Southeastern Wadeable Streams R-EMAP

Overview, Interim Findings, and Status

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Project Goals

- **Statistical characterization of wadeable streams Region-wide**
- **Complement to state random and non-random sampling**
- **Component of Regional integrated assessment [Regional Ecological Assessment Program (REAP)]**

GPRA

- **FY 2003 Core Performance Measures for Water:**

Wadeable Streams R-EMAP supports:

- **up-dating of Fish Consumption Advisory database**
- **up-dating of assessments of beneficial use support [GOMP]**
- **assessment for Watershed Restoration Action Strategies**

Process

- Acquire R-EMAP sample points
- Expand scope of data
- Add ecoregional reference sites
- Contractor support
  - Permission for access
  - Reconnaissance
  - Sampling
  - Identification
- Descriptive, spatial, & temporal statistics
- Multivariate analyses

DQOs

- 10 % precision, at
- 90 % confidence,
- requires n = 200.

- QA/QC per EPA SOPs

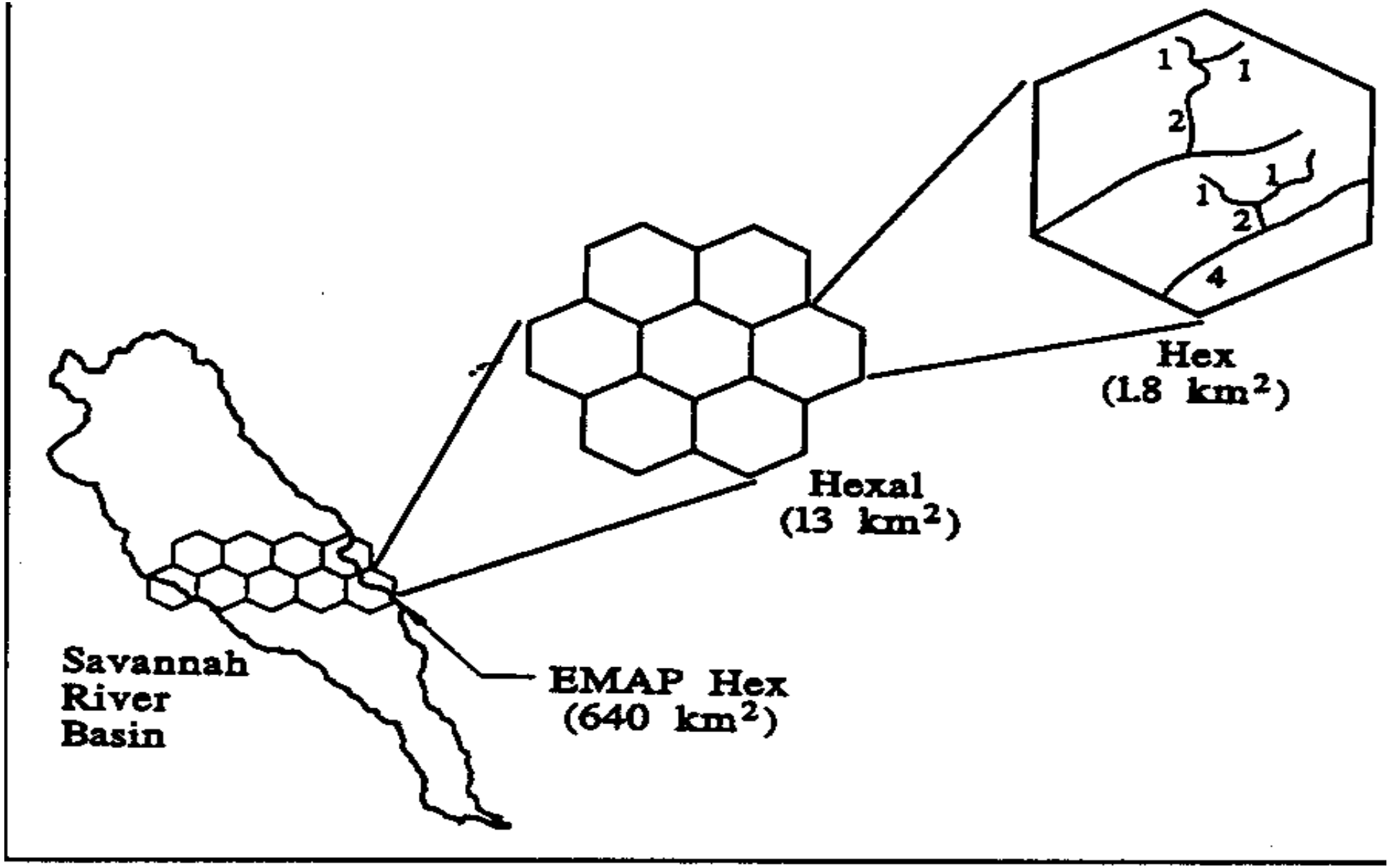


Figure 2.1. Illustration of Base Grid for the Savannah River Basin

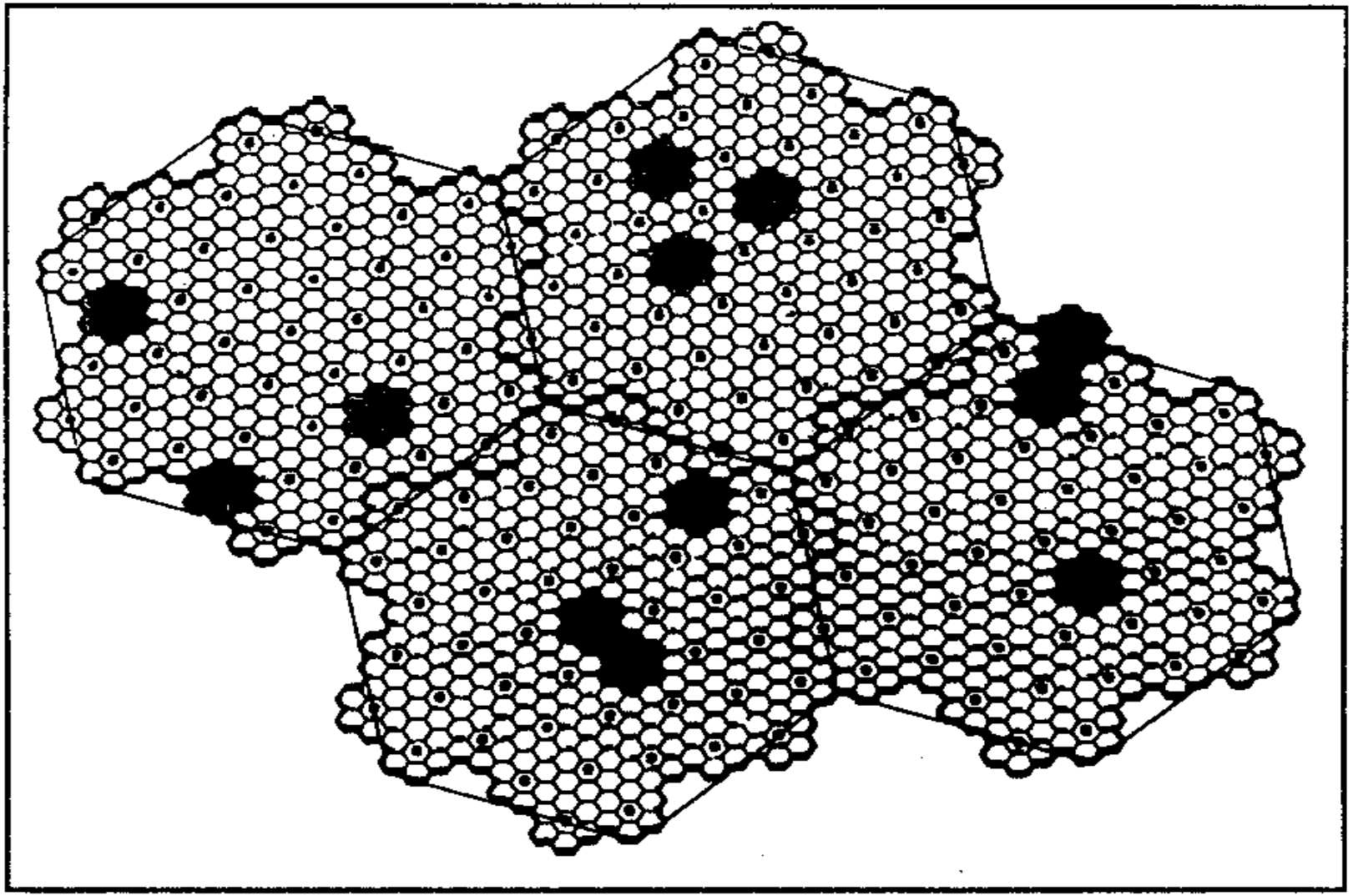


Figure 2.2. Illustration of Random Selection of Hexals from 640-km^2 Hexagon

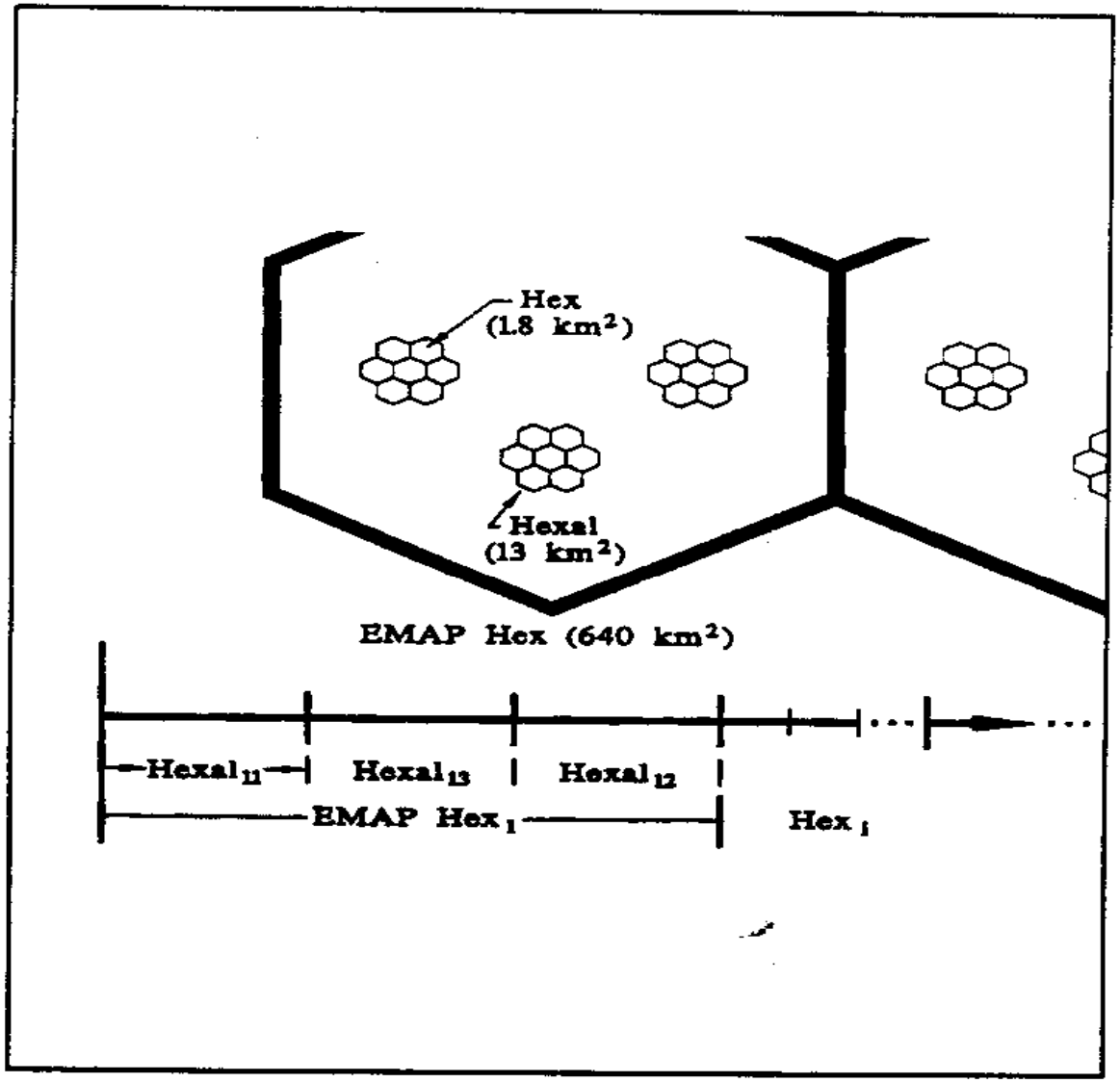


Figure 2.4. Total Weighted Stream Length Selected in Stage I Sample

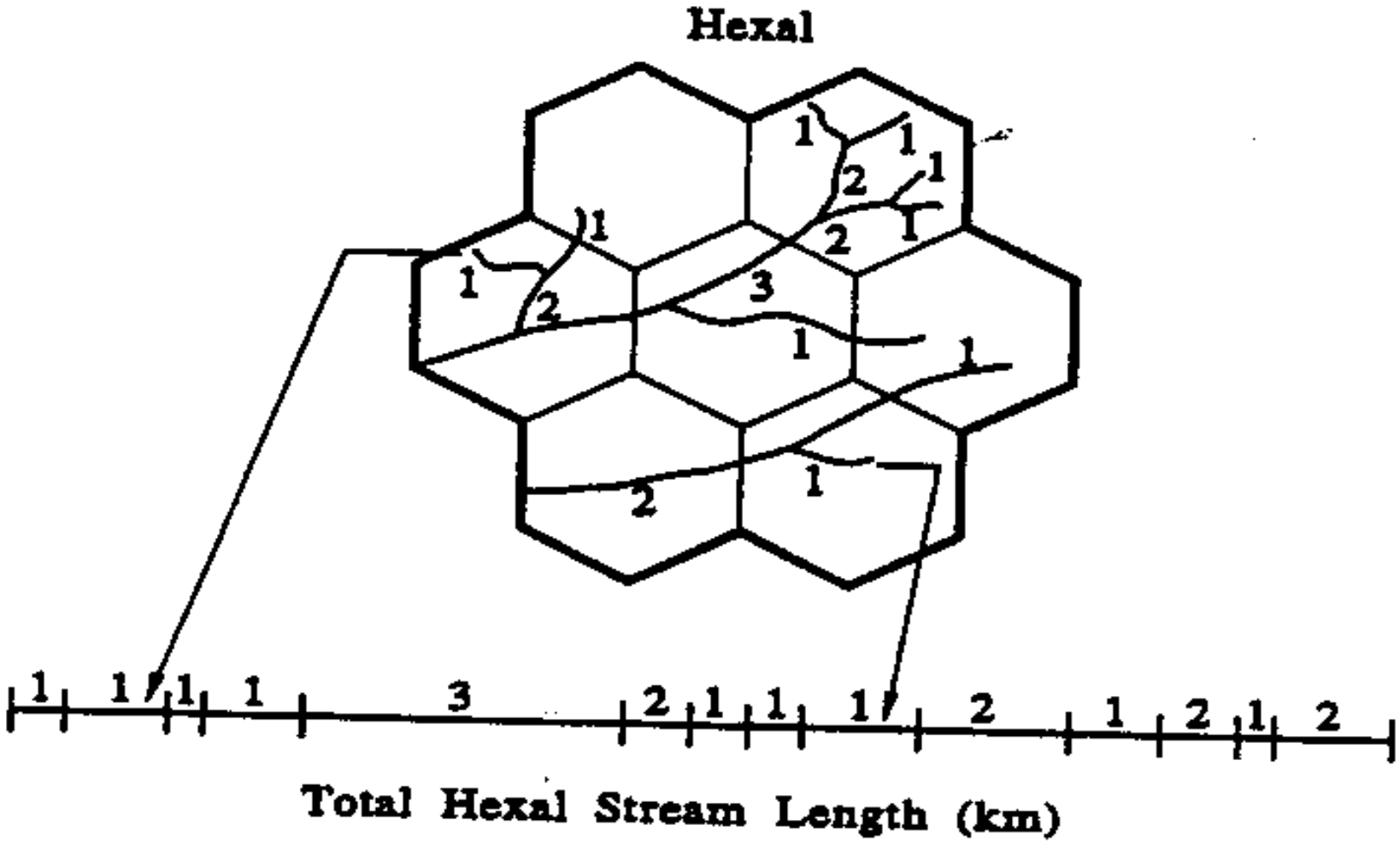
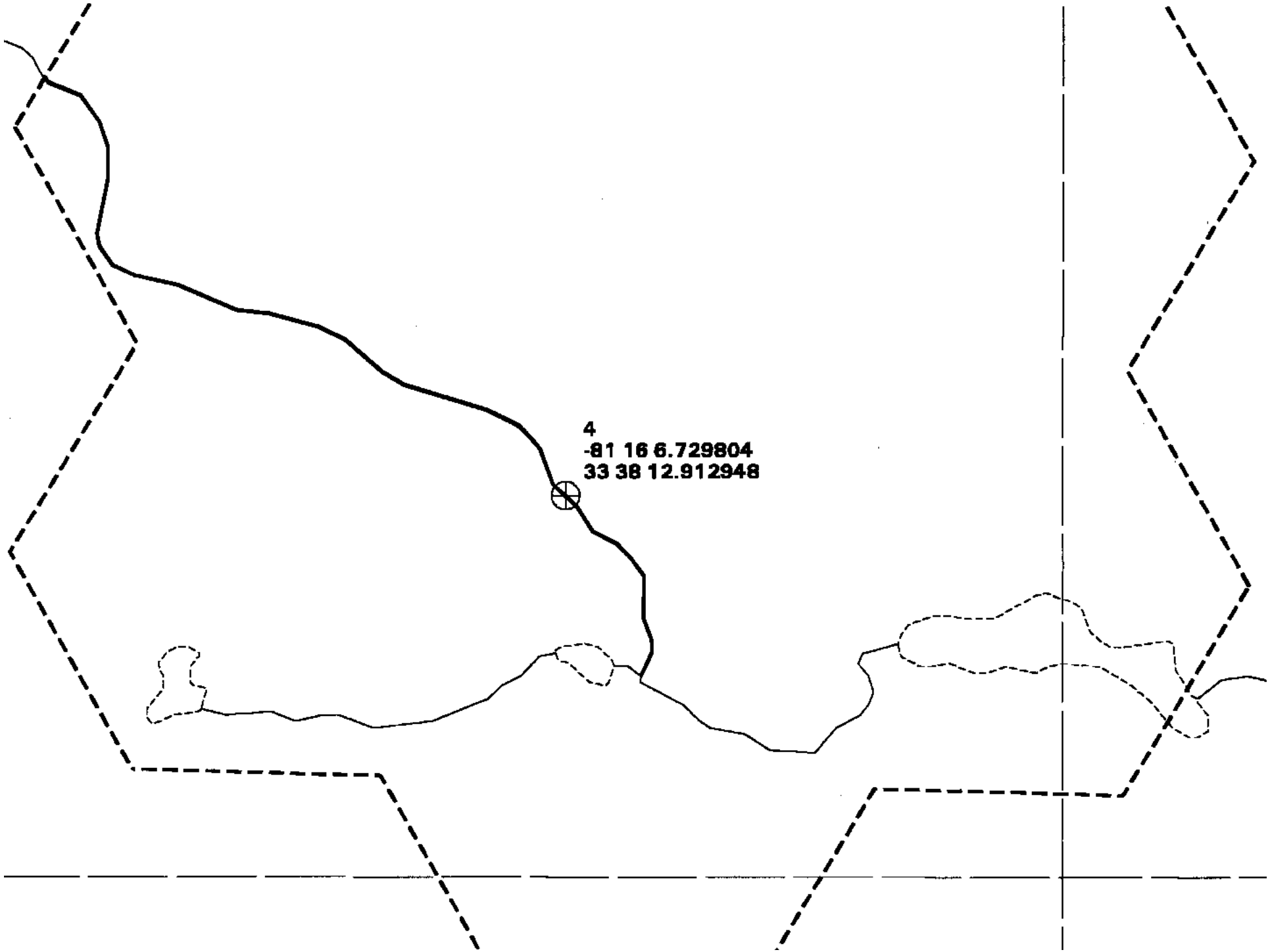
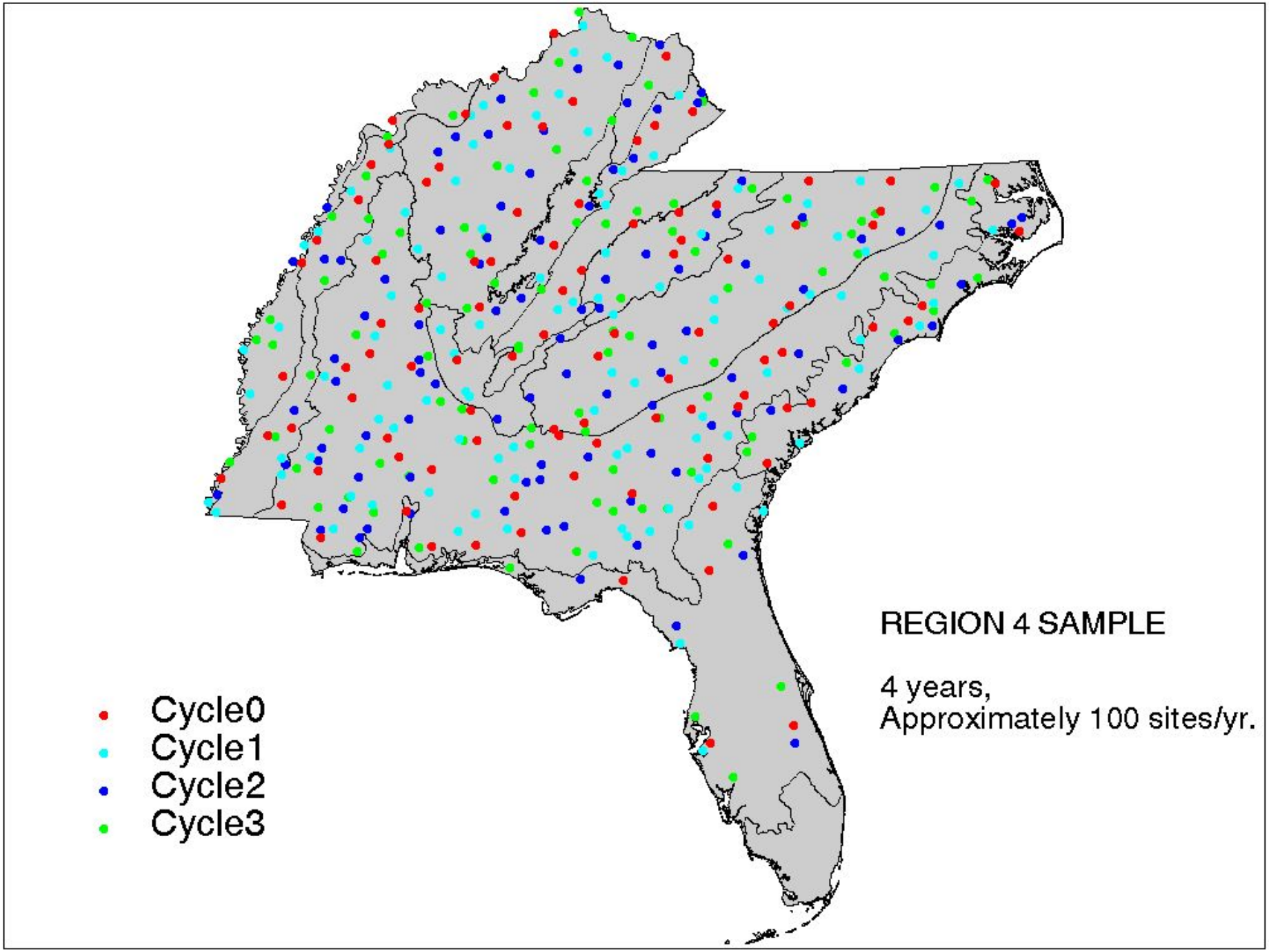
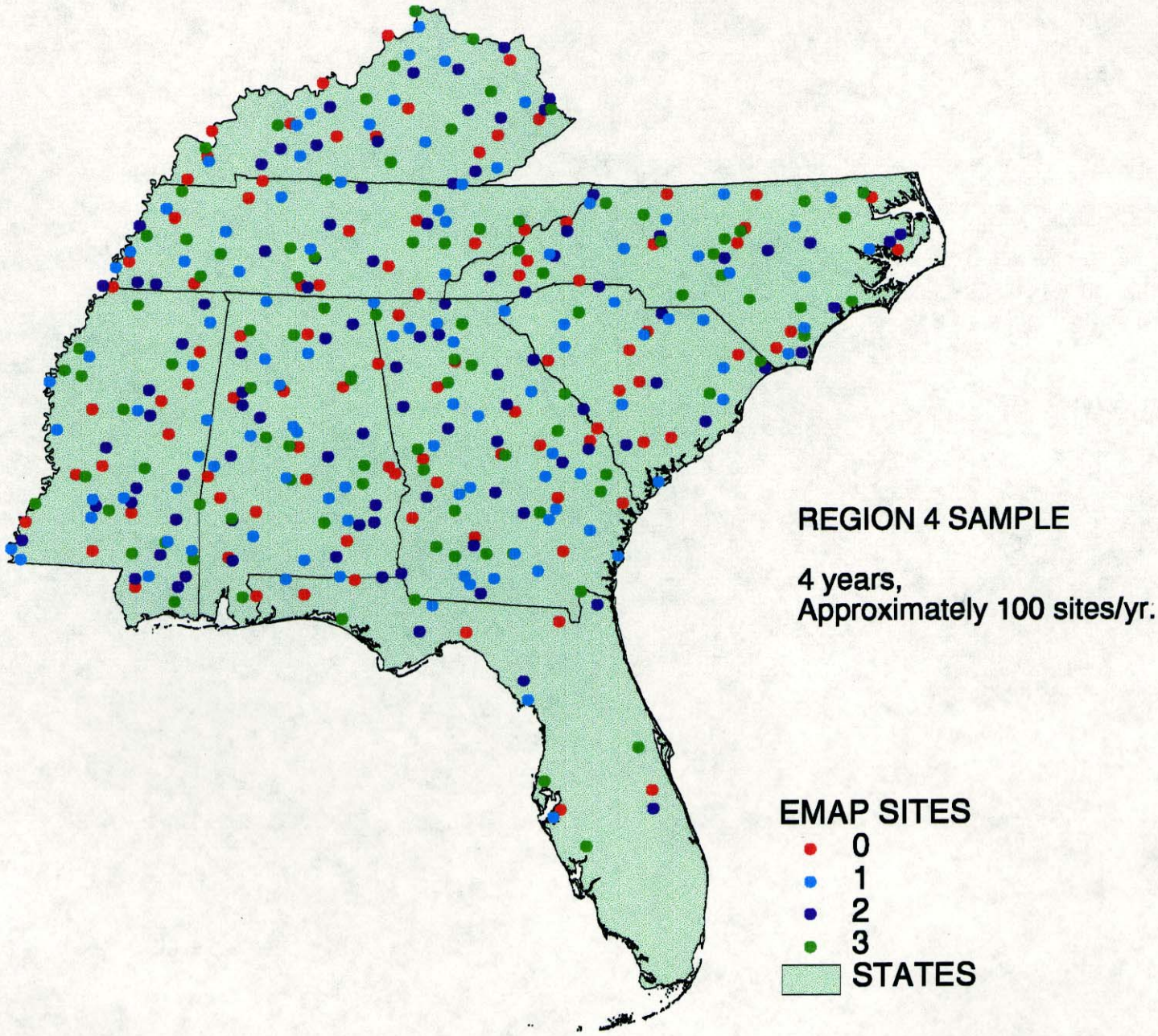
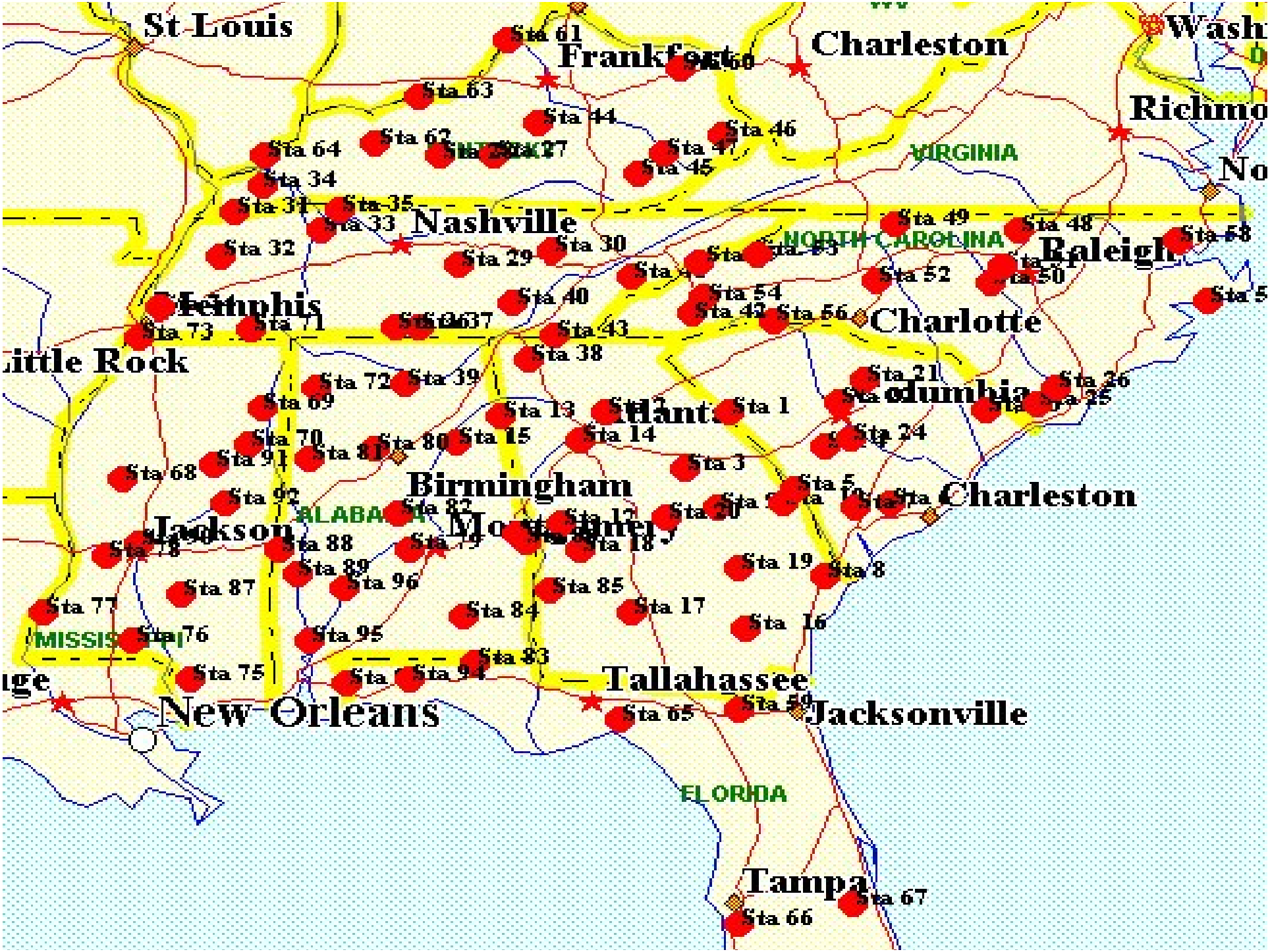


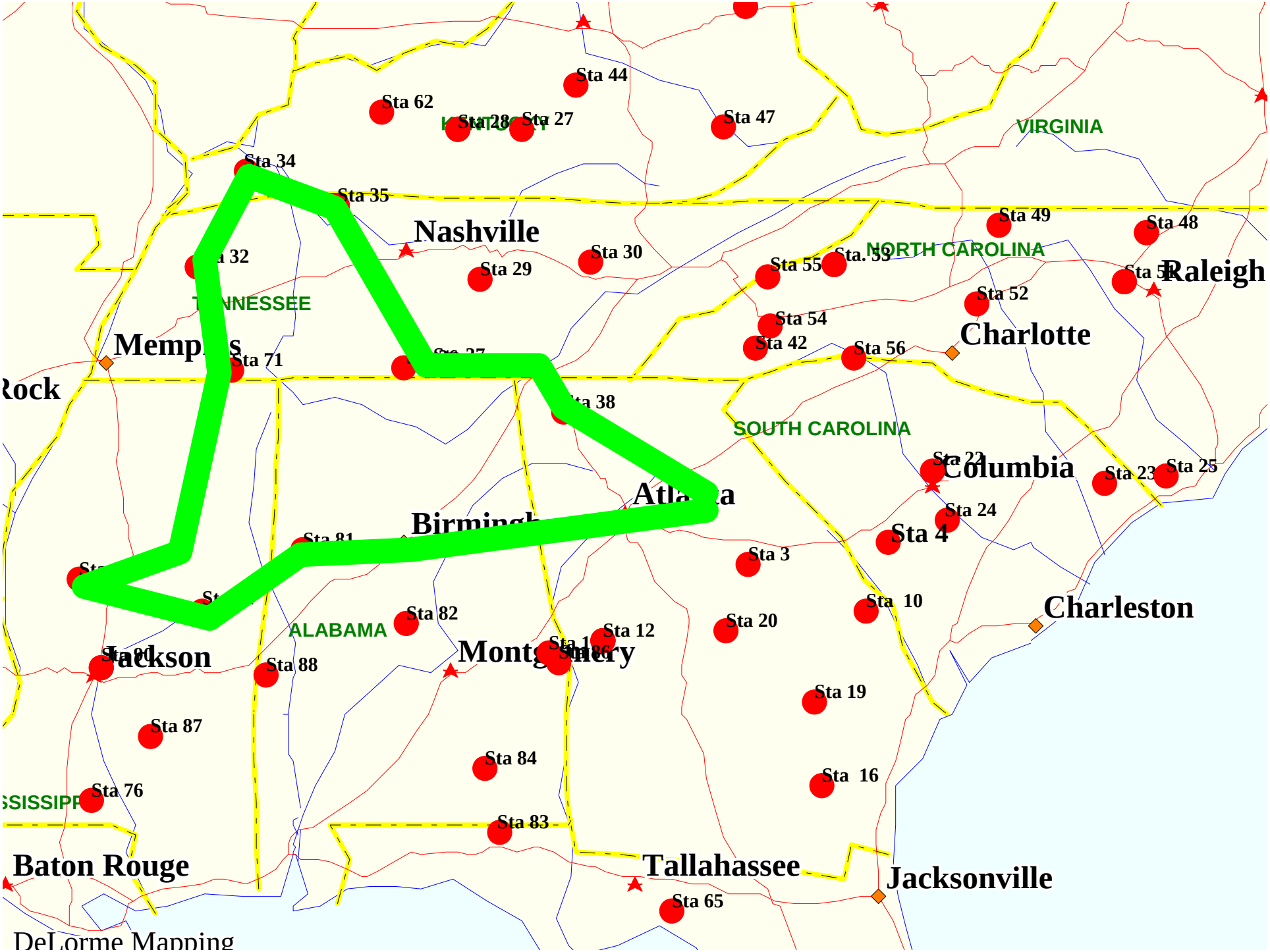
Figure 2.3. Weighted Hexal Stream Length

