

GIS tools for assessing nutrient cycling, water quality and biomass potential

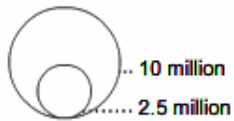
**Northeast Sun Grant Regional Feedstock Summit,
November 12, 2007**

**John Mackenzie
University of Delaware**

GLOBAL PERSPECTIVE: The US is the world's 3rd biggest oil-producer...

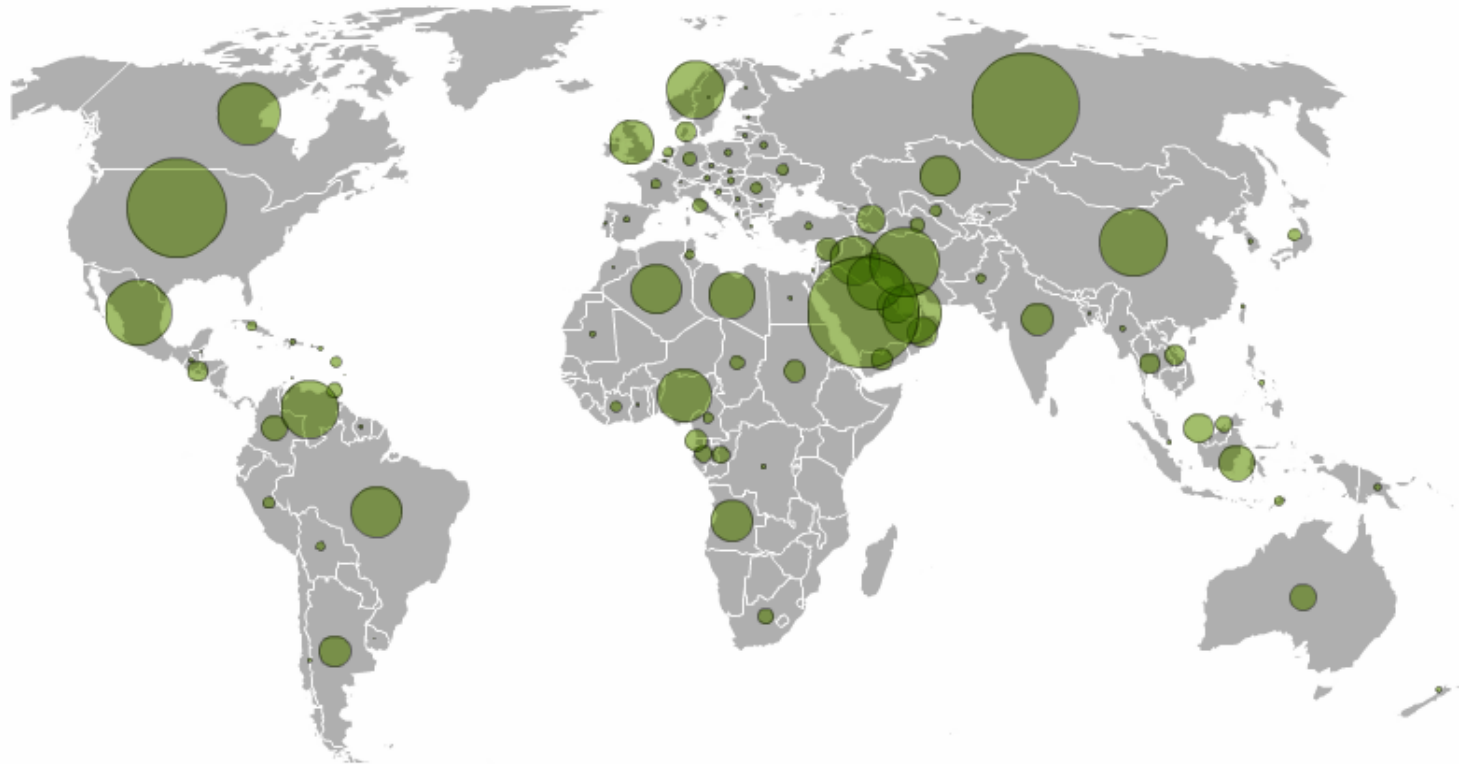
Oil produced, barrels per day

Circles are proportional
to the number of barrels.



Top producers

1. Saudi Arabia	10.7 mil.
2. Russia	9.7 mil.
3. United States	8.4 mil.
4. Iran	4.1 mil.
5. China	3.9 mil.
6. Mexico	3.7 mil.
7. Canada	3.3 mil.
8. United Arab Emirates	2.9 mil.
9. Venezuela	2.8 mil.
10. Norway	2.8 mil.



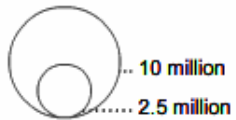
Source: Energy Information Administration

Vu Nguyen / The New York Times

...by far the world's biggest consumer,...

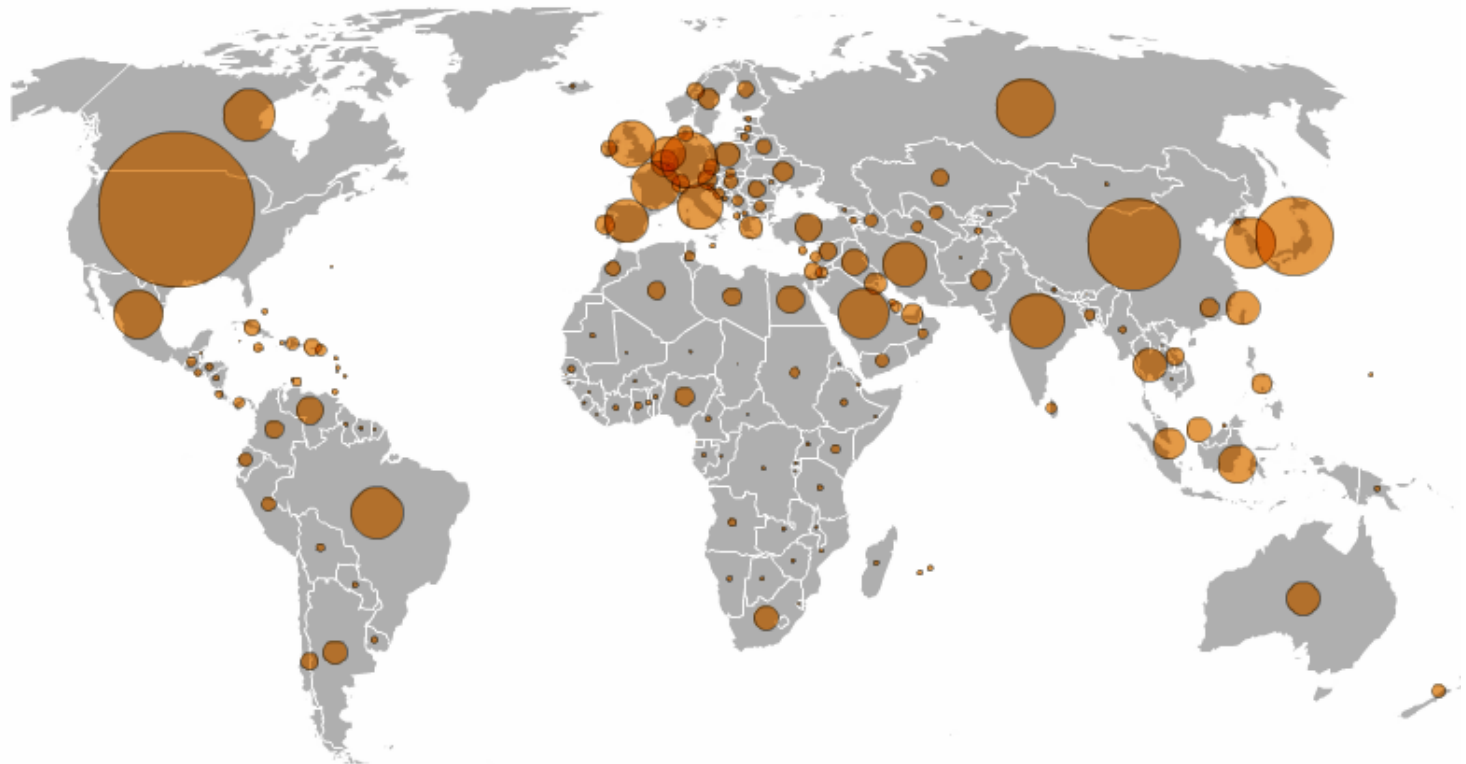
**Oil consumed,
barrels per day**

Circles are proportional
to the number of barrels.



Top consumers

1. United States	20.6 mil.
2. China	7.3 mil.
3. Japan	5.2 mil.
4. Russia	2.9 mil.
5. Germany	2.7 mil.
6. India	2.5 mil.
7. Brazil	2.3 mil.
8. Canada	2.2 mil.
9. South Korea	2.2 mil.
10. Saudi Arabia	2.1 mil.



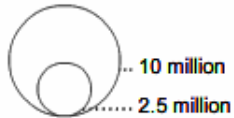
Source: Energy Information Administration

Vu Nguyen / The New York Times

...and the world's biggest importer

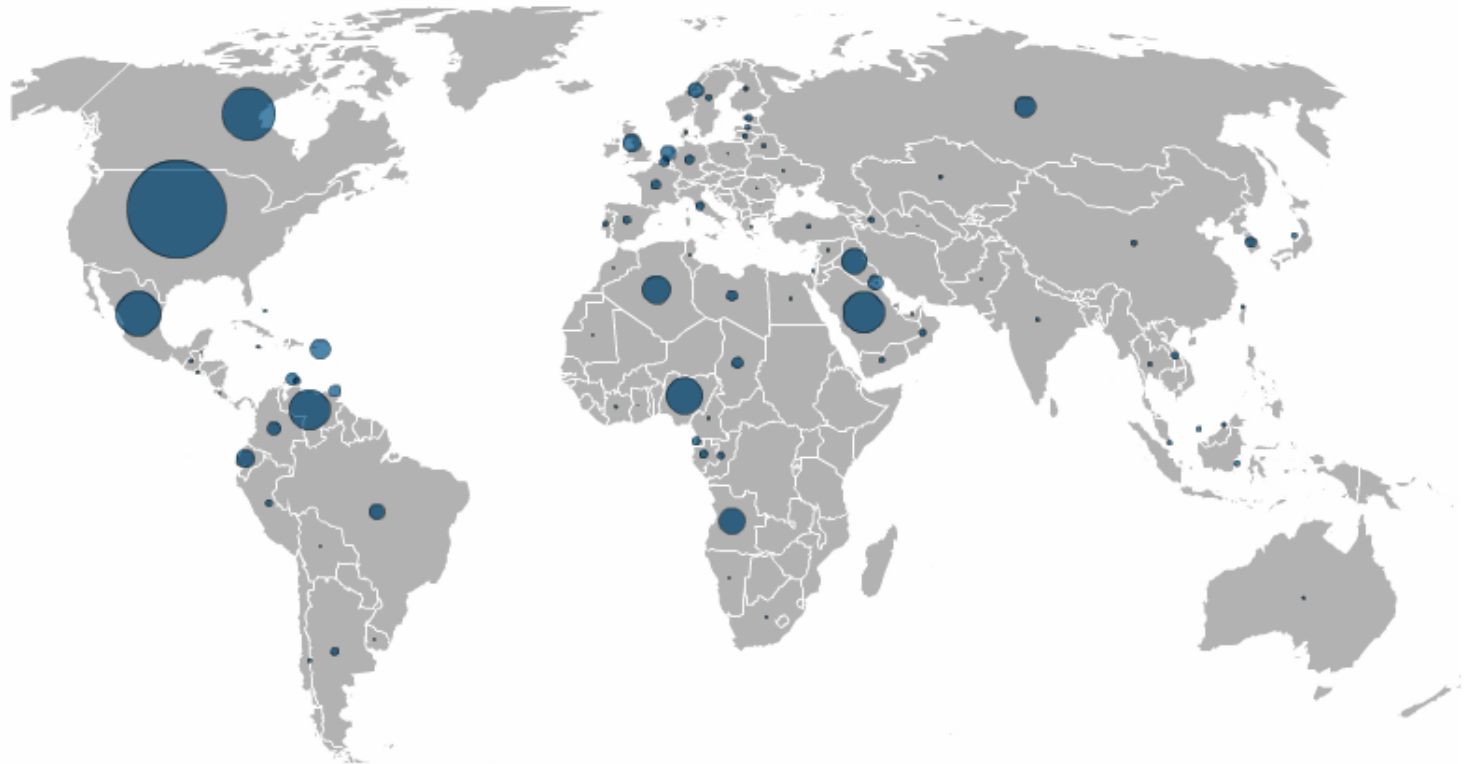
**Oil supplied to
the United States,
barrels per day**

Circles are proportional
to the number of barrels.



Top suppliers to the U.S.

1. United States	8.3 mil.
2. Canada	2.4 mil.
3. Mexico	1.7 mil.
4. Saudi Arabia	1.5 mil.
5. Venezuela	1.4 mil.
6. Nigeria	1.1 mil.
7. Algeria	0.7 mil.
8. Iraq	0.6 mil.
9. Angola	0.5 mil.
10. Russia	0.4 mil.

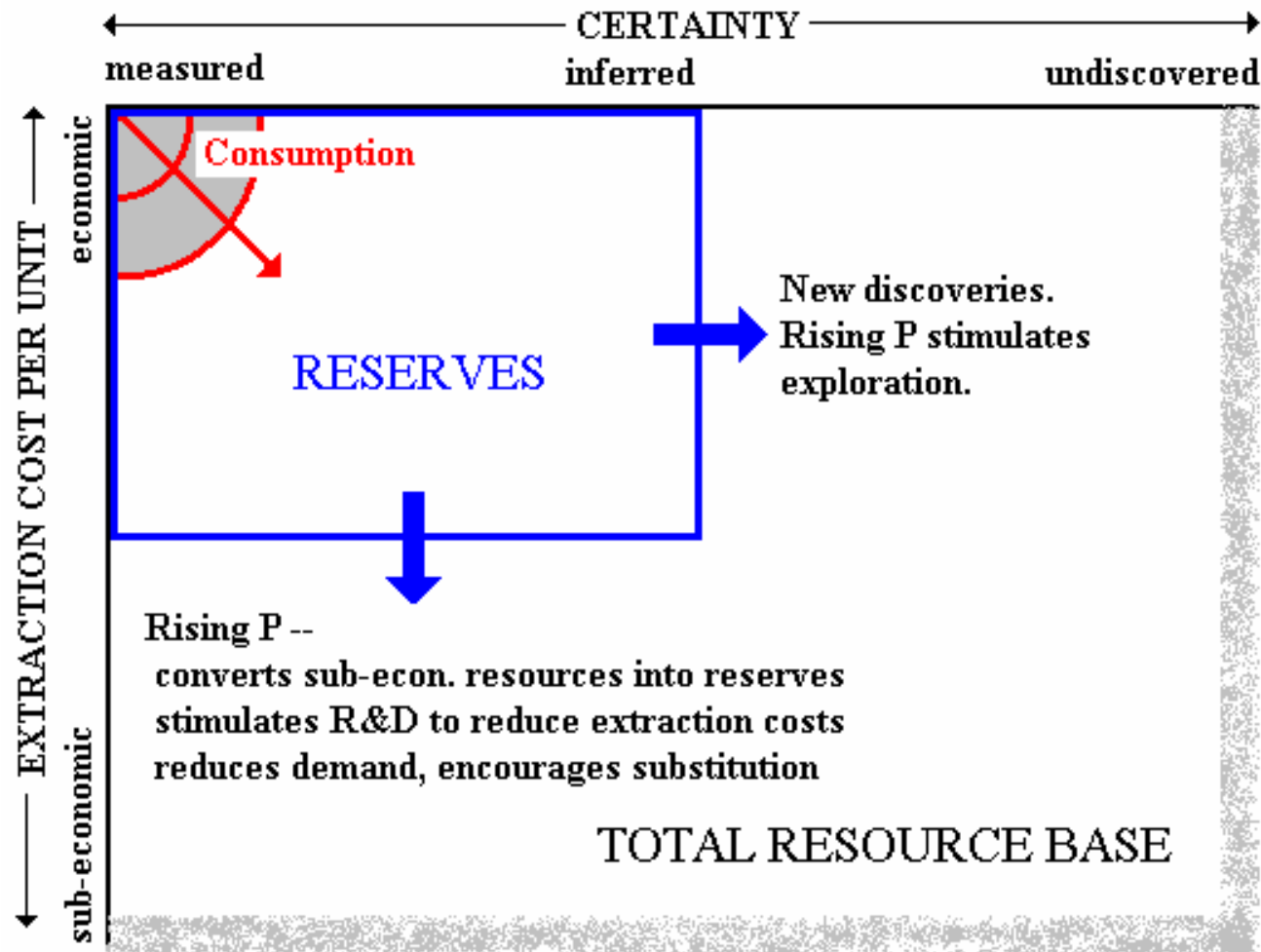


Source: Energy Information Administration

Vu Nguyen / The New York Times

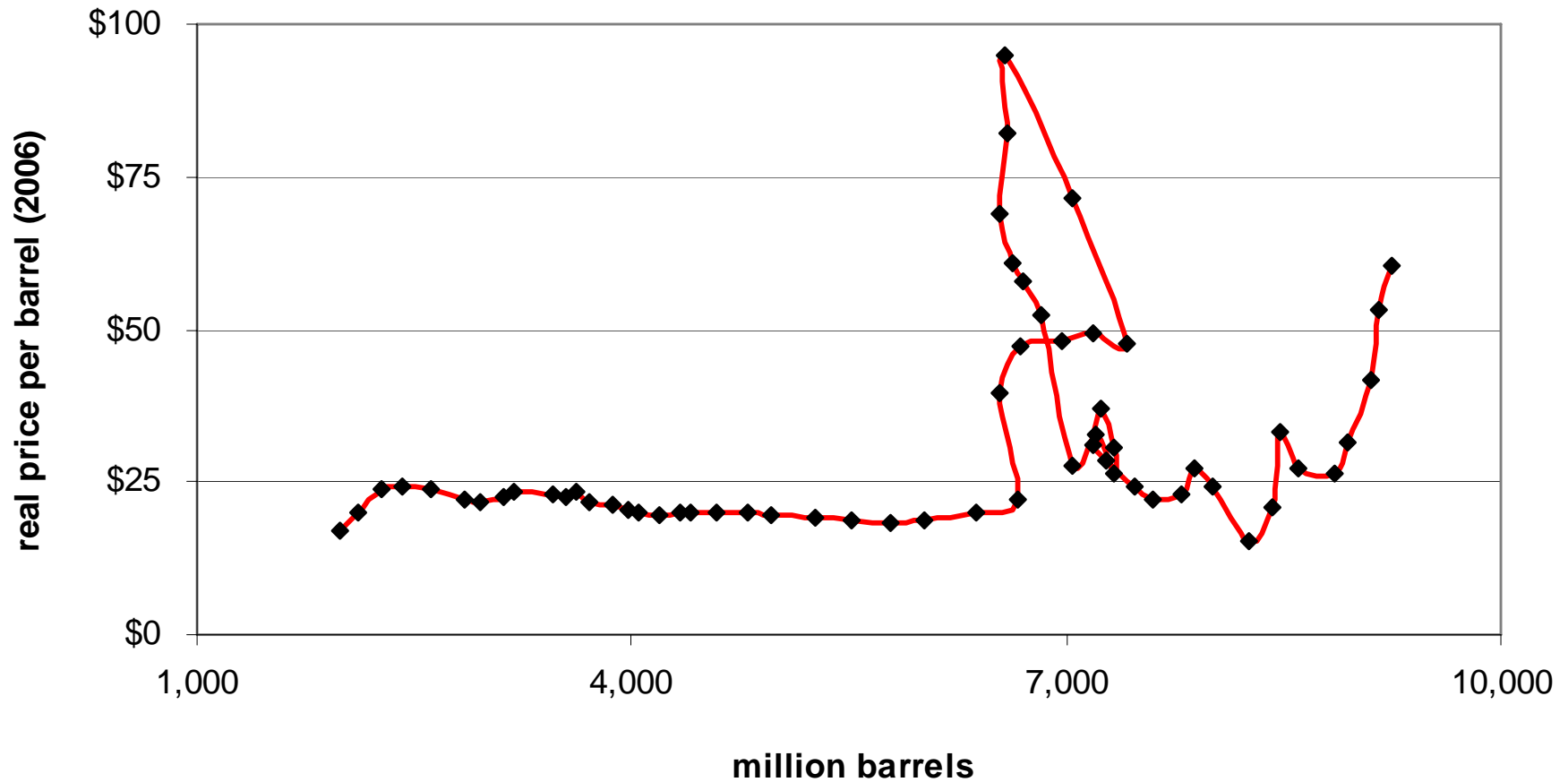
So there is huge capacity for conservation

