

# Diagnostic Decision Support and BMP Effectiveness for Water Quality Gains

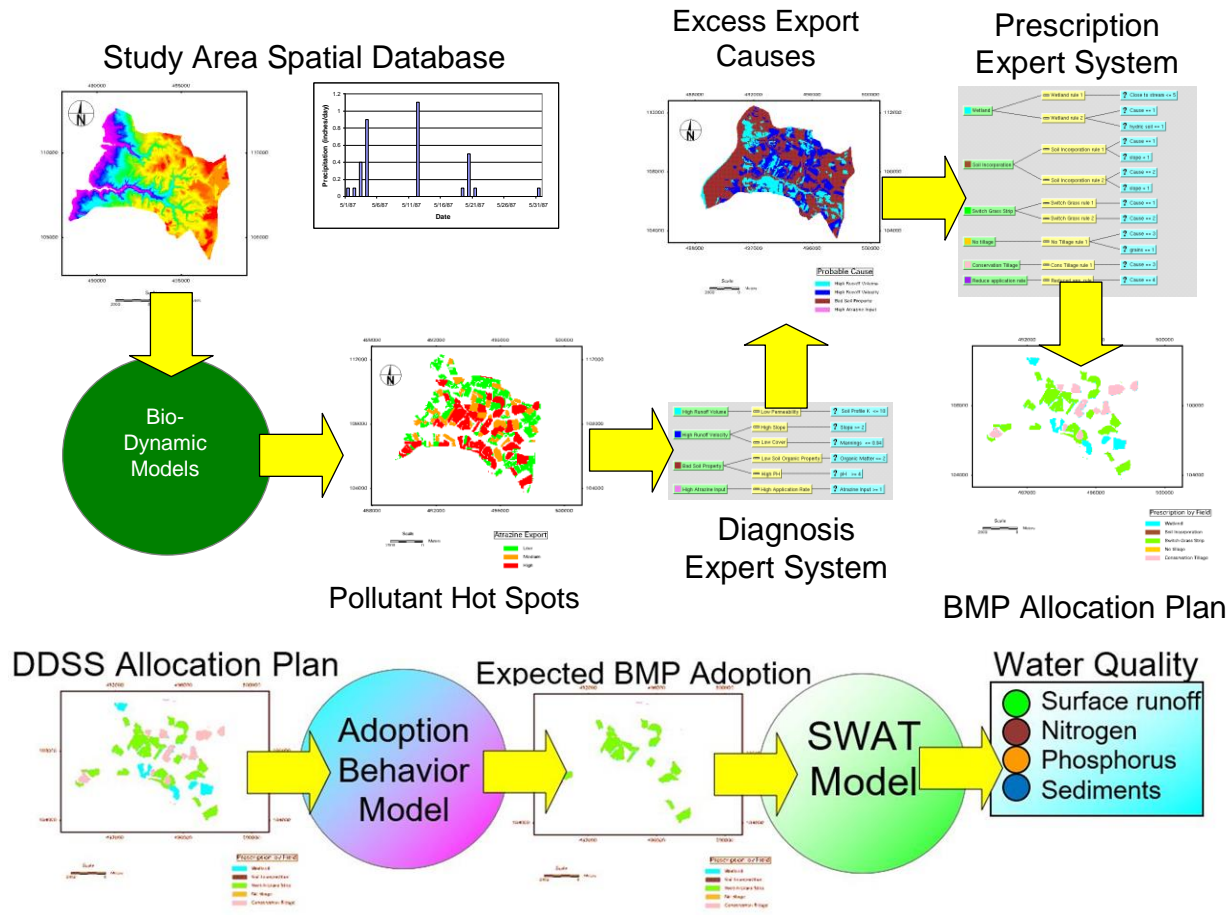
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MARYLAND

# Diagnostic Decision Support Systems (DDSS)



**Components:** GIS, Hydrologic Models, Expert Systems, Behavioral Models

**Goal:** More “bang for the buck”: Target BMPs to CSAs, Interventions to Low Adoption Areas

# 1) Agricultural Team:



Hubert Montas,  
*Diagnostic Tools*



Paul Leisnham,  
*Socio-Ecology*



Adel Shirmohammadi,  
*Hydrology*



Jaison Rekenberger,  
*Diagnostic Tools*



Dan Boward,  
MD-DNR  
*Ecology*



David Lansing,  
UMBC  
*Sociology*



Daniel Schall,  
UMBC  
*Sociology*



Julianna  
Brightman,  
*Sociology*



Victoria Chanse, Amanda  
Rockler & numerous  
students  
*Extension & Sociology*



Tom Hutson & Nicole Barth,  
*Extension*



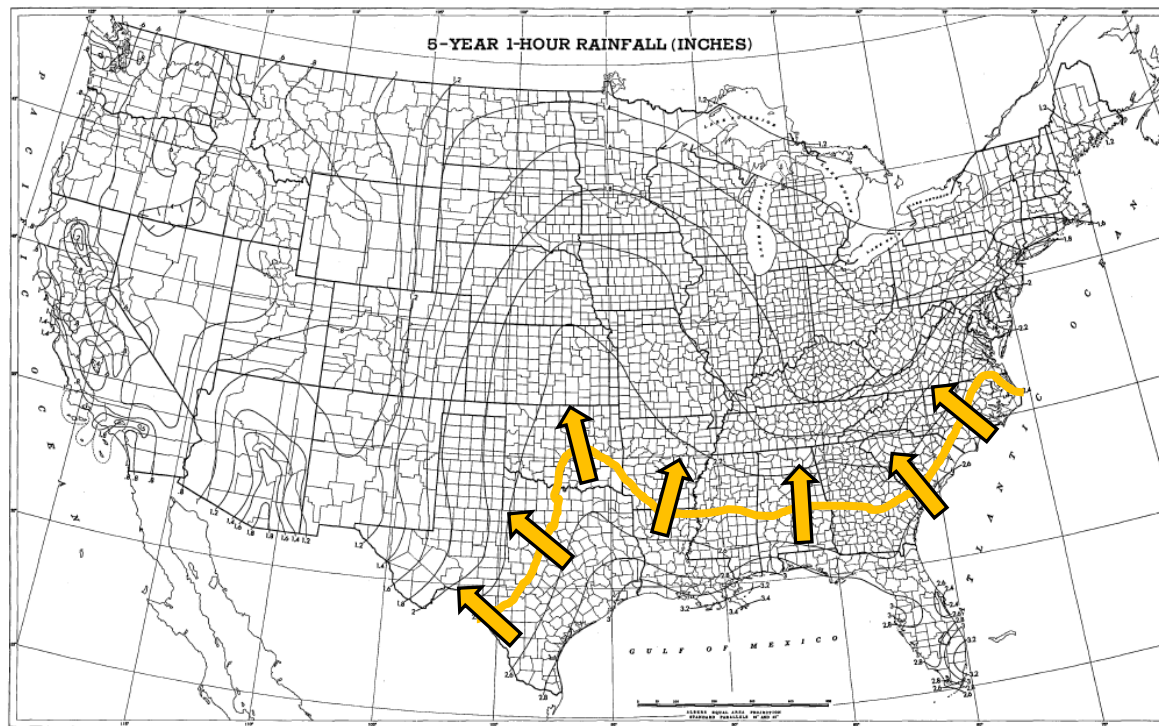
# 2) Urban and Sub-Urban Team: Yan Wang, Zhongrun Xiang, Many more...





# Climate Change and Design Rainfall

(hypothetical change – 5-yr, 1-hr, 2.4 inch curve shown; DC is 2.2 inch)



Source: U.S. Weather Bureau, 1961. Technical Paper No. 40, Rainfall Frequency Atlas of the U.S.

# Climate Change: Robustness of Designs



Gravitational Force:

$$F = G \frac{m_1 m_2}{r^2}$$

What if the Gravitational Constant (G) changed over time?

