Evaluating Hydrological Response of Future Land Cover Change Scenarios in the San Pedro River (U.S./Mexico) with the Automated Geospatial Watershed Assessment (AGWA) Tool

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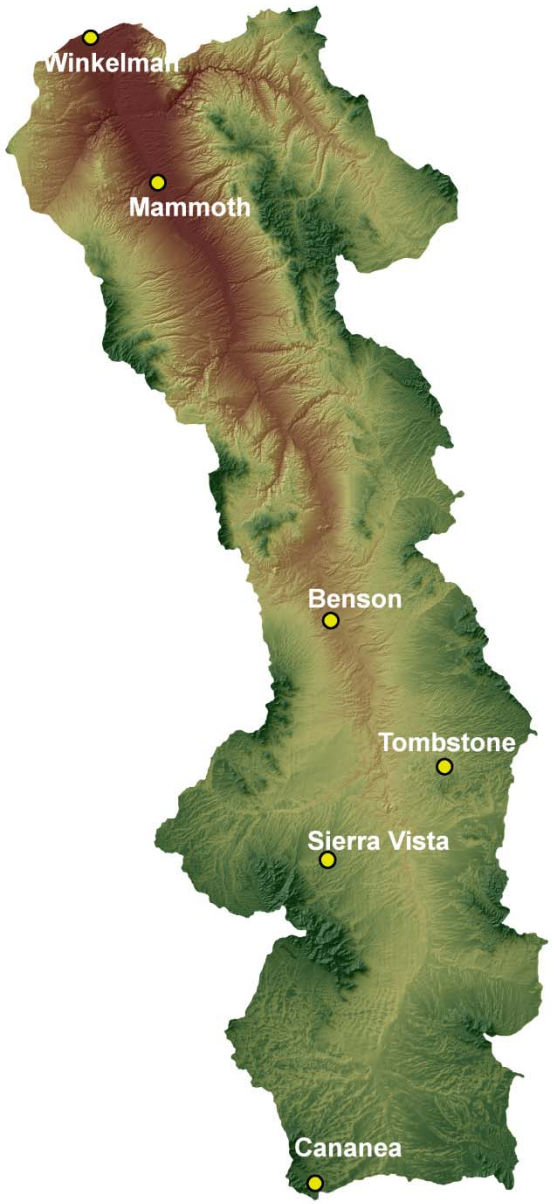
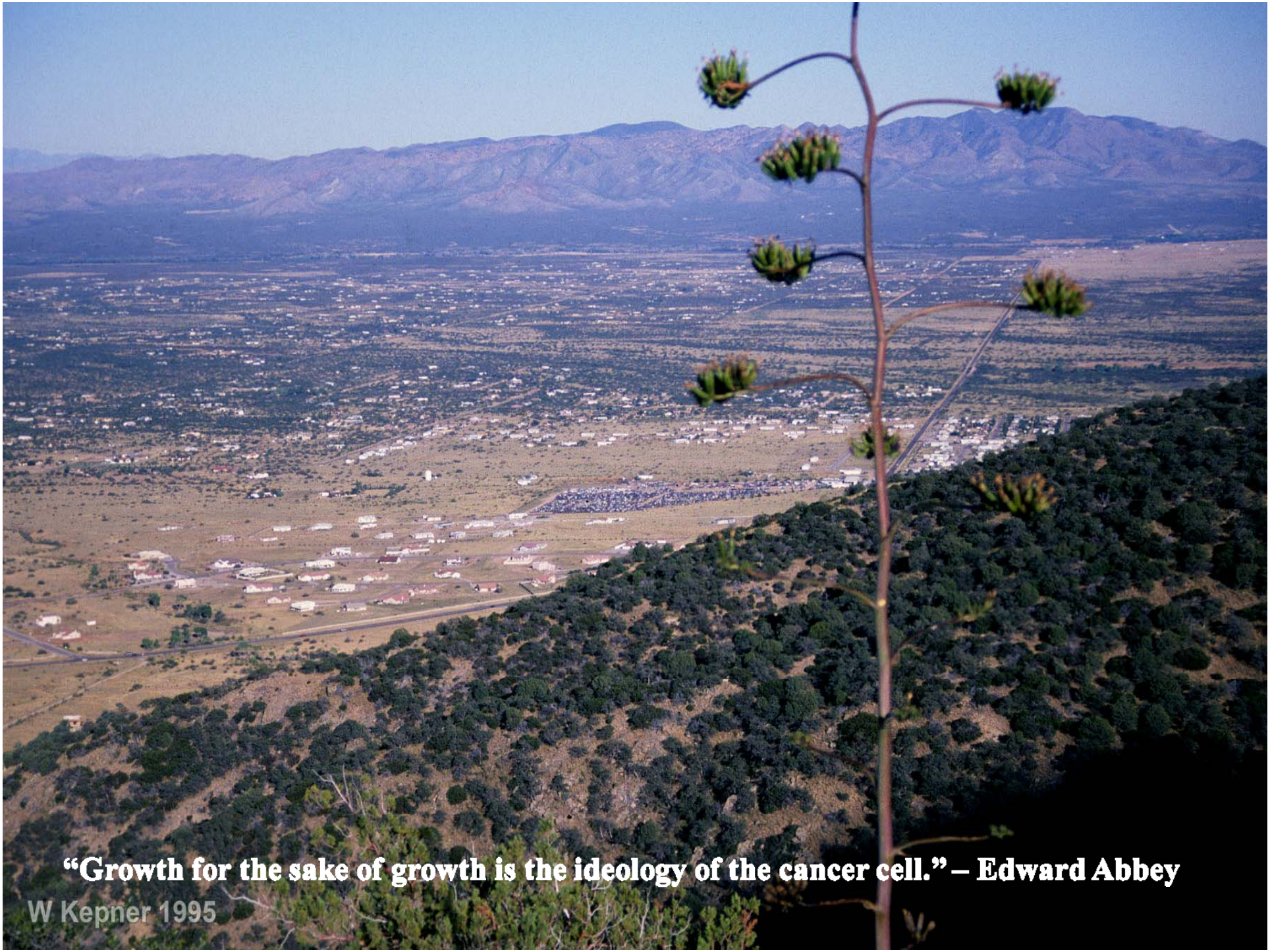
Charleston, SC