Reserves are not fixed



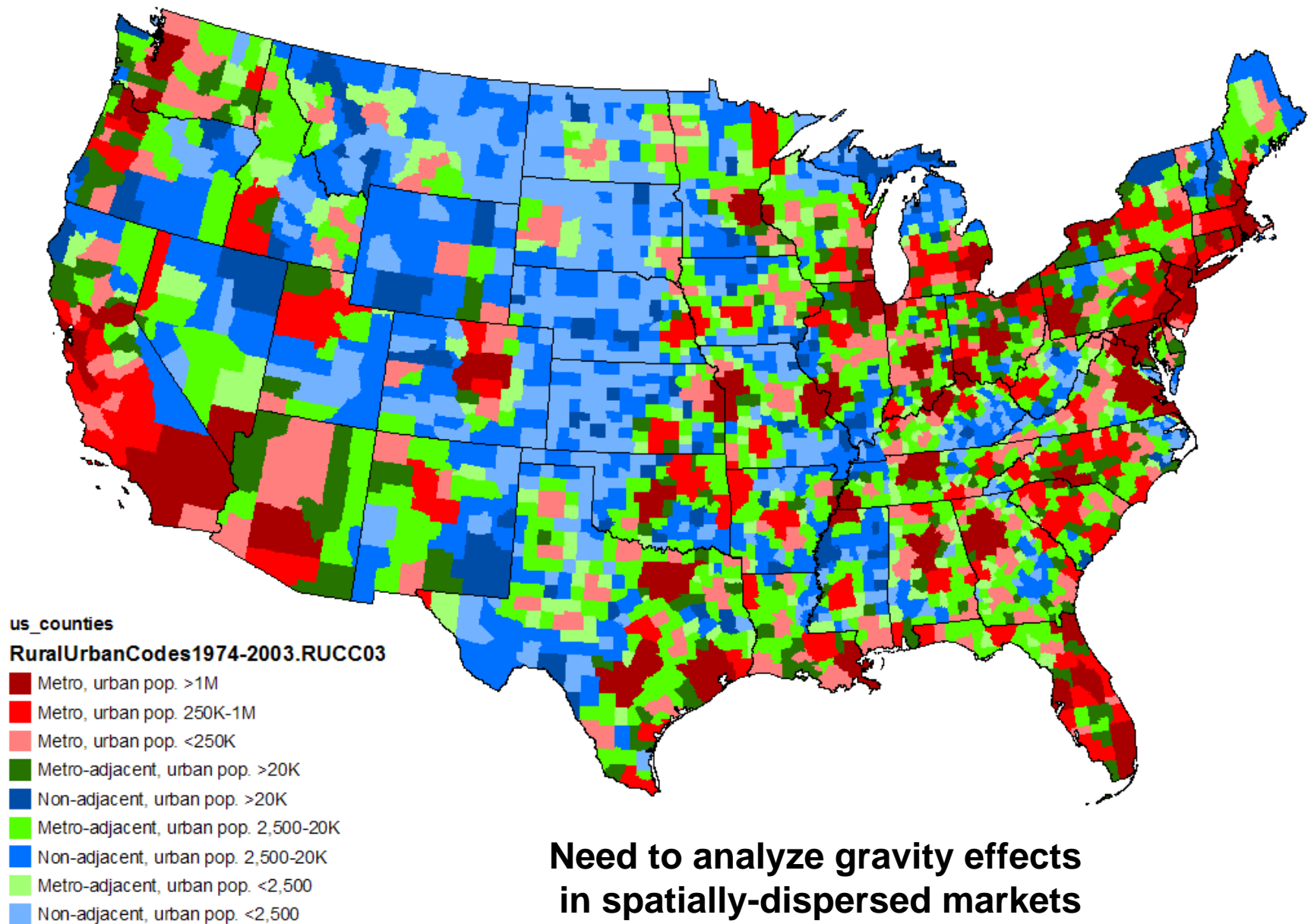
The next loop-de-loop will be bigger

US Gasoline Consumption vs. Real Price/Barrel of Crude, 1946-2006



NATIONAL PERSPECTIVE

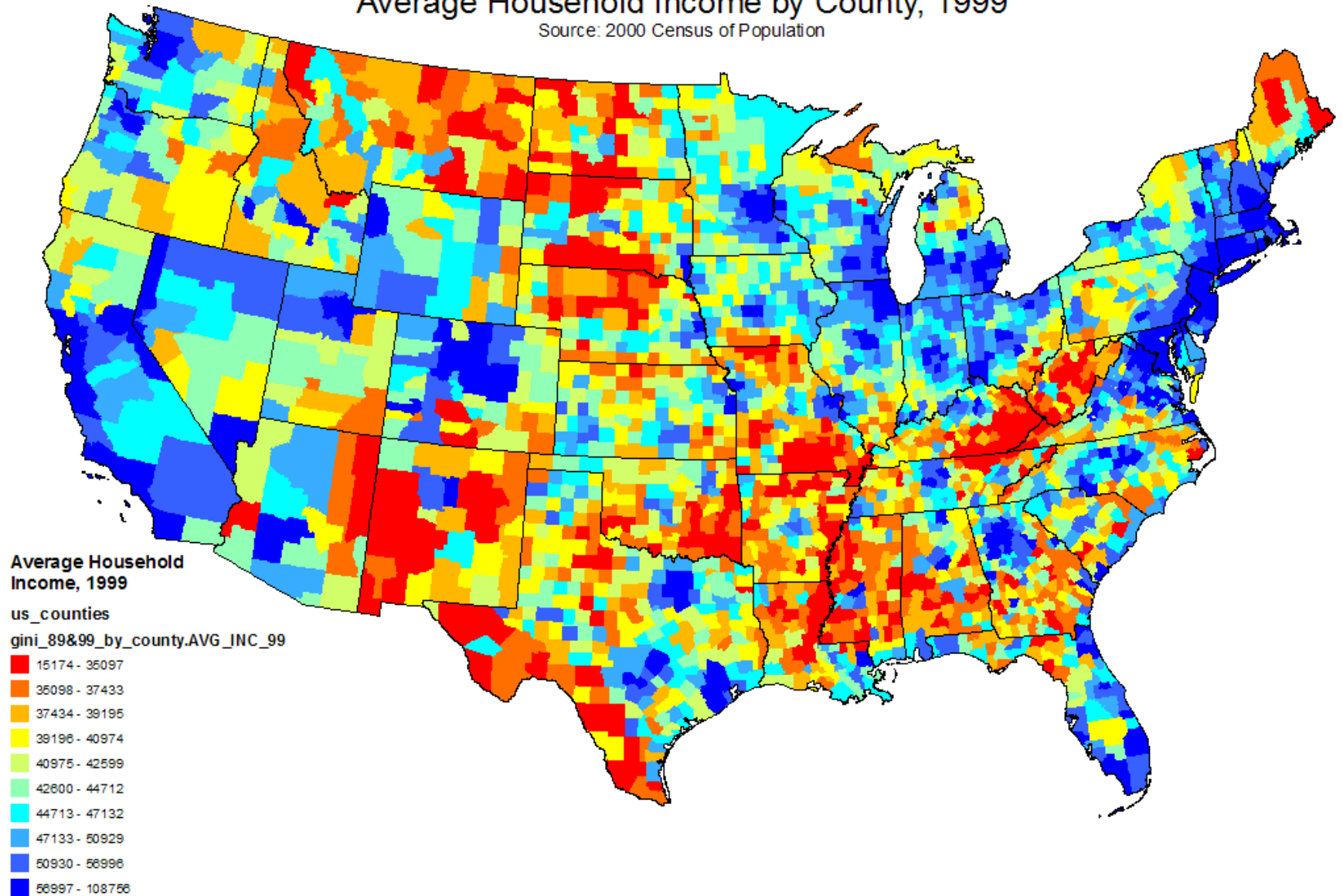
Rural-Urban Continuum Codes, 2003 by County



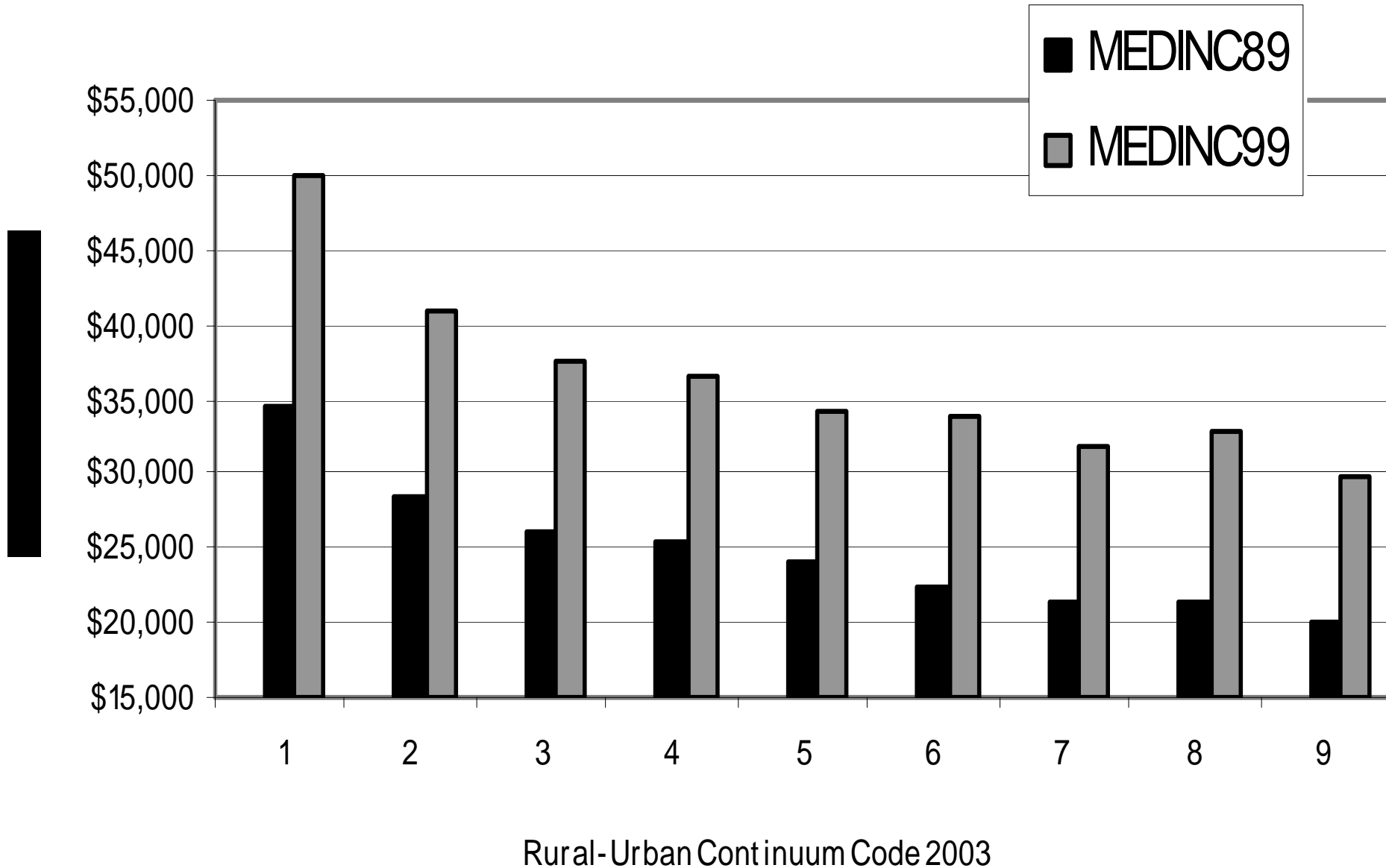
The eternal issue of rural poverty

Average Household Income by County, 1999

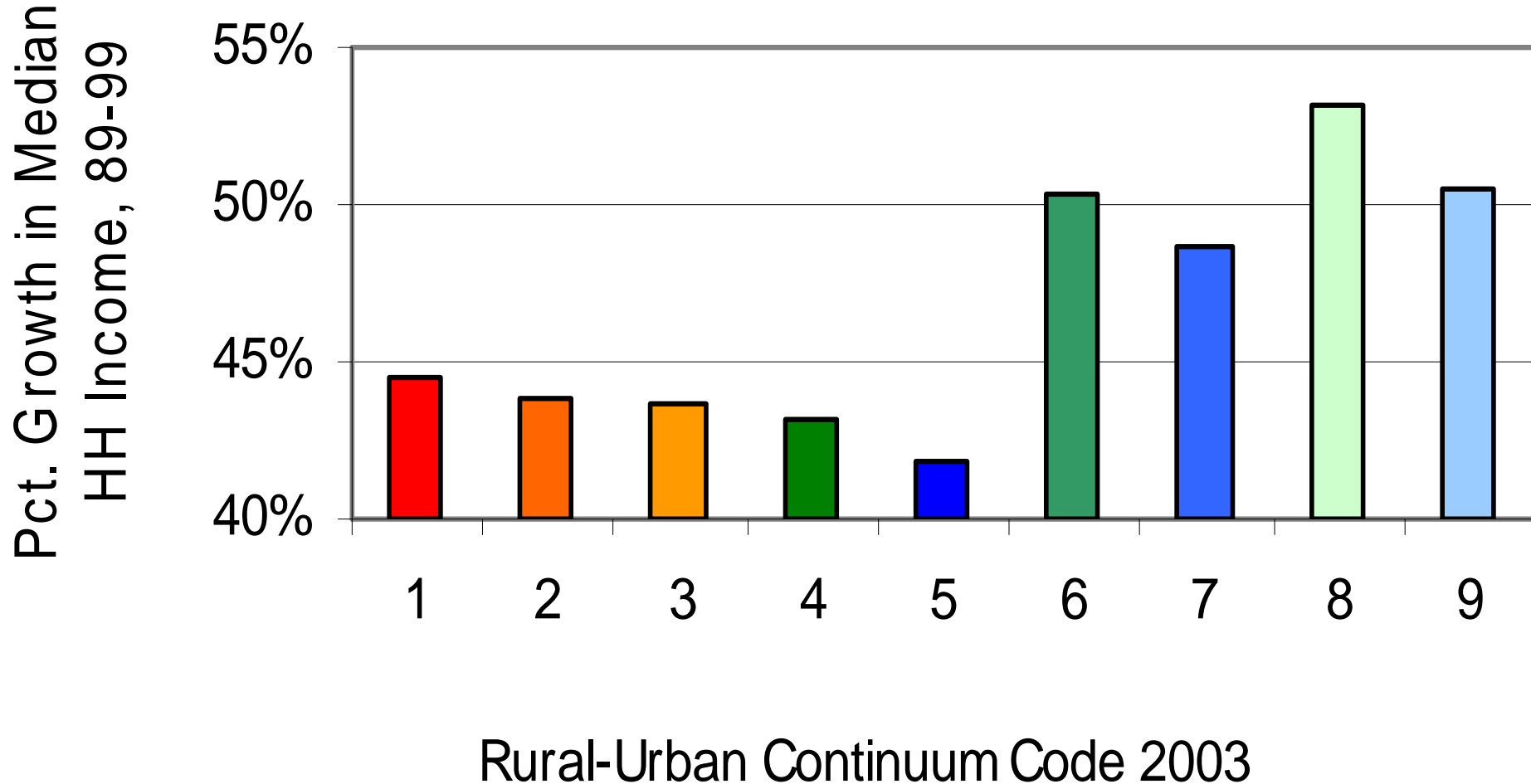
Source: 2000 Census of Population



Median Income 1989 & 1999 by RUCC 2003



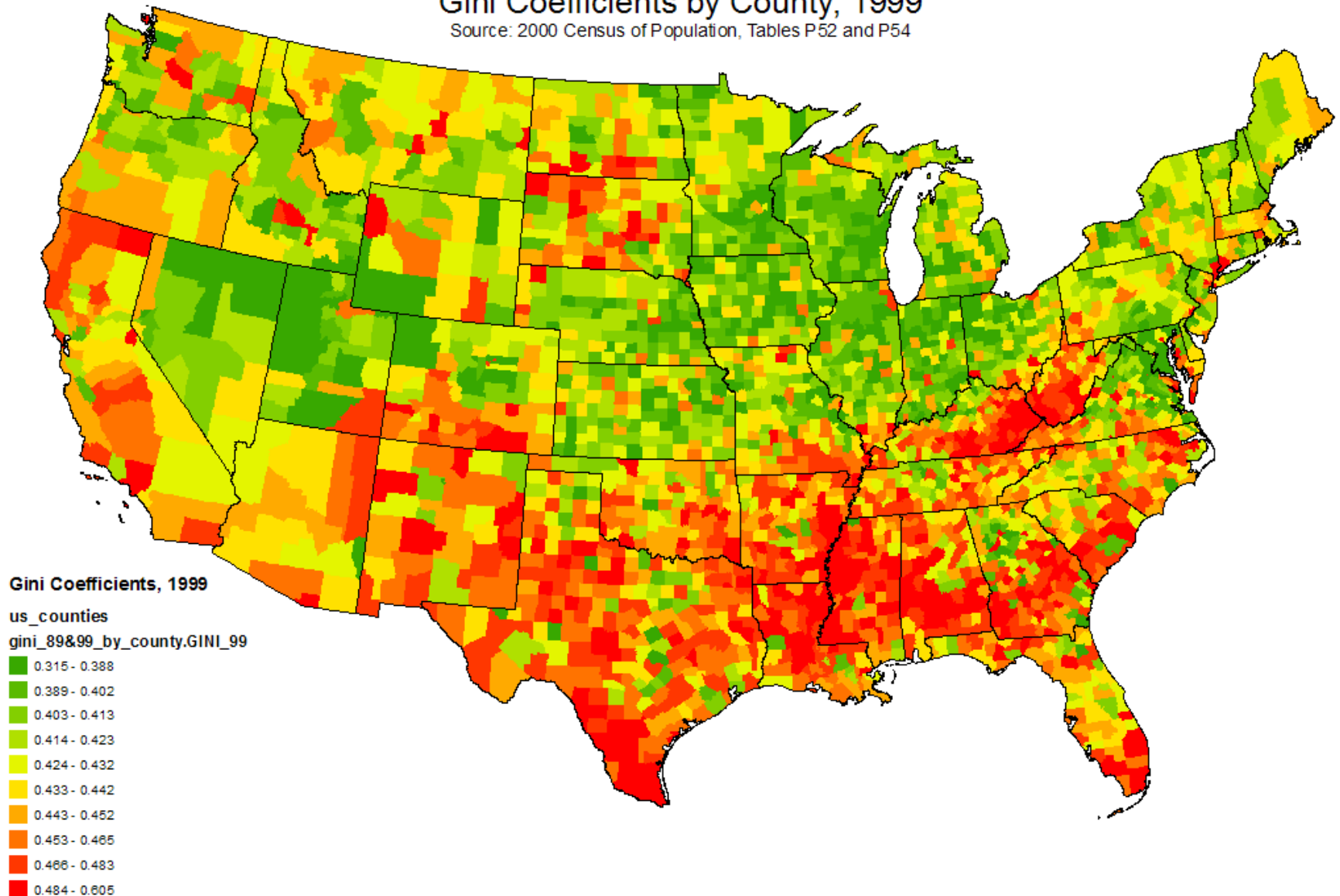
Percent Changes In Median Income, 1989-1999, by RUCC 2003



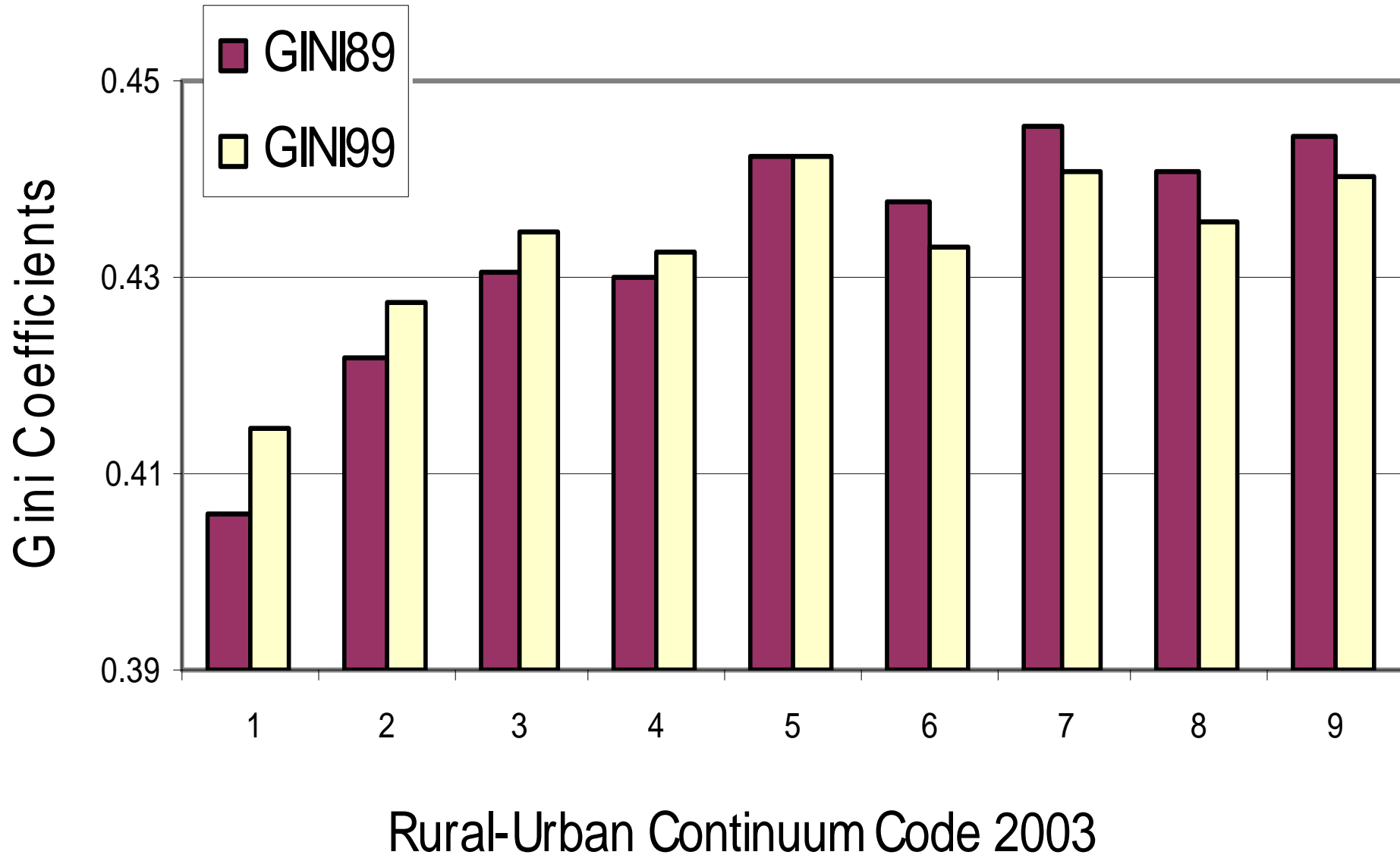
Negative correlation between income inequality and average incomes:
Does farm consolidation and industrialization worsen rural poverty?