**Will chair designed for today's conditions remain comfortable tomorrow?**

# Investigation 1:

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- ❑ Agricultural watershed
- ❑ Maryland Eastern Shore (Coastal Plains)
- ❑ 300 km<sup>2</sup>
- ❑ Single CMIP3 model: GFDL –CM2.1 (US)
- ❑ Scenarios B1, A1B and A2
- ❑ 50- and 100-year time horizons
- ❑ Fixed Threshold for CSAs (TMDL)

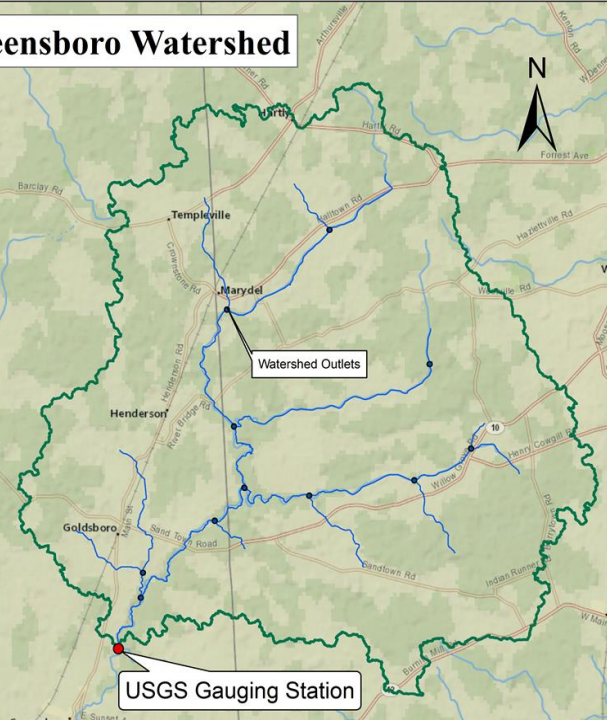


## Greensboro Watershed

### Choptank Watershed



### Greensboro Sub-watershed

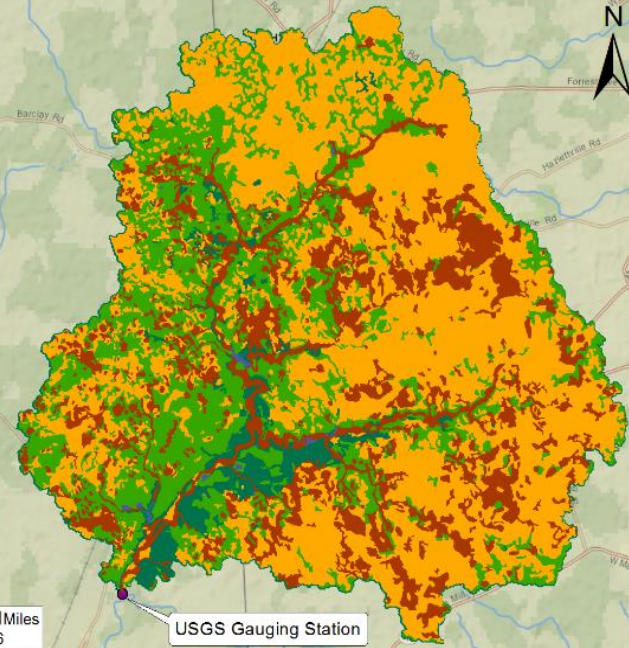
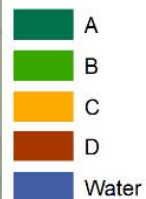


USGS Gauging Station

Sources: USGS National Map Viewer, USGS Water Resources, Texas A&M University (<http://globalweather.tamu.edu/>), and ArcOnline.

## Greensboro Hydrologic Soil Group Characterization

### Hydrologic Group Soil Classifications

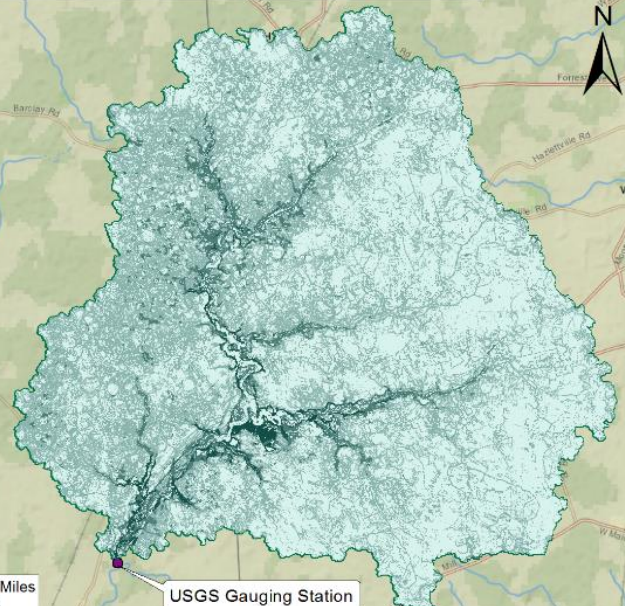


USGS Gauging Station

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## Greensboro Slope Classification Map

### Mean HRU Slope %

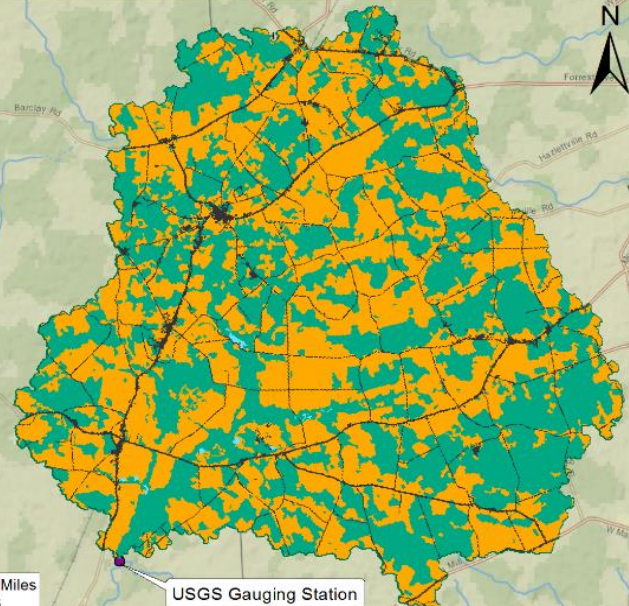
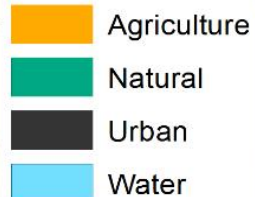


USGS Gauging Station

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## Greensboro Landuse Classification Map

