Land Use Scenarios to Assess Global Change Impacts on Water Resources and Ecosystems

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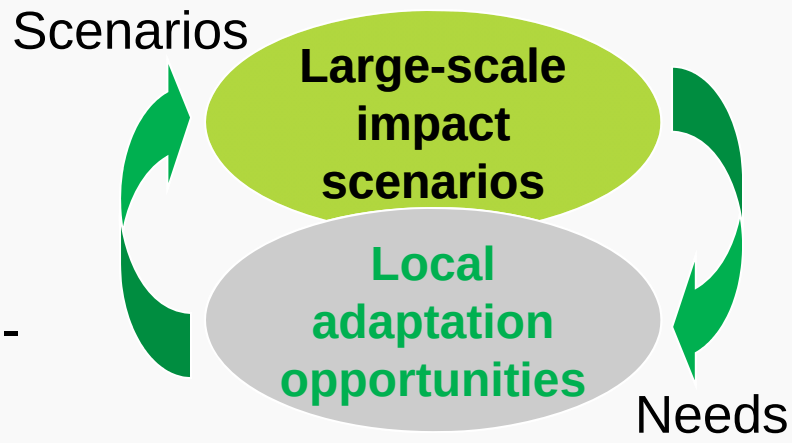
Outline

- Introduction to land use scenarios: ICLUS
- Use of scenarios in water quality modeling
- Use of scenarios in vulnerability assessment of Northeastern streams for monitoring

ICLUS: Integrated Climate and Land Use Scenarios

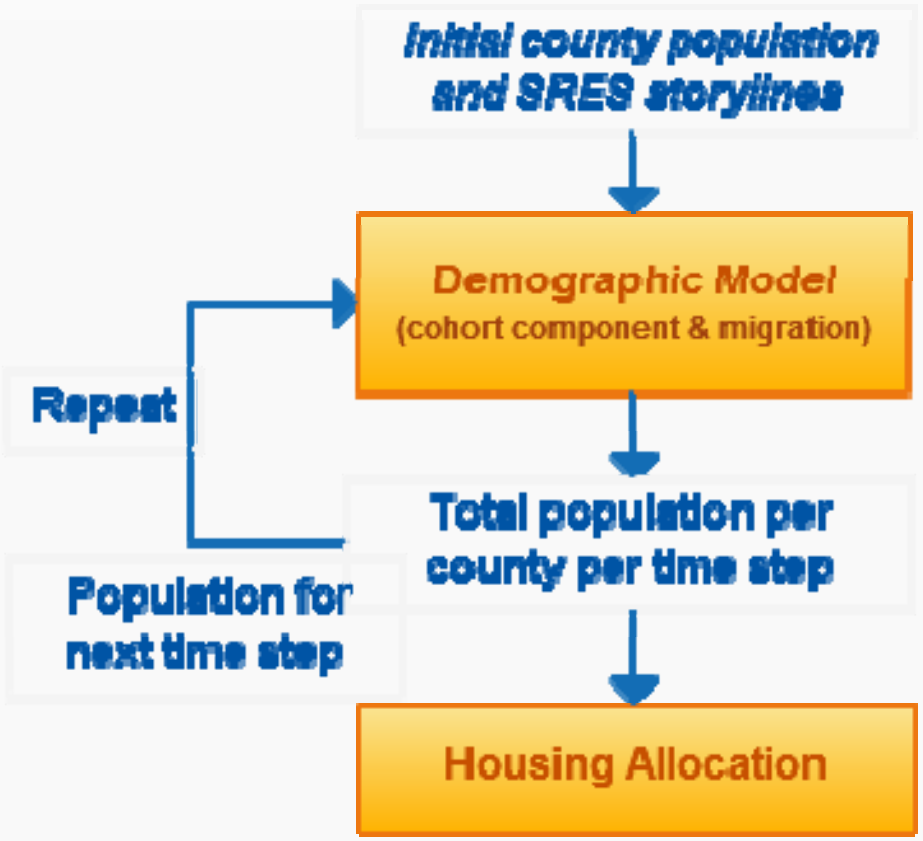
Goals:

- Create seamless land use scenarios for the conterminous United States consistent with IPCC emissions storylines (SRES)
- Provide consistent benchmarks for local and regional land use studies
- Identify geographic areas where climate-land use interactions may exacerbate impacts or create adaptation opportunities