Gini Coefficients by County, 1999

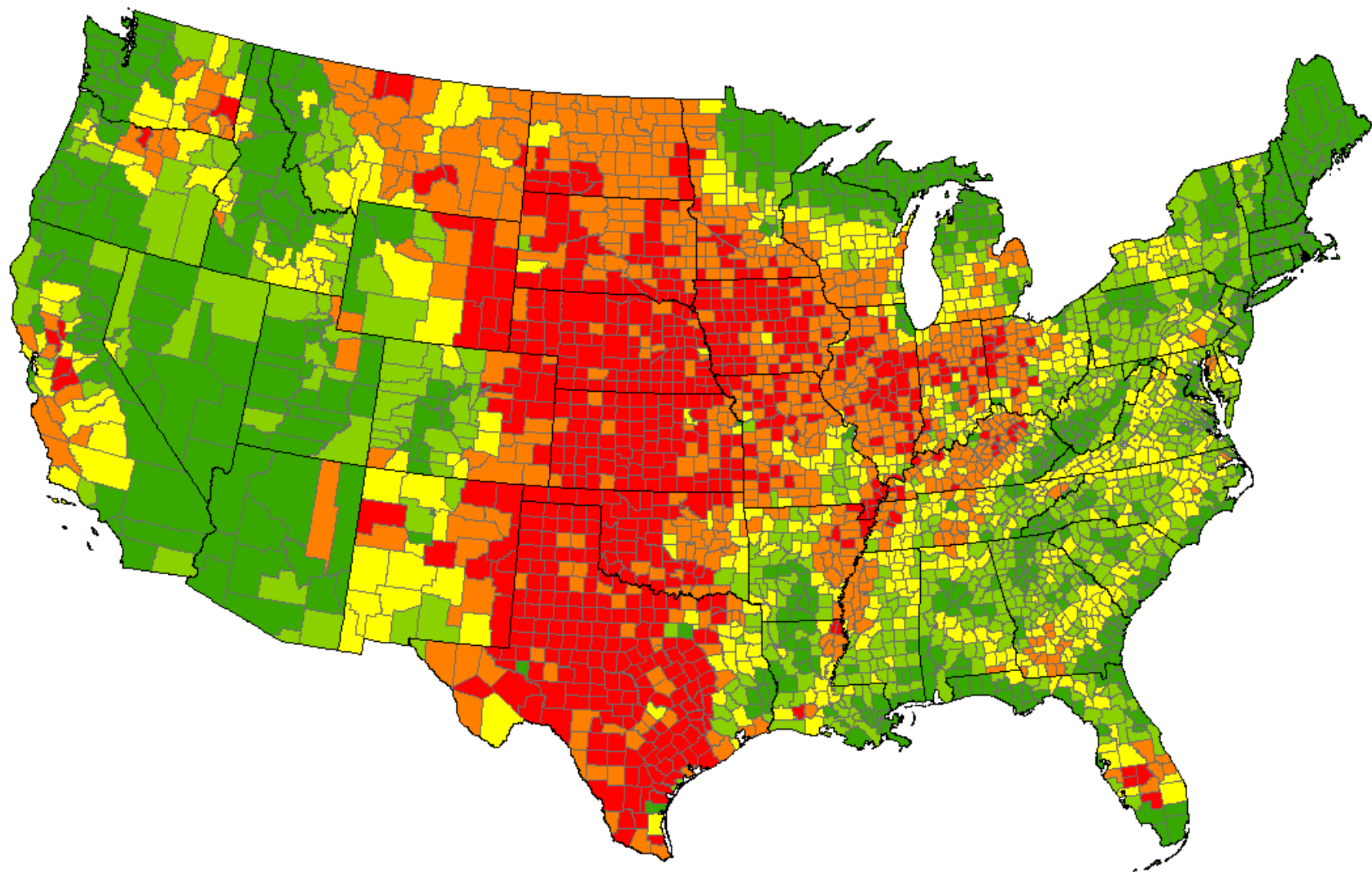
Source: 2000 Census of Population, Tables P52 and P54



1989 and 1999 Gini Coefficients by RUCC 2003



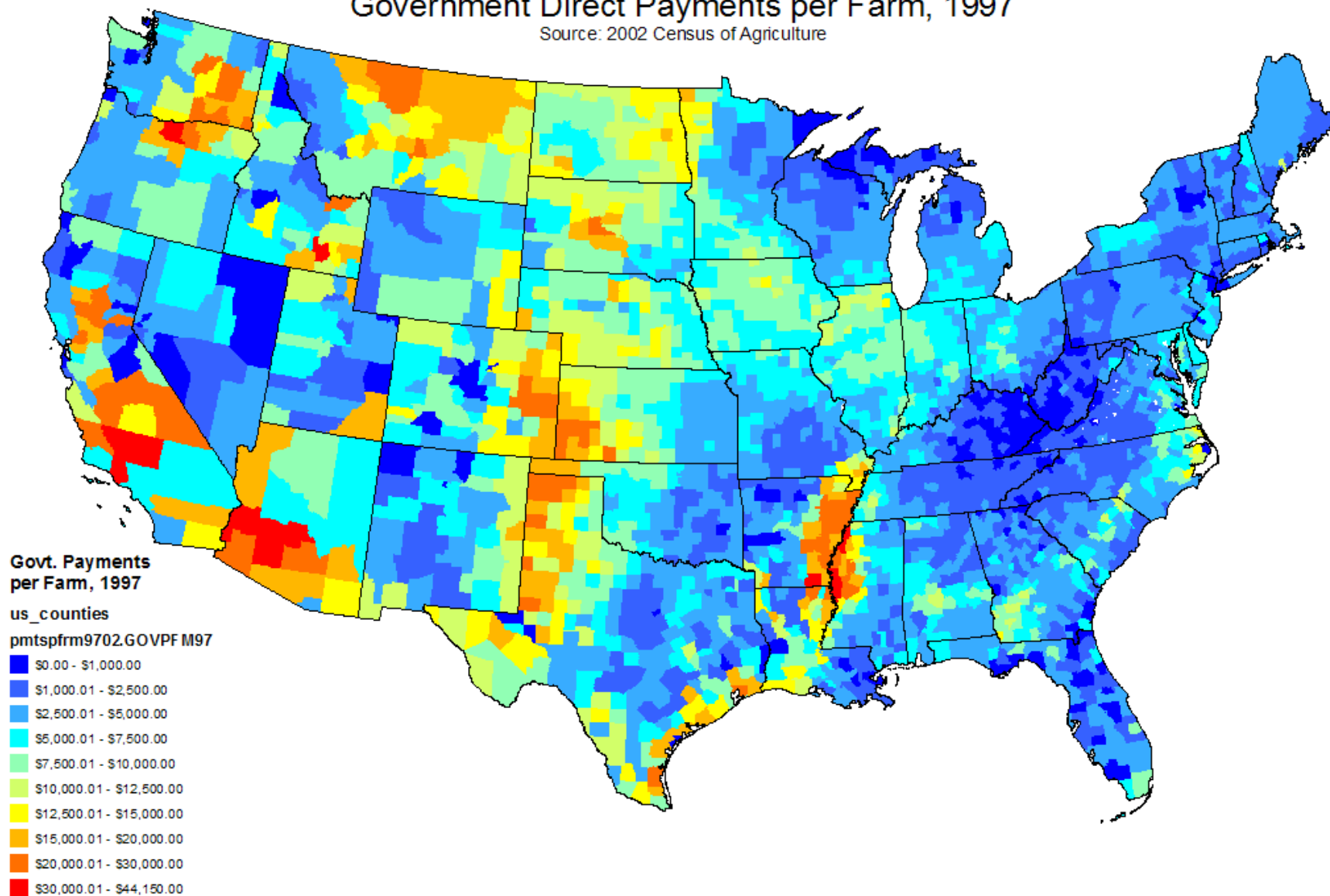
Percent of County Land Area in Farms, 2002



Re-drawing the policy map

Government Direct Payments per Farm, 1997

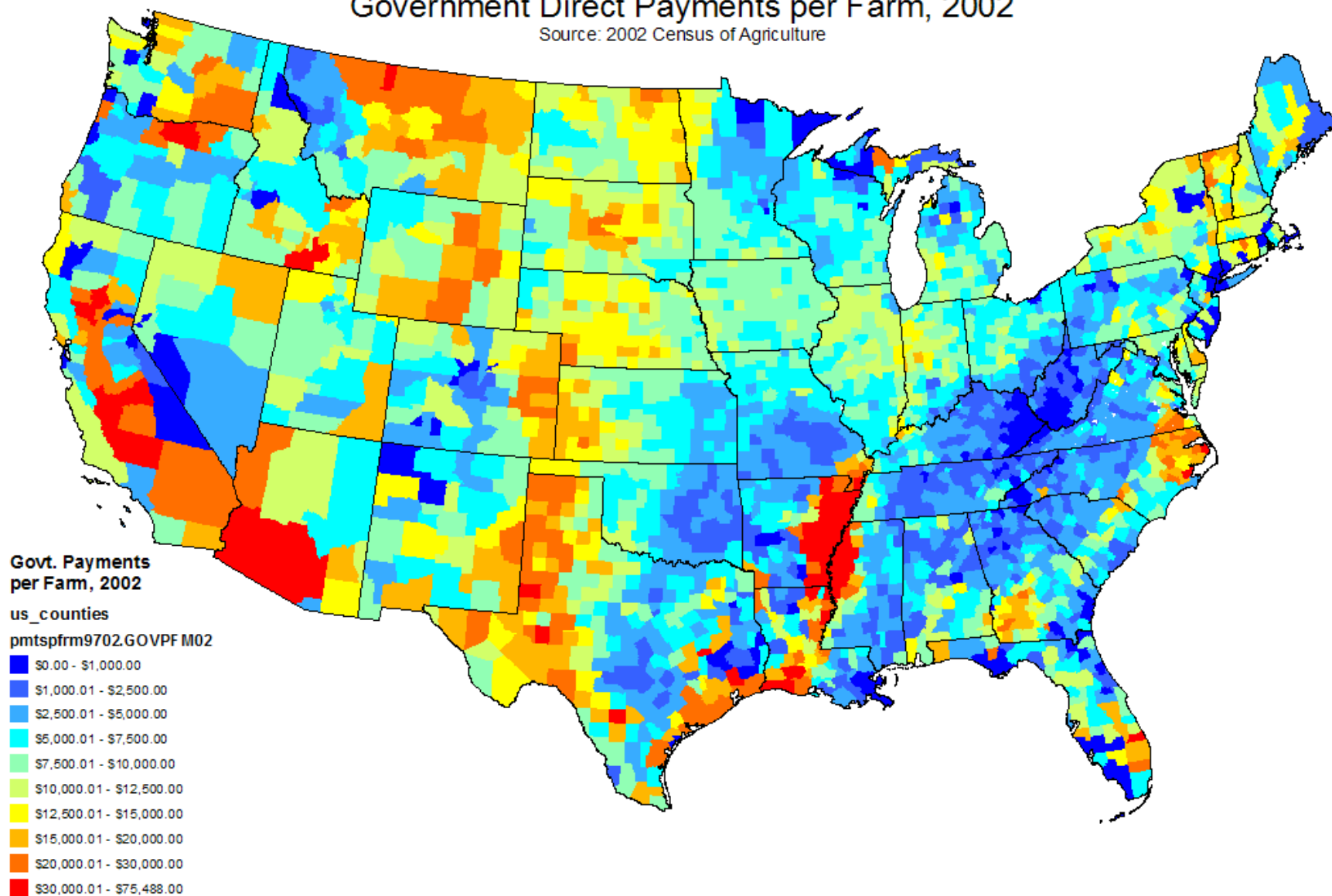
Source: 2002 Census of Agriculture



Subsidies are highly addictive

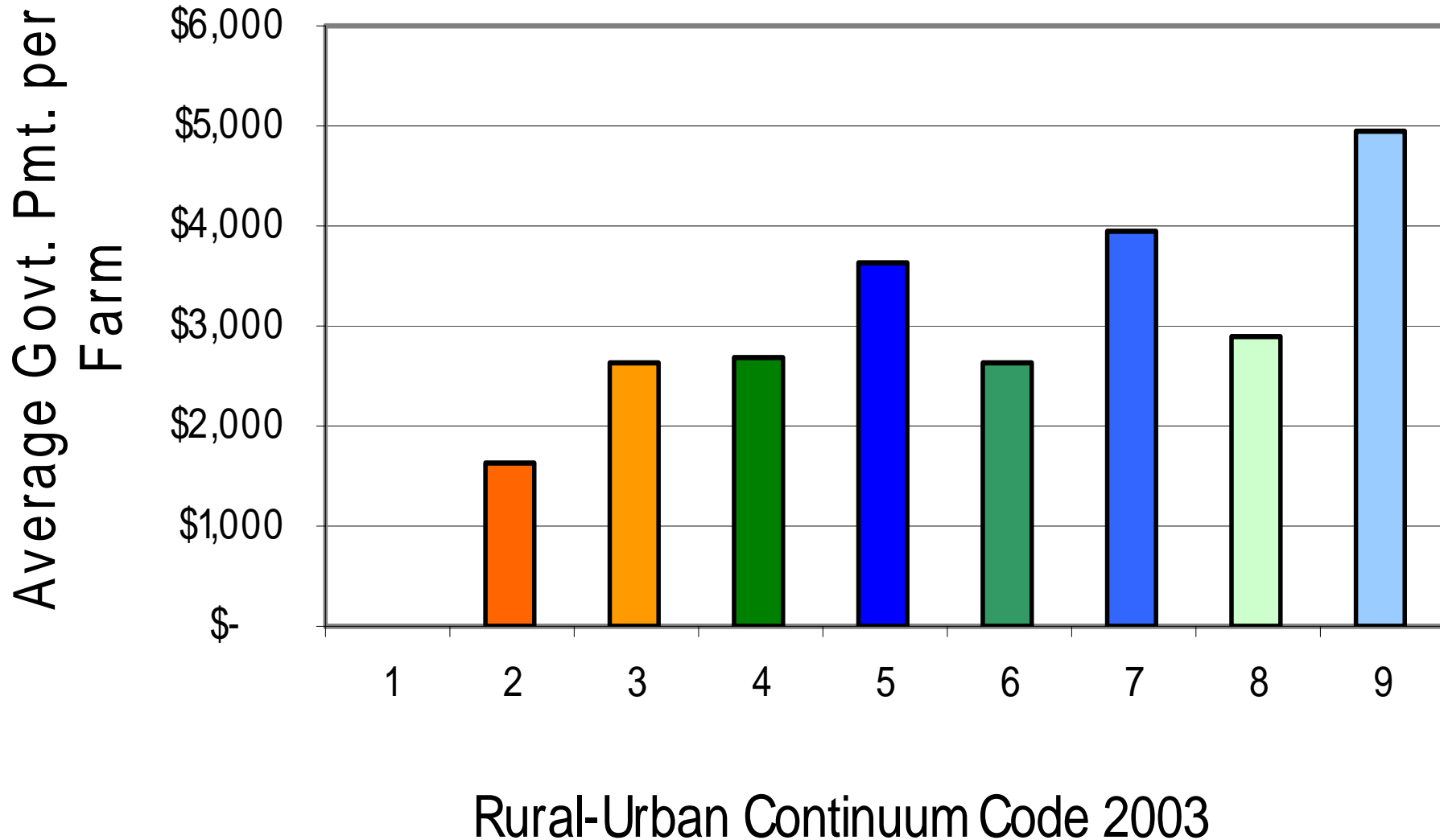
Government Direct Payments per Farm, 2002

Source: 2002 Census of Agriculture



Federal Payments per Farm 2002 by RUCC 2003

Non-adjacent counties are the most dependent

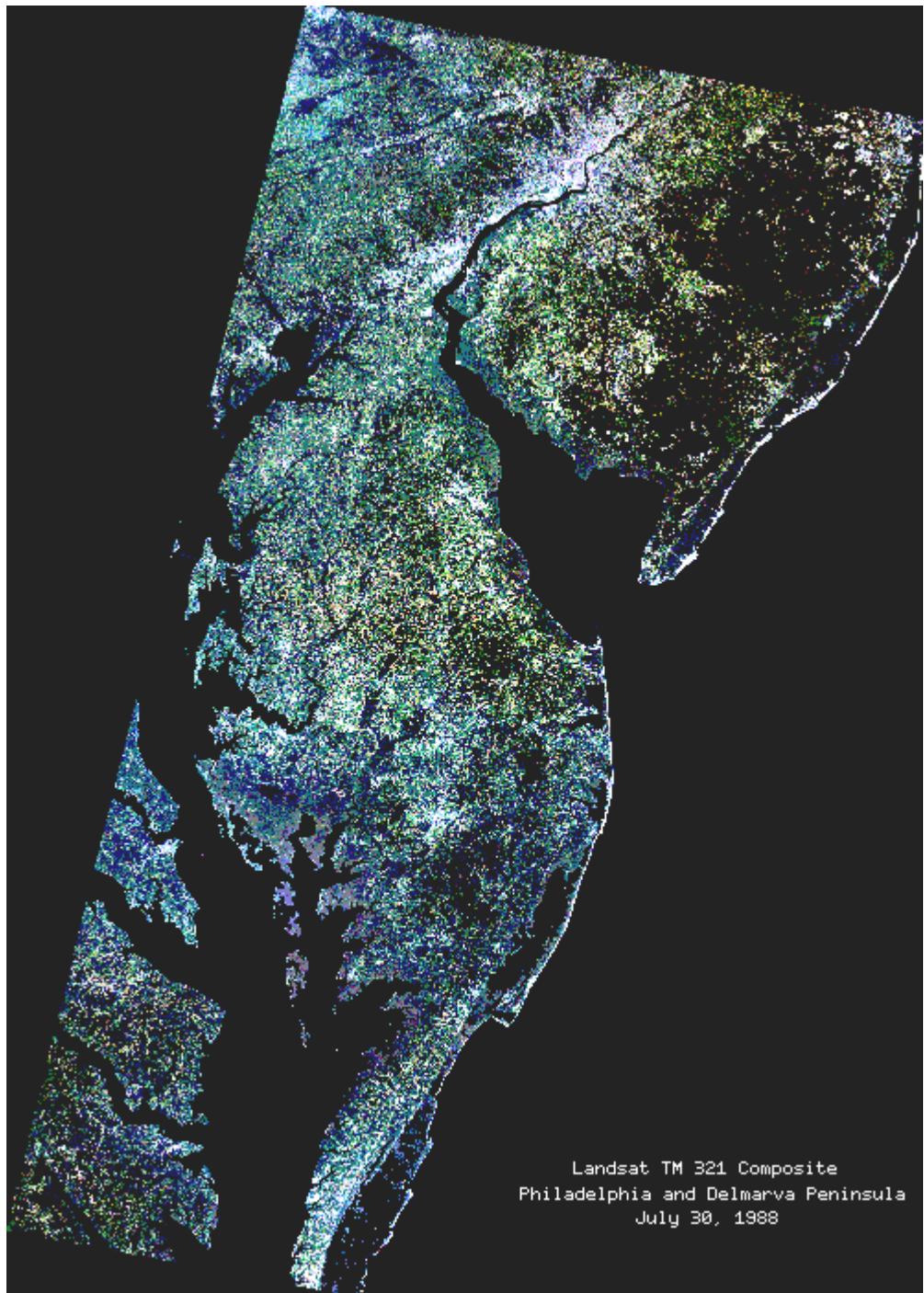


Biomass assessment via
remote sensing

Landsat

SPOT

Hyper-spectral sensors



Landsat TM 321 Composite
Philadelphia and Delmarva Peninsula
July 30, 1988

Landsat: 7 bands

Blue

Green

Red

Near IR

Mid IR 1

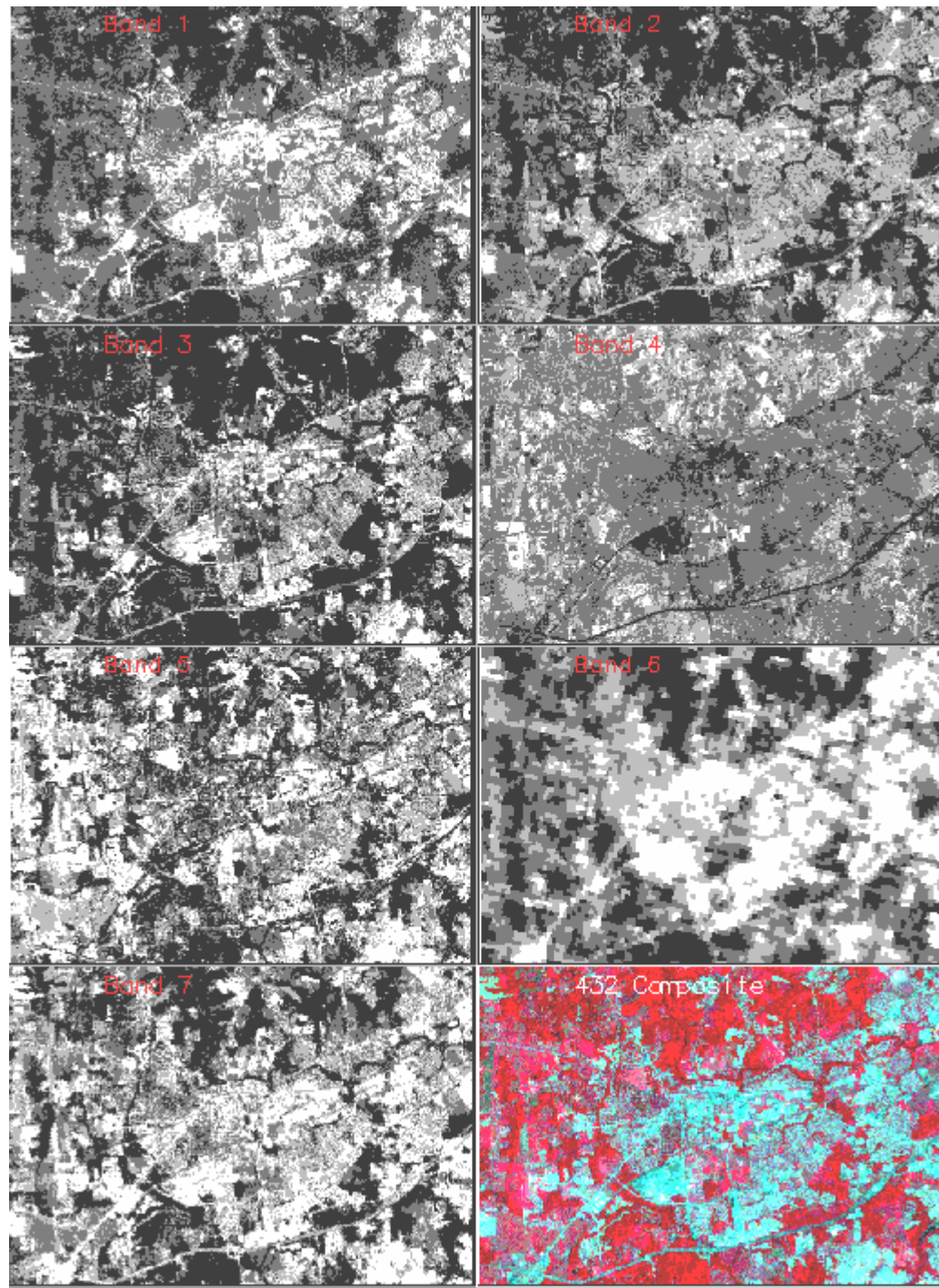
Thermal IR

Mid IR 2

Color-IR composite
indicates biomass
density.

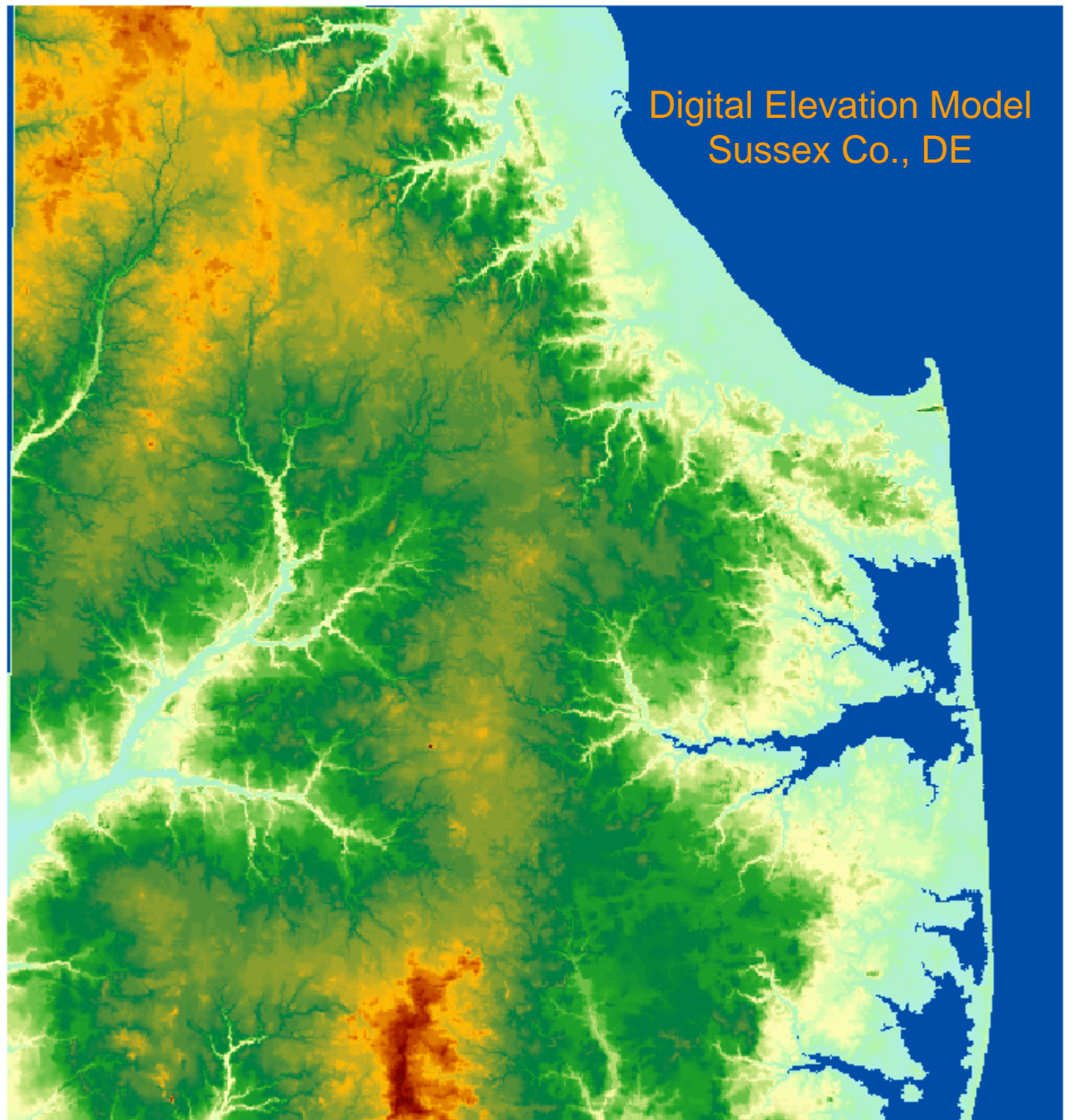
NDVI $(\text{NIR} - \text{red}) / (\text{NIR} + \text{red})$
other density metrics