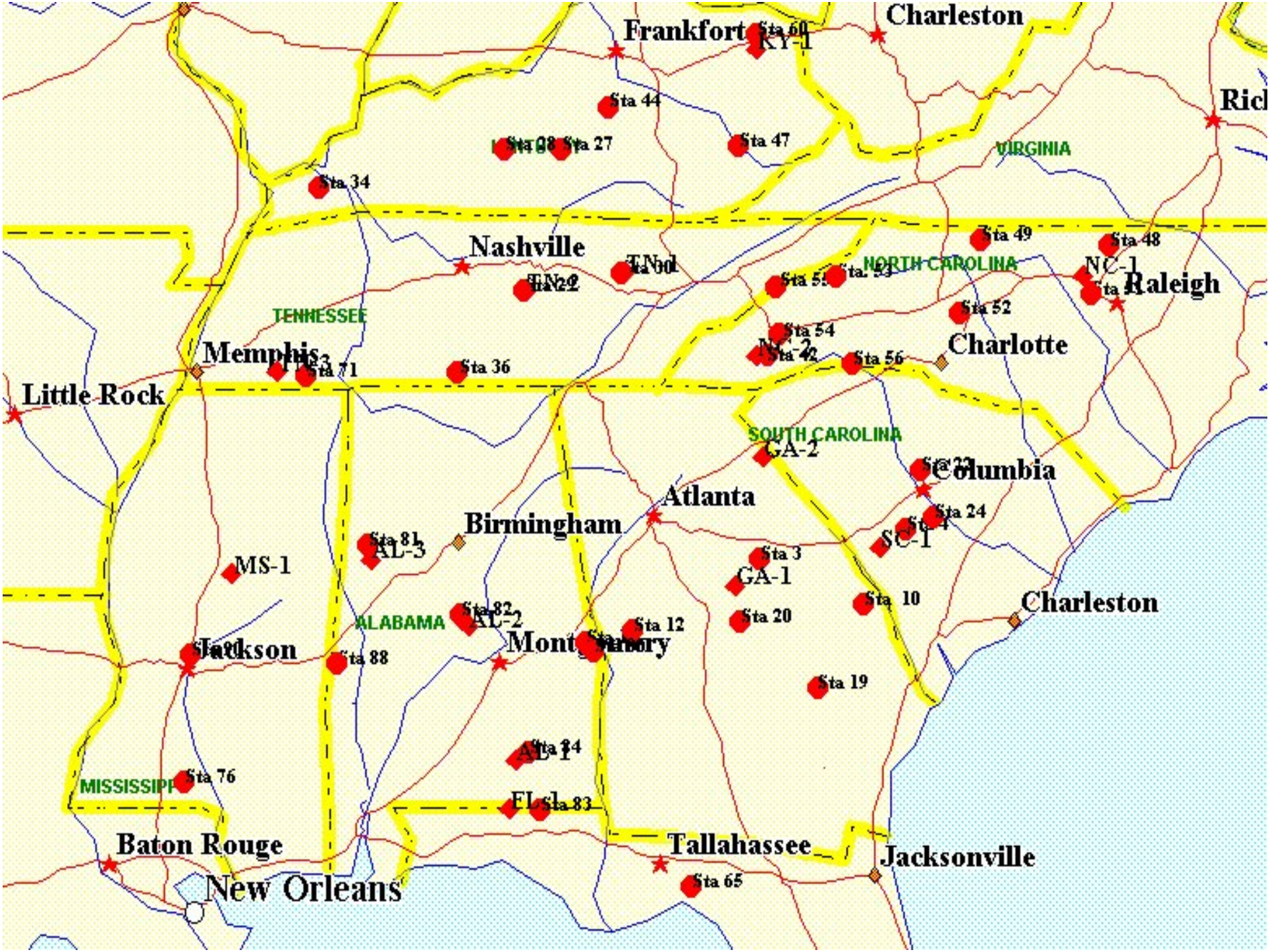

4
-81 16 6.729804
33 38 12.912948


REGION 4 SAMPLE
4 years,
Approximately 100 sites/yr.
Cycle0
Cycle1
Cycle2
Cycle3


REGION 4 SAMPLE
4 years,
Approximately 100 sites/yr.
EMAP SITES
0
1
2
3
STATES


St Louis
Frankfort
Charleston
Richmo
VIRGINIA
Nashville
NORTH CAROLINA
Raleigh
Memphis
Charlotte
Little Rock
Atlanta
Columbia
Birmingham
Charleston
ALABAMA
Jackson
Montgomery
MISSIS
New Orleans
Tallahassee
Jacksonville
FLORIDA
Tampa
Sta 61
Sta 63
Sta 44
Sta 46
Sta 64
Sta 62
Sta 47
Sta 45
Sta 34
Sta 31
Sta 35
Sta 33
Sta 32
Sta 29
Sta 30
Sta 49
Sta 48
Sta 52
Sta 50
Sta 40
Sta 54
Sta 42
Sta 56
Sta 73
Sta 71
Sta 43
Sta 38
Sta 72
Sta 39
Sta 21
Sta 26
Sta 69
Sta 13
Sta 1
Sta 24
Sta 70
Sta 80
Sta 15
Sta 14
Sta 91
Sta 81
Sta 68
Sta 3
Sta 92
Sta 82
Sta 5
Sta 88
Sta 19
Sta 8
Sta 89
Sta 96
Sta 87
Sta 85
Sta 77
Sta 84
Sta 17
Sta 16
Sta 76
Sta 95
Sta 83
Sta 75
Sta 94
Sta 65
Sta 66
Sta 67


Sta 44
Sta 62
Sta 28
Sta 27
Sta 47
VIRGINIA
Sta 34
Sta 35
Nashville
Sta 49
Sta 48
Sta 30
Sta 29
Sta 55
Sta. 53
NORTH CAROLINA
Raleigh
Sta 52
Sta 54
Sta 42
Sta 56
Charlotte
Sta 71
Sta 38
SOUTH CAROLINA
Columbia
Sta 23
Sta 25
Sta 24
Sta 4
Sta 3
Sta 10
Charleston
Sta 82
ALABAMA
Sta 12
Sta 20
Sta 88
Sta 19
Sta 87
Sta 84
Sta 16
Sta 76
Sta 83
Baton Rouge
Tallahassee
Jacksonville
Sta 65
DeLorme Mapping


Frankfort
Charleston
Rich
Sta 60
KY-1
Sta 44
Sta 27
Sta 47
VIRGINIA
Sta 34
Nashville
Sta 49
Sta 48
NORTH CAROLINA
NC-1
Raleigh
Sta 52
TENNESSEE
Sta 54
Charlotte
Memphis
Sta 71
Sta 36
Sta 56
Little Rock
SOUTH CAROLINA
GA-2
Columbia
Atlanta
Sta 24
Birmingham
Sta 81
AL-3
SC-1
Sta 3
MS-1
GA-1
Sta 10
Charleston
Sta 82
AL-2
Sta 20
ALABAMA
Sta 12
Jackson
Sta 88
Sta 19
Sta 34
AL-1
MISSISSIPPI
Sta 76
FL
Sta 83
Baton Rouge
Tallahassee
Jacksonville
Sta 65
New Orleans

Target Streams

-In 1999 96 streams were selected

*of those, 12 were too large or estuarine

*Permission was requested for 84 sites

*Permission was granted for 62 sites, of which none were inaccessible

*25 sites were non-target for a total of 37 sites being sampled

-14 reference sites sampled

(continued)

-In 2000 120 streams were selected

*of those, 13 were too large or estuarine

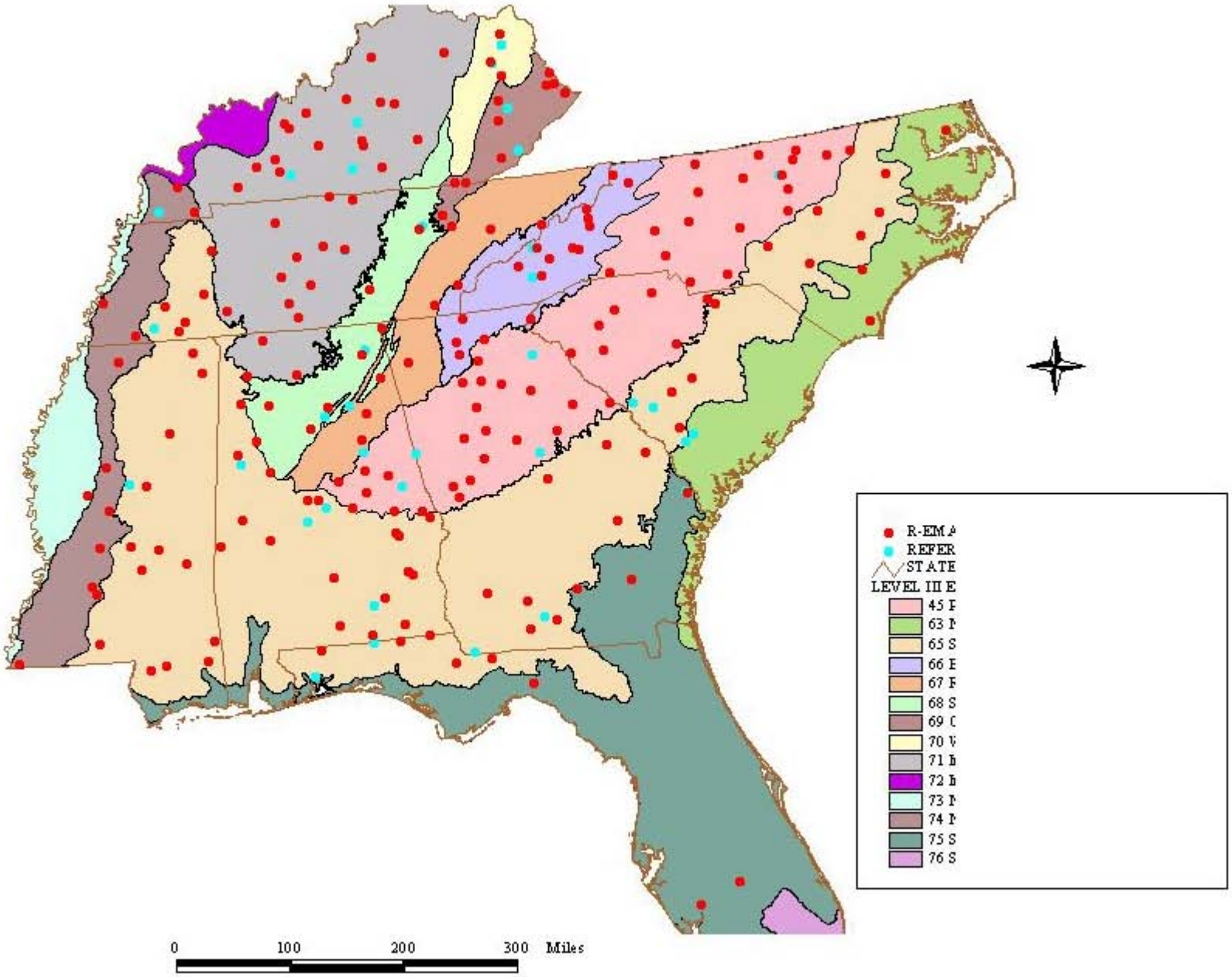
*Permission was requested for 107 sites

*Permission was granted for 88 sites, of which 16 were inaccessible

*17 sites were non-target for a total of 52 sites being sampled

-9 reference sites sampled

WADEABLE STREAM STATIONS SAMPLED, 1999, 2000, 2001 AND 2002



6 23 '99

A

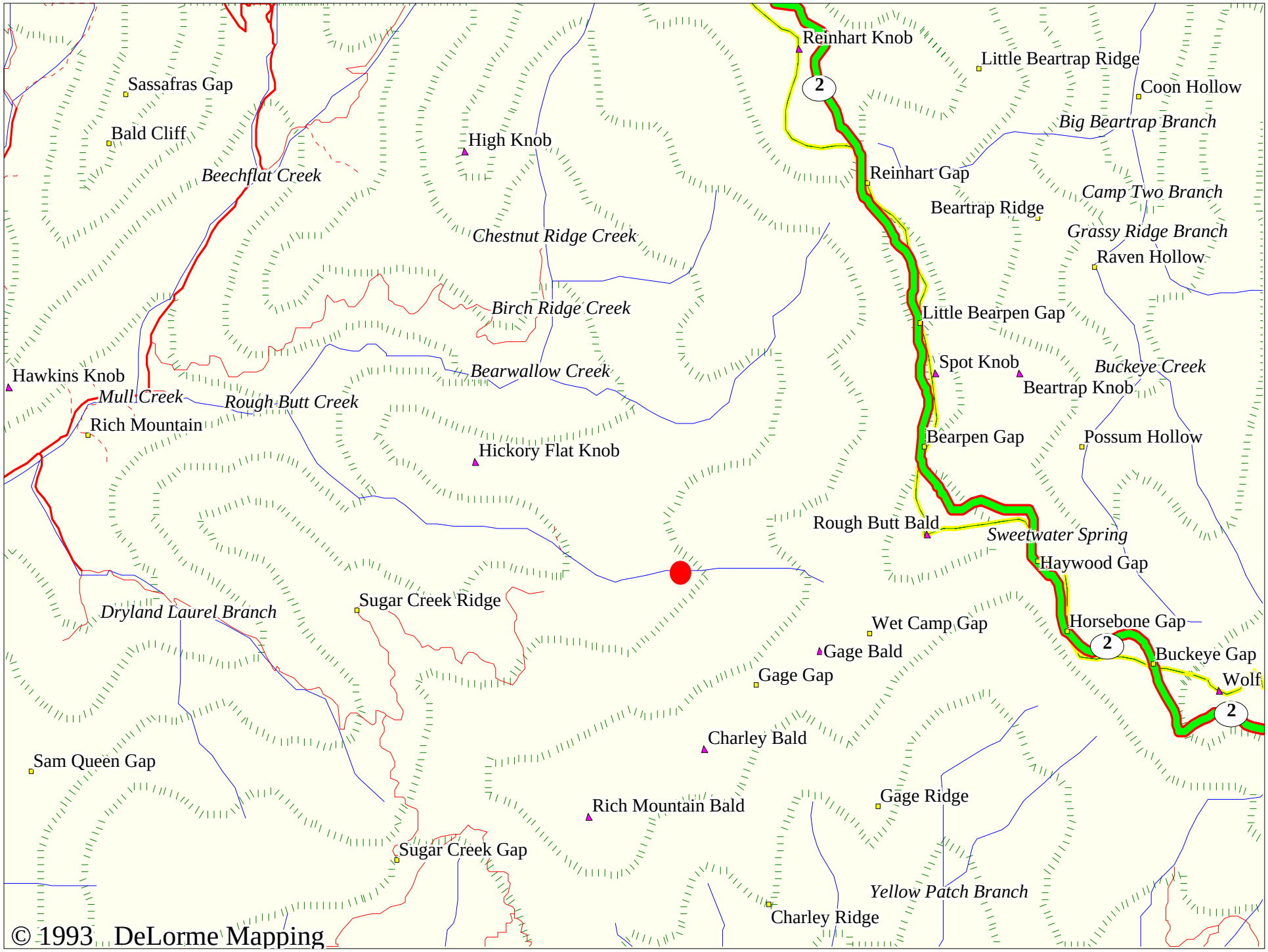
A
6 29 '99

gate
B

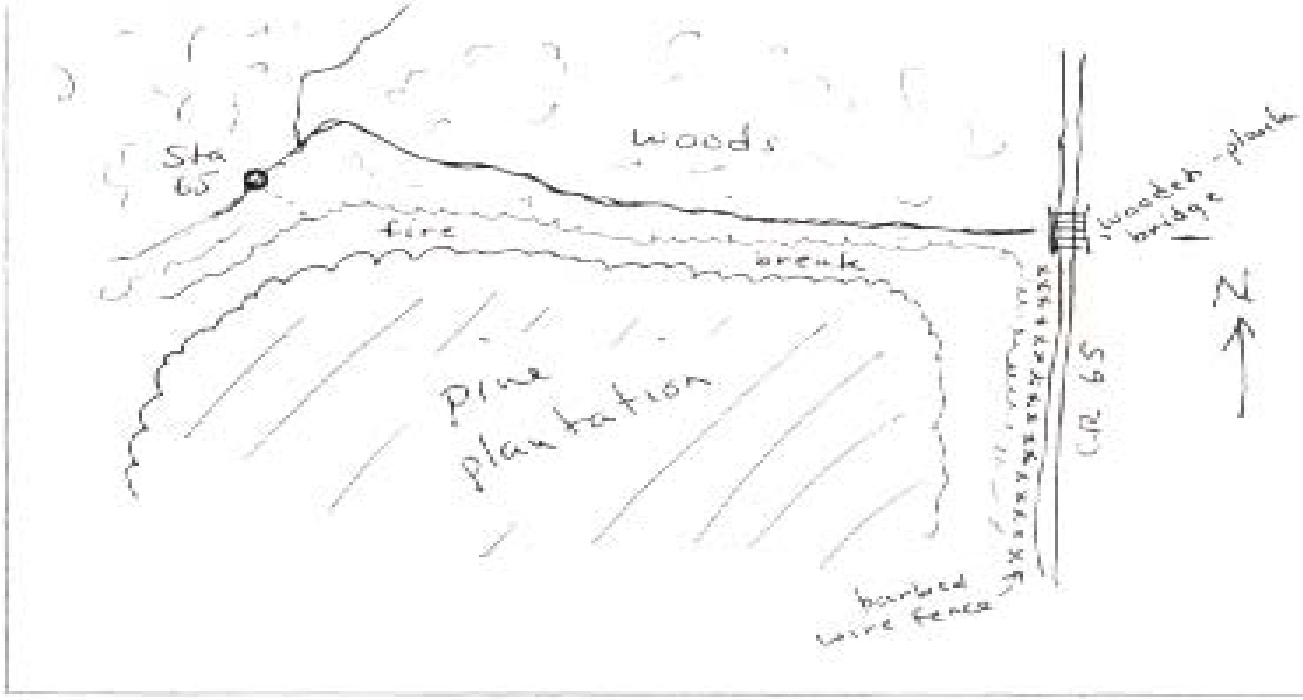
C
6 29 '99

to site
D

trail to site
E


Reinhart Knob
Little Beartrap Ridge
Coon Hollow
Sassafras Gap
2
Big Beartrap Branch
Bald Cliff
High Knob
Beechflat Creek
Reinhart Gap
Camp Two Branch
Beartrap Ridge
Grassy Ridge Branch
Chestnut Ridge Creek
Raven Hollow
Birch Ridge Creek
Little Bearpen Gap
Spot Knob
Buckeye Creek
Hawkins Knob
Bearwallow Creek
Beartrap Knob
Mull Creek
Rough Butt Creek
Rich Mountain
Bearpen Gap
Possum Hollow
Hickory Flat Knob
Rough Butt Bald
Sweetwater Spring
Haywood Gap
Sugar Creek Ridge
Dryland Laurel Branch
Wet Camp Gap
Horsebone Gap
Gage Bald
2
Buckeye Gap
Gage Gap
Wolf
2
Charley Bald
Sam Queen Gap
Gage Ridge
Rich Mountain Bald
Sugar Creek Gap
Yellow Patch Branch
Charley Ridge
© 1993 DeLorme Mapping

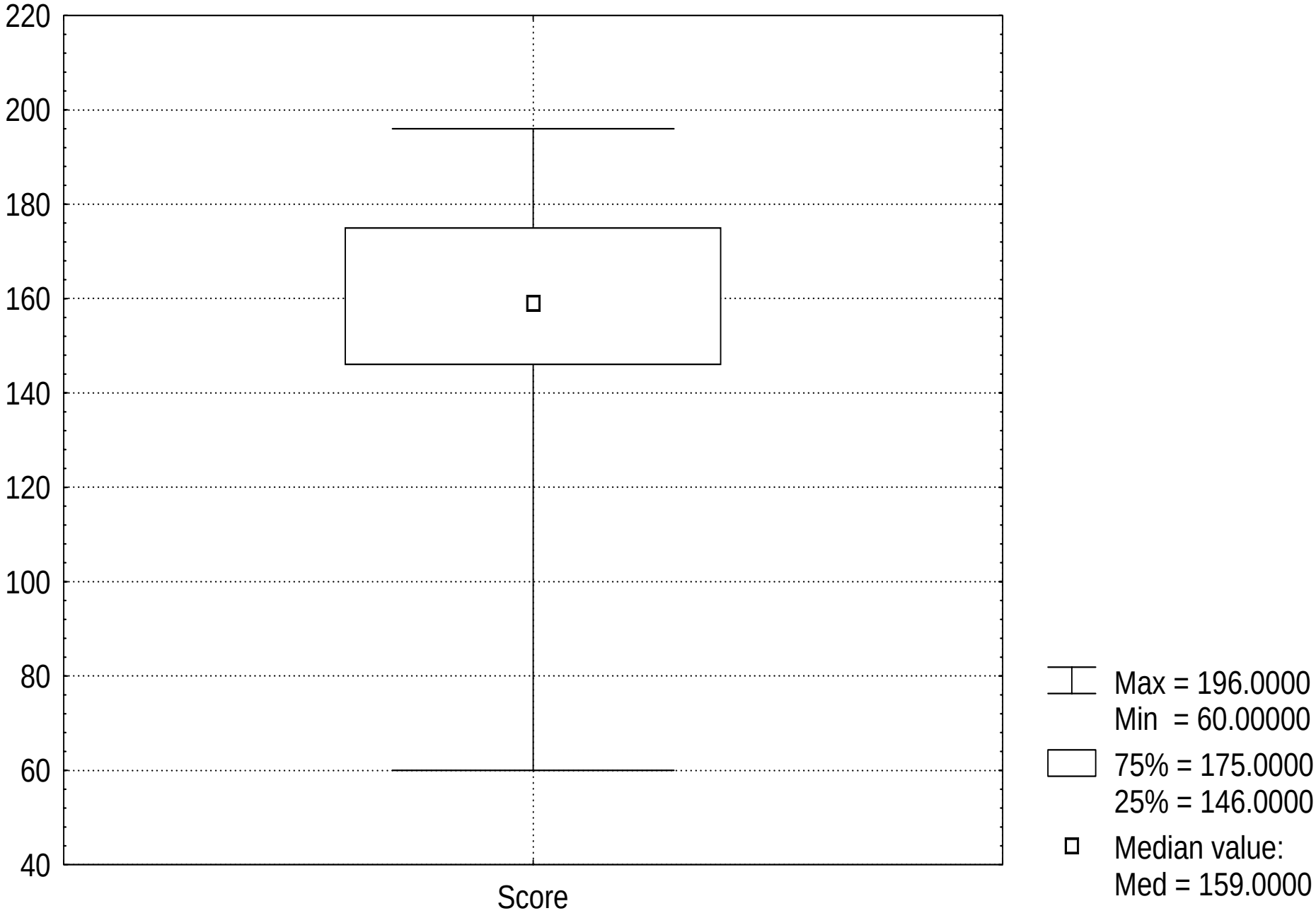
to site
(over fence)
6 6 '99

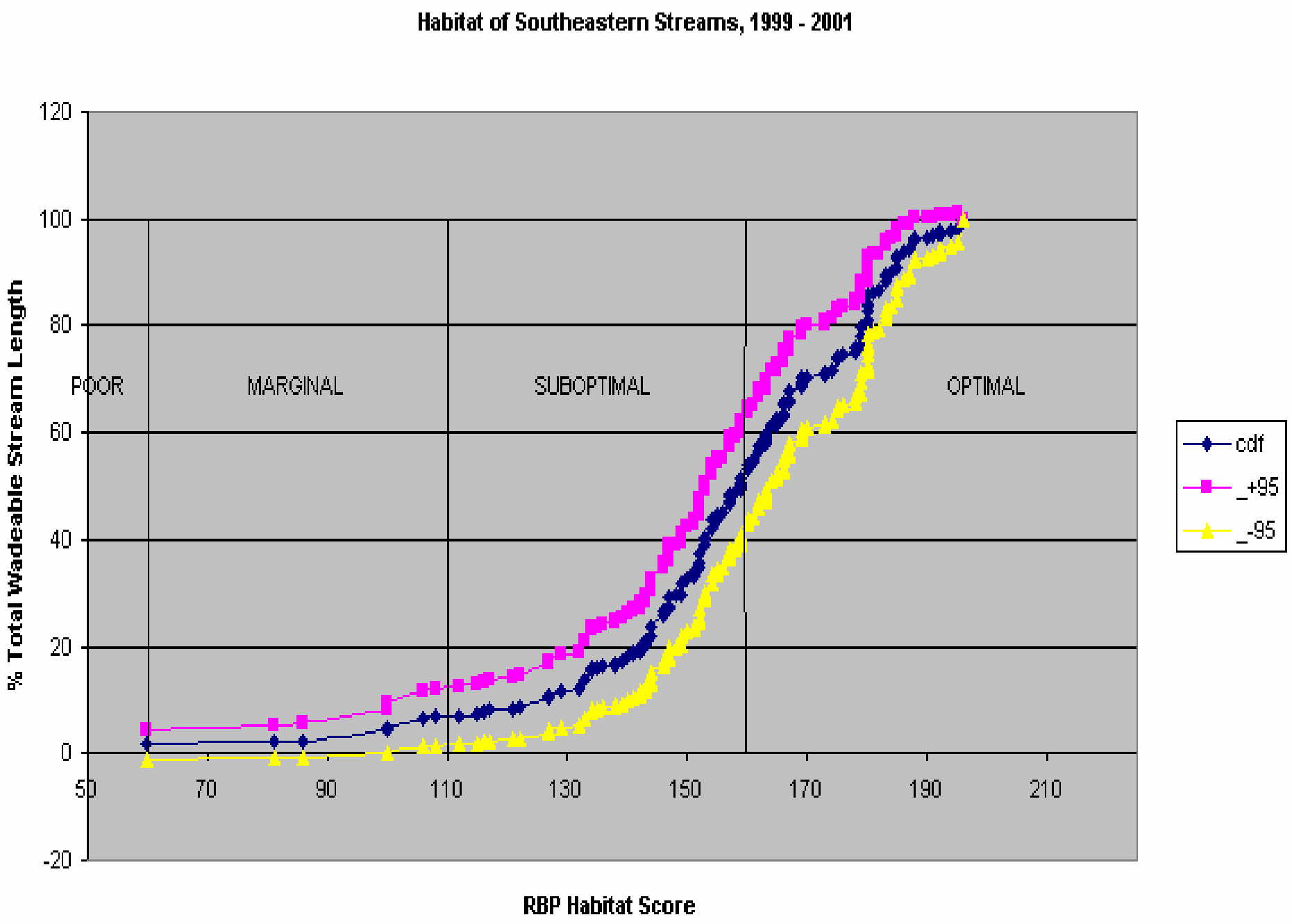

Sta 65
woods
fire
creek
pine plantation
wooden plank bridge
CR 65
N
barbed wire fence

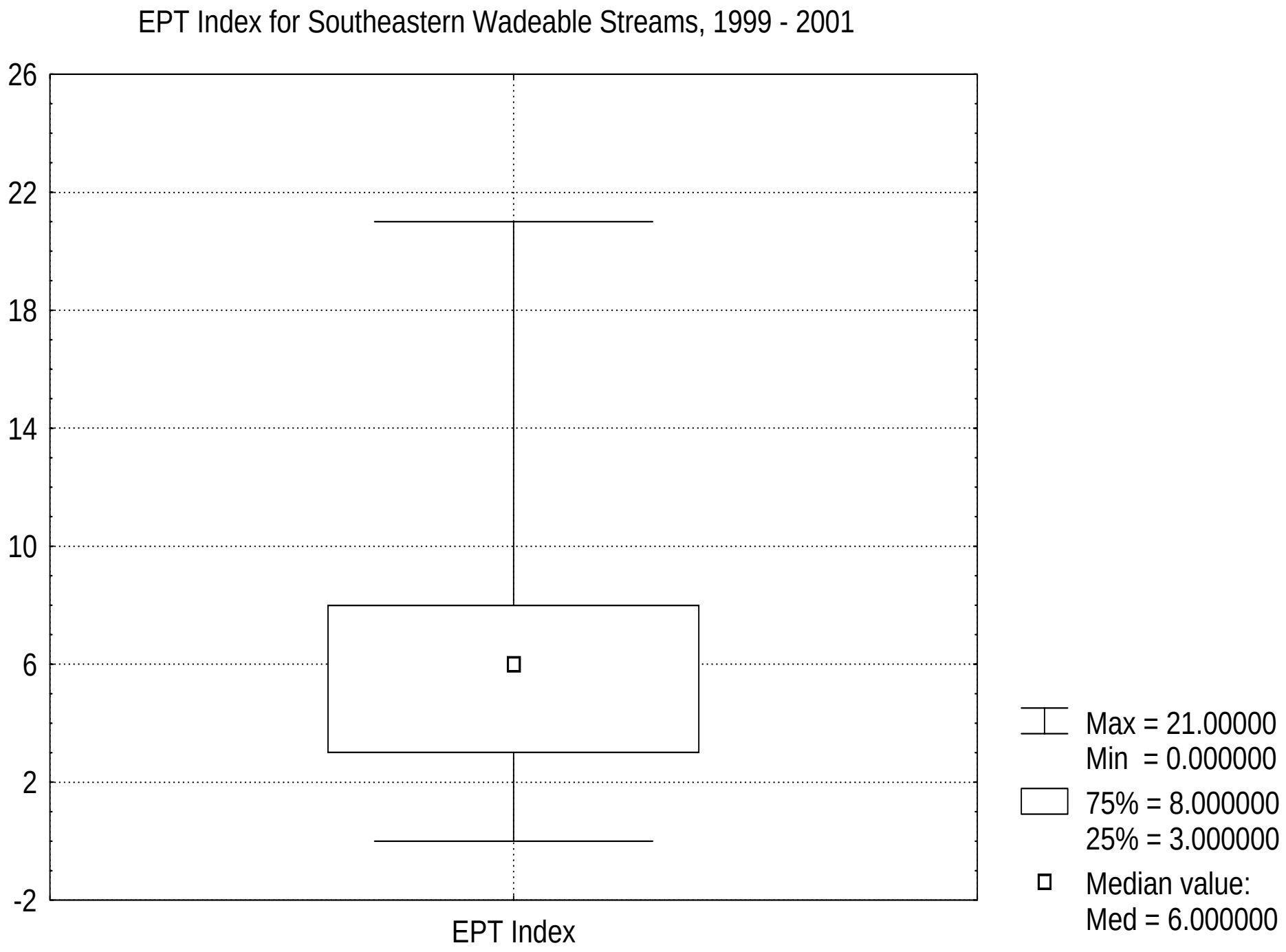
Aquatic Community Parameters

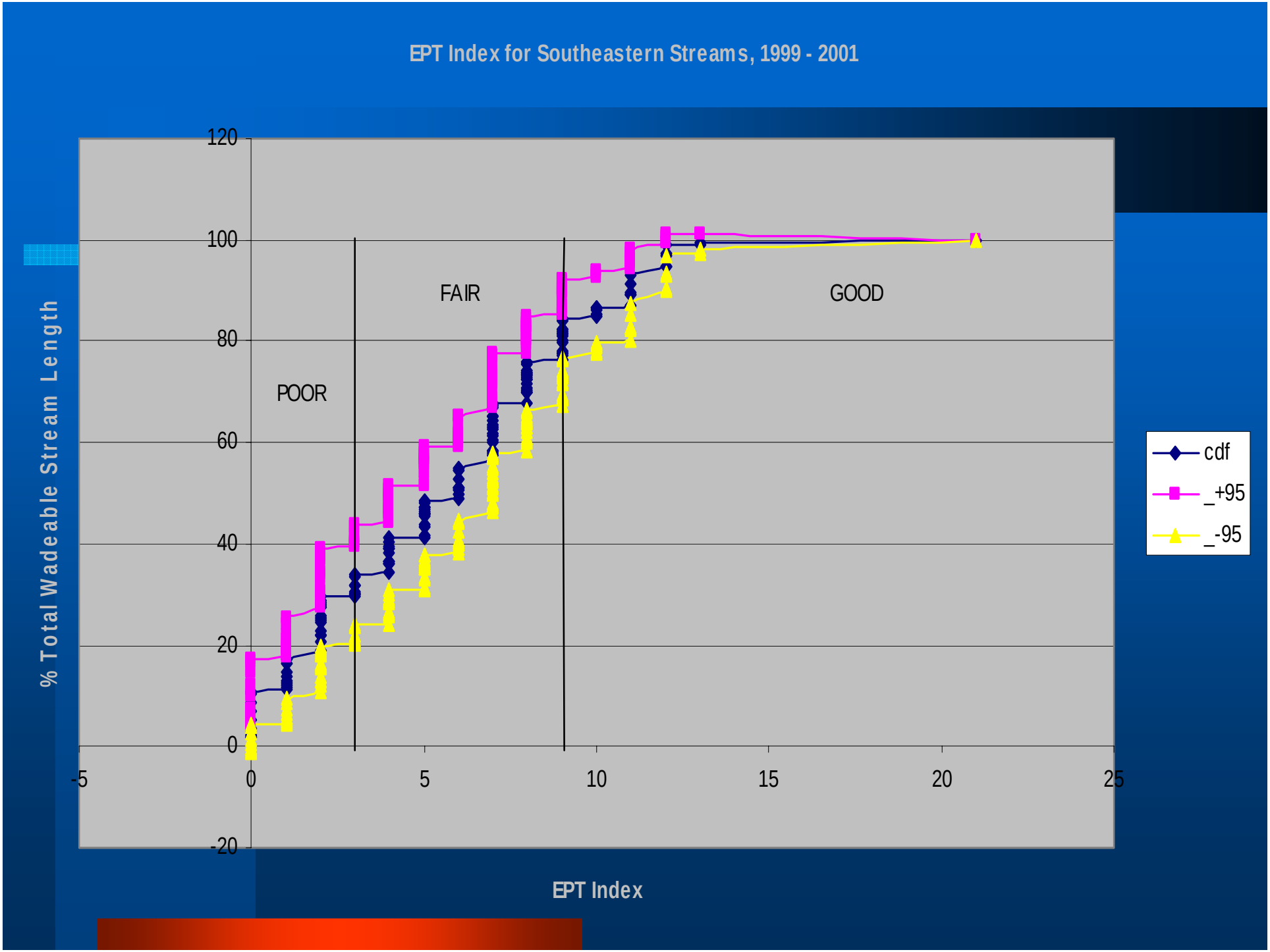
- **Benthic macroinvertebrates**
  - **Habitat**
  - **RBP II [(family level) ’99 revision]**
- **Periphyton**
  - **RBP VI [’99 revision]**
- **Fish**
  - **RBP V [’99 revision]**

RBP Habitat Scores for Southeastern Wadeable Streams, 1999 - 2001



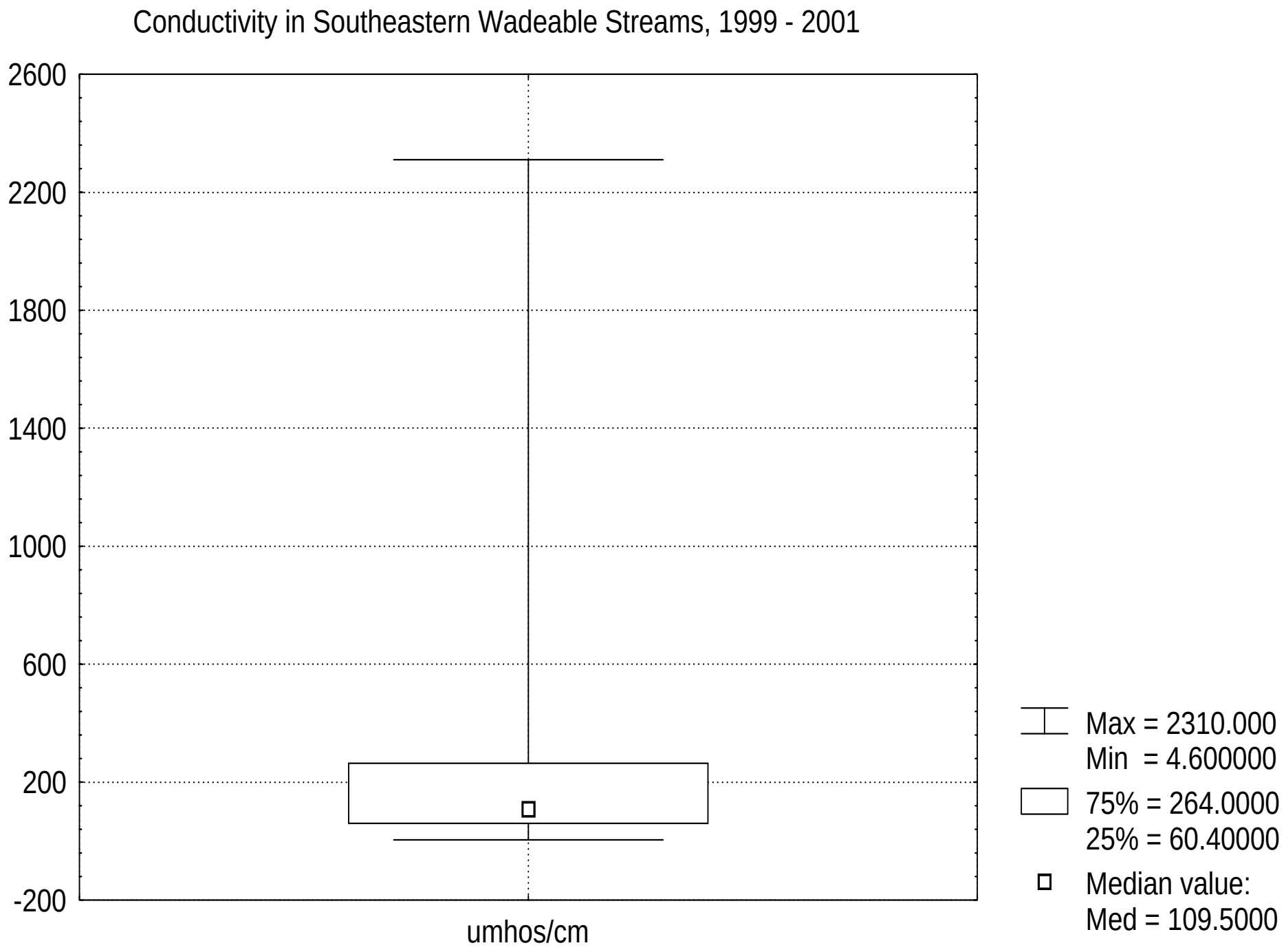

Habitat of Southeastern Streams, 1999 - 2001
% Total Wadeable Stream Length
RBP Habitat Score
POOR
MARGINAL
SUBOPTIMAL
OPTIMAL
120
100
80
60
40
20
0
-20
50
70
90
110
130
150
170
190
210
cdf
_+95
_-95

