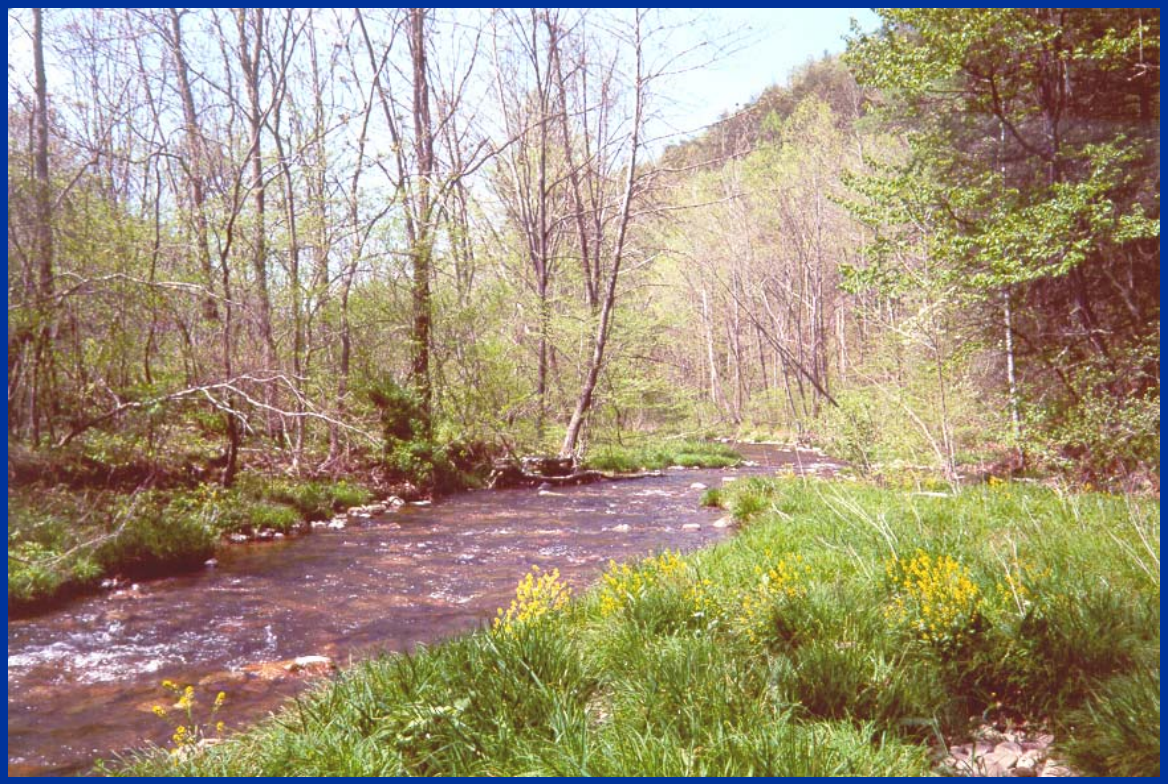
Assessment of Water Quality in Virginia's Non-Tidal Streams using a Probabilistic Sampling Design (ProbMon)



G.J. Devlin, M.R. Dail, J.R. Hill, M.J. Scanlan, W.J. VanWart and L.D. Willis; Virginia Department of Environmental Quality

Virginia's Aquatic Resources

- 9 river basins
  - 49,350 stream miles
- 248 public lakes
  - 162,230 acres
- 1,044,900 acres wetlands (23% tidal)
- 498 watersheds
- 1,510 ambient stations
- 170 biomonitoring stations
- 39,000 water samples