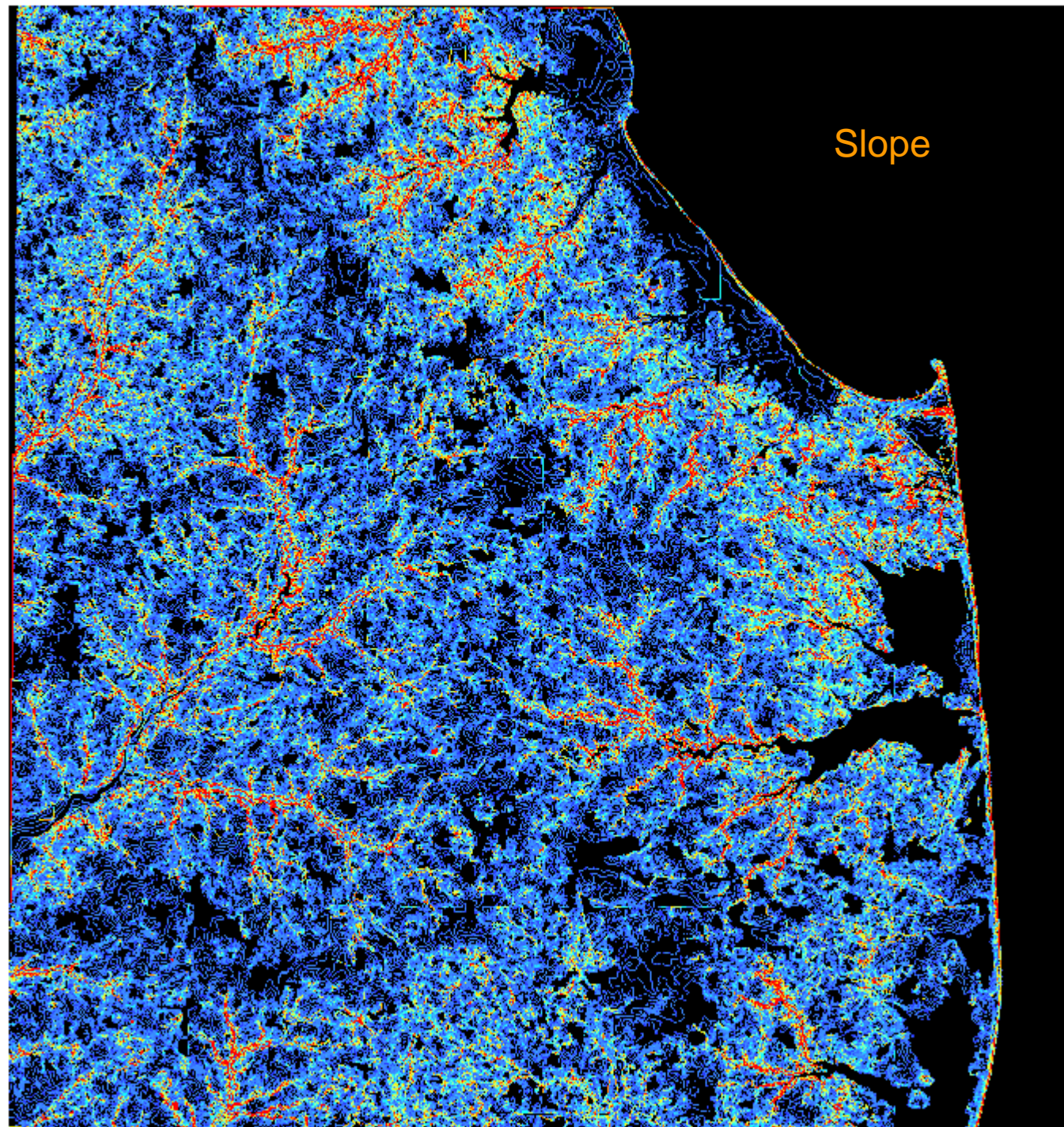
Vegetative roughness
and other neighbor-pixel
analyses



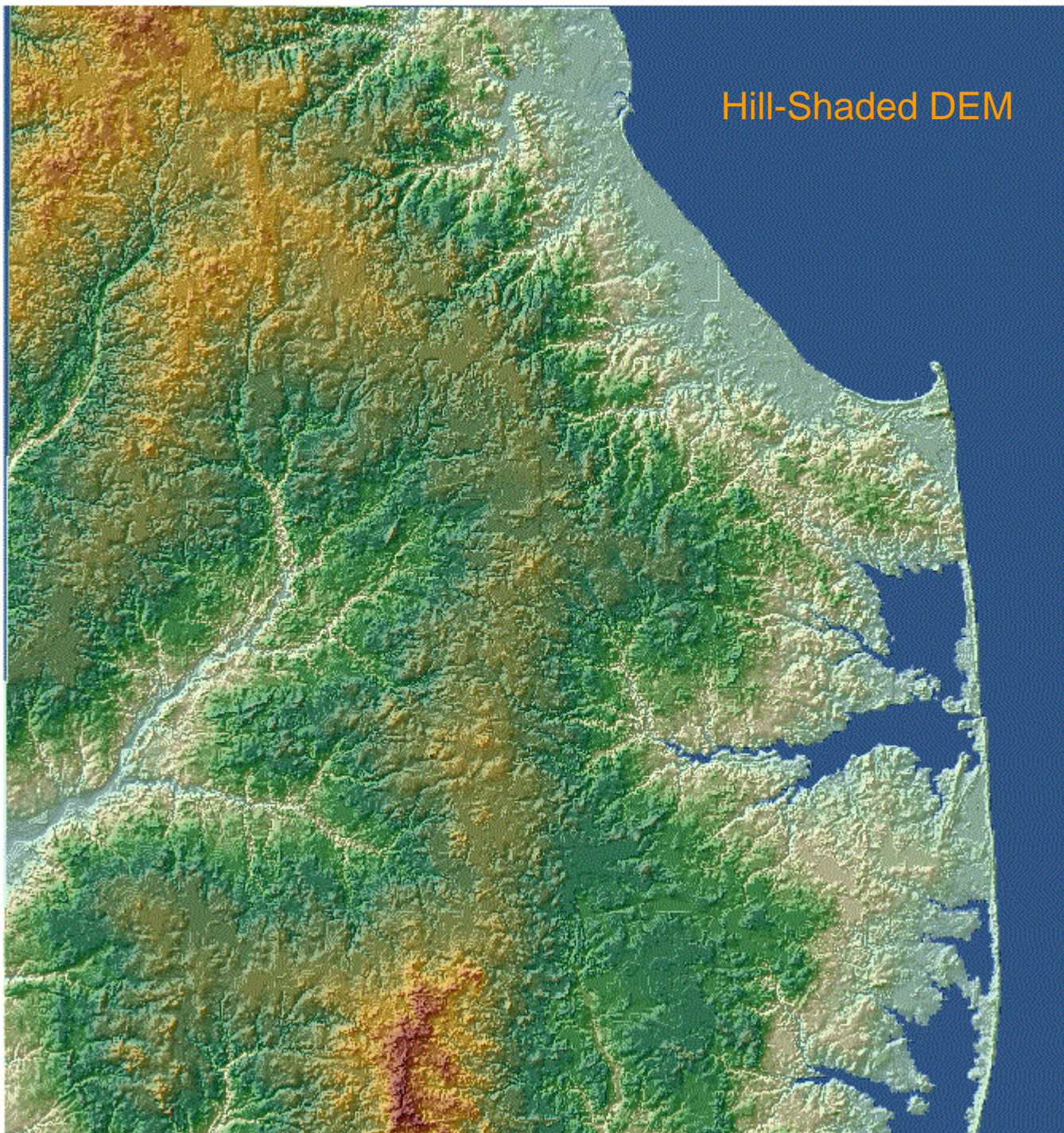
Tracking nutrient
flow across the
landscape

“Think like a pixel”