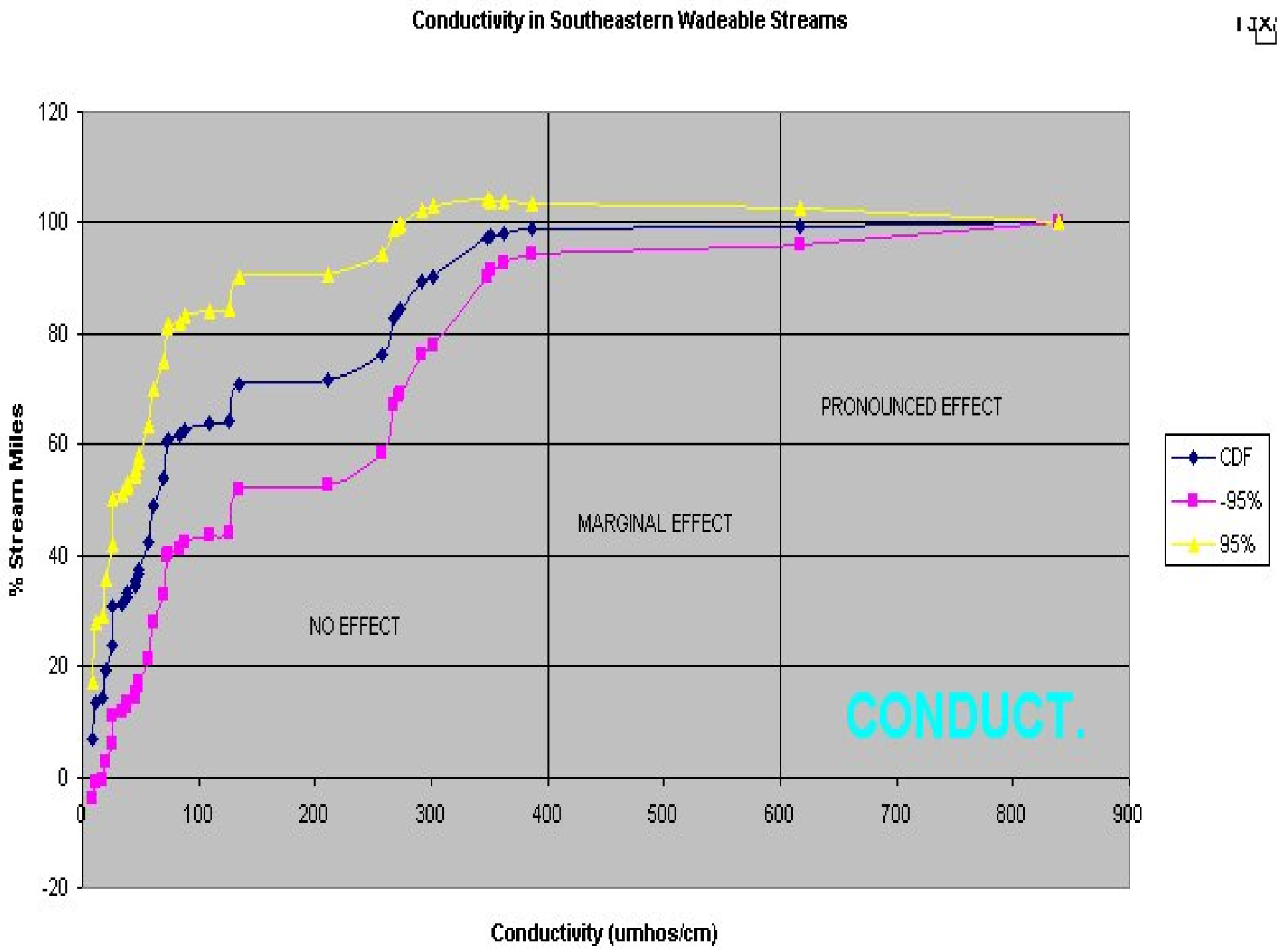

EPT Index for Southeastern Wadeable Streams, 1999 - 2001
26
22
18
14
10
6
2
-2
EPT Index
Max = 21.00000
Min = 0.000000
75% = 8.000000
25% = 3.000000
Median value:
Med = 6.000000

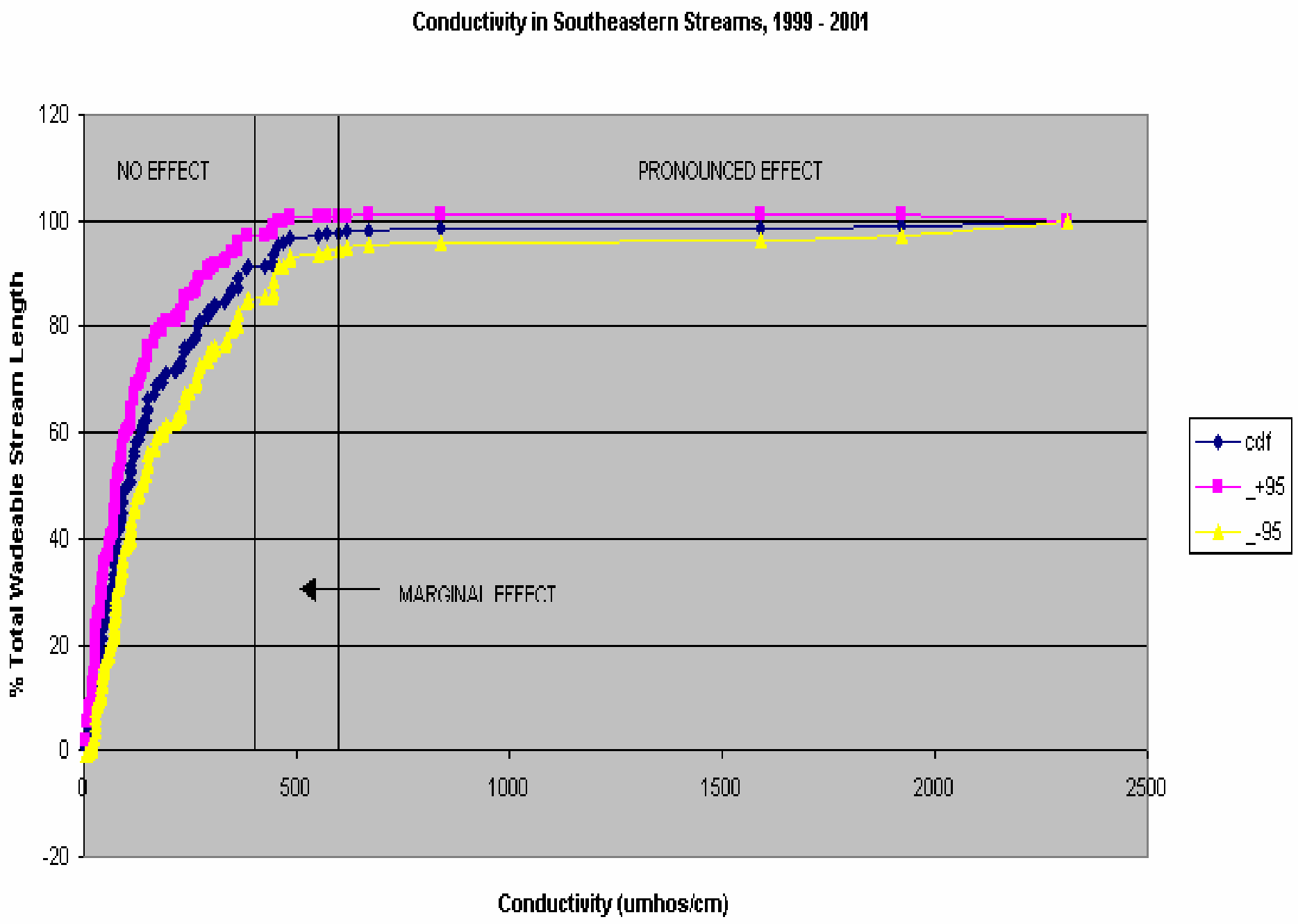

EPT Index for Southeastern Streams, 1999 - 2001
% Total Wadeable Stream Length
EPT Index
POOR
FAIR
GOOD
120
100
80
60
40
20
0
-20
-5
0
5
10
15
20
25
cdf
_+95
_-95

Aquatic Media and Analytes

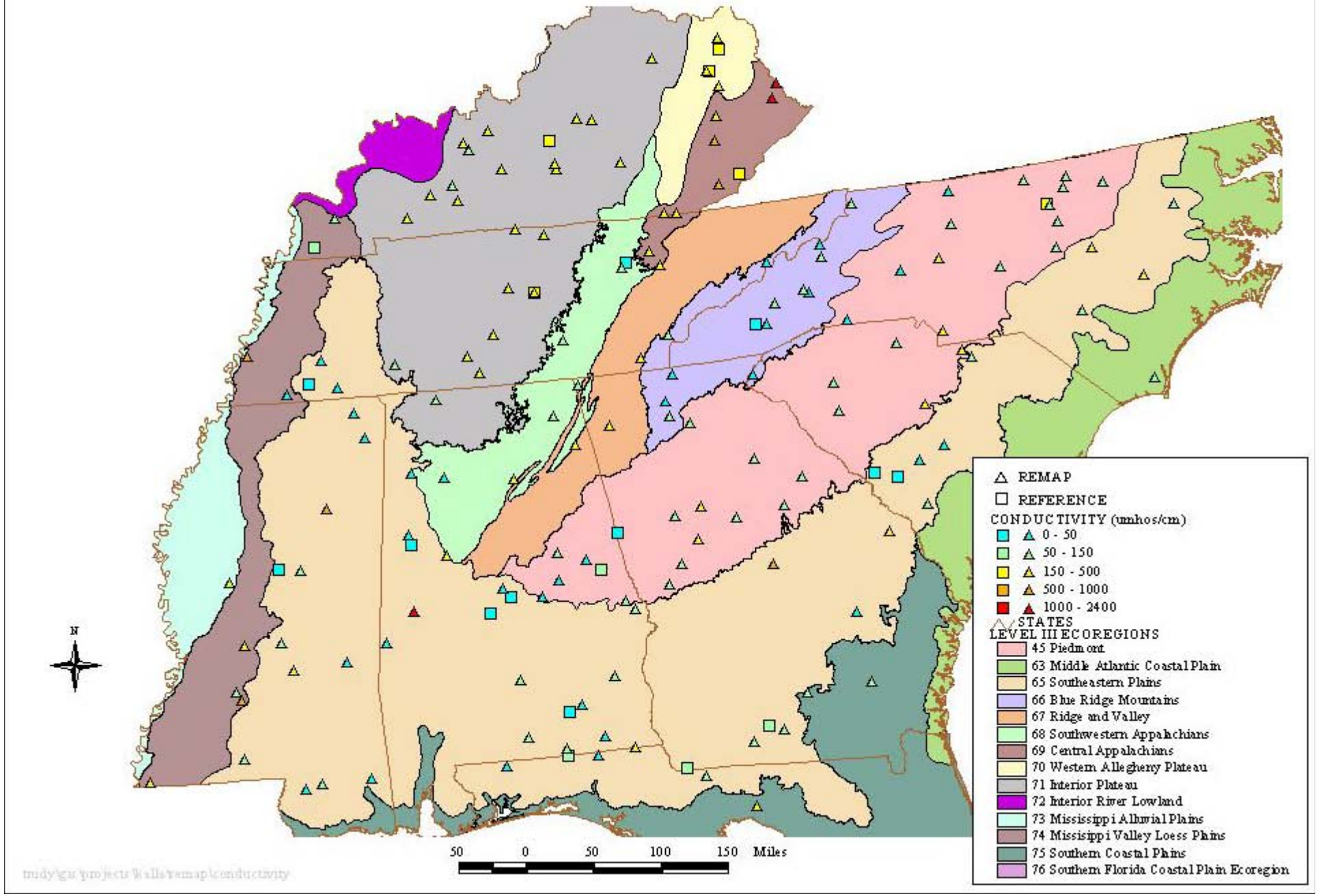
- **Water**
  - **Conductivity, D.O., pH, temperature**
  - **Nitrogen series**
  - **Total & dissolved phosphorus**
  - **Algal Growth Potential Test (AGPT)**
  - **Total suspended solids**
- **Forage Fish**
  - **Mercury [total conventional, whole-body]**
- **Periphyton**
  - **Autotrophic Index (ash-free dry wt. / chlorophyll *a*)**


Conductivity in Southeastern Wadeable Streams, 1999 - 2001
2600
2200
1800
1400
1000
600
200
-200
umhos/cm
Max = 2310.000
Min = 4.600000
75% = 264.0000
25% = 60.40000
Median value:
Med = 109.5000

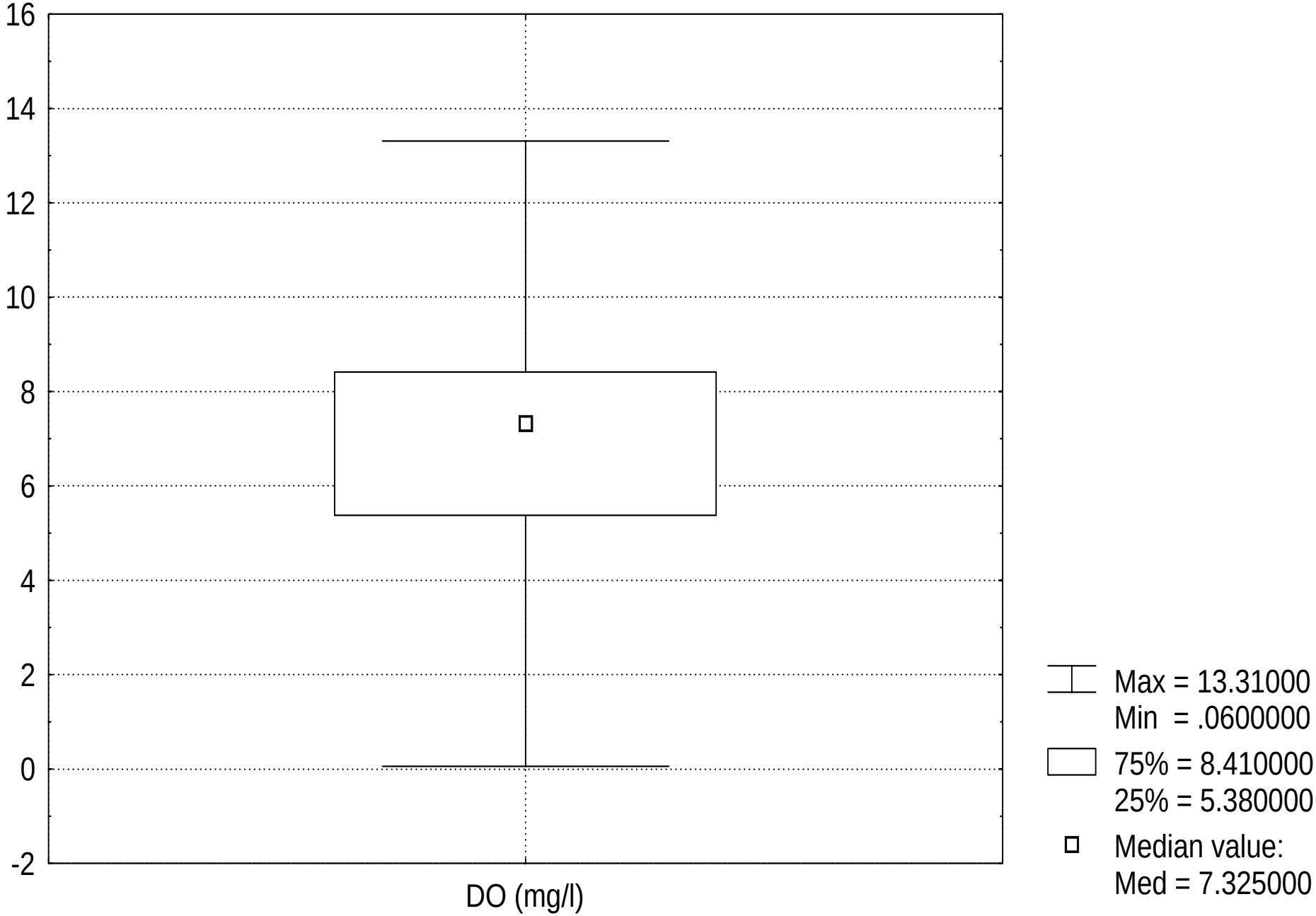

Conductivity in Southeastern Wadeable Streams
% Stream Miles
Conductivity (umhos/cm)
120
100
80
60
40
20
0
-20
0
100
200
300
400
500
600
700
800
900
NO EFFECT
MARGINAL EFFECT
PRONOUNCED EFFECT
CONDUCT.
CDF
-95%
95%

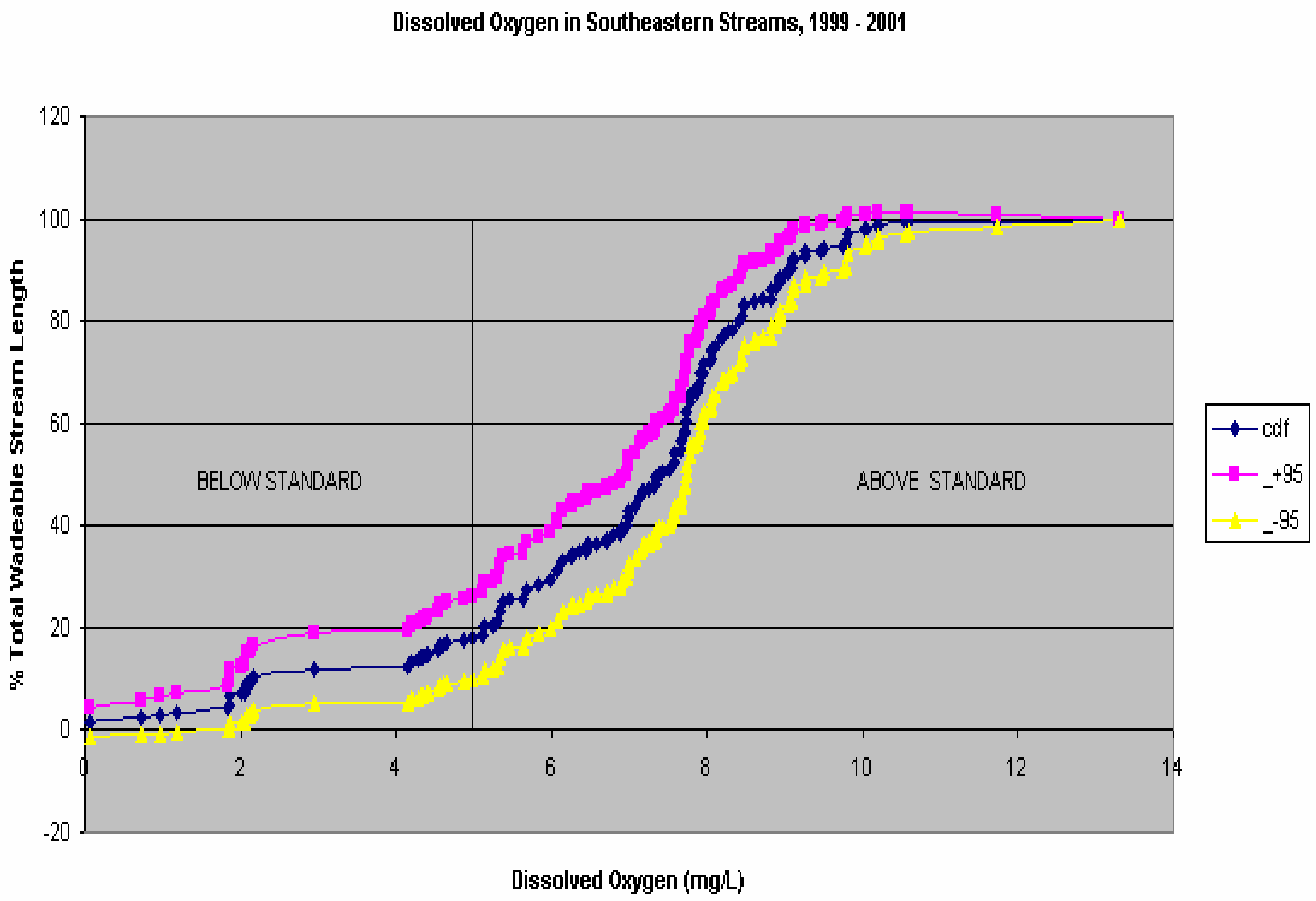

Conductivity in Southeastern Streams, 1999 - 2001
NO EFFECT
PRONOUNCED EFFECT
MARGINAL EFFECT
% Total Wadeable Stream Length
Conductivity (umhos/cm)
120
100
80
60
40
20
0
-20
0
500
1000
1500
2000
2500
cdf
_+95
_-95

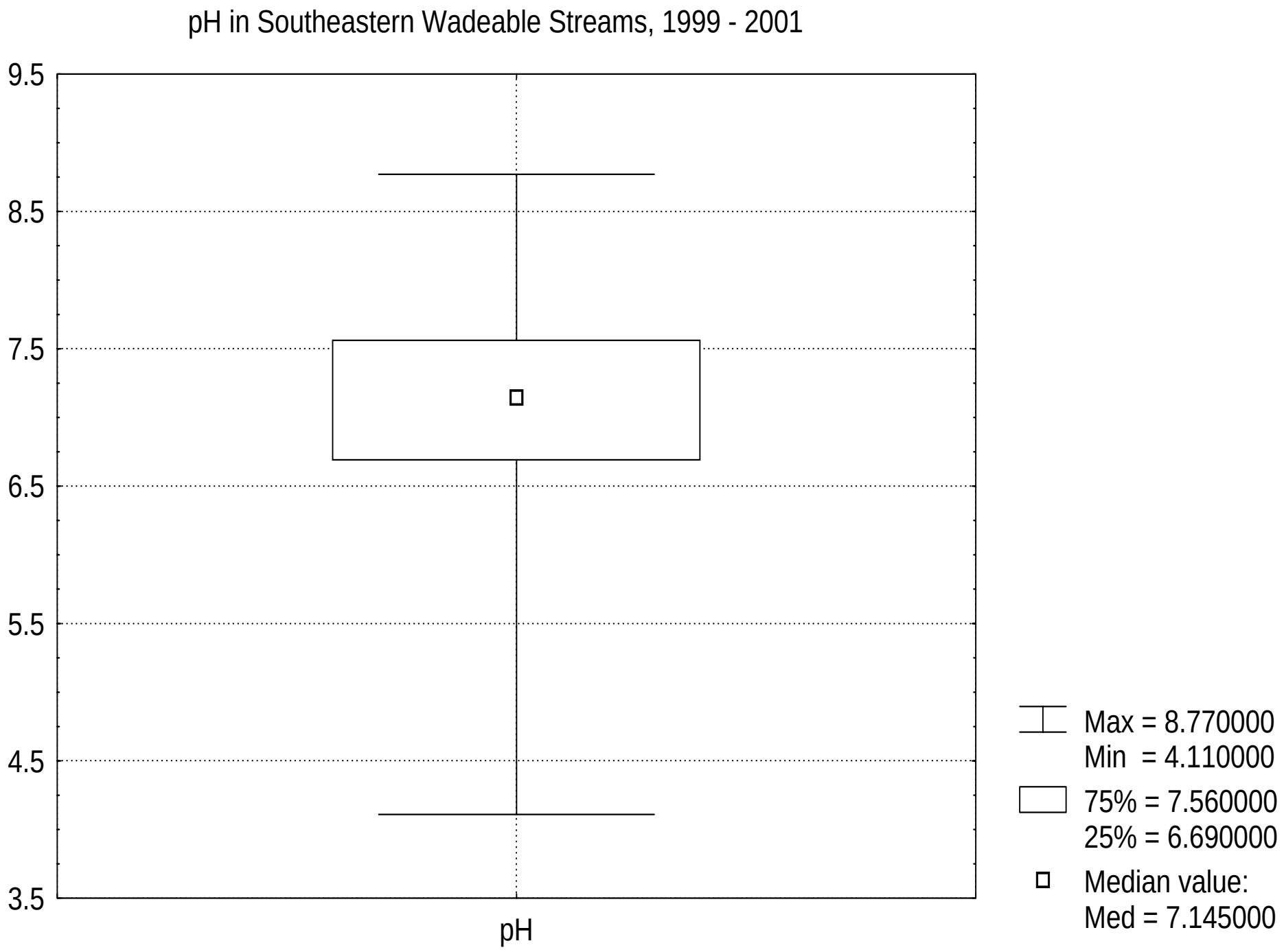
CONDUCTIVITY, YEARS 1999, 2000 AND 2001

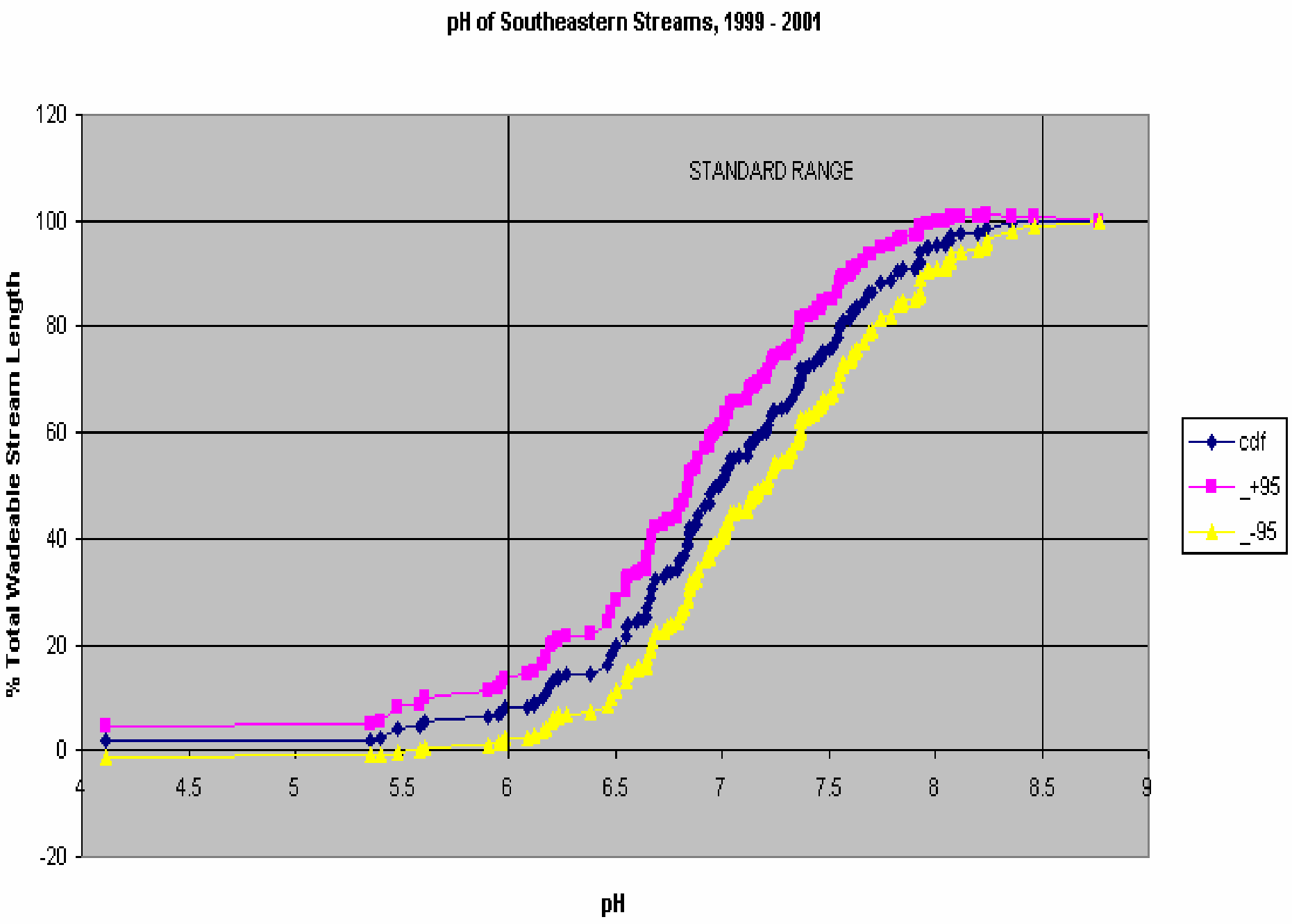


Dissolved Oxygen in Southeastern Wadeable Streams, 1999 - 2001

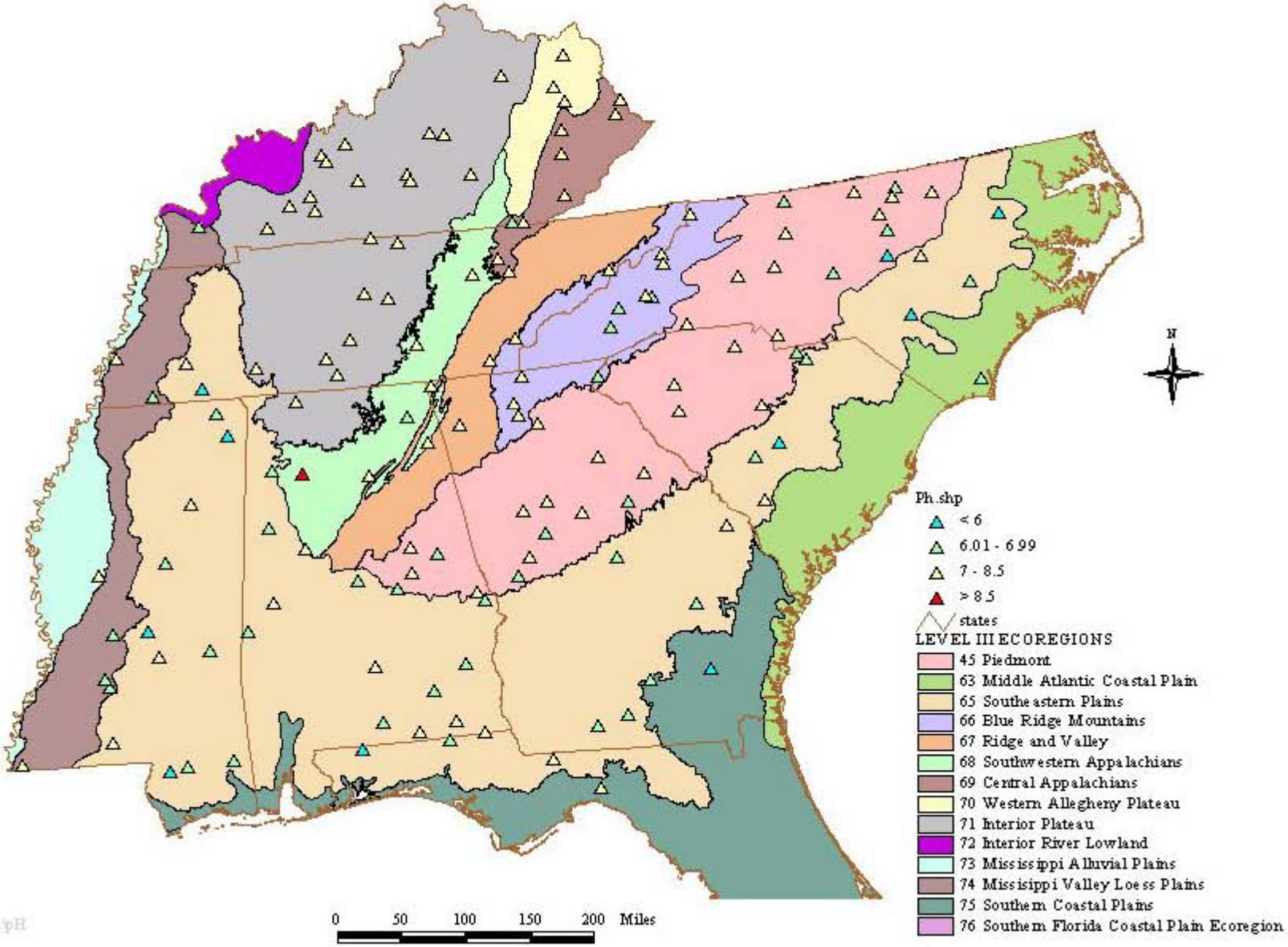



Dissolved Oxygen in Southeastern Streams, 1999 - 2001
% Total Wadeable Stream Length
120
100
80
60
40
20
0
-20
0
2
4
6
8
10
12
14
BELOW STANDARD
ABOVE STANDARD
cdf
_+95
_-95
Dissolved Oxygen (mg/L)

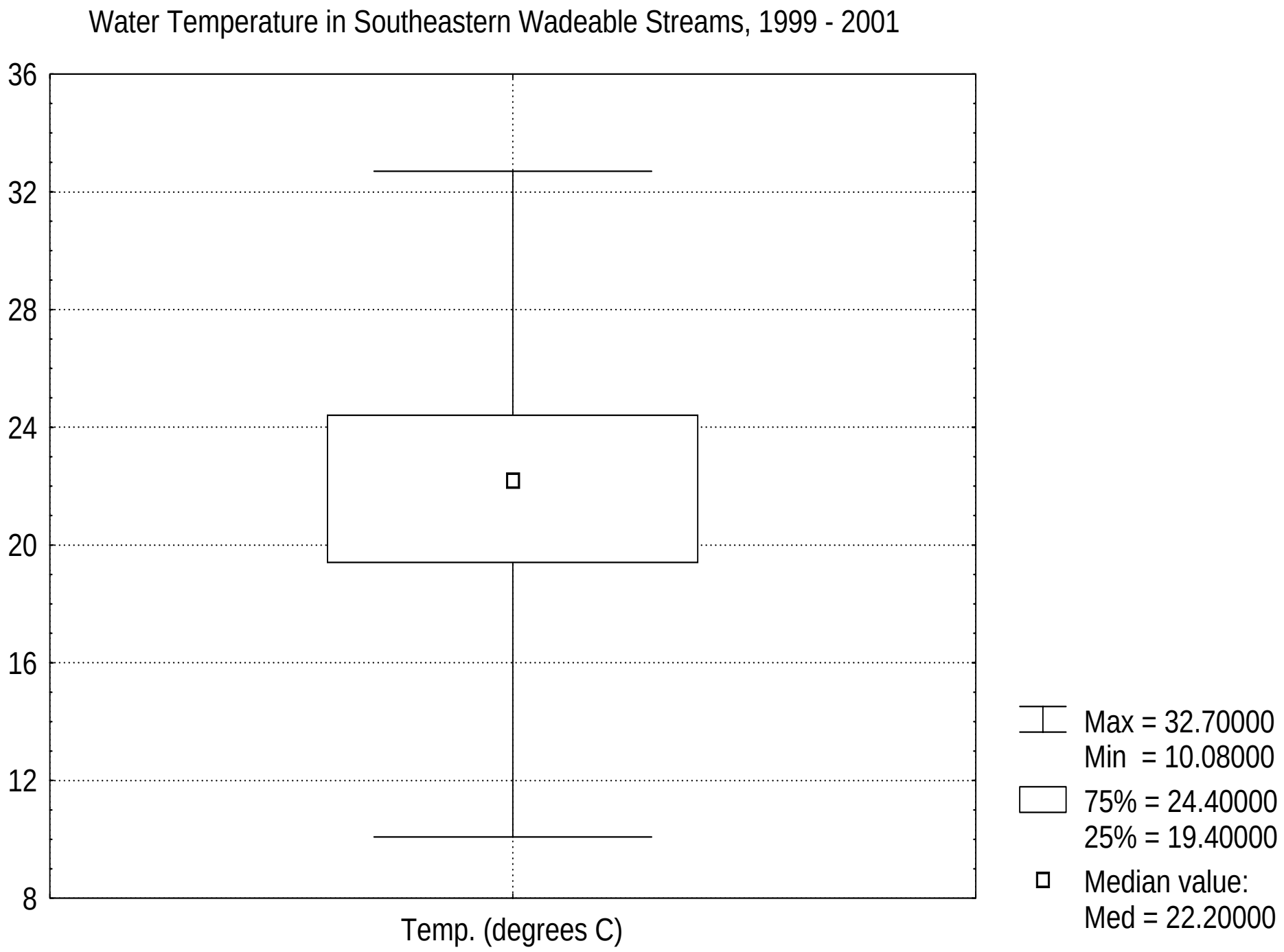

pH in Southeastern Wadeable Streams, 1999 - 2001
9.5
8.5
7.5
6.5
5.5
4.5
3.5
pH
Max = 8.770000
Min = 4.110000
75% = 7.560000
25% = 6.690000
Median value:
Med = 7.145000