Targeted vs Probabilistic Design

Targeted

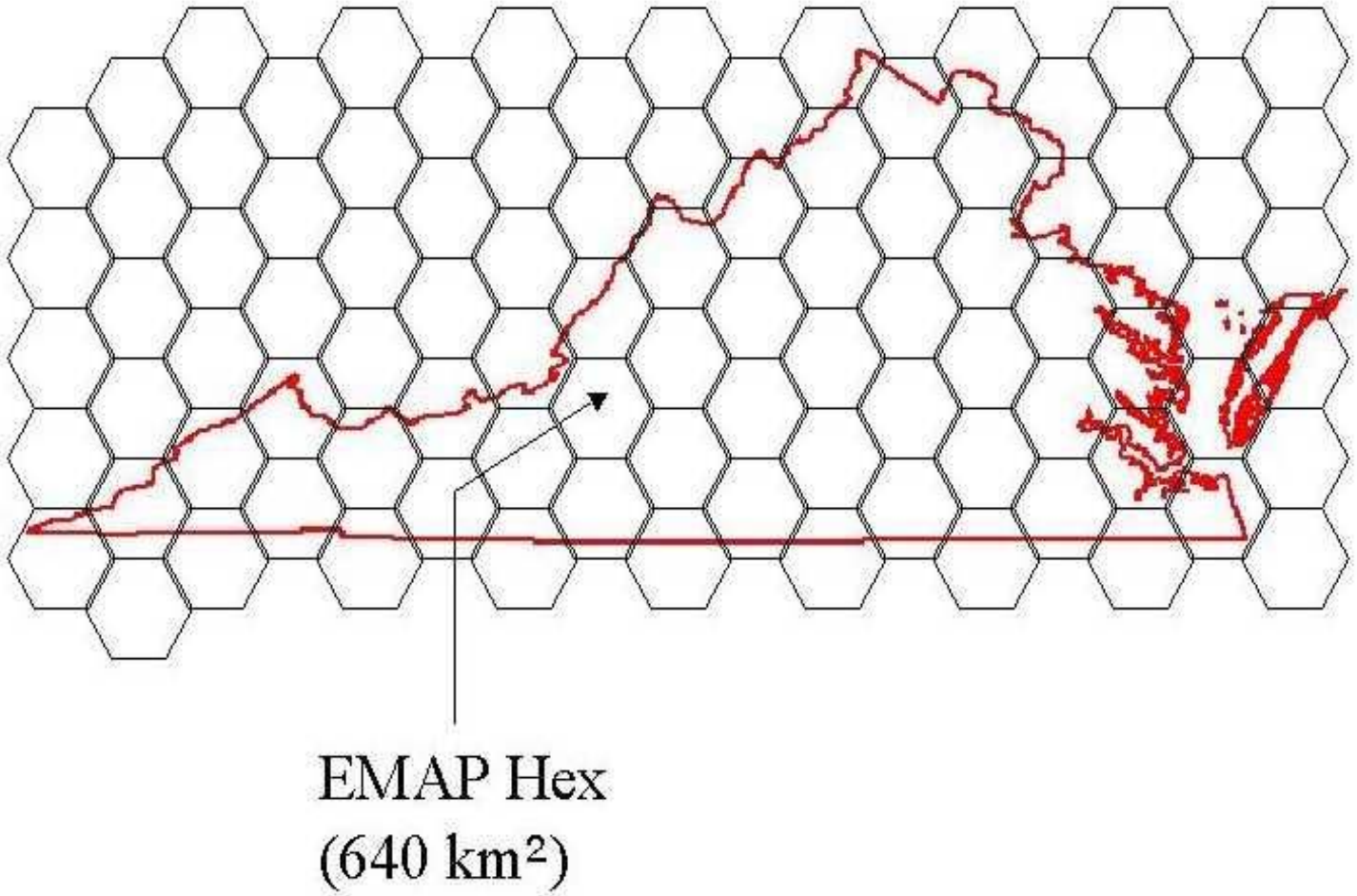
- Strategically located above and below WWTPs
- Located at bridges and other easy access sites
- Biased
- Can not be used to assess overall water quality

Probabilistic

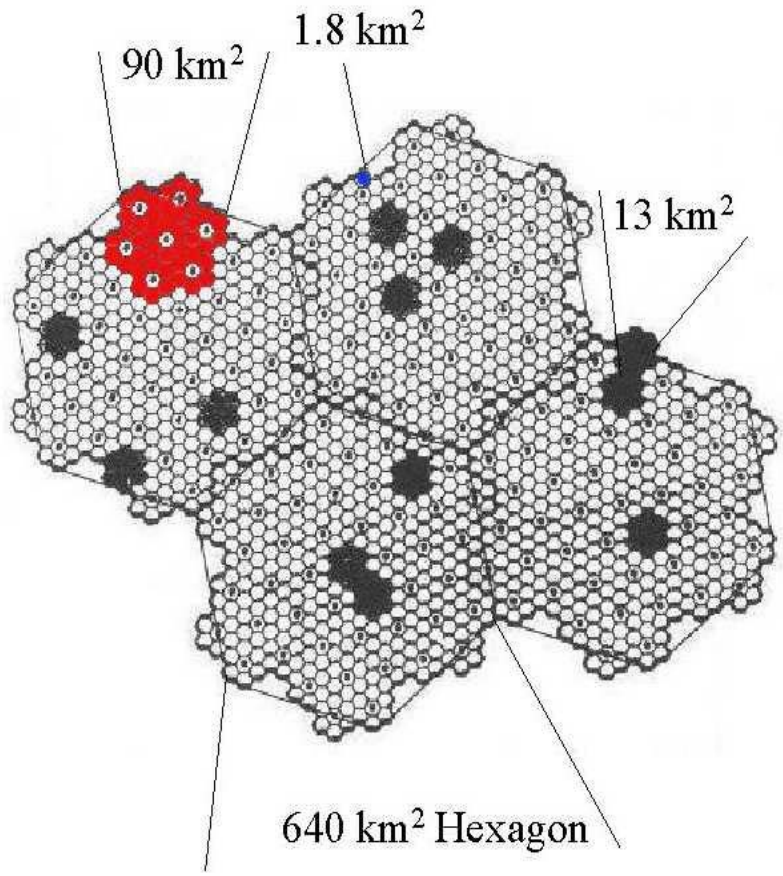
- Randomly sited sampling locations
- Located in remote as well as developed areas
- Unbiased
- Can be used to assess general water quality for 100% of stream kilometers with confidence