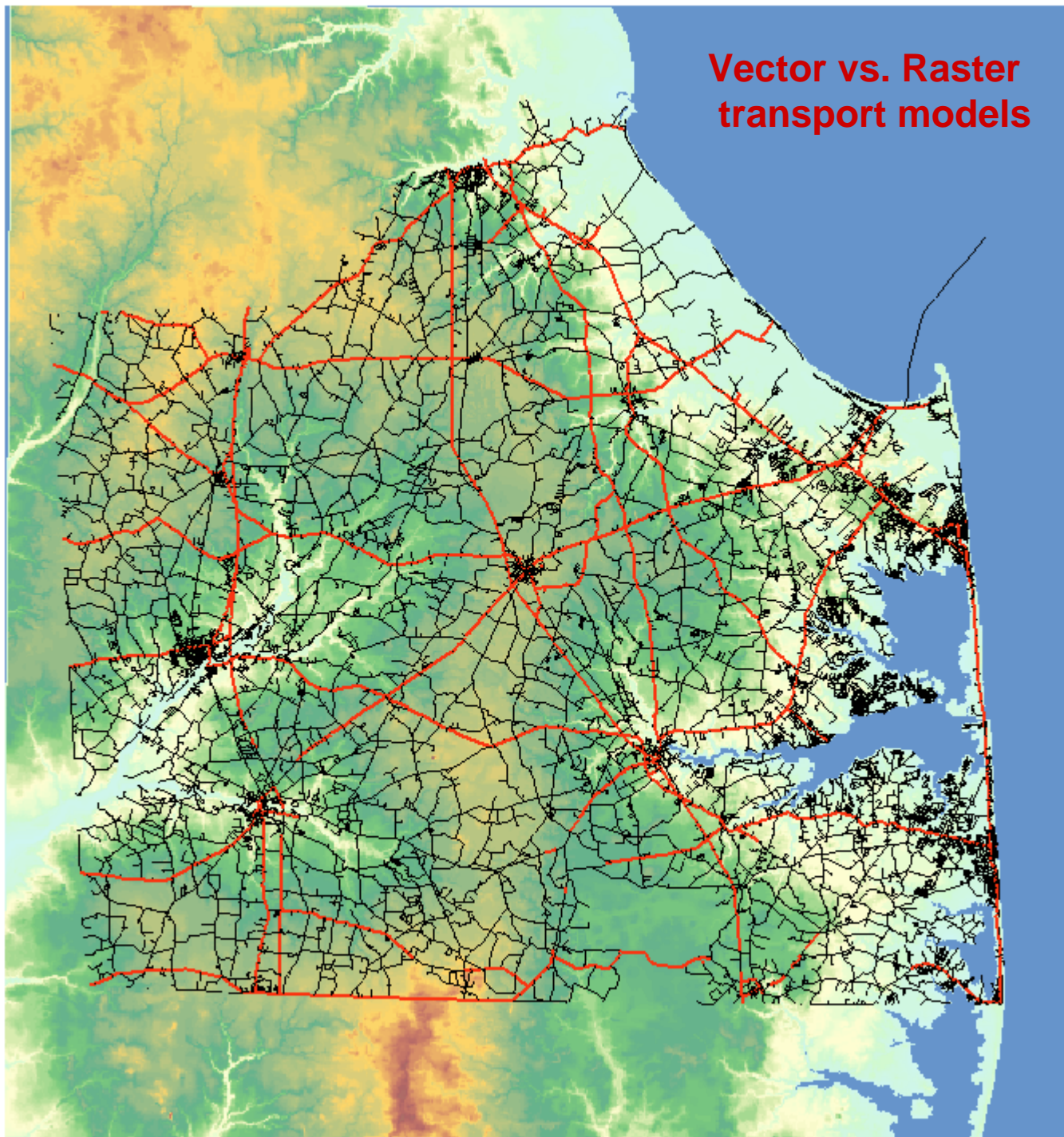




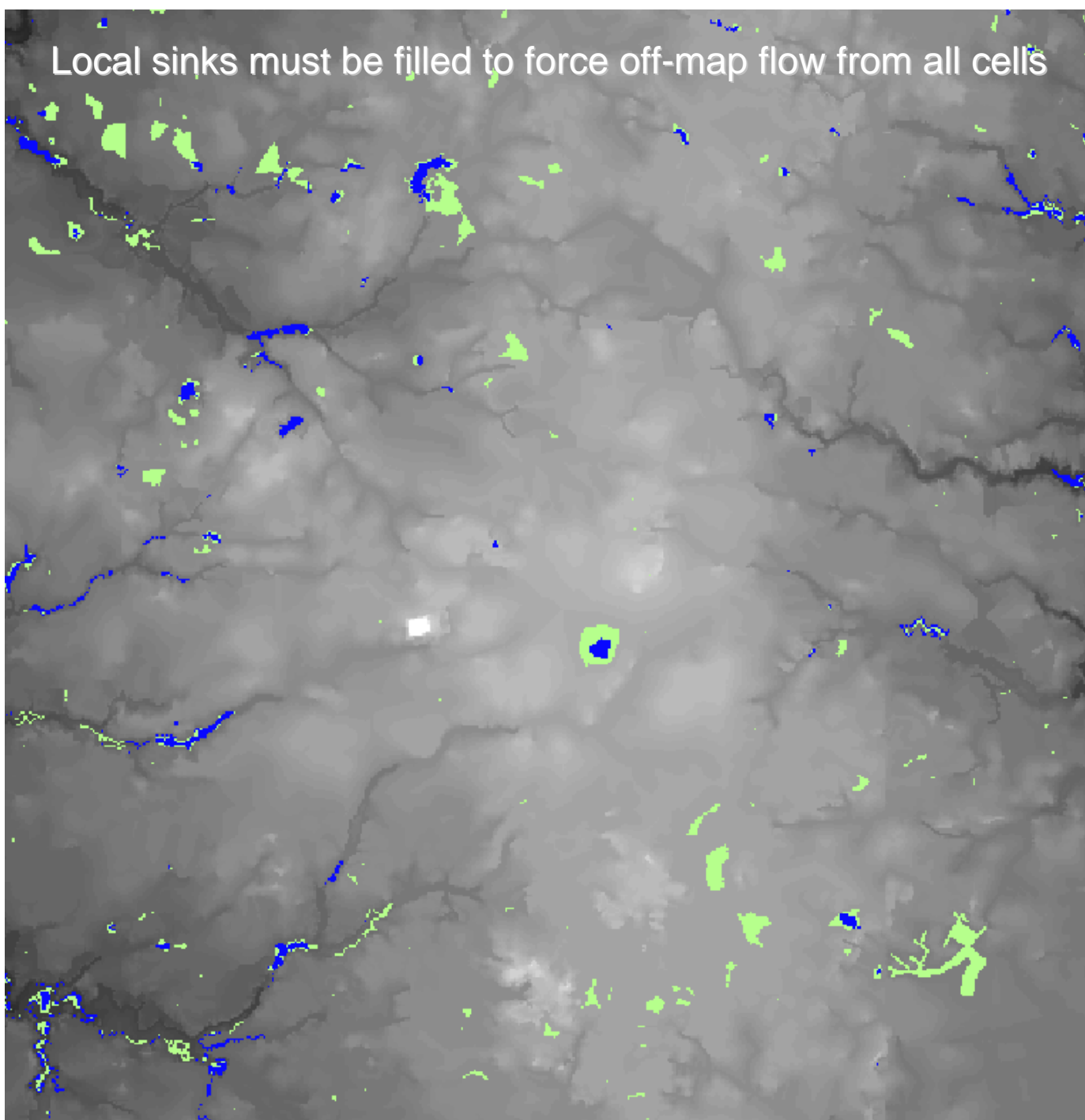
Hill-Shaded DEM



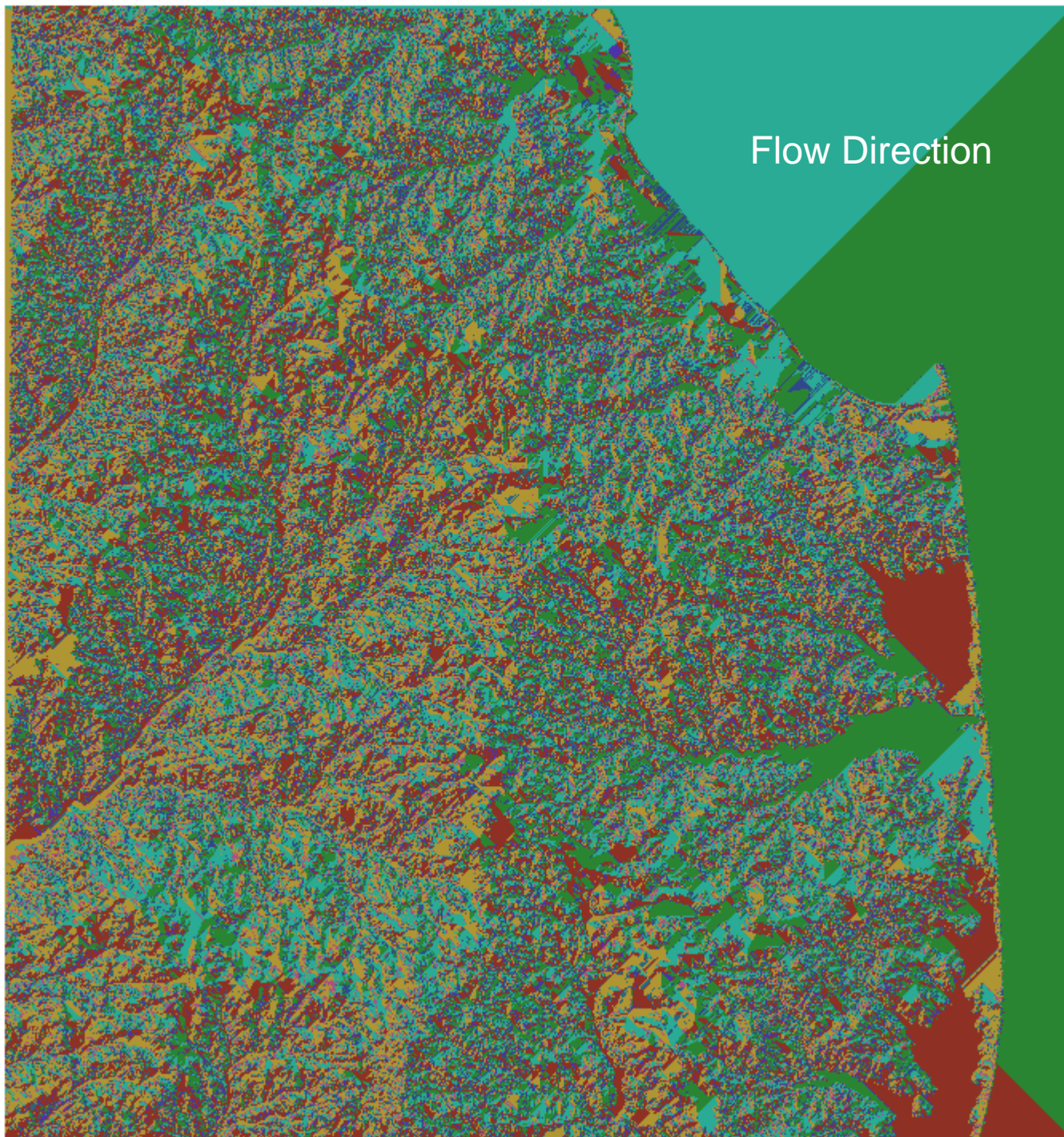
Vector vs. Raster transport models



Local sinks must be filled to force off-map flow from all cells



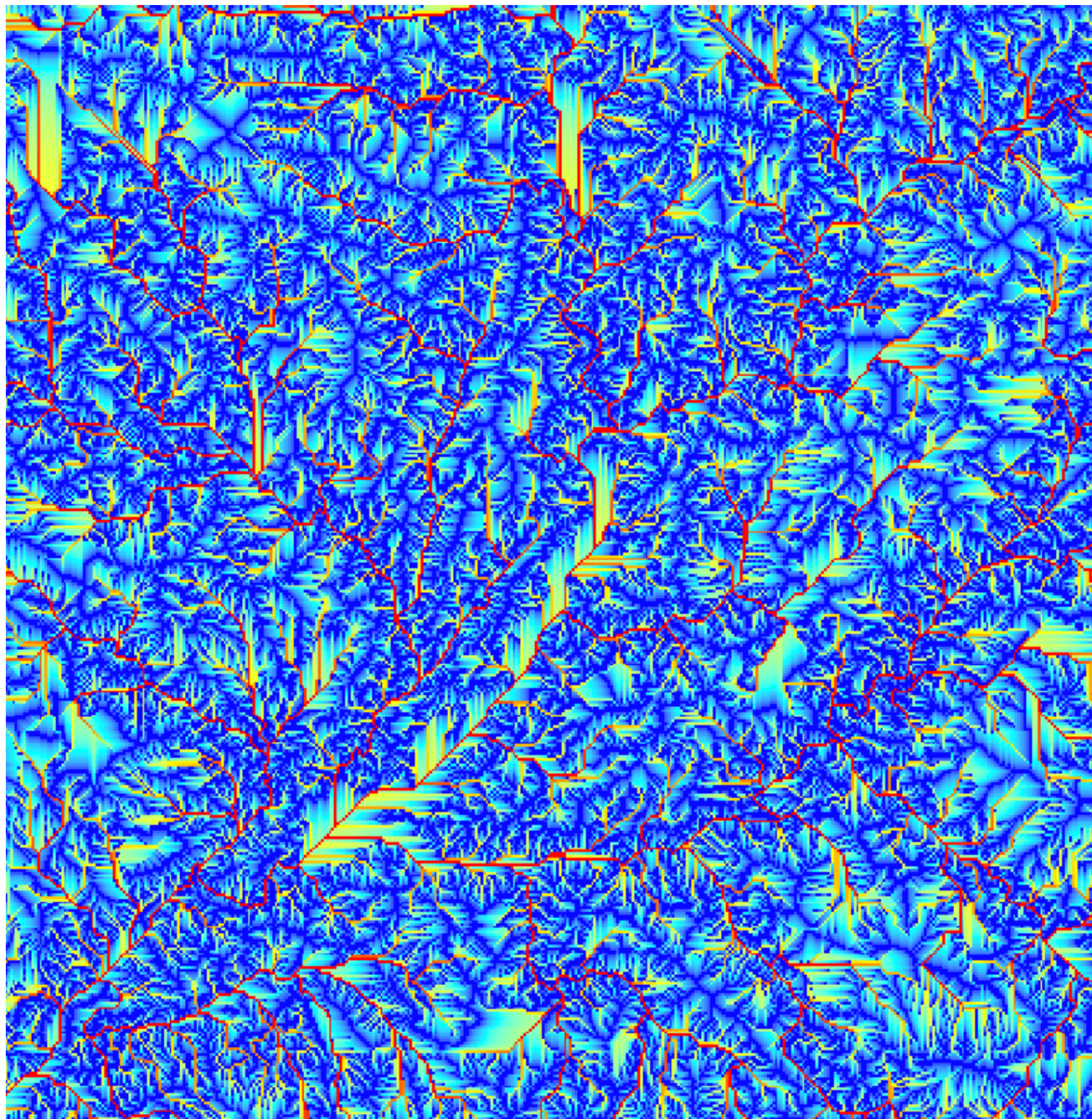
Flow Direction



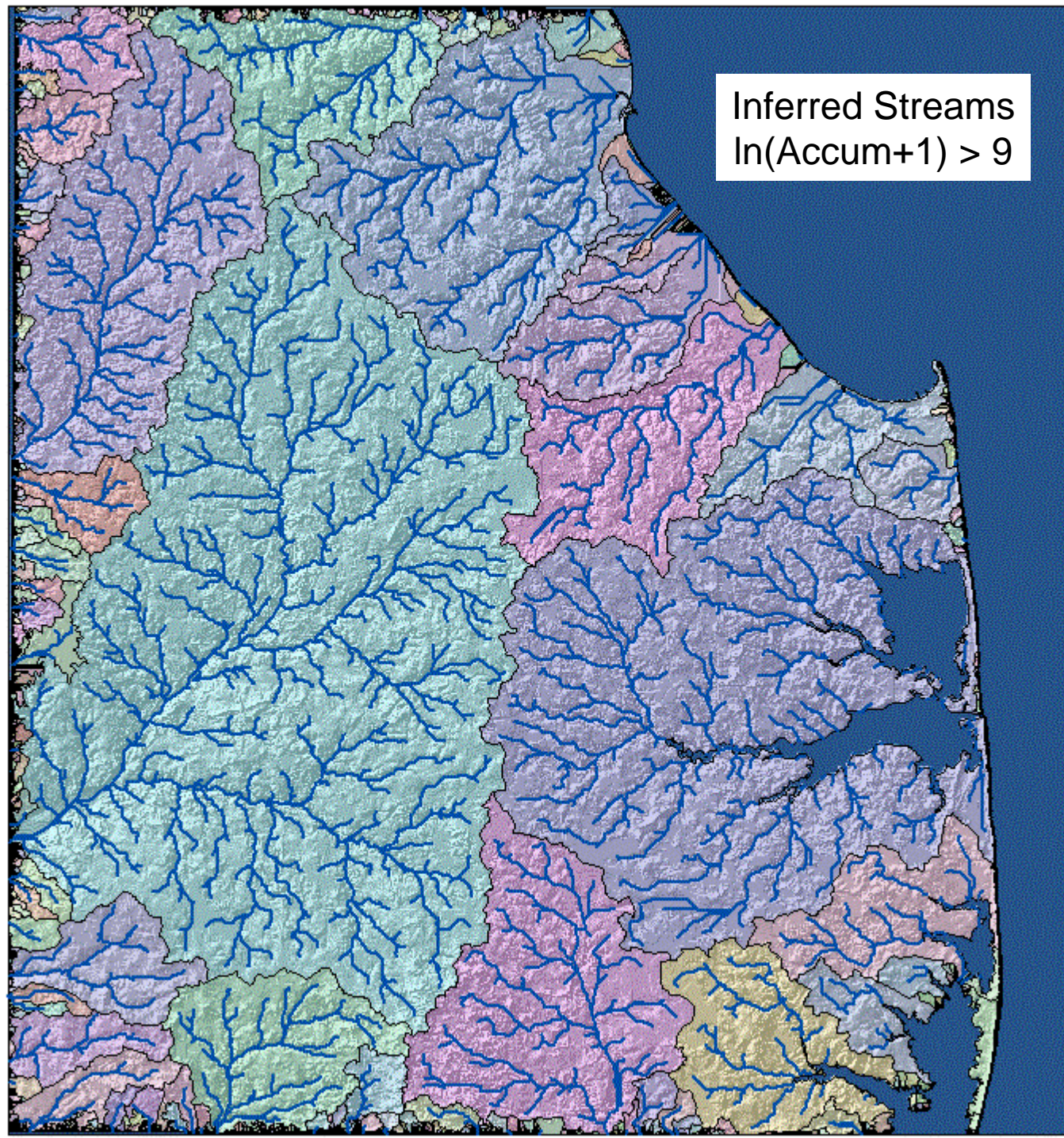
Principal Basins



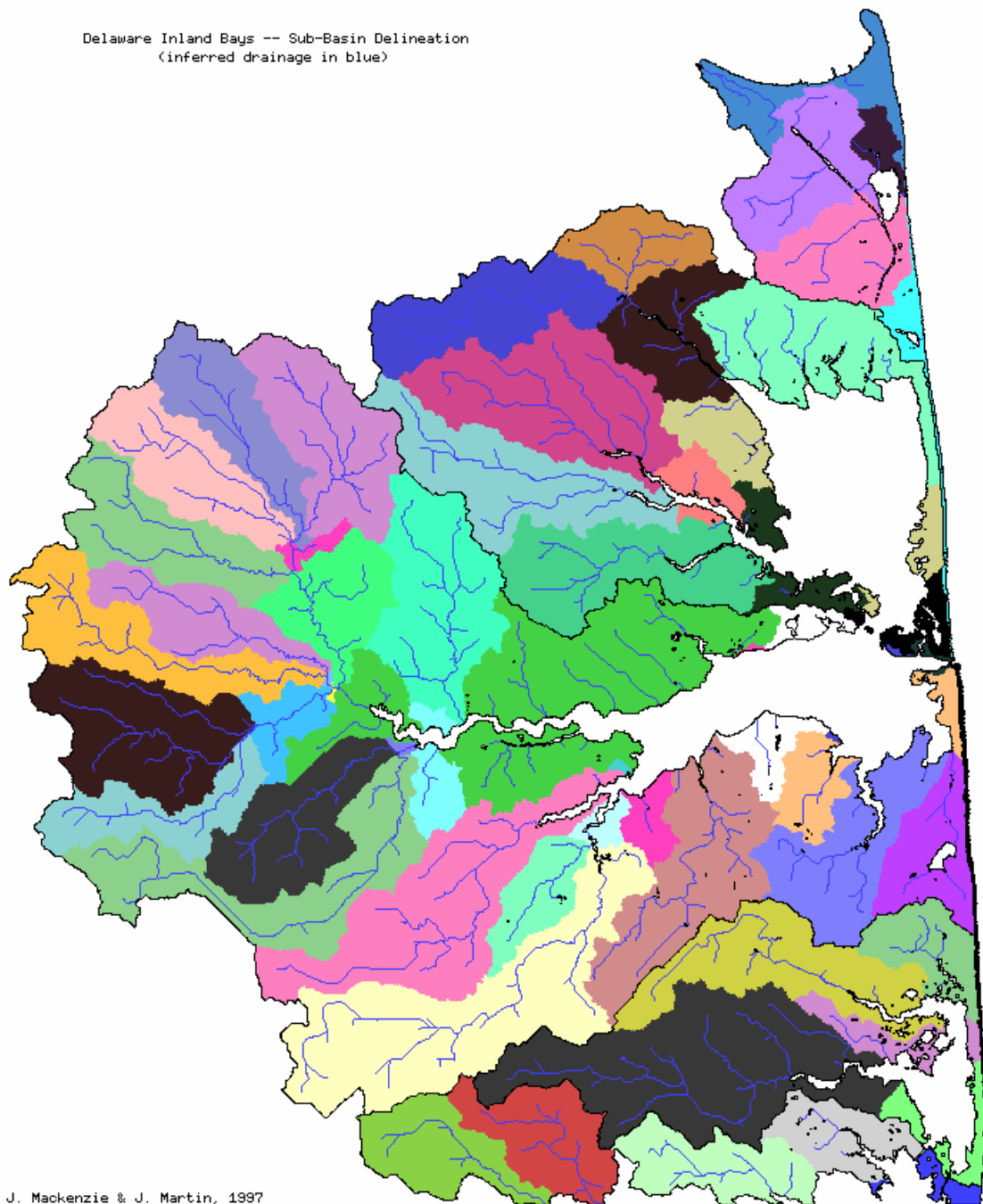
$\text{Ln}(\text{Accumulation}+1)$



Inferred Streams
 $\ln(\text{Accum}+1) > 9$



Delaware Inland Bays -- Sub-Basin Delineation
(inferred drainage in blue)



J. Mackenzie & J. Martin, 1997



- residential
- commercial
- industrial
- other urbanized
- agriculture
- brushland
- deciduous forest
- coniferous forest
- mixed forest
- clear-cut forest
- water
- wetlands
- barren

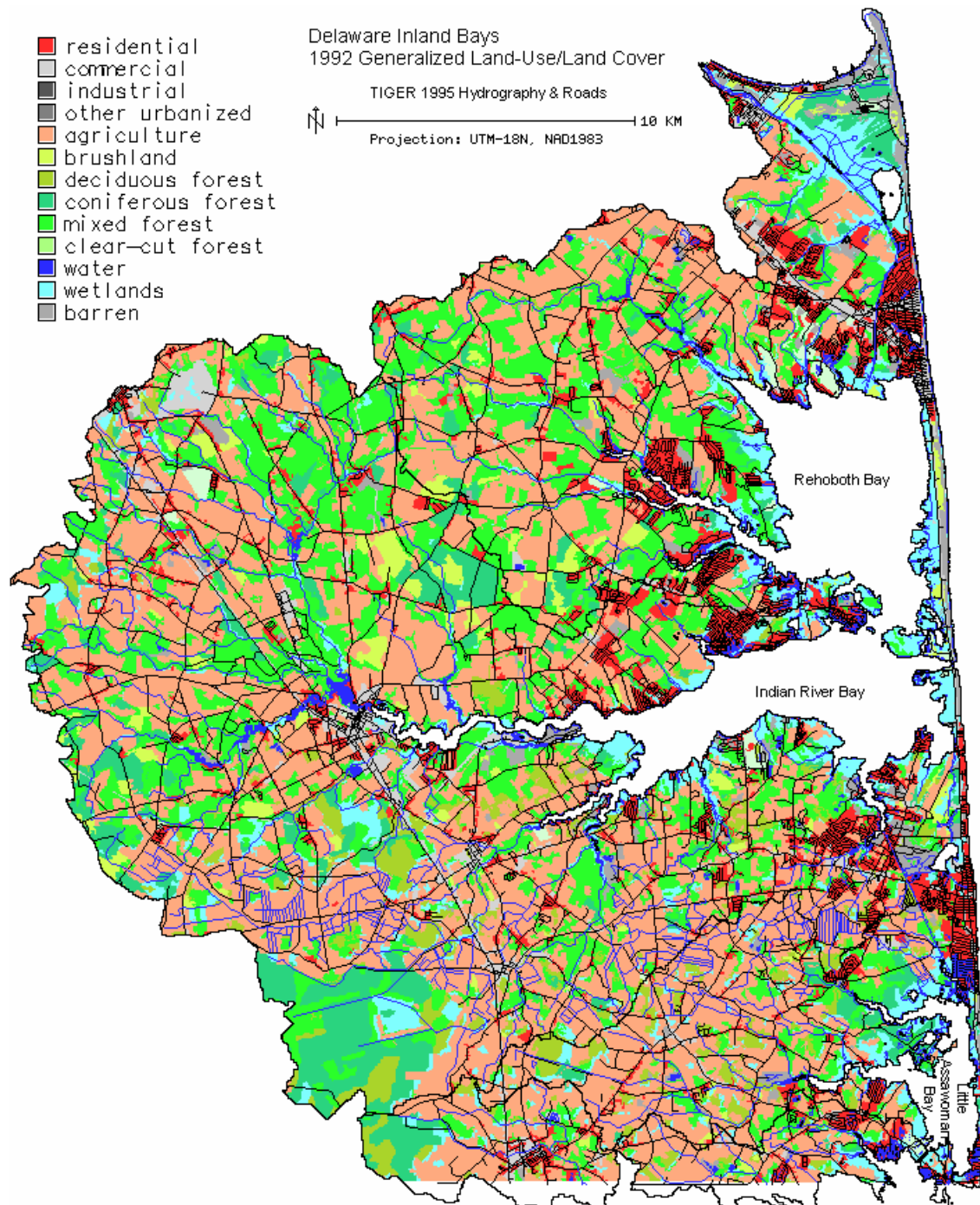
Delaware Inland Bays
1992 Generalized Land-Use/Land Cover

TIGER 1995 Hydrography & Roads

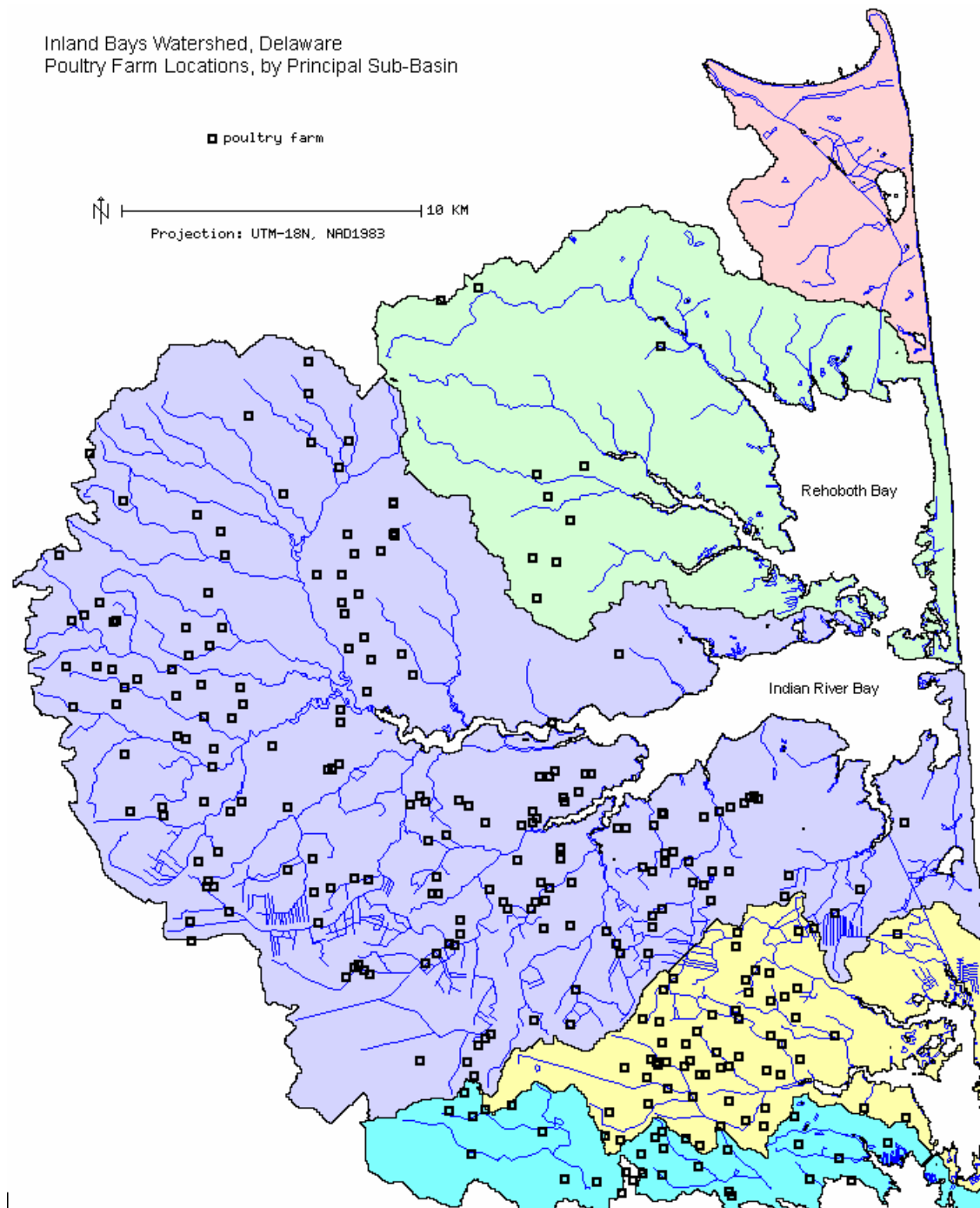


Projection: UTM-18N, NAD1983

10 KM



Inland Bays Watershed, Delaware
Poultry Farm Locations, by Principal Sub-Basin

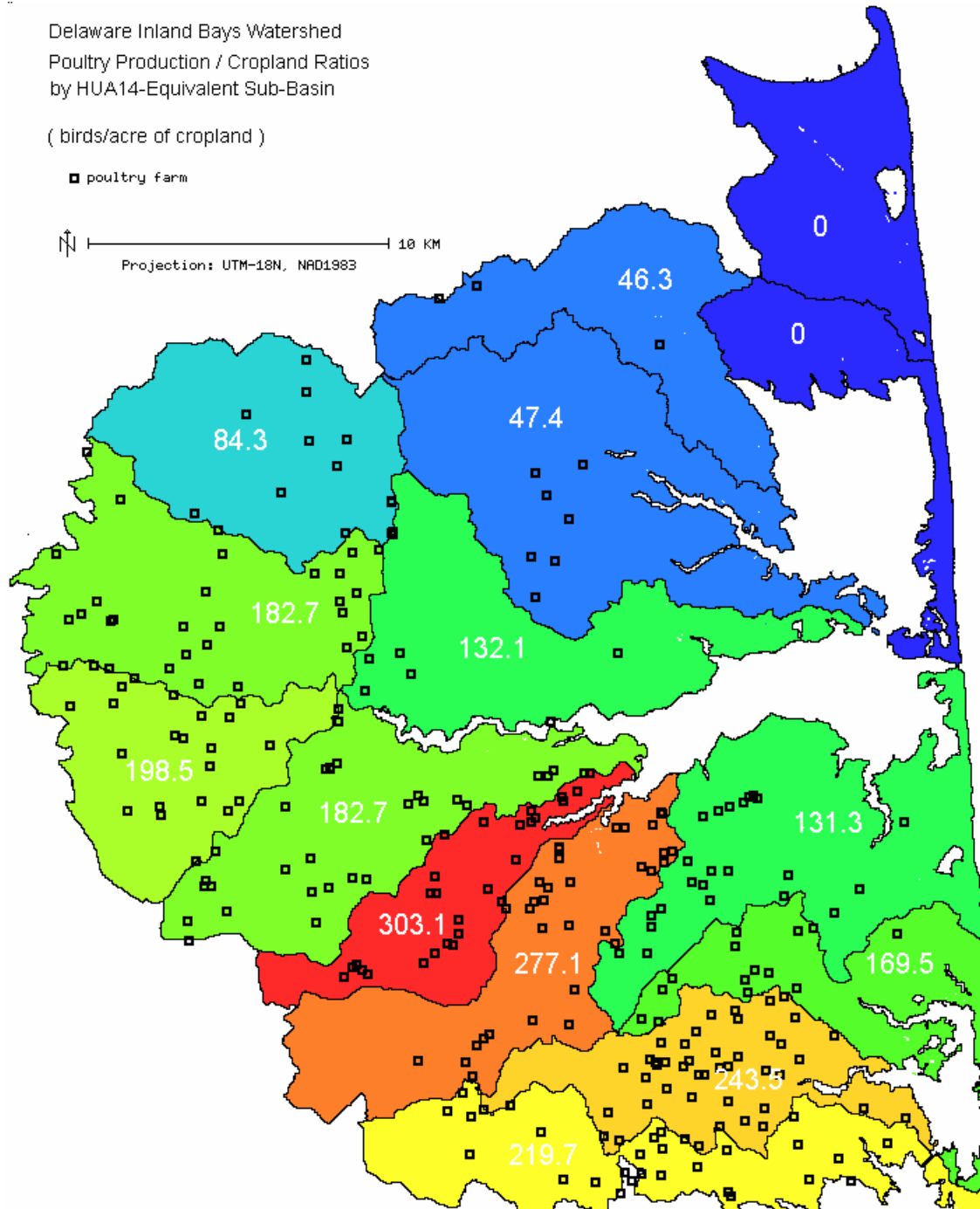


Delaware Inland Bays Watershed
Poultry Production / Cropland Ratios
by HUA14-Equivalent Sub-Basin

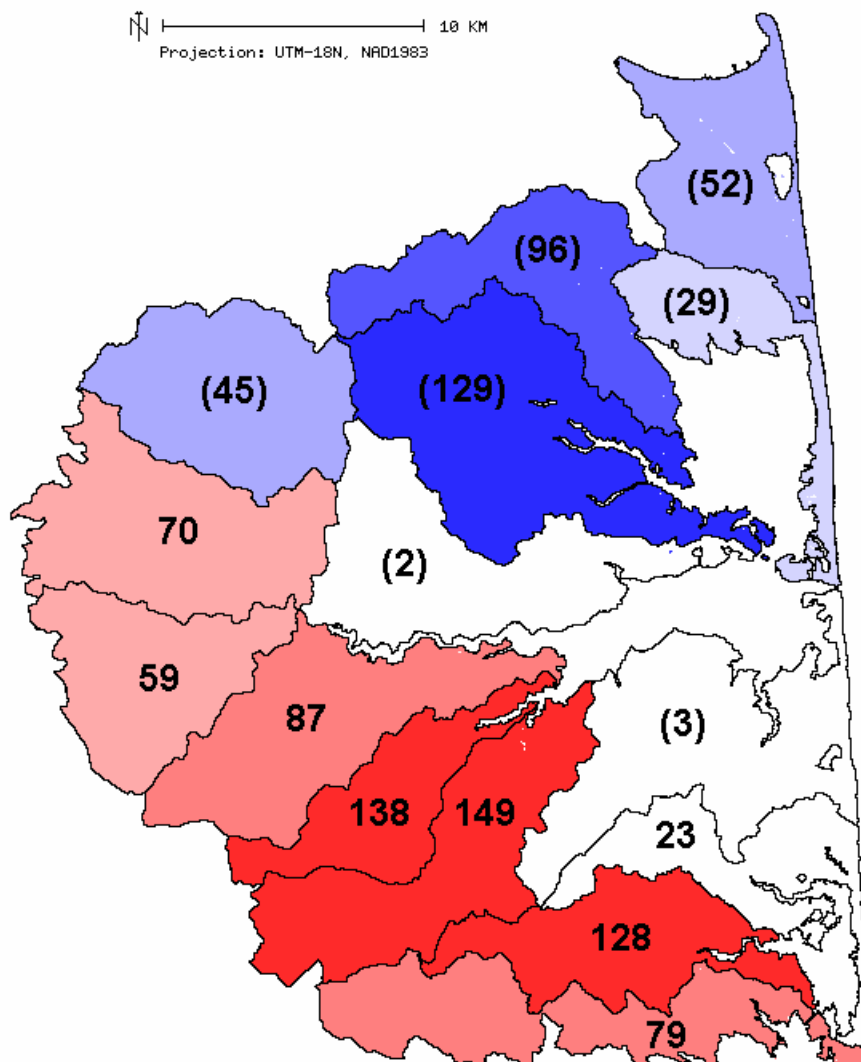
(birds/acre of cropland)