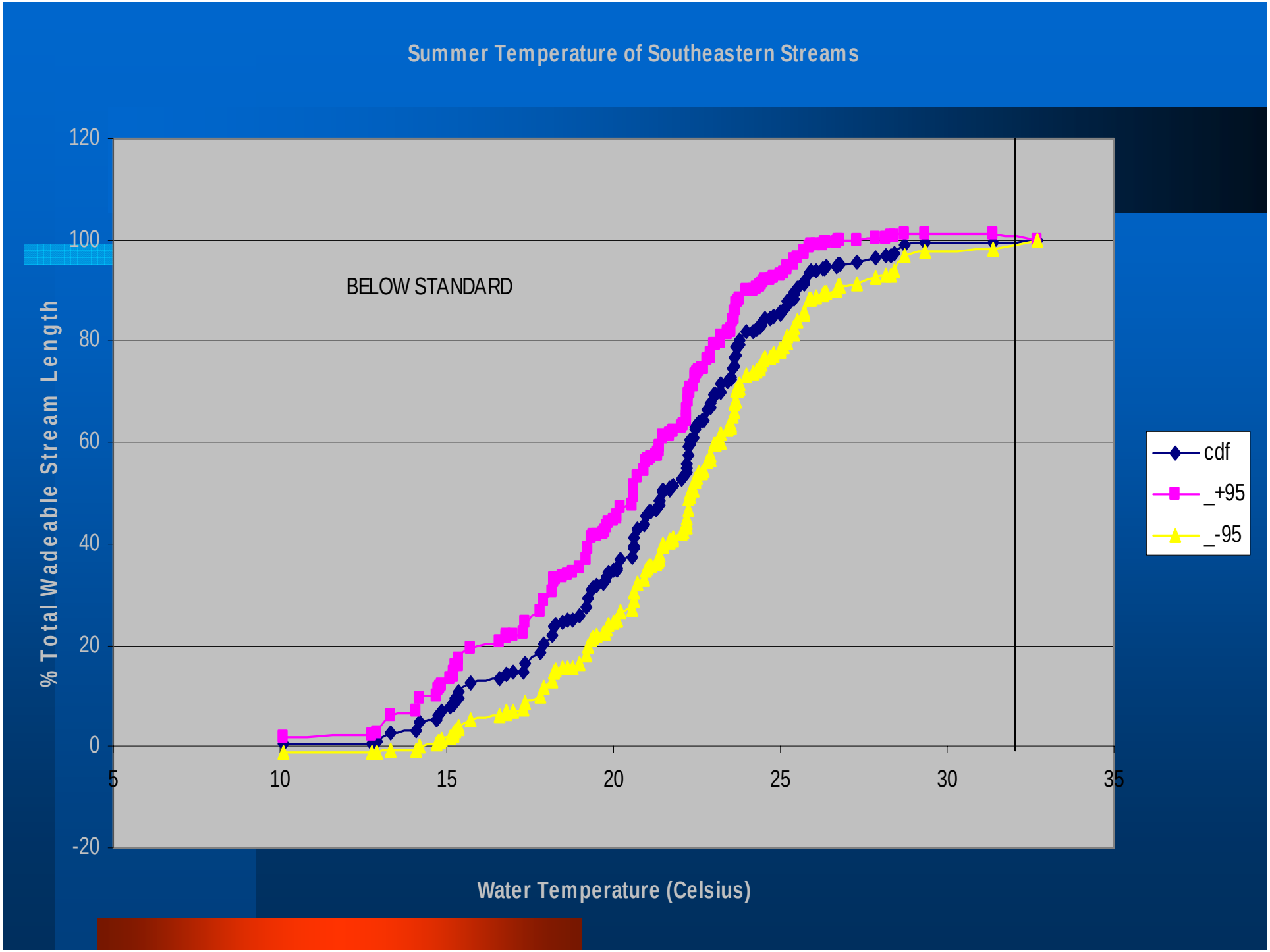

pH of Southeastern Streams, 1999 - 2001
STANDARD RANGE
% Total Wadeable Stream Length
pH
120
100
80
60
40
20
0
-20
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
cdf
_+95
_-95

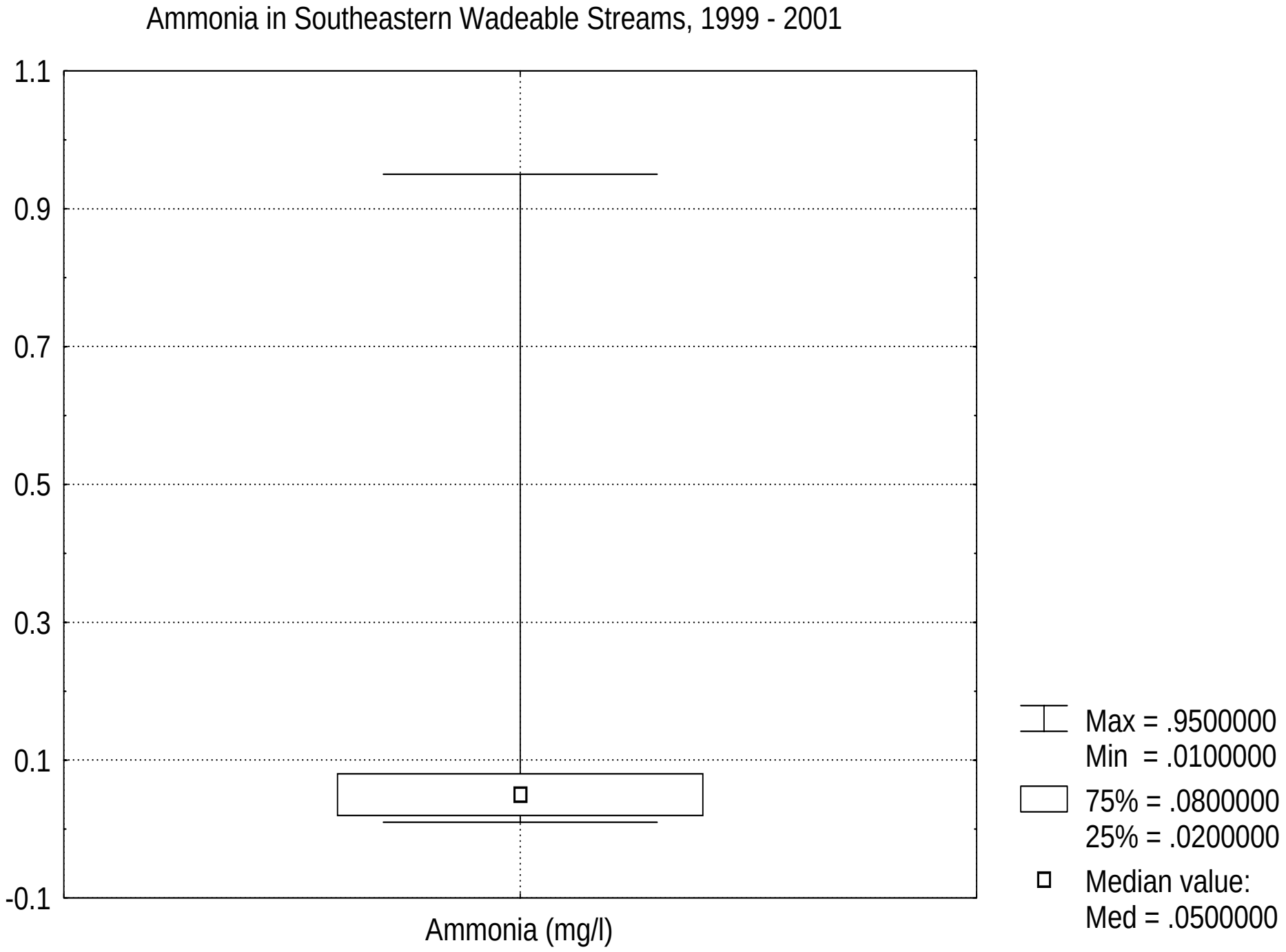
pH, YEARS 1999, 2000 AND 2001



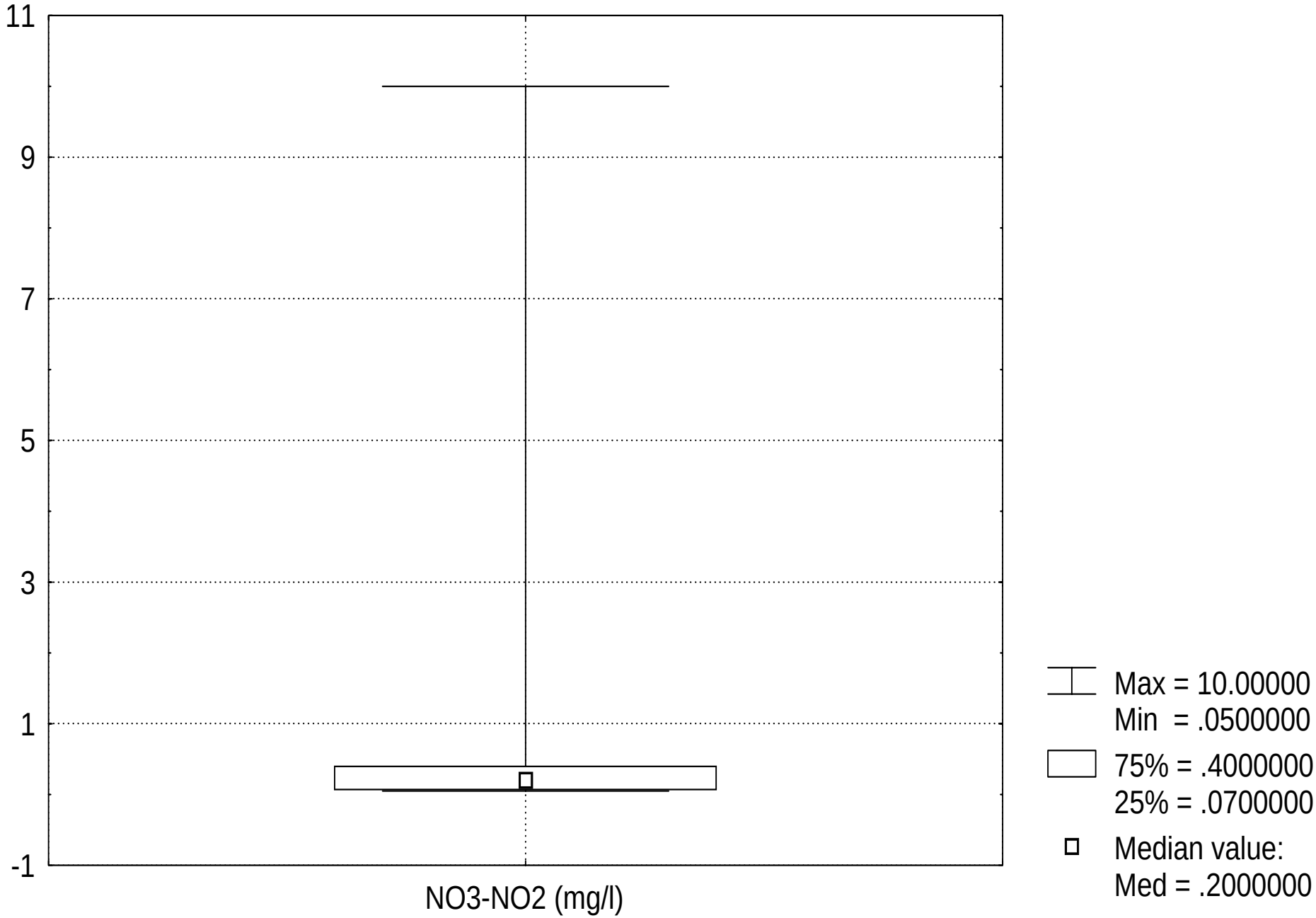
trudy\gis\alla\remap\pH


Water Temperature in Southeastern Wadeable Streams, 1999 - 2001
36
32
28
24
20
16
12
8
Temp. (degrees C)
Max = 32.70000
Min = 10.08000
75% = 24.40000
25% = 19.40000
Median value:
Med = 22.20000

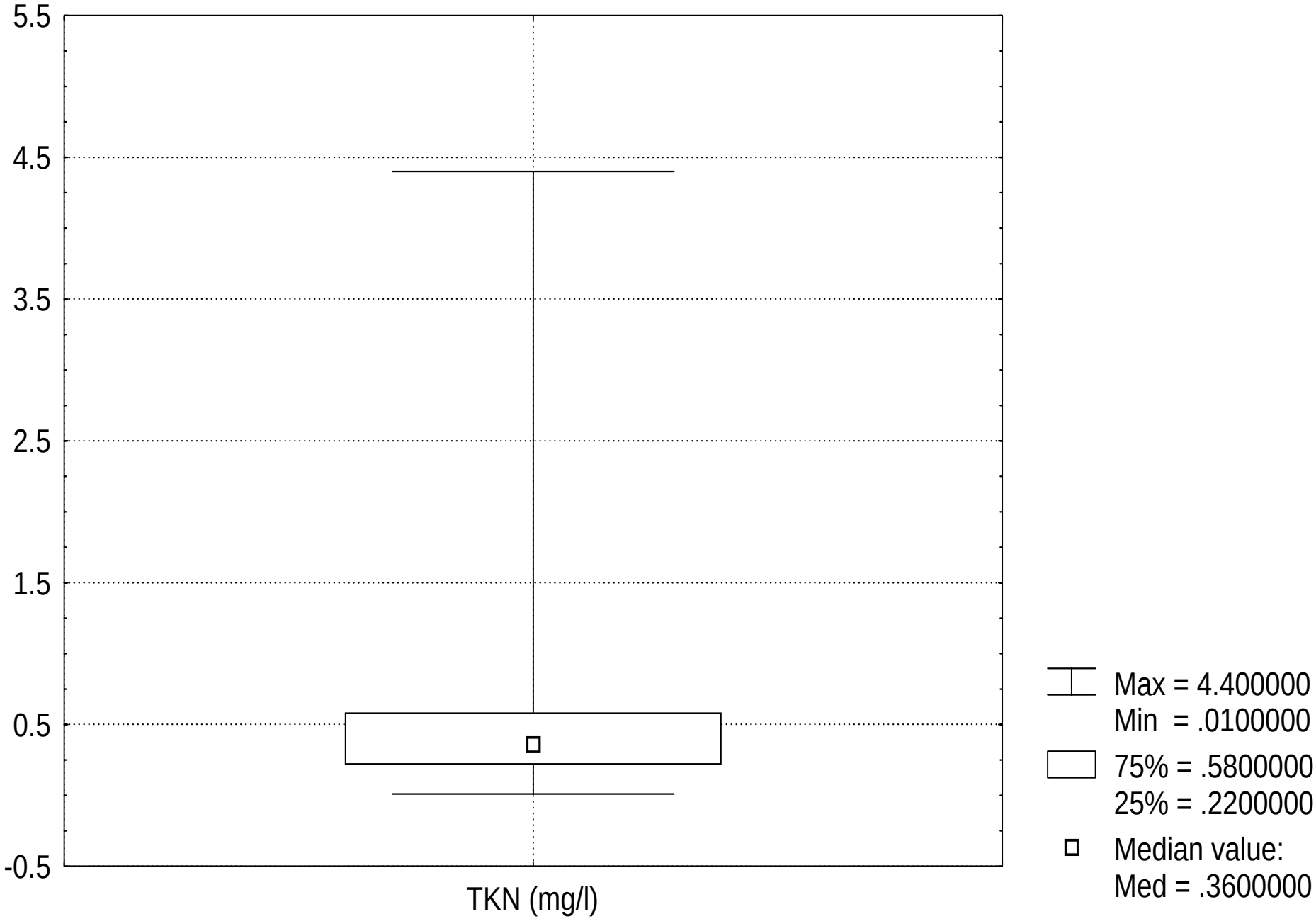

Summer Temperature of Southeastern Streams
% Total Wadeable Stream Length
120
100
80
60
40
20
0
-20
5
10
15
20
25
30
35
BELOW STANDARD
cdf
_+95
_-95
Water Temperature (Celsius)


Ammonia in Southeastern Wadeable Streams, 1999 - 2001
1.1
0.9
0.7
0.5
0.3
0.1
-0.1
Ammonia (mg/l)
Max = .9500000
Min = .0100000
75% = .0800000
25% = .0200000
Median value:
Med = .0500000

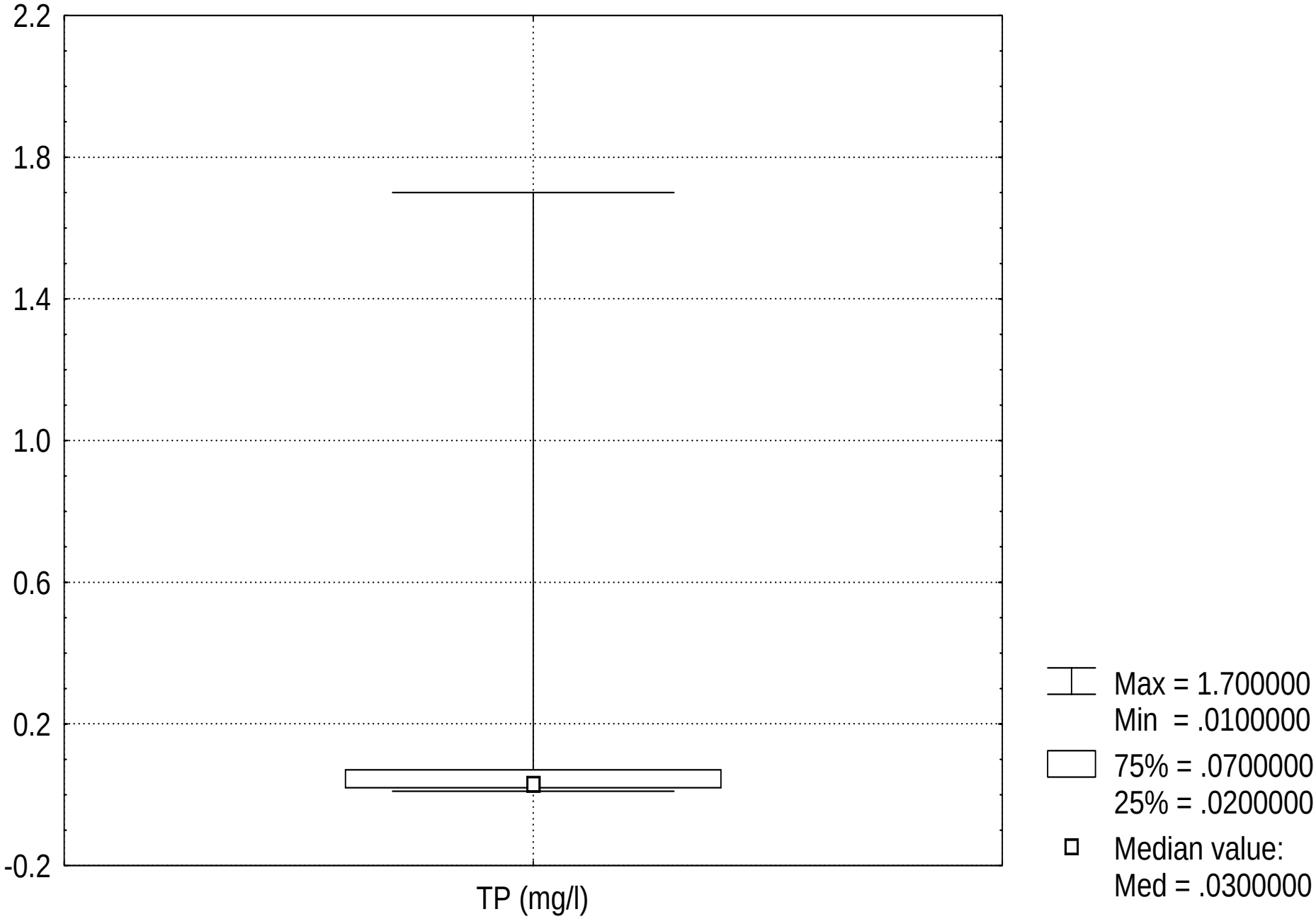
Nitrate-Nitrite in Southeastern Wadeable Streams, 1999 - 2001

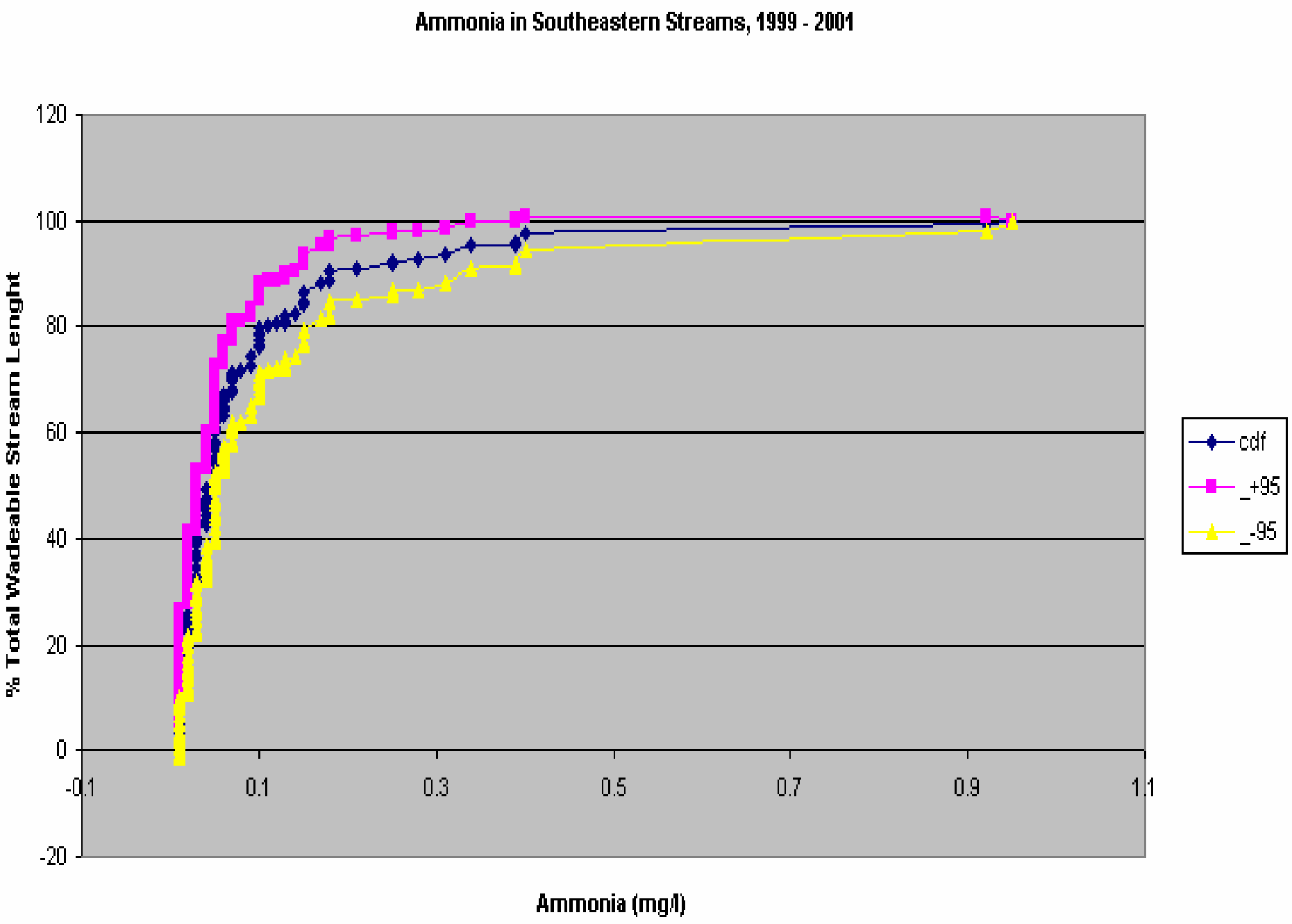


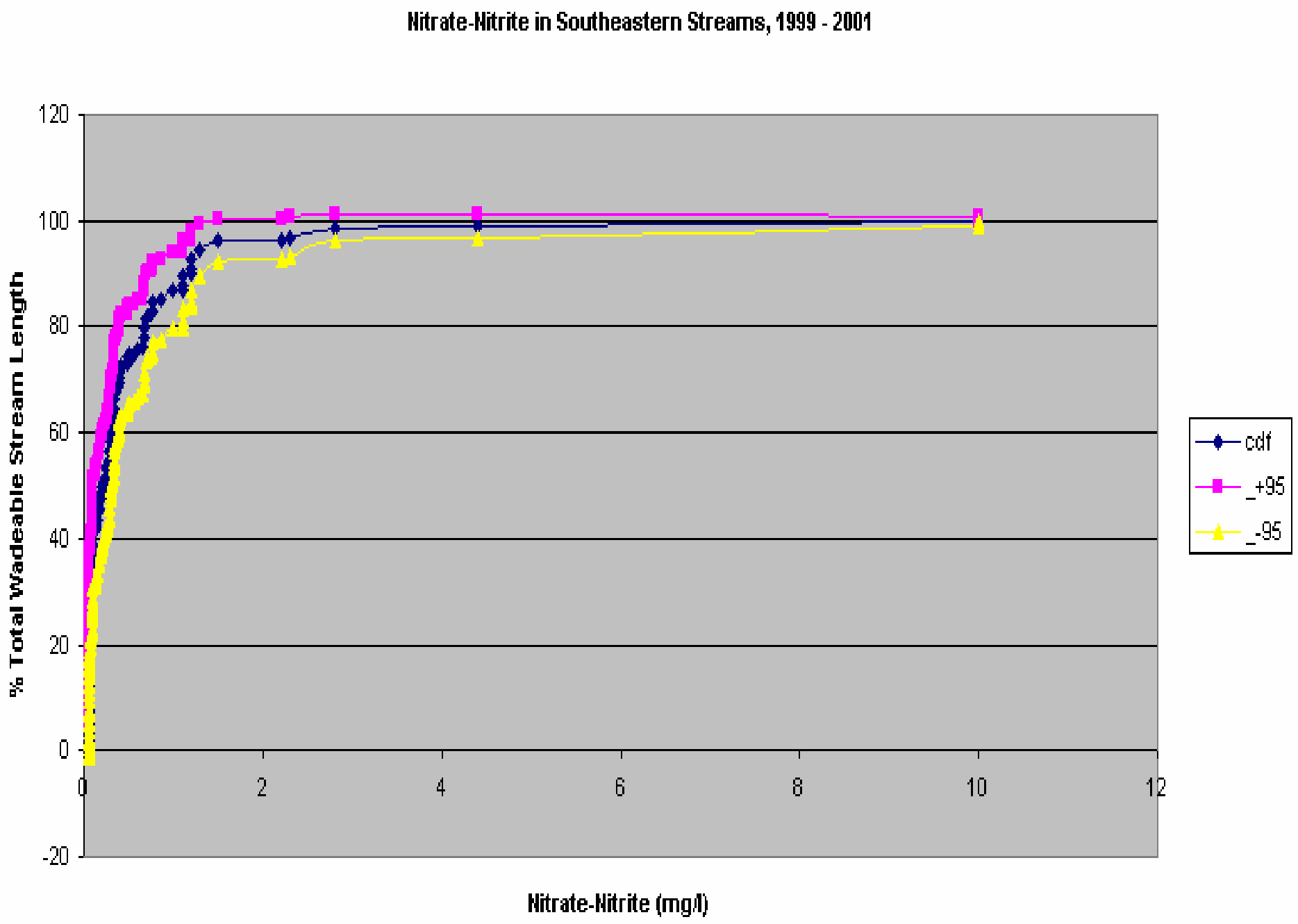
Total Kjeldahl Nitrogen in Southeastern Wadeable Streams, 1999 - 2001



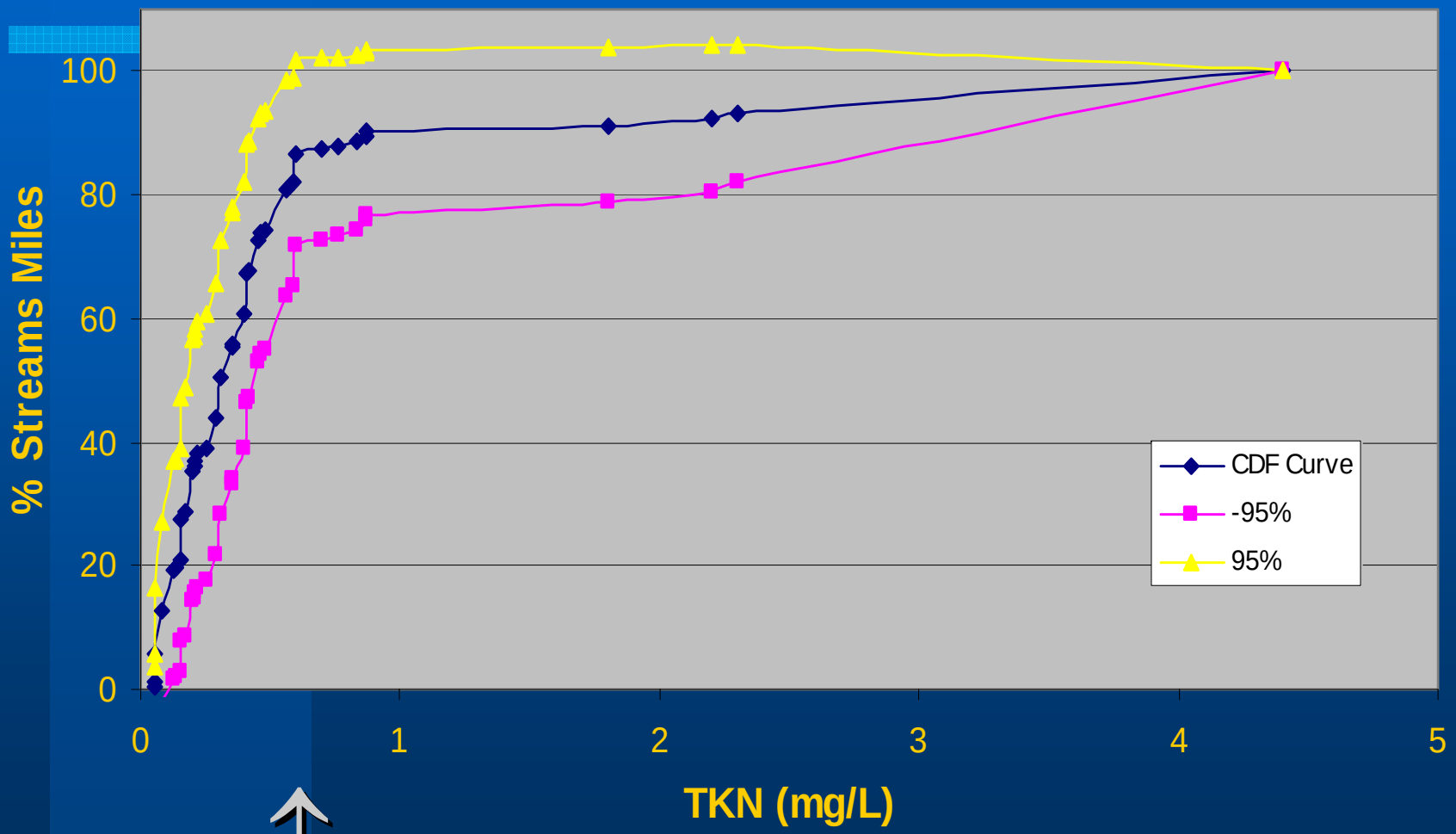
Total Phosphorus in Southeastern Wadeable Streams, 1999 - 2001




Ammonia in Southeastern Streams, 1999 - 2001
% Total Wadeable Stream Lenght
120
100
80
60
40
20
0
-20
-0.1
0.1
0.3
0.5
0.7
0.9
1.1
Ammonia (mg/l)
cdf
_+95
_-95

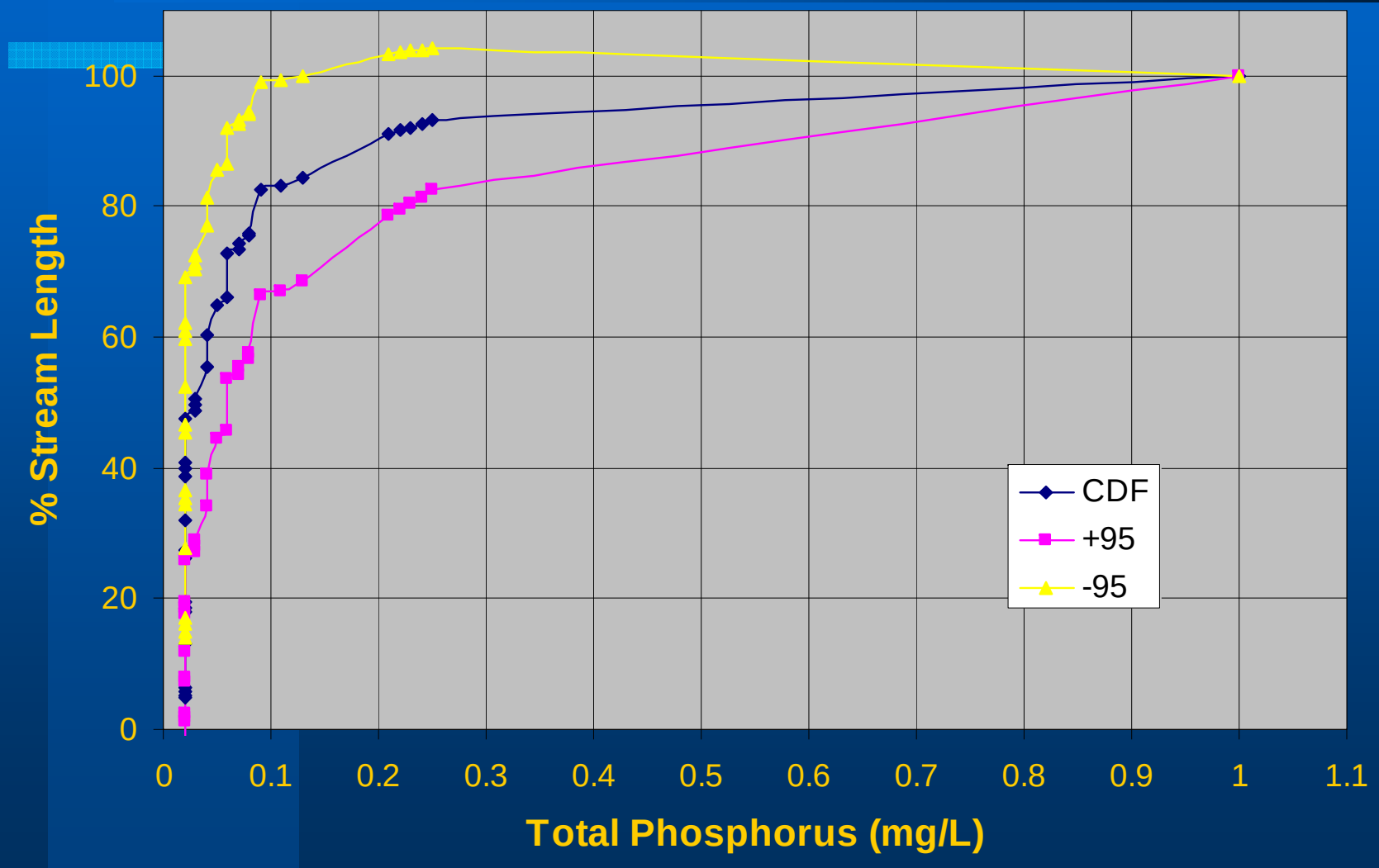

Nitrate-Nitrite in Southeastern Streams, 1999 - 2001
% Total Wadeable Stream Length
120
100
80
60
40
20
0
-20
0
2
4
6
8
10
12
Nitrate-Nitrite (mg/l)
cdf
_+95
_-95

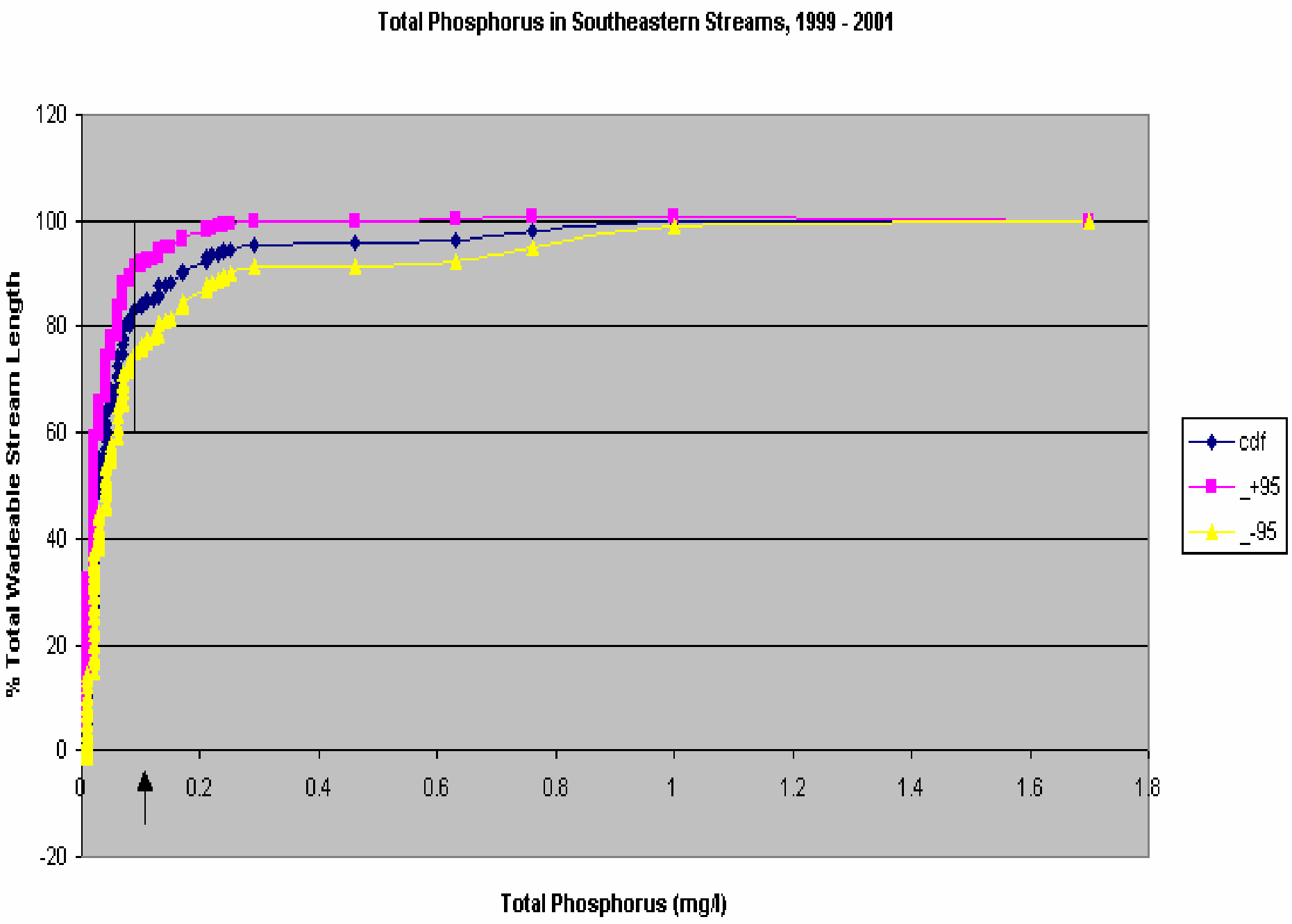
TKN Concentrations in Region 4 Wadeable Streams