Report: http://www.epa.gov/ncea; go to Global Change -> Land-Use Scenarios

ICLUS Conceptual Diagram

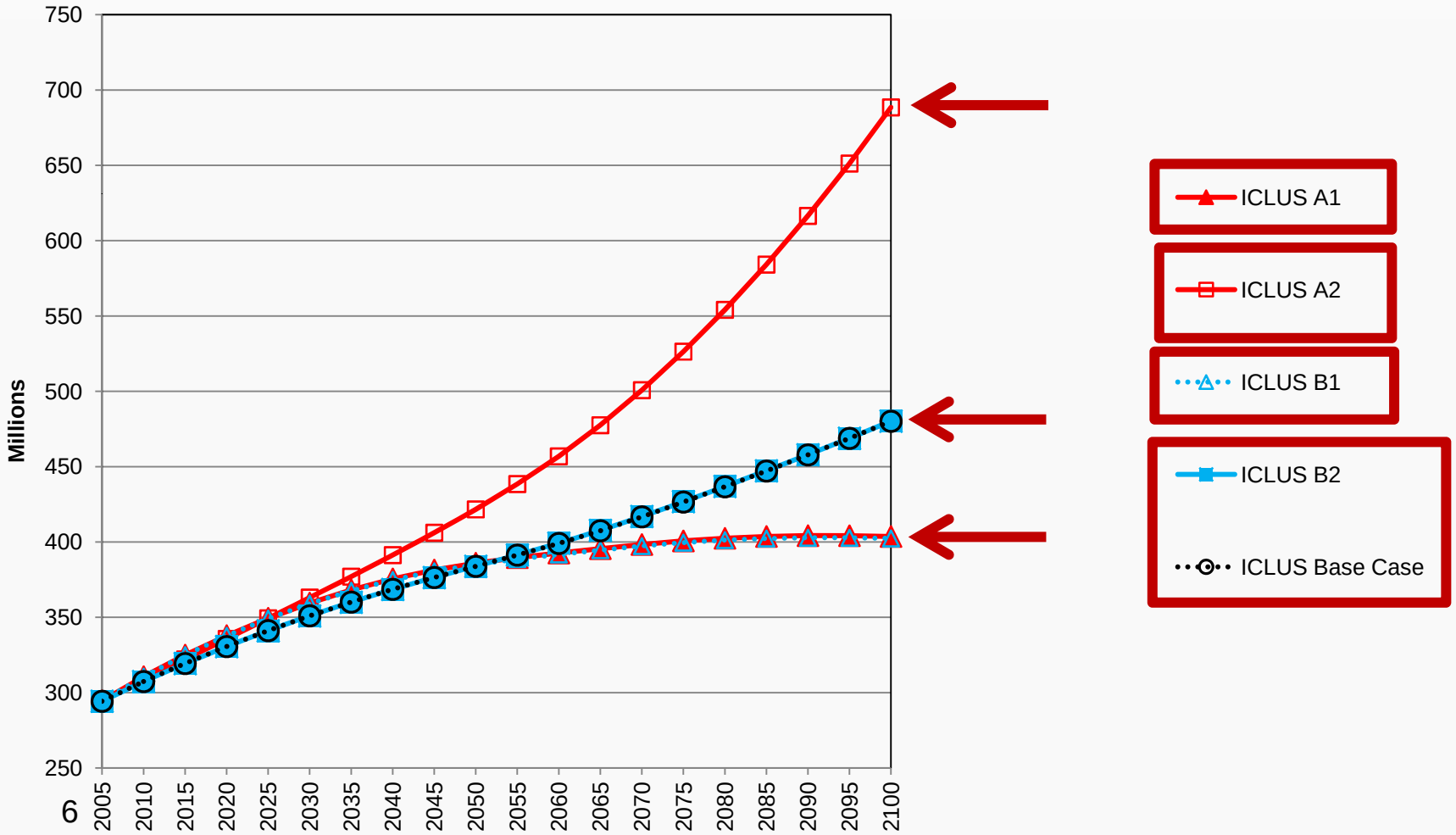


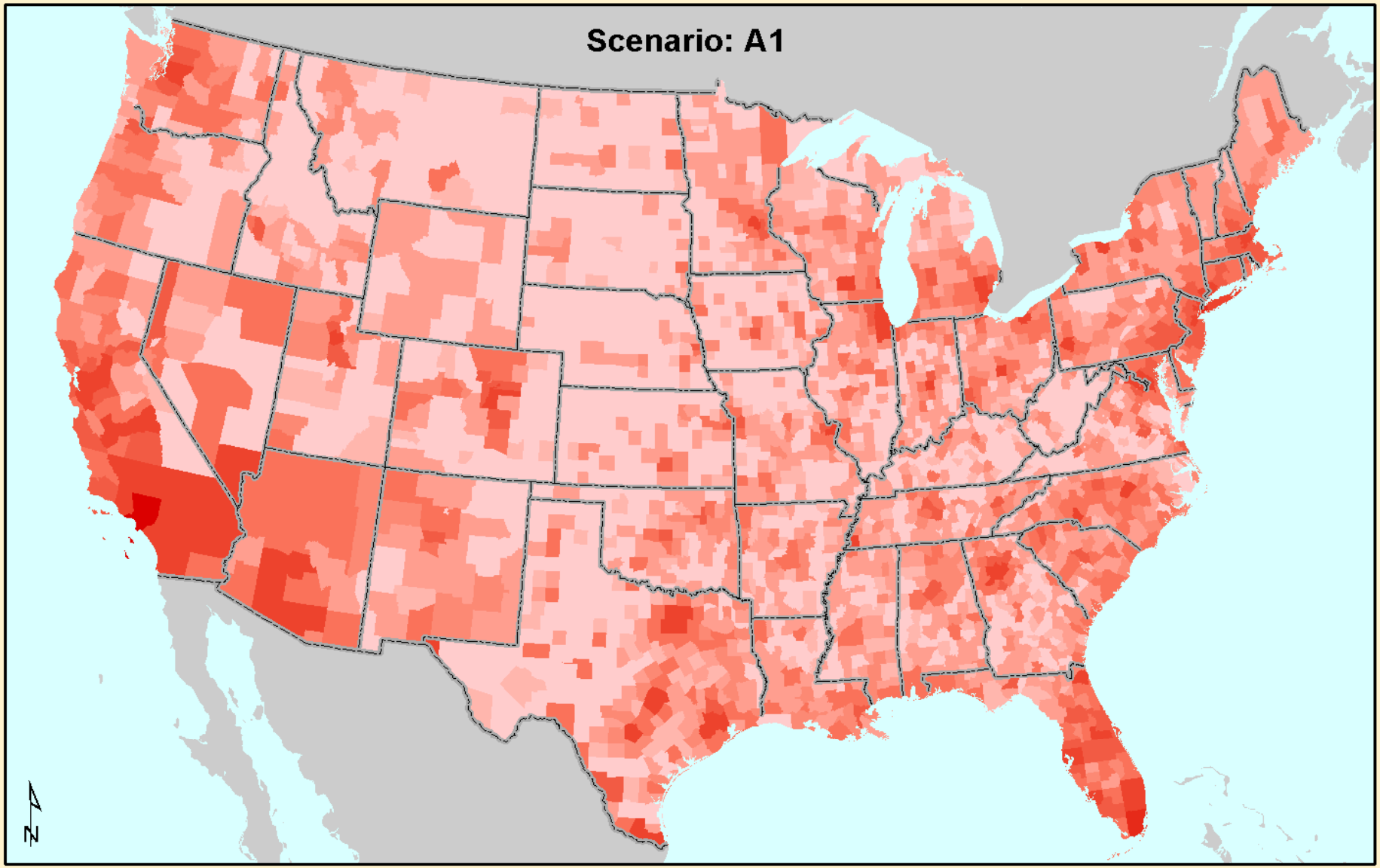
Model and information flow within the ICLUS project

Interpretation of SRES for US

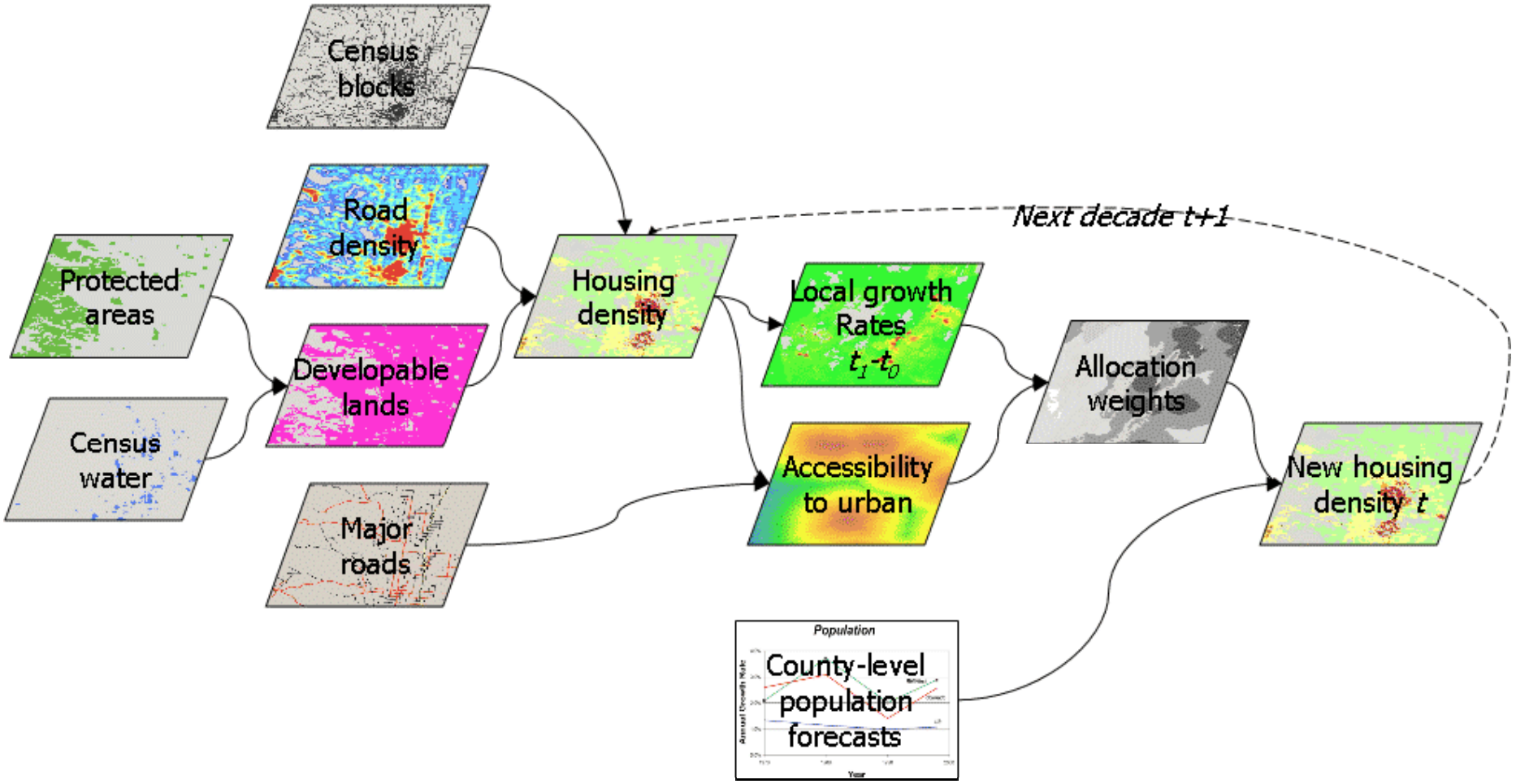
Global Scenario	Demographic Model			Spatial Allocation Model	
	Fertility	*Domestic migration*	*Net int'l migration*	*Household size*	*Urban Form*
A1: fast econ. dev.; med. pop growth; high global integration	Low	High	High	Smaller (-15%)	No change
B1: med. pop growth; high global integration; rapid social dev.	Low	Low	High	Smaller (-15%)	Slight compact
A2: regional focus, slower econ. growth; low/med int'l migr.; high pop growth	High	High	Low	Larger (+15%)	BAU
B2: moderate econ. dev.; med. pop growth; med int'l migration	Medium	Low	Low	No change	Slight compact
Baseline: US Census medium scenarios	Medium	Medium	Medium	No change	No change