■ poultry farm

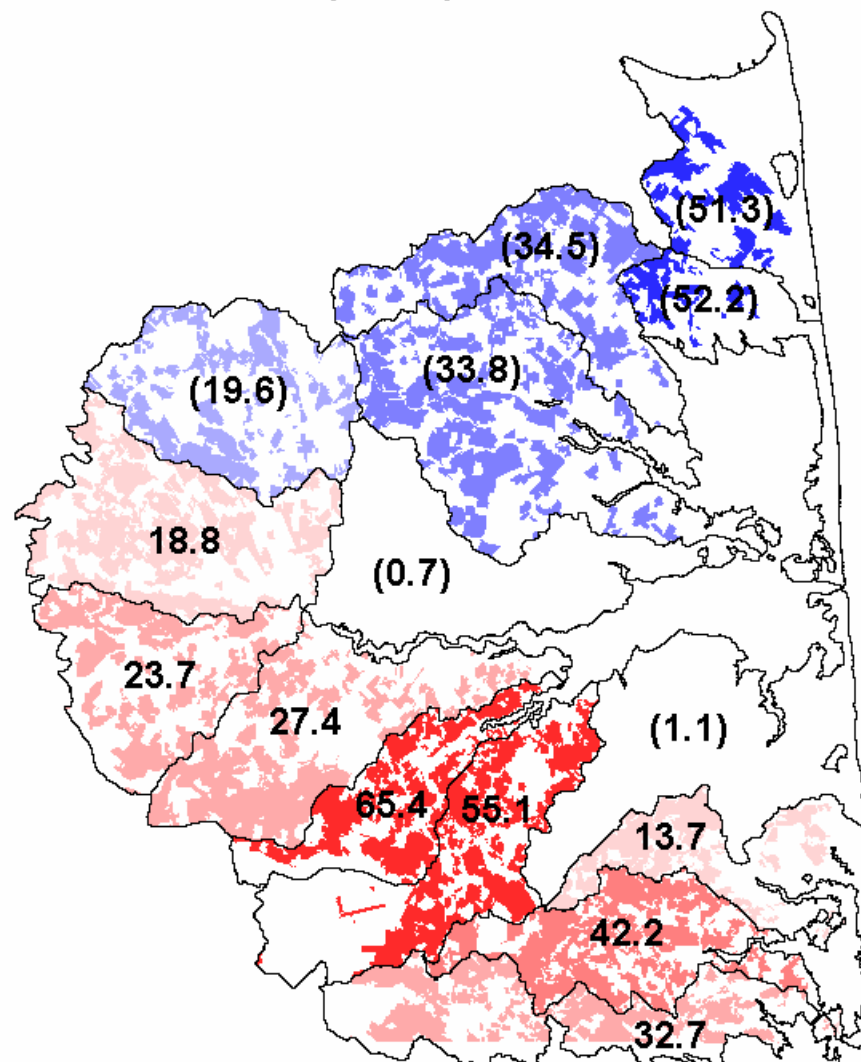
10 KM
Projection: UTM-18N, NAD1983




**Aggregate Agricultural Nutrient Surplus/Deficit,
Inland Bays, by Sub-Basin -- NITROGEN (Tons)**



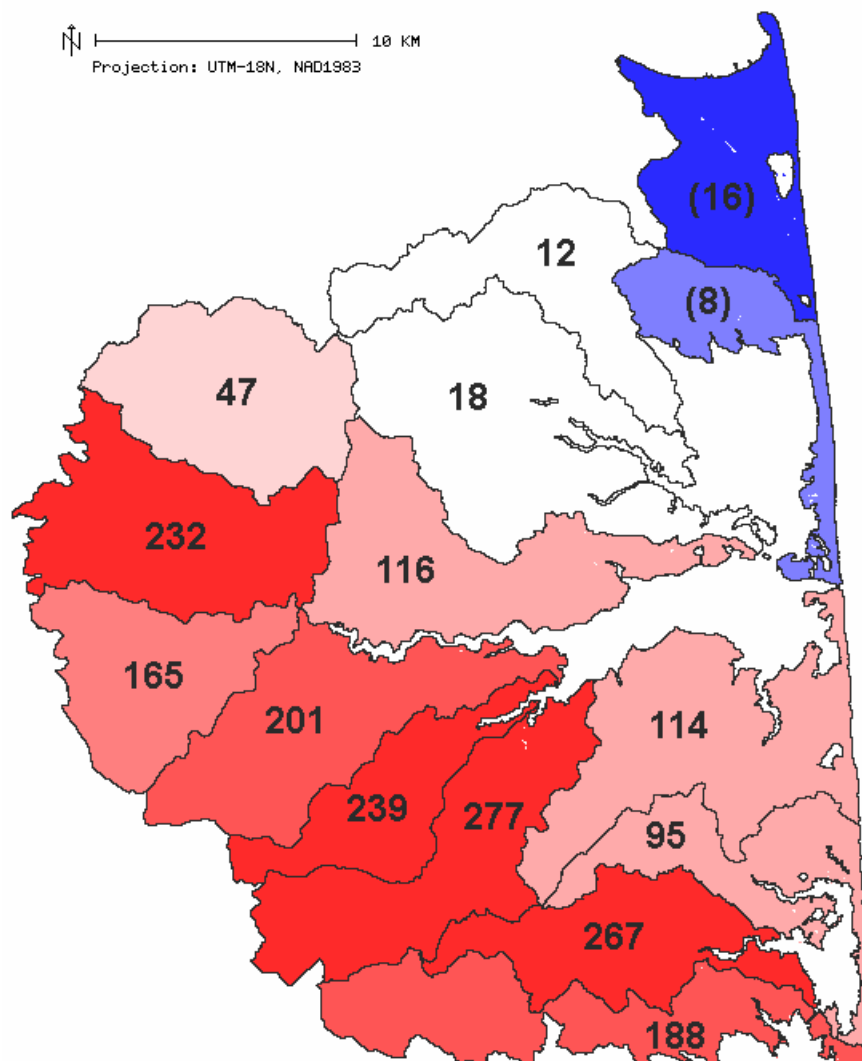
**Agricultural Nutrient Surplus/Deficit
Inland Bays, by Sub-Basin -- NITROGEN
Pounds per Cropland Acre**



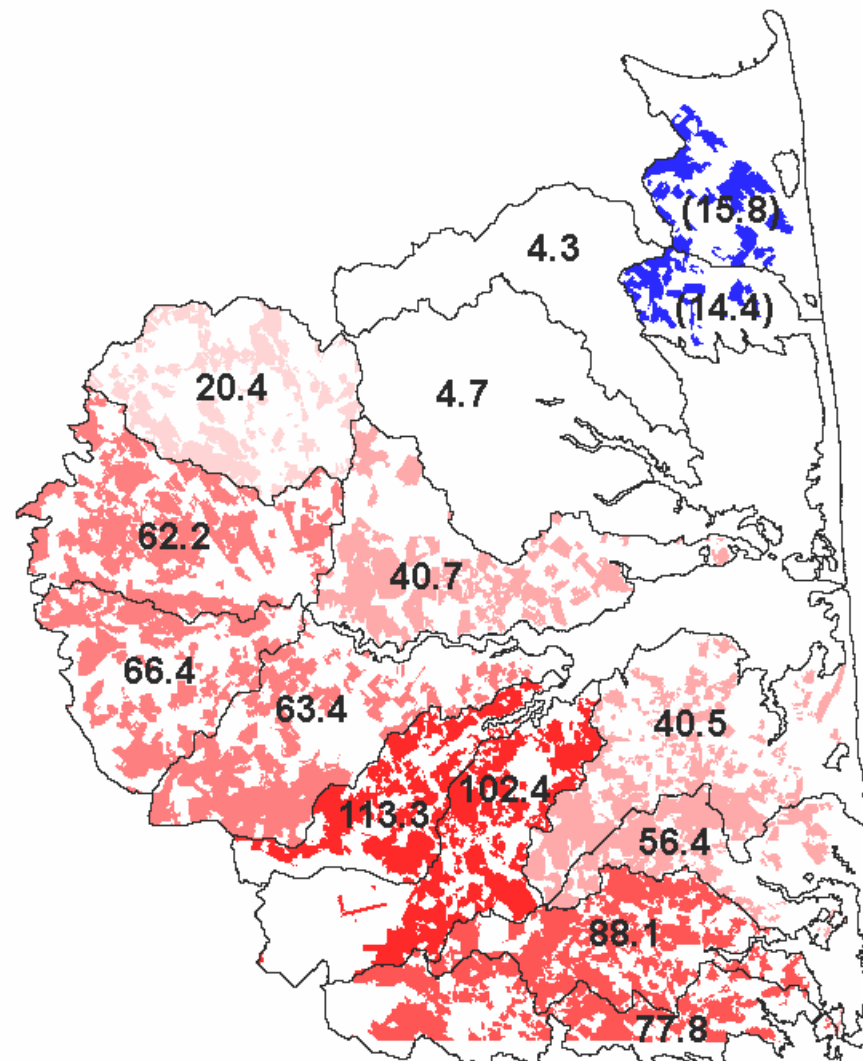
**Aggregate Agricultural Nutrient Surplus/Deficit,
Inland Bays, by Sub-Basin -- PHOSPHORUS (Tons)**



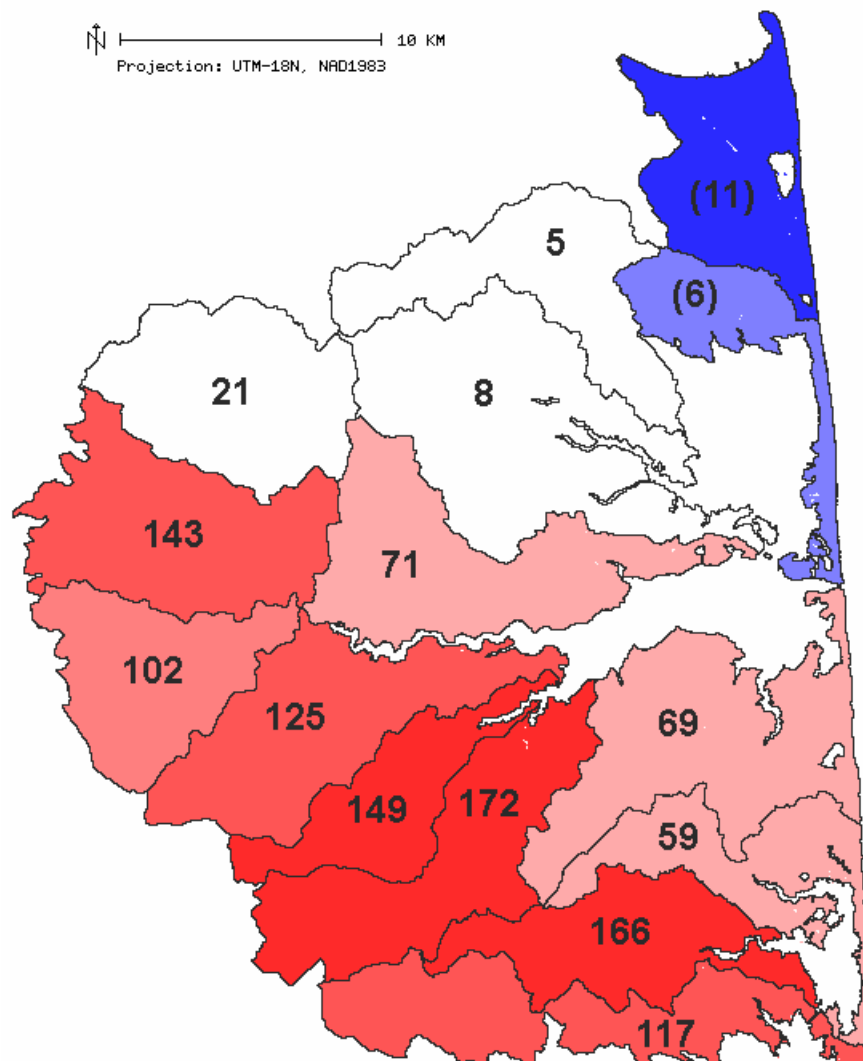
 Projection: UTM-18N, NAD1983



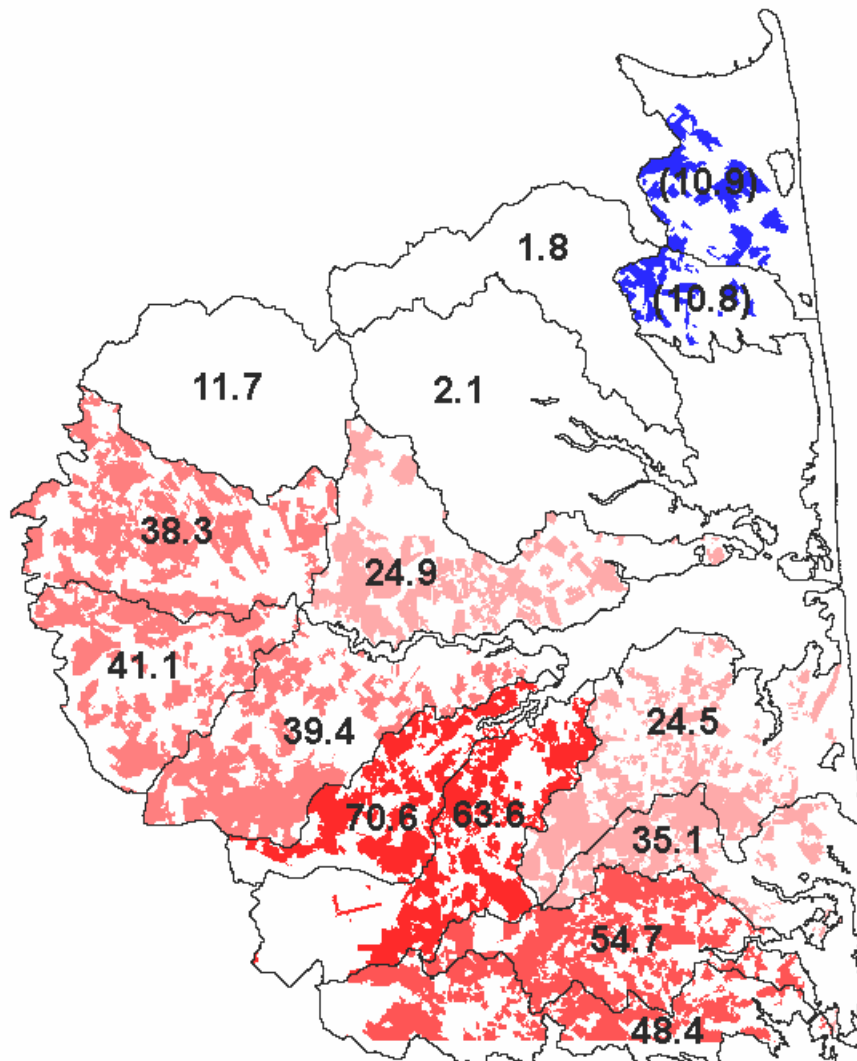
**Agricultural Nutrient Surplus/Deficit
Inland Bays, by Sub-Basin -- PHOSPHORUS
Pounds per Cropland Acre**



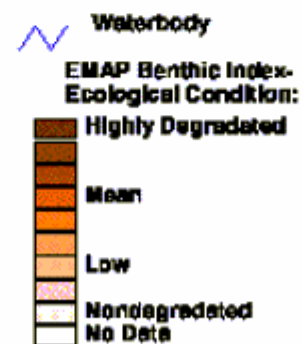
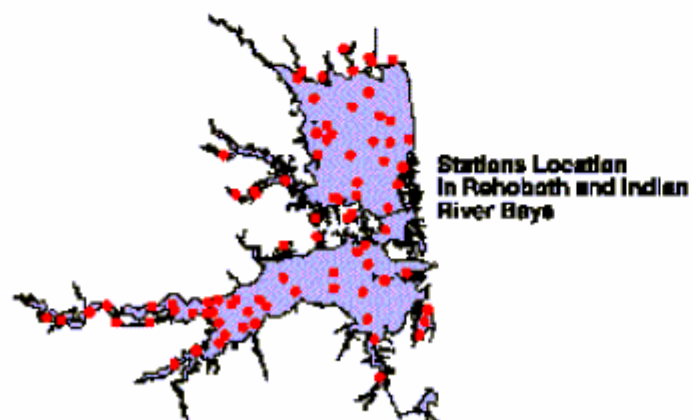
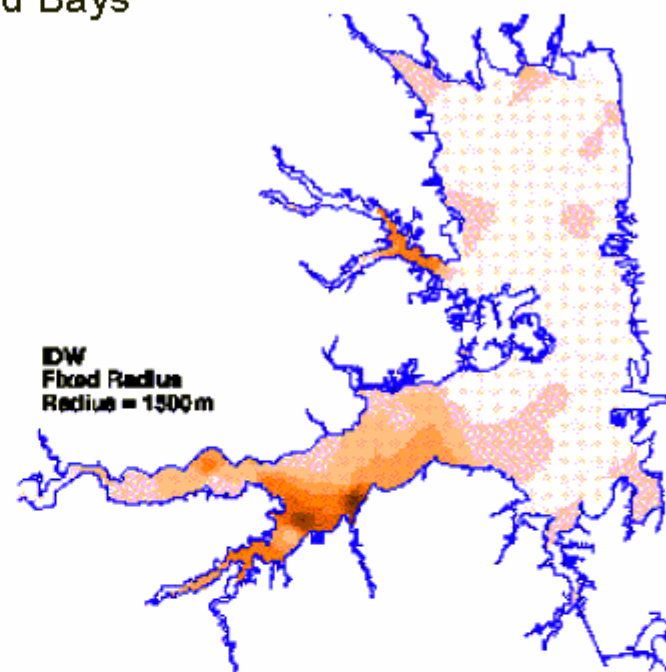
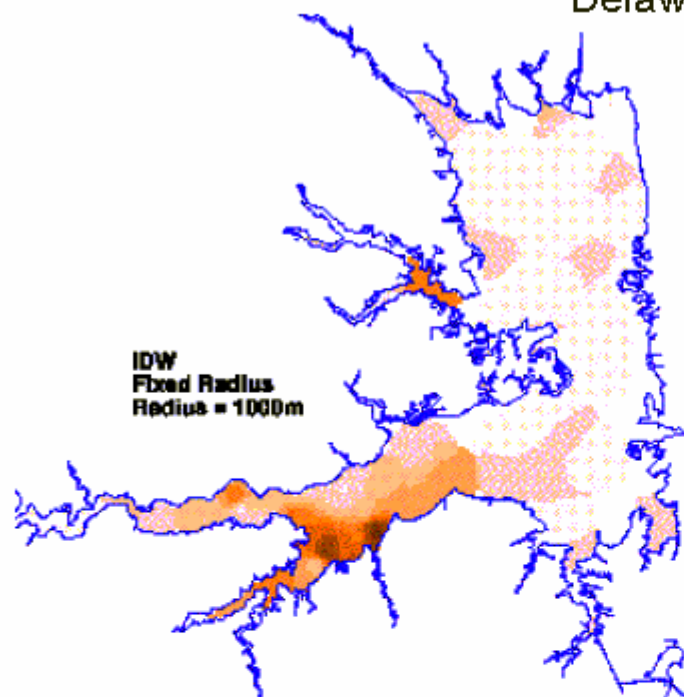
**Aggregate Agricultural Nutrient Surplus/Deficit,
Inland Bays, by Sub-Basin -- POTASSIUM (Tons)**



**Agricultural Nutrient Surplus/Deficit
Inland Bays, by Sub-Basin -- POTASSIUM
Pounds per Cropland Acre**



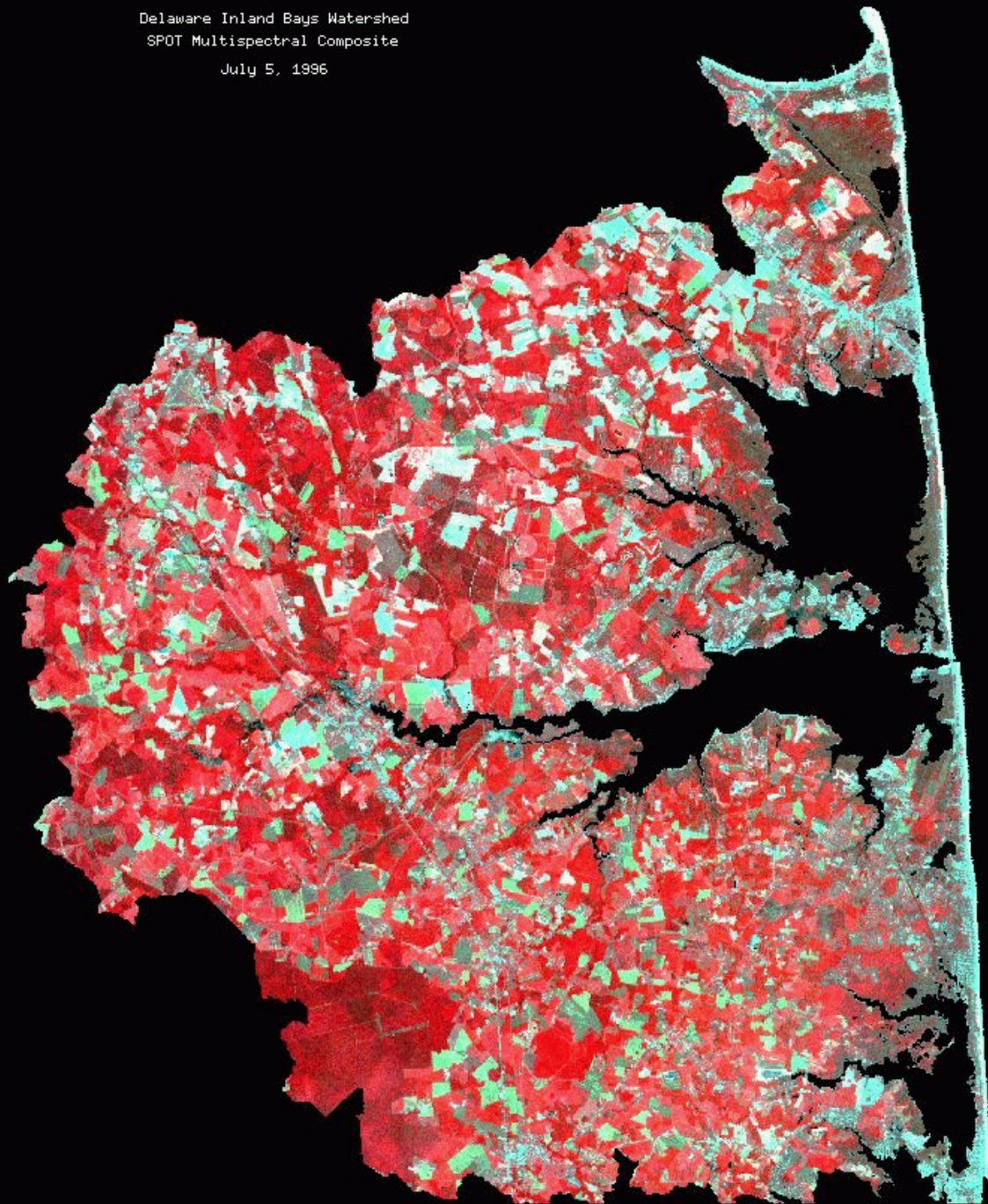
Benthic Index, IDW Interpolation at 1,000- and 1,500-Meter Radii Delaware Inland Bays