### Land Use and Land Cover

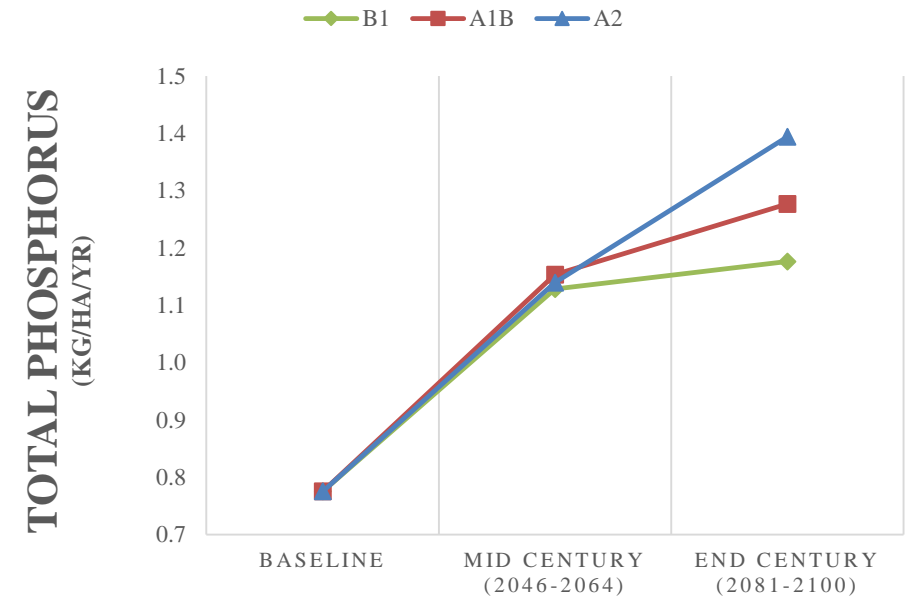
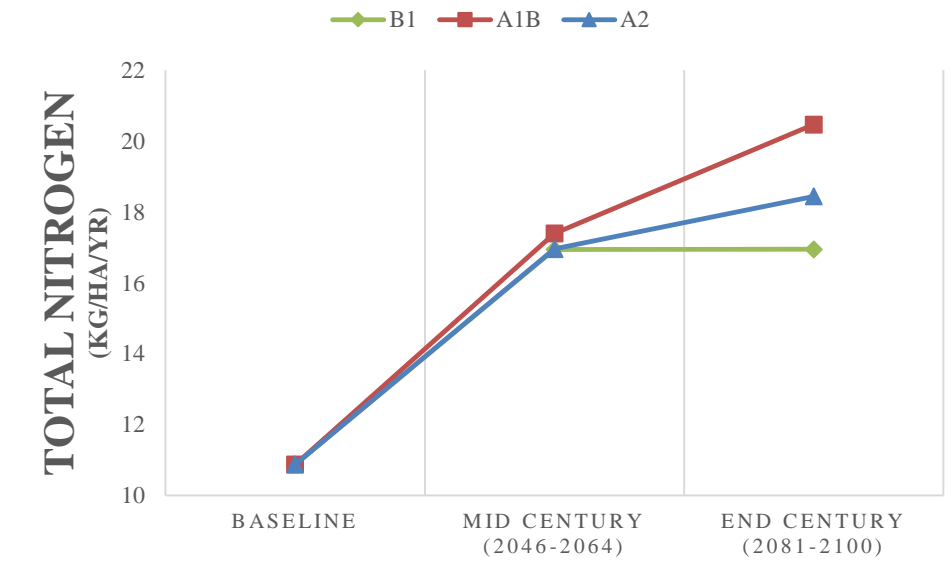
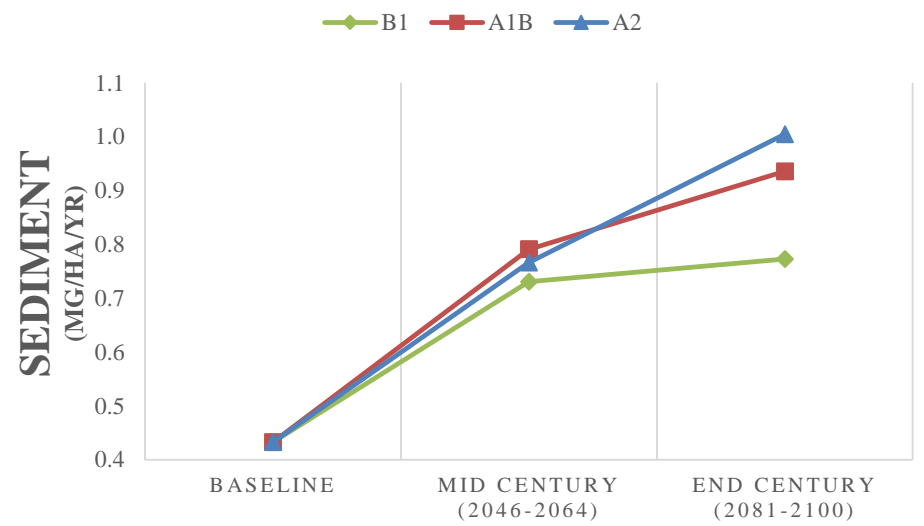
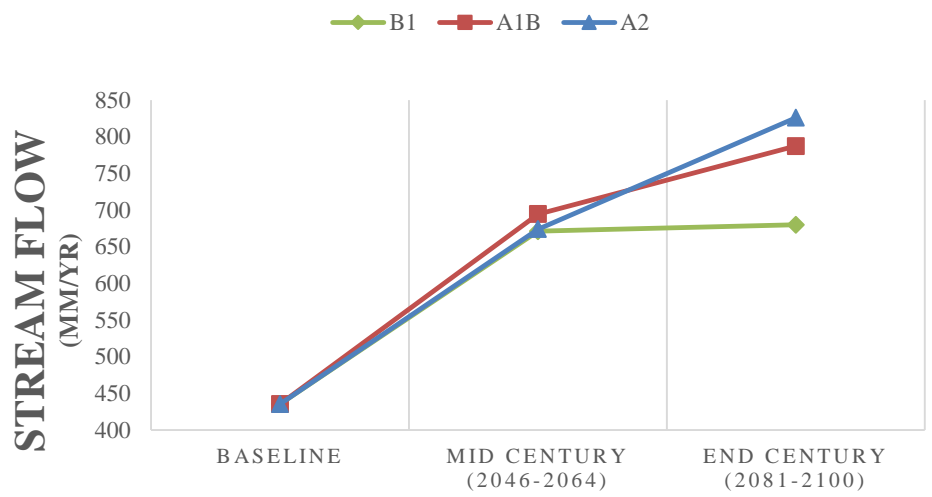


USGS Gauging Station

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# Watershed Response: Baseline and Climate Change Scenarios



# Surface Run-off & Total Suspended Solids

Present Day CSAs

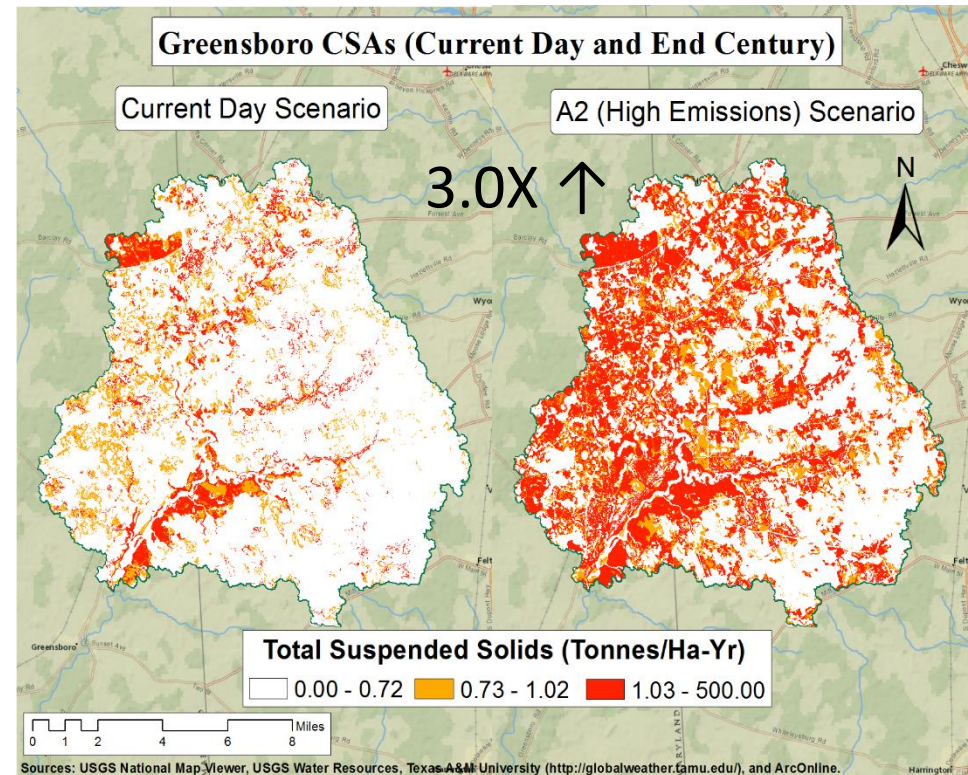
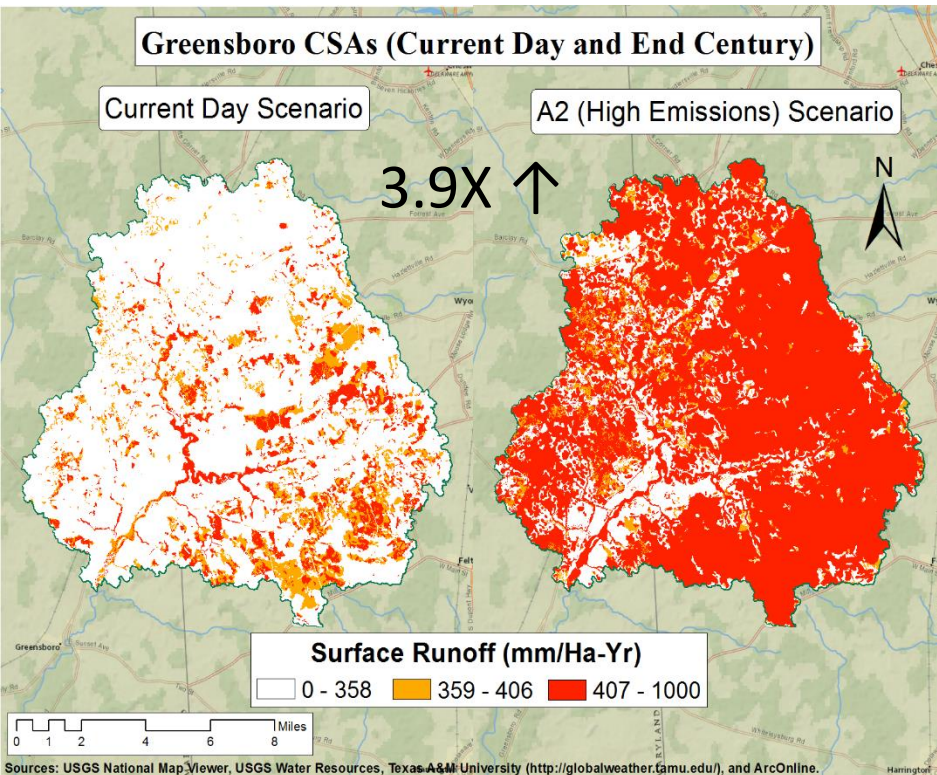