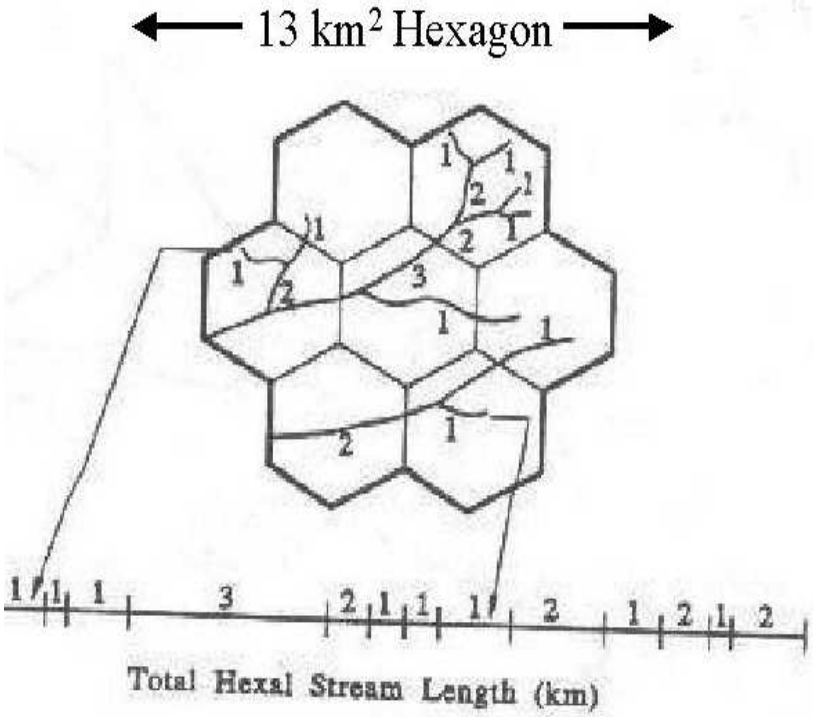
Random Sample Site Selection

Base hexagonal grid for the Commonwealth of Virginia



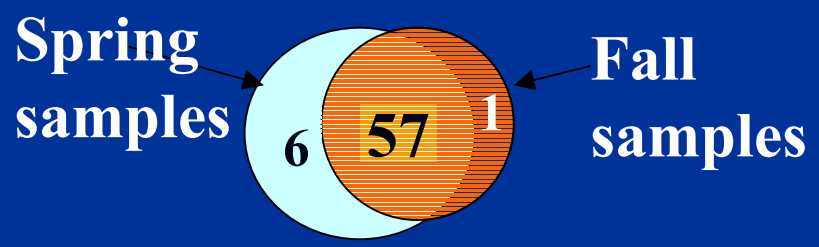
Randomly selected 13 km2 hexals from 640 km2 hexagons. Virginia stream segments were selected from the 13 km2 hexals



