National Biological Assessment and Criteria Workshop

Advancing State and Tribal Programs

Coeur d'Alene, Idaho
31 March – 4 April, 2003

TALU 201

Landscape Data and Tools to Document Human Disturbance Gradients

Presented by

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US EPA Region 4

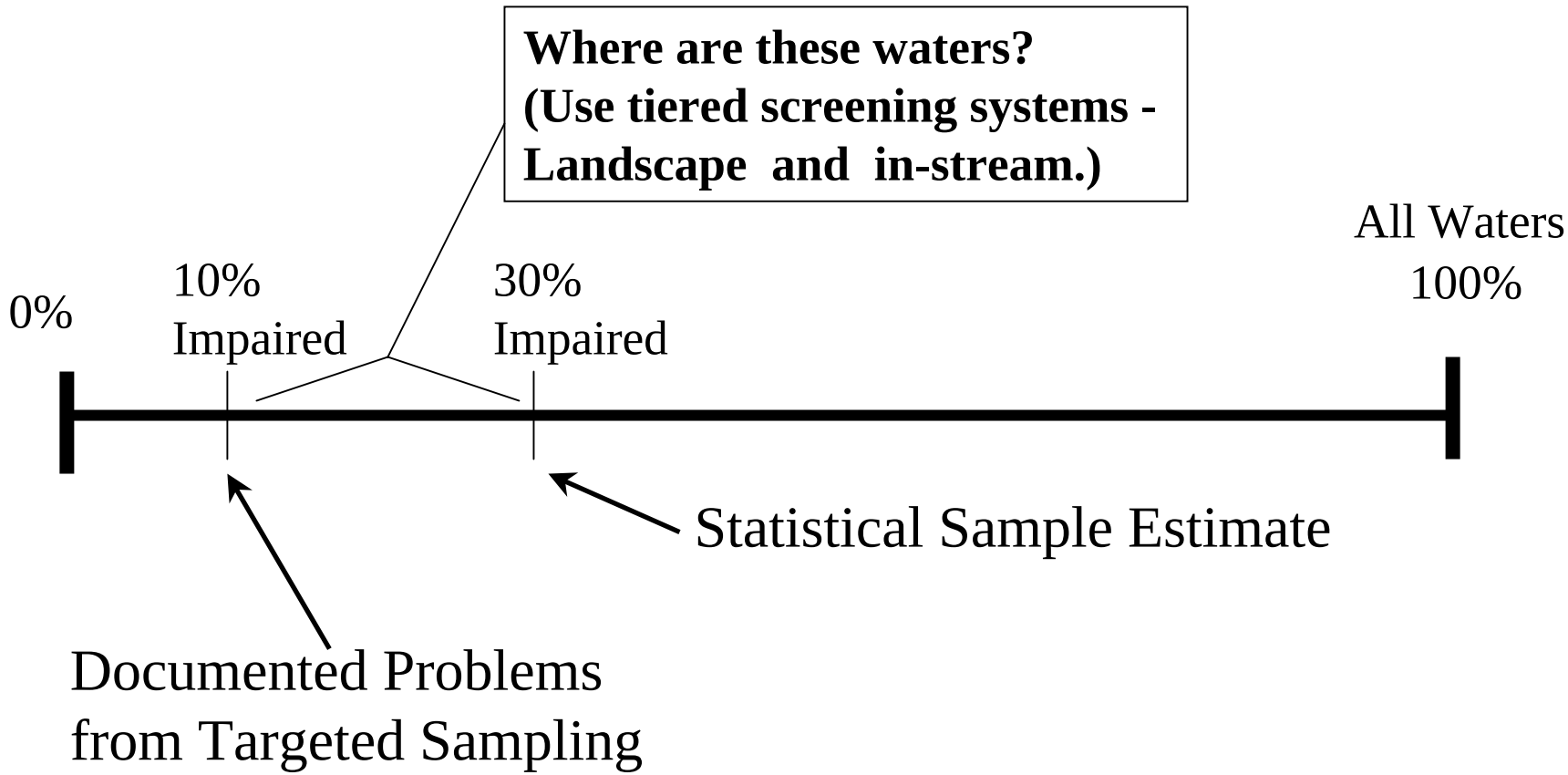
Topics

- Monitoring questions and landscape approaches
- Ecoregional landscape patterns
- Watershed landscape patterns by ecoregion
- Roads and urban stresses
- Imperviousness (one hydrologic stress)
- Examples relating landscape & in-stream response
- Recommended options
- Needs for data, research and application

Key Questions for a Water Quality Monitoring System

- What is the desired/reference condition? (Standards/criteria)
- **Where (and what) are our problems? (Screening)**
- How do we fix (or prevent) them? (TMDL's, permit limits, BMP's, etc.)
- Are we making progress over time at all scales? (evaluation/statistical sample)

Need for Screening Systems



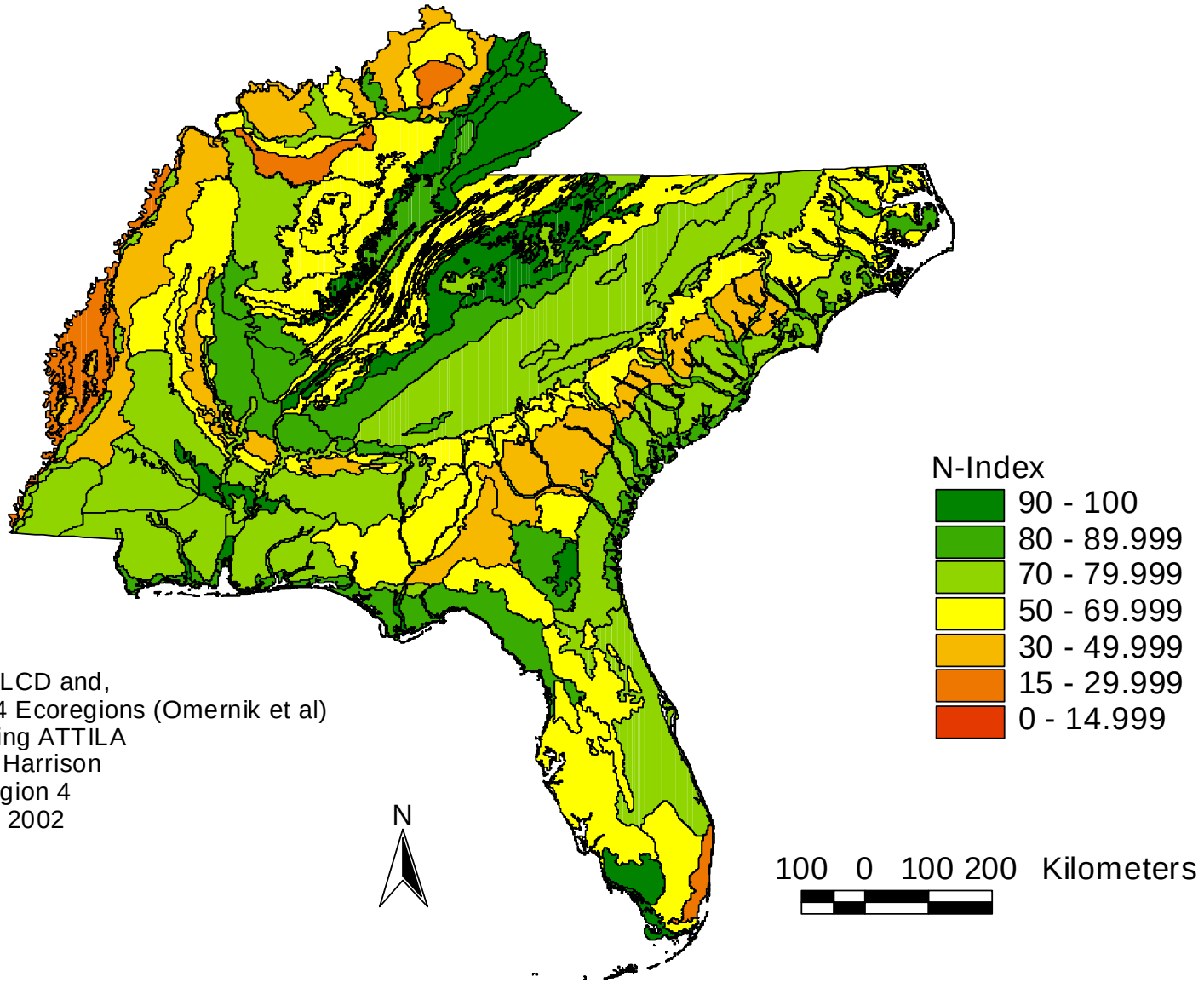
Uses of Landscape Data, Tools and Screening Techniques

- Extrapolate condition estimates to waters lacking in-stream data
- Identify suspected problem areas (likely impaired waters)
- Identify candidate reference areas (least impaired waters)
- Target additional monitoring to confirm problems

Uses of Landscape Approaches (cont.)

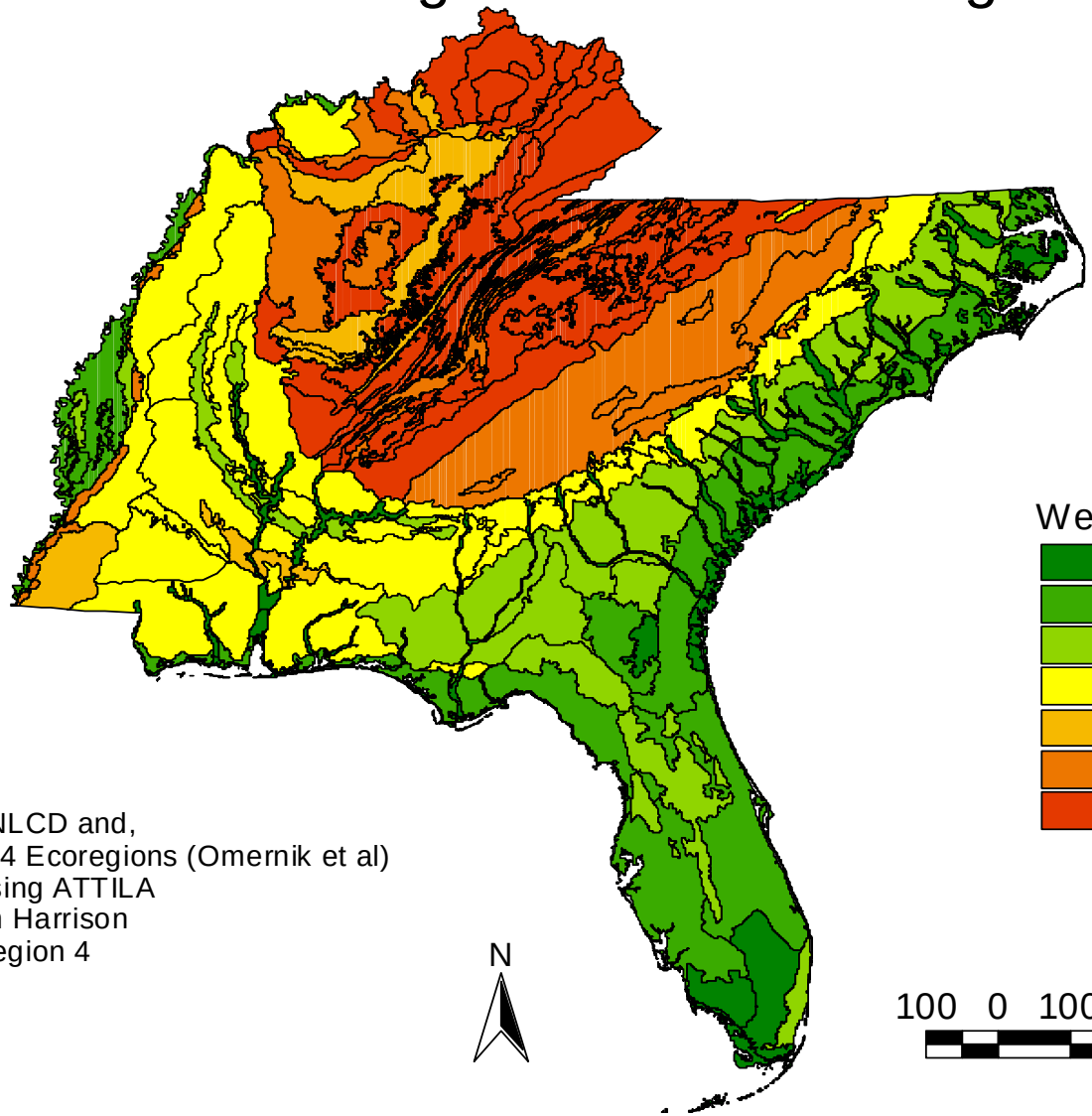
- Target areas for prevention emphasis
- Prioritize TMDL, restoration and rehabilitation efforts
- Evaluate landscape stresses and water quality problem causes for large areas
- Define and document human disturbance gradients
- Provide scientific basis to relate human disturbance to in-stream effects

Natural Land Cover Percent (N-Index): Omernik Ecoregions (Level 4)

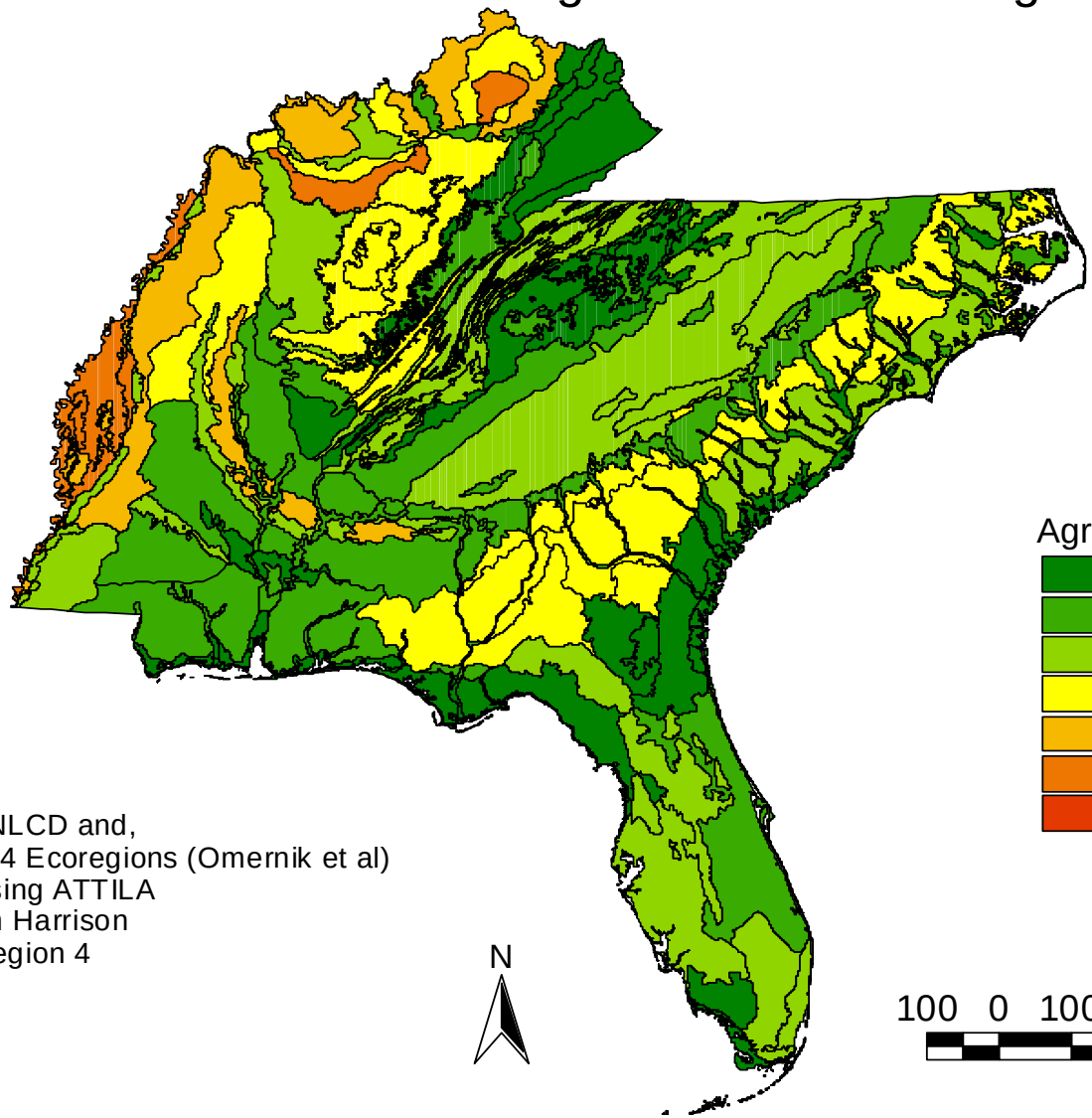


Based on NLCD and,
draft Level 4 Ecoregions (Omernik et al)
Analysis using ATTILA
May by Jim Harrison
US EPA Region 4
January 28, 2002