SRES A2



End Century CSAs

25-30% ↑ rainfall





# Nitrogen & Phosphorous

Present Day CSAs

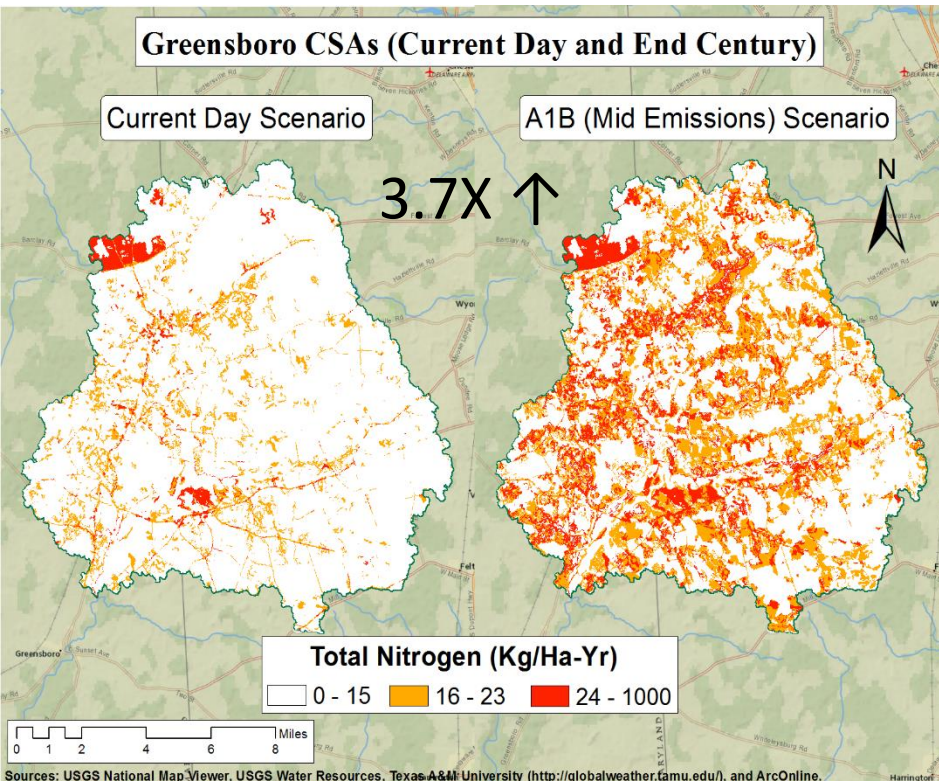


SRES A2/A1B

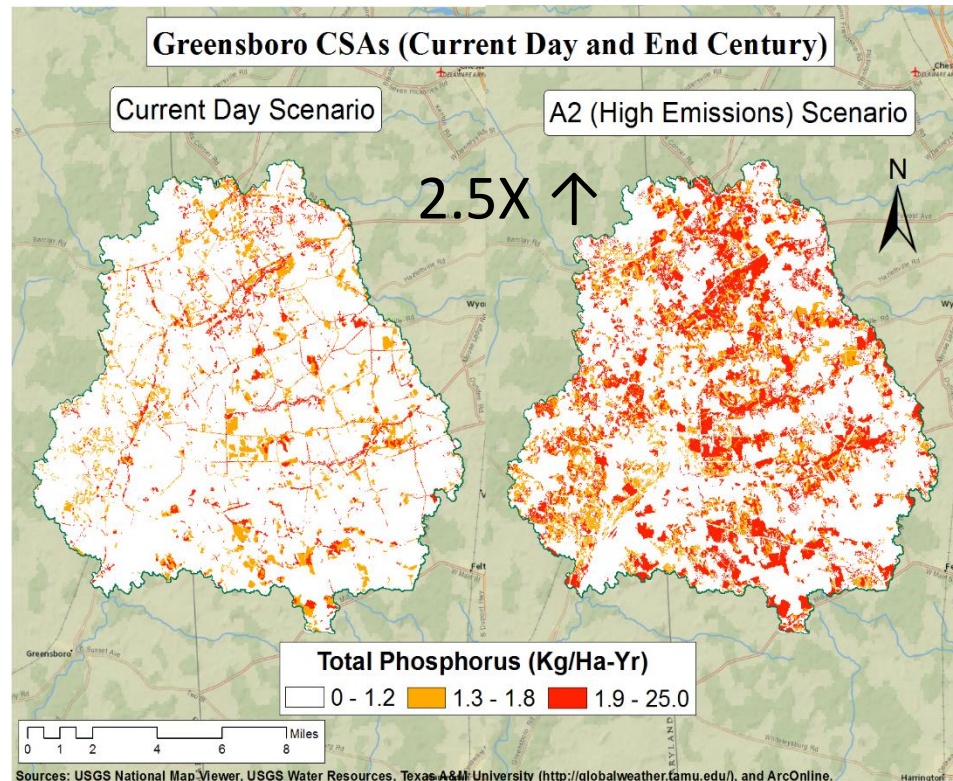


End Century CSAs

25-30% ↑ rainfall



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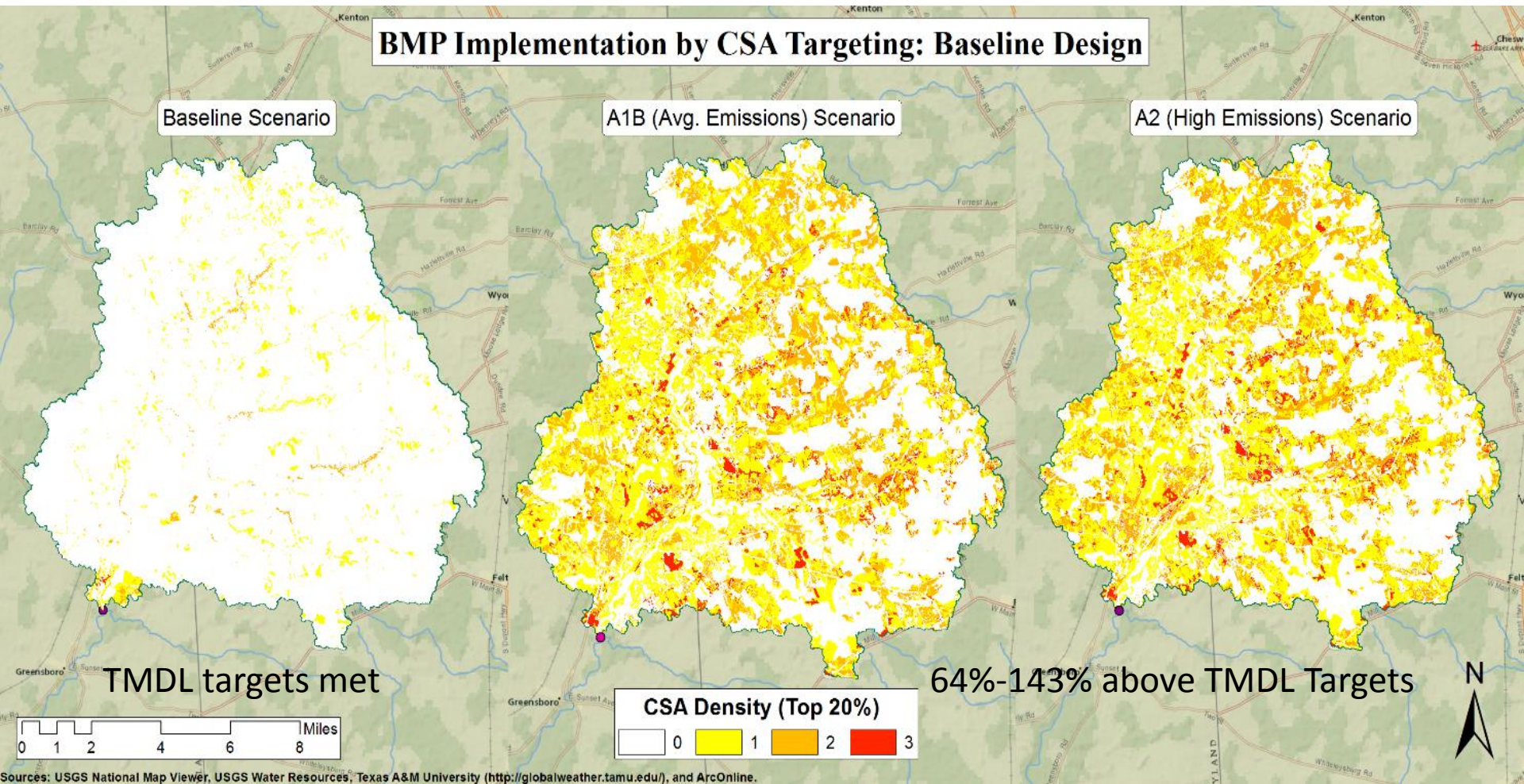