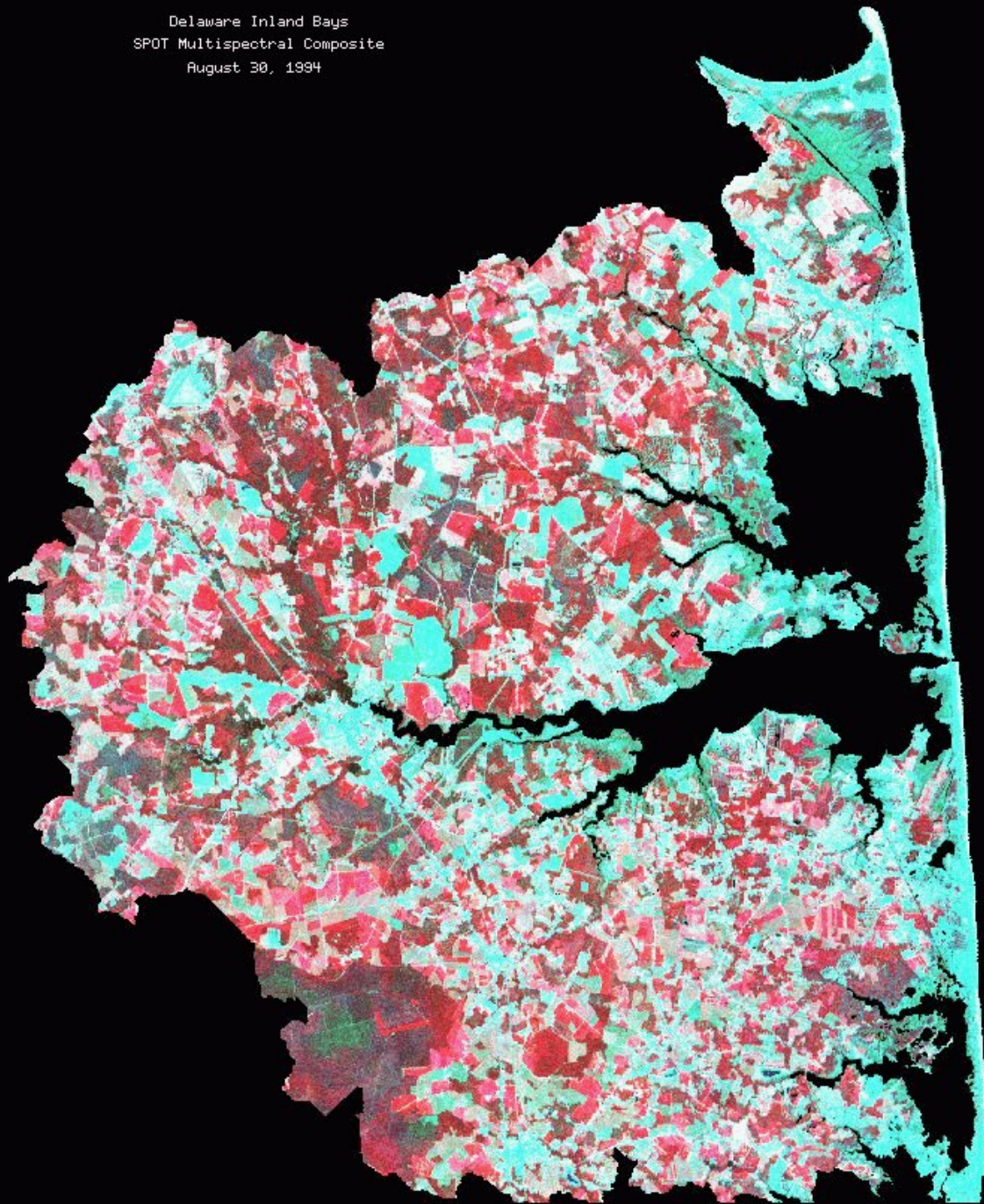
Pintea, 1998

Delaware Inland Bays Watershed
SPOT Multispectral Composite

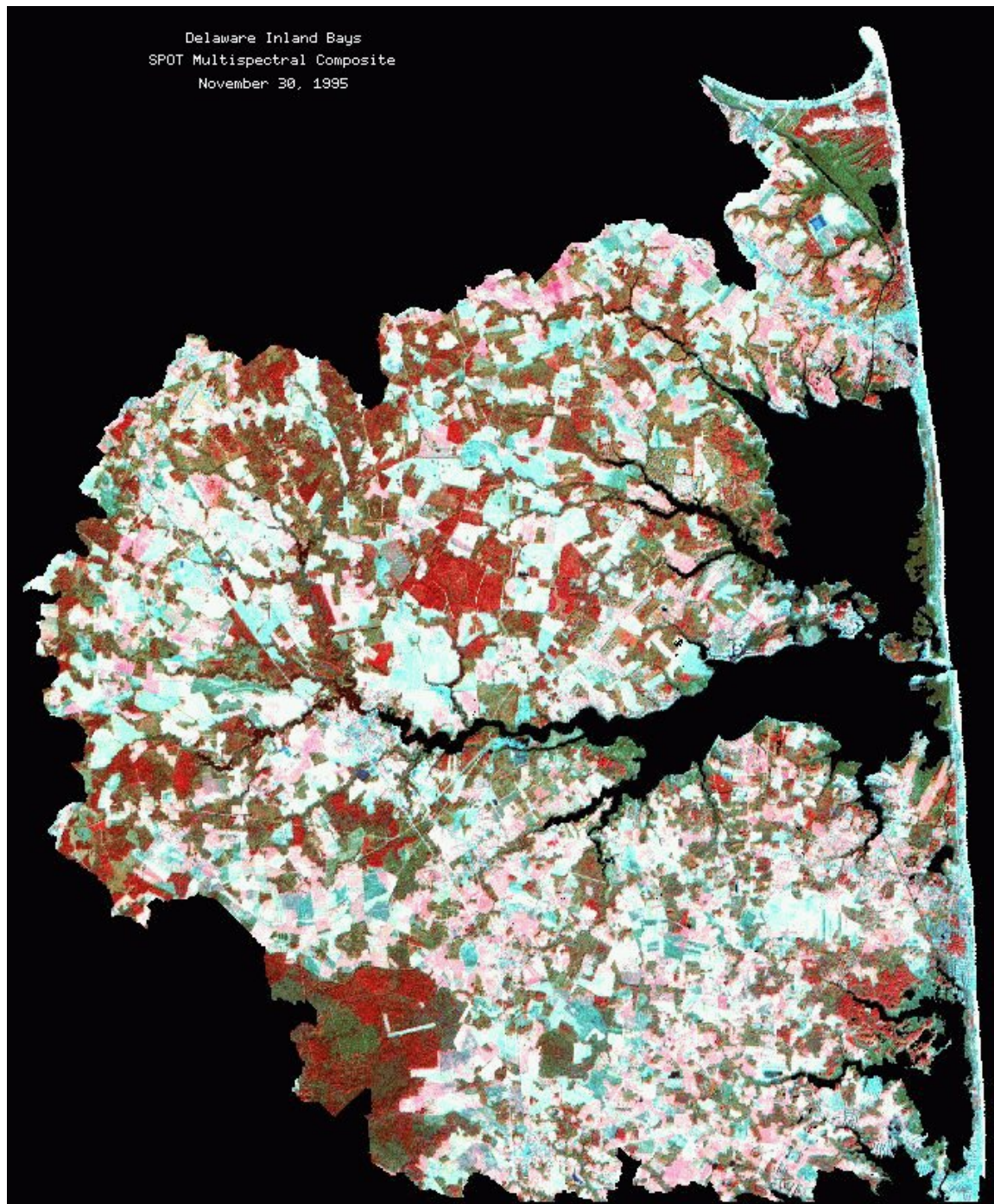
July 5, 1996



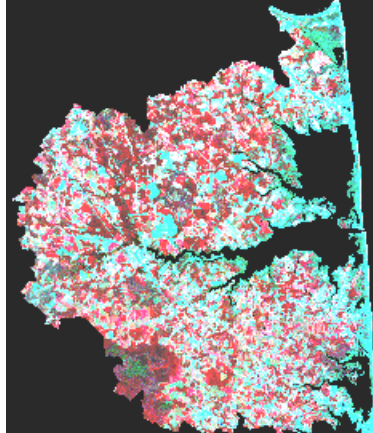
Delaware Inland Bays
SPOT Multispectral Composite
August 30, 1994



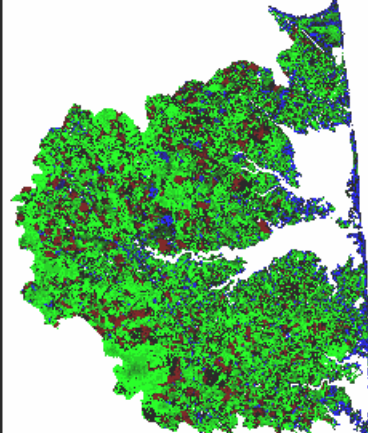
Delaware Inland Bays
SPOT Multispectral Composite
November 30, 1995



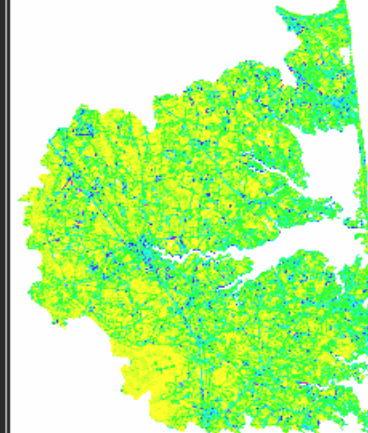
SPOT HRV Composite, Aug 30, 1994



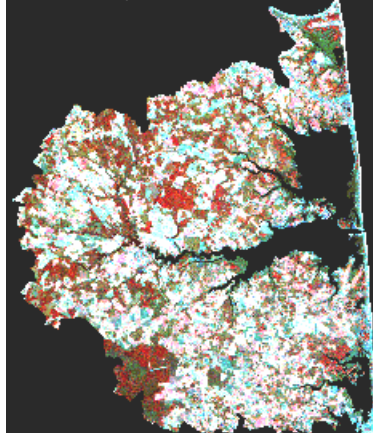
NDVI, Aug 30, 1994



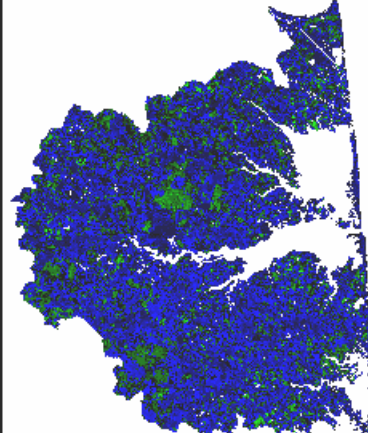
Vegetation Texture, Aug 30, 1994



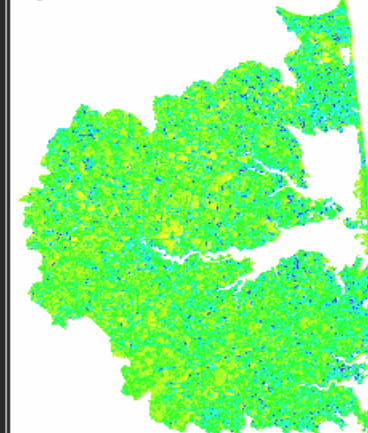
SPOT HRV Composite, Nov 30, 1995



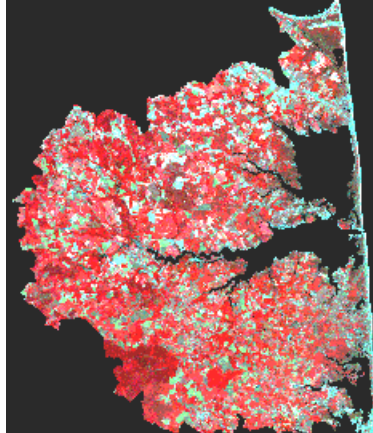
NDVI, Nov 30, 1995



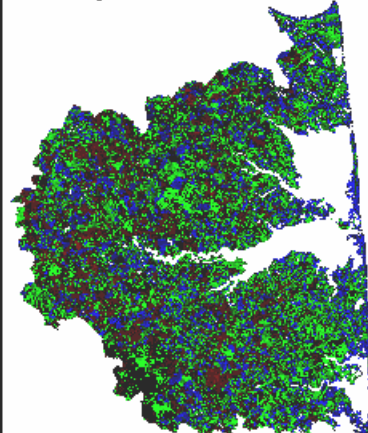
Vegetation Texture, Nov 30, 1995



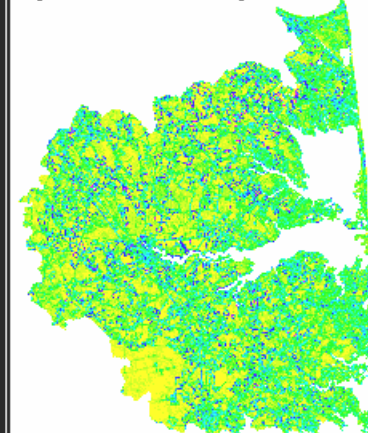
SPOT HRV Composite, July 5, 1996



NDVI, July 5, 1996



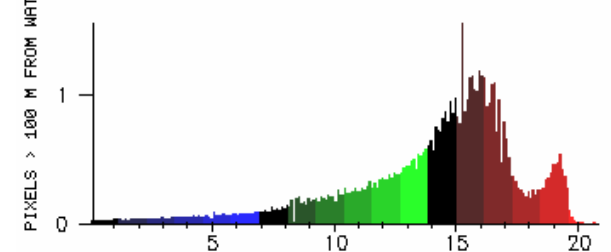
Vegetation Texture, July 5, 1996



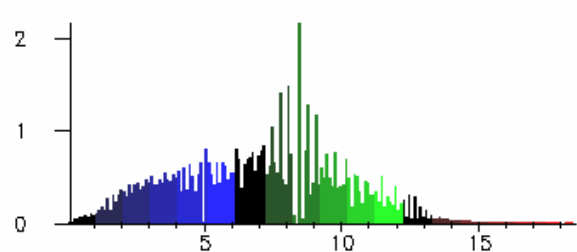
ib.ndvi94 August 30, 1994

ib.ndvi95 November 30, 1995

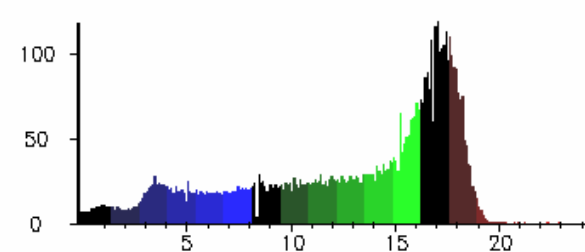
ib.ndvi96 July 5, 1996



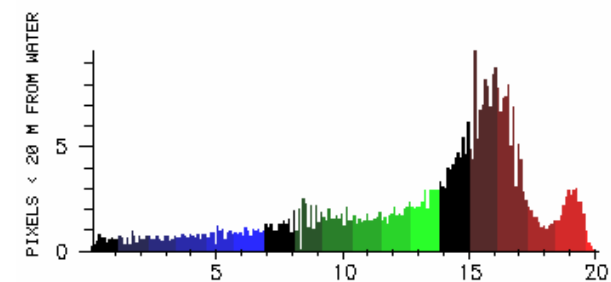
X-AXIS: Category Values in tens
Y-AXIS: Number of cells in hundreds of thousands



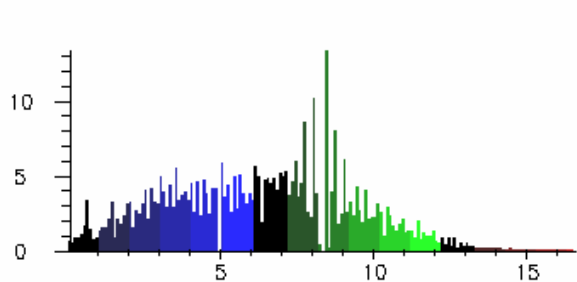
X-AXIS: Category Values in tens
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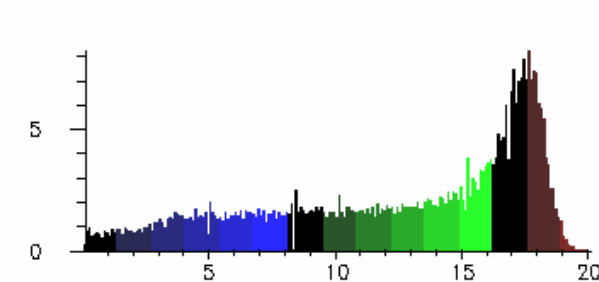
X-AXIS: Category Values in tens
Y-AXIS: Number of cells in thousands



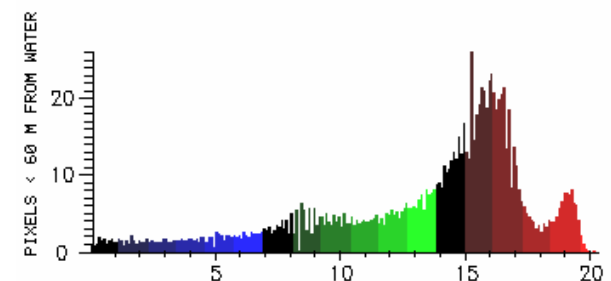
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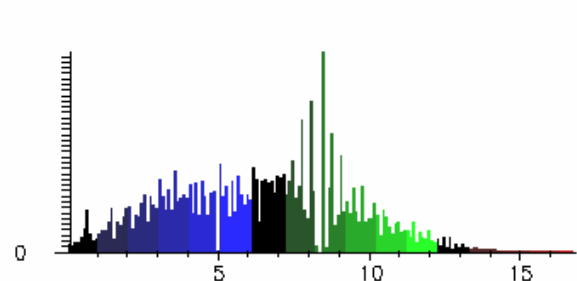
X-AXIS: Category Values in tens
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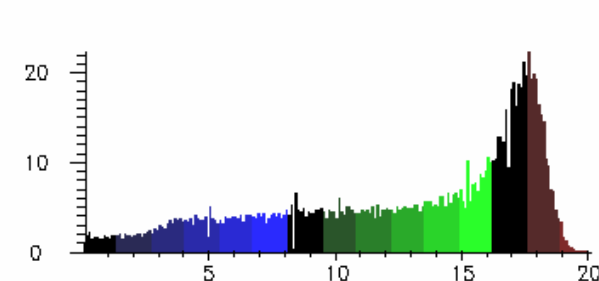
X-AXIS: Category Values in tens
Y-AXIS: Number of cells in thousands



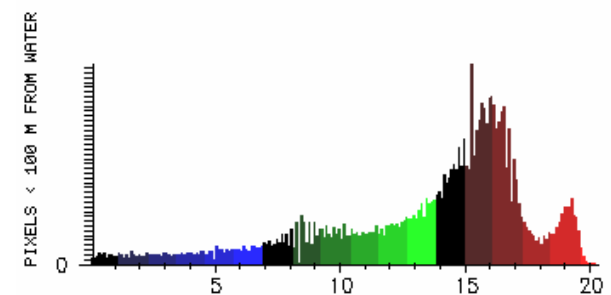
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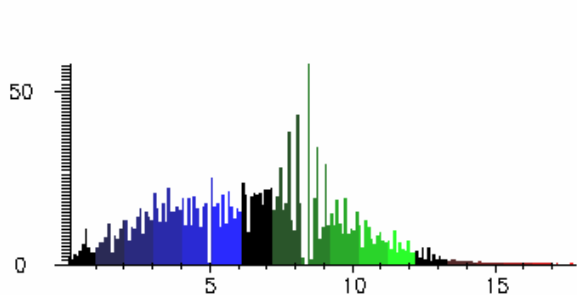
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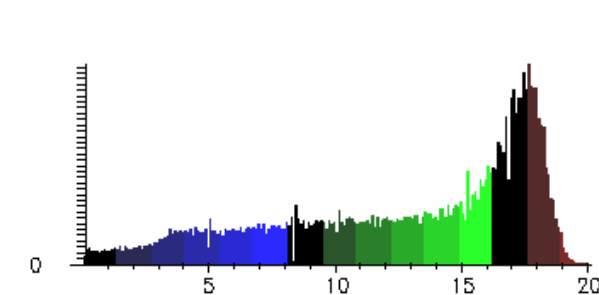
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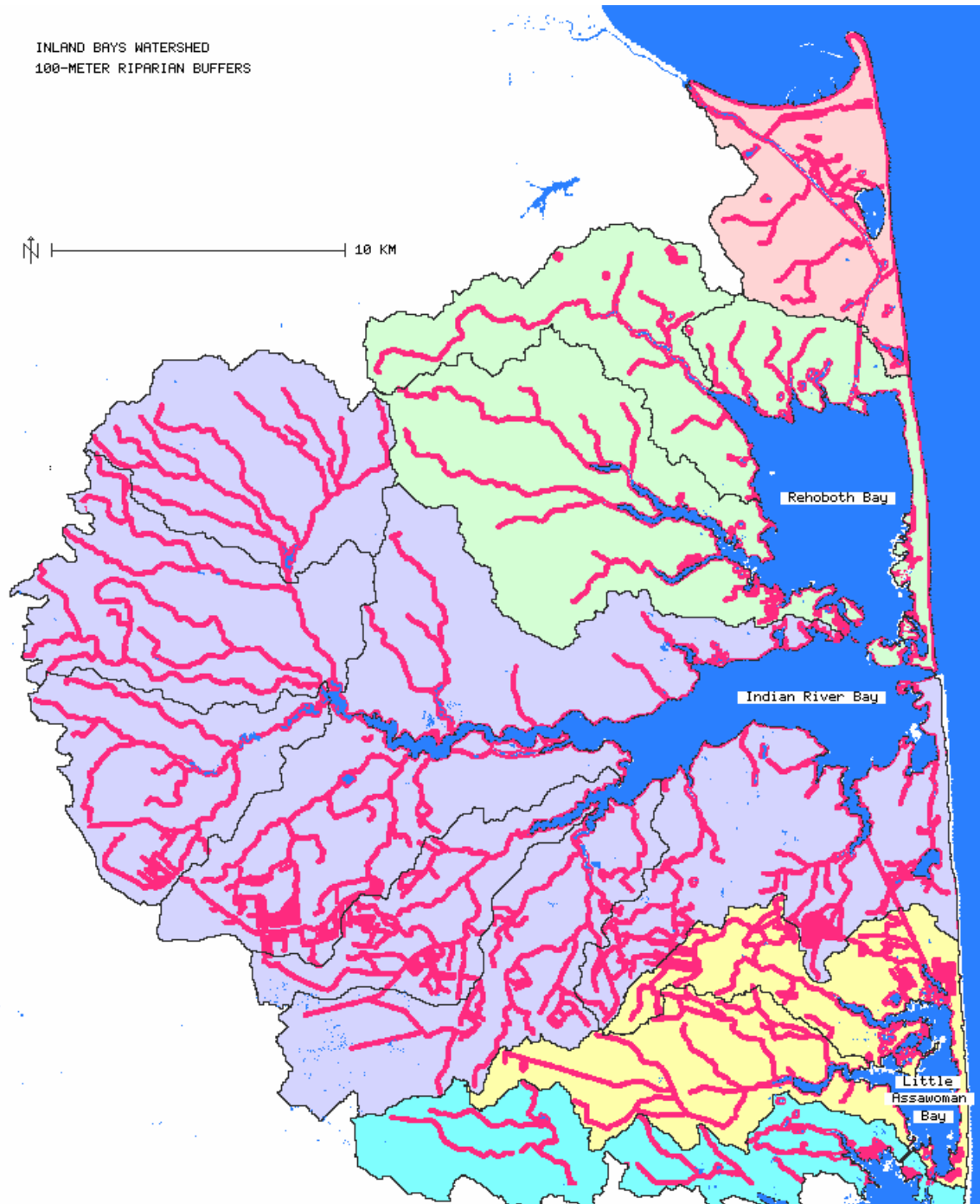
X-AXIS: Category Values in tens
Y-AXIS: Number of cells in thousands