National Population Projections



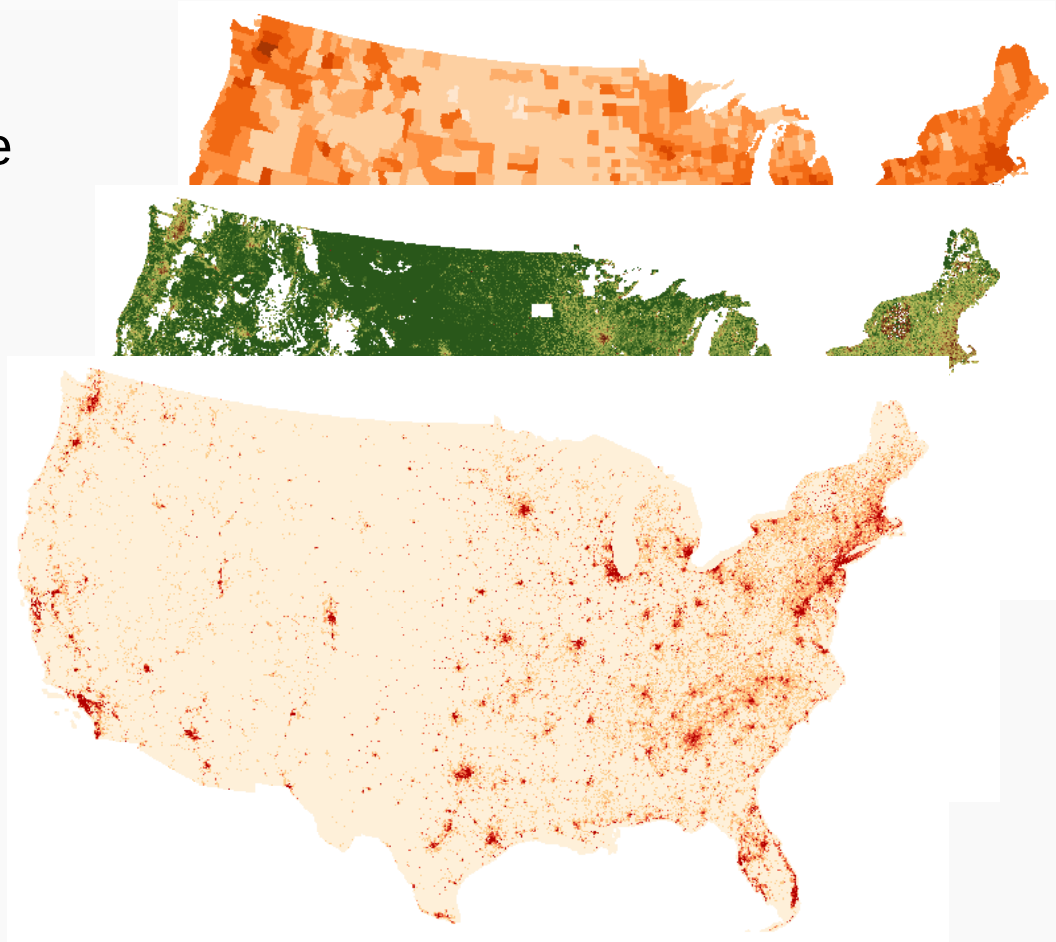

Scenario: A1
N
Thousands of People Per County
<= 5
5 - 10
10 - 50
50 - 100
100 - 500
500 - 1,000
1,000 - 5,000
5,000 - 10,000
> 10,000
Integrated Climate and Land-Use Scenarios (ICLUS)
Population Projections for 2050
Albers Projection
Central Meridian: -96
1st Std Parallel: 20
2nd Std Parallel: 60
Latitude of Origin: 40
300 Miles
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SERGoM v3


Census blocks
Road density
Protected areas
Developable lands
Census water
Major roads
Housing density
Next decade t+1
Local growth Rates t_1-t_0
Accessibility to urban
Allocation weights
New housing density t
Population
County-level population forecasts

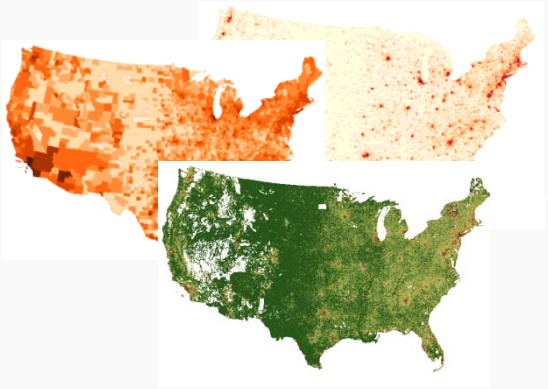
Review: Data to Distribute

- County population by decade for each scenario (shapefile)
- Classified housing density (raster)
- Impervious surface cover (raster)

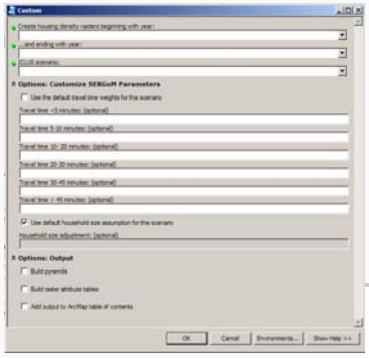


ICLUS Toolbox for ArcGIS

- **Re-create maps**
  - county population
  - housing density (1 ha)
  - impervious surface cover (1 km^2)



- **Customize SERGoM parameters**
  - more/less compact development pattern
  - household size



Tools available at:

http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=205305

Looking ahead…

ICLUS v2.0

Improvements in ICLUS v2.0

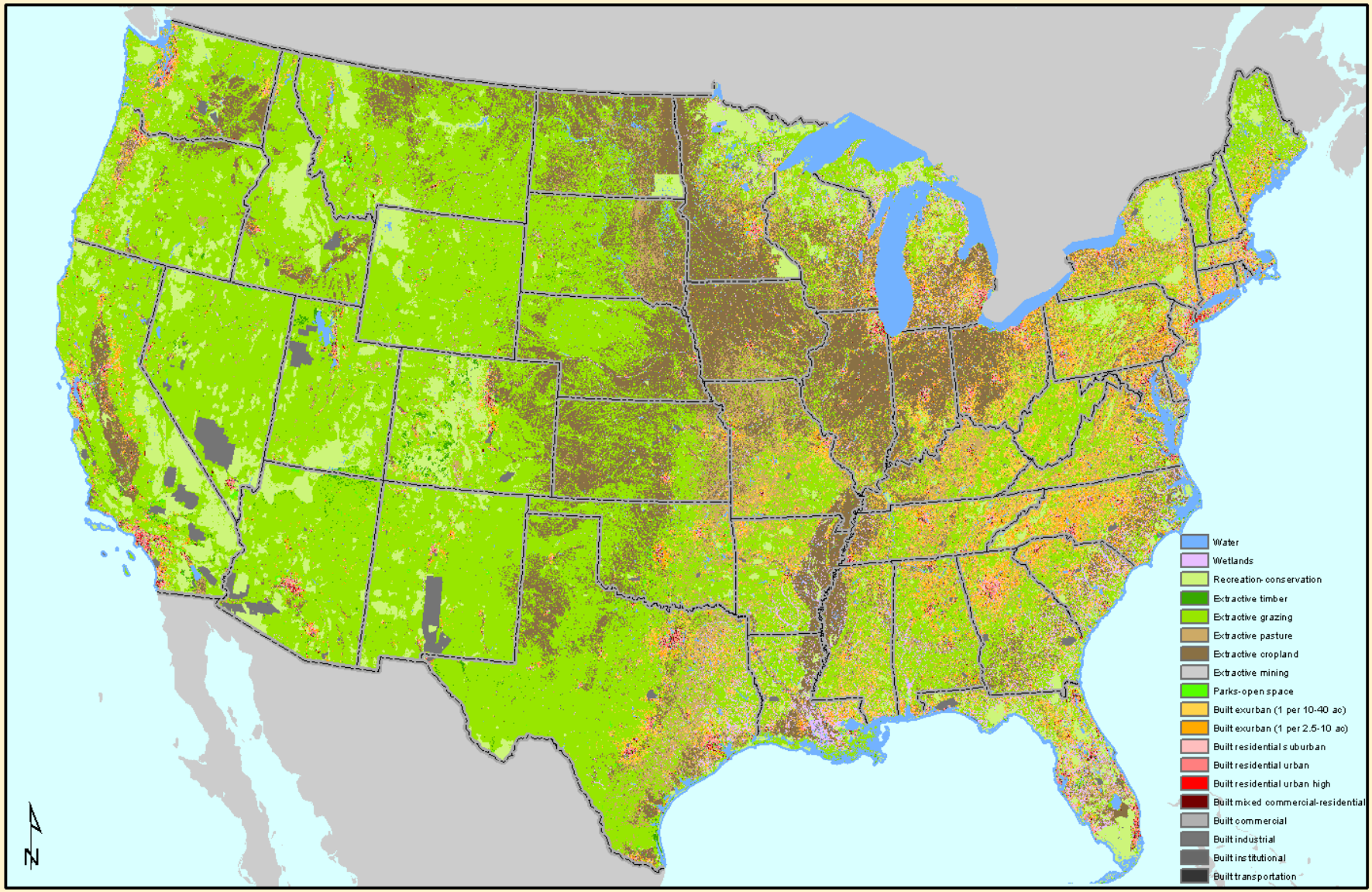
- *Really* incorporate climate change

Climate change information in ICLUS v2.0

- Bias-Correction Spatial Disaggregation-Coupled Model Intercomparison Project phase 3 (BCSD-CMIP3)
  - Three SRES emissions scenarios
  - 16 climate models
- Explore many more possible futures
- Crucial for impacts assessments
  - National migration patterns
  - Regional demographic profiles