Wetland Percentage: Omernik Ecoregions (Level 4)



Agriculture - Total Percentage: Omernik Ecoregions (Level 4)



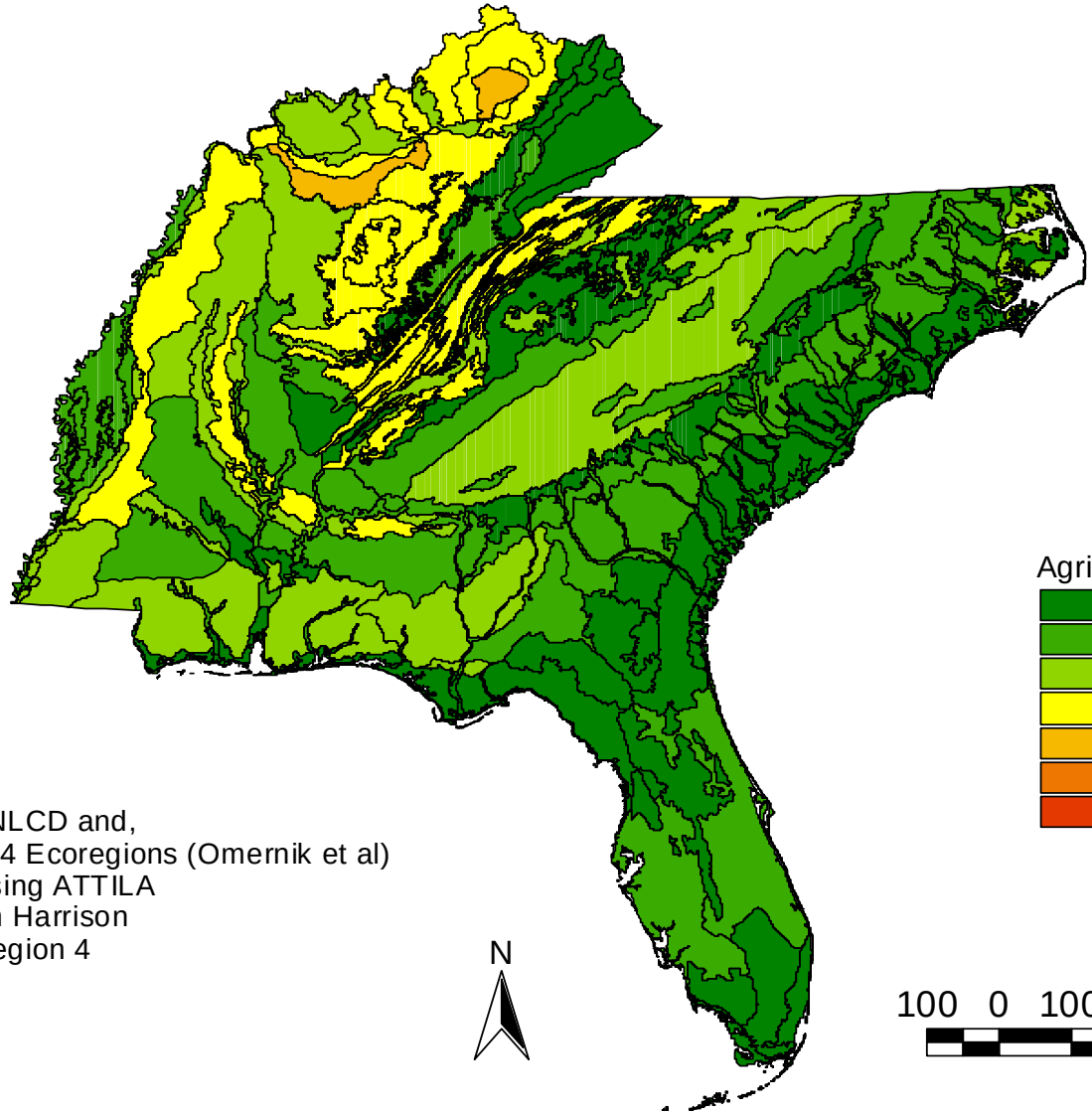
Agriculture - Total
0 - 9.999
10 - 19.999
20 - 29.999
30 - 49.999
50 - 69.999
70 - 84.999
85 - 100

Based on NLCD and,
draft Level 4 Ecoregions (Omernik et al)
Analysis using ATTILA
Map by Jim Harrison
US EPA Region 4
2/14/2002

N

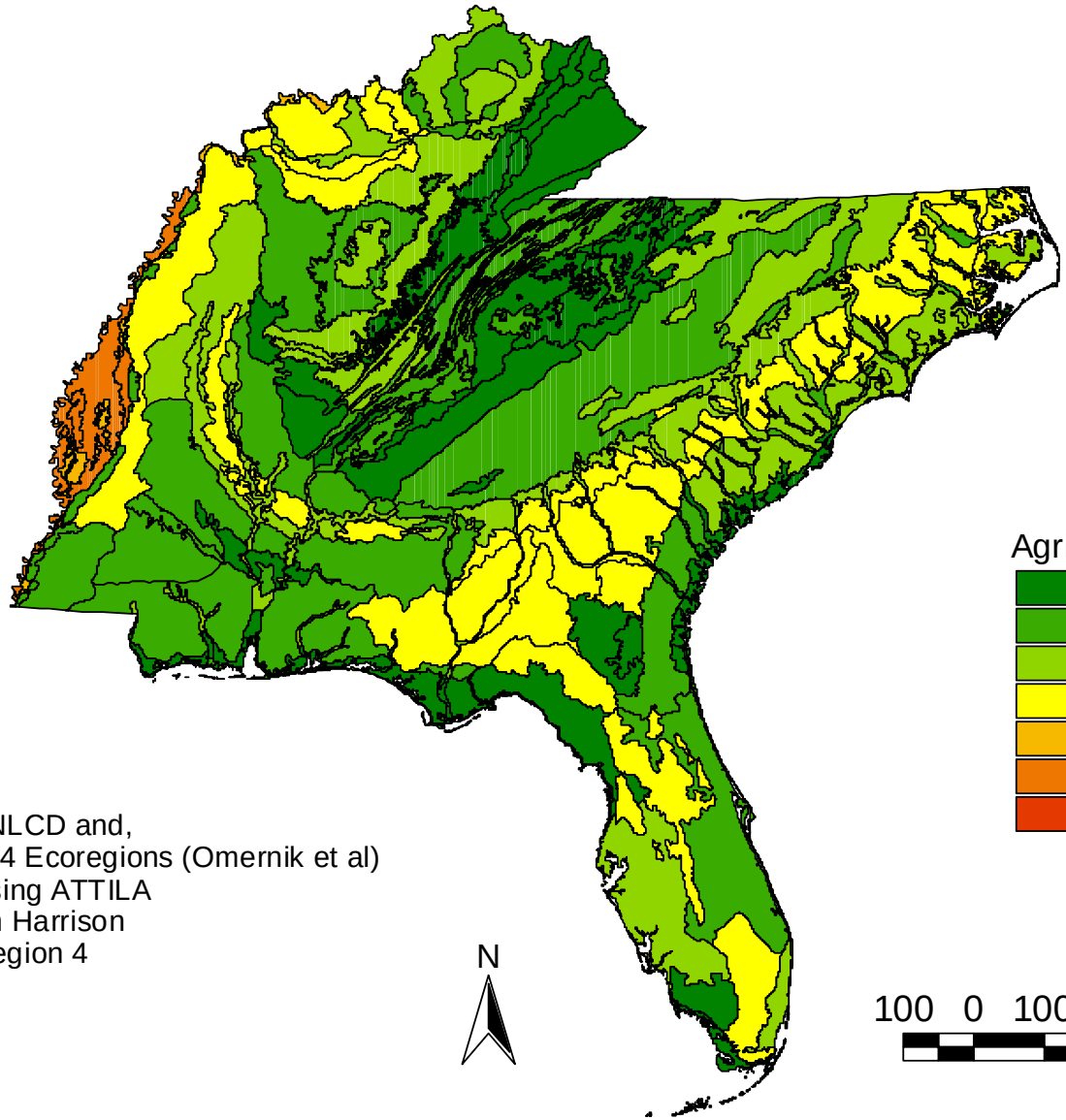
100 0 100 200 Kilometers

Agriculture - Pasture Percentage: Omernik Ecoregions (Level 4)



Based on NLCD and,
draft Level 4 Ecoregions (Omernik et al)
Analysis using ATTILA
Map by Jim Harrison
US EPA Region 4
2/14/2002

Agriculture - Crops Percentage: Omernik Ecoregions (Level 4)



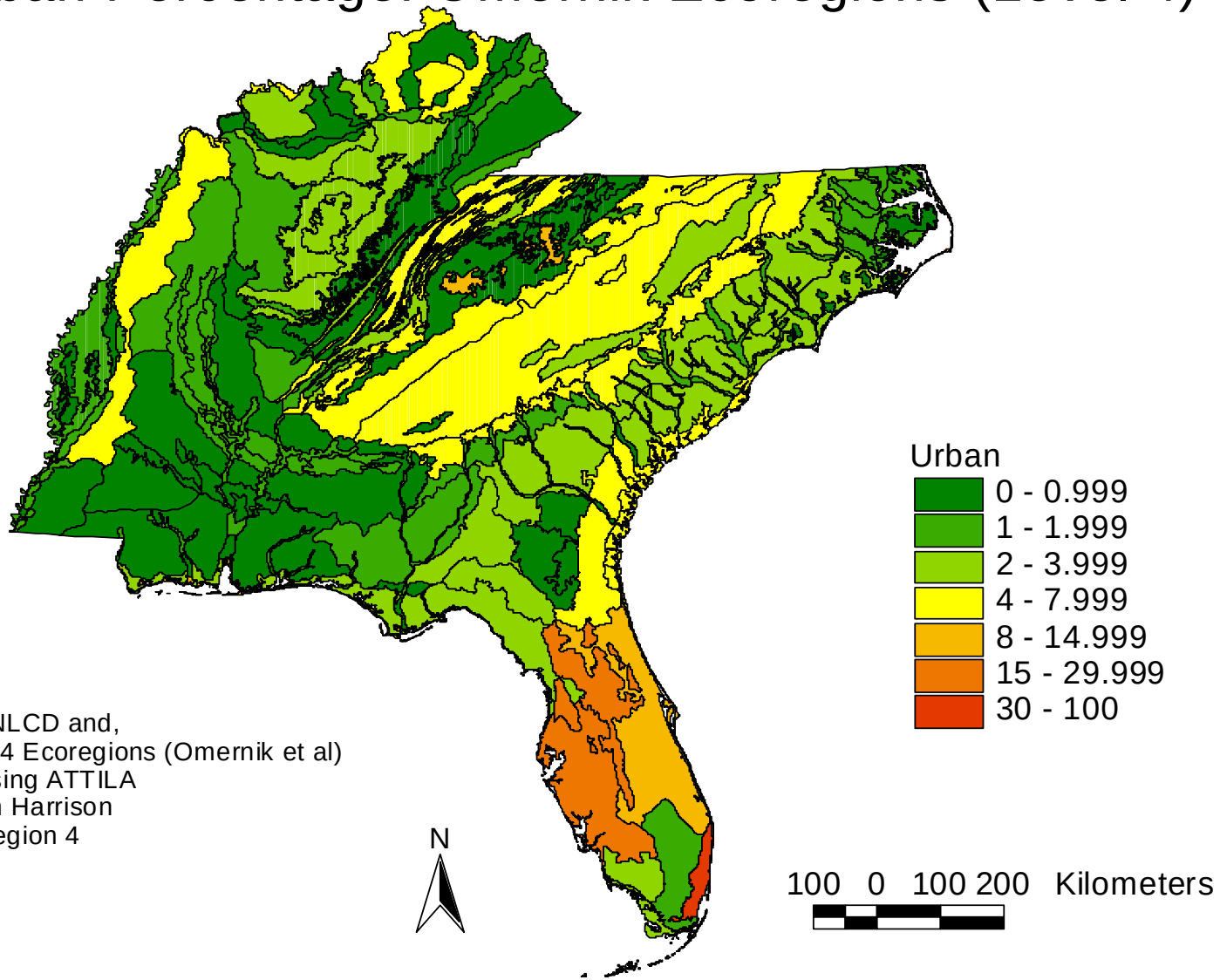
Agriculture - Crops
0 - 4.999
5 - 9.999
10 - 19.999
20 - 39.999
40 - 59.999
60 - 79.999
80 - 100

Based on NLCD and,
draft Level 4 Ecoregions (Omernik et al)
Analysis using ATTILA
Map by Jim Harrison
US EPA Region 4
2/14/2002

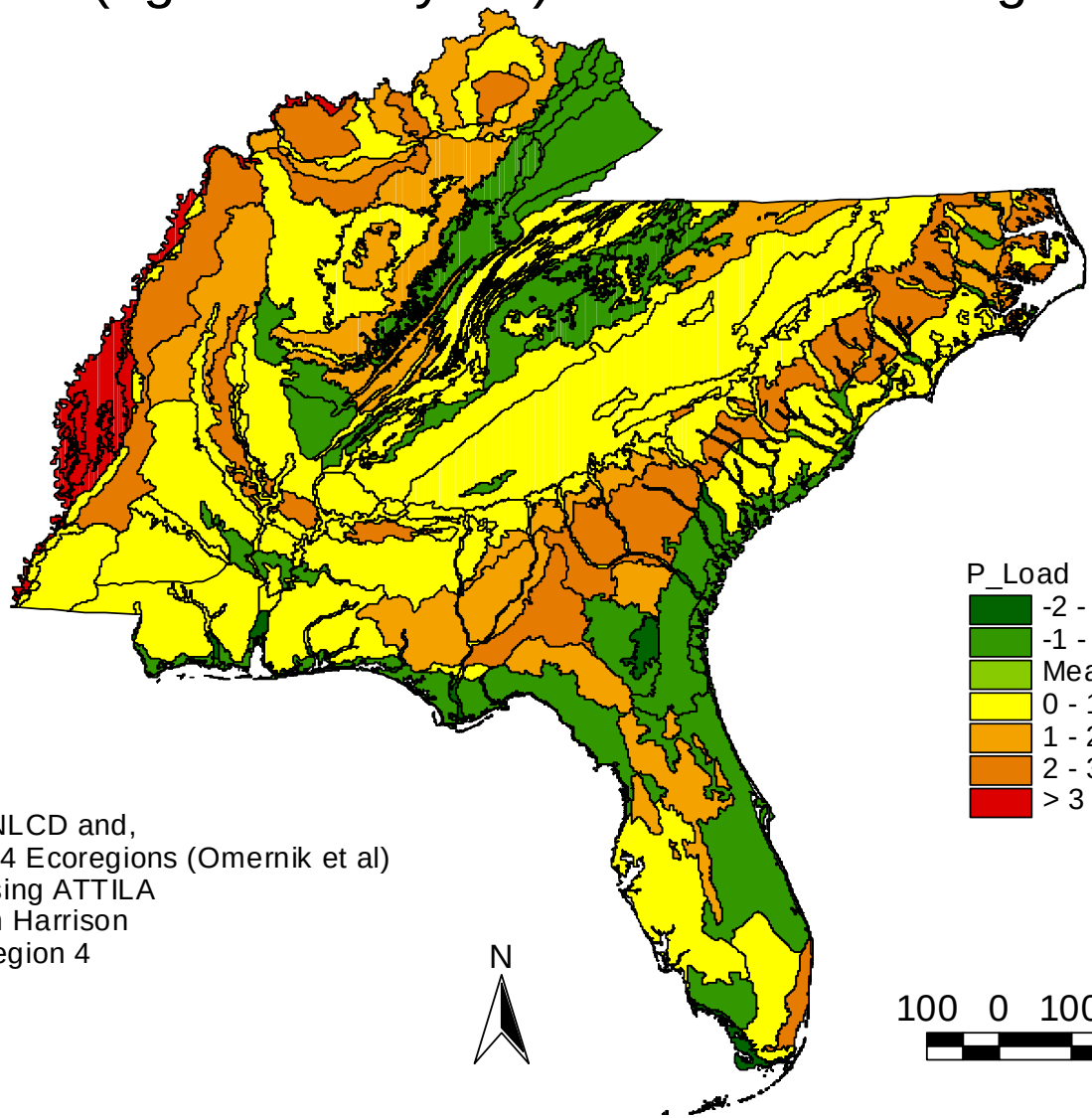
N

100 0 100 200 Kilometers

Urban Percentage: Omernik Ecoregions (Level 4)

