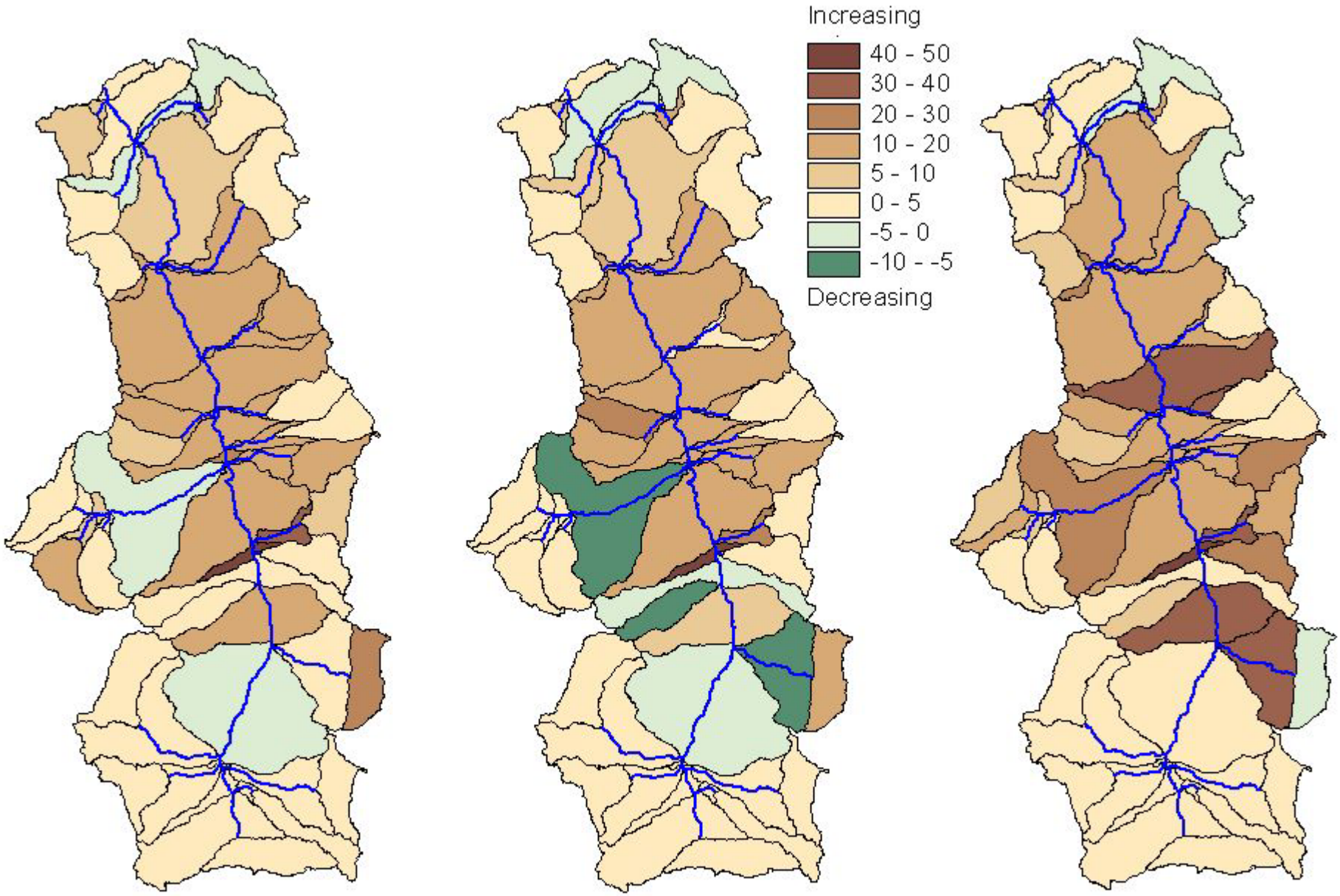
Percent Change in Surface Runoff, 2000 - 2020