Improvements in ICLUS v2.0

- *Really* incorporate climate change
- Use revised land use categories



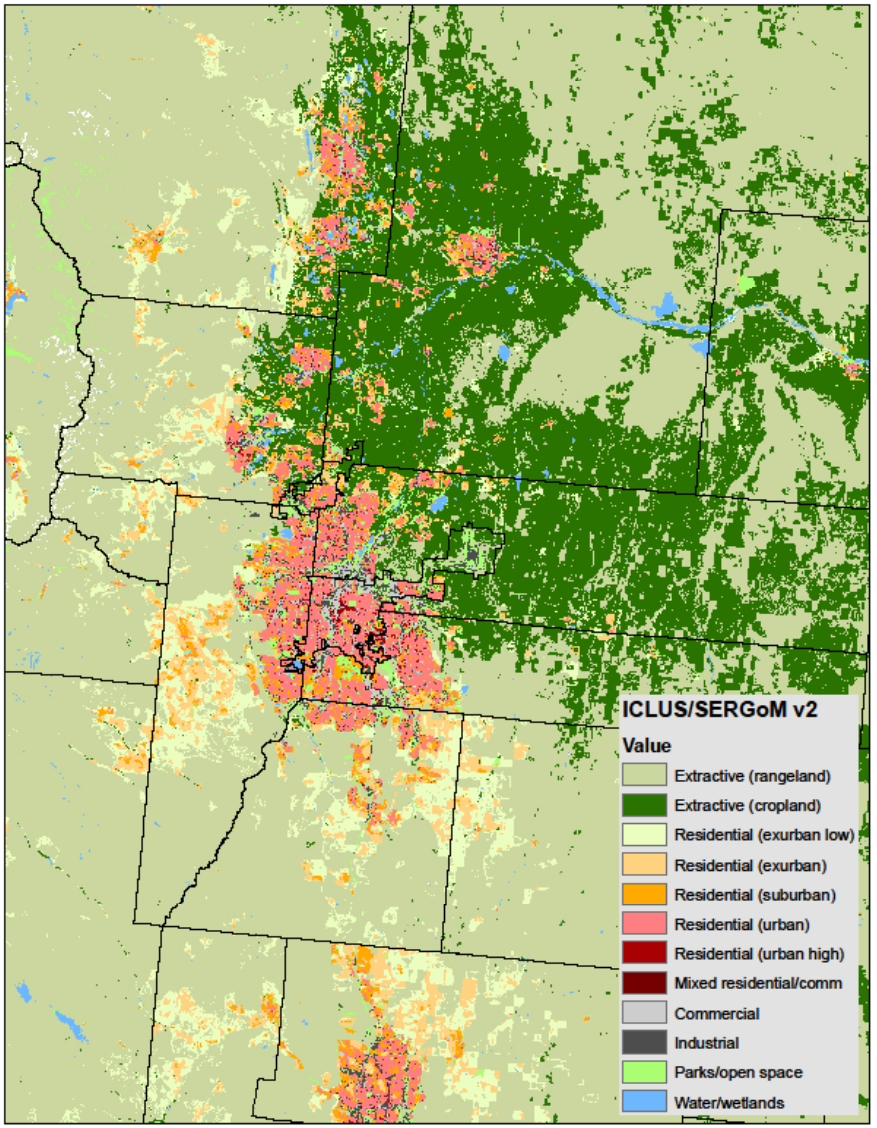
National Land Use Database

Dave Theobald, Colo. State Univ.

300 Miles

Albers Projection
Central Meridian: -96
1st Std Parallel: 20
2nd Std Parallel: 60
Latitude of Origin: 40

- Public datasets synthesized to ~17 land uses
  - NLCD 2006
  - PAD-US
  - Many others…
- Transition probabilities
  - Dynamic land use, including commercial and industrial!
- Still driven by human development
  - Not a fully dynamic LULC model
- Introduce patterns of development
  - Smart Growth
  - Conservation Clusters
  - Centralized Infilling
- Introduce “effective” percent impervious



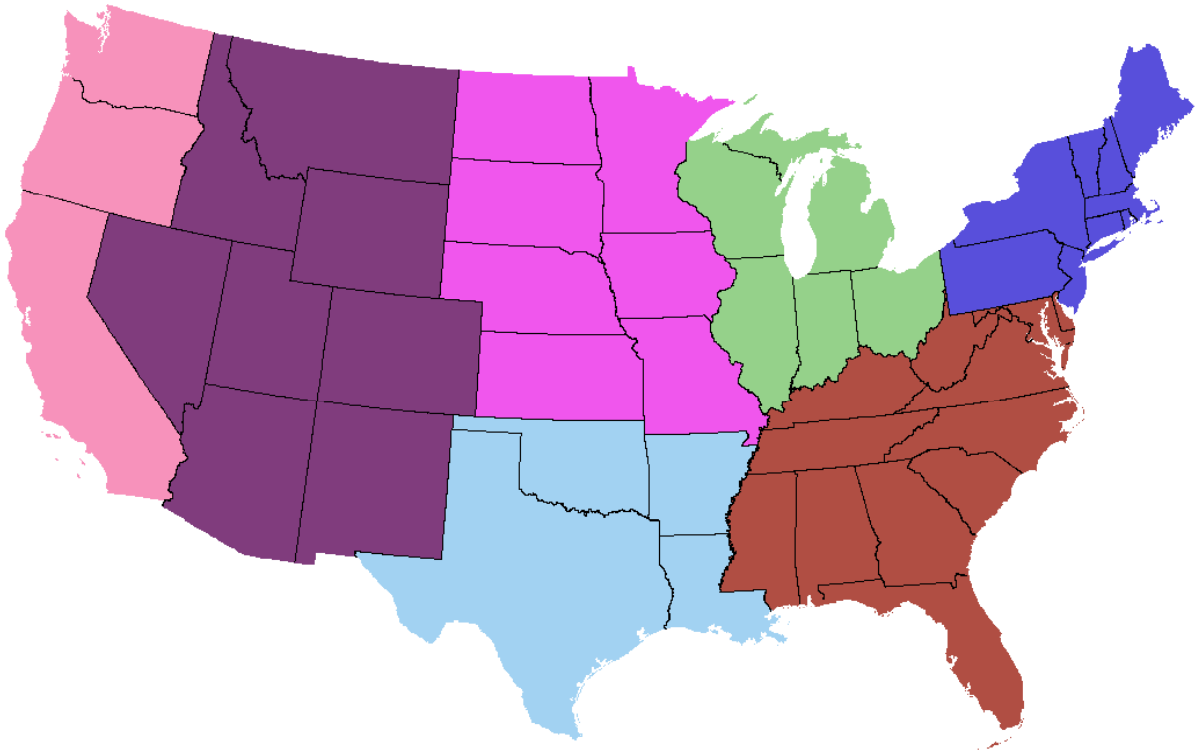
Improvements in ICLUS v2.0

- *Really* incorporate climate change
- Move toward meaningful land use categories
- Regionalize everything