Sources: USGS National Map Viewer, USGS Water Resources, Texas A&M University (<http://globalweather.tamu.edu/>), and ArcOnline.



# Targeting Dense CSAs of Today

*Residual CSA Density with Baseline BMP Design Subjected to Current, A1B and A2 Climate Conditions*

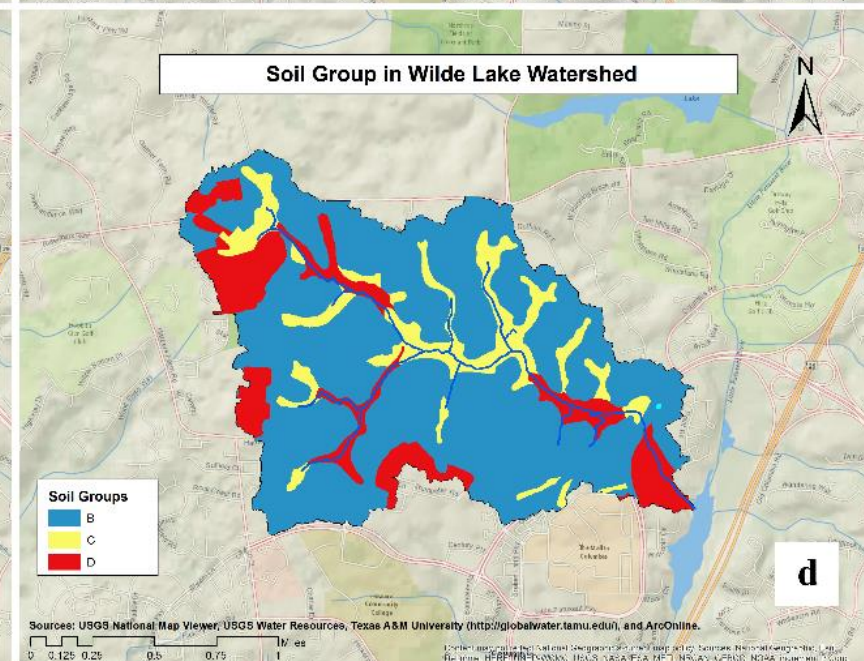
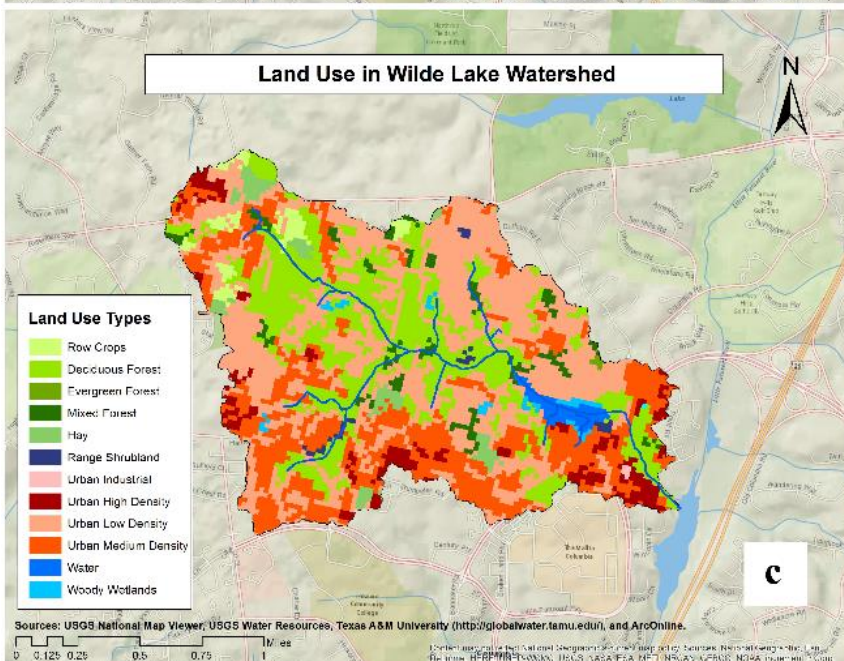
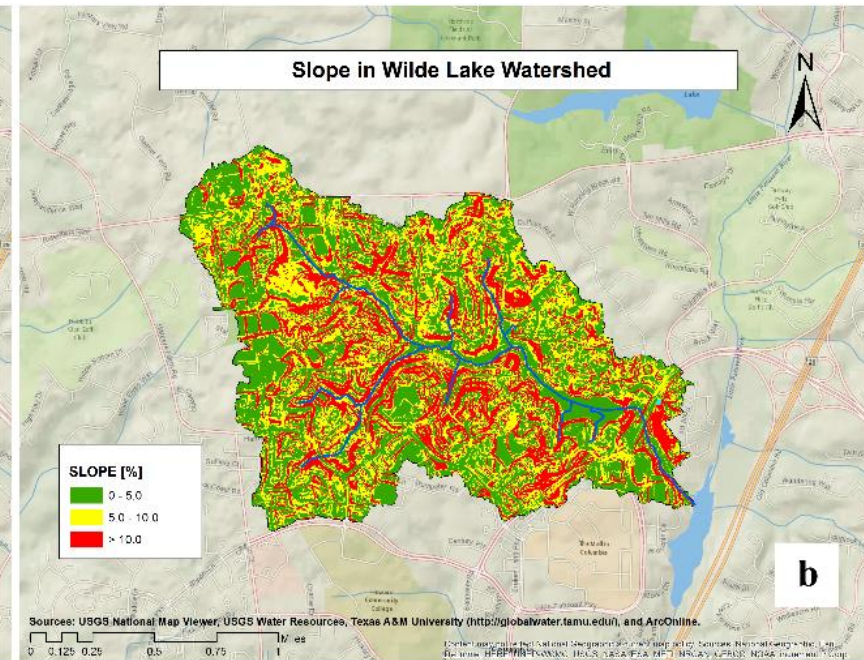
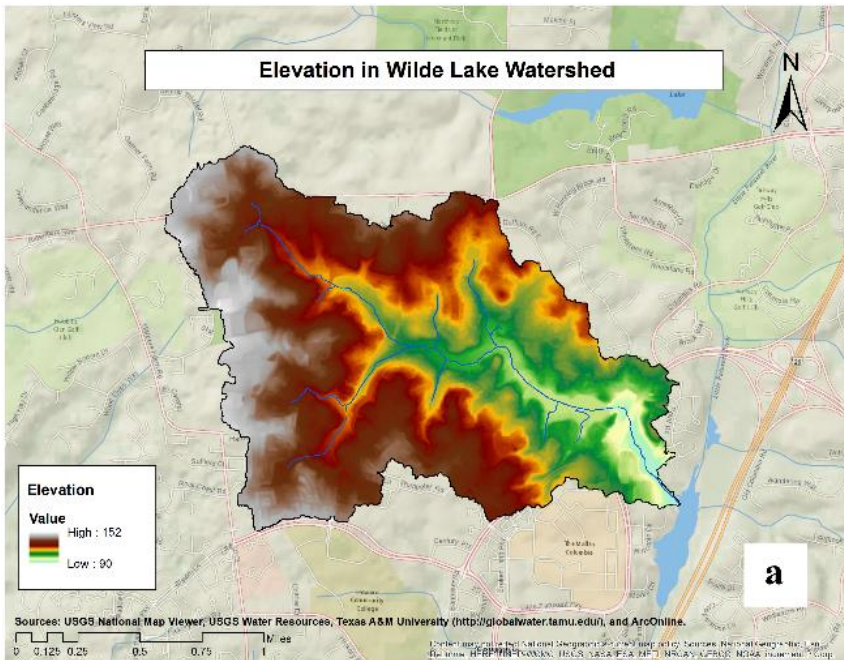