San Pedro River Basin

(U.S./Mexico, 9,800 km^2 and 1,800 km^2, respectively)




"Growth for the sake of growth is the ideology of the cancer cell." – Edward Abbey
W Kepner 1995

PROBLEM:

How do changes in land use, and any subsequent change to land cover, affect ecological and **hydrological** conditions and what are the trade-offs between management decisions?

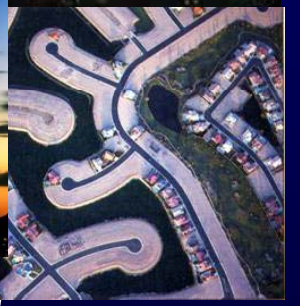
APPROACH:

- Systematically explore implications of wide range of *alternative futures* related to key environmental stressors: **climate variation** *and* **land use** *or* endpoints: e.g., **reliable water supply**

- Invoke scenario analysis framework; apply watershed process models via the **Automated Geospatial Watershed Assessment** (AGWA) tool based on digital land cover derived from ICLUS at decadal intervals to 2100; spatially analyze hydrological response for each alternative future; quantify, visualize, and compare results for each scenario.

2. Land Use

1. Climate



3. Socially Relevant Endpoints, e.g. sustainable development

GIS tools: ICLUS and AGWA

EPA's **Integrated Climate and Land-Use Scenarios** (*ICLUS*)

- Follows IPCC social, economic, and demographic storylines
- Applies storylines to conterminous US
- Demography and population at county level
- Seamless maps of **housing density** and **impervious surface cover**
- Scenarios were run for the period 2010 to 2100 in **decadal steps**

Developed to assist climate change impact assessment and mitigation in US

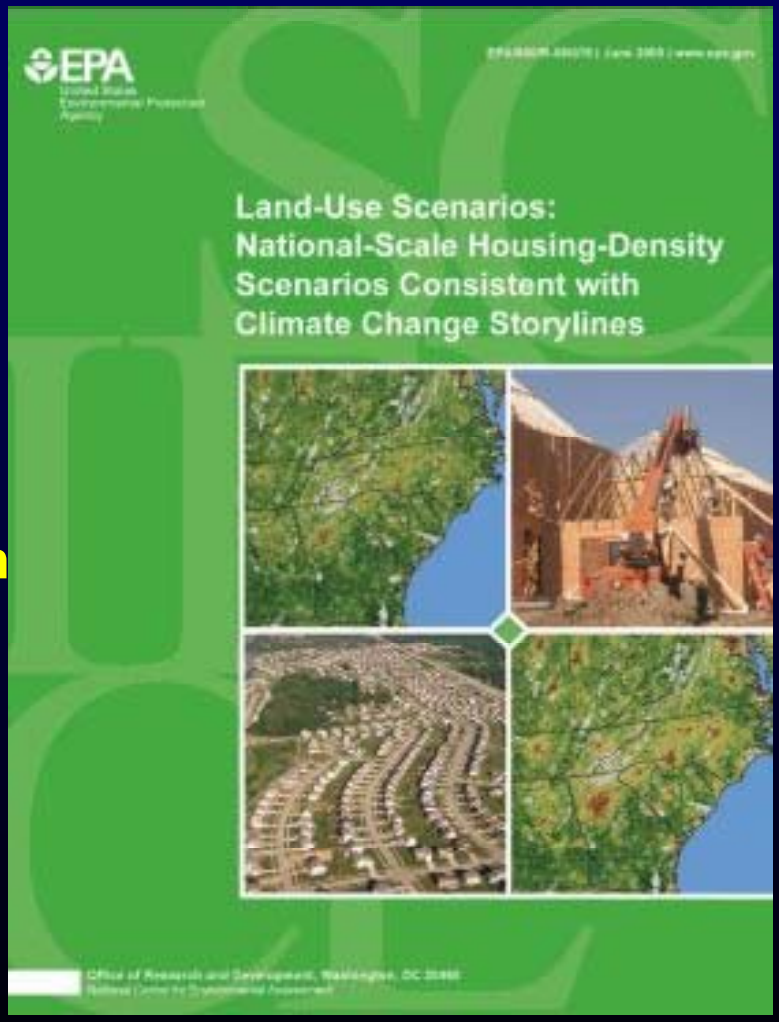
Automated Geospatial Watershed Assessment (*AGWA*)

- Joint EPA, USDA-ARS, and University of Arizona product
- Supports hydrologic and water quality analyses
- **Multiple spatial and temporal scales**
- Can run **forecasted or observed** simulations
- Compute and **visualize** the simulation results

Developed to automate steps required for hydrologic modeling and visualizing outputs