Extract regional transition probabilities

Regionalize future development patterns

- Smart Growth
- Conservation Clusters
- Centralized Infilling



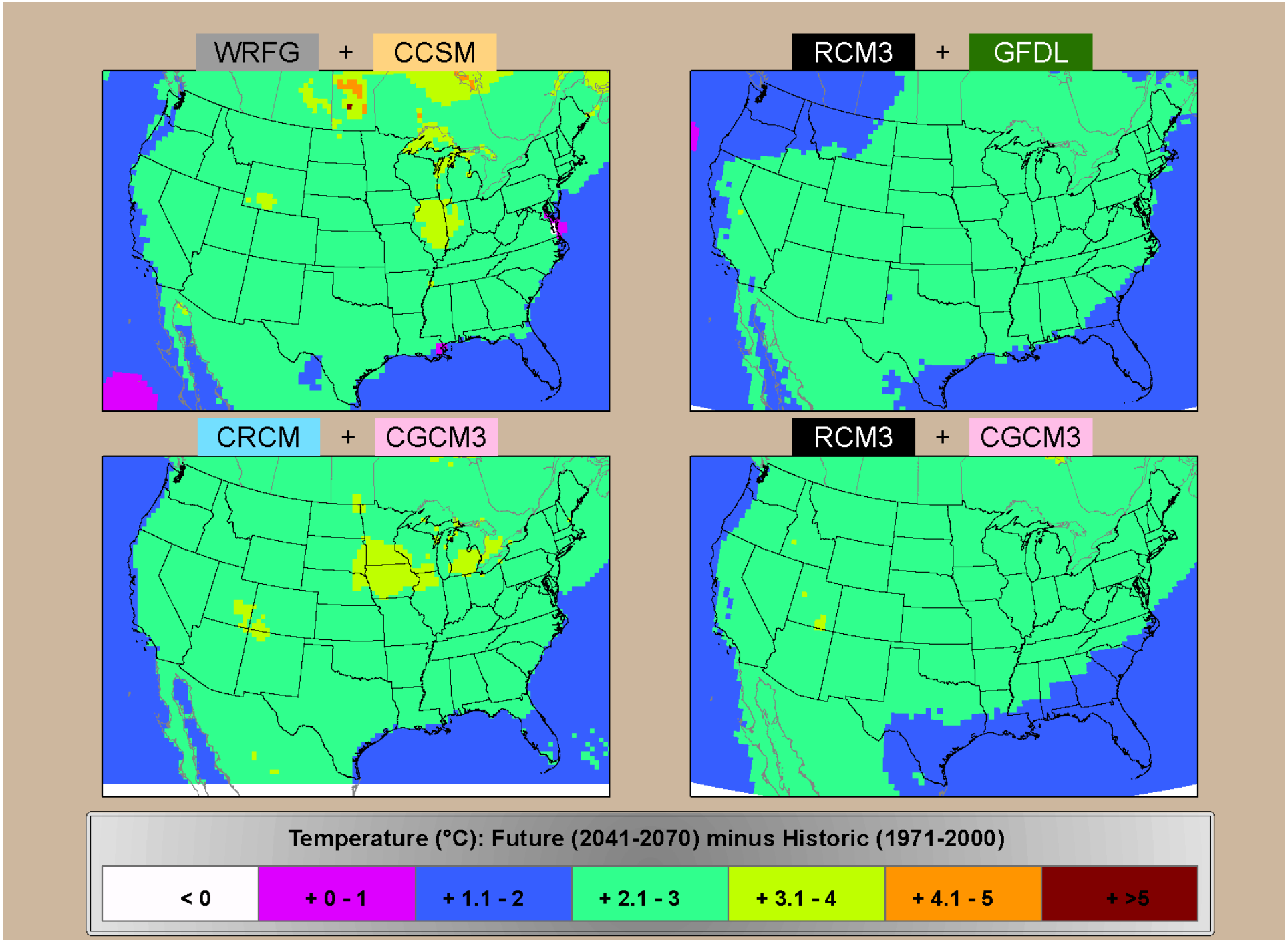
Improvements in ICLUS v2.0

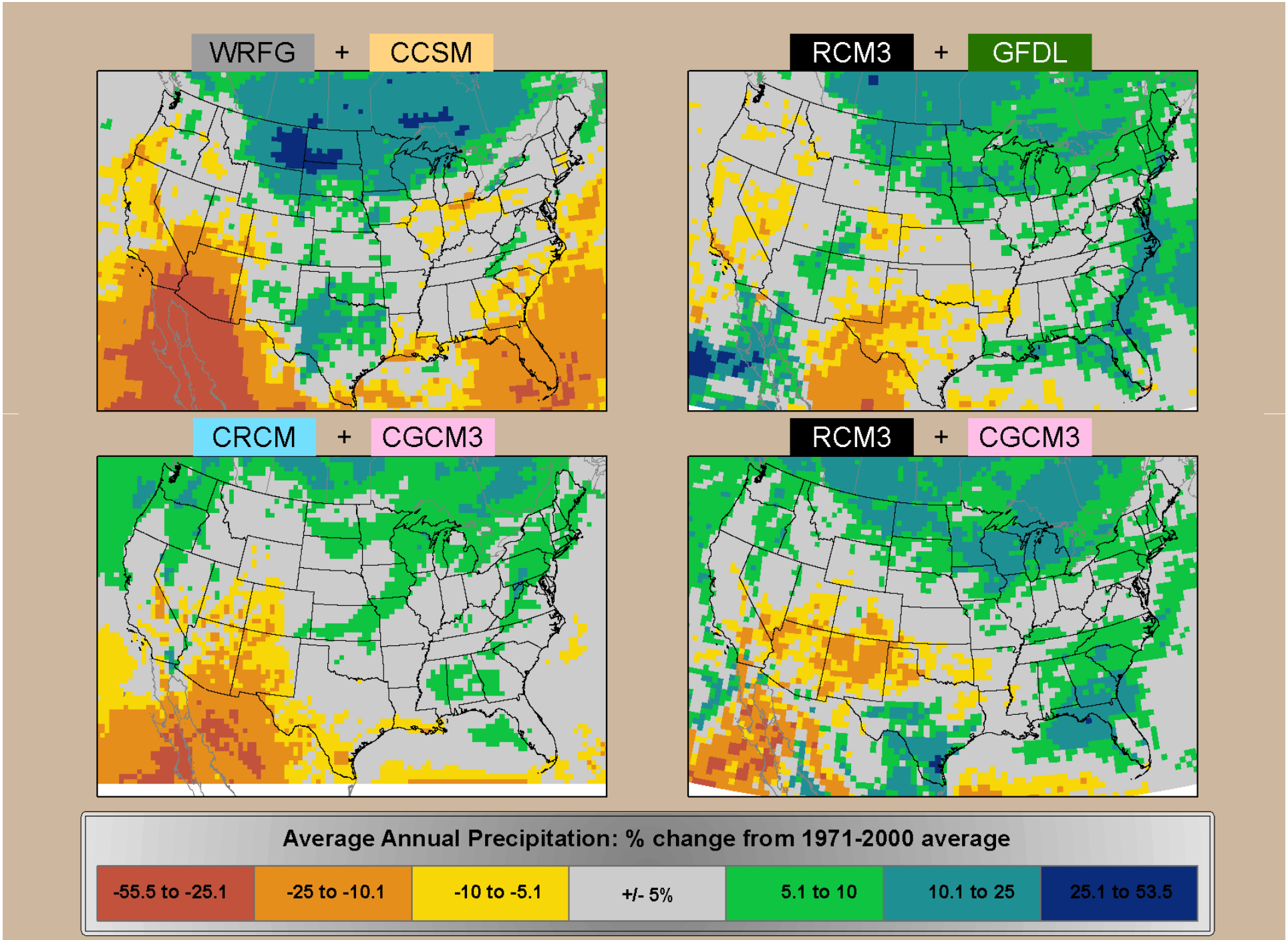
- *Really* incorporate climate change
- Move toward meaningful land use categories
- Regionalize development patterns
- Improve impervious estimates

Improvements in ICLUS v2.0

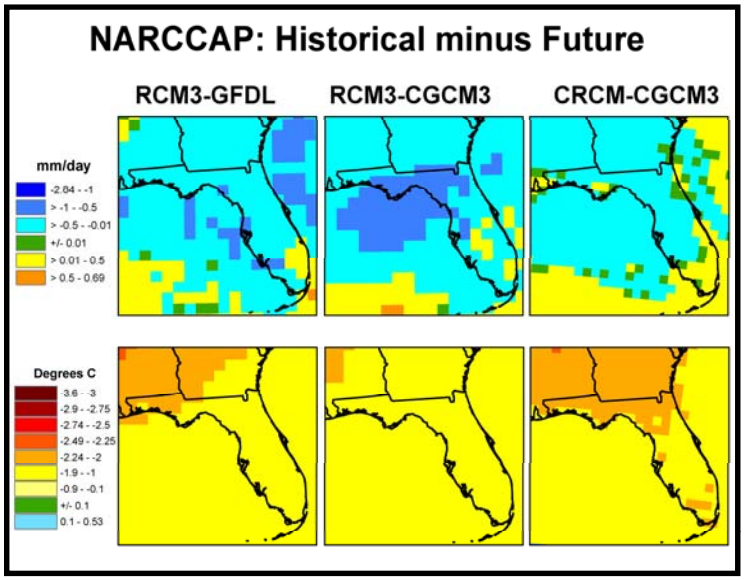
- *Really* incorporate climate change
- Move toward meaningful land use categories
- Regionalize development patterns
- Improve impervious estimates
- Other stuff…
  - Update transportation network – mass transit
  - Better migration data (IRS)

Modeling water quality in 20 watersheds using variety of climate change and land use scenarios