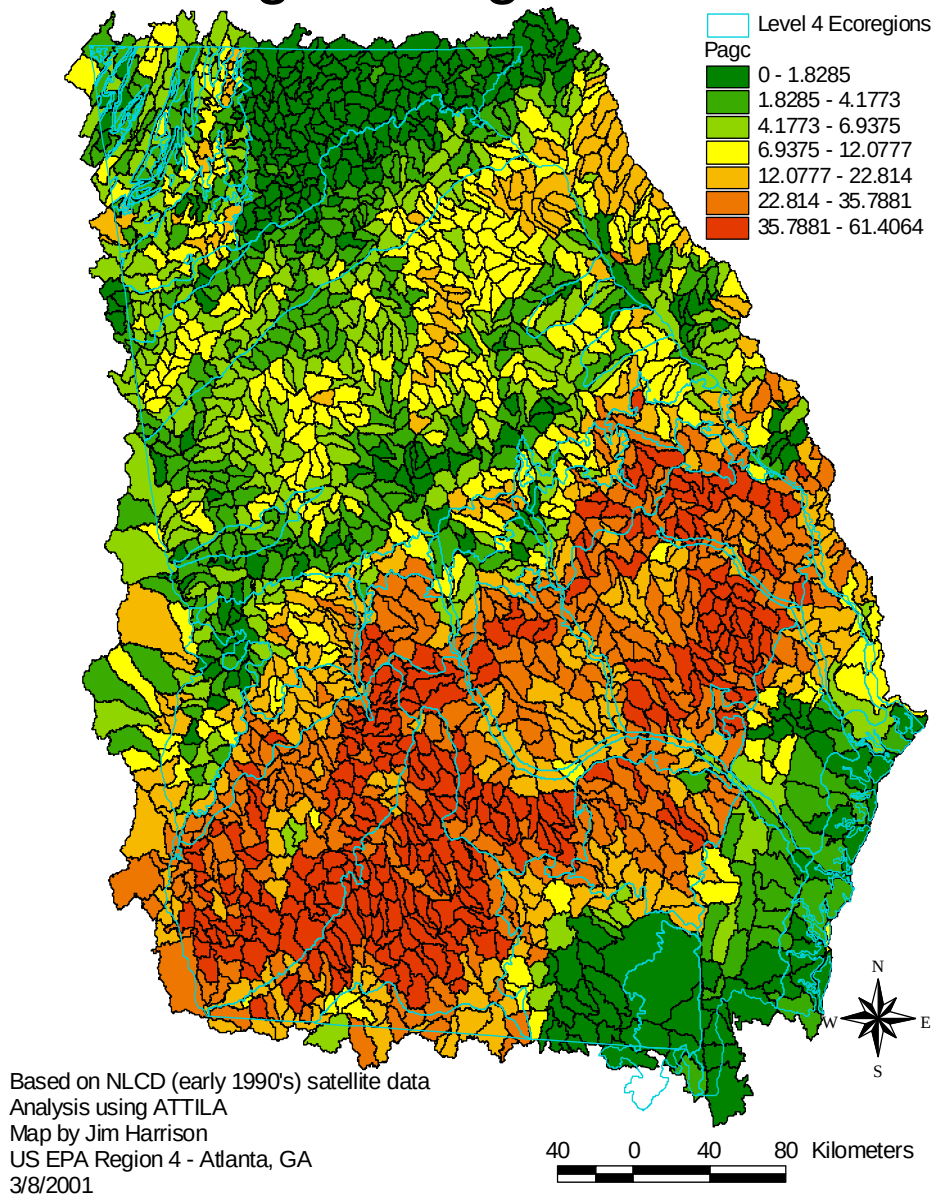


P Load (kg/hectare/year): Omernik Ecoregions (Level 4)

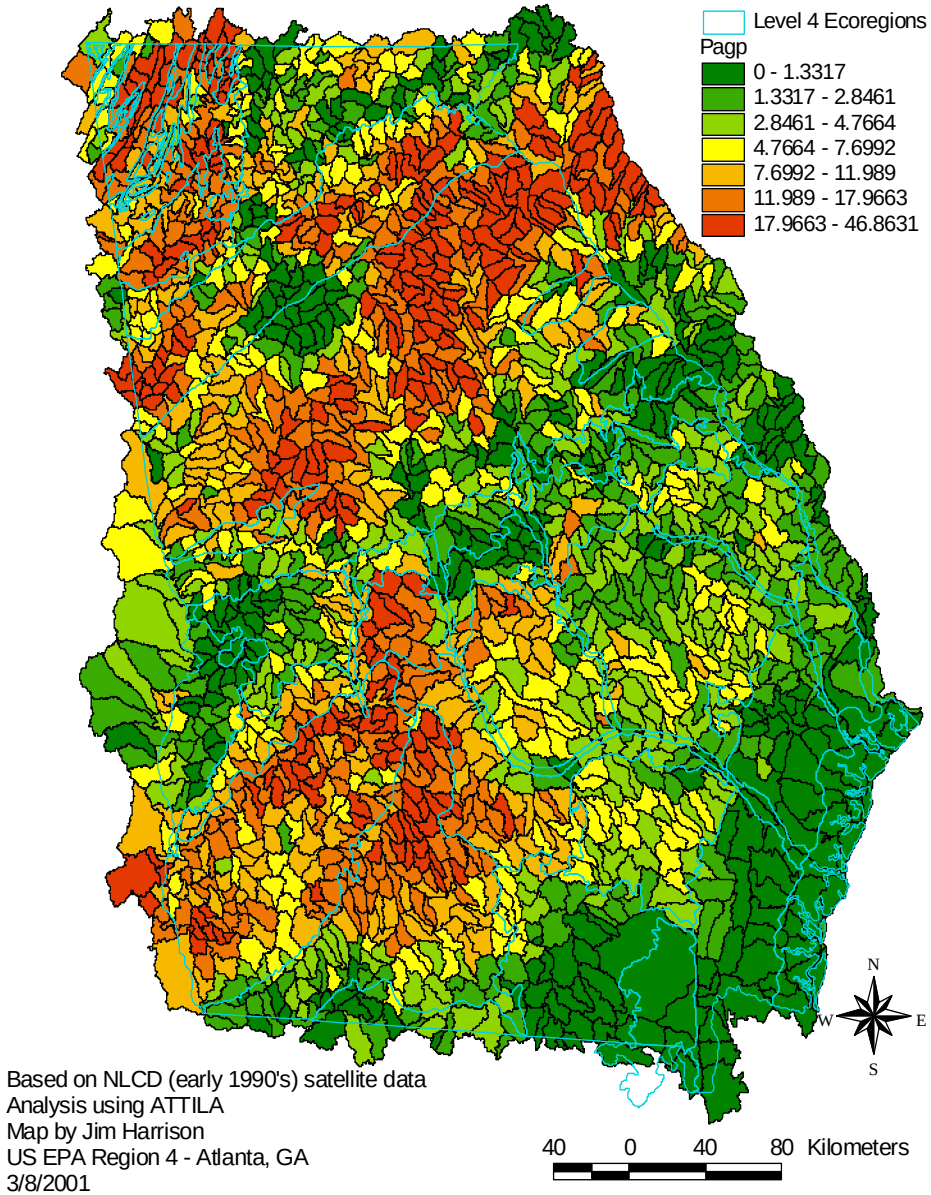


Based on NLCD and,
draft Level 4 Ecoregions (Omernik et al)
Analysis using ATTILA
Map by Jim Harrison
US EPA Region 4
2/14/2002