ICLUS: Integrated Climate and Land-Use Scenarios

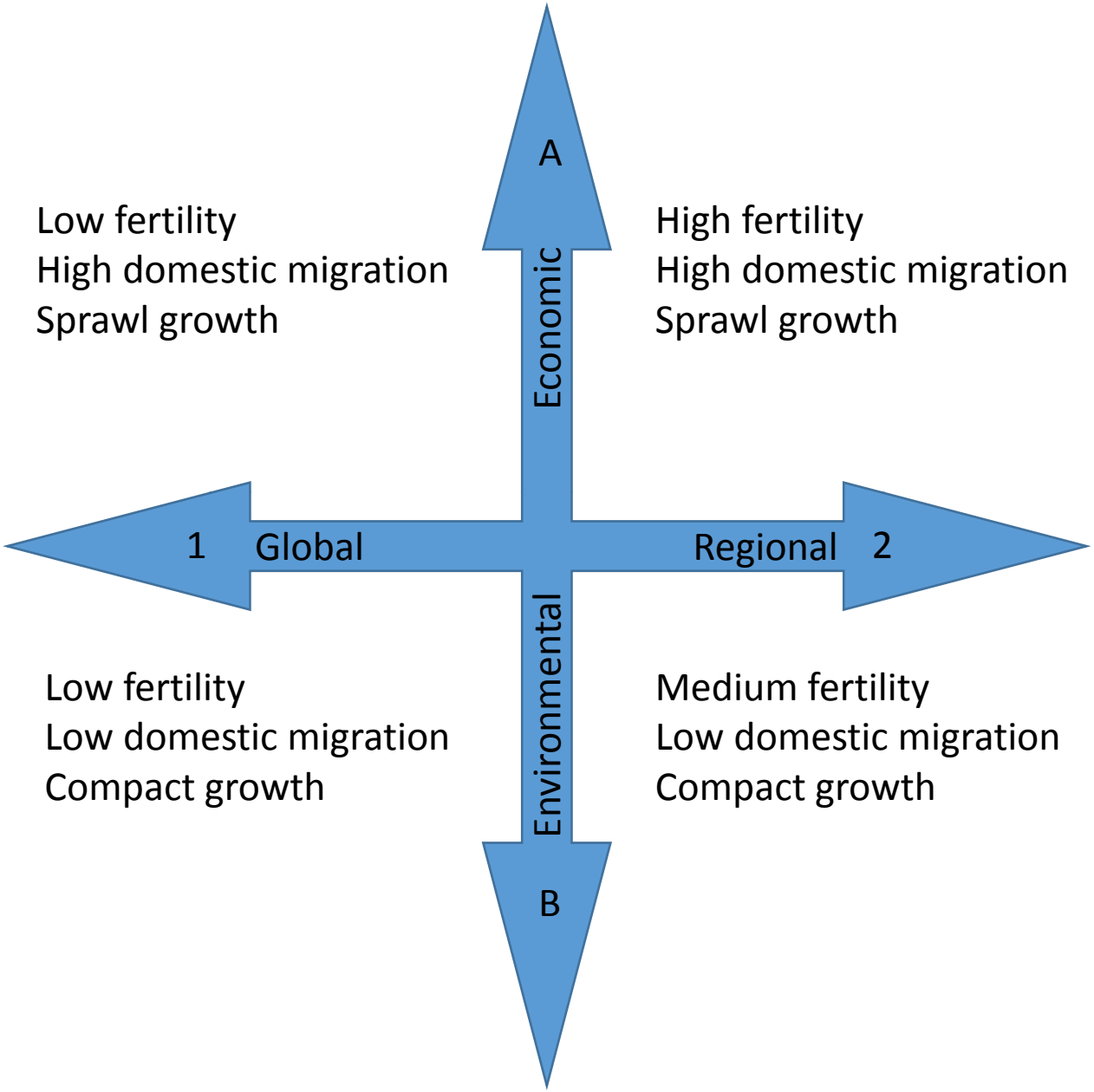
- Provides seamless land use scenarios for the **conterminous** United States consistent with IPCC emission storylines
- Demography and population at county level
- **Housing density allocated at 1 ha resolution**
- Estimated % impervious surface at 1 km^2 resolution



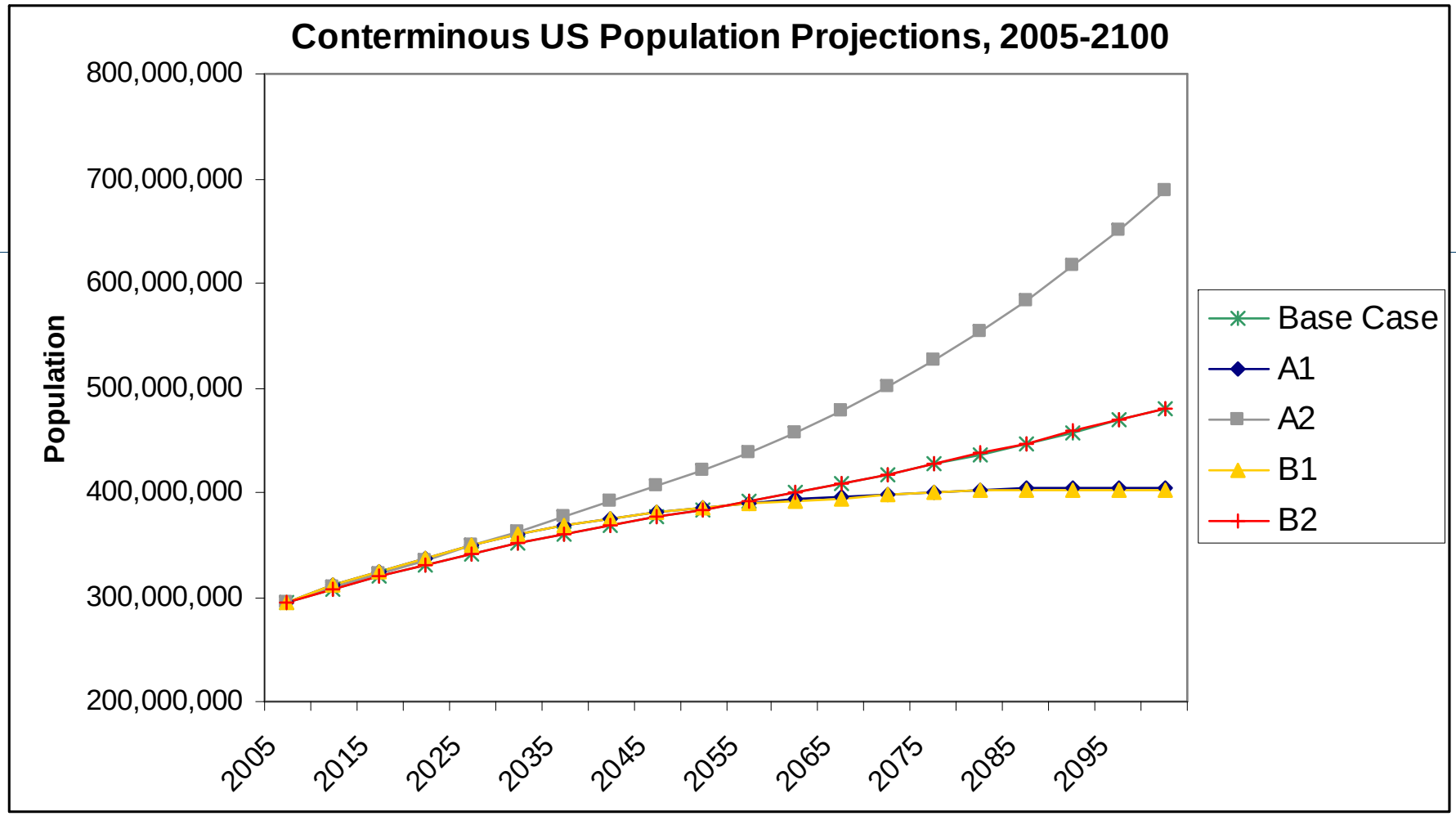
EPA Global Change Research Program
EPA/600/R-08/076F June 2009