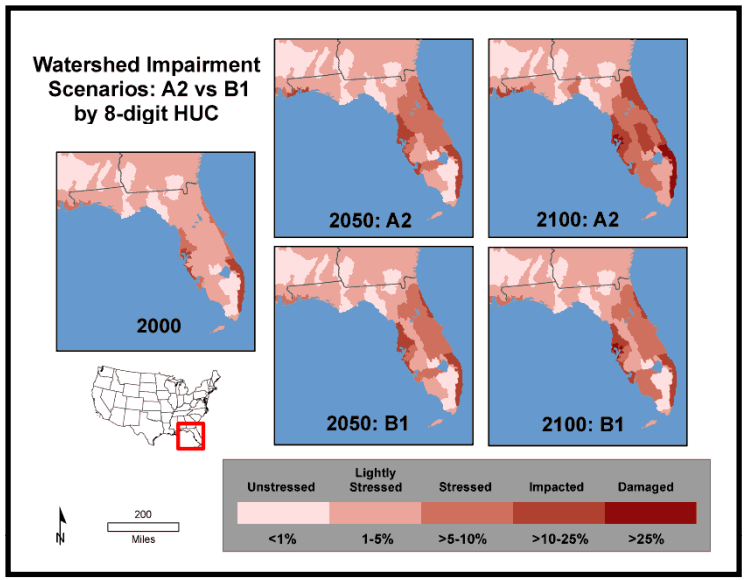

WRFG + CCSM
RCM3 + GFDL
CRCM + CGCM3
RCM3 + CGCM3
Temperature (°C): Future (2041-2070) minus Historic (1971-2000)
< 0
+ 0 - 1
+ 1.1 - 2
+ 2.1 - 3
+ 3.1 - 4
+ 4.1 - 5
+ >5

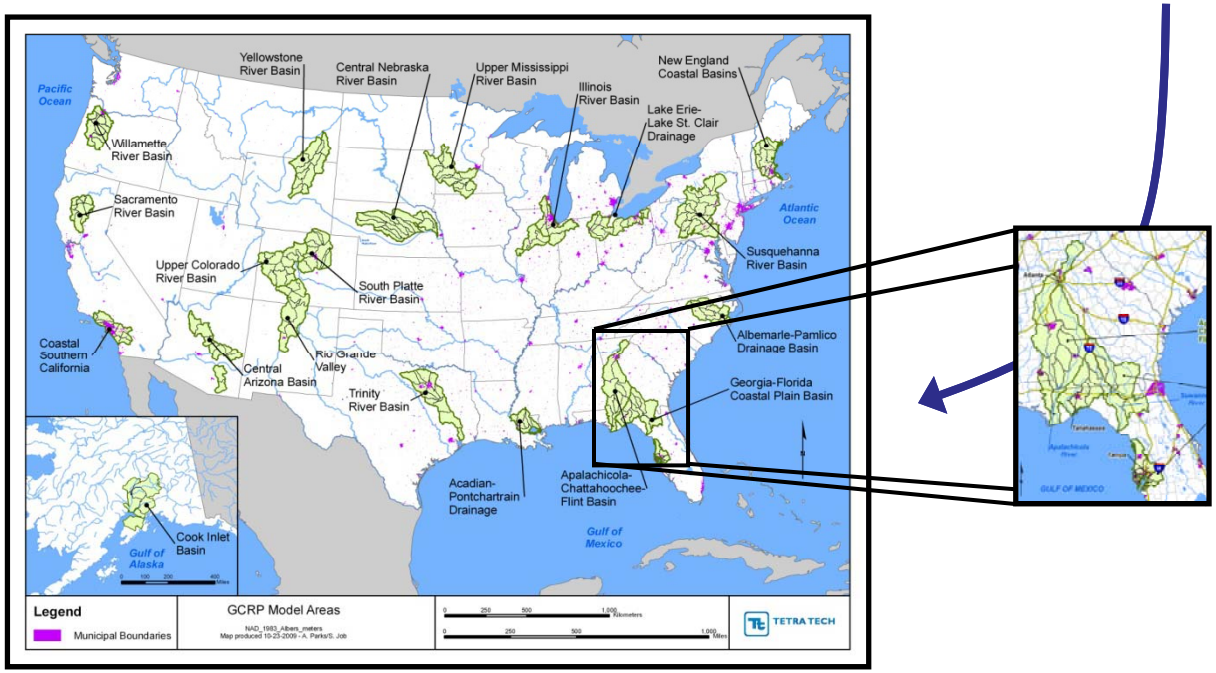

WRFG + CCSM
RCM3 + GFDL
CRCM + CGCM3
RCM3 + CGCM3
Average Annual Precipitation: % change from 1971-2000 average
-55.5 to -25.1
-25 to -10.1
-10 to -5.1
+/- 5%
5.1 to 10
10.1 to 25
25.1 to 53.5

CLIMATE



LAND USE





STREAMFLOW, NUTRIENTS, SEDIMENT

Overview of Watershed Modeling

- Watershed modeling in 20 U.S. watershed regions (~ 10 HUC8 each)
- Focus on streamflow, N, P, sediments
- Daily simulations for 30-year historical and 30-year future periods

In 5 pilot watersheds:

- Use 2 watershed models, HSPF and SWAT
    - 14 climate change scenarios (NARCCAP, raw GCM, BCSD)
    - 2 land-use scenarios, current and future (EPA ICLUS)
- Effects of climate change, land-use change, coupled C-L change
- Sensitivity studies to assess influence of different methods of downscaling

In 15 non-pilot watersheds:

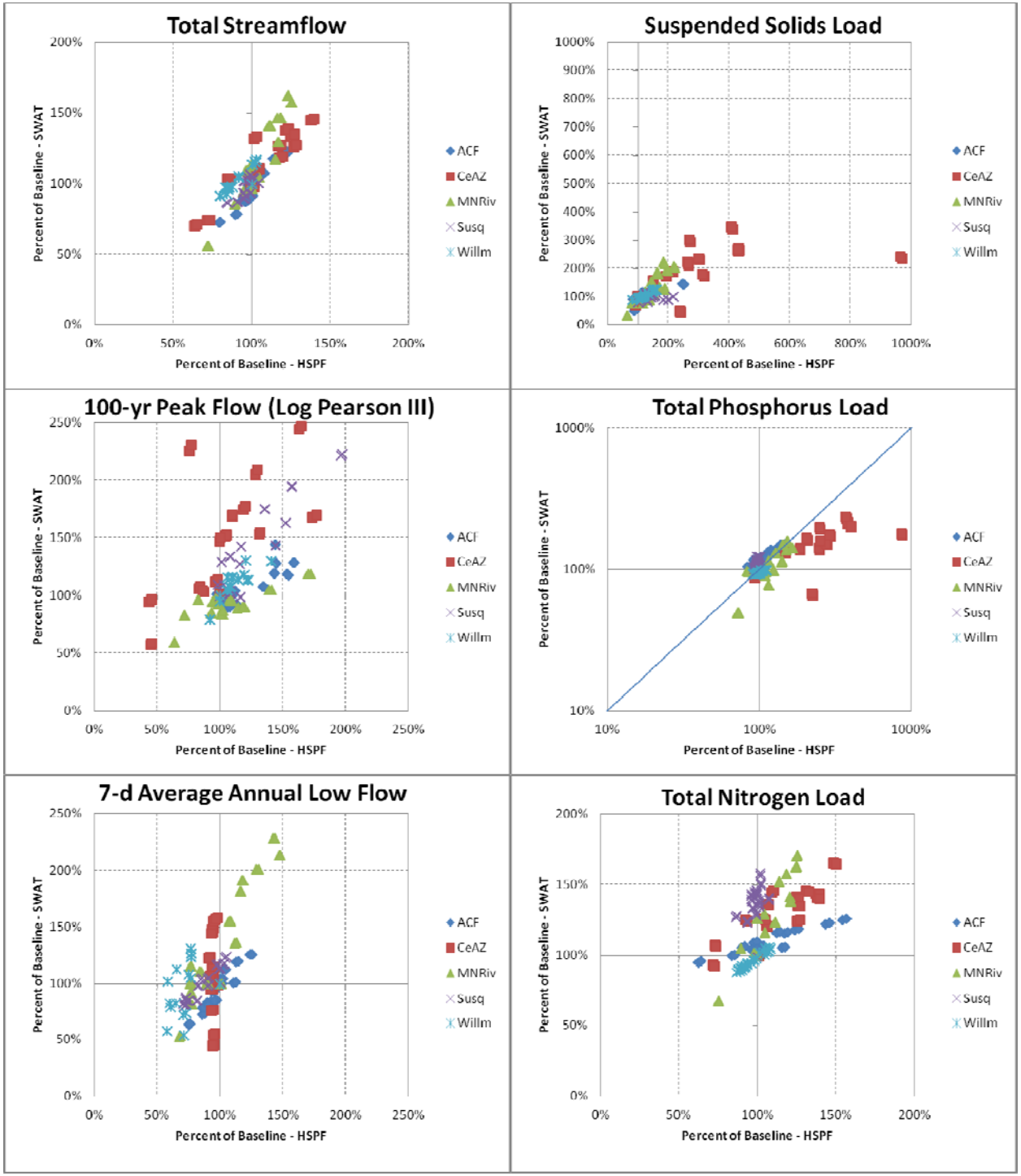
- Use 1 watershed model, SWAT
    - 6 climate change scenarios (NARCCAP)
    - 2 land-use scenarios, current and future (EPA ICLUS)
- Effects of climate change, land-use change, coupled C-L change

http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=212763

All 5 Pilot Sites

SWAT

HSPF



20 Watersheds Project – Key Insights

Sensitivity to climate change different for low flows, high flows, and sediment/nutrient loading – some scenarios result in both lower low flows and increased loading