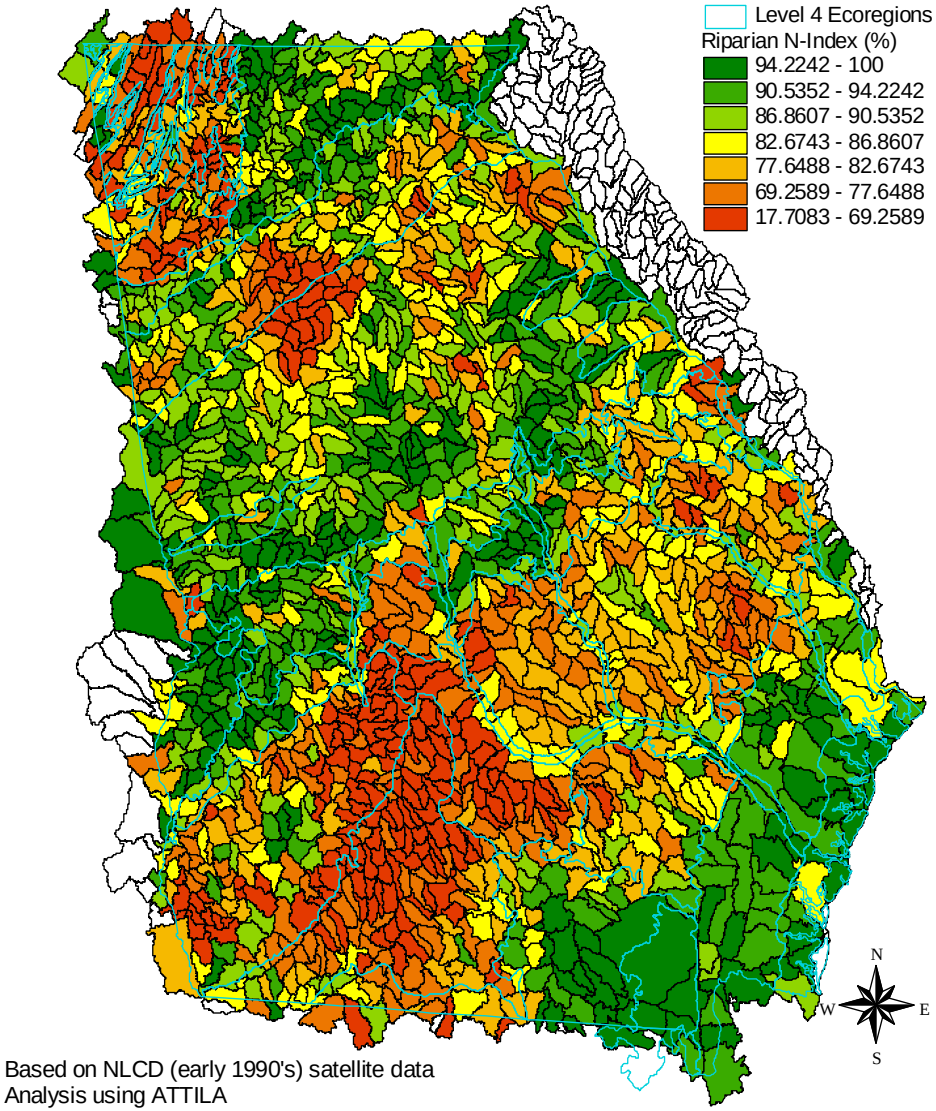
Crop Percent
Georgia12 Digit HUC's



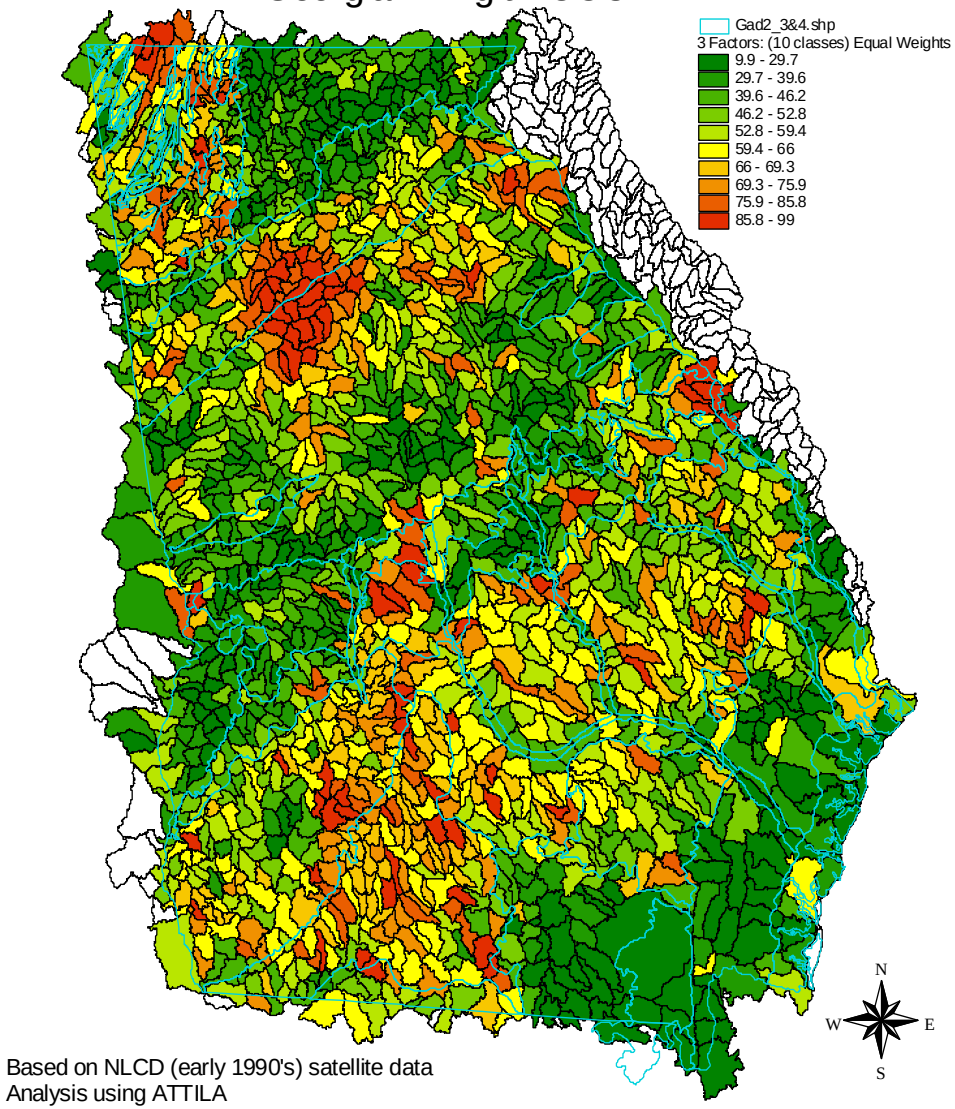
Pasture Percent
Georgia12 Digit HUC's



Riparian N - Index (%) with Ecoregions
Georgia12 Digit HUC's

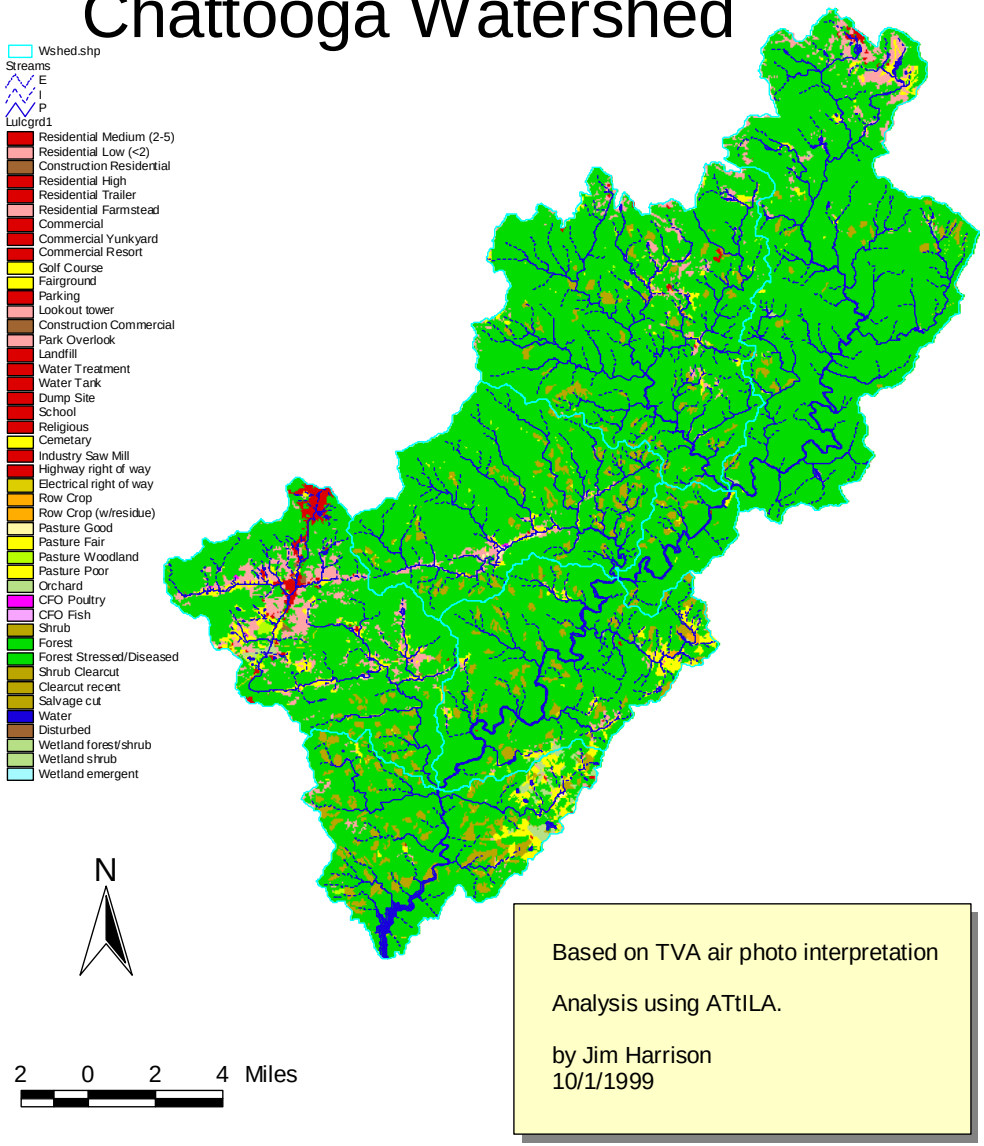


Three Stress Factors Model
Watershed N-Index, Riparian N-Index (90m), and Impervious Percent
Georgia12 Digit HUC's

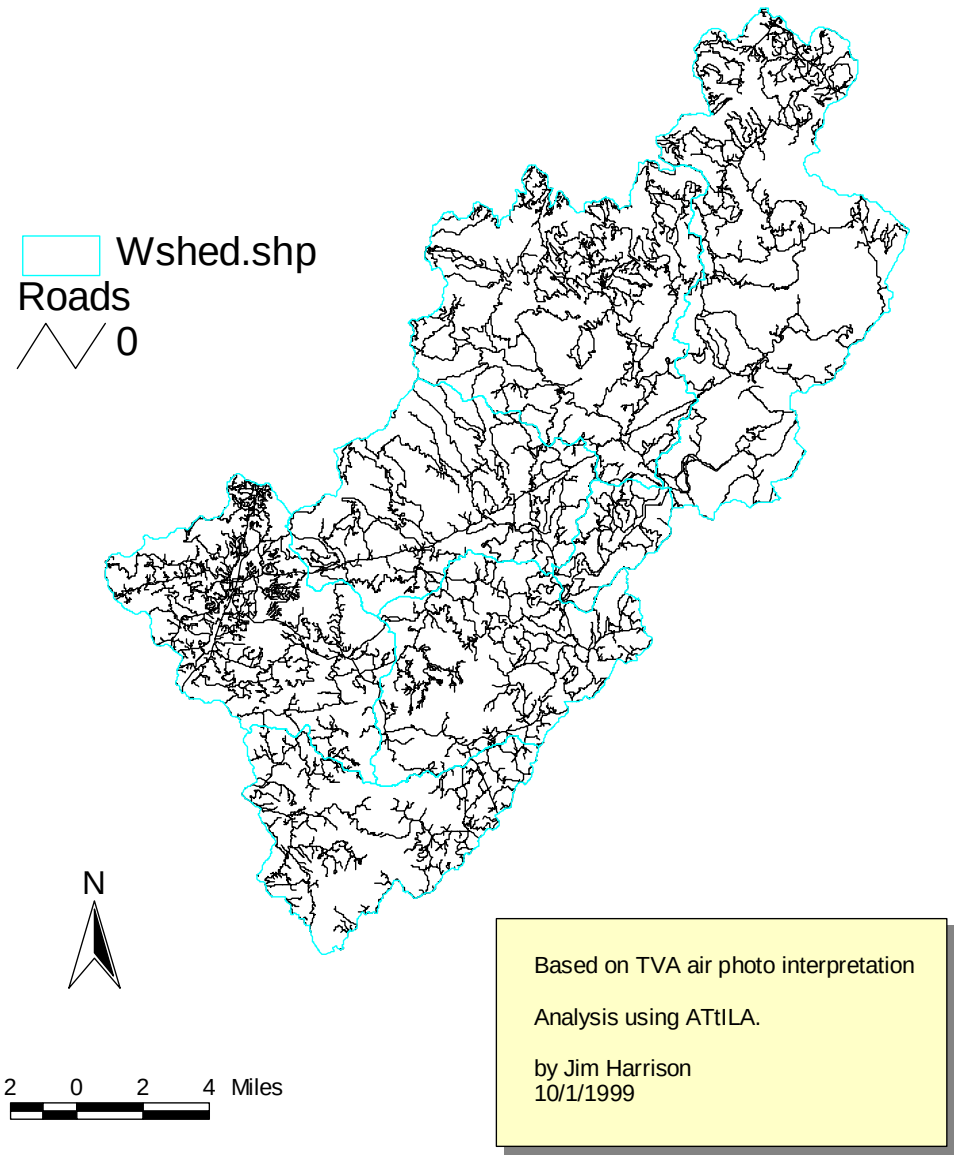


Based on NLCD (early 1990's) satellite data
Analysis using ATTILA
Map by Jim Harrison
US EPA Region 4 - Atlanta, GA
7/26/2001

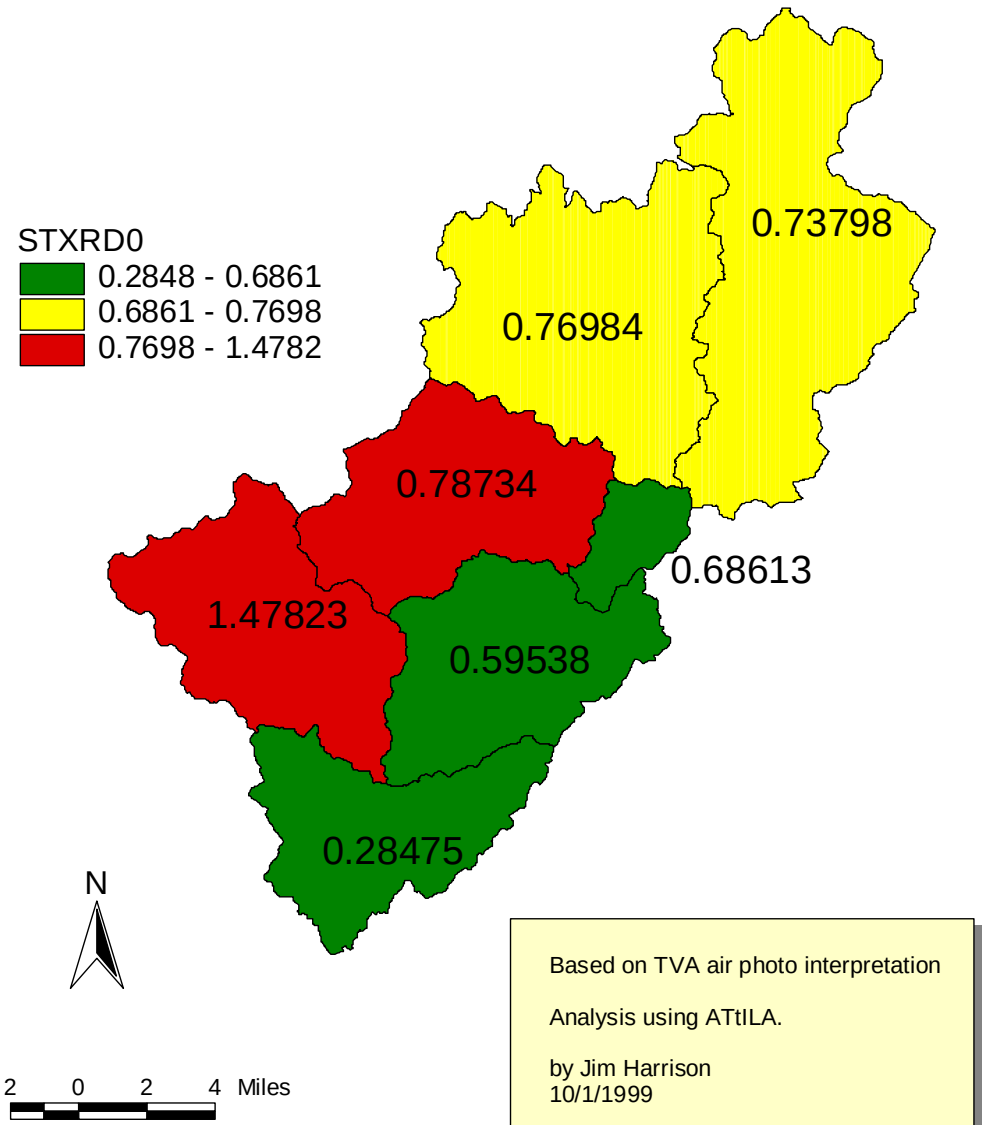
Land Use/Land Cover and Streams Chattooga Watershed



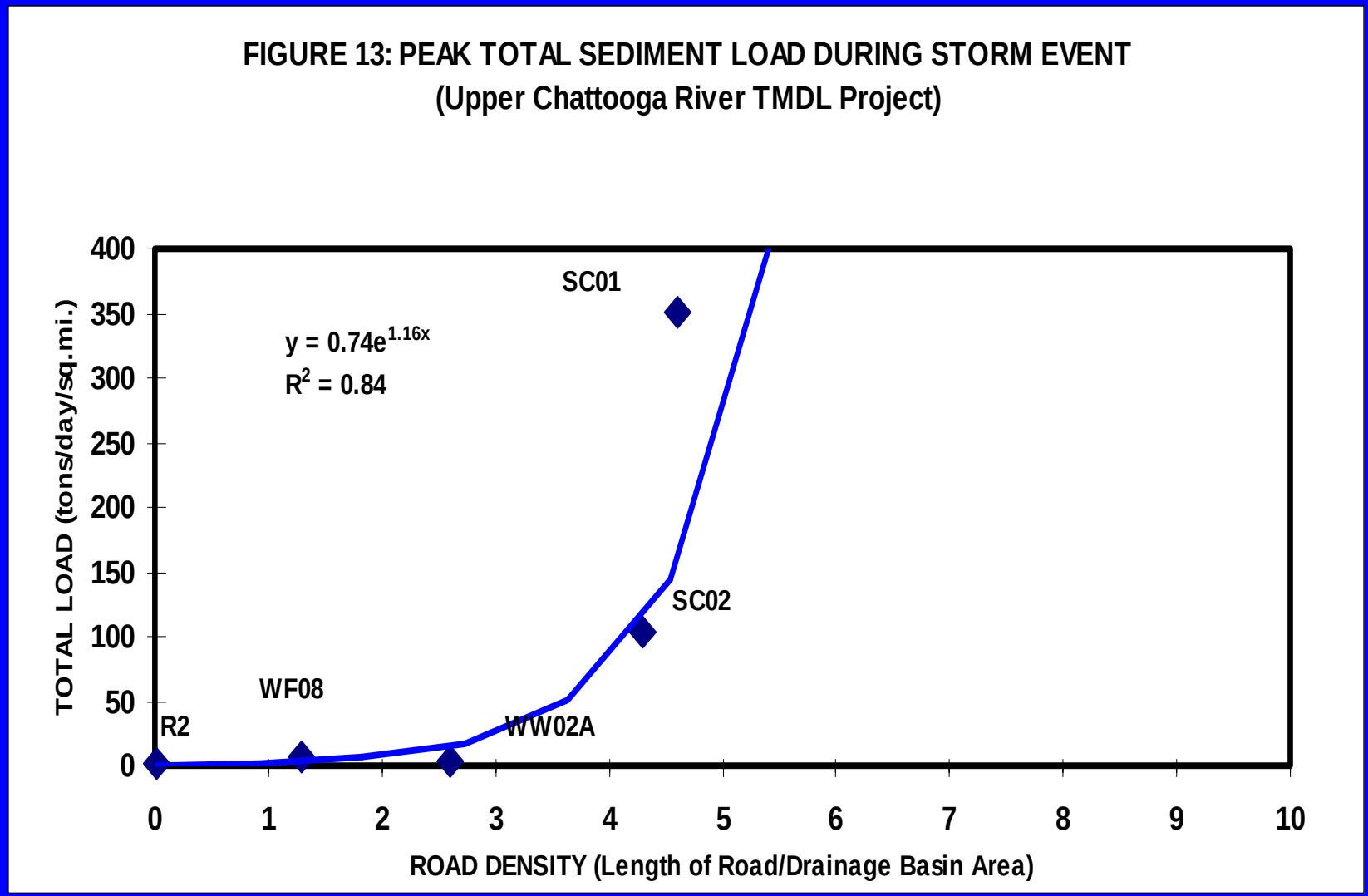
Roads
Chattooga Watershed



Road - Stream Crossing Density
Chattooga Watershed



TOTAL SEDIMENT LOAD vs. ROAD DENSITY (Chattooga River TMDL Study)



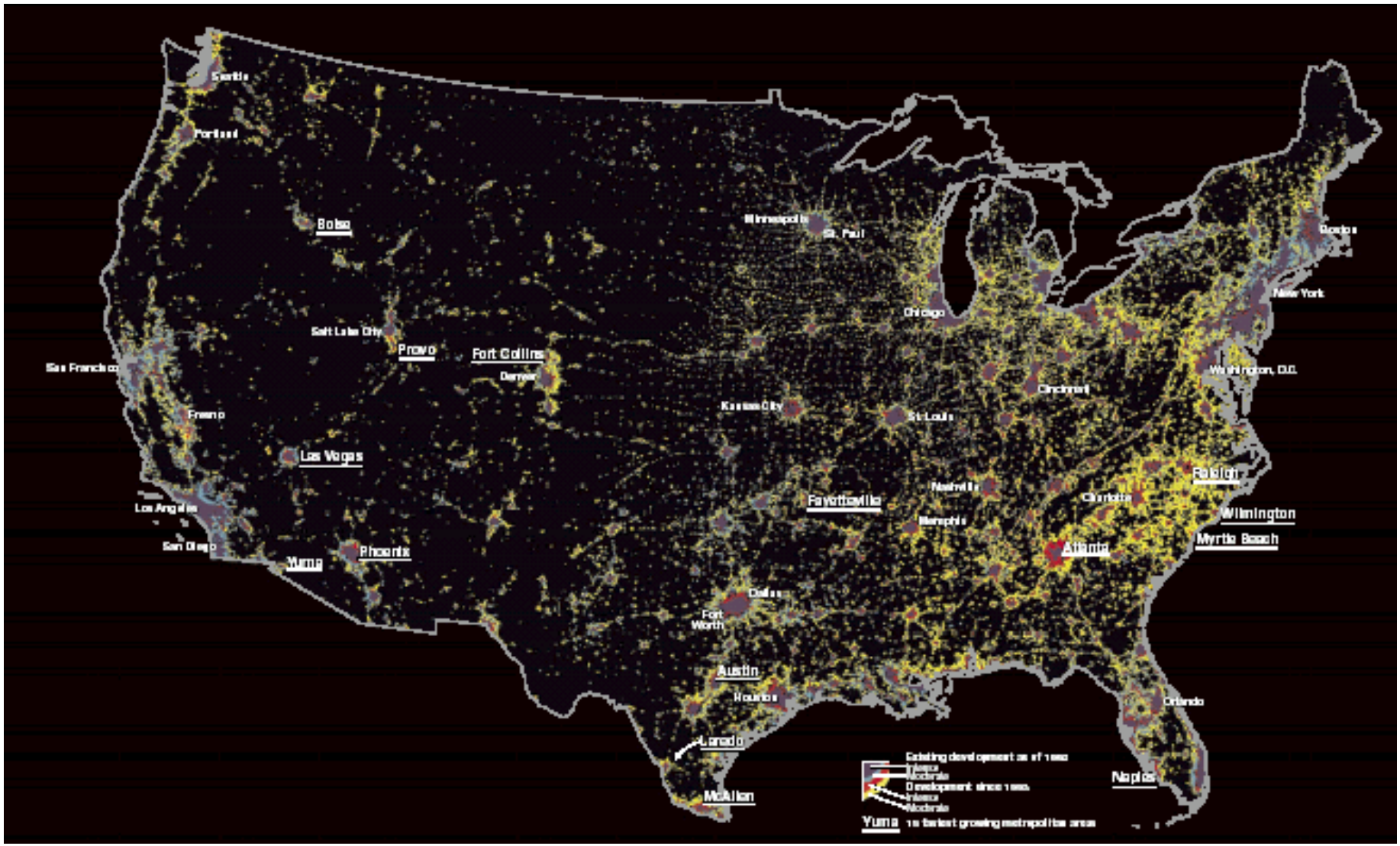
Multiple Stresses on Urban Streams

- Combined Sewer Overflows (CSO's)
- Sanitary Sewer Overflows (SSO's)
- Leaky Sewers/Faulty Septic Systems
- **Hydrologic Alteration - mainly from impervious surfaces**
- Riparian Area Destruction/Degradation