Interpretation of Base Condition and Scenario Families for US

National Scenario	Demographic Model			Spatial Allocation Model	
	Fertility	*Domestic migration*	*Net int'l migration*	*Household size*	*Urban Form*
A1: fast economic development; medium population growth; high global integration	Low	High	High	Smaller (-15%)	No change
B1: medium pop. growth rate; low domestic migration resulting in compact urban development	Low	Low	High	Smaller (-15%)	Slight compaction
A2: high population growth rate, greatest land conversion, high dispersal (domestic migration) resulting in new pop. centers	High	High	Low	Larger (+15%)	No change
B2: moderate economic dev.; medium population growth; medium international migration	Medium	Low	Low	No change	Slight compaction
Baseline (2000): US Census medium scenario	Medium	Medium	Medium	No change	No change


A
Economic
B
Environmental
1
Global
Regional
2
Low fertility
High domestic migration
Sprawl growth
High fertility
High domestic migration
Sprawl growth
Low fertility
Low domestic migration
Compact growth
Medium fertility
Low domestic migration
Compact growth

Population Projections for ICLUS Scenarios



Conceptual Design of AGWA

PROCESS

Build GIS Database

Discretize Watershed
f (topography)

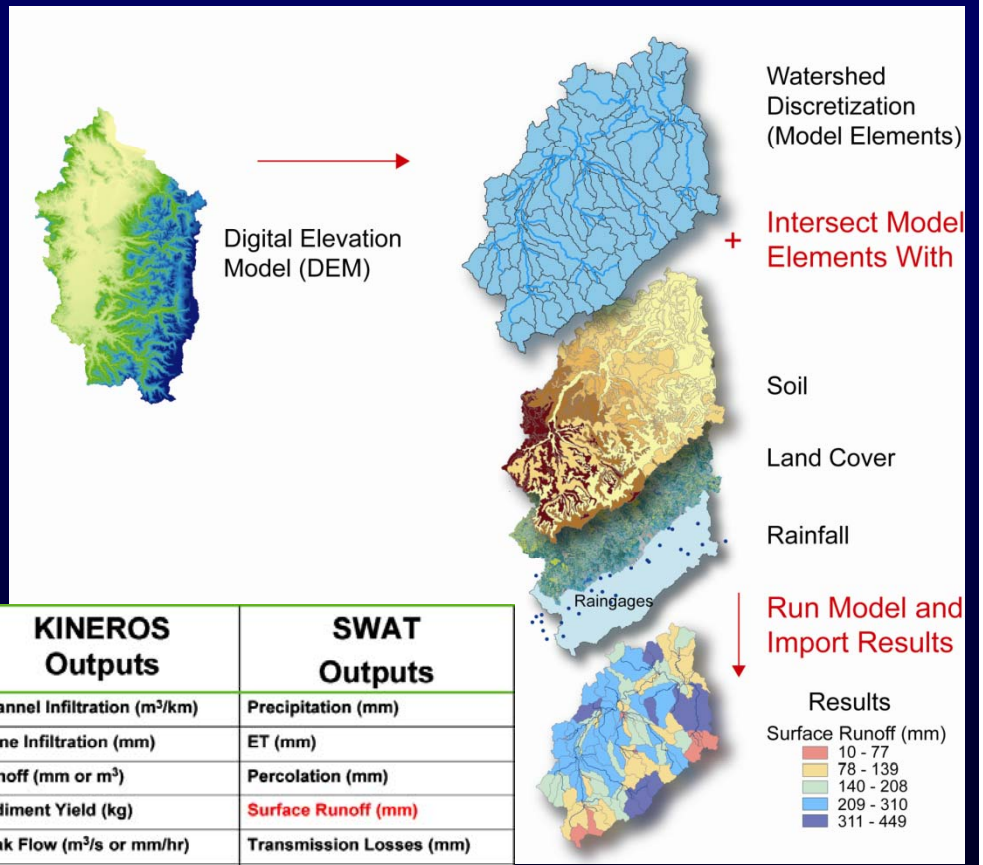
Characterize Model Elements
f (land cover, precipitation, soils)