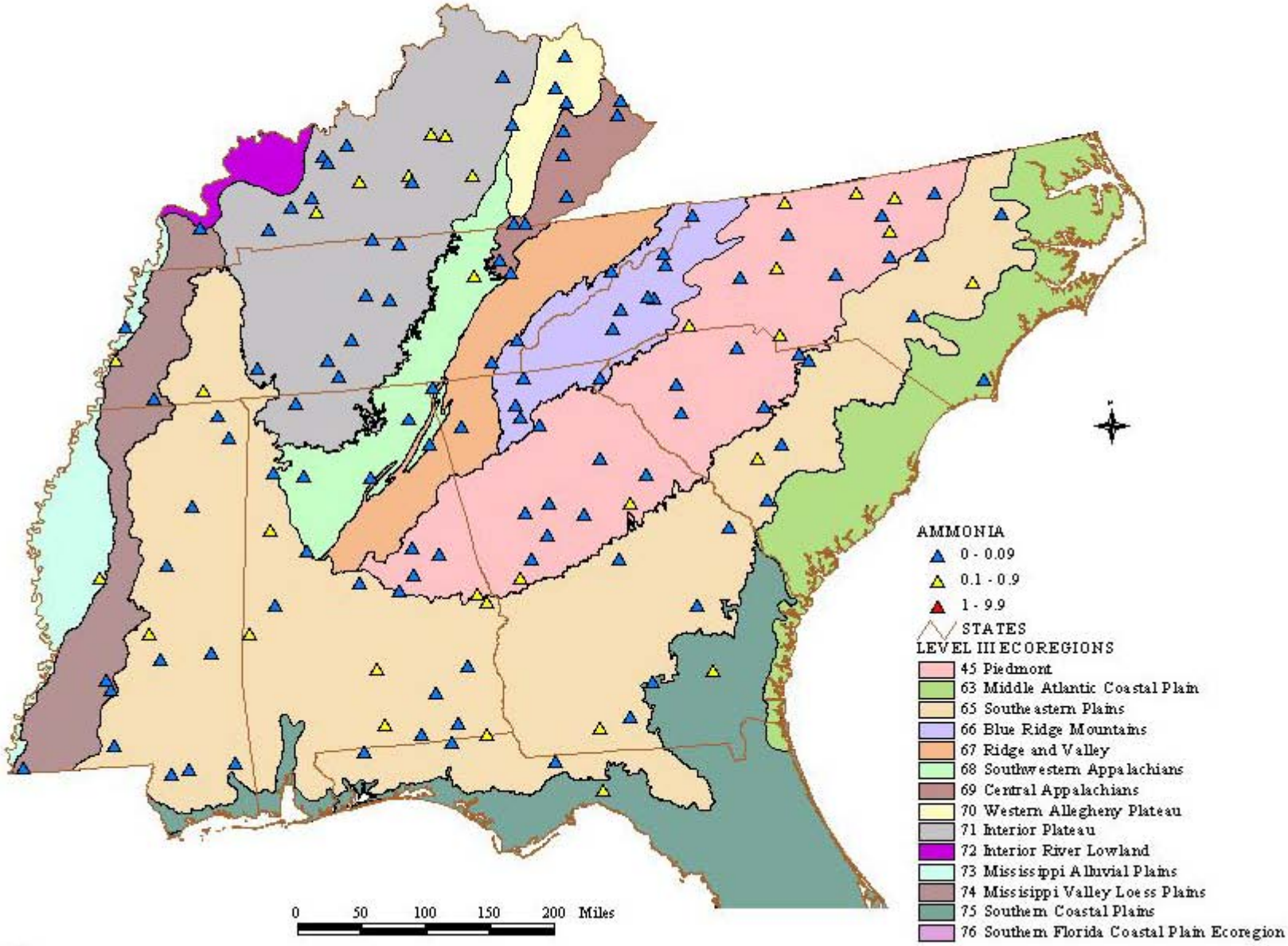
Total Kjeldahl Nitrogen in Southeastern Streams, 1999 - 2001
% Total Wadeable Stream Length
120
100
80
60
40
20
0
-20
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
TKN (mg/l)
cdf
_+95
_-95

Total Phosphorus Concentrations in Region 4 Streams



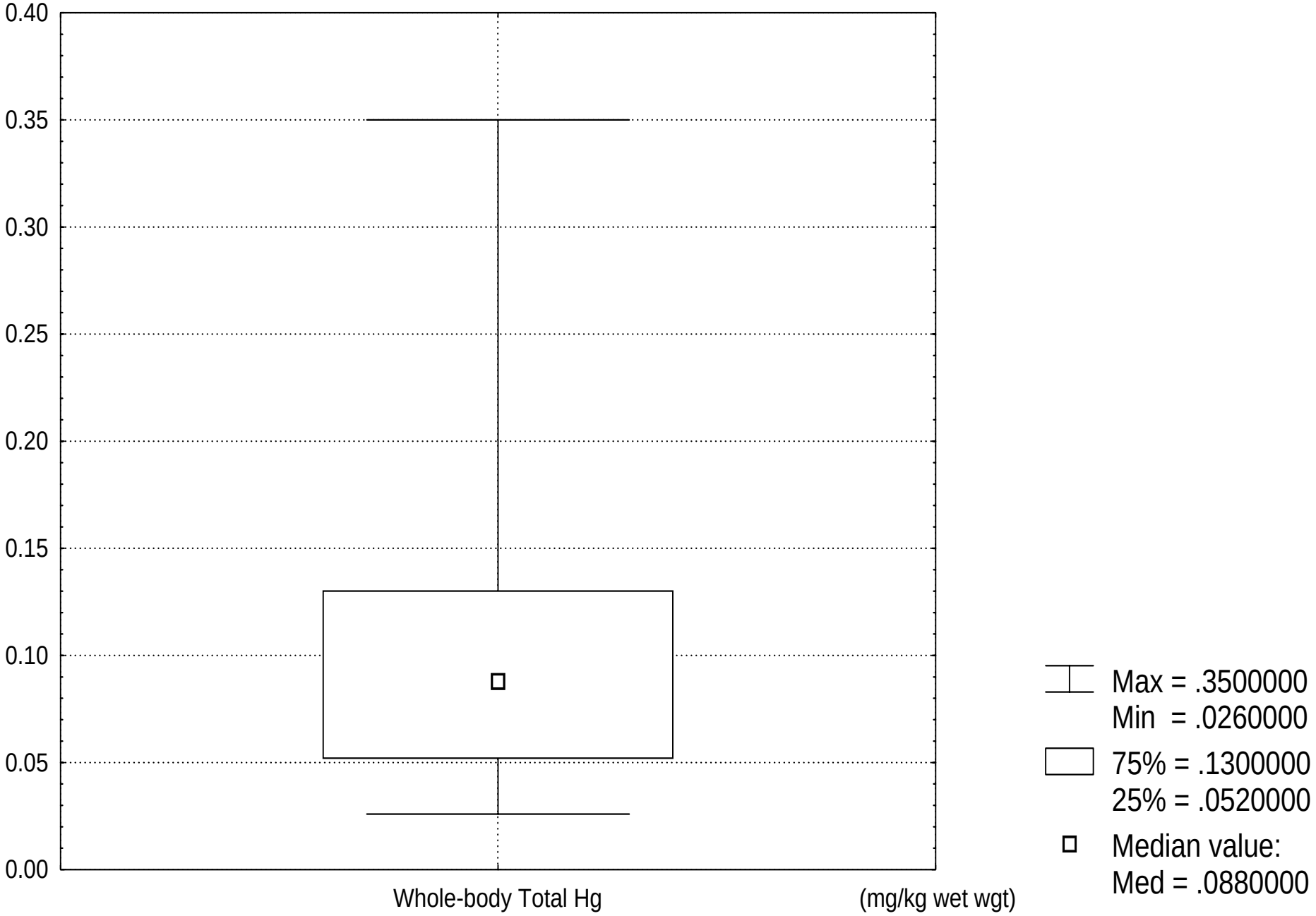

Total Phosphorus in Southeastern Streams, 1999 - 2001
% Total Wadeable Stream Length
120
100
80
60
40
20
0
-20
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Total Phosphorus (mg/l)
cdf
_+95
_-95

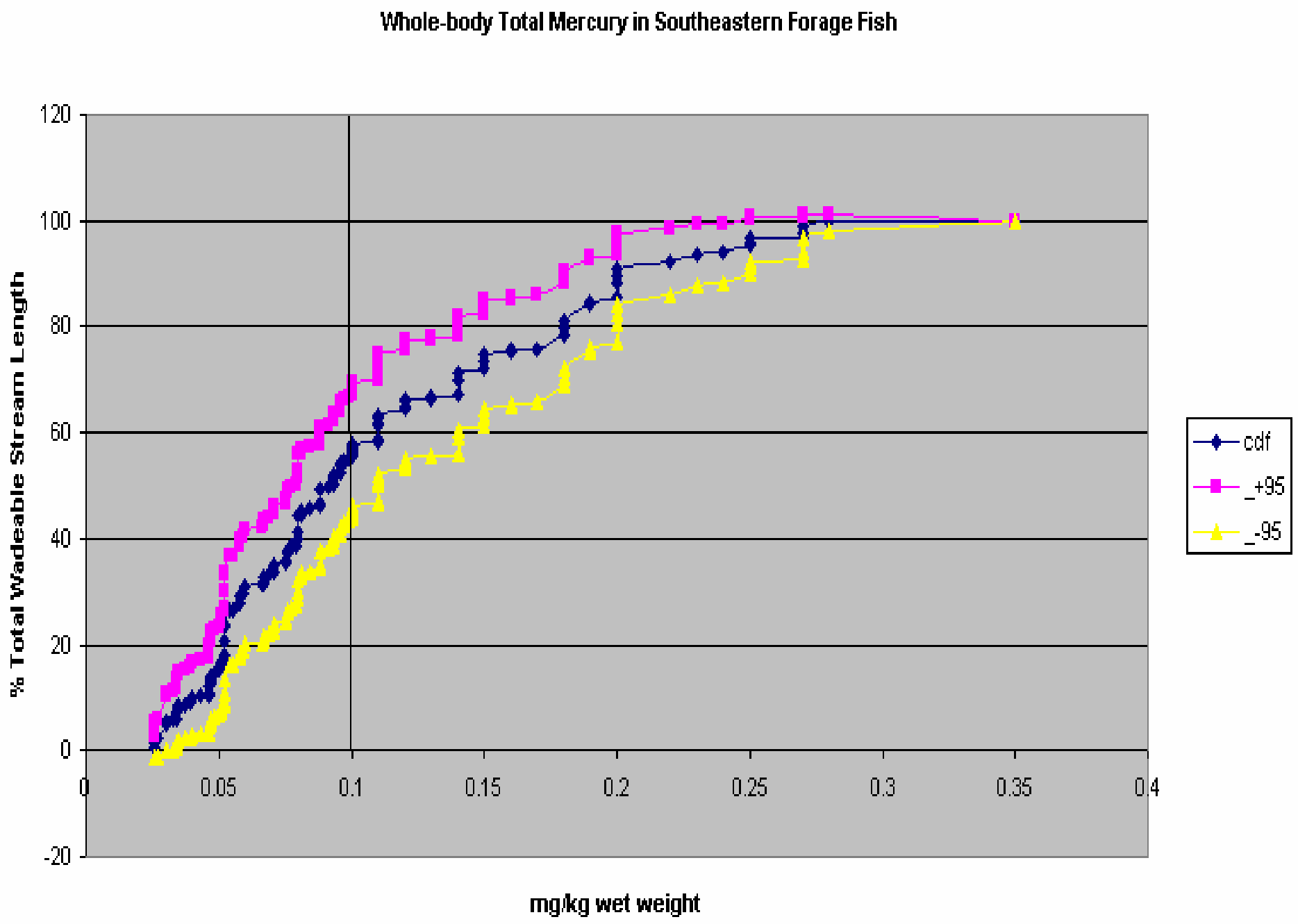
AMMONIA, YEARS 1999, 2000 AND 2001



rudy\gis\alla\emap\ammonia

Mercury in Forage Fish from Southeastern Wadeable Streams, 1999 - 2001

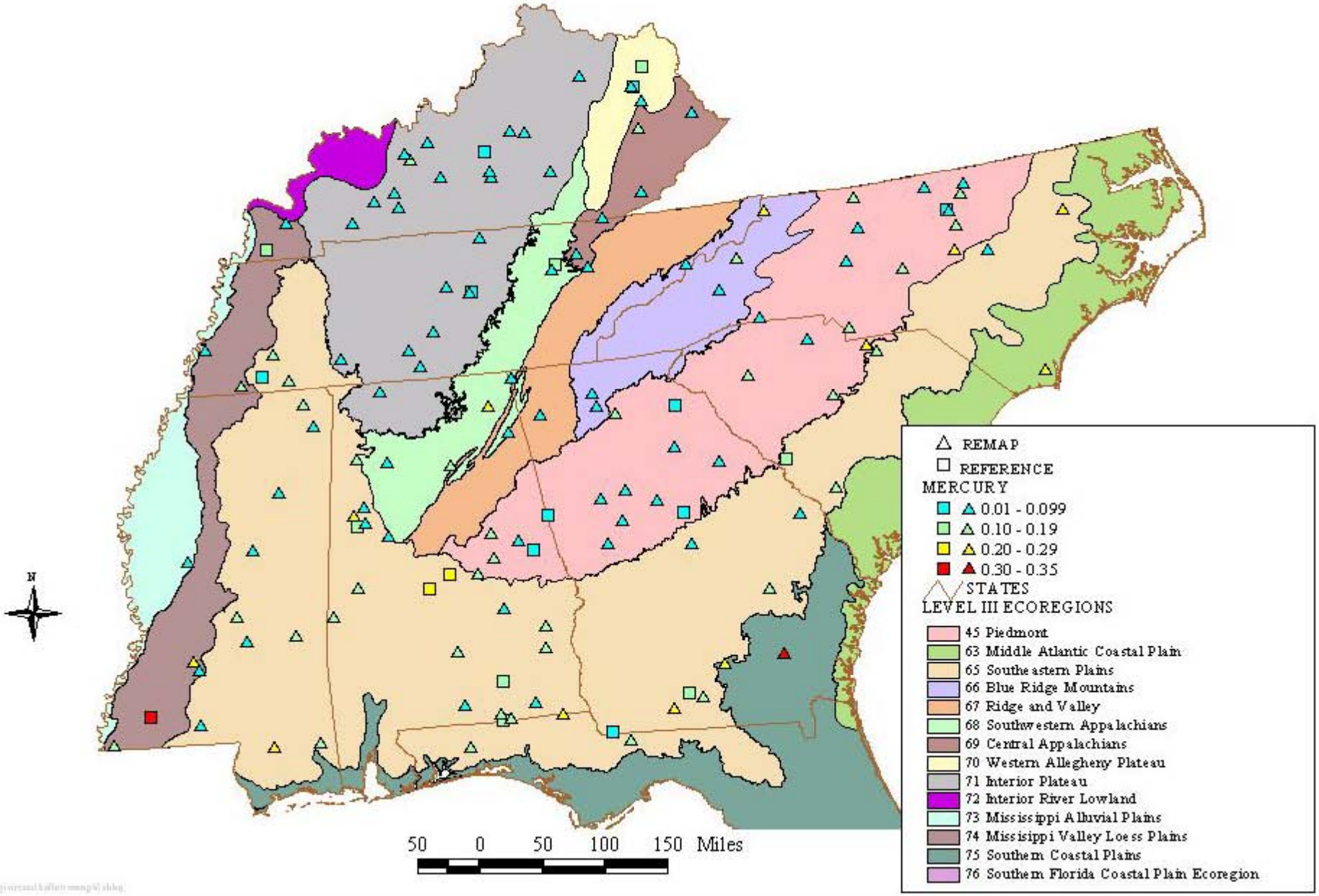



Whole-body Total Mercury in Southeastern Forage Fish
% Total Wadeable Stream Length
120
100
80
60
40
20
0
-20
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
mg/kg wet weight
cdf
_+95
_-95

Interpretation of Hg data:

- **“We are 95 % certain that 45 to 65 per cent of our watersheds are at risk for mercury contamination.”**

TOTAL MERCURY IN REGION 4 FORAGE FISH, CY 1999-2001



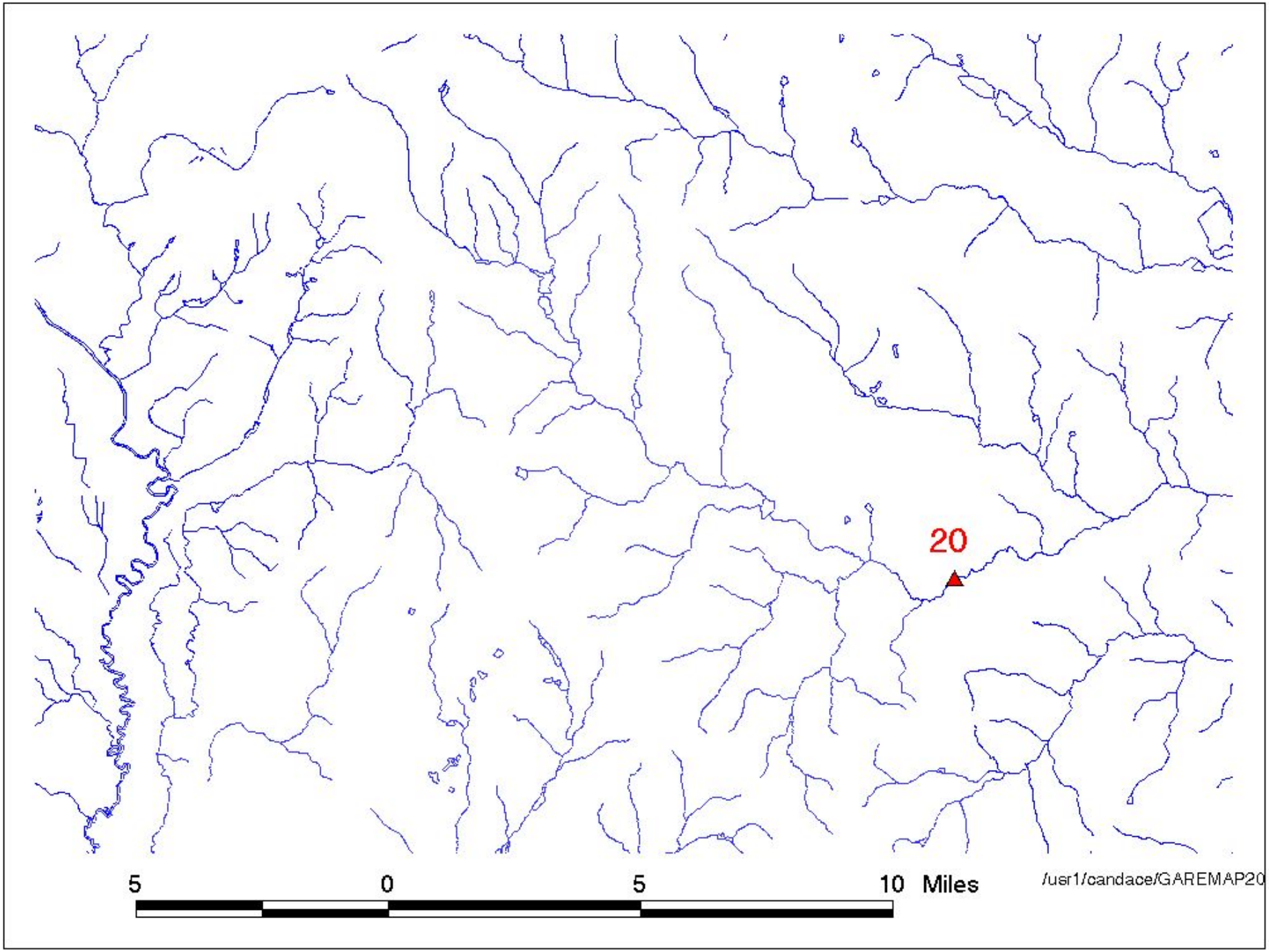
Landscape Factors

Recent and concurrent data on:

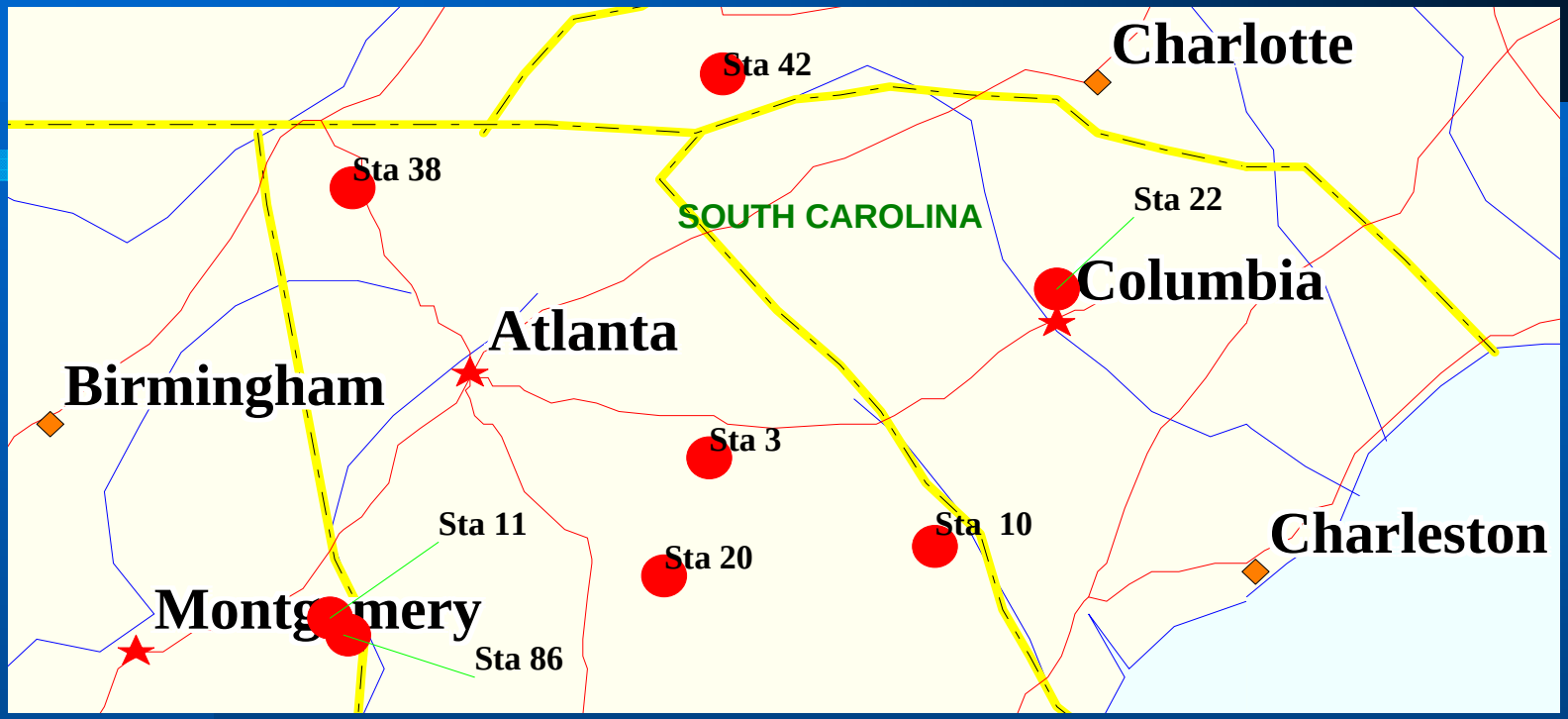
Sub-watershed land use,

Riparian cover, &

Channel conditions


20
5
0
5
10 Miles
/usr1/candace/GAREMAP20

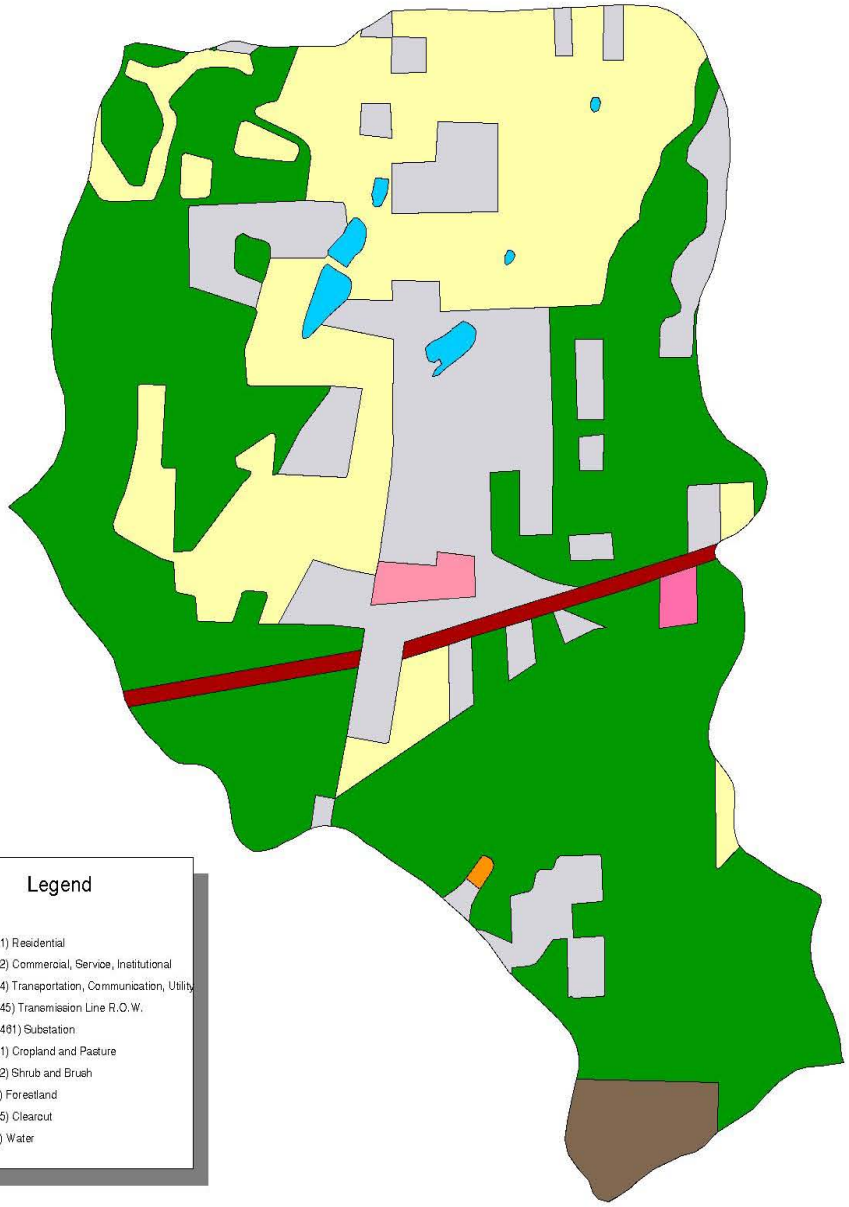
Landscape Pilot Studies



- **NAPP: 8 stations, sampled in 1999:**
  - **Georgia, Alabama, Carolinas**
  - **3 SE Plains, 3 Pied., 1 R&V, 1 B.R.**
  - **D.A.: 1 - 4 - 9 - 16 - 36 - 100 sq. mi.**

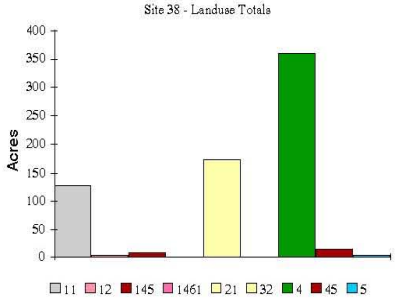
Landuse - Site 38
Tributary to East Chickamauga Creek

600 0 600 1200 1800 2400 3000 Feet



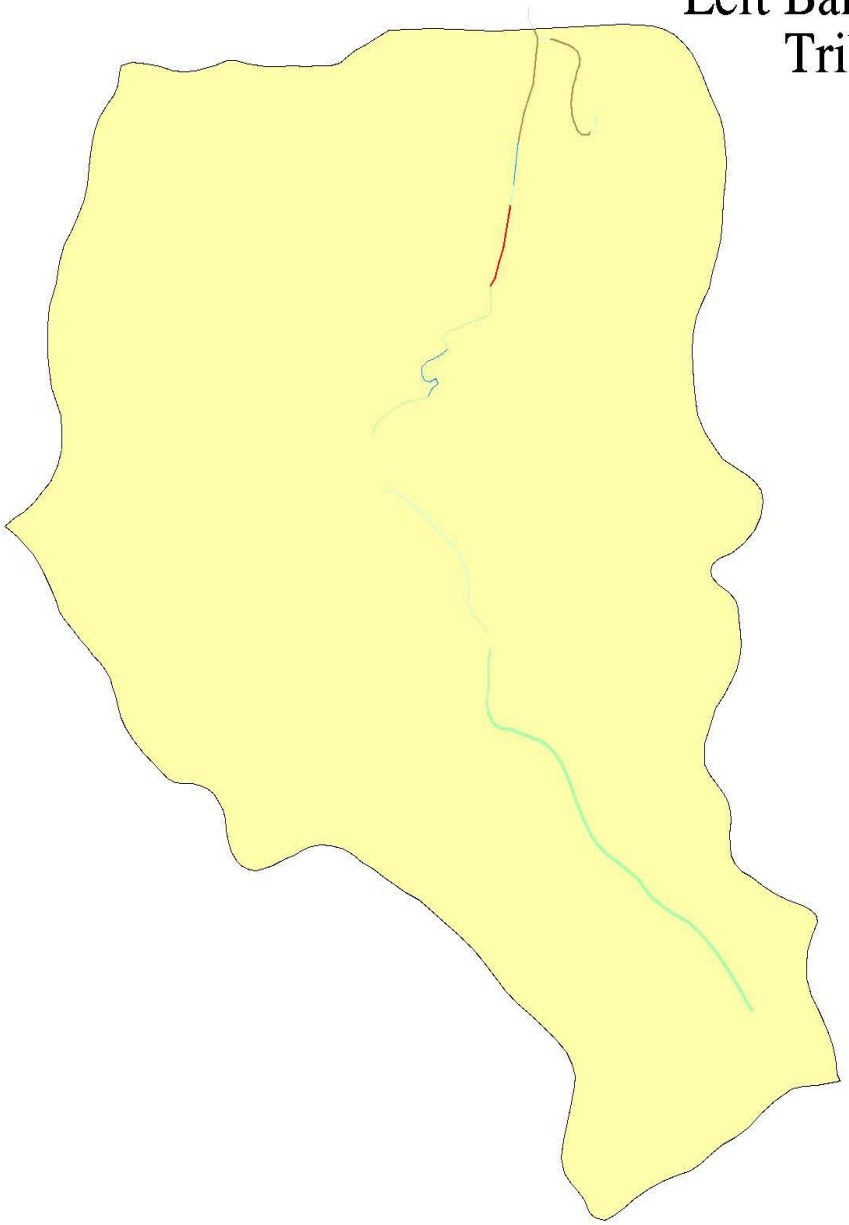
Lengths in Feet

Landuse	Total acres	Percentage of landuse
11	127.92	18.26
12	4.81	0.69
145	10.38	1.48
1461	2.33	0.33
21	173.22	24.72
32	0.58	0.08
4	360.30	51.43
45	15.48	2.21
5	5.57	0.79
Total	700.59	100.00



Data Compiled by Tennessee Valley Authority's
Geographic Information and Engineering
from Color-Infrared Photography at a scale of 1:24000.
Date of Photography: October 1, 1999.

Left Bank Vegetation Type and Width - Site 38
Tributary to East Chickamauga Creek



600 0 600 1200 1800 2400 3000 Feet

Lengths are in Feet

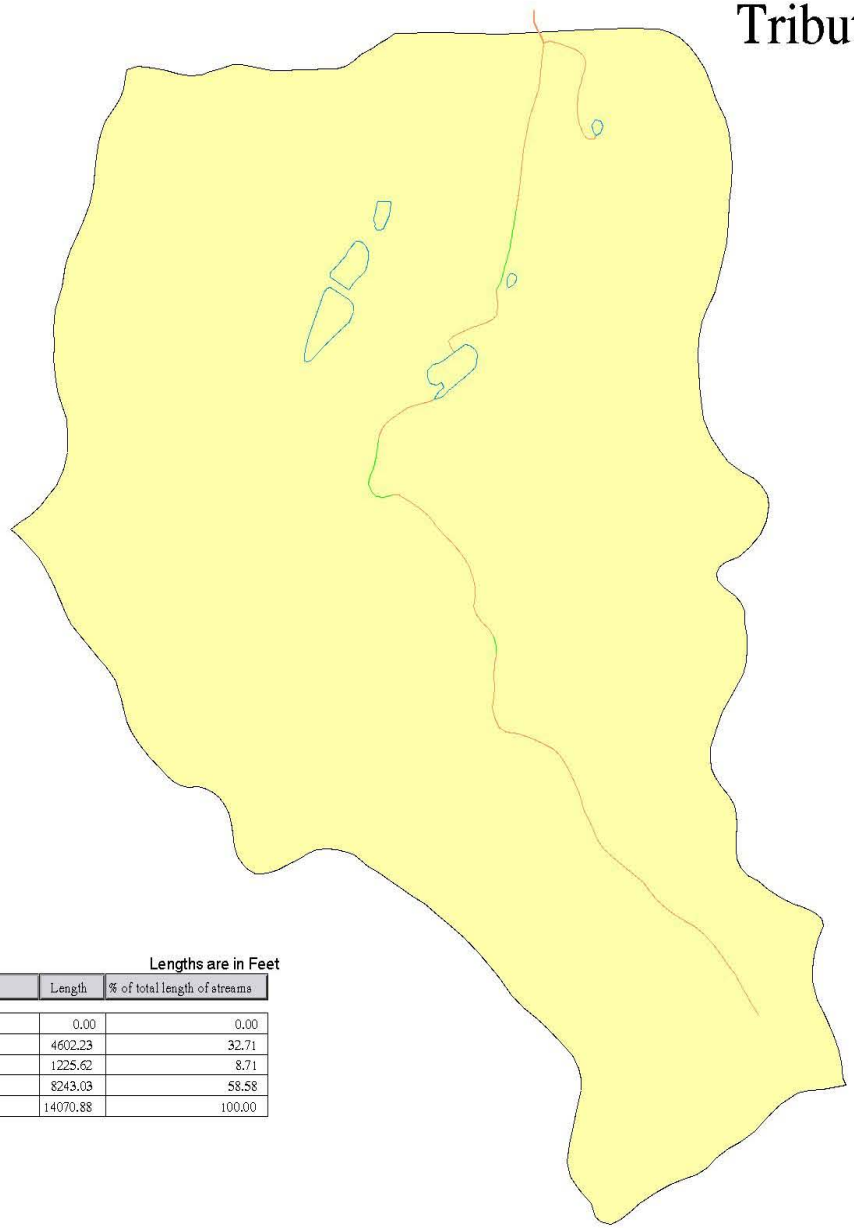
Type	Lengths	0 to 25 feet	% of total length	26 to 100 feet	% of total length	> 100 feet	% of total length
Grass	1683.50	0.00	0.00	1683.50	100.00	0.00	0.00
Shrub/Grass	648.41	535.59	82.60	112.82	17.40	0.00	0.00
Shrub/Scrub	861.54	861.54	100.00	0.00	0.00	0.00	0.00
Trees/Grass	1507.19	1507.19	100.00	0.00	0.00	0.00	0.00
Trees/Shrub	4886.63	1517.33	31.05	419.72	8.59	2949.58	60.36
Urban	577.20	0.00	0.00	577.20	100.00	0.00	0.00
Totals	10164.46	4421.64	43.50	2793.25	27.48	2949.58	29.02

Legend

- Urban (> 100 Feet)
- Urban (26 to 100 Feet)
- Urban (0 to 25 Feet)
- Grass (> 100 Feet)
- Grass (26 to 100 Feet)
- Grass (0 to 25 Feet)
- Shrub/Grass (> 100 Feet)
- Shrub/Grass (26 to 100 Feet)
- Shrub/Grass (0 to 25 Feet)
- Shrub/Scrub (> 100 Feet)
- Shrub/Scrub (26 to 100 Feet)
- Shrub/Scrub (0 to 25 Feet)
- Trees/Grass (> 100 Feet)
- Trees/Grass (26 to 100 Feet)
- Trees/Grass (0 to 25 Feet)
- Trees/Shrub (> 100 Feet)
- Trees/Shrub (26 to 100 Feet)
- Trees/Shrub (0 to 25 Feet)
- Trees (> 100 Feet)
- Trees (26 to 100 Feet)
- Trees (0 to 25 Feet)

Data Compiled by Tennessee Valley Authority's
Geographic Information and Engineering
from Color-Infrared Photography at a scale of 1:24000.
Date of Photography: October 1, 1999.