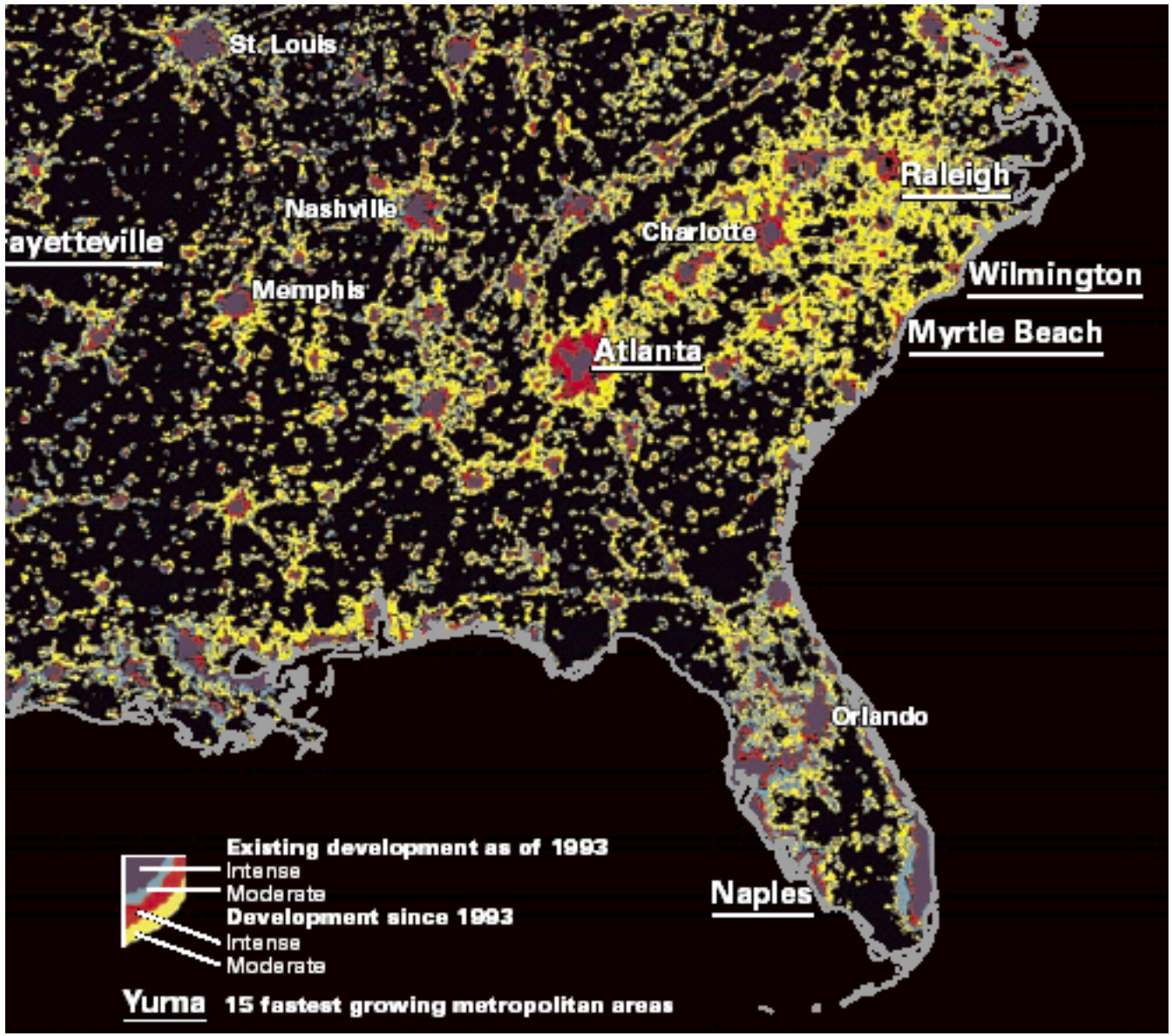
Multiple Stresses (cont.)

- Polluted Runoff from streets, parking, buildings, homes and lawns/landscaping
- Sedimentation from construction
- Point sources
- Illicit discharges

“Sprawl at Night: Seeing the Light”
Change in City Lights: Before and After 1993



Close-up of **“Sprawl at Night: Seeing the Light”**



Increases in Impervious Area Result in:

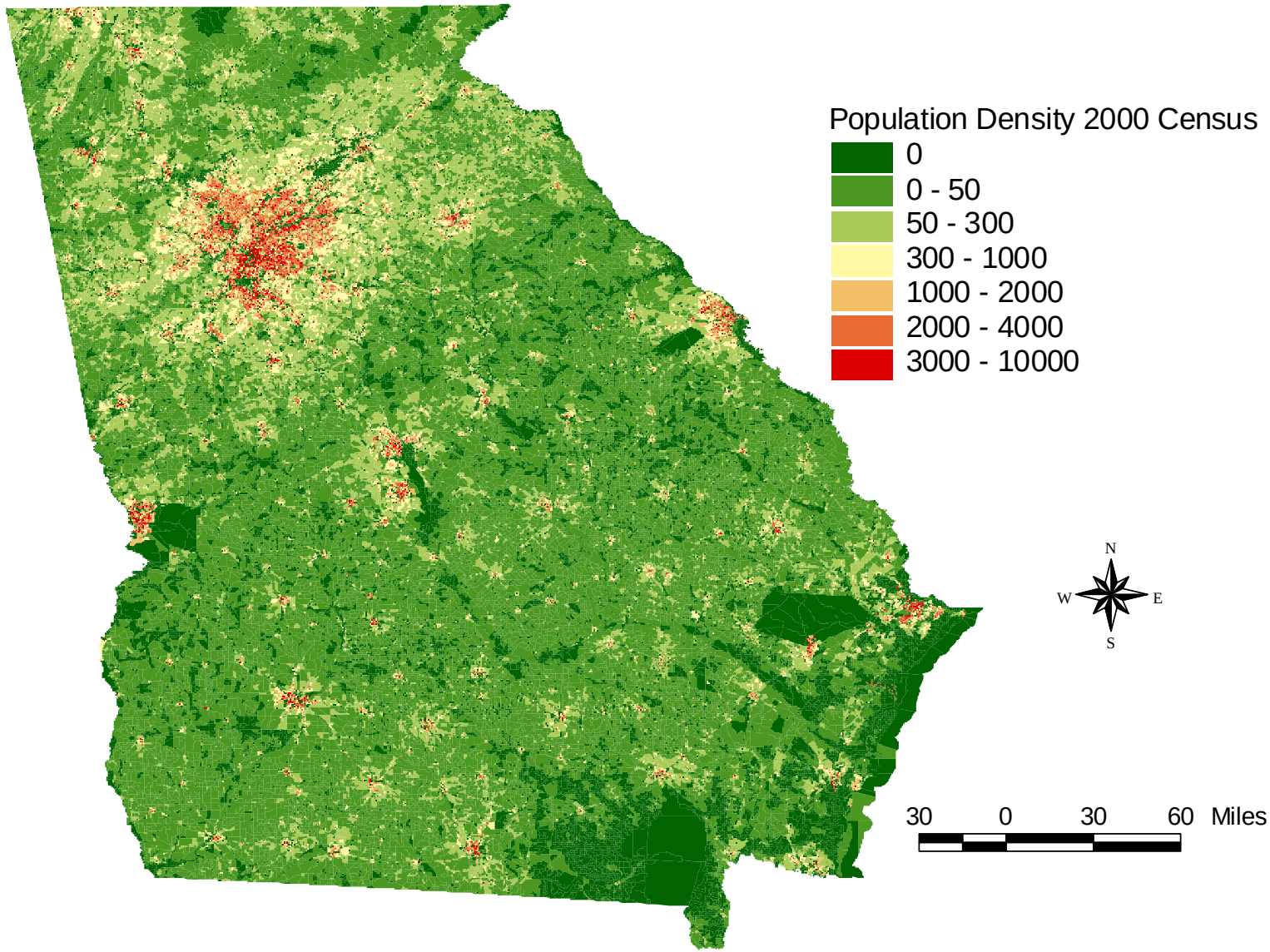
- Detrimental hydrologic changes
  - More frequent, higher peaks
  - Lower base flow
- Channel erosion/enlargement - sediment
- Habitat degradation - unstable substrate
- Biological impairment - poor community integrity

The Importance of Imperviousness

Schueler, T. 1994. Watershed Protection Techniques. 1(3): 100-111.

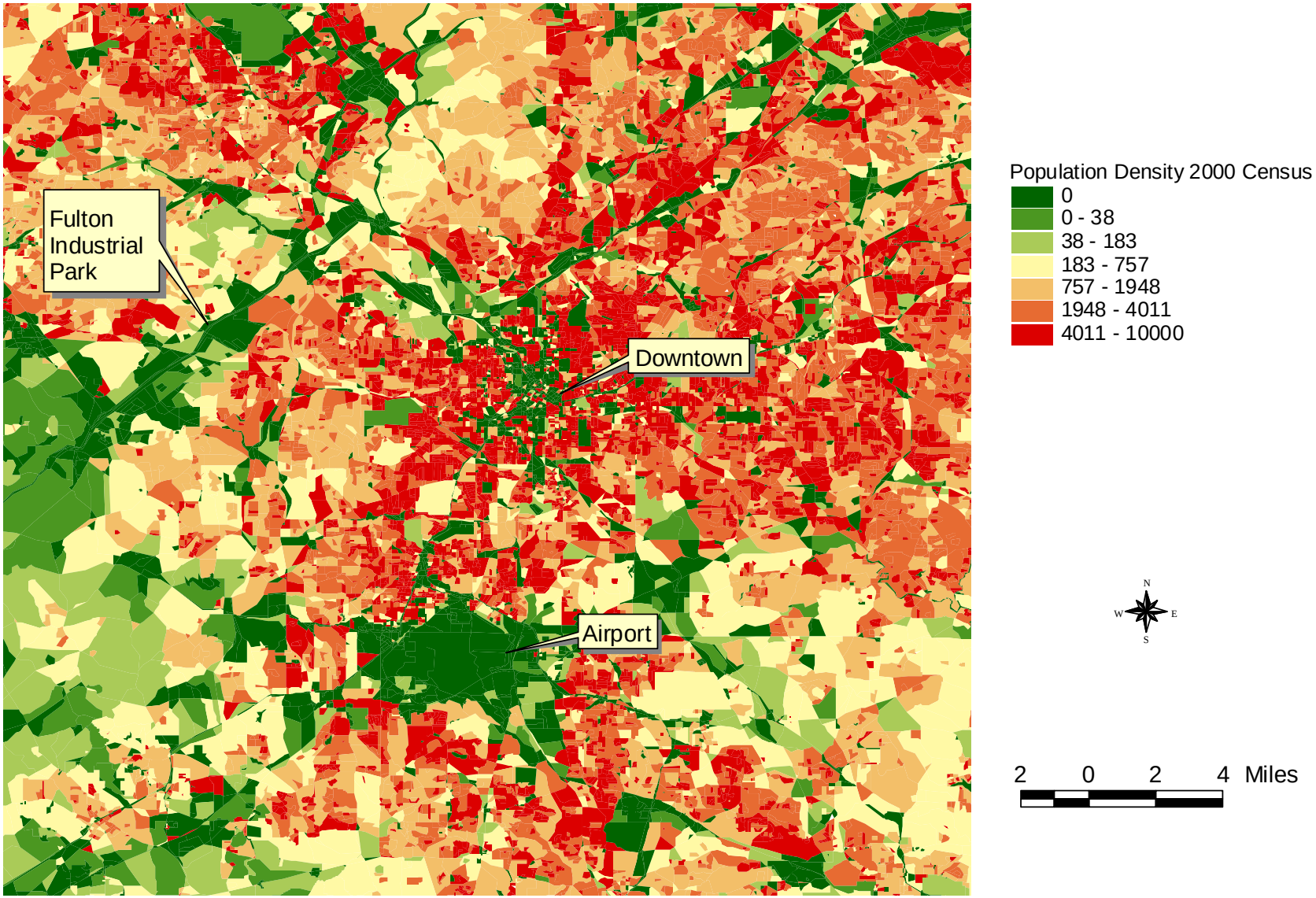
- < 10% impervious: Sensitive streams - usually good quality if riparian zones are intact
- 10 - 25% impervious: Impacted streams - clear signs of degradation
- > 25% impervious: Non-supporting streams- channel highly unstable

Georgia Population Density: 2000 Census (persons per square mile)