Derive Secondary Parameters
look-up tables

Build Model Input Files

View Model Results
link model to GIS

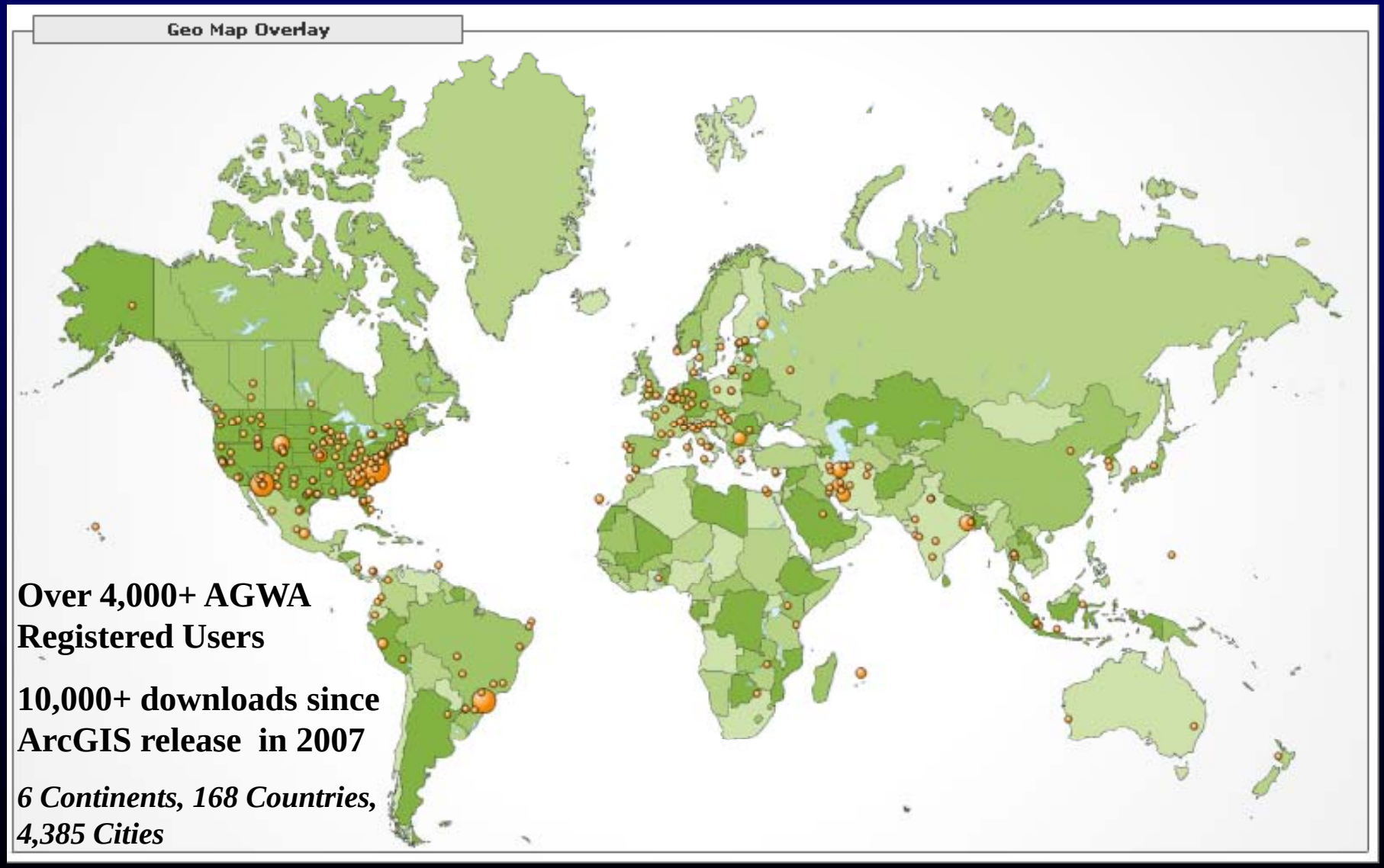
INPUTS & OUTPUTS



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)

Worldwide Interest

Google Analytics



Land cover reclassification

First NALC to NLCD to unify basin cover classes…

…then ICLUS to NLCD to create 5 land cover change scenarios at 10 decadal interval steps…

…add DEM, drainage network, soil layer, and historical weather data…

...and then run AGWA for each scenario for each decade 2010 - 2100.

Table 2: Reclassification Table for 1992 NALC in Mexico to 2006 NLCD Land Cover Types.

1992 NALC (Mexico)		2006 NLCD	
Code	Land Cover Type	Code	Land Cover Type
1	Forest	42	Evergreen Forest
2	Oak Woodlands	41	Deciduous Forest
3	Mesquite Woodlands	52	Scrub/Shrub
4	Grasslands	52	Scrub/Shrub
5	Desert Scrub	52	Scrub/Shrub
6	Riparian	90	Woody Wetlands
7	Agricultural	82	Cultivated Crops
8	Urban	22	Developed, Medium Intensity
9	Water	11	Open Water
10	Barren	31	Barren Land

Table 3: Explanation of ICLUS Housing Density Categories.