Stream Type, Condition, and Width - Site 38
Tributary to East Chickamauga Creek



600 0 600 1200 1800 2400 3000 Feet

Legend

- Perennial Non-Eroding Stream - Stream Order 5
- Perennial Non-Eroding Stream - Stream Order 4
- Perennial Non-Eroding Stream - Stream Order 3
- Perennial Non-Eroding Stream - Stream Order 2
- Perennial Non-Eroding Stream - Stream Order 1
- Intermittent Non-Eroding Stream - Stream Order 5
- Intermittent Non-Eroding Stream - Stream Order 4
- Intermittent Non-Eroding Stream - Stream Order 3
- Intermittent Non-Eroding Stream - Stream Order 2
- Intermittent Non-Eroding Stream - Stream Order 1
- Intermittent Eroding Stream - Stream Order 5
- Intermittent Eroding Stream - Stream Order 4
- Intermittent Eroding Stream - Stream Order 3
- Intermittent Eroding Stream - Stream Order 2
- Intermittent Eroding Stream - Stream Order 1
- Perennial Eroding Stream - Stream Order 4
- Perennial Eroding Stream - Stream Order 3
- Perennial Eroding Stream - Stream Order 2
- Perennial Eroding Stream - Stream Order 1

Lengths are in Feet

Type	Length	% of total length of streams
Perennial Broding	0.00	0.00
Perennial Non-Broding	4602.23	32.71
Intermittent Broding	1225.62	8.71
Intermittent Non-Broding	8243.03	58.58
Total	14070.88	100.00

Data Compiled by Tennessee Valley Authority's
Geographic Information and Engineering
from Color-Infrared Photography at a scale of 1:24000.
Date of Photography: October 1, 1999.

IKONOS image
4-m panchromatic

Griffin, GA
Sept. 13, 2001

Other Potential Landscape Factors

- Road & bridge density
- % Impervious area
- Drainage ditch density

  - Soil loss rates
  - Geomorphology & geology
  - Livestock operations
  - Land application sites
  - Septic tank density

PROBABILITY SAMPLING

- DISADVANTAGES
  - Most can be overcome
  - –Non-targets
  - –Accessibility
  - –Dependability

- ADVANTAGES
  - –Unbiased data
    - Many uses
  - –Statistical Inference
    - No model assumptions

Acknowledgements

- QA/QC
  - Hoke Howard
  - Lonnie Dorn, Dave Etnier
- Field Team
  - Jim Maudsley
  - Jerry Ackerman
  - Don Fortson
- Chemical Analysis
  - Roseanne Hutchinson, Roberta Howes
  - Bob Quinn, Bill Simpson
- Data Analysis
  - Jason Hill, Eddie Bonnell
- GIS Support
  - Trudy Stiber

Collaboration

- States
  - Ecoregional reference sites
- ORD Corvallis (Tony Olsen), UGA (Steve Rathbun)
  - Survey sampling
- ORD Duluth, Athens; Region 4; HQ
  - Funding

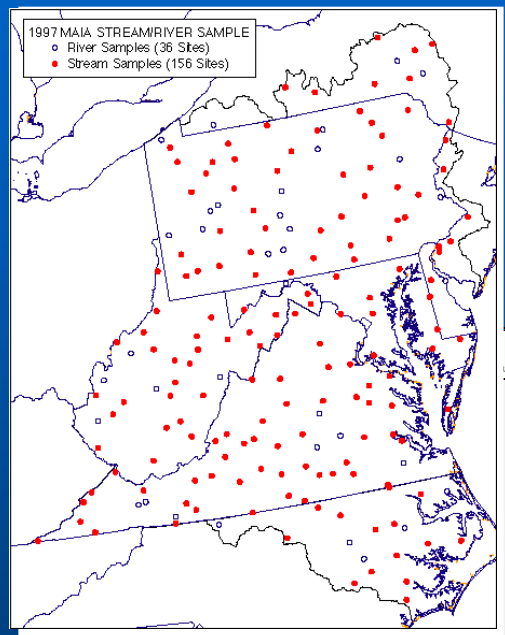
Integrated Monitoring Design

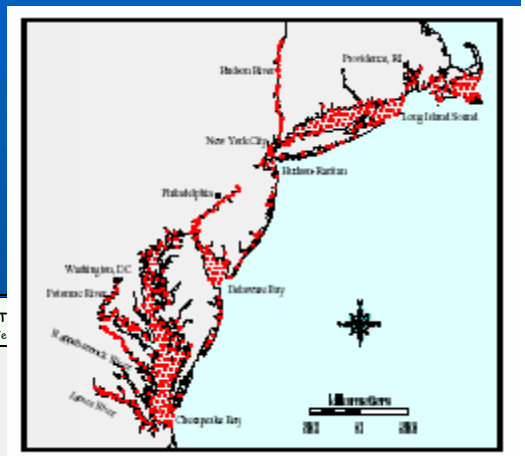
Serves Watershed, State, & National Scales

Management Question	Monitoring Design
How big is the problem?	***Probability surveys* to predict the proportion of waters which may be impaired**
Where is the problem?	***Landscape modeling* to predict the likely locations of impaired waters**
How do I deal with the problem?	***Targeted monitoring* to verify impairment, identify causes, and support planning and implementation of control measures**

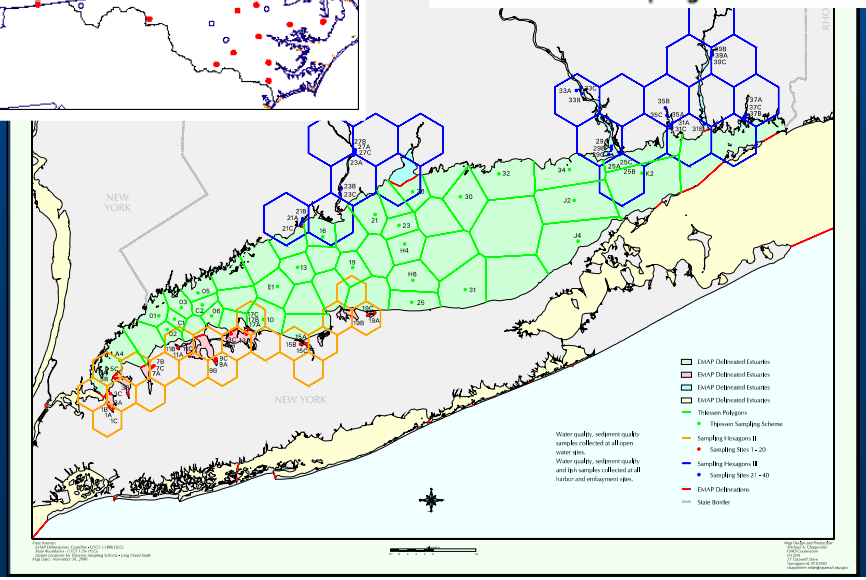
Probability-based Designs

- Simple concepts of sampling
- Allows description of the whole by only sampling parts
- Used in economic surveys, opinion polls
- Used in all terrestrial surveys

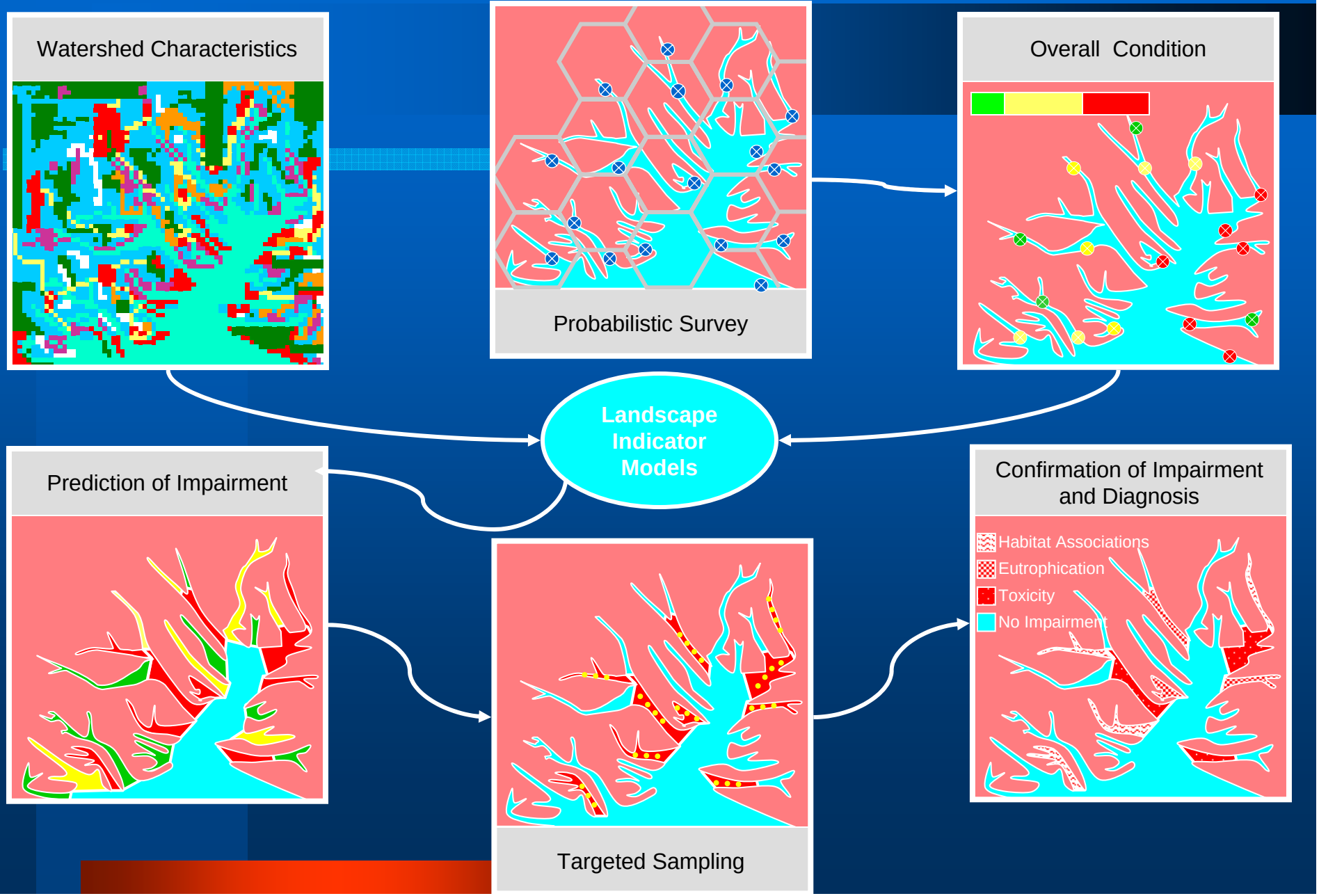




Sampling Sites

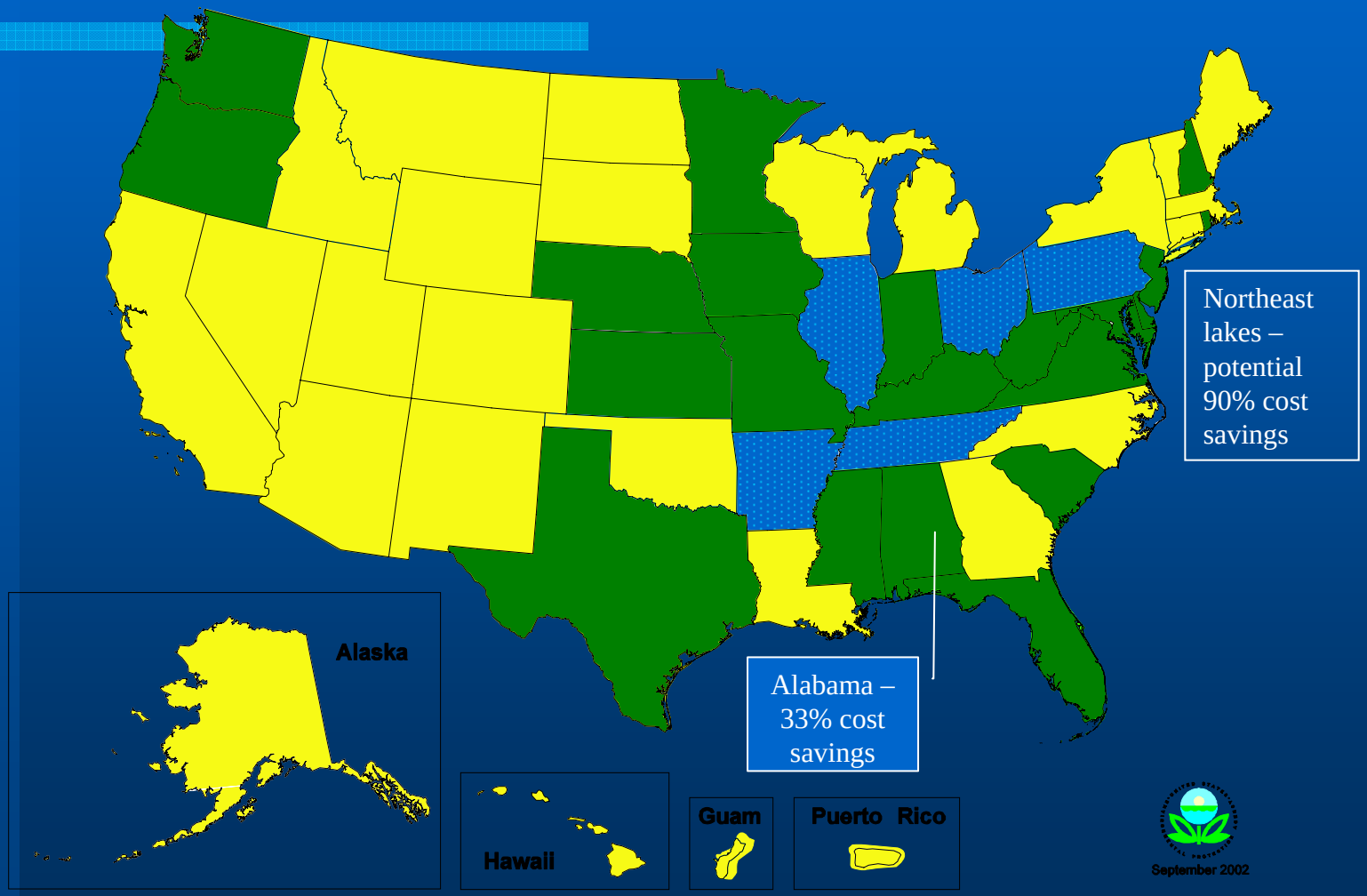


Integrated Monitoring Framework



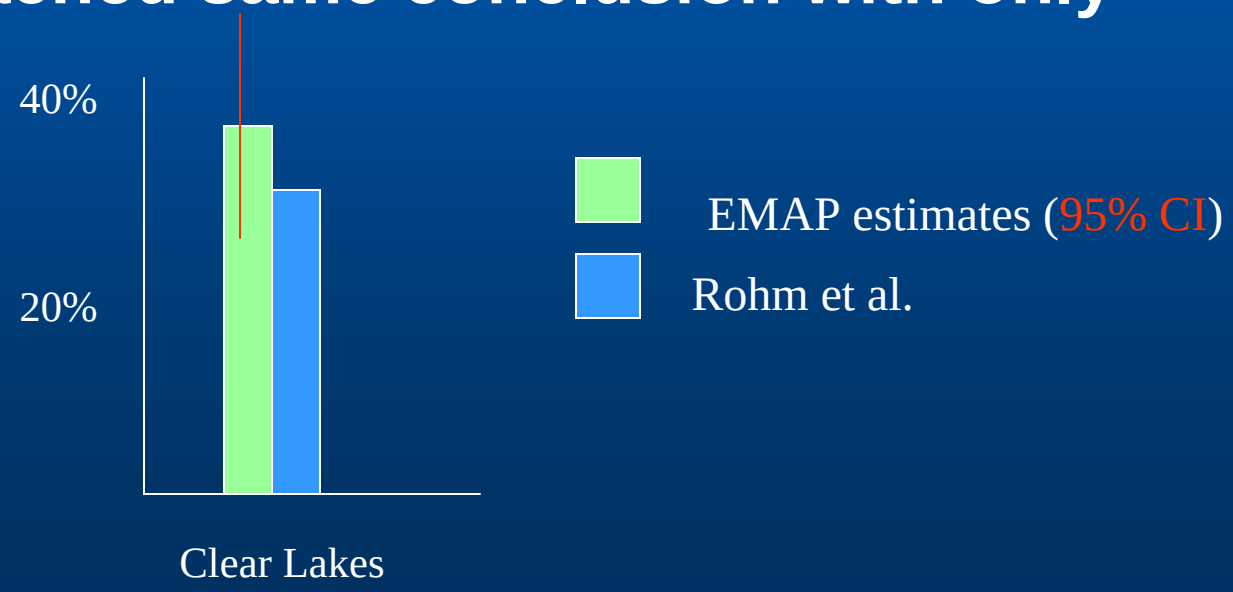
State Use of Probability Survey Designs: Streams and Estuaries

- Adopted probability design
- Evaluating probability design
- No decision yet

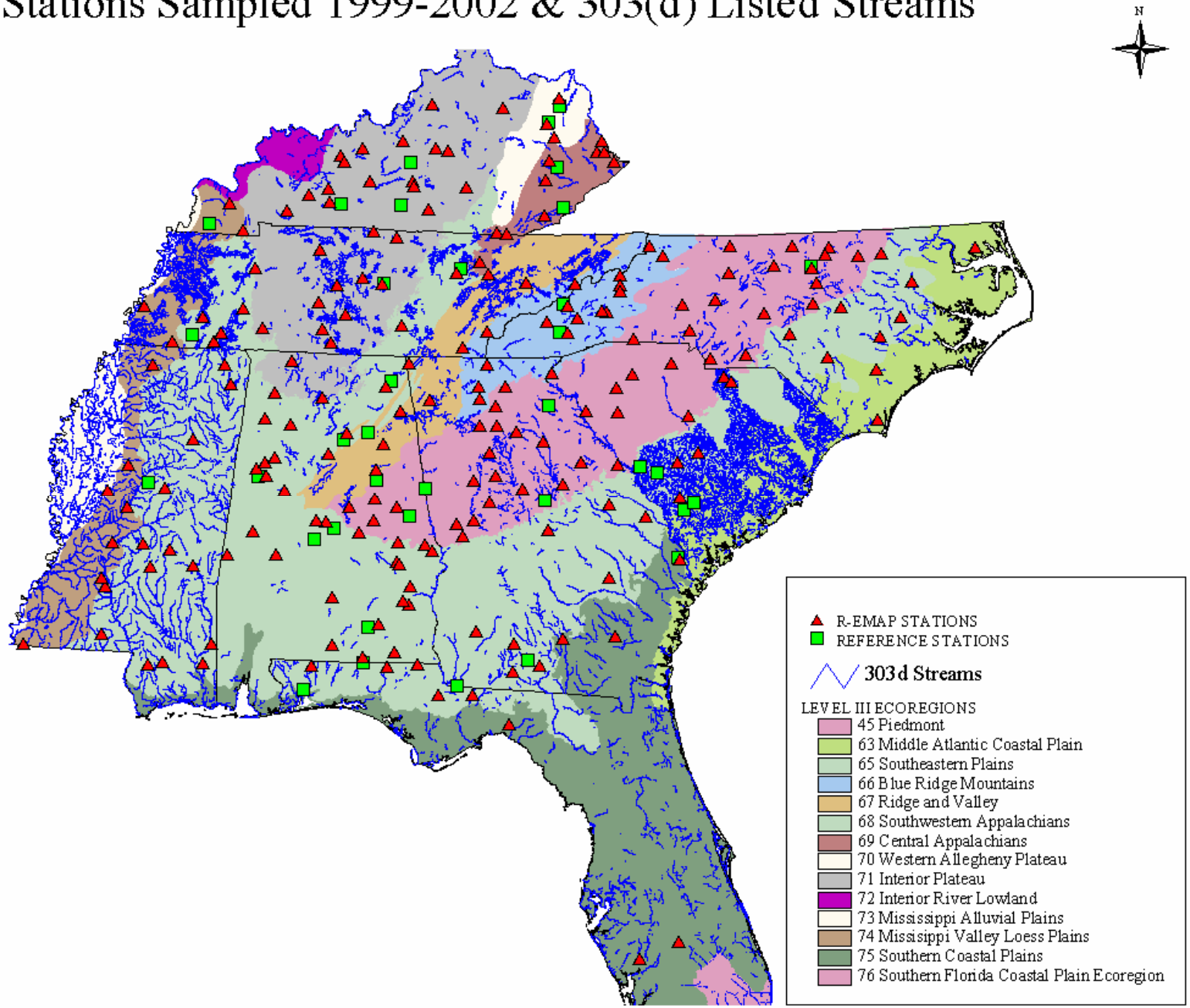


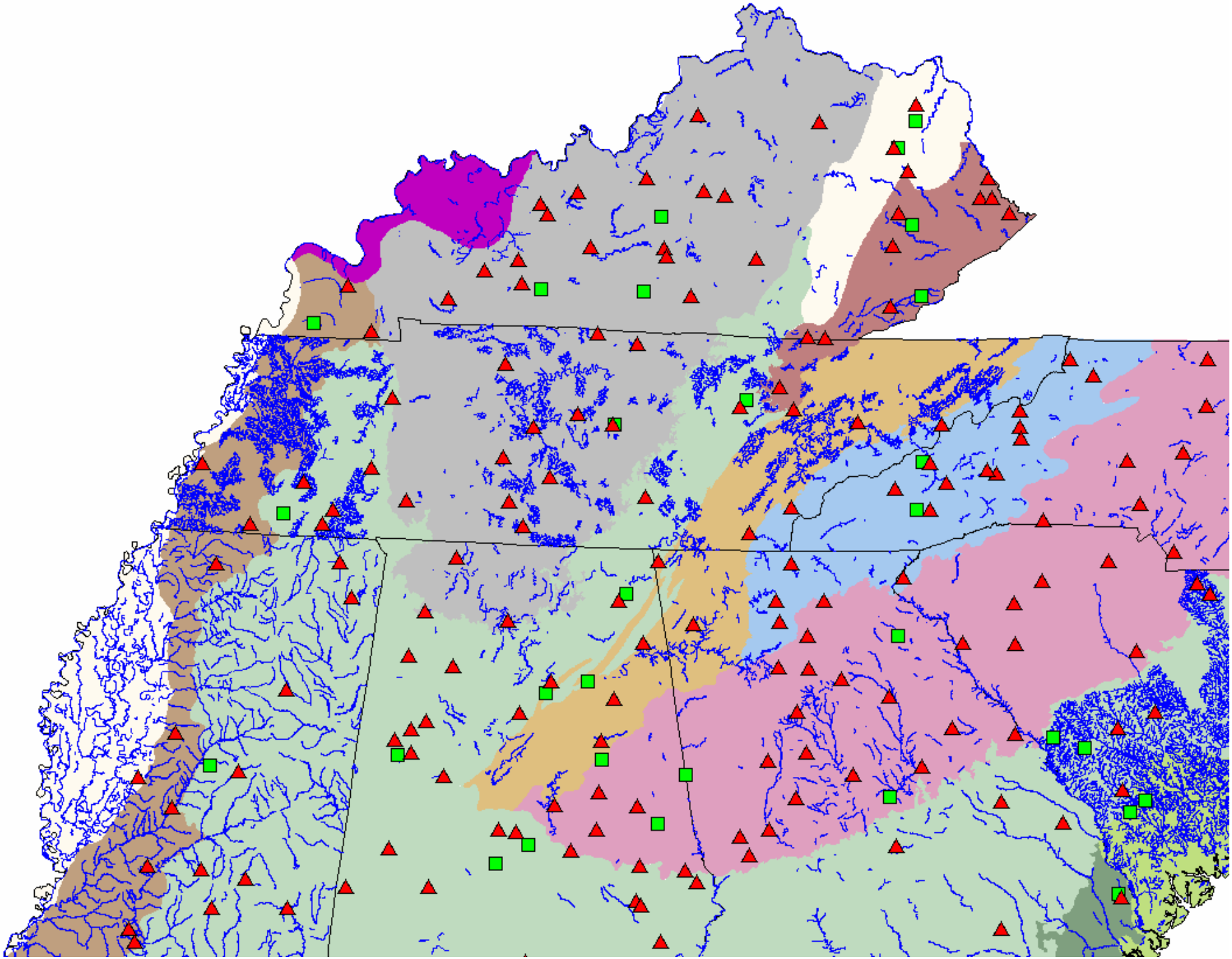
Cost Effectiveness of EMAP Approach

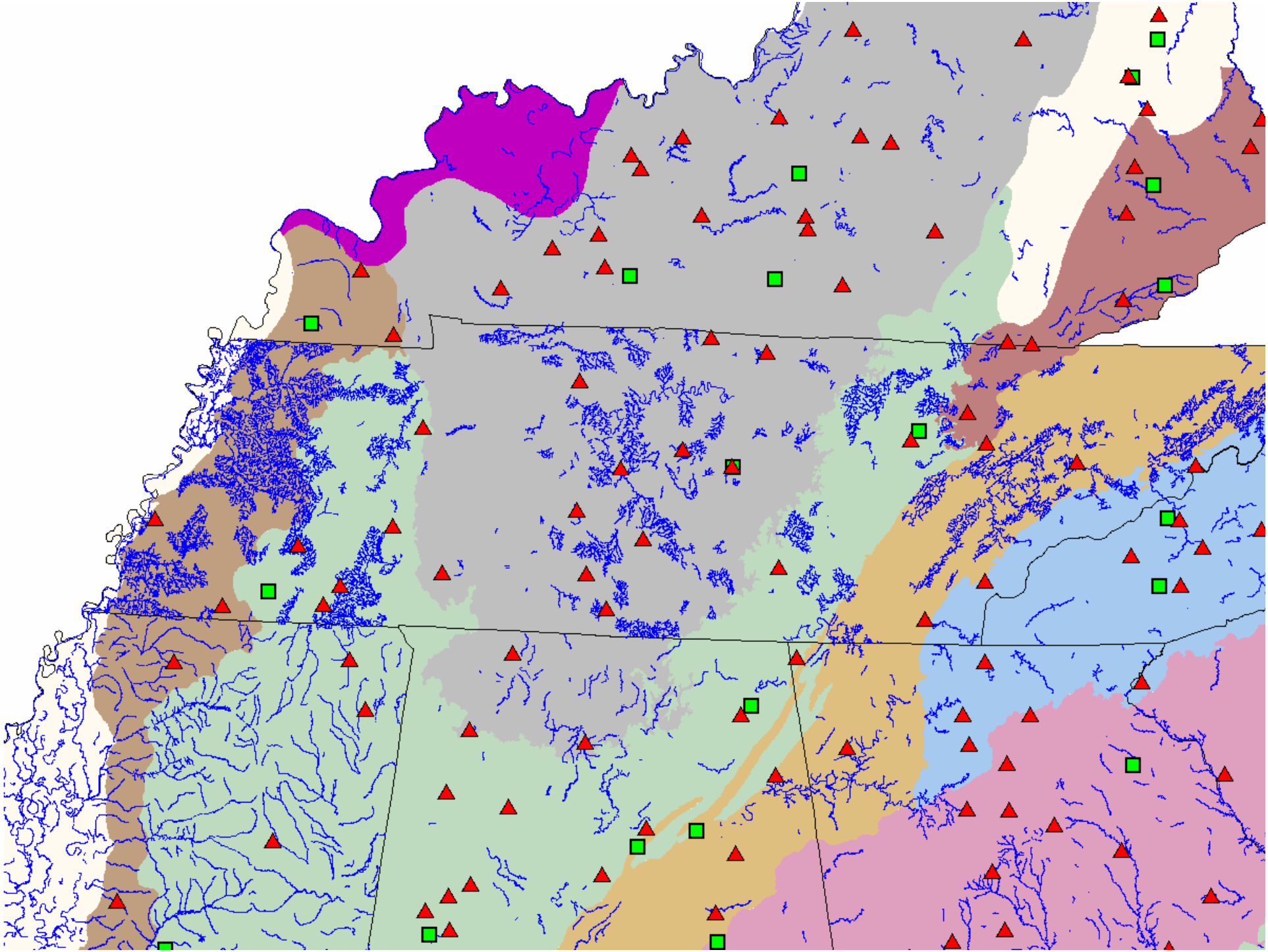
- Eutrophication of NE US lakes
  - **2756 non-random lakes censused (Rohm et al. 1995)**
  - **EMAP reached same conclusion with only 344 lakes**

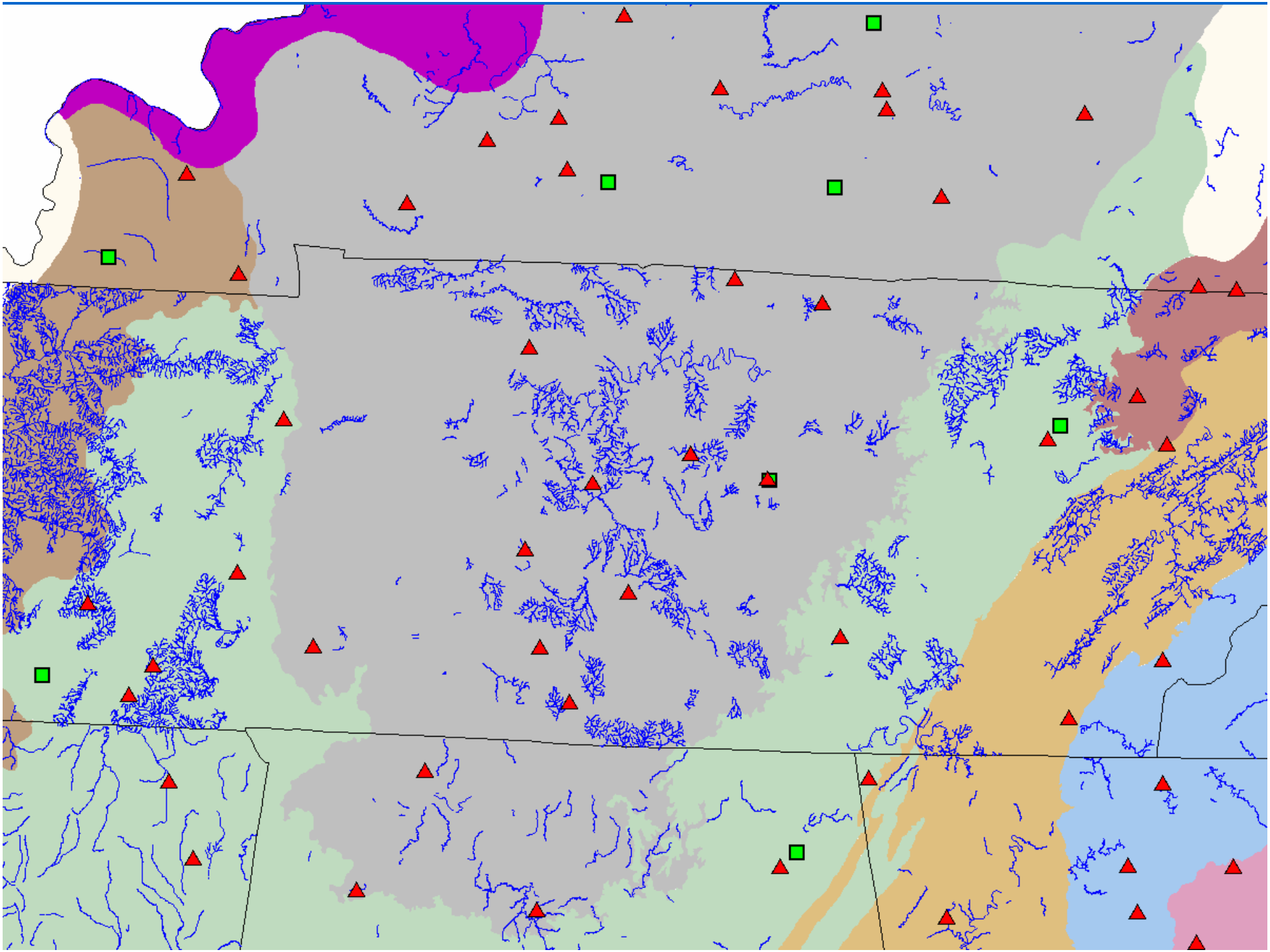


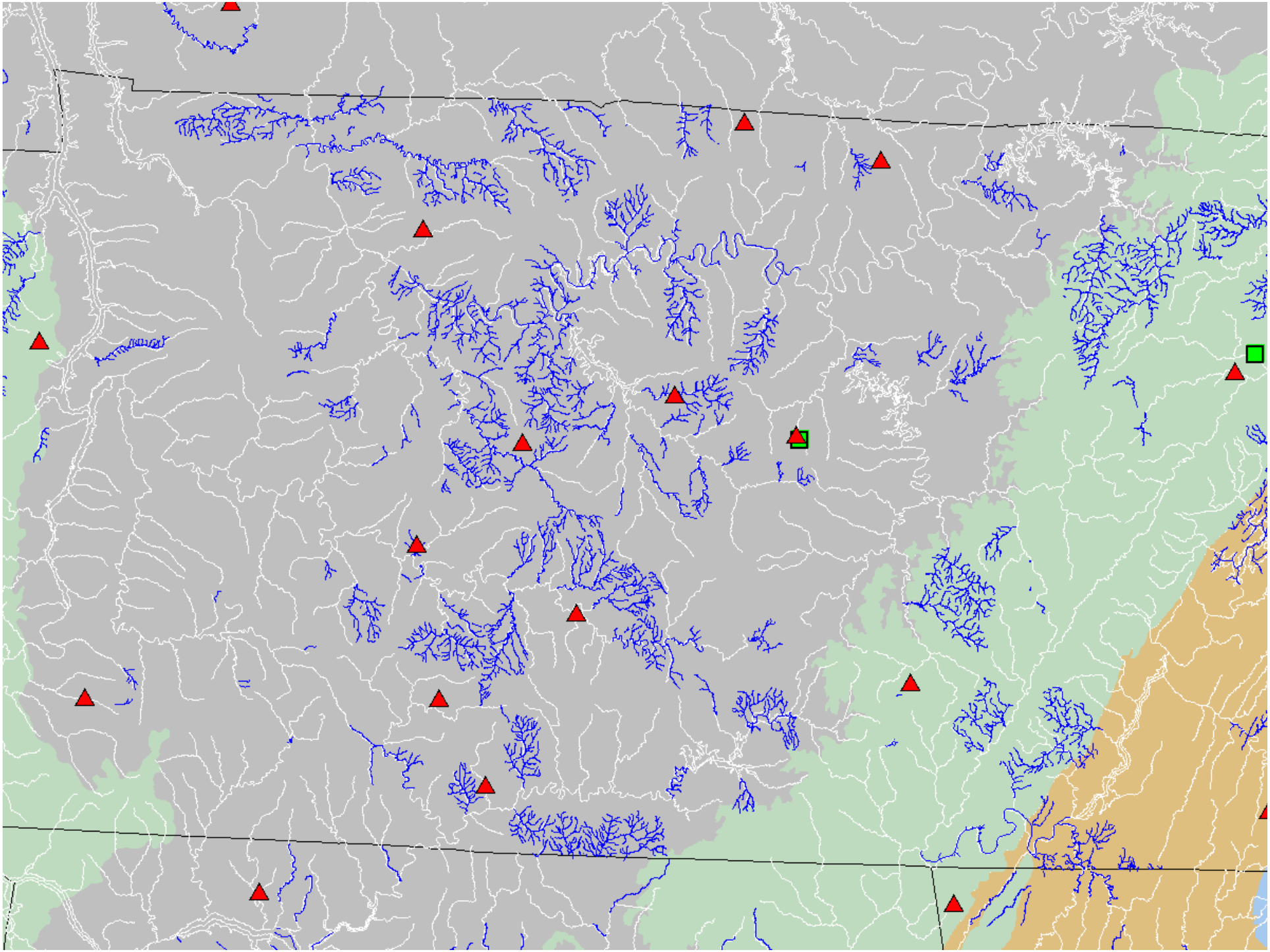
R-EMAP Stations Sampled 1999-2002 & 303(d) Listed Streams