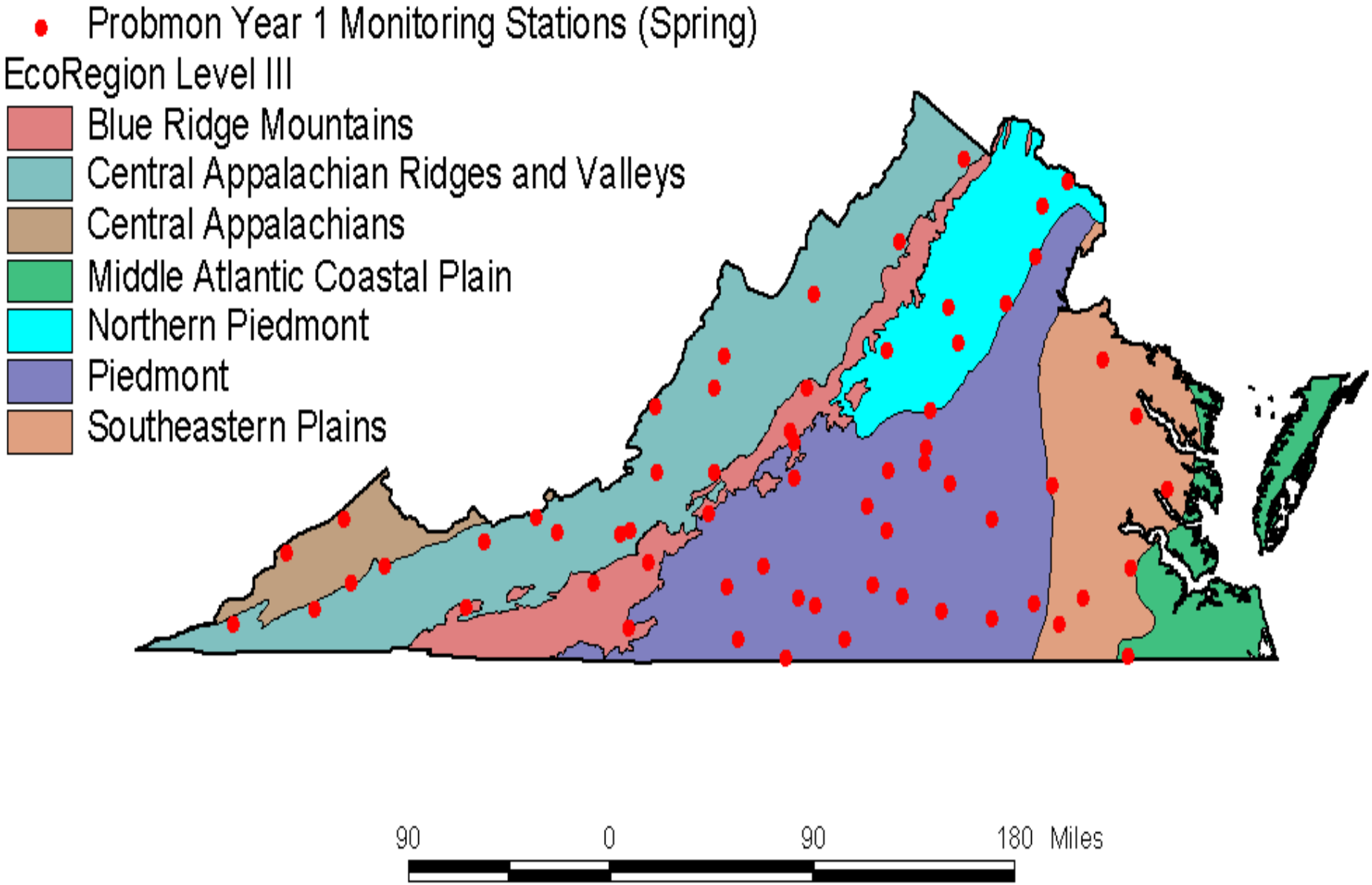


Station Count by Stream Order

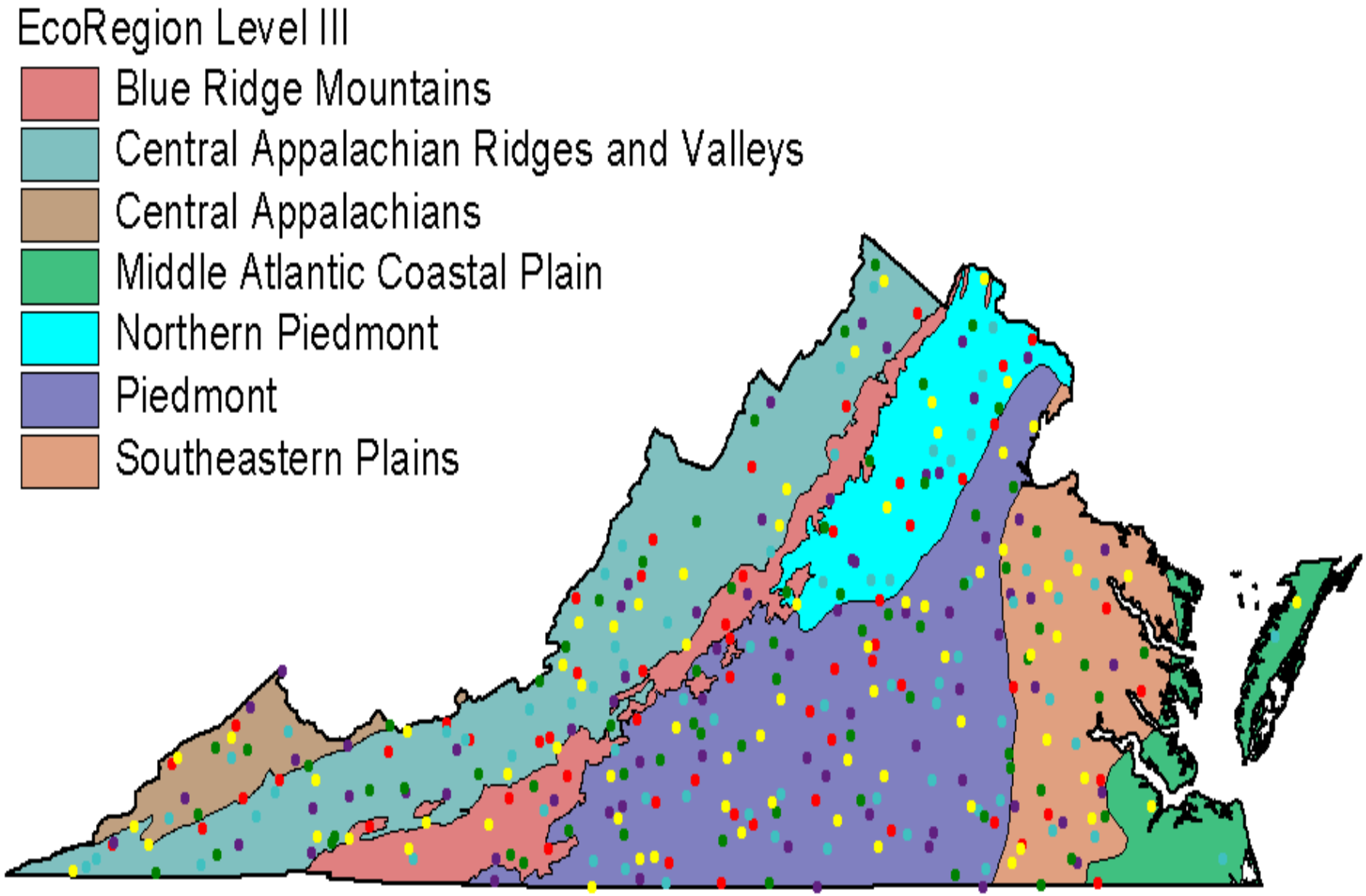
Strahler Stream Order	2001 Sample Sites			
	Spring Benthos & Habitat	Fall Chemistry	Spring Benthos & Habitat only	Fall Chemistry only
1	17	12	6	1
2	13	13	0	0
3	14	14	0	0
4	7	7	0	0
5	11	11	0	0
6	1	1	0	0
Totals:	63	58	6	1



Coverage by Ecoregion after Year 1 (n = 63)



Coverage by Ecoregion after 5 years (n = 300)