Strong sensitivity of the modeled flow and water quality endpoints to the climate model and downscaling approach applied

Sensitivity to climate change dominates over sensitivity to land-use change at the scale of an entire watershed – not necessarily true as scale decreases

Climate change, urbanization, and atmospheric CO_2 increase can have synergistic effects on flow and loading

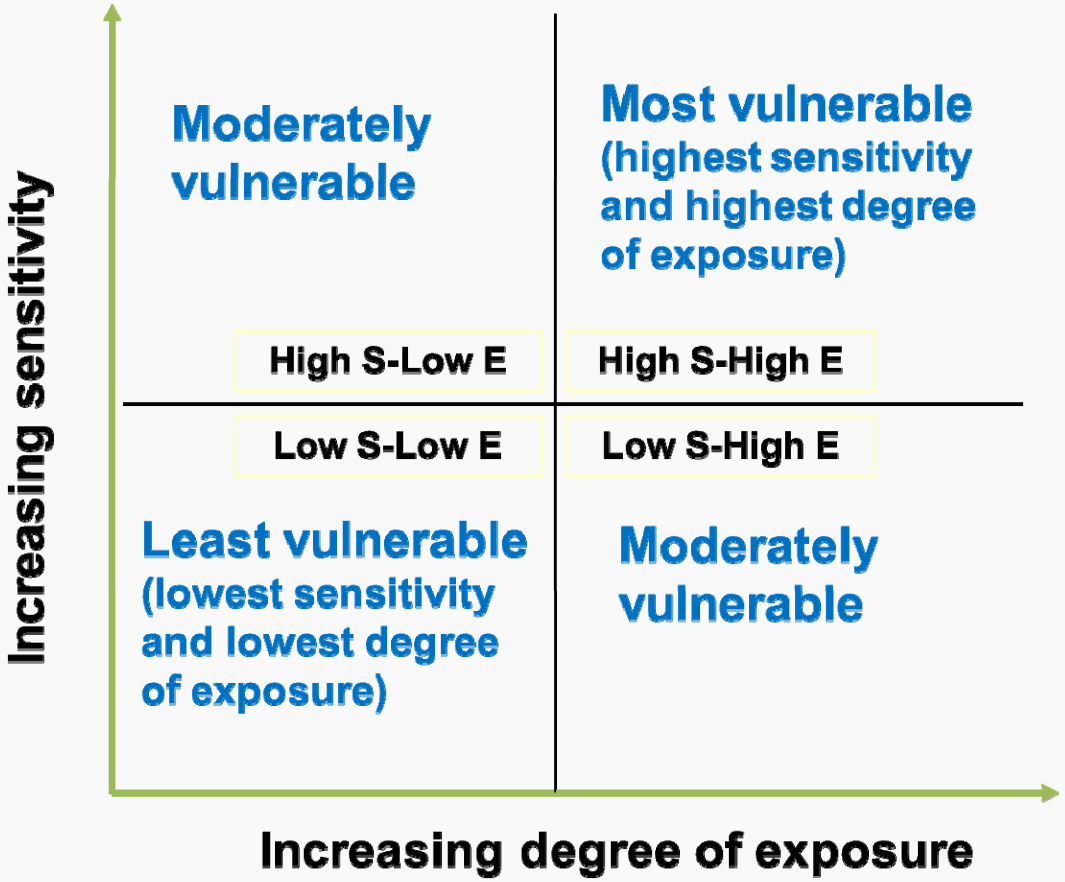
Use of ICLUS in vulnerability assessment of Northeastern streams for monitoring

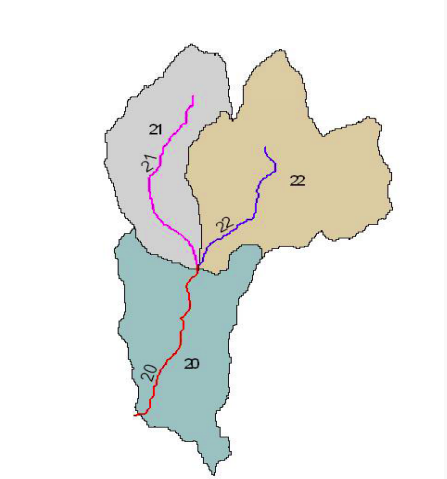
Monitoring Objectives for Northeastern Streams

- Detect climate-related changes early and inform management (e.g., restoration, adaptation) strategies
- Distinguish climate change effects from other sources of environmental variation and stressors

Climate Change Vulnerability Assessment

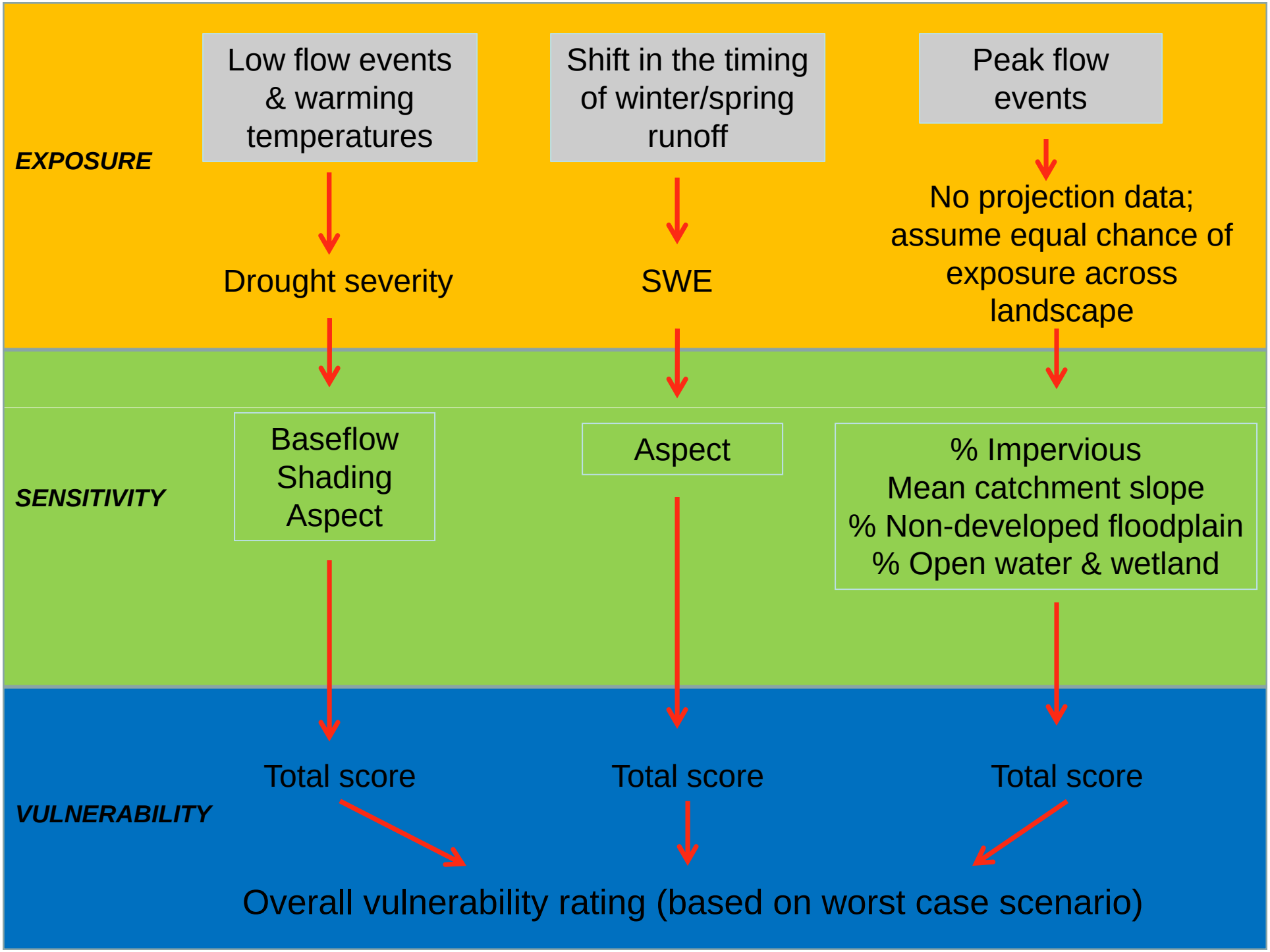
Local catchments sorted by degree of exposure to climatic change (E) X sensitivity (S)