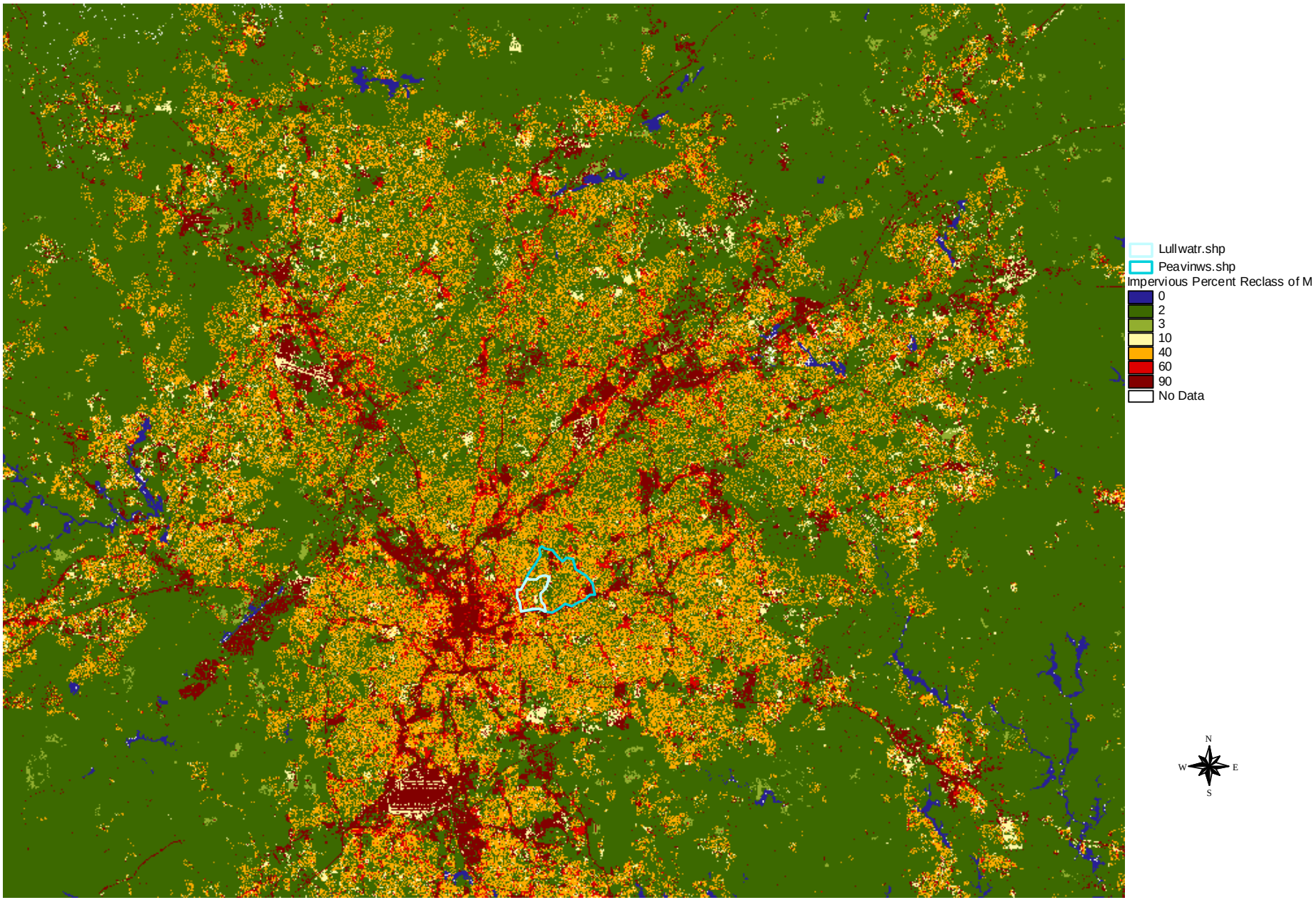


EPA 2002

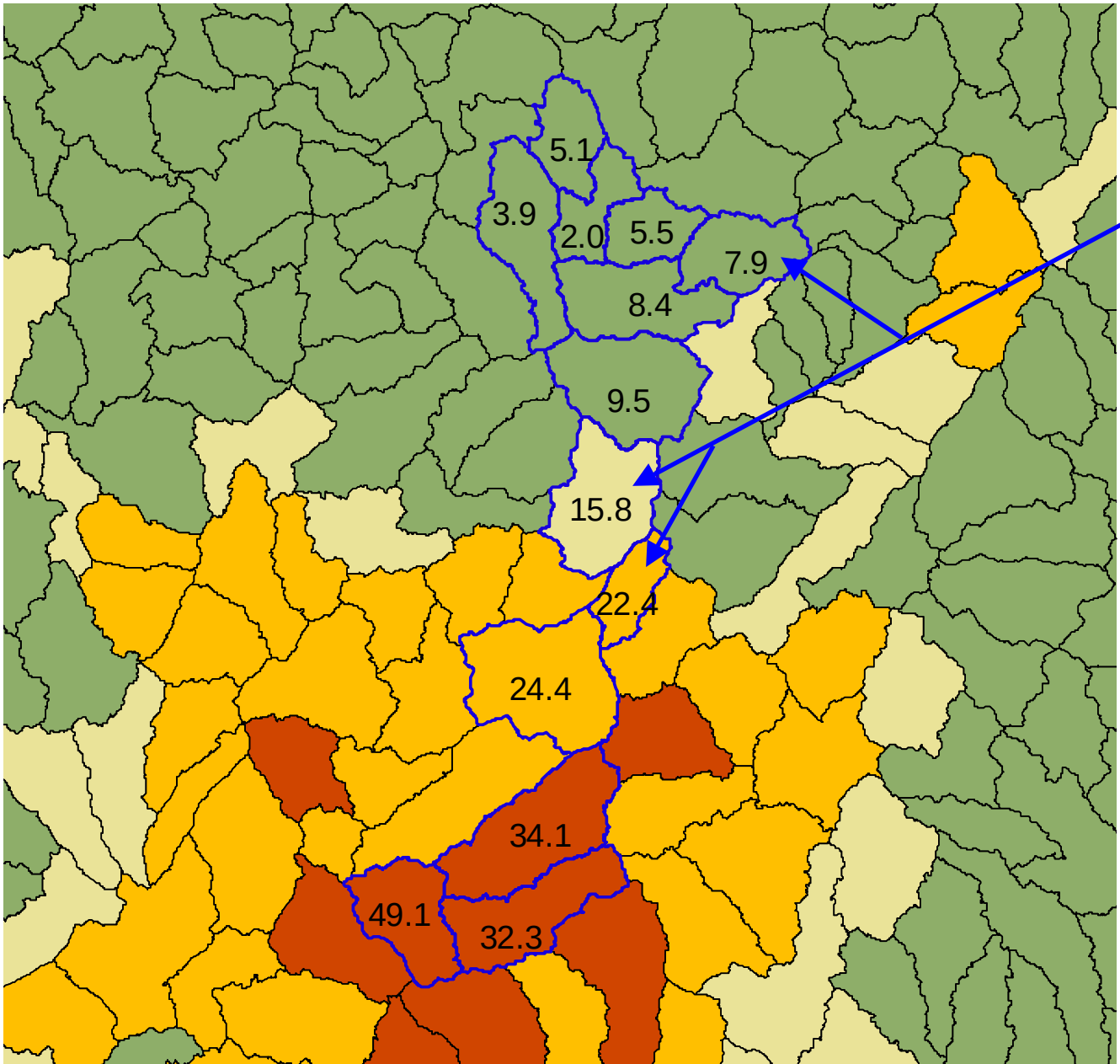
Atlanta, GA Population Density: 2000 Census



North Atlanta
(Percent Impervious Reclass from MRLC)



1999 Air Photo Results (DOQQ): Percent Impervious



TAI Doubles:
1993 to 1999

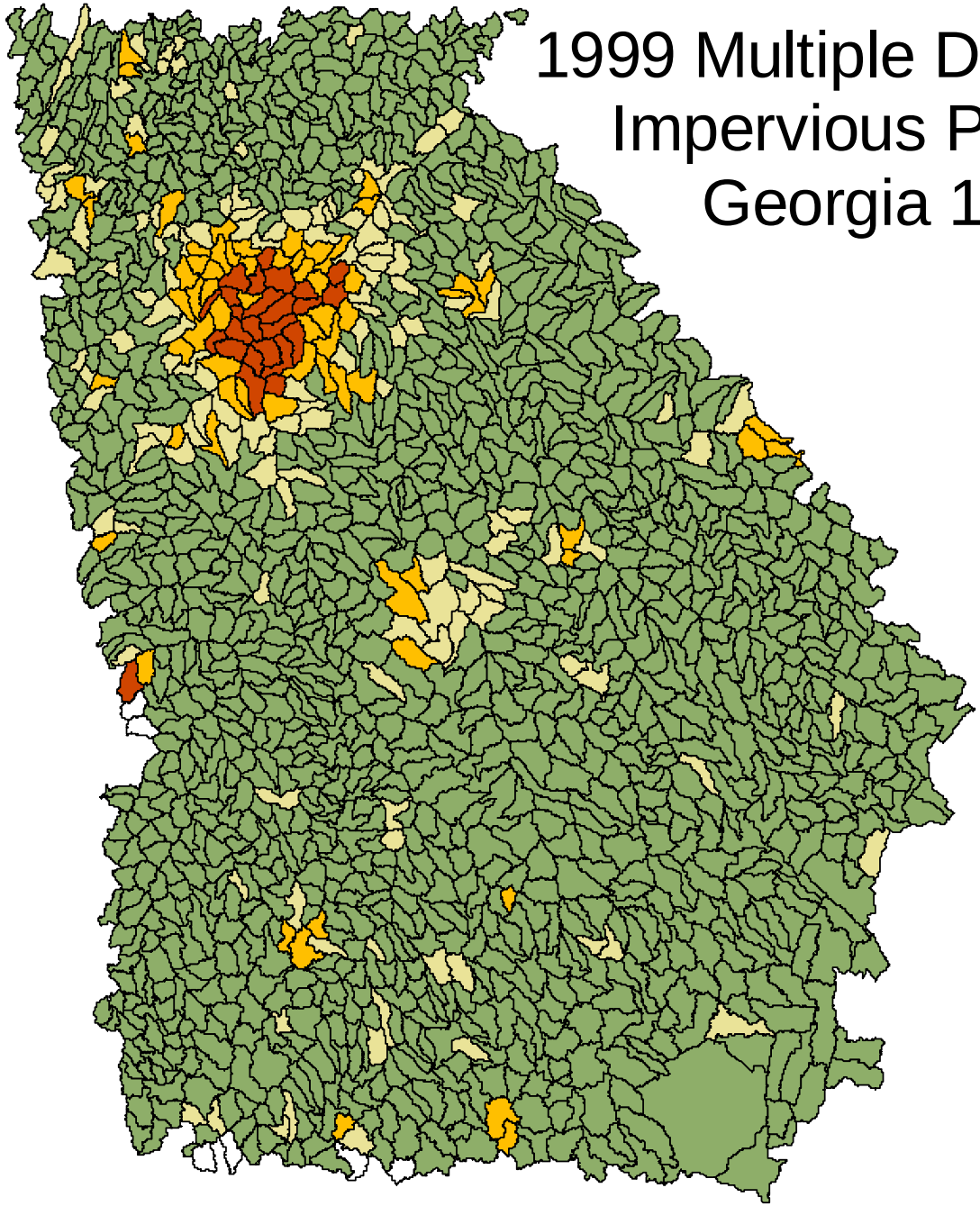
Air Photo (DOQQ) Interpreted HUCs
1993 NLCD Only (%TIA)
0.22 - 4.999
5 - 9.999
10 - 24.999
25 - 60

7 0 7 14 Kilometers

N
W E
S

EPA 2002

1999 Multiple Data Source (MDS) Impervious Percent Estimate Georgia 12 digit HUCs



1999 MDS (%TIA)

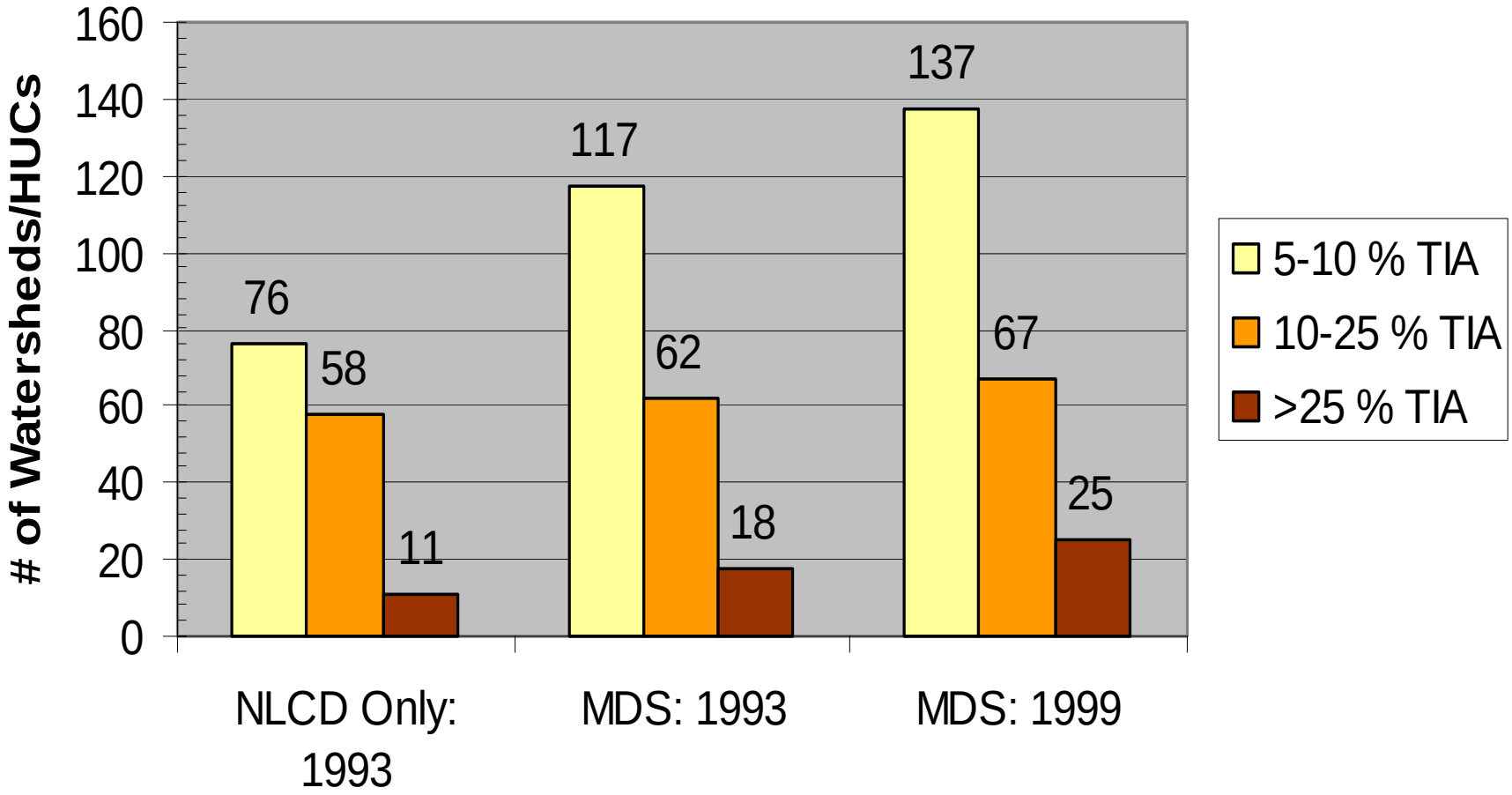
- 0.22 - 4.999
- 5 - 9.999
- 10 - 24.999
- 25 - 60

30 0 30 60 Kilometers

N W E S

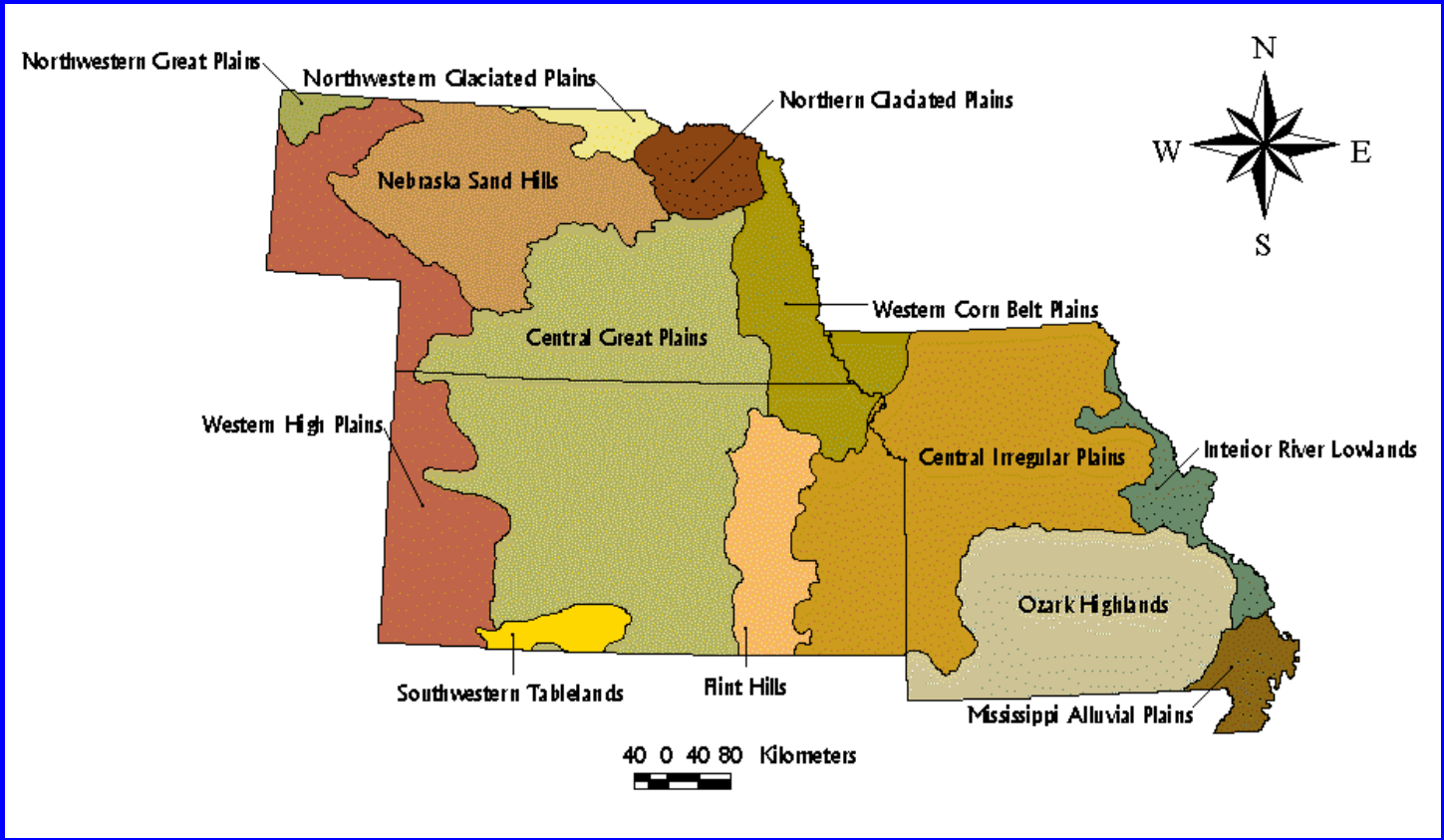
EPA 2002

Number of Georgia Watersheds/HUCs by Impervious Class



“Interrelationships among Landscapes, NDVI, and Stream Water Quality in the U.S. Central Plains”