# Investigation 2:

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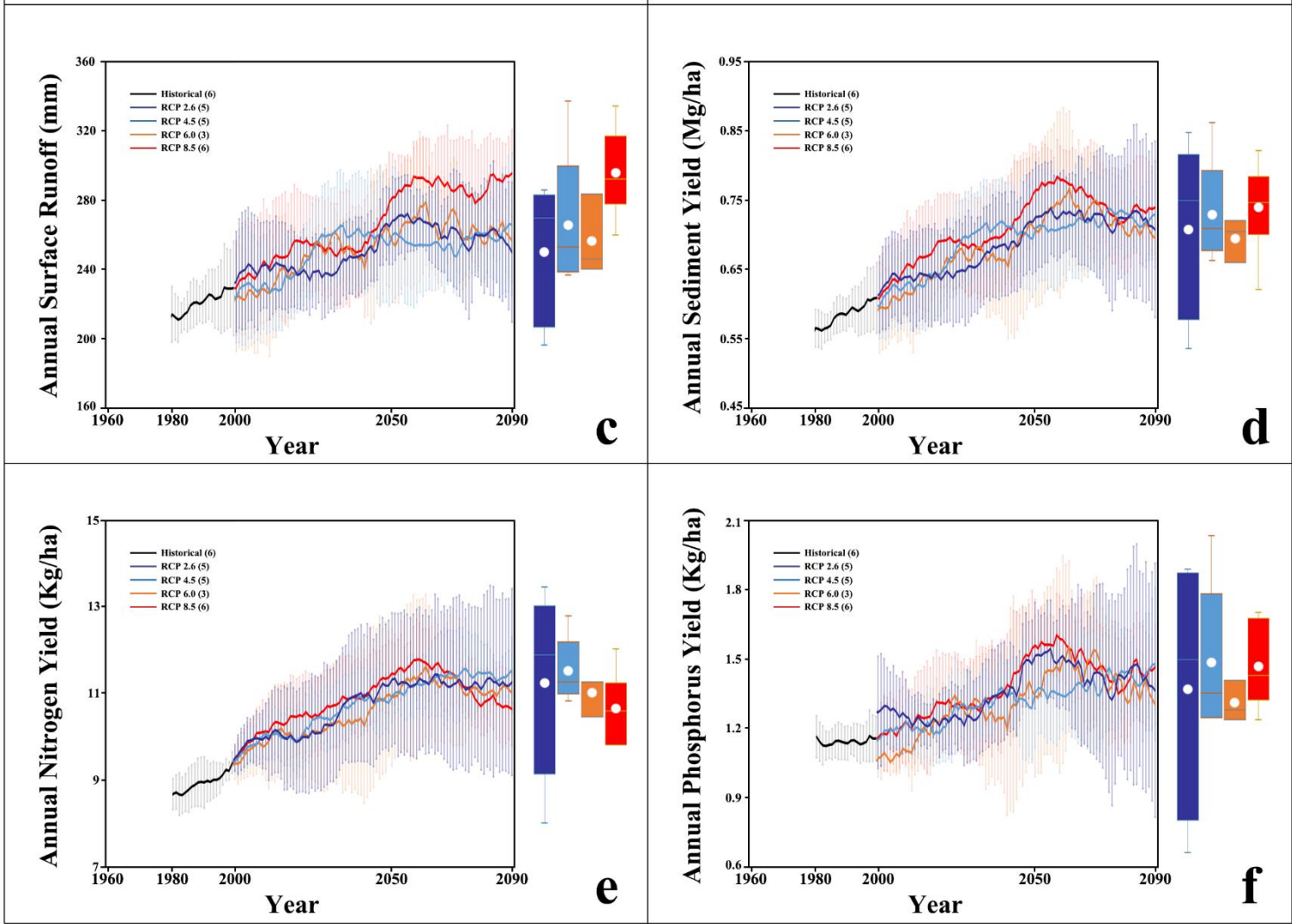
- ❑ Suburban Watershed
- ❑ Central Maryland (Piedmont)
- ❑ 5 km<sup>2</sup>
- ❑ Six CMIP5 models (US, Canada, France, Japan)
- ❑ Four RCP Scenarios 2.6, 4.5, 6.0 and 8.5
- ❑ 50- and 100-year time horizons
- ❑ Fixed (TMDL) and Relative Thresholds for CSAs