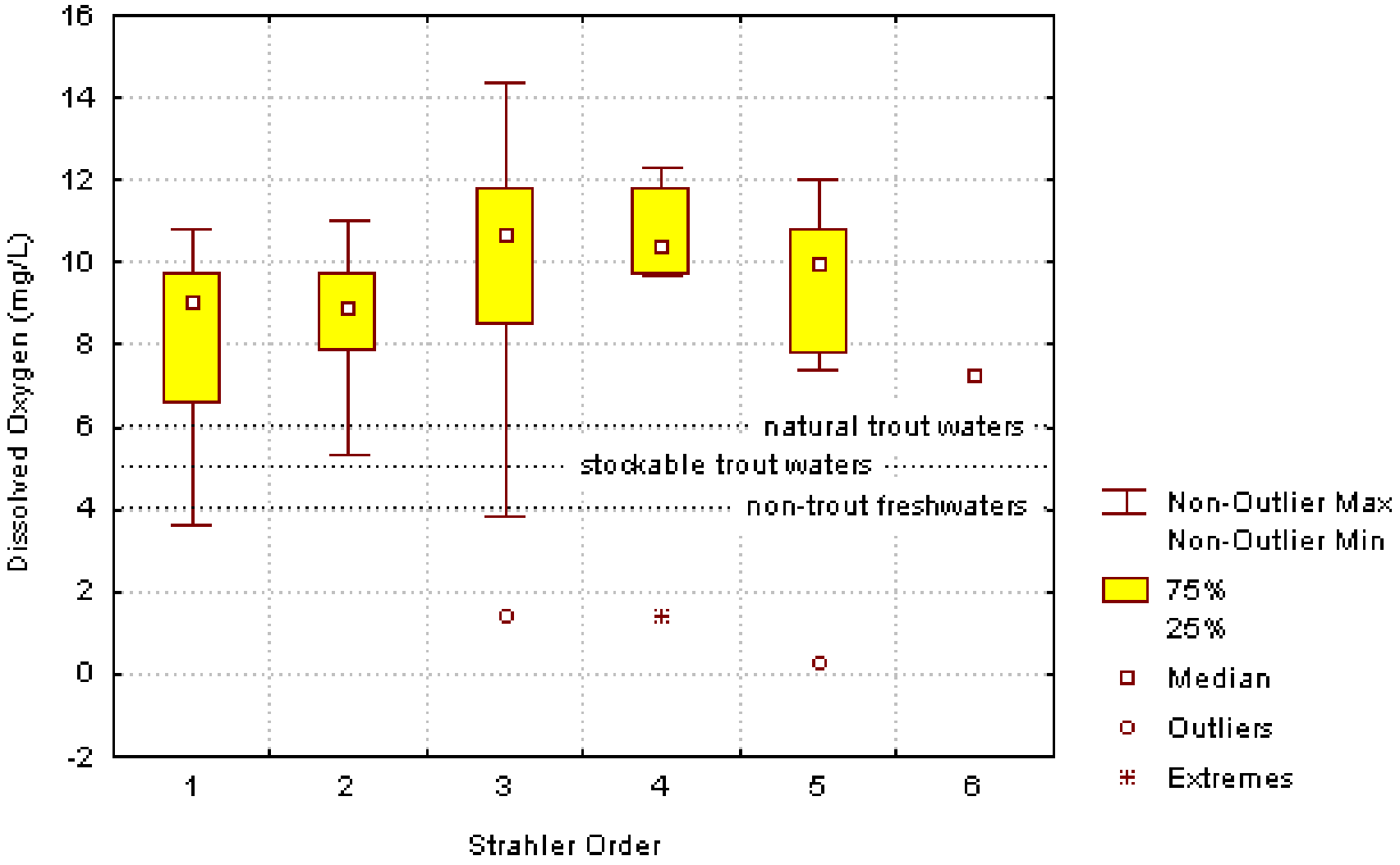


Data Collected

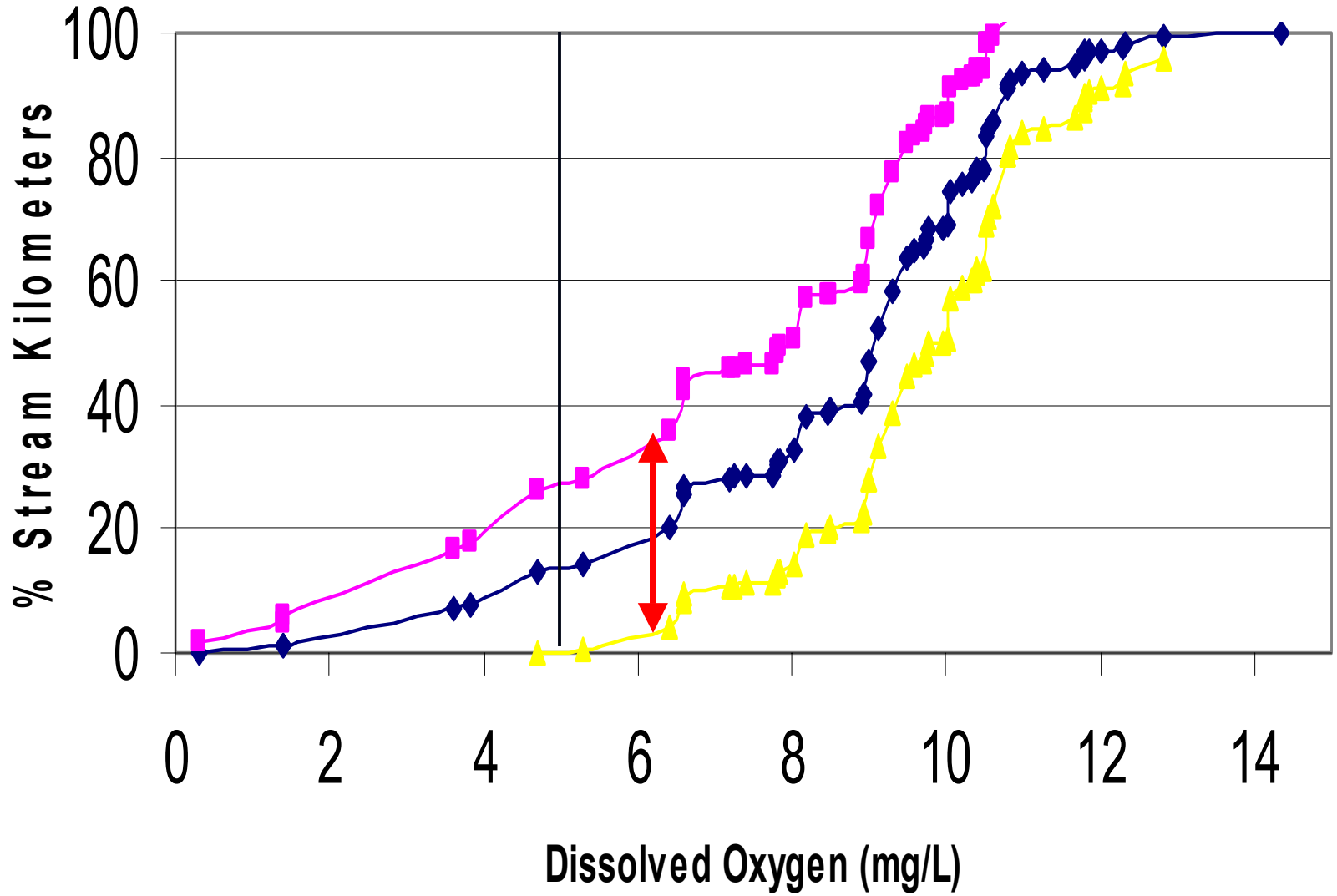
- Field data
  - DO, Temp, pH, Cond
- Benthic community metrics (RBPII)
- Habitat Survey
  - RBP
- Fecal coliform
- Nutrients
  - Phosphorus & Nitrogen
- Solids
  - total & suspended
- Hardness
- Alkalinity
- Turbidity
- Heavy Metals & Pesticides (in sediment)