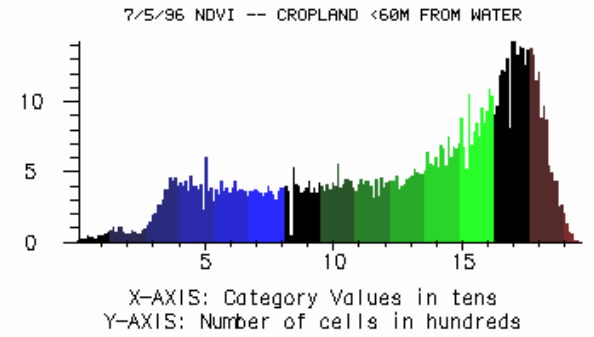
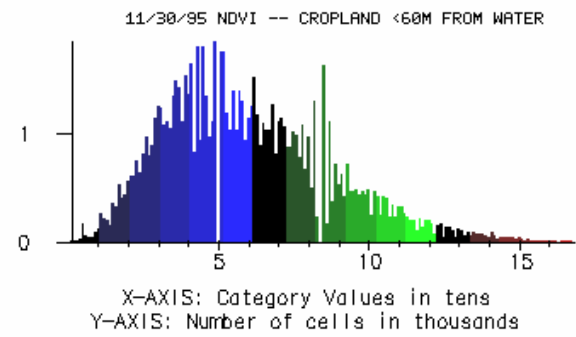
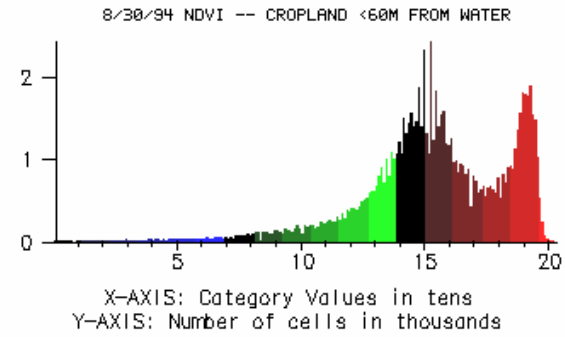
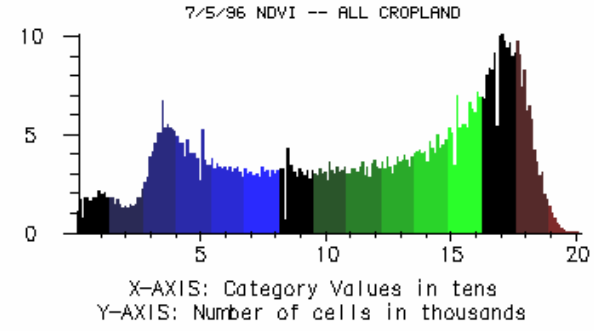
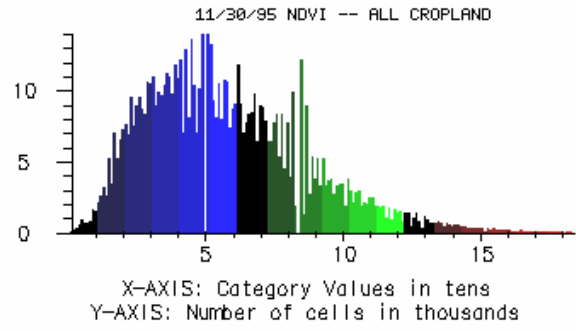
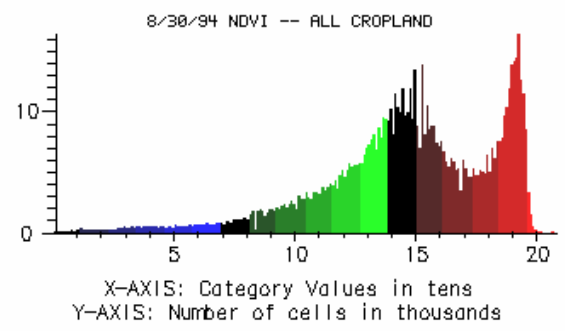
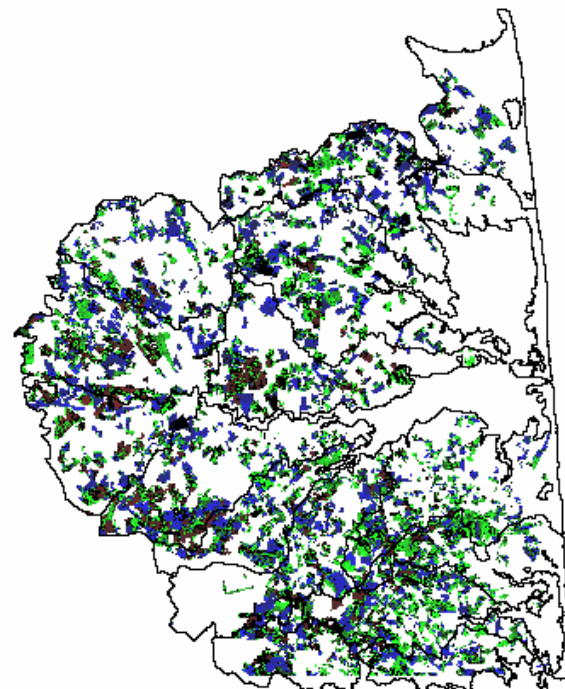
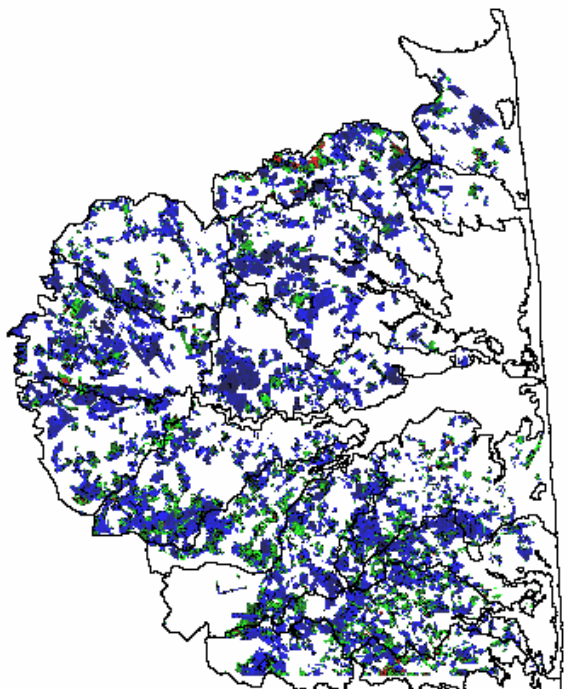
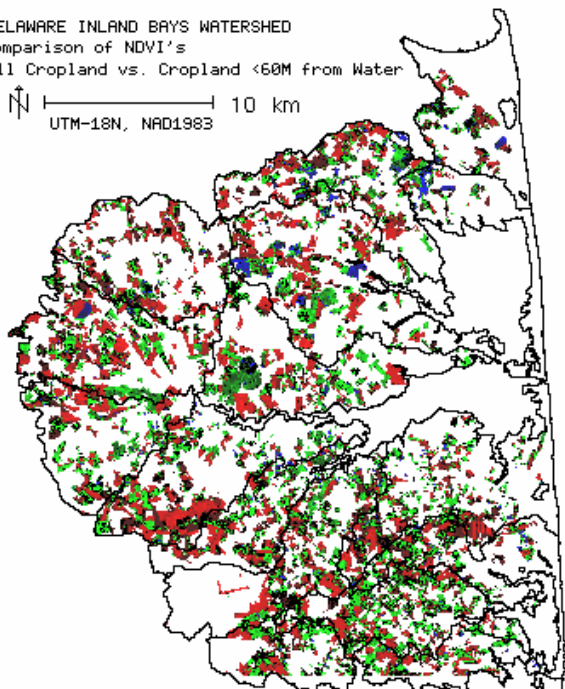
X-AXIS: Category Values in tens
Y-AXIS: Number of cells in thousands

INLAND BAYS WATERSHED
100-METER RIPARIAN BUFFERS

10 KM

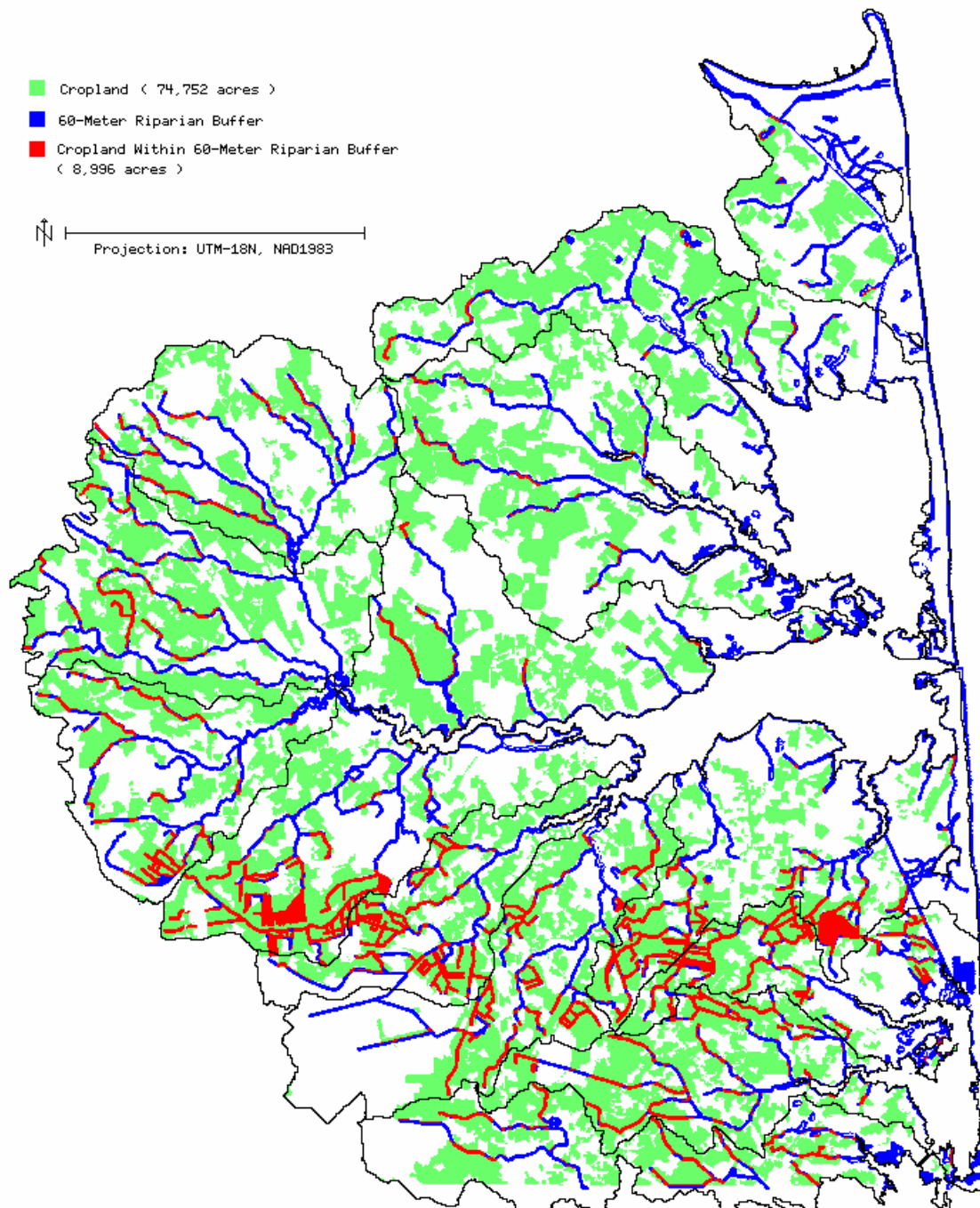


DELAWARE INLAND BAYS WATERSHED
Comparison of NDVI's
All Cropland vs. Cropland <60M from Water
10 km
UTM-18N, NAD1983



- Cropland (74,752 acres)
- 60-Meter Riparian Buffer
- Cropland Within 60-Meter Riparian Buffer
(8,996 acres)

↑
Projection: UTM-18N, NAD1983





Perdue-AgriRecycle Poultry Manure Pelletization Plant

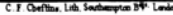
Just south of Seaford, the world's largest chicken manure pelletization plant has processed about 60,000 tons of chicken manure since it opened in July, 2001. The plant was designed as a solution for poultry farmers in the area who needed to remove waste from their facilities. Most had no option but to spread it on fields according to their Nutrient Management Plan or store it in special leak-proof structures. [Perdue Farms, Inc.](#) understood how critical this problem was and researched different methods of ridding the area of the excess manure. Perdue considered building an incinerator (an idea that was abandoned due to emissions restrictions) or a composting facility (which proved to have too many logistical problems). The pelletization plant, which handles manure from both Delaware and Maryland, was chosen because the waste could be transported easily before and after processing and it produced a marketable product. After an investment of \$13 million from the company, and a grant from the State of Delaware, the plant was built to handle up to 95,000 tons of manure a year.

The original strategy of the plant was to create a "recycling" effect; as feed is transported to the Delmarva Peninsula's poultry farms from the Midwest bread basket, the pelletized waste is distributed from the Peninsula back to the grain farms for fertilizer. David Ennis, Perdue's General Manager of Production and Administration, explains, "It's estimated that 600,000 tons of manure are generated on the Eastern Shore... and only maybe half can be applied to land according to the Nutrient Management Plans. Perdue is primarily concerned with moving some of that volume off the peninsula."

Mid-Atlantic Biodiesel Inc., Clayton, DE



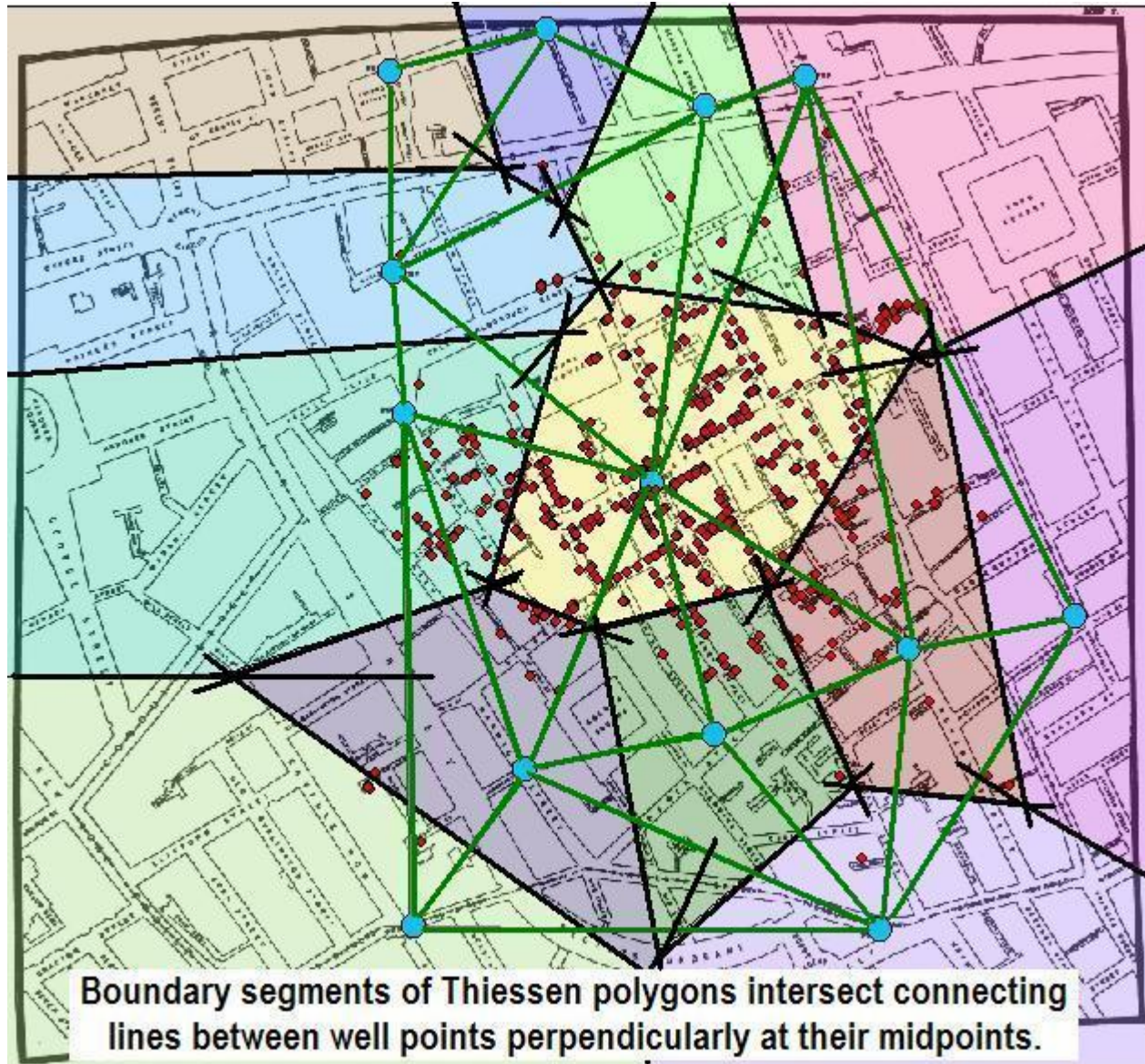
ACUP 1



SCALE 30 INCHES TO A MILE.

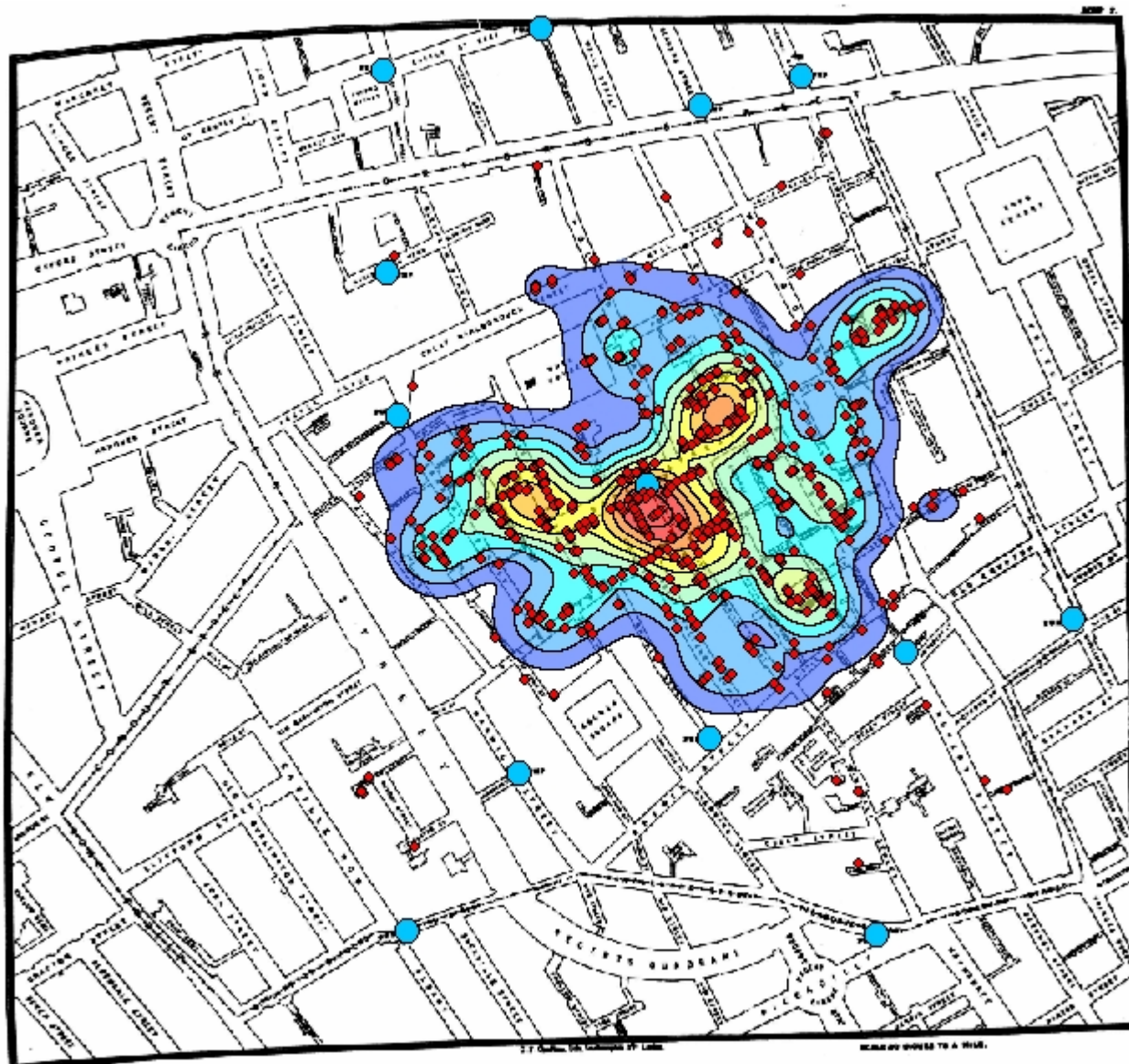
Disproving the “Miasma” theory: Straight-Line Distance Allocation to Pumps

62% of cholera deaths were nearest the Broad Street pump



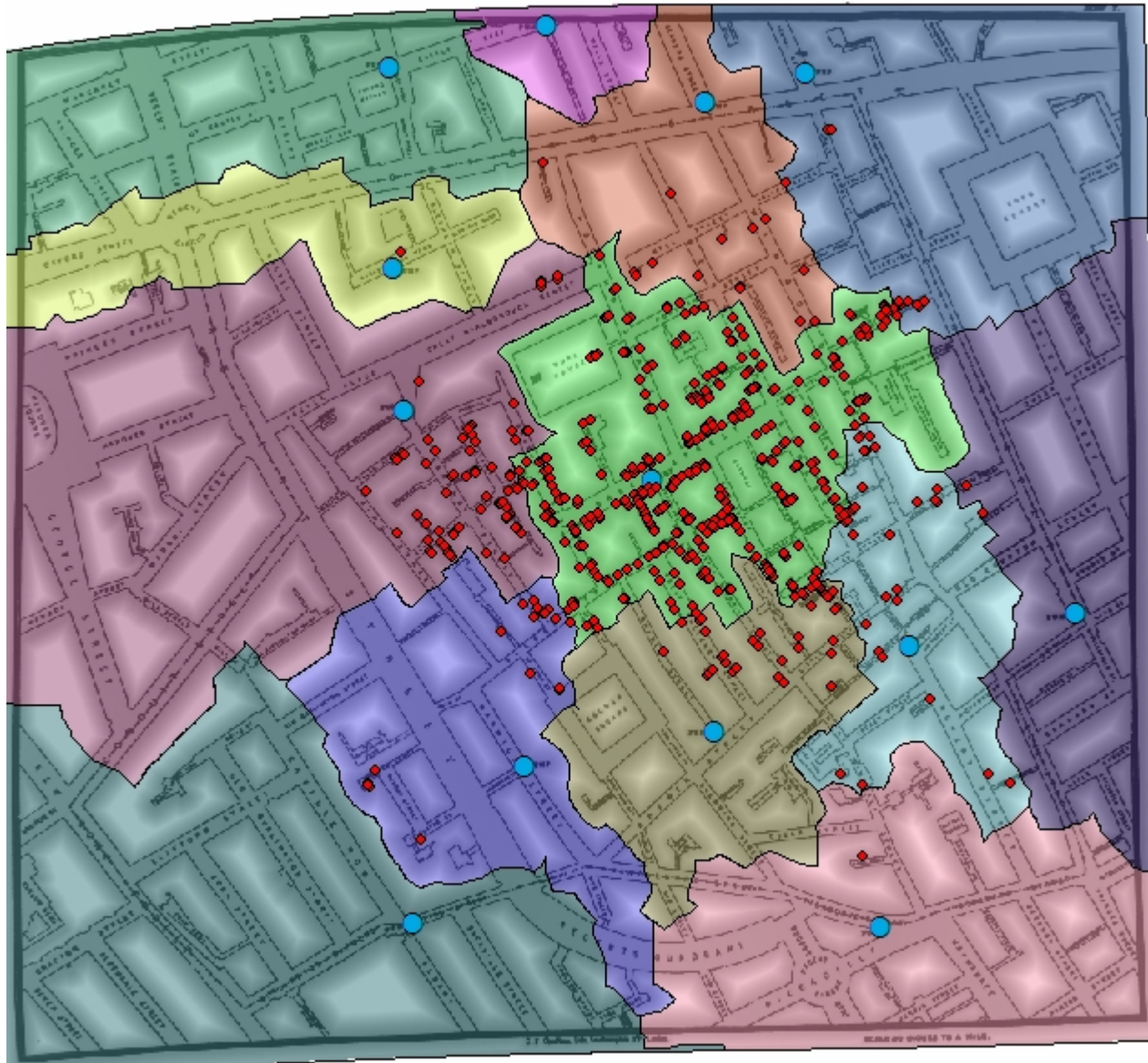
Kernel-Density Mapping of Cholera Deaths

(kernel size = 1.0; cellsize = 0.0025)



Cost-Weighted Allocation of Cholera Deaths to Pumps

66% of cholera deaths assigned to Broad Street pump



THE END