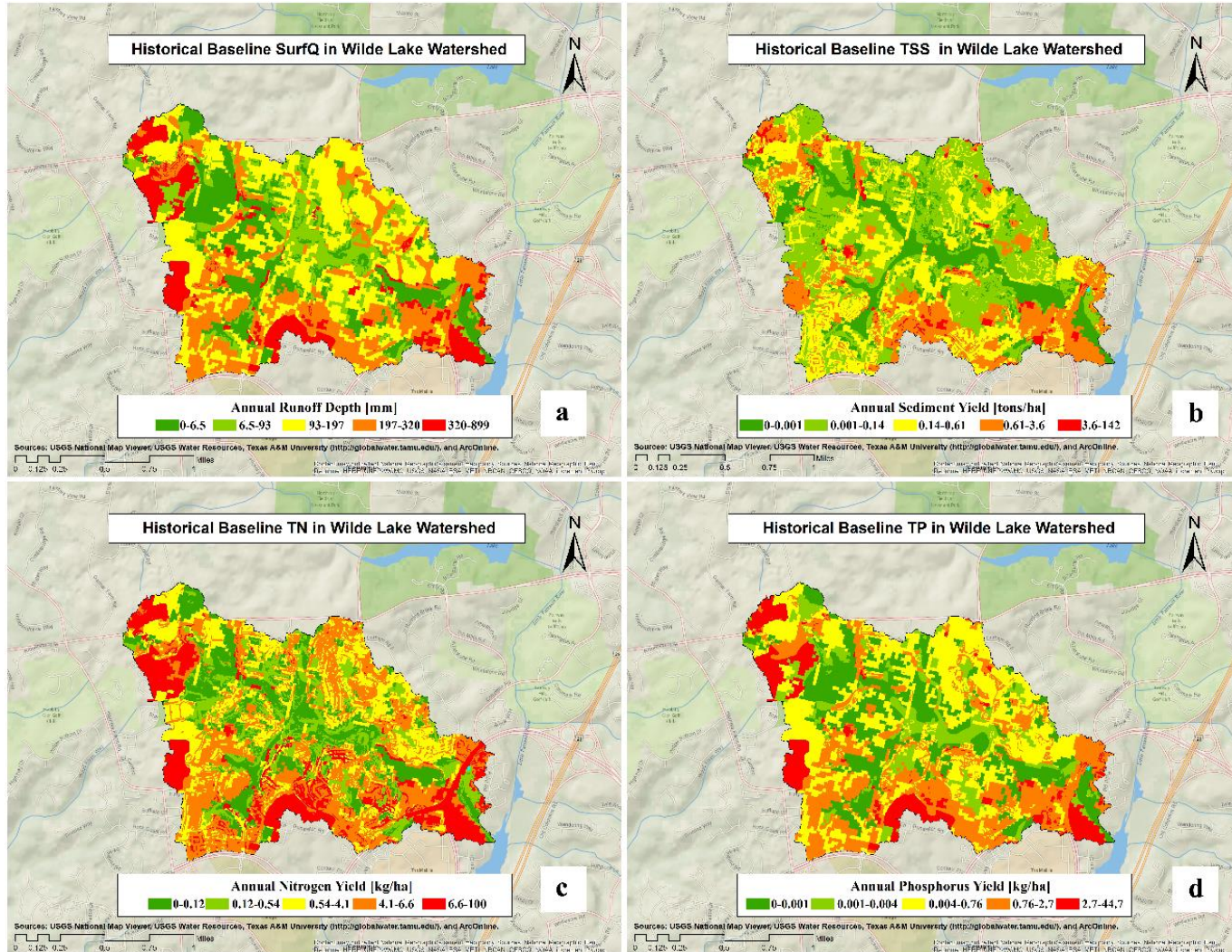




# Watershed Response: Baseline and Climate Change Scenarios

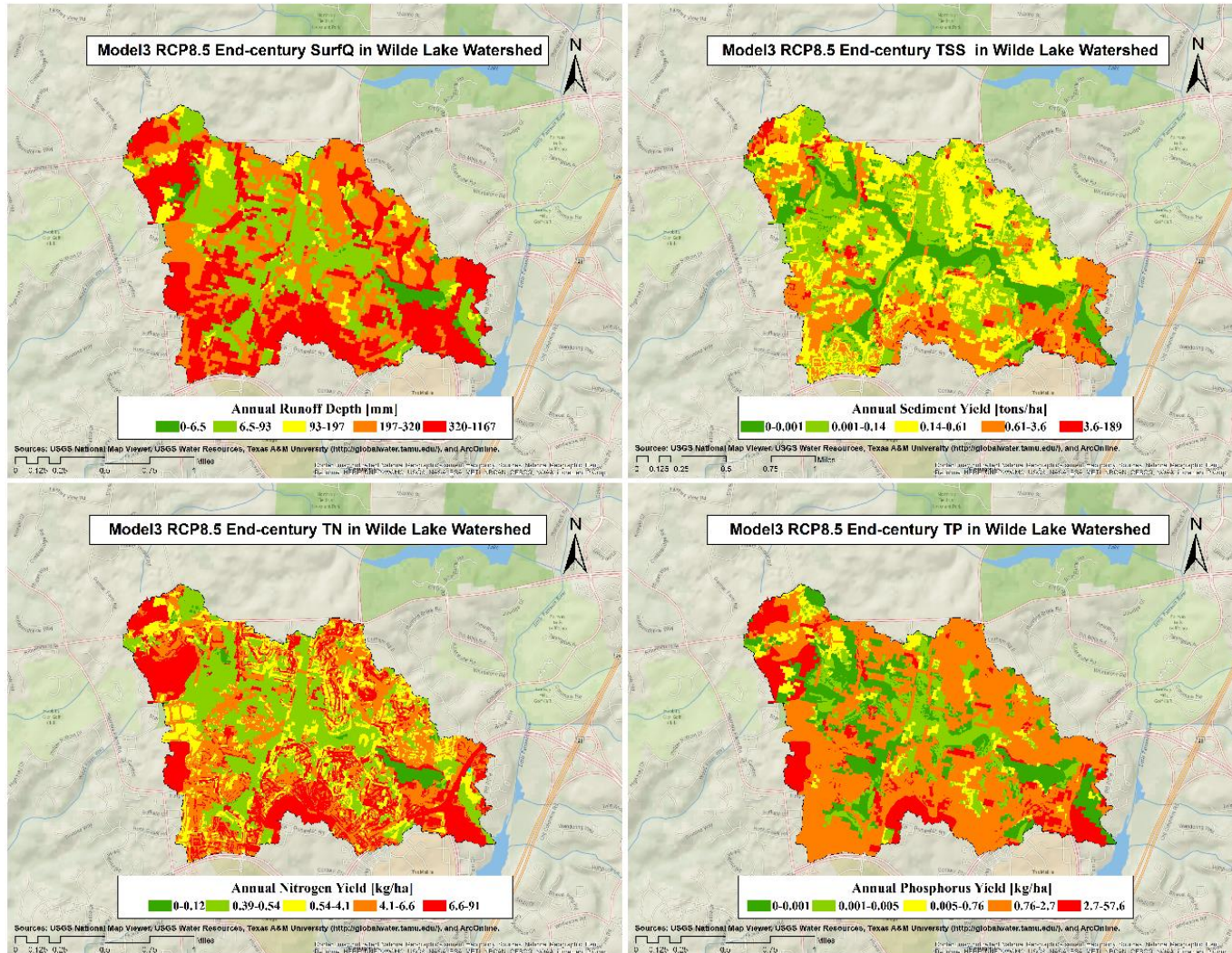


# Watershed Response: Baseline CSAs



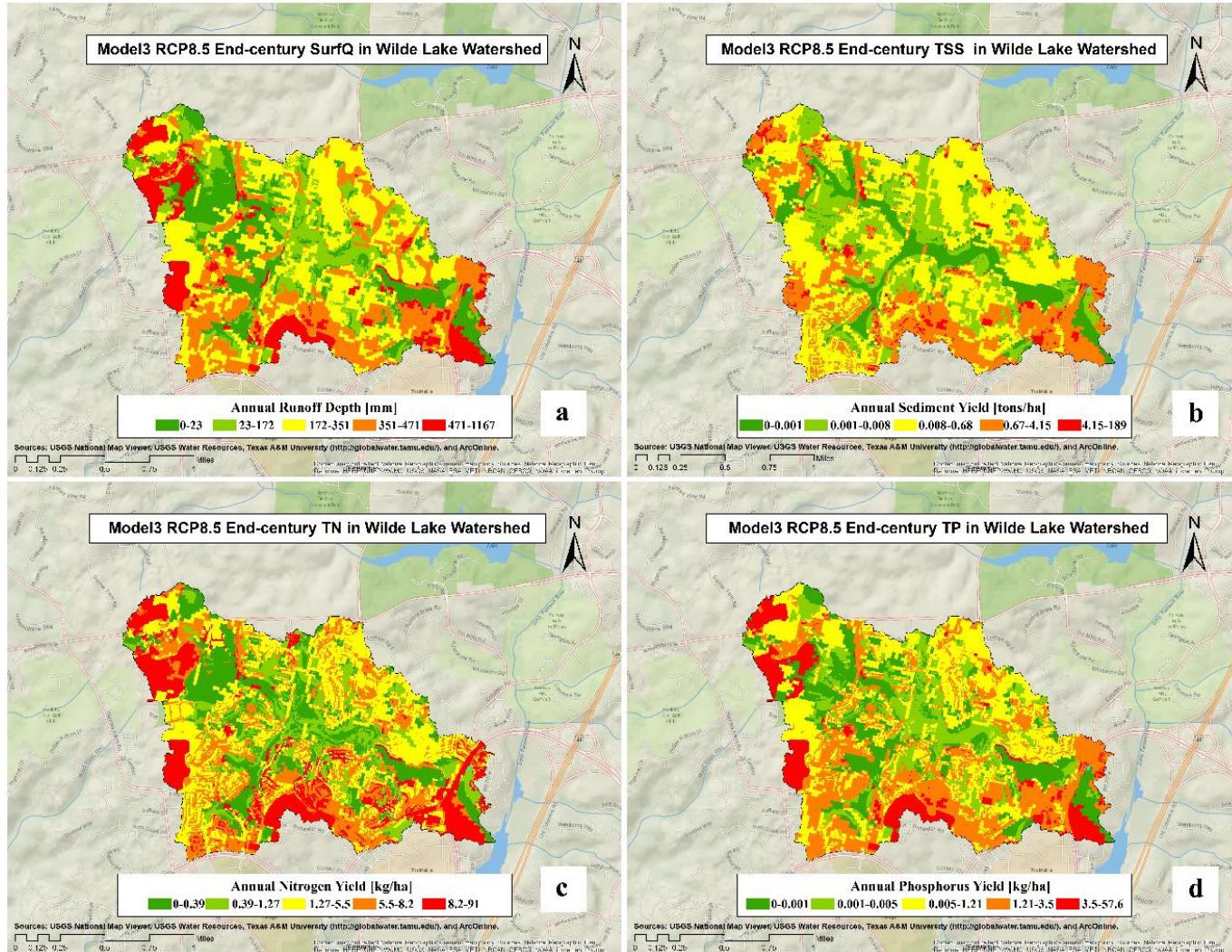


# Watershed Response: Fixed Threshold CSAs in 2100 (Model 3, RCP8.5)





# Watershed Response: Relative Threshold CSAs in 2100 (Model 3, RCP8.5)



# Summary

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In Maryland (US North East), changing rainfall patterns (volume and intensity) are expected to result in:

- Increased runoff, sediment, nitrogen and phosphorus production (nonlinear)
- Increased area of CSAs (1.5X to 4X) for constituents that need to be controlled by mass (fixed TMDLs -> fixed targeting threshold)
- Similar area and location of CSAs for constituents that need to be controlled by concentration (eg. TMDLs adjusted for increases in runoff).

For the latter, BMP plans and social interventions designed for today's conditions are expected to be robust against climate change.

For the former, the changing climate will require additional resources and efforts to maintain water quality gains (and flood control).

# Extra Slides

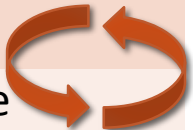
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# Model Construction and Analysis

Data Type	Characteristics	
<b>Topography/DEM</b>	10 meter	} HRU
<b>Landuse/Land Cover</b>	NLCD 2006	
<b>Soils</b>	NRCS SSURGO	
<b>Weather (Calibration)</b>	3 stations NCEP CFSR	
<b>Flow, Nutrients and Sediment</b>	1 USGS Gauging Station Greensboro	
<b>Climate Change</b>	CMIP3 (B1, A1B, A2)	