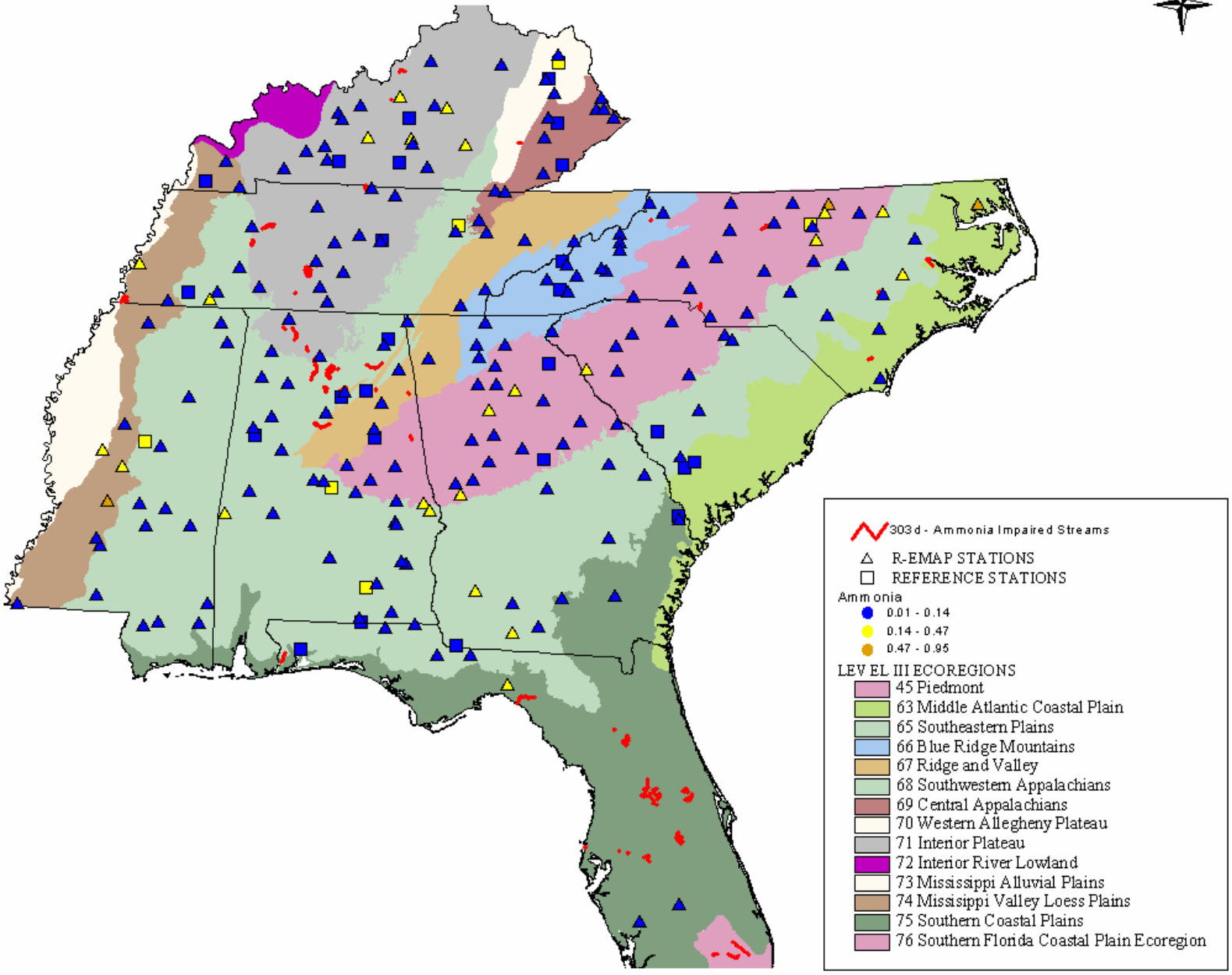








Data Integration: Ammonia - R-EMAP & 303(d)



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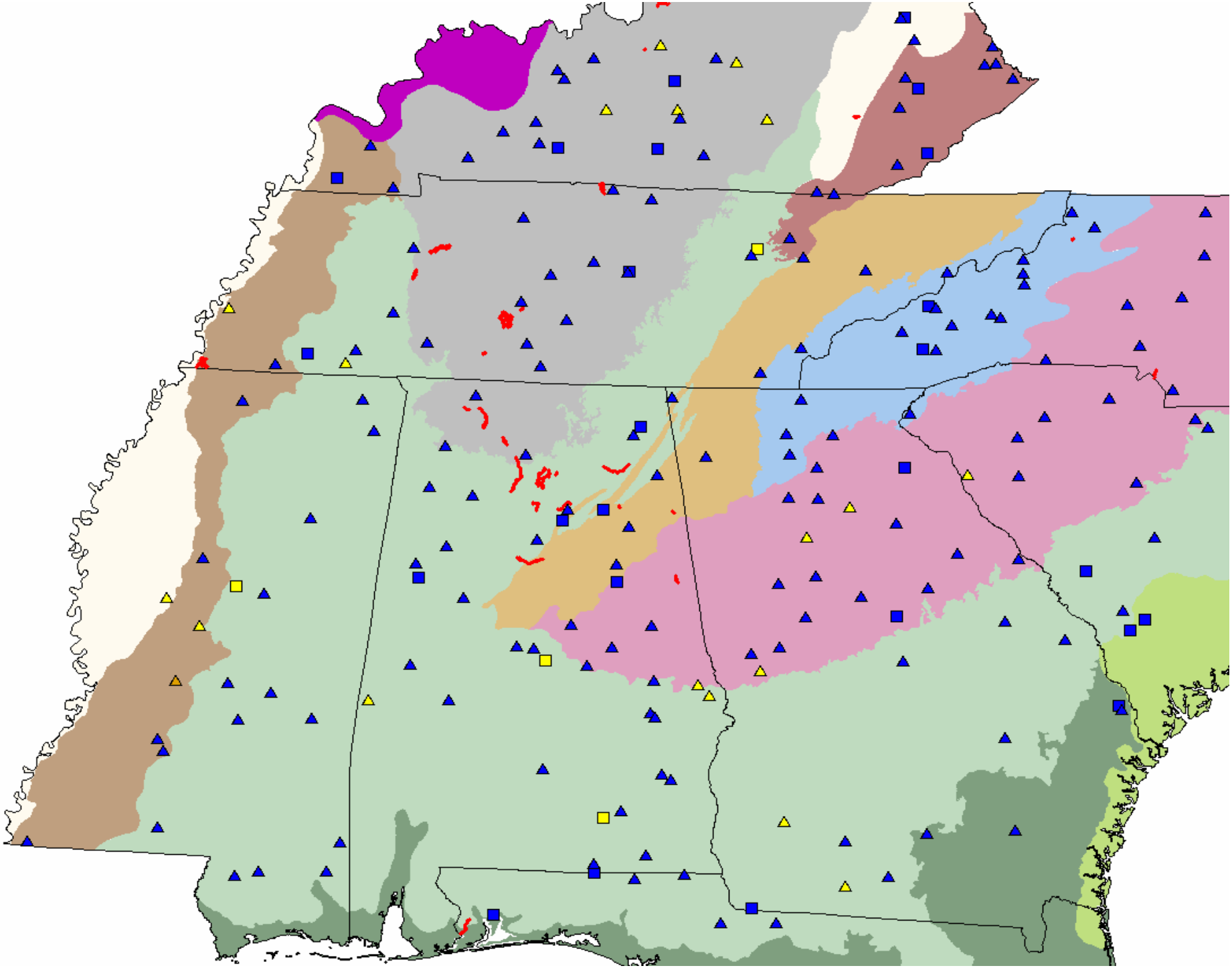
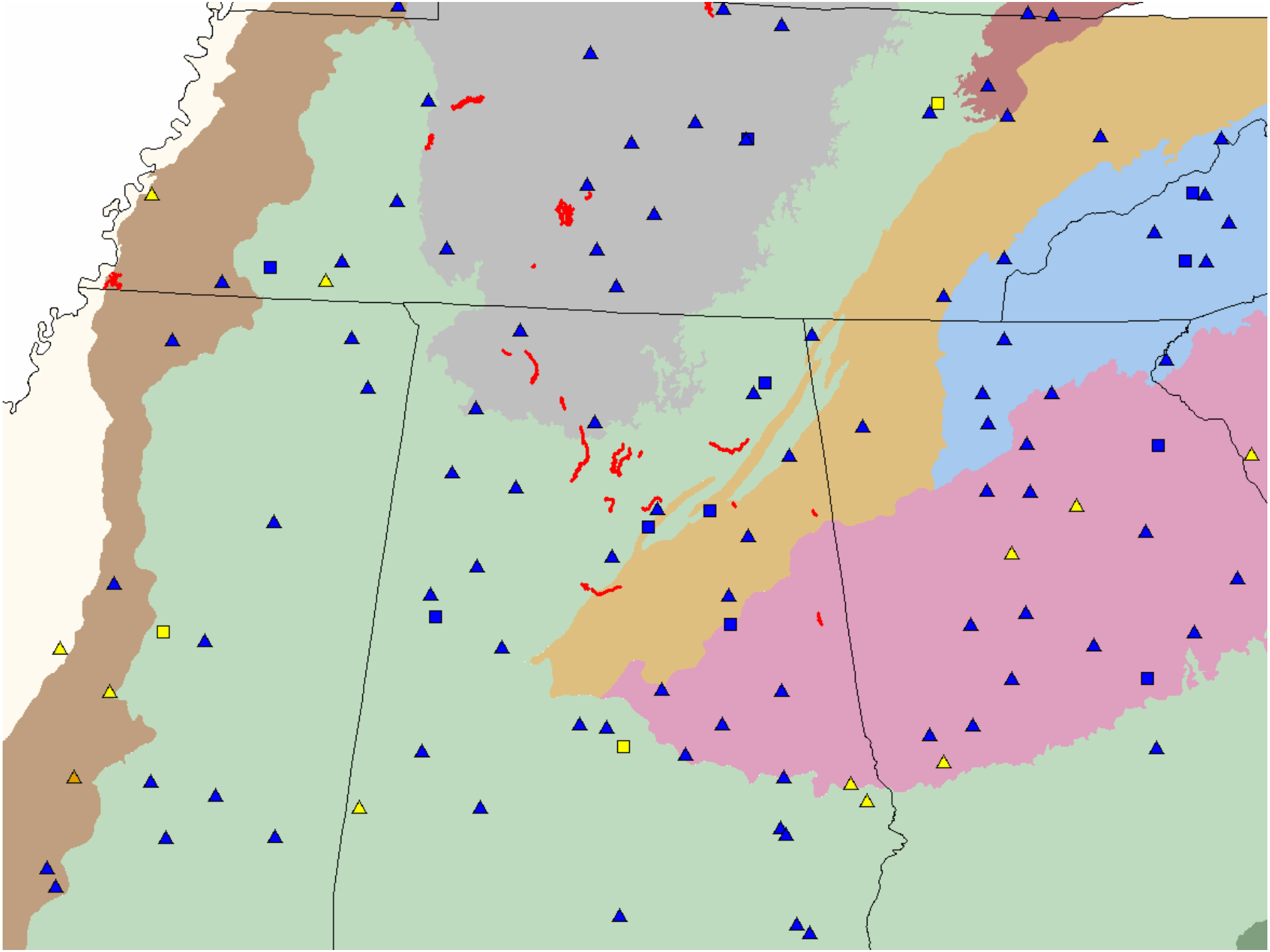
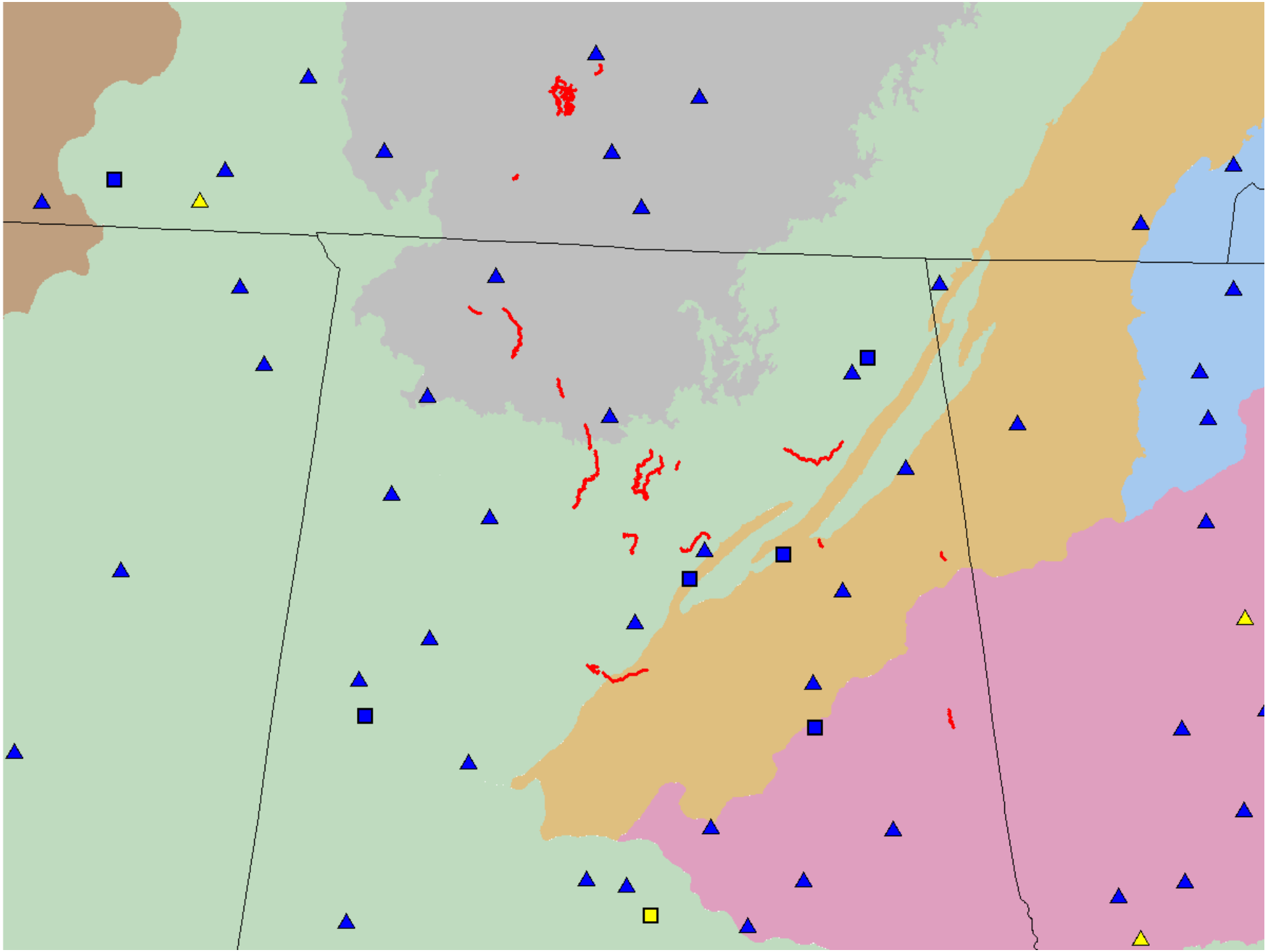
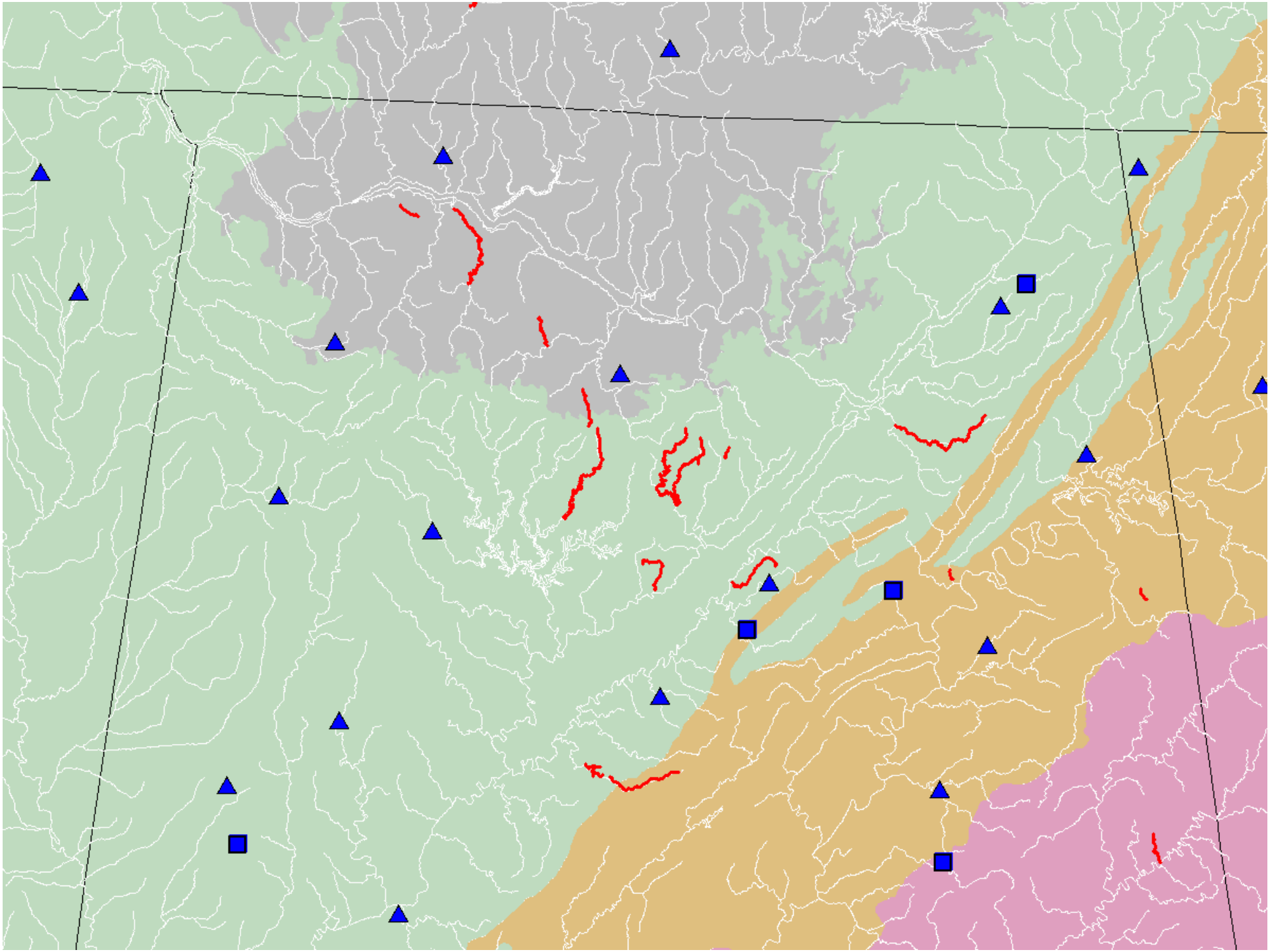
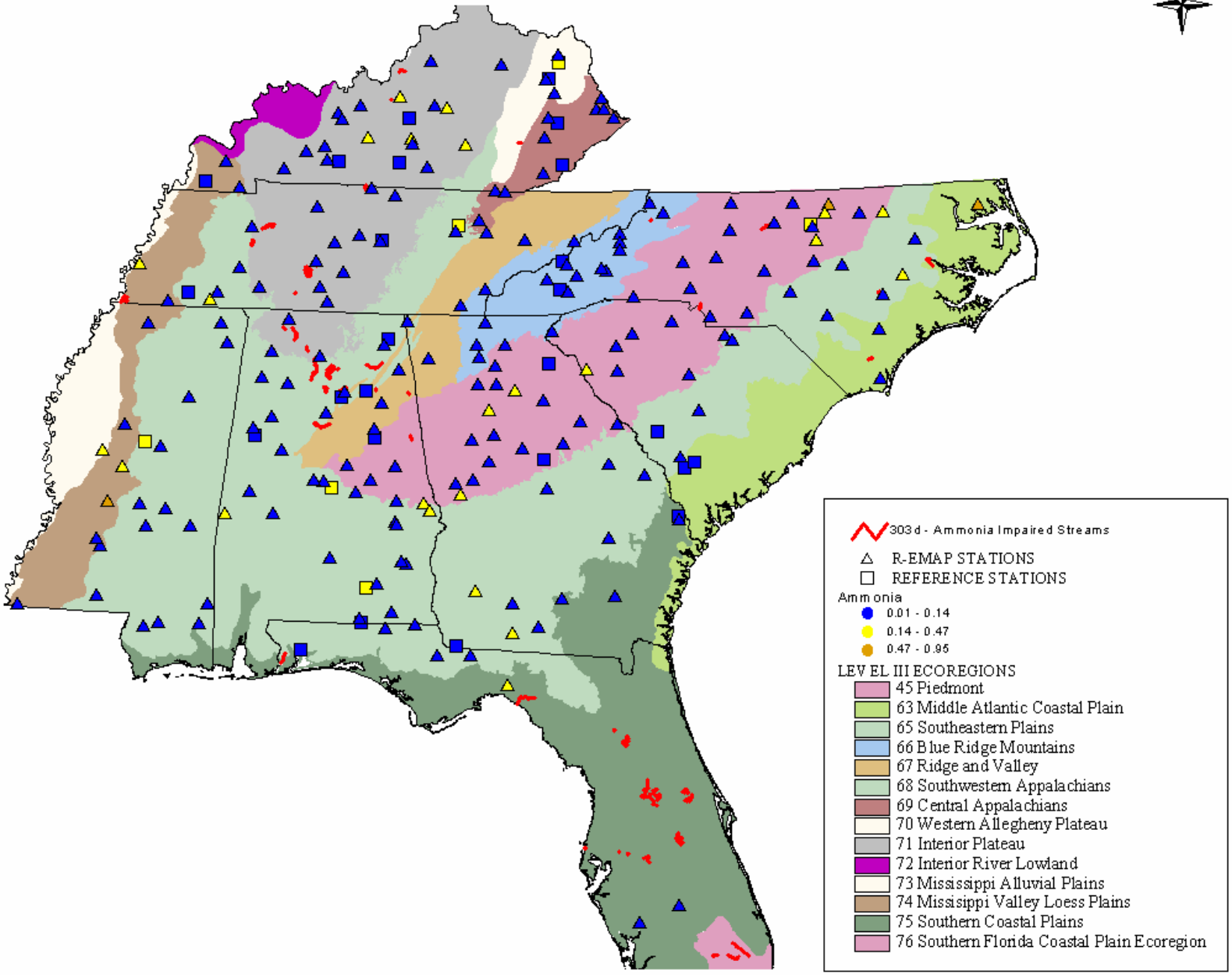








Data Integration: Ammonia - R-EMAP & 303(d)



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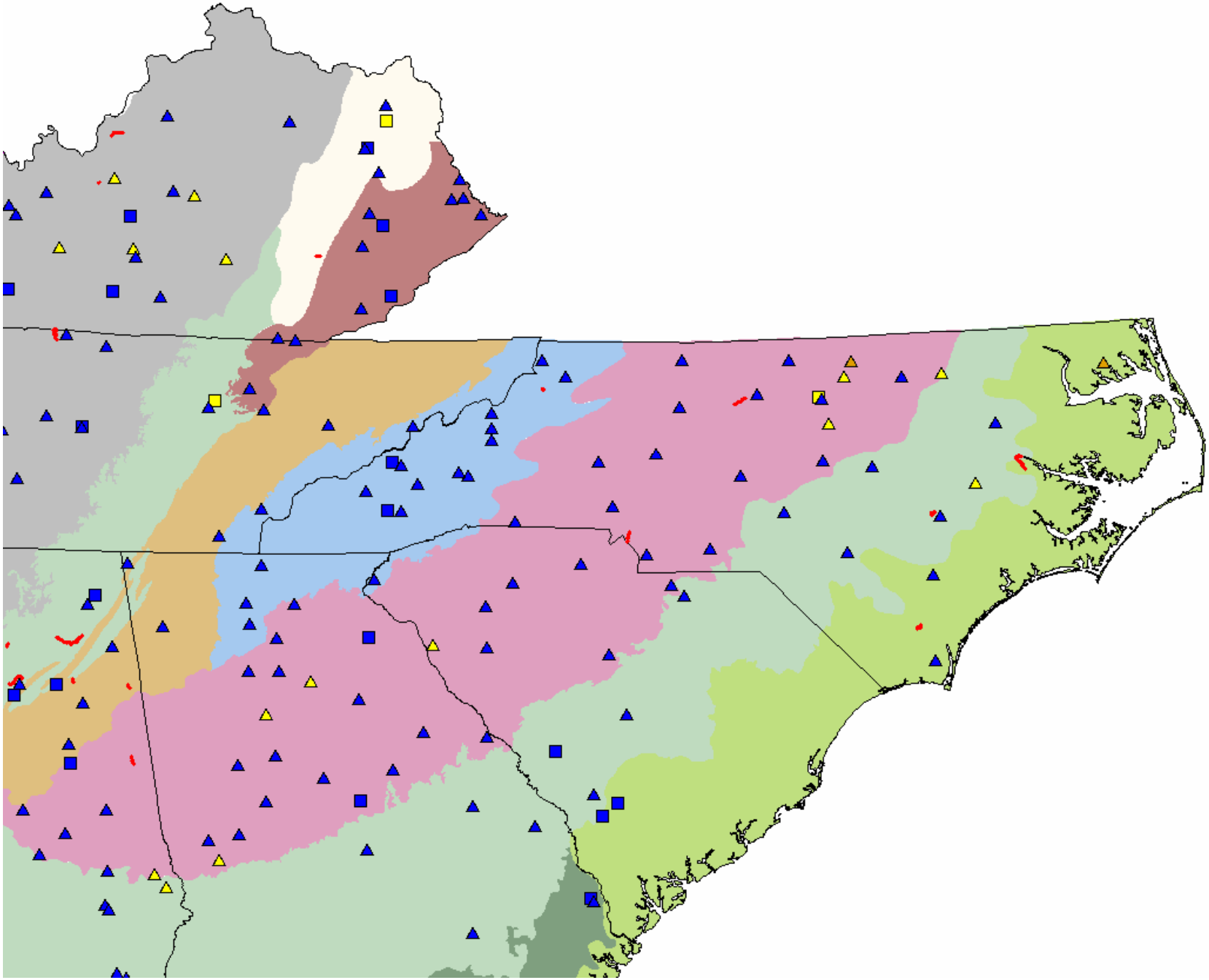
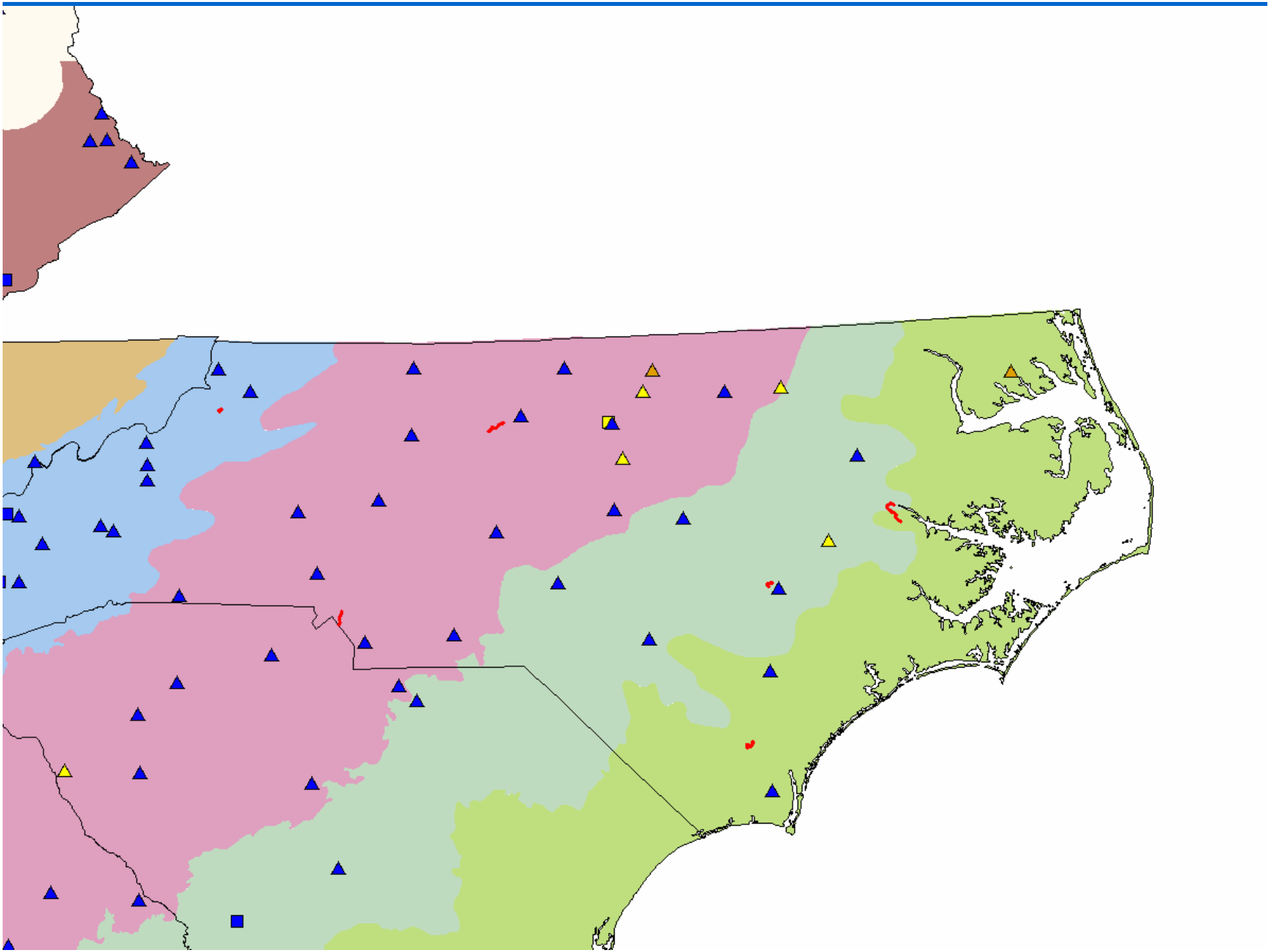
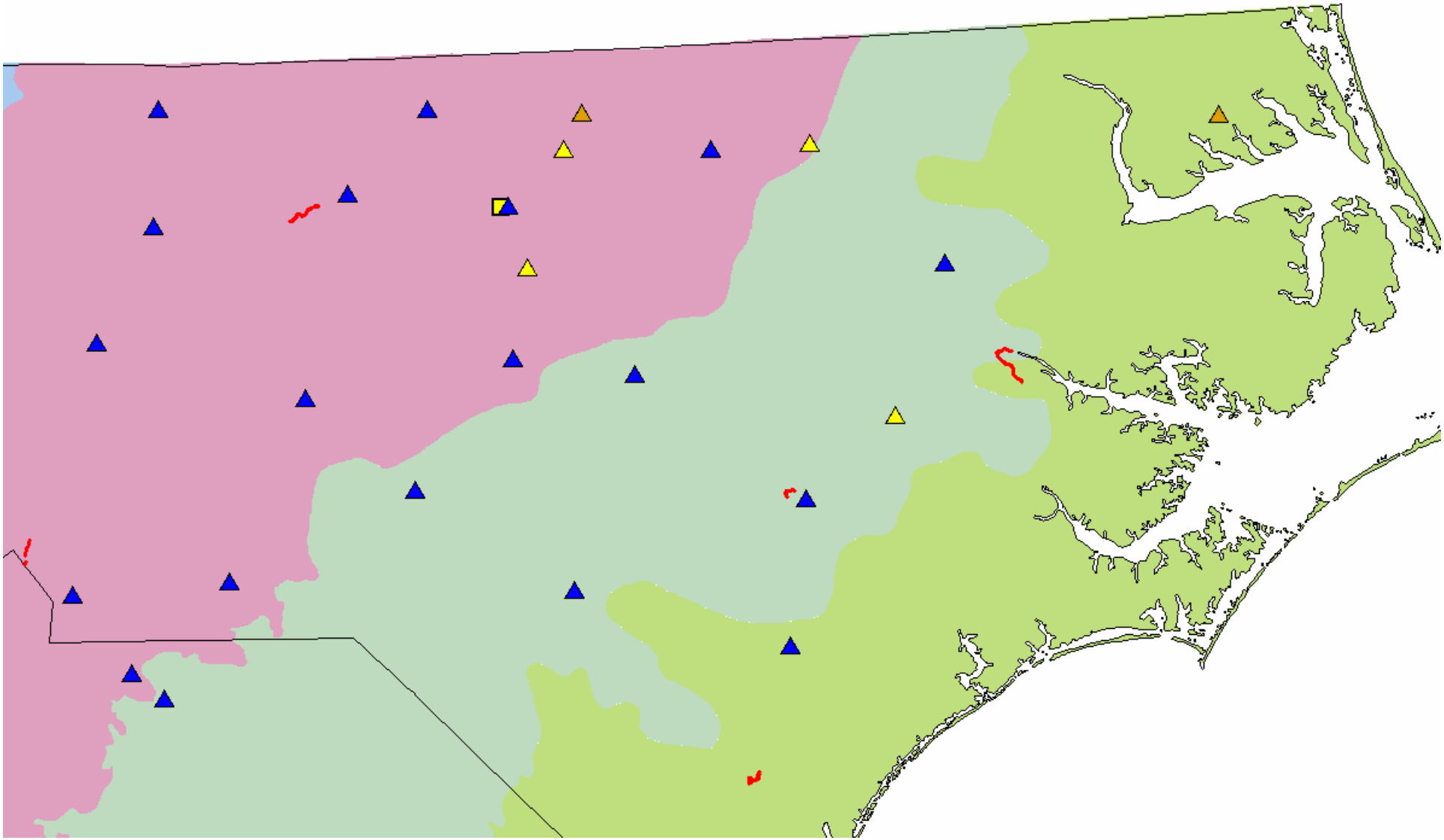
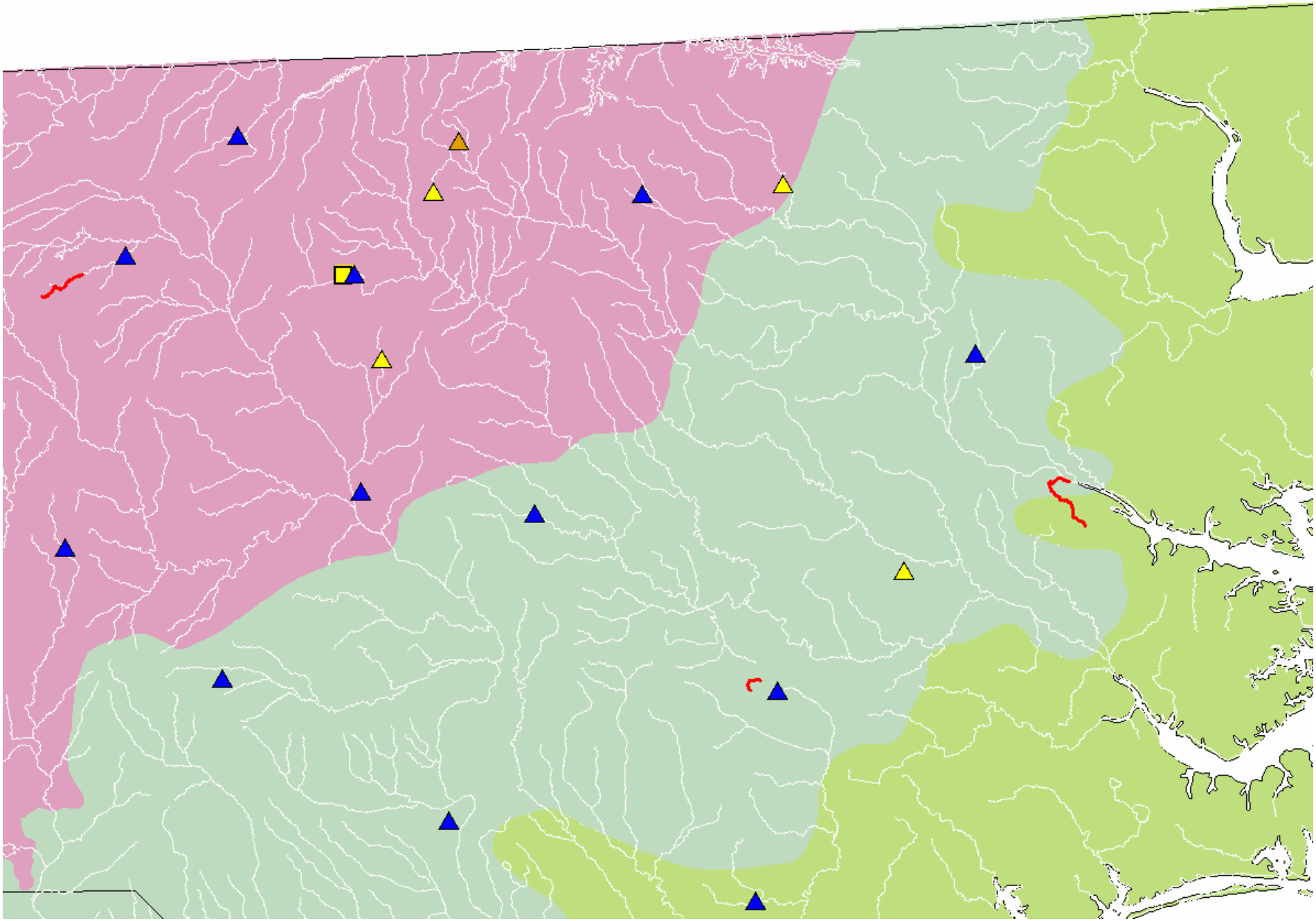
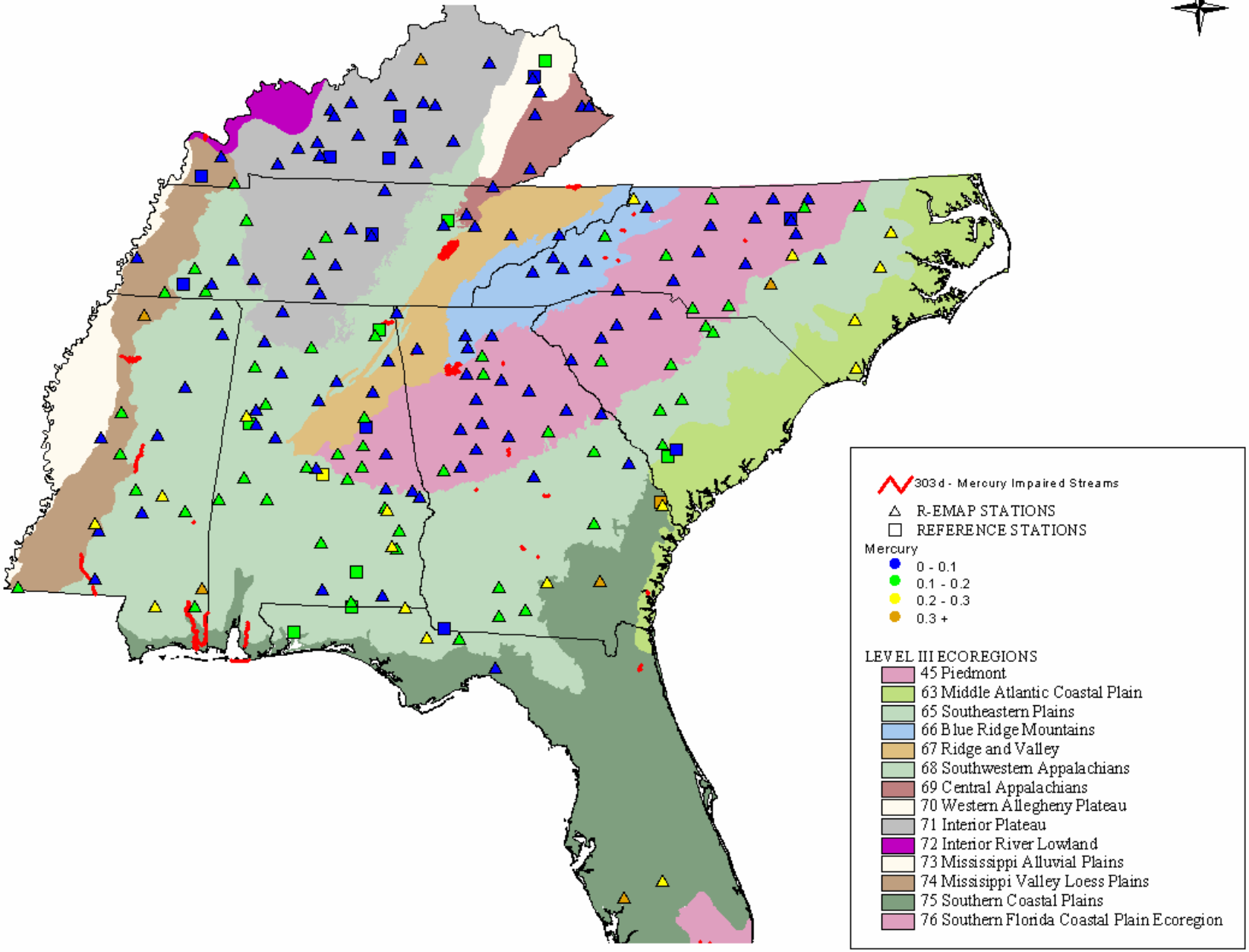