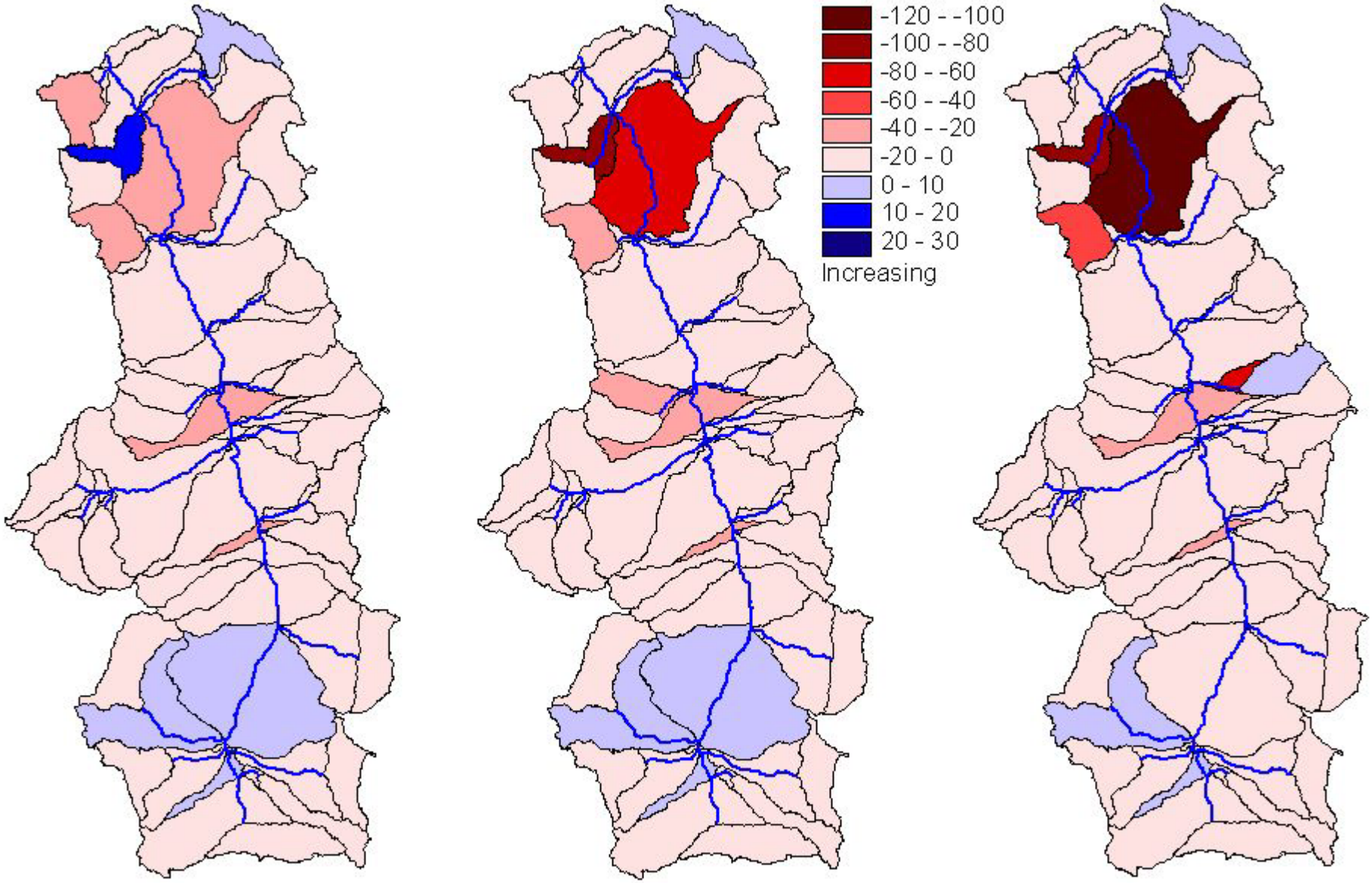
Percent Change in Channel Discharge, 2000 - 2020



Percent Change in Sediment Yield 2000 - 2020



Percent Change in Percolation 2000 - 2020



Model Results

Average values over 20 years, m3/day

Baseline 2000		Constrained 2020	Plans 2020	Open 2020
-131,494	Change in groundwater storage	-55,726	-76,133	-142,102
186,538	Surface runoff	194,573	193,364	199,325
42,760	Percolation	41,593	41,483	40,774

Model Results

	Percent Relative Change 2000 - 2020		
	Constrained 2020	**Plans 2020**	**Open 2020**
Groundwater overdraft	-57.6	-42.1	8.1
Surface runoff	4.3	3.7	6.9
Percolation	-2.7	-3.0	-4.6

Conclusions

- The developed methods provide the potential to assess the spatial and temporal changes in land cover at a landscape scale
- Specifically, they provide an ability to characterize large assessment areas and establish reference condition
- Pattern measurements provide predictive inference for measuring and evaluating change
- Collectively, the combination of technology and the decision analysis framework provide an improved ability to understand the conditions of current and past environment and provide a better predictor for consequences of future actions.

The End, I mean really

…..the End!