<b>GFDL-CM2.1</b>	(Mid and End Century)	

Software	Purpose and Progression
<b>ArcGIS</b>	Spatial Data Analysis (Graphics and Database)
<b>ArcSWAT</b>	Model development SWAT input file Generation
<b>SWAT-CUP</b>	Model calibration (SUF2 Method)
<b>SWAT</b>	Experimental engine (SWAT.exe)



**Downscaled climate predictions from global model based around 3 IPCC scenarios that lead to low, medium, and high future levels of CO<sub>2</sub>**

## Model Calibration

- Warm-up (3 yrs): 1/1/1990 to 12/31/1992
- Calibration Period (15 yrs): 1/1/1990 to 12/31/2004

## Model Validation

- Warm-up (2 yrs): 1/1/2005 to 12/31/2006
- Validation Period (6 yrs): 1/1/2005 to 12/31/2010

# Definition of a Critical Source Area (CSA)

**An area that exports a target pollutant at concentrations significantly above average**

Rank	SurQ (mm H2O)	TSS (tonnes/ha/yr)	TN (kg/ha/yr)	TP (kg/ha/yr)
<b>Top 10%</b>	>406	>1.03	>24	>1.9
<b>Top 20%</b>	>359	>0.73	>16	>1.6

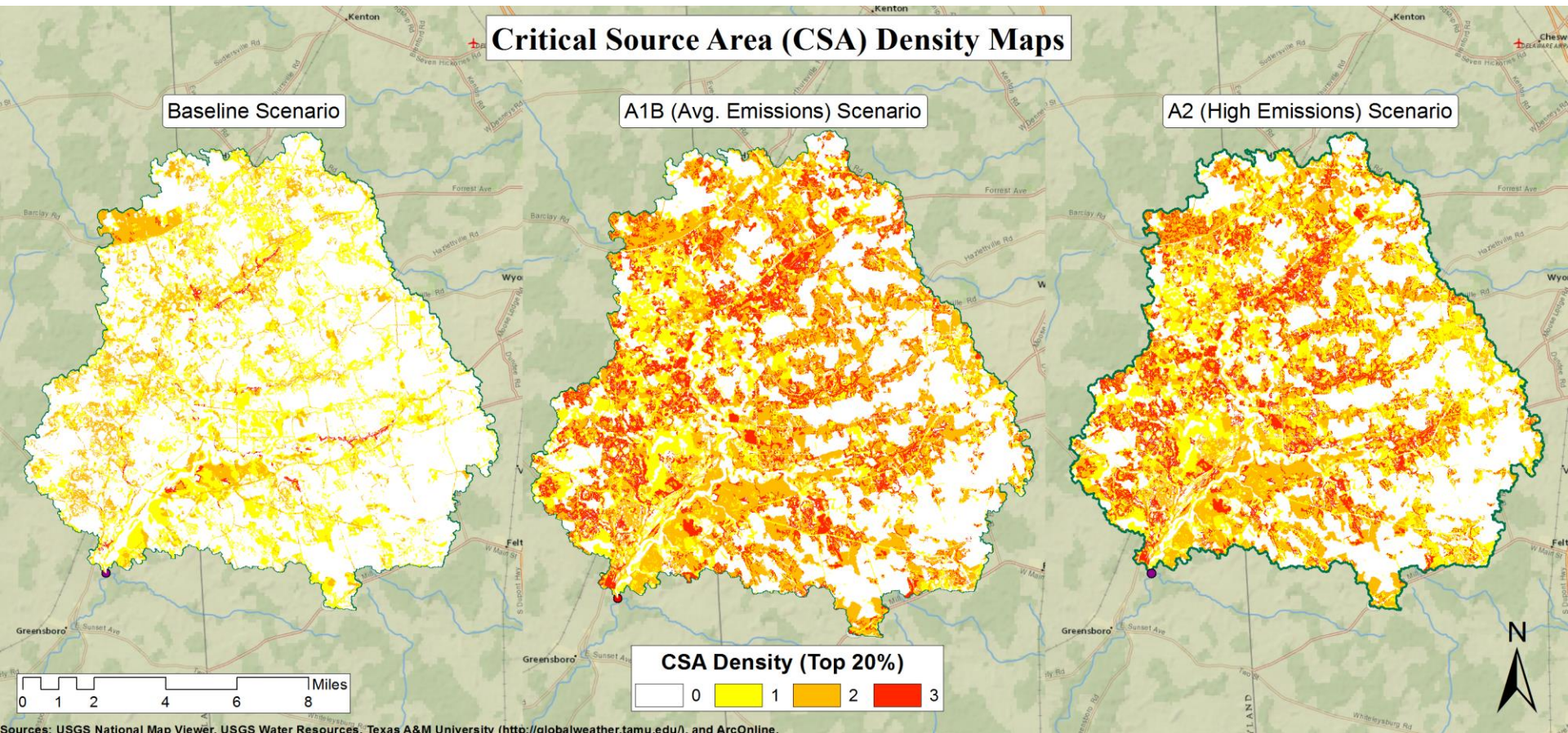
Top 10%: Value for which the top ~770 HRUs is separated from the other 7705 HRUs

Top 20%: Value for which the top ~1540 HRUs is separated from the other 7705 HRUs

**Always defined a watershed area (or HRU) a CSA if it exported a given pollutant at these fixed thresholds**

# Targeting Method: Dense CSAs

*Critically Dense Areas at the top 20% Break Value*



Rank	SurQ (mm H2O)	TSS (tonnes/ha/yr)	TN (kg/ha/yr)	TP (kg/ha/yr)
<b>Top 10%</b>	>406	>1.03	>24	>1.9
<b>Top 20%</b>	>359	>0.73	>16	>1.6



# Targeting Dense CSAs of the Future

*Residual CSA Density with A2 BMP Design Subjected to Current, A1B and A2 Climate Conditions.*