Class	Acres Per Housing Unit	Housing Units Per Acre	Hectares Per Housing Unit	Housing Units Per Hectare	Density Category
99	NA	NA	NA	NA	Commercial/Industrial
4	<0.25	>4	<0.1	>10	Urban
3	0.25-2	0.5-4	0.1-0.81	1.23-10	Suburban
2	2-40	0.025-0.5	0.81-16.19	0.06-1.23	Exurban
1	>40	<0.025	>16.19	<0.06	Rural

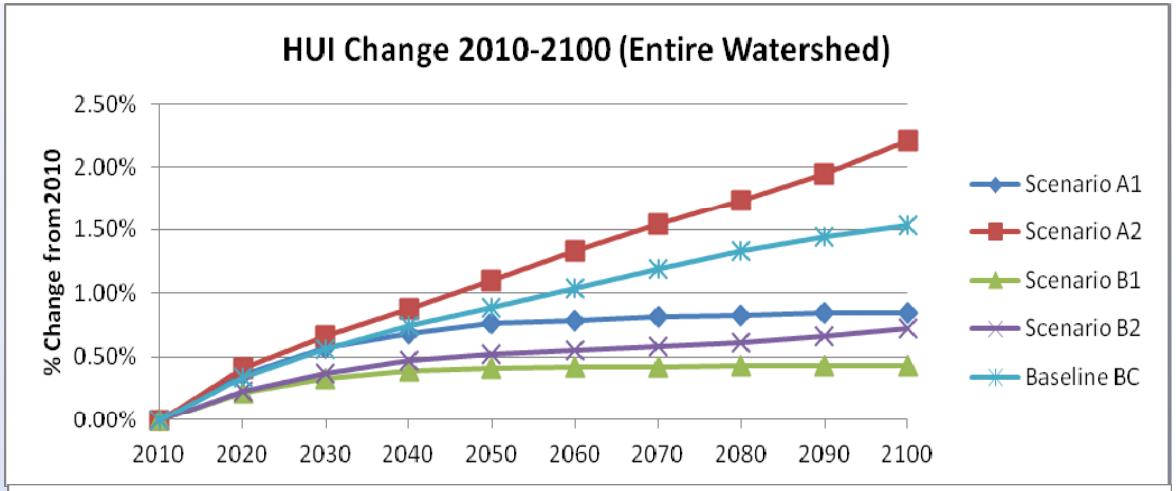
Table 4: Reclassification Table for ICLUS Housing Density Classes to 2006 NLCD Land Cover Types.

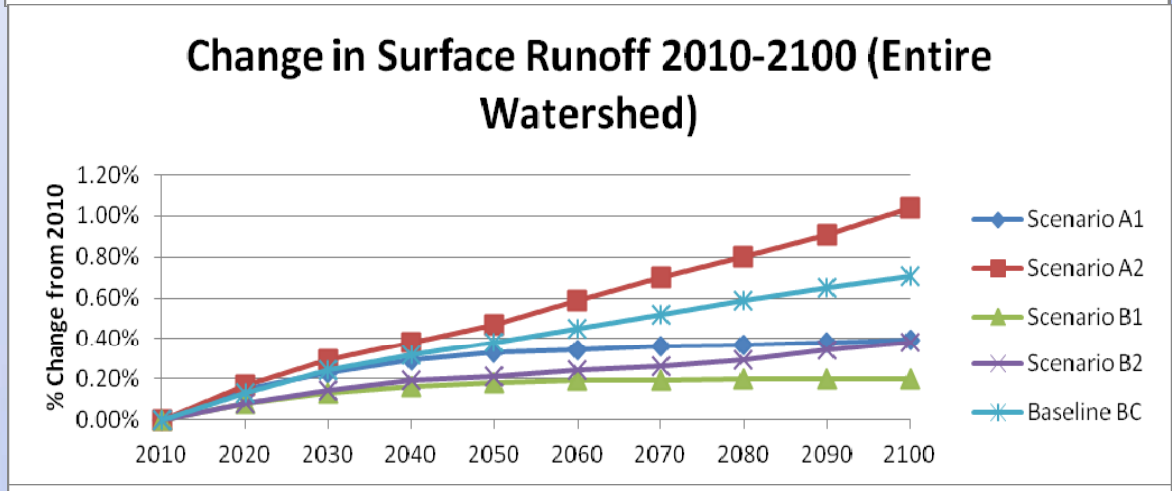
ICLUS Data		2006 NLCD	
Code	Land Cover Type	Code	Land Cover Type
1	Rural	-	Default to NLCD cover type
2	Exurban	22	Developed, Low Intensity
3	Suburban	23	Developed, Medium Intensity
4	Urban	24	Developed, High Intensity
99	Commercial/Industrial	24	Developed, High Intensity