Level III Ecoregions

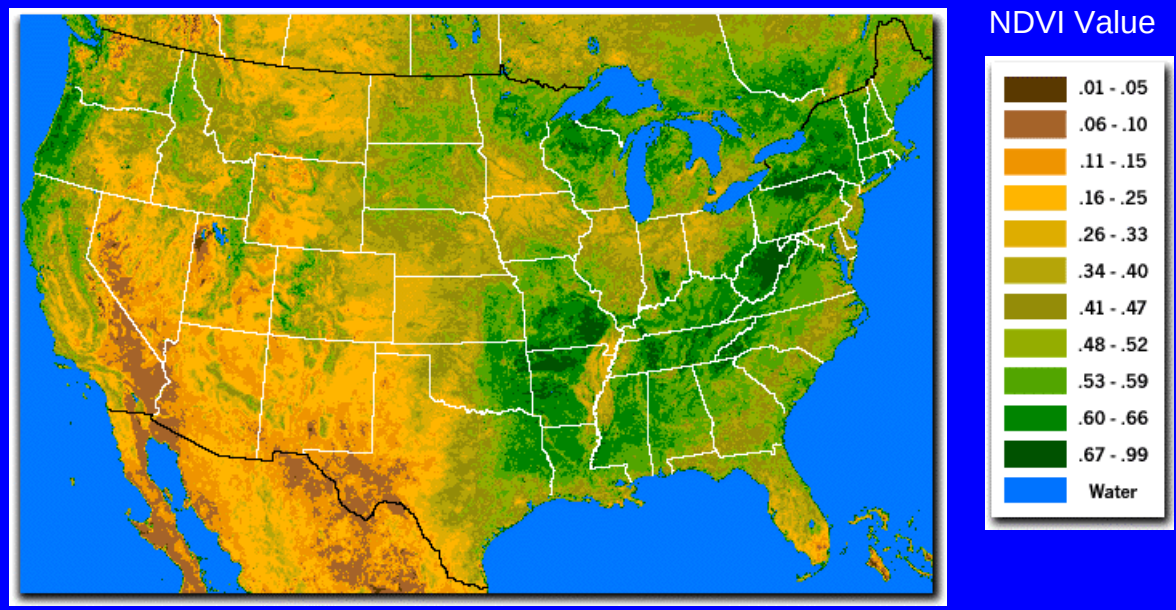


Jerry Griffith (U. of Southern MS), Edward Martinko (U KS), Jerry Whistler (U KS) and Kevin Price (U KS). 2002. Ecological Applications. Interrelationships among Landscapes, NDVI, and Stream Water Quality in the U.S. Central Plains. 12(6), pp. 1702 -1718.

What is NDVI?
(Normalized Difference Vegetation Index)

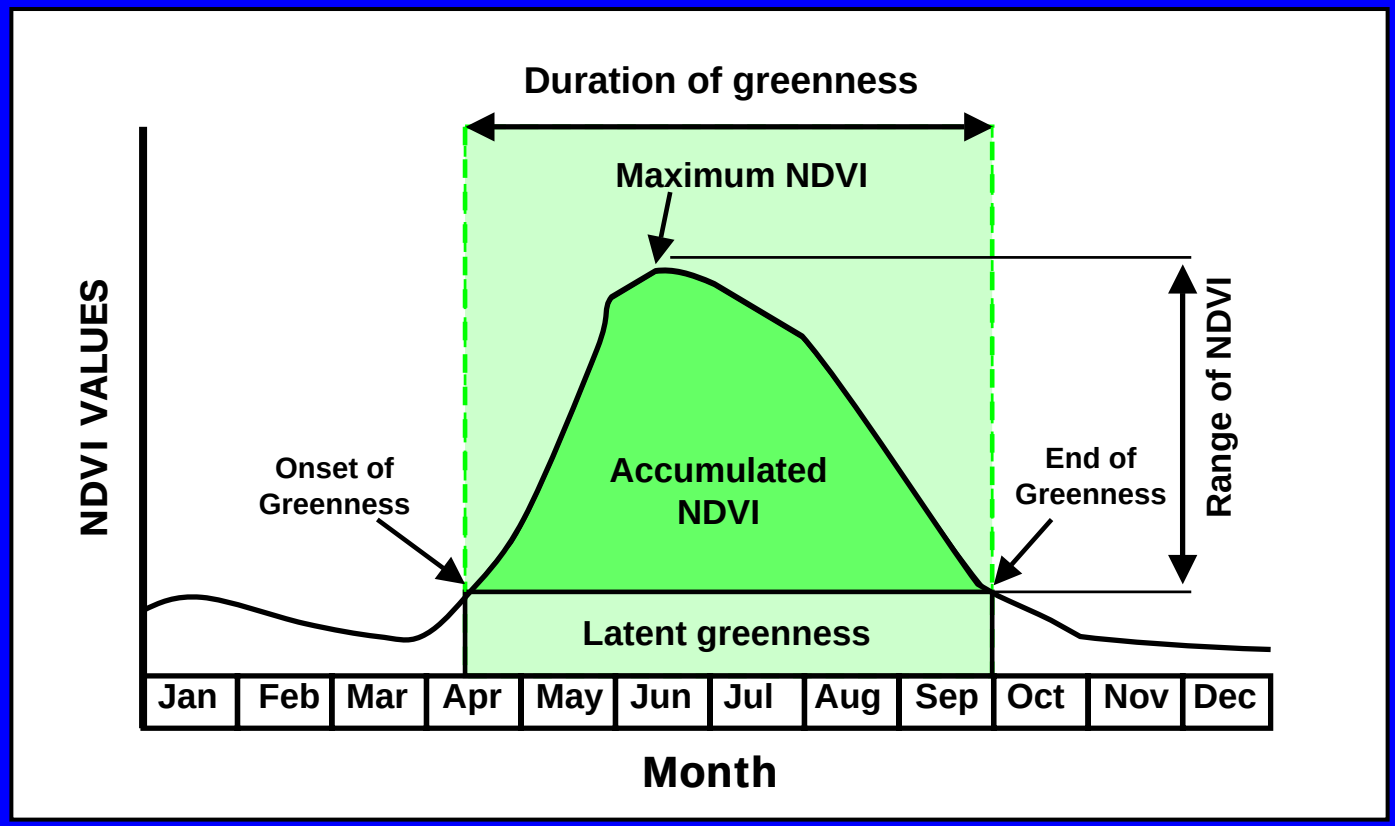
- NDVI is a ratio based on the relative reflectance values in the red and near infrared (NIR)
- NDVI = (NIR - Red) / (NIR + Red)
- NDVI is correlated with green plant biomass and is often used as a surrogate for primary plant productivity
- higher NDVI values = higher amounts of live plant biomass

NDVI Map for Period 24, June 2 - June 15, 2000



Q: What are VPMs? (Vegetation Phenological Metrics)
A: Metrics based on a time series of NDVI images.

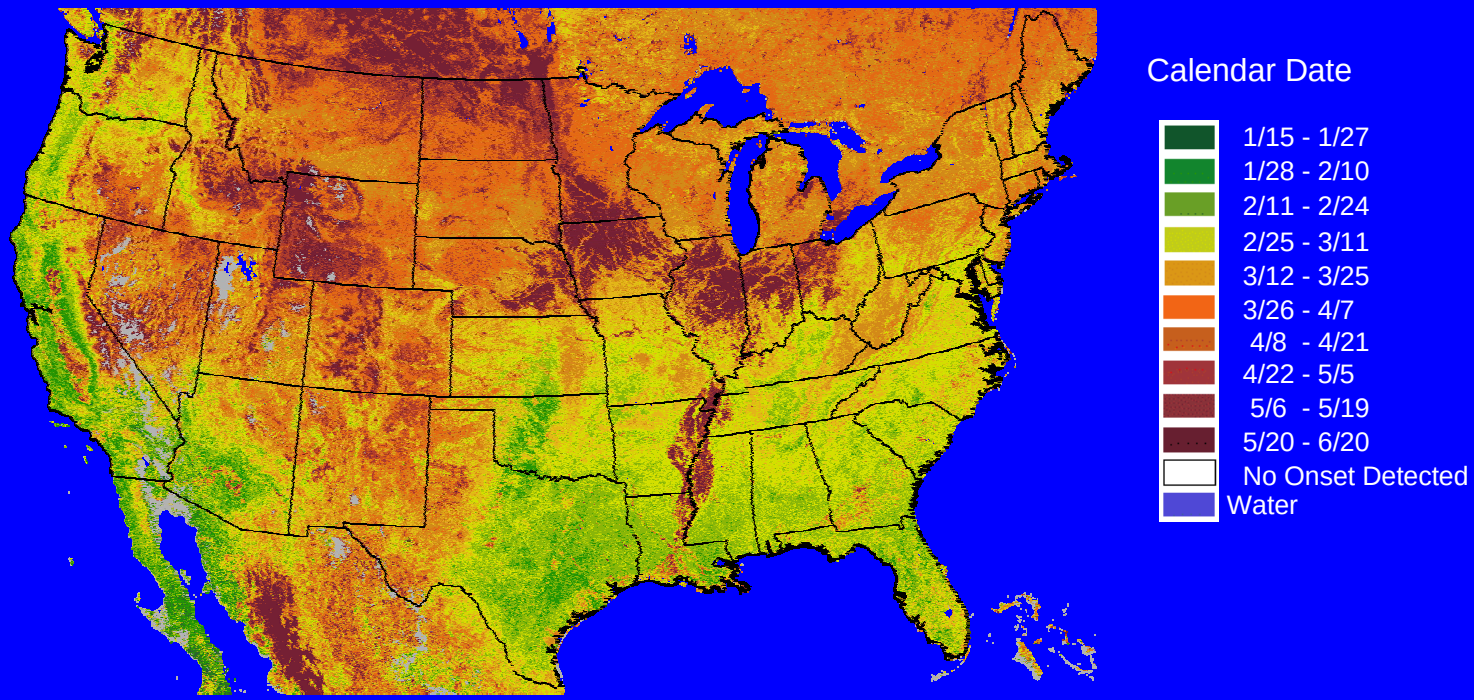
Vegetation Phenology Curve and Derived Vegetation Phenology Metrics



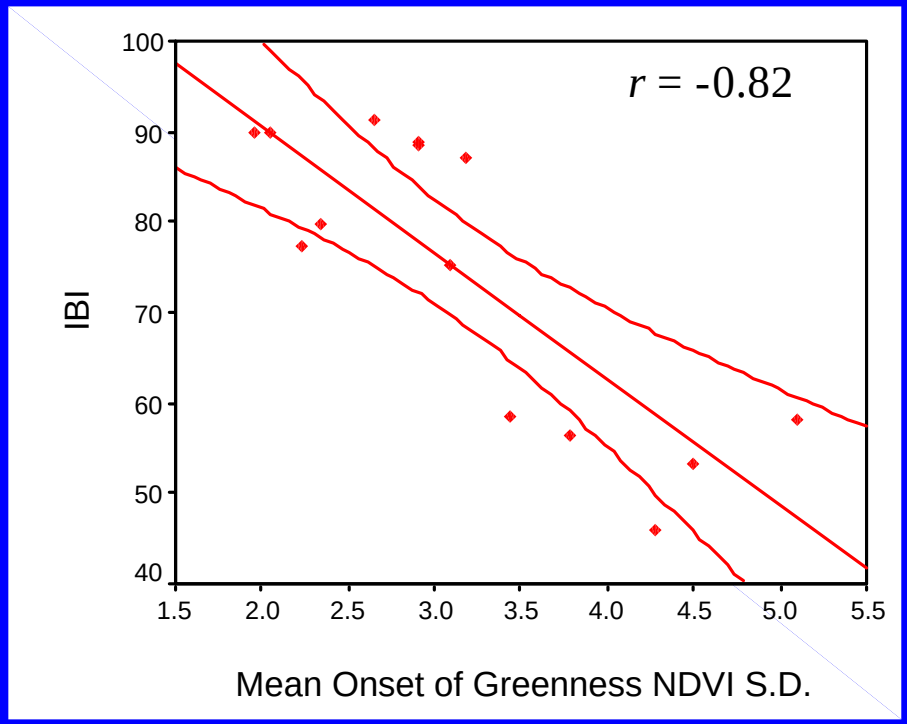
Onset Date Metric Example

- The Onset Date Metric represents the Julian date that the AVHRR sensor detects vegetation green up

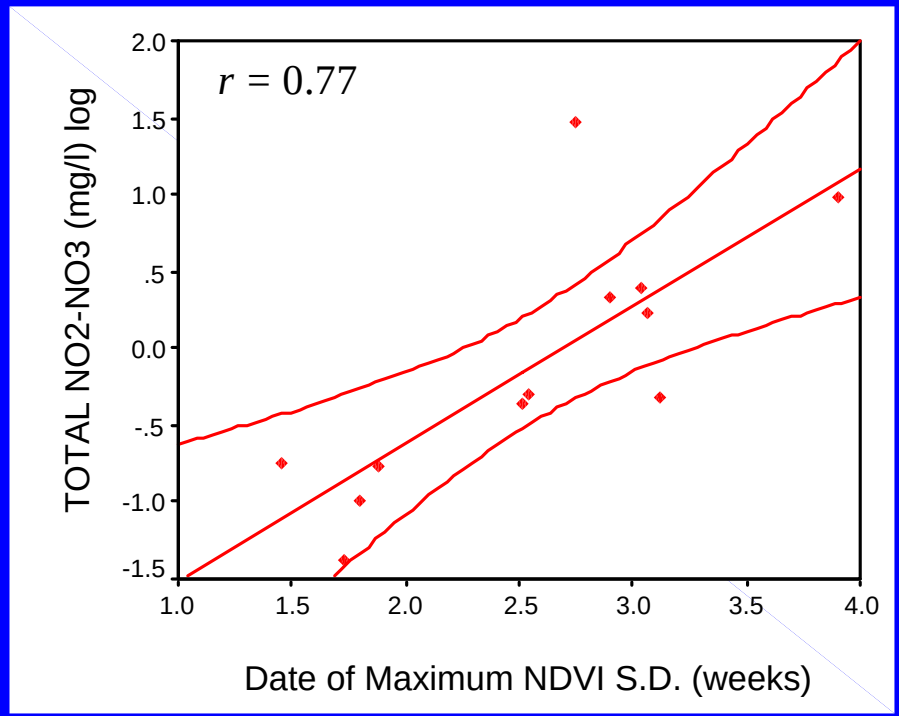
11-year Average Onset of Greenness for Vegetation in the United States



Ozark Highlands (< 50 km^2)