Data Integration: Mercury - R-EMAP & 303(d)



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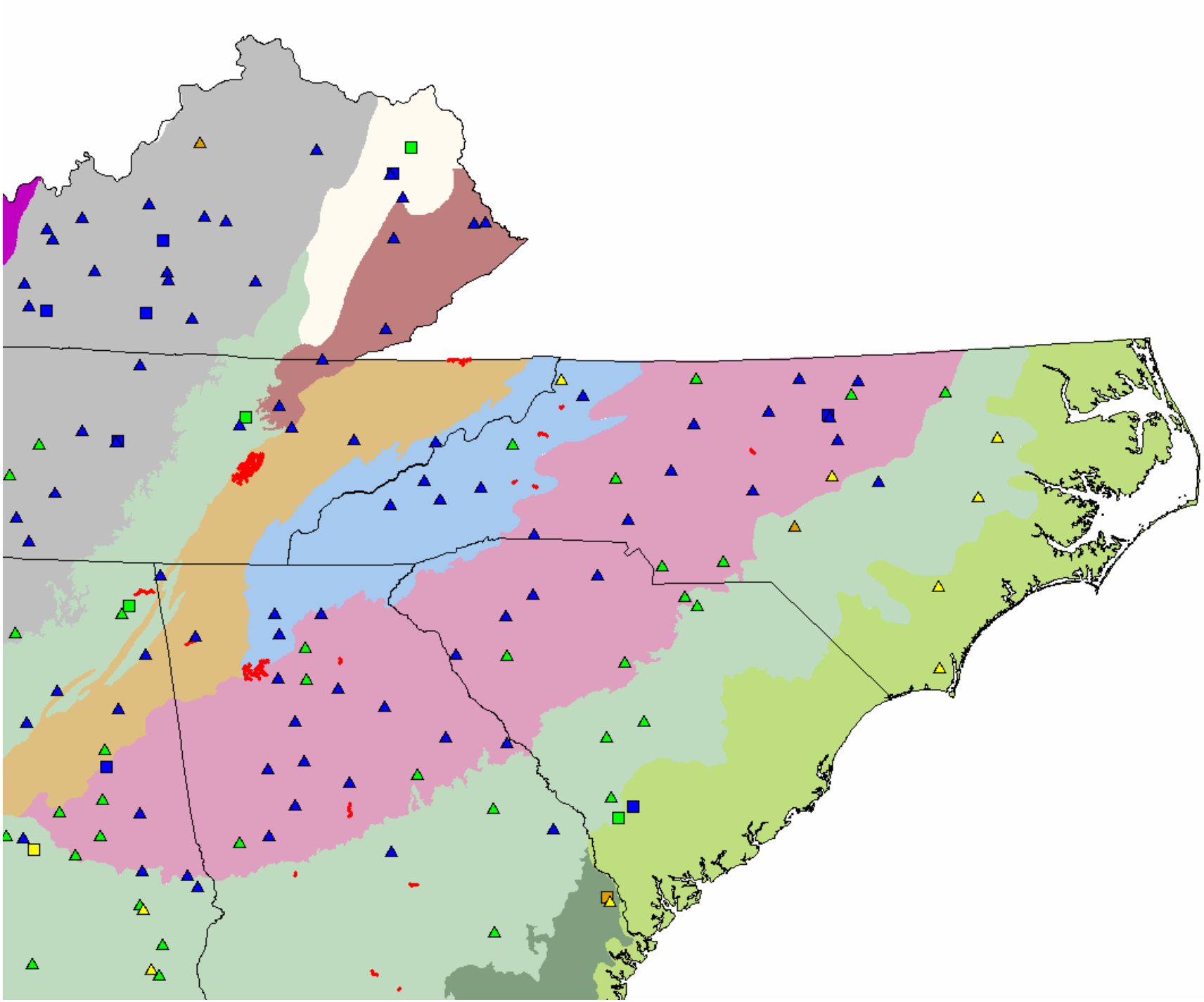
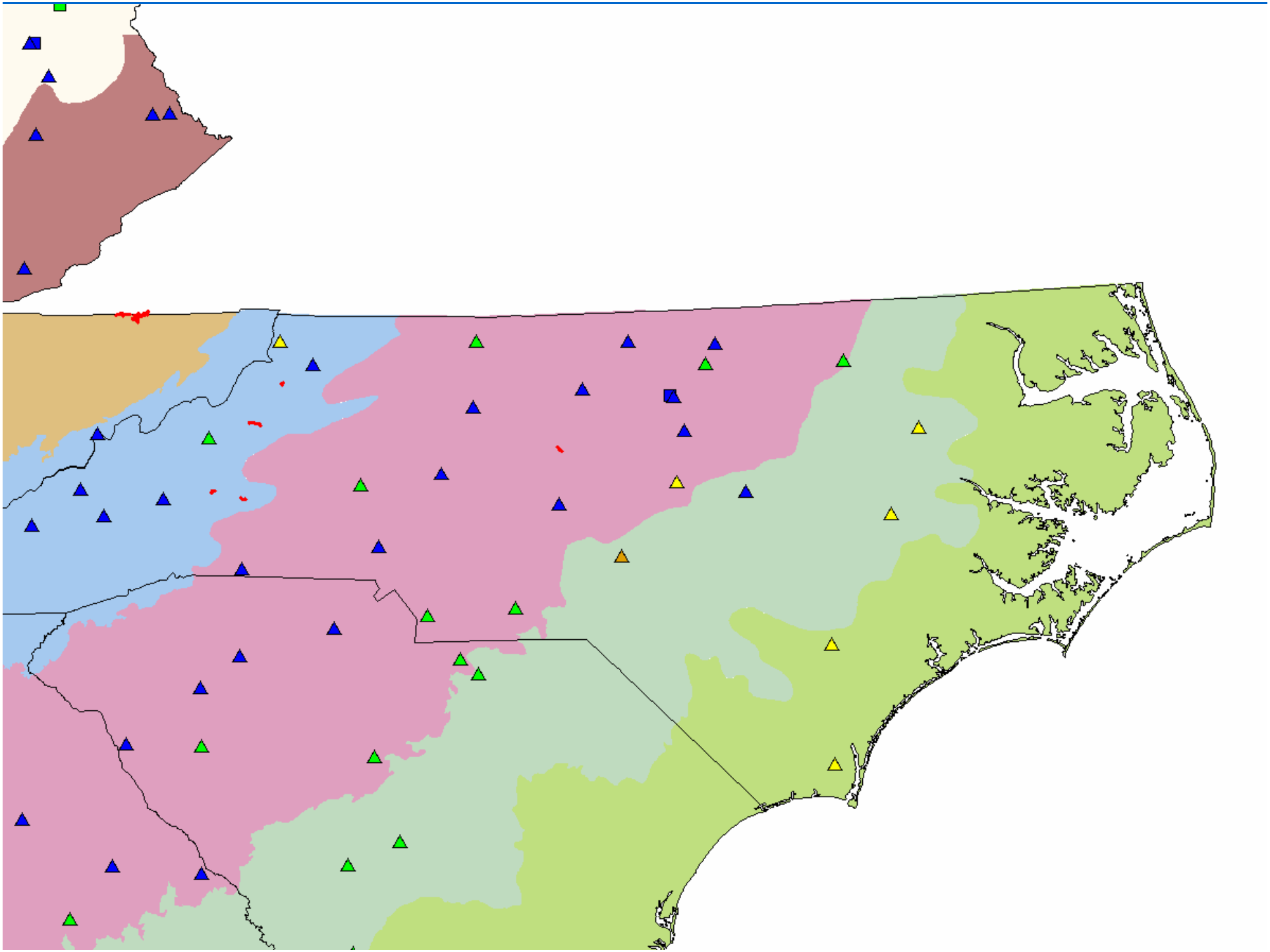
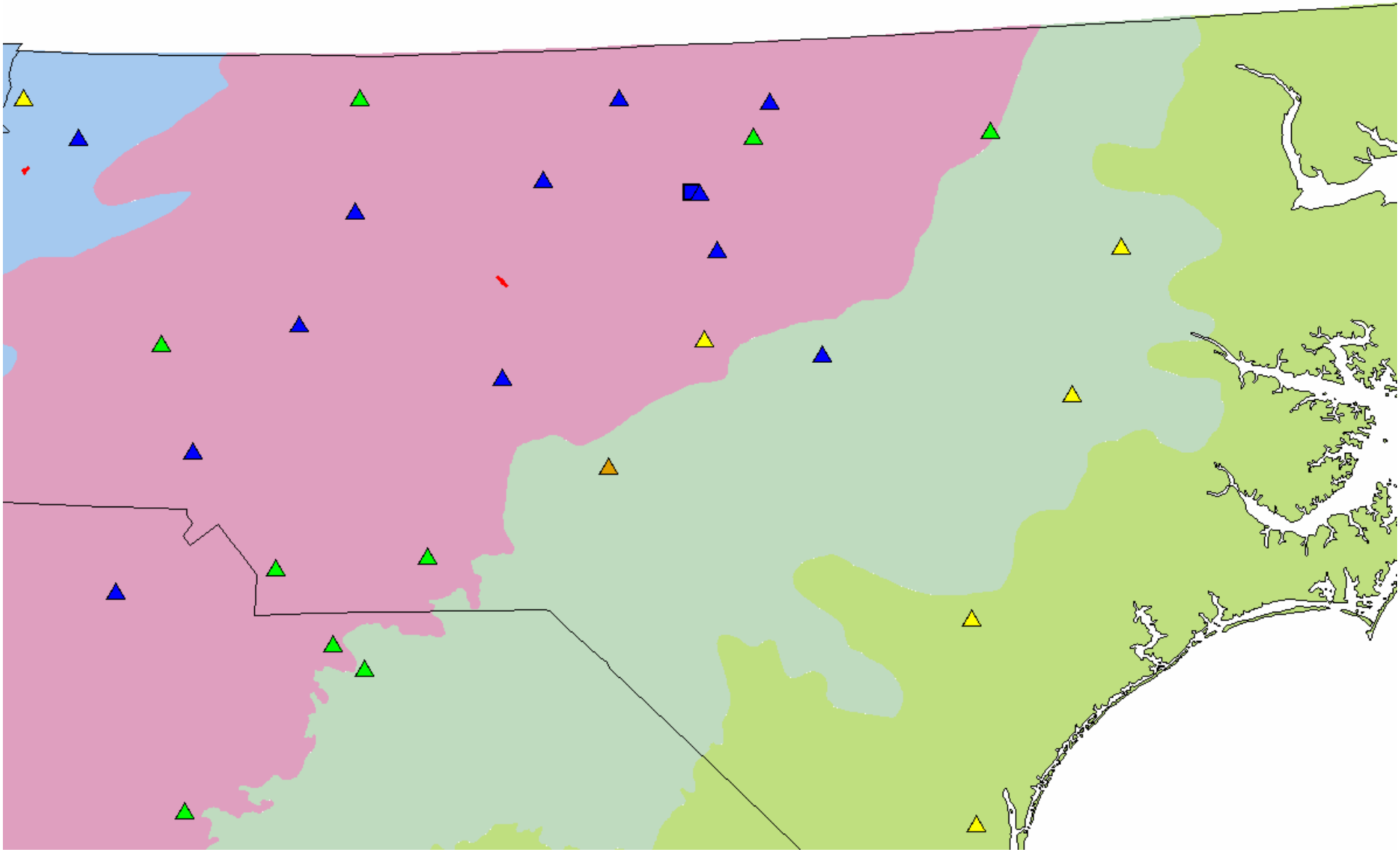
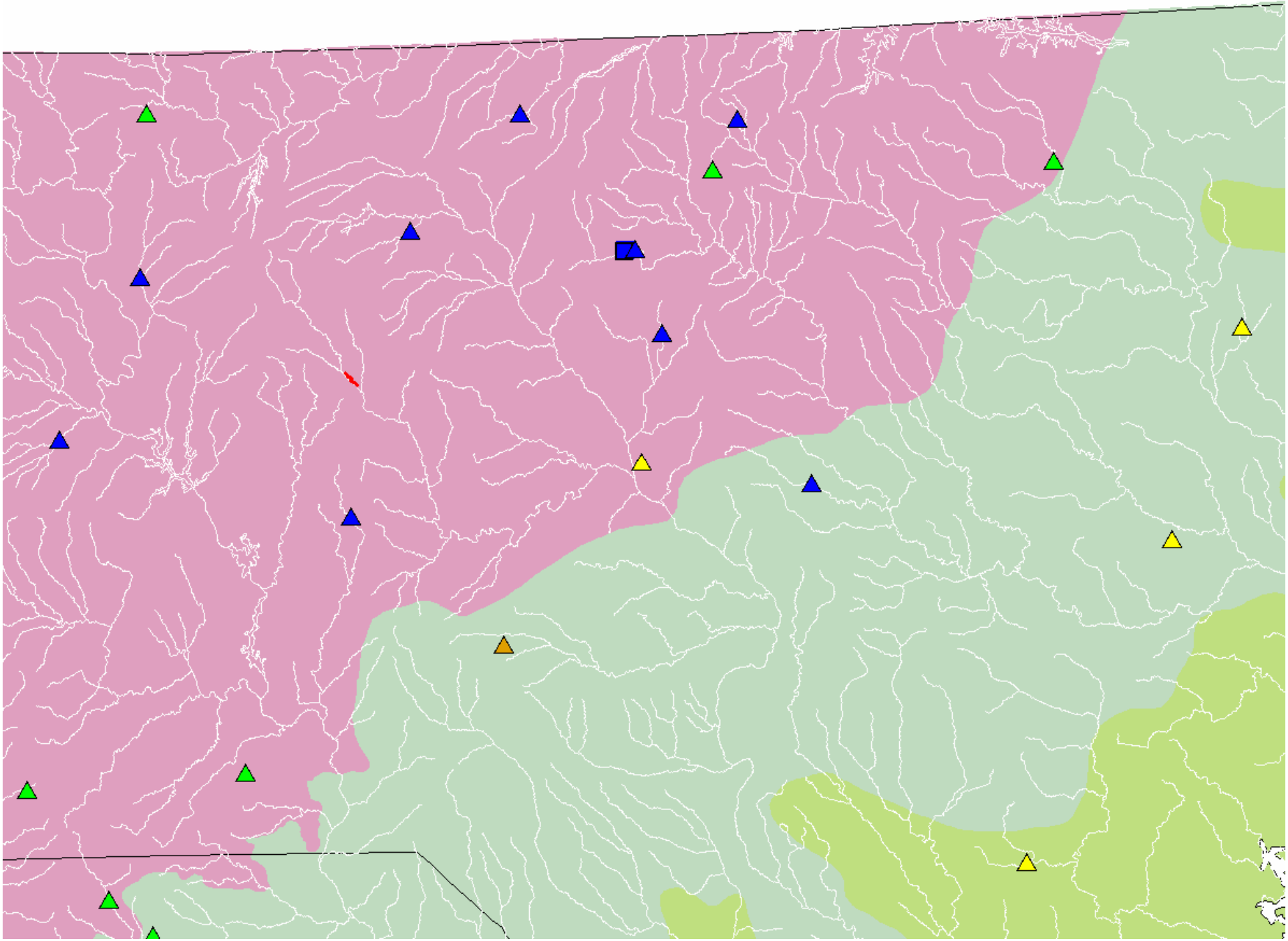
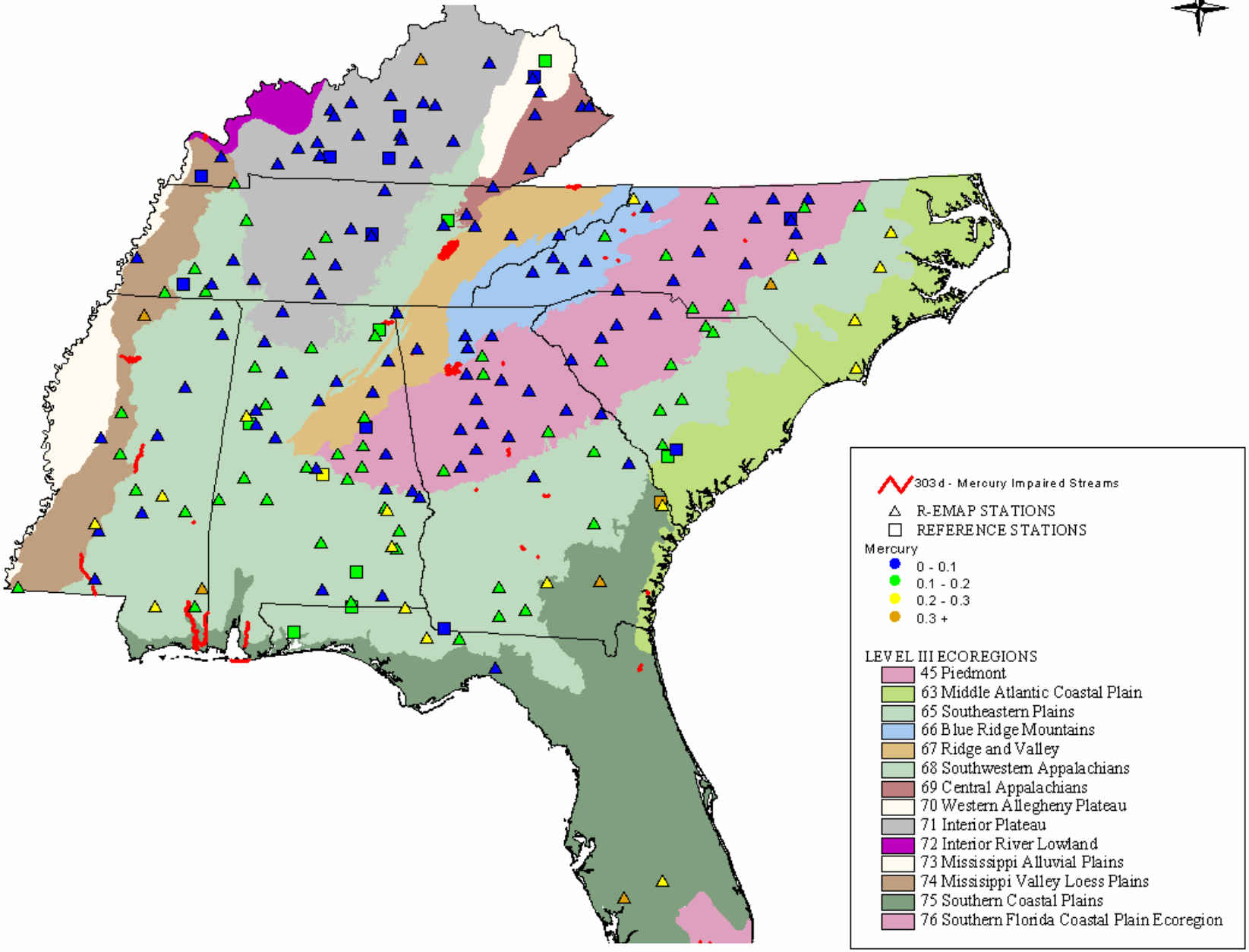
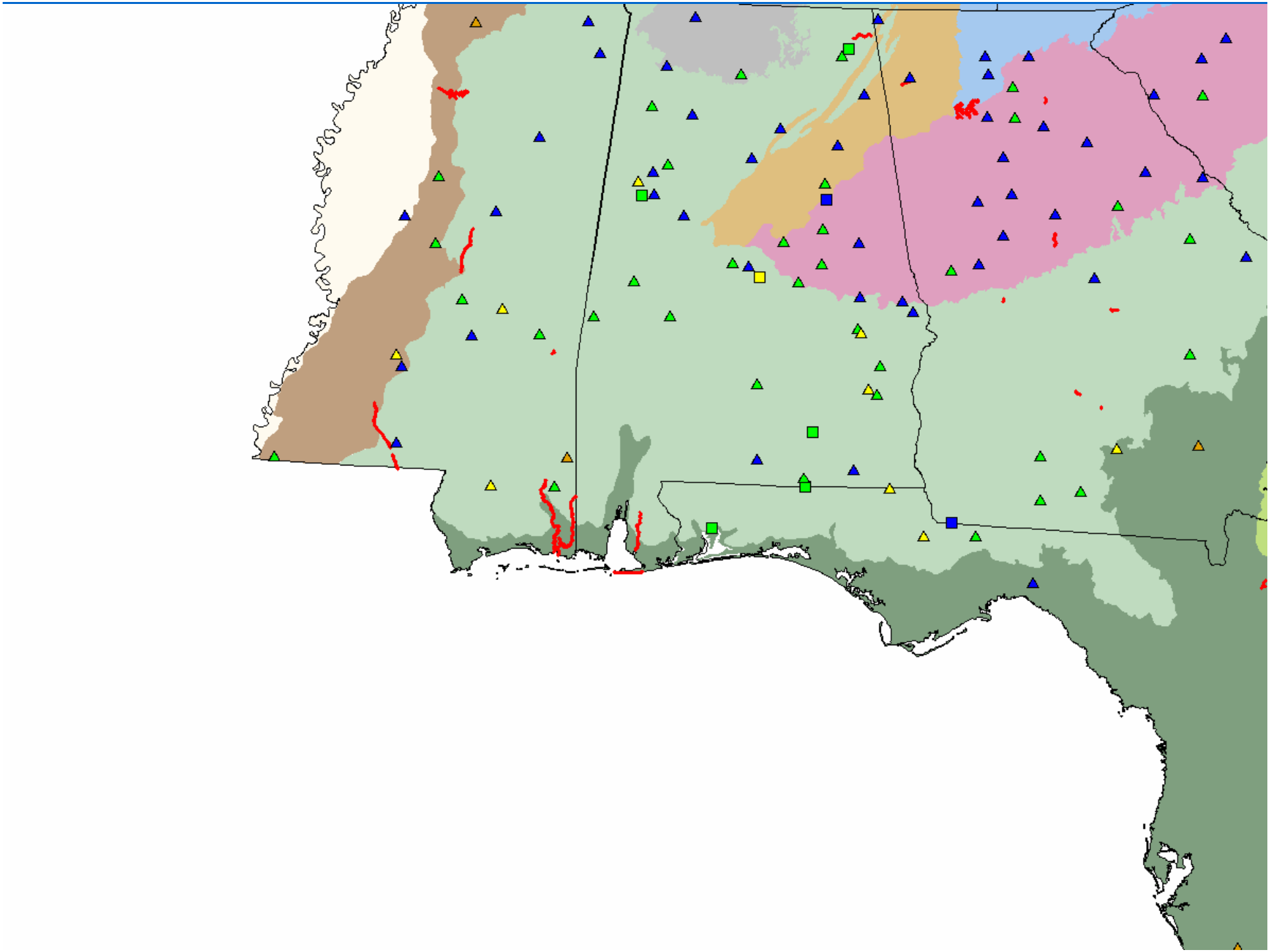
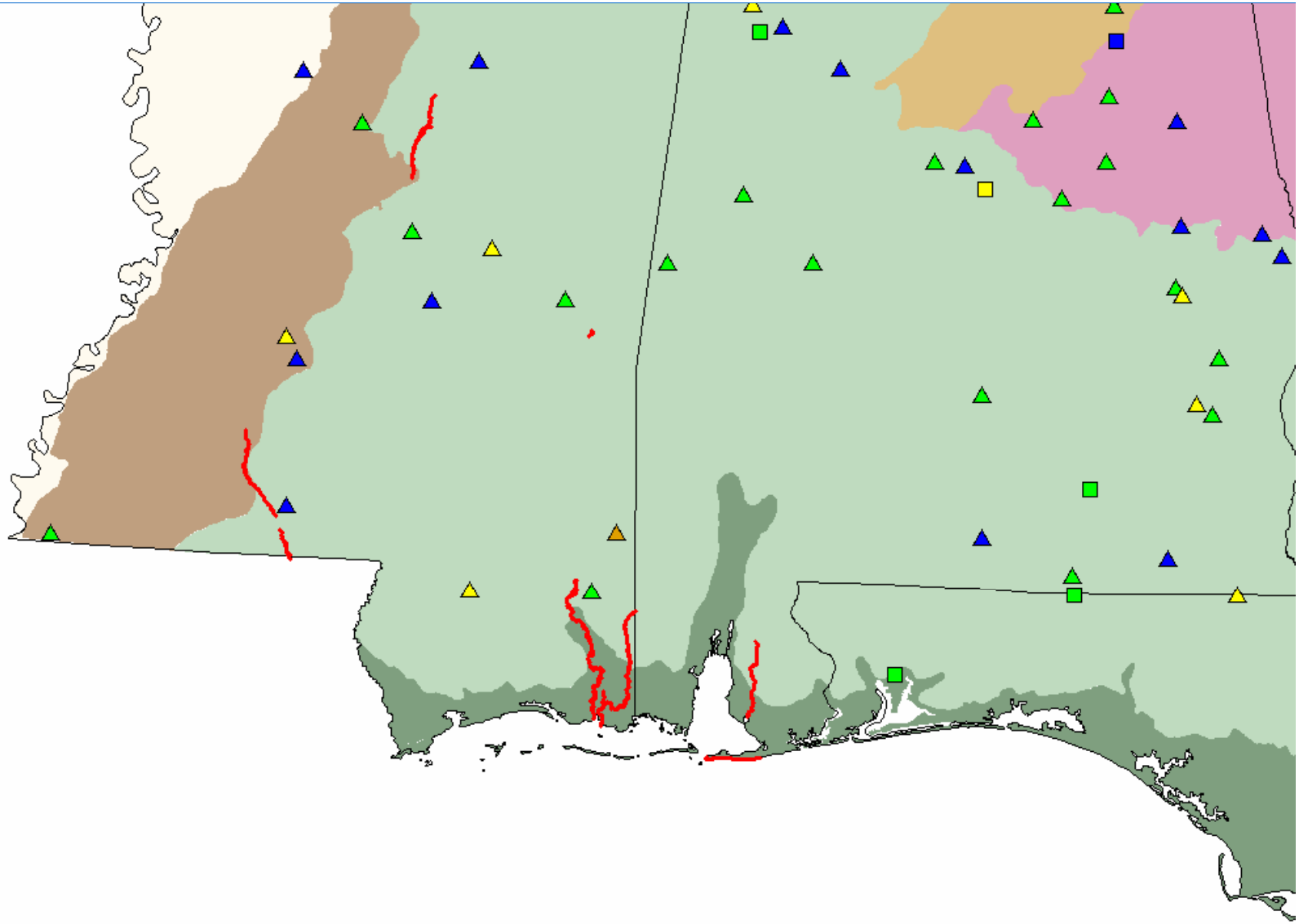
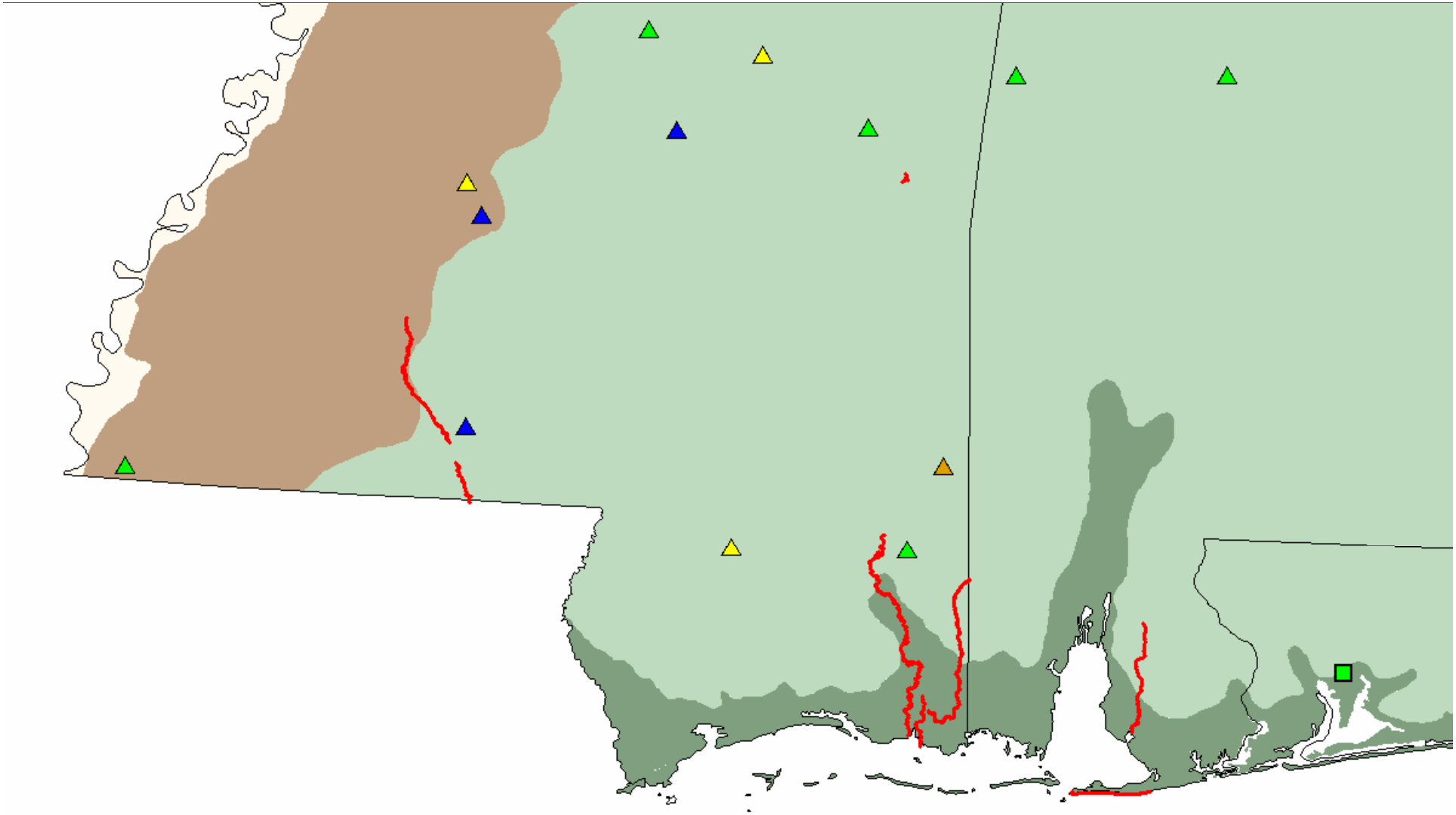
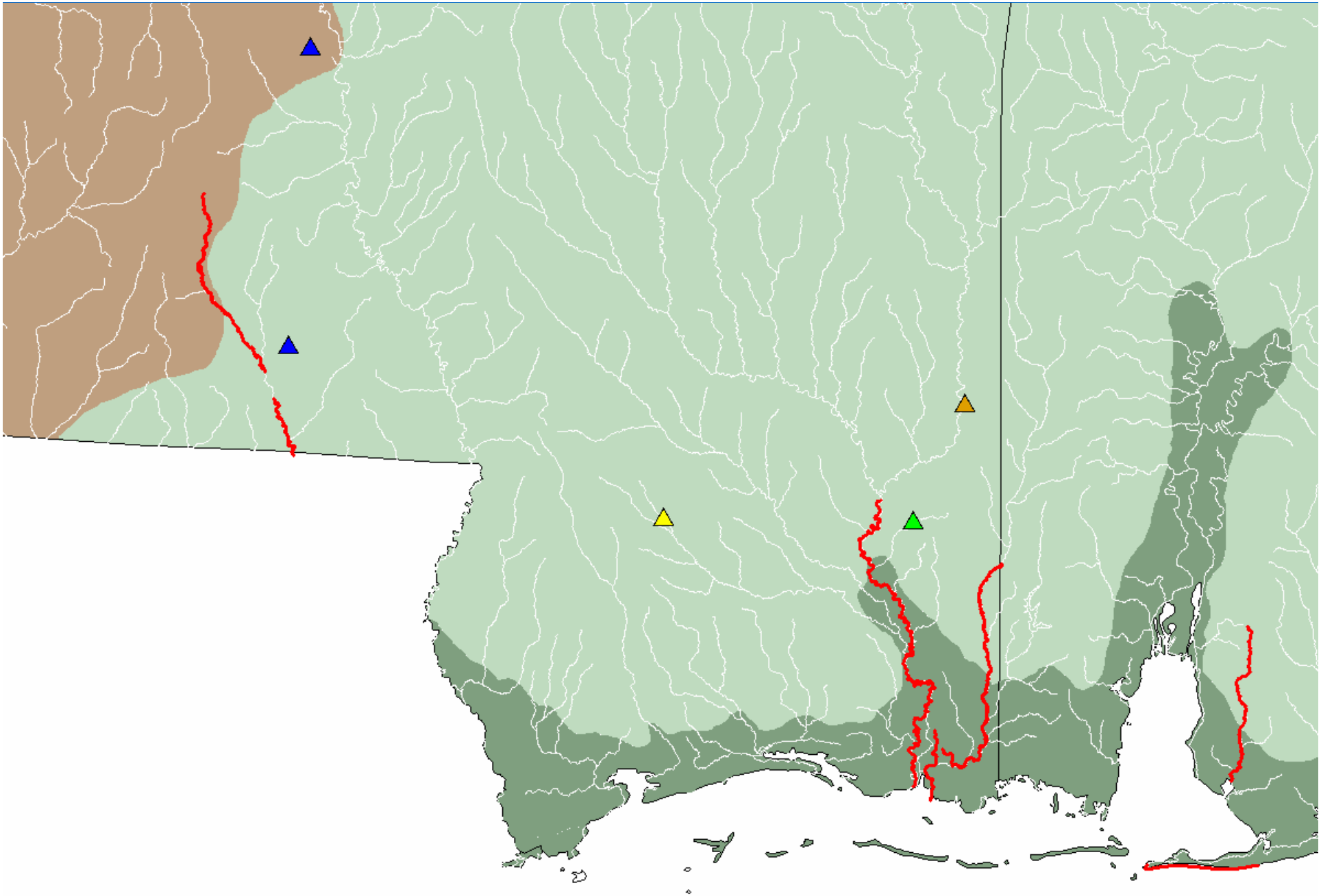








Data Integration: Mercury - R-EMAP & 303(d)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