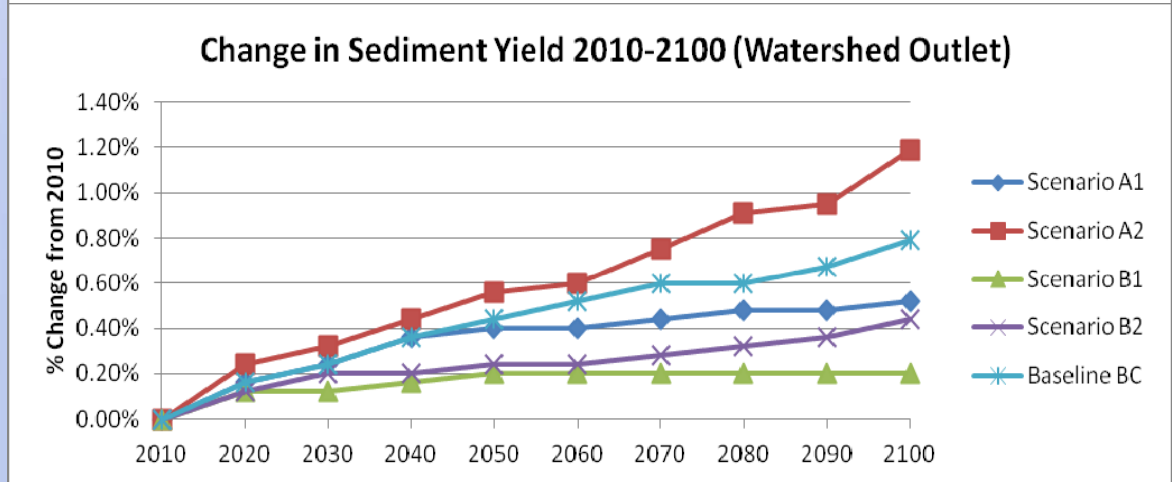
Basinwide Results

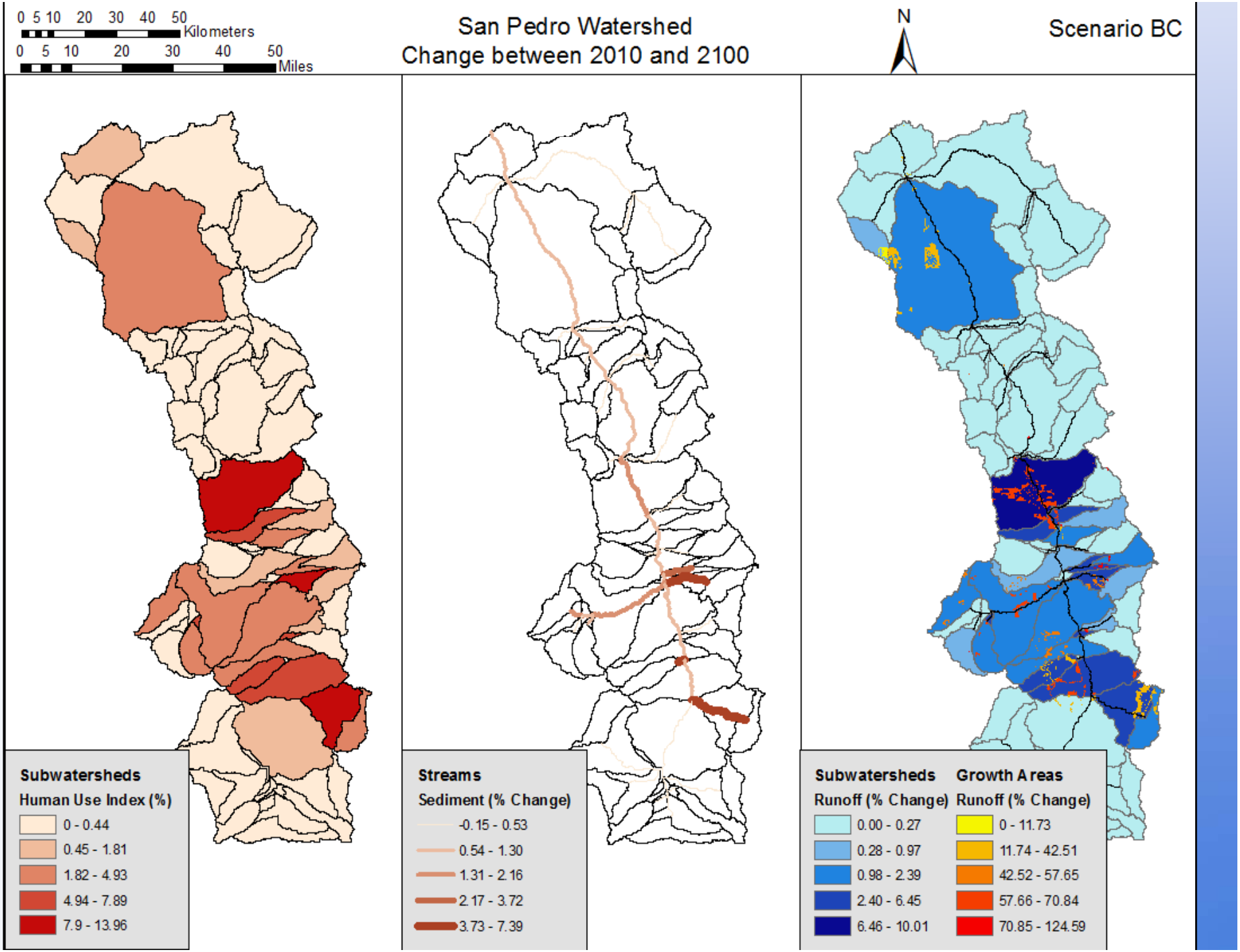
Both surface runoff and sediment yield changes closely tracked increases to Human Use Index (HUI) changes.