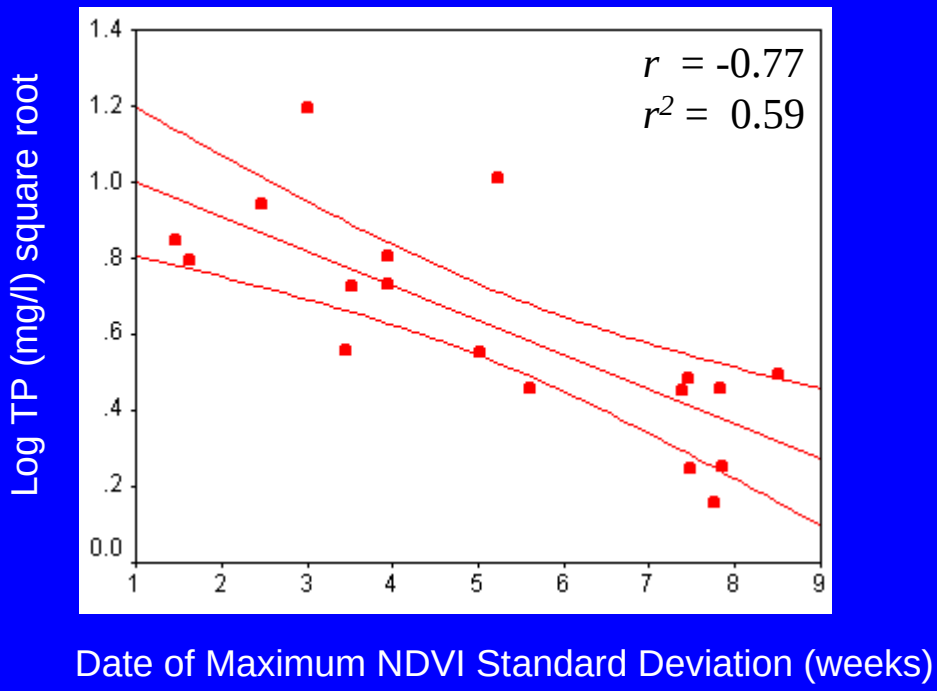
Ozark Highlands (> 260 km^2)



Ozark Highlands > 260 km^2	***% ag.***	***% forest***	***% urban***
Date of max. NDVI s.d.	**0.75**	**-0.75**	**0.80**

Map Application - Total Phosphorous in the Central Great Plains

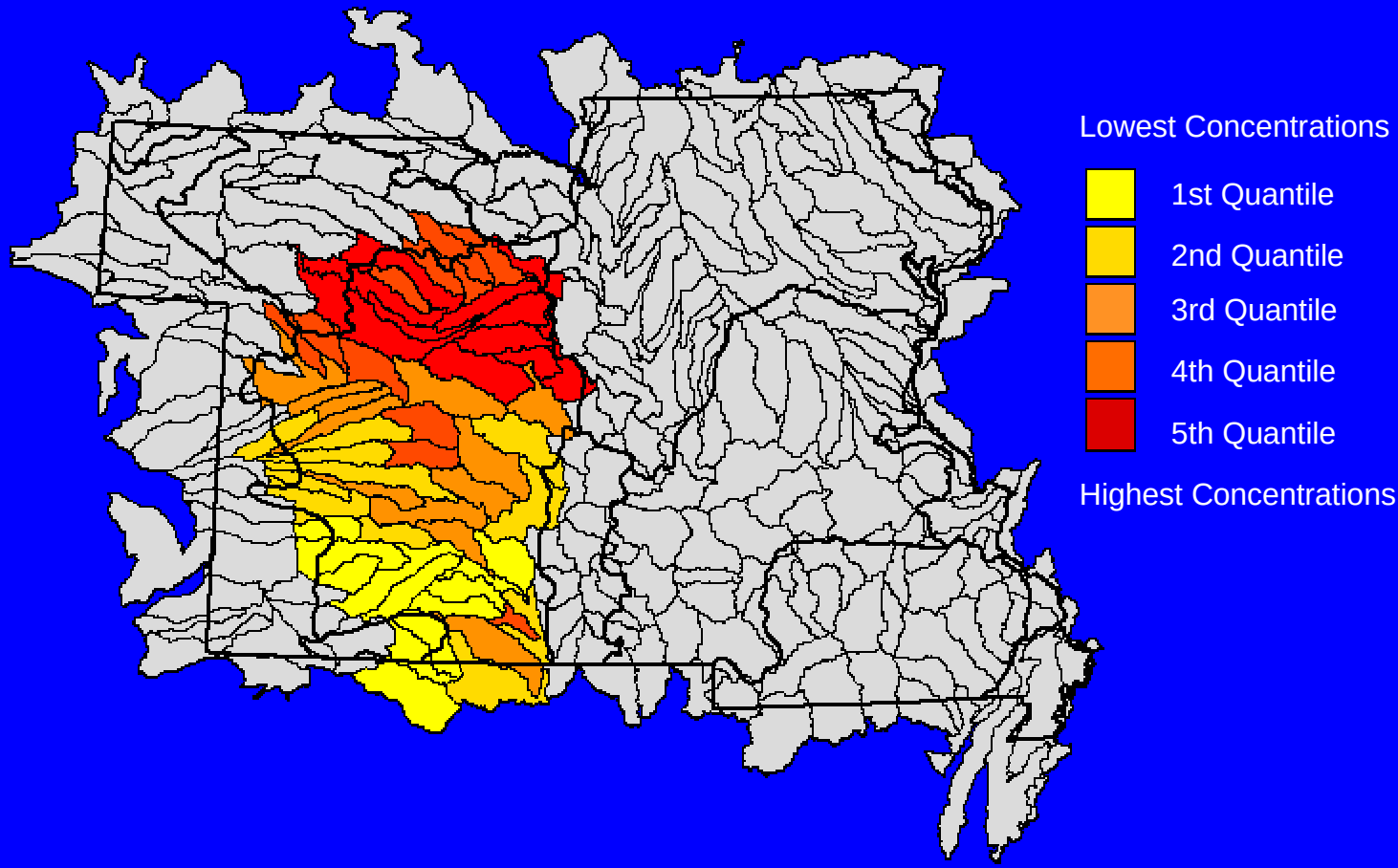
Scatterplot with 95% confidence interval shown around regression line



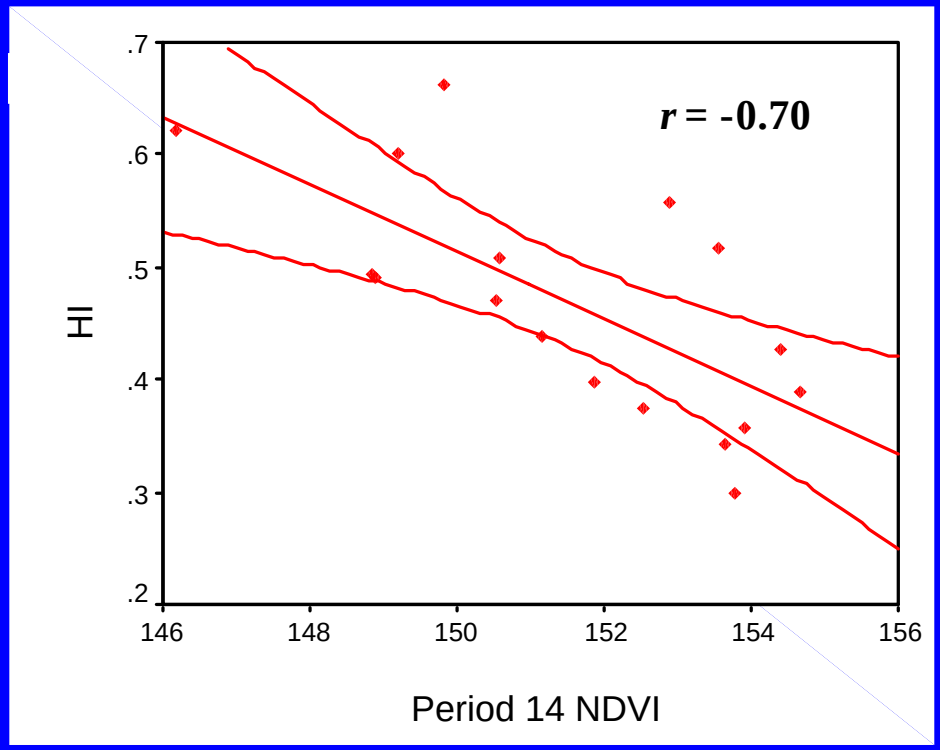
Regression Equation:

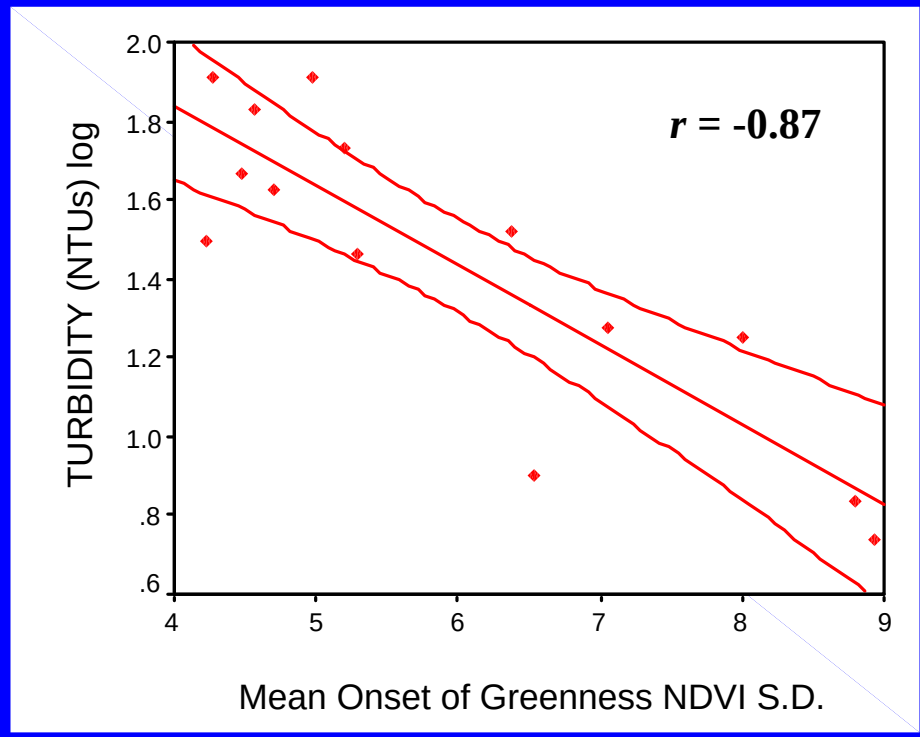
TP = 1.092 + -9.08E-02 x date of max NDVI sd
Adjusted r^2 = 0.56

Potential Total Phosphorous - Central Great Plains

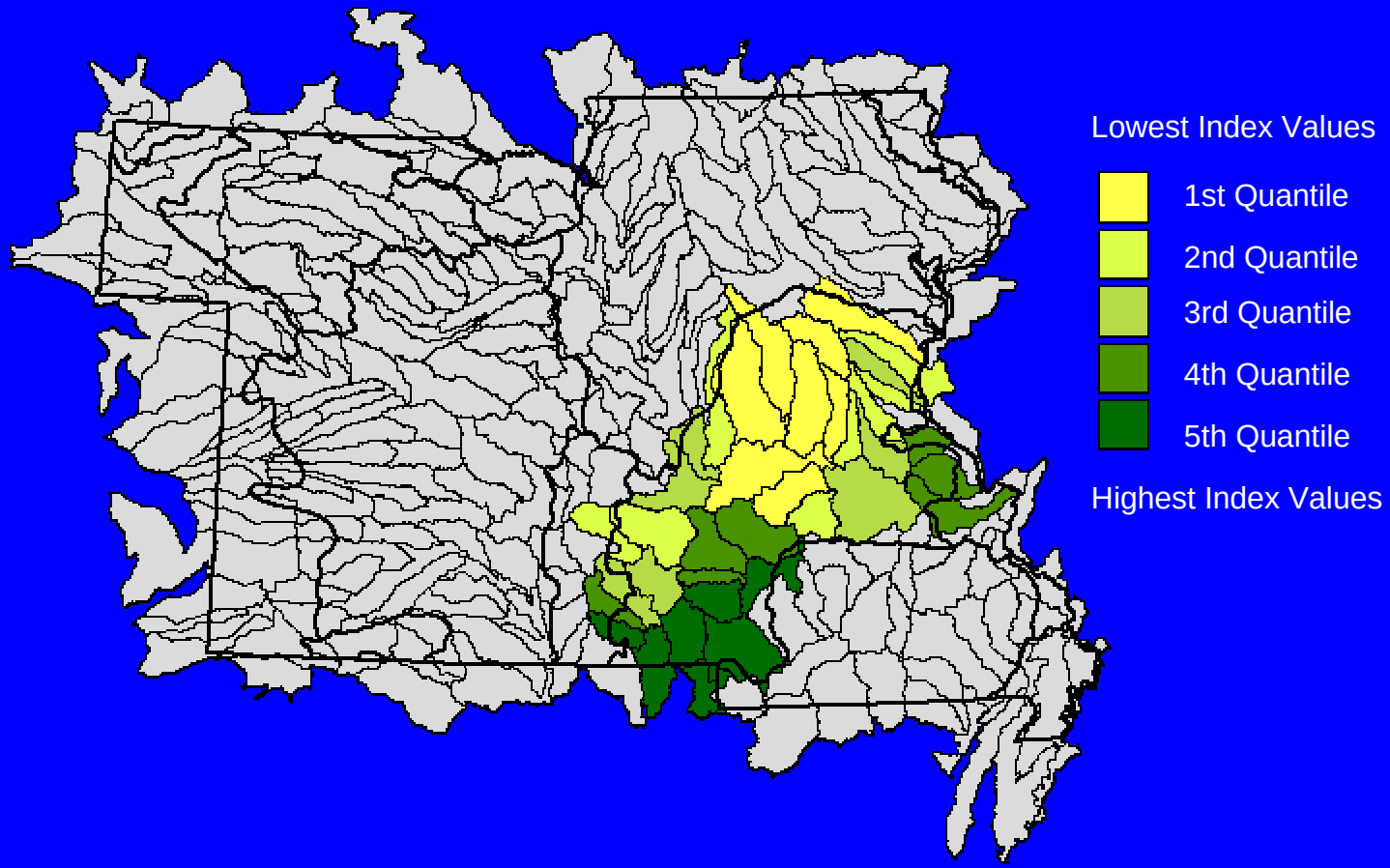


Central Irregular Plains (>260 km^2)





Potential Habitat Index - Central Irregular Plains



Conclusions

- NDVI and VPMs are biophysical integrators of watershed condition that correlate strongly with water quality and stream habitat conditions
- Early growing season NDVI or onset of greenness was most often correlated with water quality
- Stratifying watersheds by ecoregion yielded stronger relationships between the field data and landscape data

Human Disturbance Gradient Recommended Options

- Landscape Character (LC)
  - Satellite (NLCD) or air photo (DOQQ) LU/LC
  - N-Index ("natural" classes)
  - Greenness measures from NDVI/AVHRR
- Riparian Condition (RC)
  - Riparian buffer N-Index
  - Riparian components of habitat assessments

Recommended Options (cont.)

- Barriers (B)
  - Road/stream crossings
  - Dam/impoundment influenced reaches
- Channel Morphology (CM)
  - Channel stability
  - Pfankuch visual assessment
  - W/D ratio, area, etc. vs. reference & "regional" curves

Recommended Options (cont.)

- Habitat Structure
  - Visual habitat assessment "in-channel" factors
  - Pebble count (d50, %fines, etc.)
- Flow Regime (FR)
  - Hydrologic integrity metrics
  - Imperviousness
- Water Quality (WQ)
  - Turbidity/TSS, temp, diurnal DO, conductivity, nutrients

Needs for Data, Research and Application

- Regular updates of:
  - Satellite LU/LC (NLCD), AVHRR (NDVI) & MODIS (NDVI/EVI)
  - Roads
  - Population
  - Farm animal populations (cattle, hogs, etc.)
  - Pesticide/herbicide & fertilizer application
  - Atmospheric deposition (particularly N & Hg)
  - Air photos (Digital Orthophoto Quarter Quad's)

Needs (continued)

- More complete coverage for hydrography and watersheds
  - 1/24K hydrography (including intermittent & ephemeral)
  - Watersheds/12 digit HUC's
  - "Stream node" watersheds & point watershed tools

Needs (continued)

- Data Integration and Tools
  - Biological community, habitat, geomorphology and chemistry data collected and available through national systems (STORET)
  - Tools and resources to build relationships between landscape stresses/factors and in-stream conditions