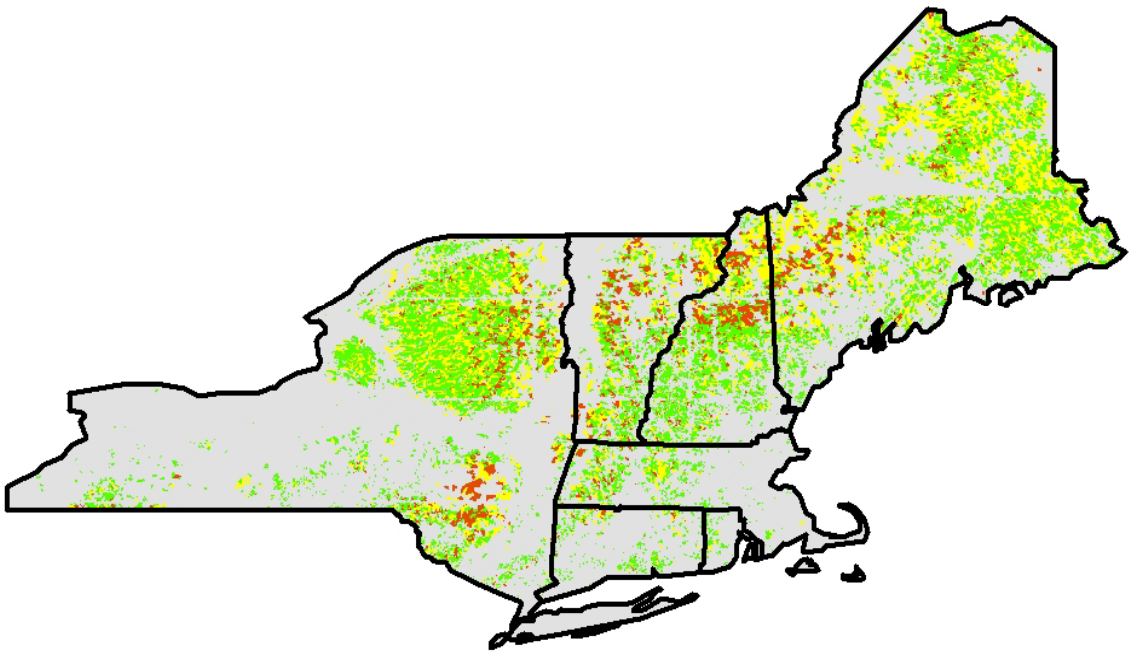


A. Local Catchments for Reaches 20, 21, and 22

NHD-plus local catchments


EXPOSURE
Low flow events & warming temperatures
Shift in the timing of winter/spring runoff
Peak flow events
Drought severity
SWE
No projection data; assume equal chance of exposure across landscape
SENSITIVITY
Baseflow
Shading
Aspect
Aspect
% Impervious
Mean catchment slope
% Non-developed floodplain
% Open water & wetland
VULNERABILITY
Total score
Total score
Total score
Overall vulnerability rating (based on worst case scenario)

EXPOSURE 3: peak flow events



Reference catchments

Vulnerability to peak flow events

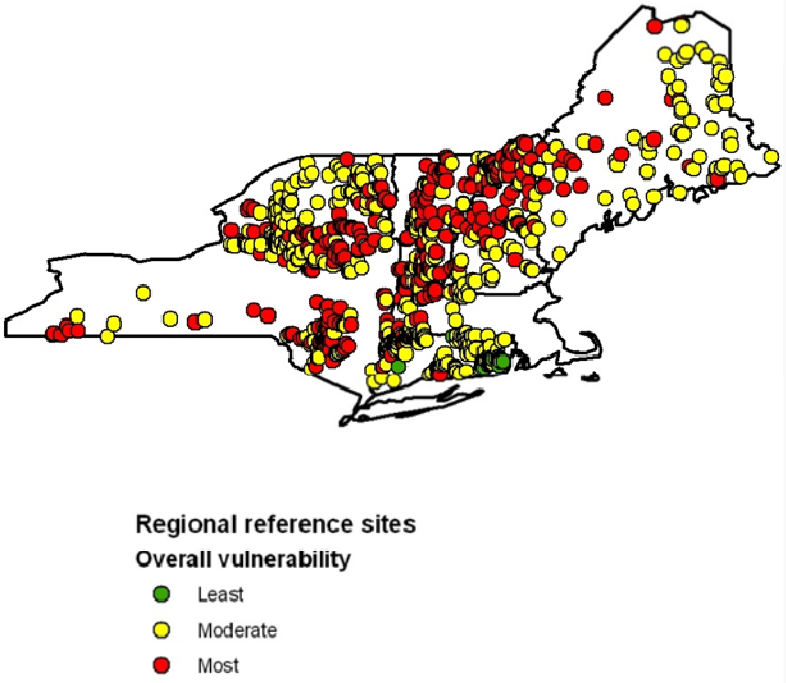
- Least
- Moderate
- Most

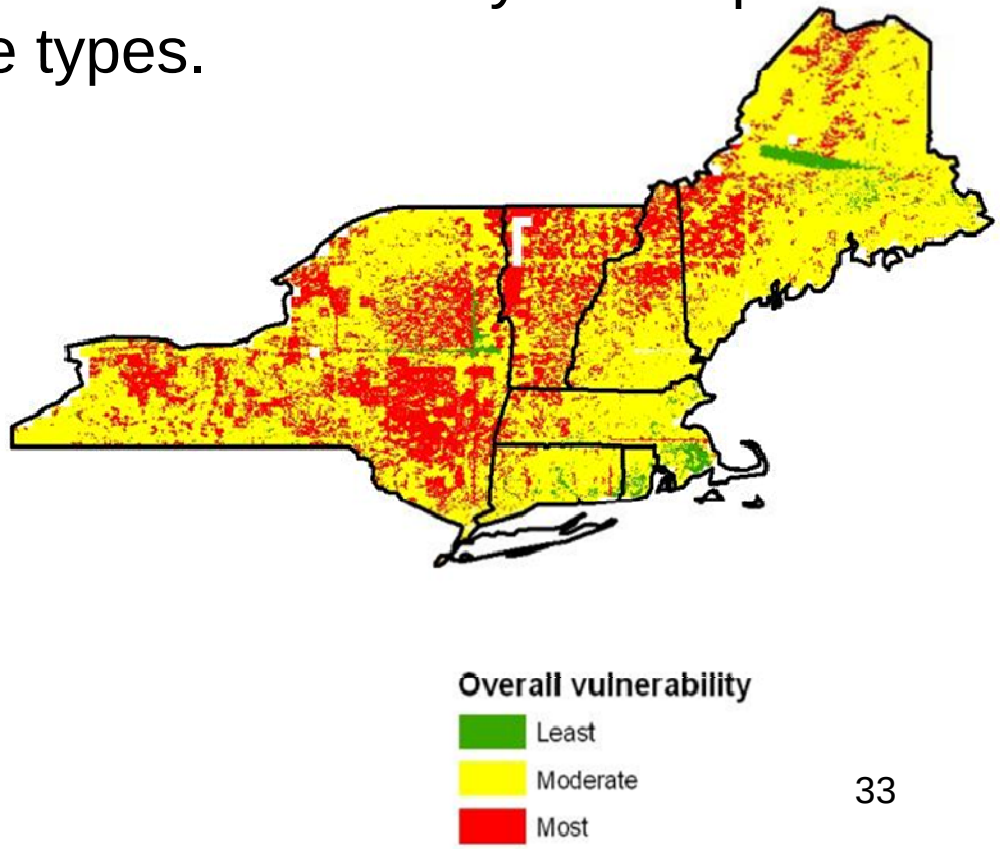
Non-reference catchments

Overall vulnerability rating

If we assign an overall vulnerability category based on the ‘worst case’ rating, most catchments fall in ‘most’ and ‘moderate’ vulnerability categories.

Some catchments are most vulnerable to only one exposure type; others to > 1 exposure types.





Questions?

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