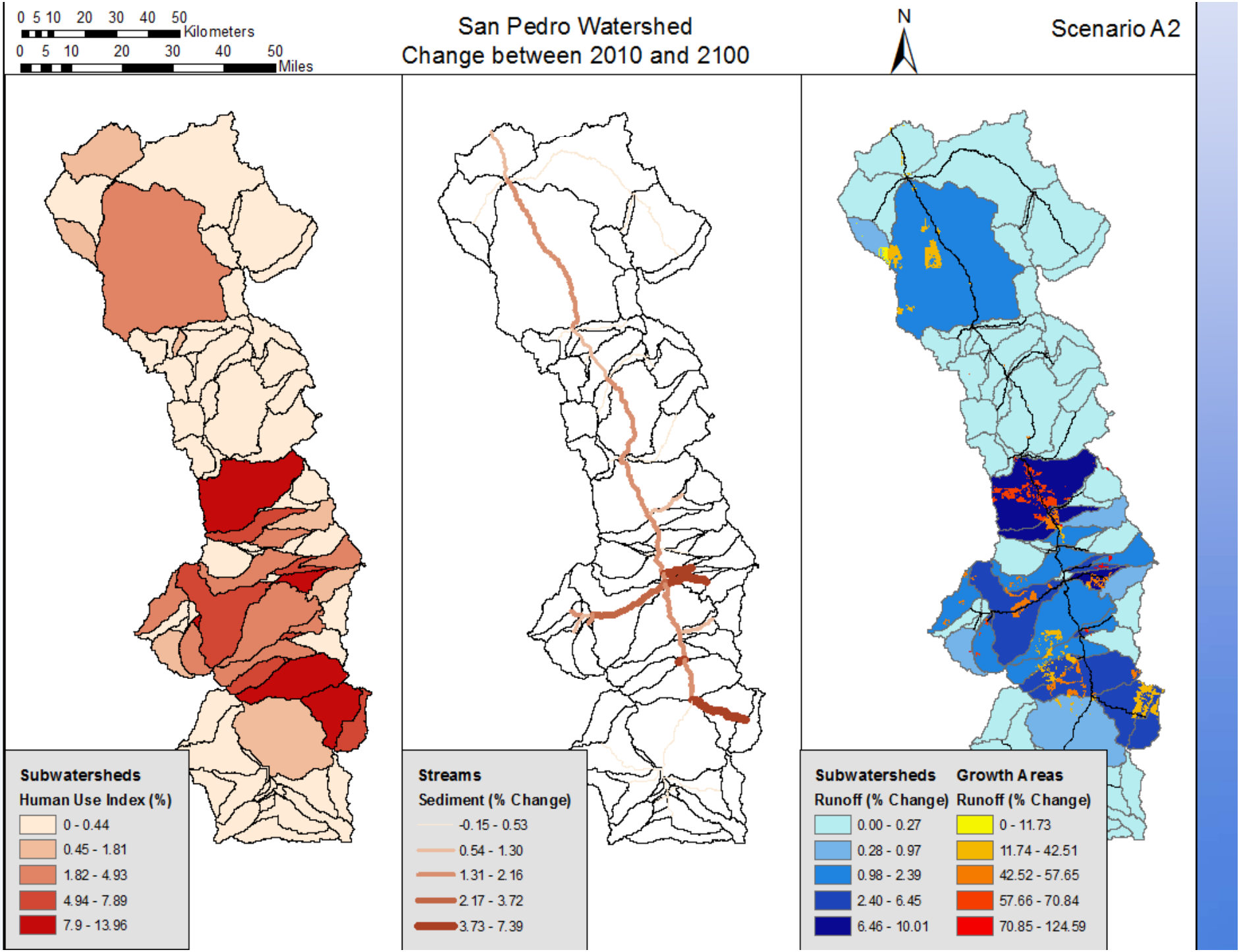
Migration and urban form are important factors.








0 5 10 20 30 40 50
Kilometers
0 5 10 20 30 40 50
Miles
San Pedro Watershed
Change between 2010 and 2100
N
Scenario BC
Subwatersheds
Human Use Index (%)
0 - 0.44
0.45 - 1.81
1.82 - 4.93
4.94 - 7.89
7.9 - 13.96
Streams
Sediment (% Change)
-0.15 - 0.53
0.54 - 1.30
1.31 - 2.16
2.17 - 3.72
3.73 - 7.39
Subwatersheds
Runoff (% Change)
0.00 - 0.27
0.28 - 0.97
0.98 - 2.39
2.40 - 6.45
6.46 - 10.01
Growth Areas
Runoff (% Change)
0 - 11.73
11.74 - 42.51
42.52 - 57.65
57.66 - 70.84
70.85 - 124.59


0 5 10 20 30 40 50
Kilometers
0 5 10 20 30 40 50
Miles
San Pedro Watershed
Change between 2010 and 2100
N
Scenario A2
Subwatersheds
Human Use Index (%)
0 - 0.44
0.45 - 1.81
1.82 - 4.93
4.94 - 7.89
7.9 - 13.96
Streams
Sediment (% Change)
-0.15 - 0.53
0.54 - 1.30
1.31 - 2.16
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General conclusions……

- **The developed methods provide the potential to assess the spatial and temporal changes in land cover at a landscape or watershed scale;**

- **Specifically, they provide an ability to characterize large assessment areas to establish reference condition and provide a comparative mechanism to visualize and understand results across scientifically meaningful assessment units, i.e. watersheds/subwatersheds;**

- **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.**

- **However, basin-wide impacts are effectively averaged out by undevelopable lands. Thus any interests in cumulative effect should be addressed at the subwatershed versus basin scale for this western watershed or others like it which contain large tracts of land in the public domain, and are therefore not subject to direct urbanization impacts.**

United States Environmental Protection Agency

EPA/600/R-13/074
ARS/294076
June 2013
www.epa.gov/research

Assessing Hydrologic Impacts of Future Land Cover Change Scenarios in the San Pedro River (U.S./Mexico)

EPA Report 600/R-13/074:
http://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=256962

ICLUS
http://www.epa.gov/ncea/global/iclus/ (**v1.3**)

AGWA v3.x
(EPA/600/C-13/148 and ARS/296053)
http://www.epa.gov/nerlesd1/land-sci/agwa/
http://www.tucson.ars.ag.gov/agwa/

RESEARCH AND DEVELOPMENT

More Information

AGWA application is worldwide and supported by 2 parallel federal Web Pages with full documentation, software downloads, quality assurance plans, tutorials, publications, and posters.

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

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

Also see *Registry of EPA Applications, Models and Databases* (READ):

http://ofmpub.epa.gov/sor_internet/registry/systmreg/resourcedetail/general/description/description.do?infoResourcePkId=11982

and ***EPA Council for Regulatory Environmental Modeling*** **(CREM)** ***Models Knowledge Base*****:**

http://cfpub.epa.gov/crem/knowledge_base/crem_report.cfm?deid=75821

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