Water Chemistry Results

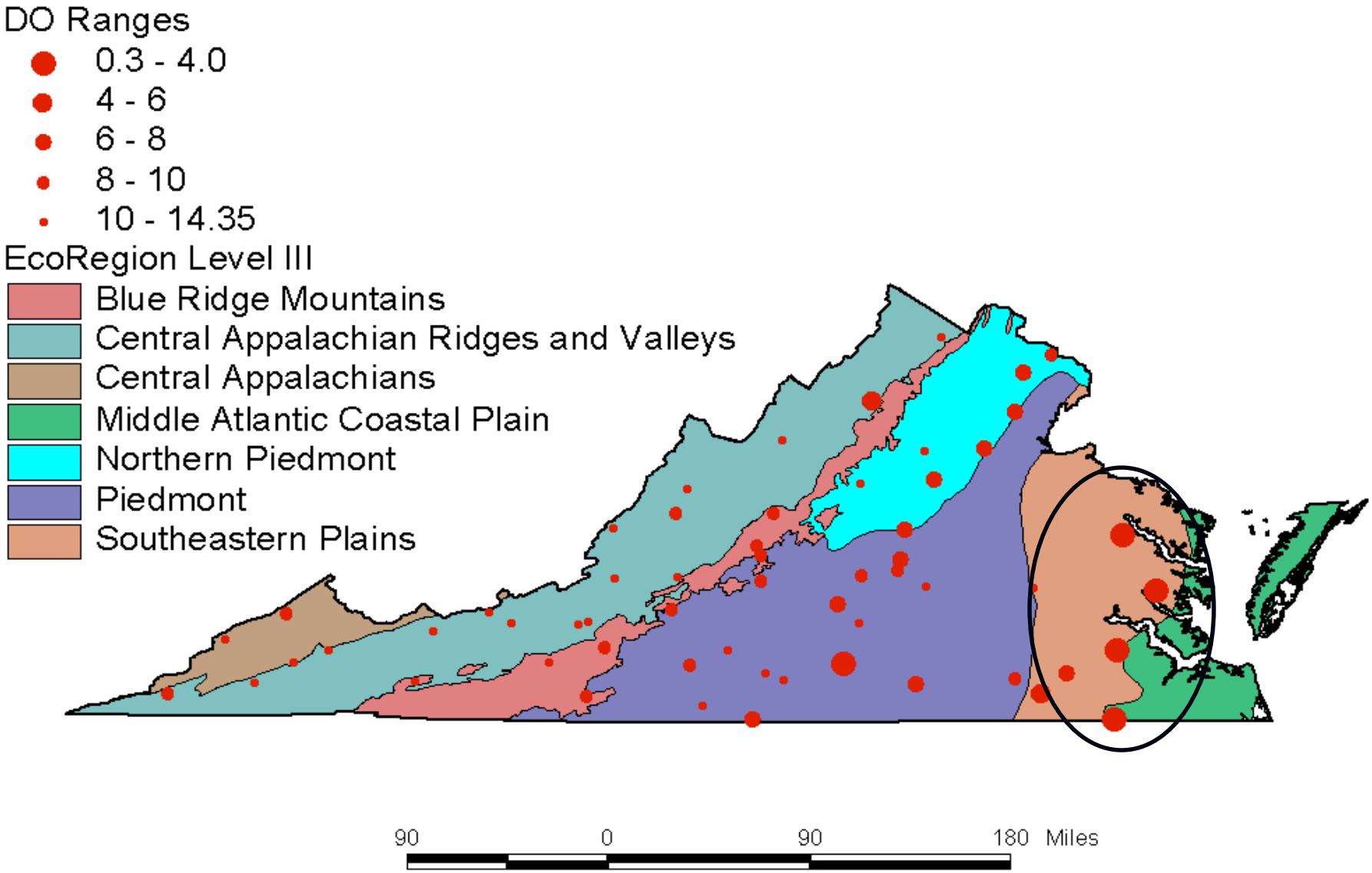
Dissolved Oxygen by Stream Order

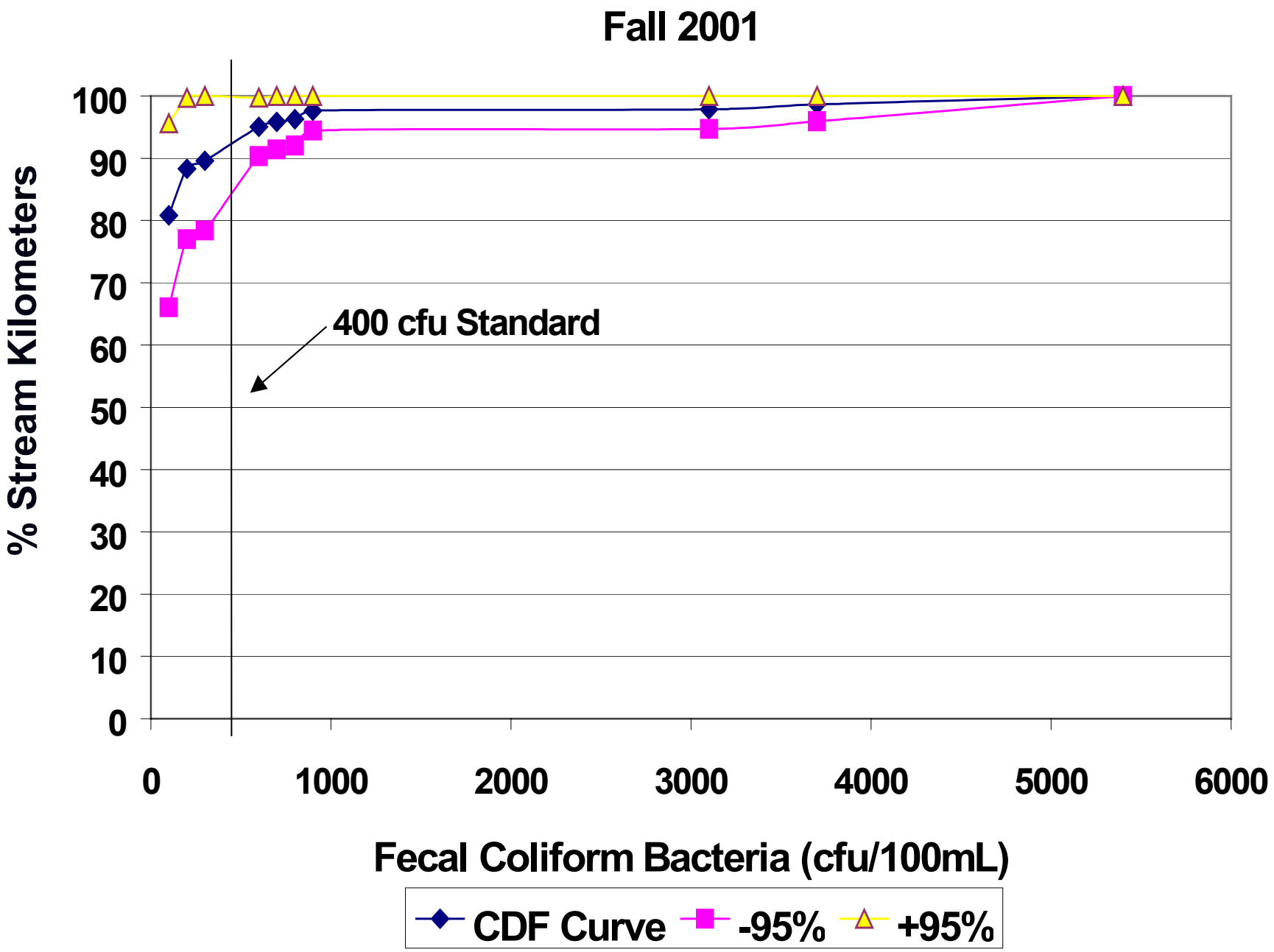


Dissolved Oxygen (Fall 2001)

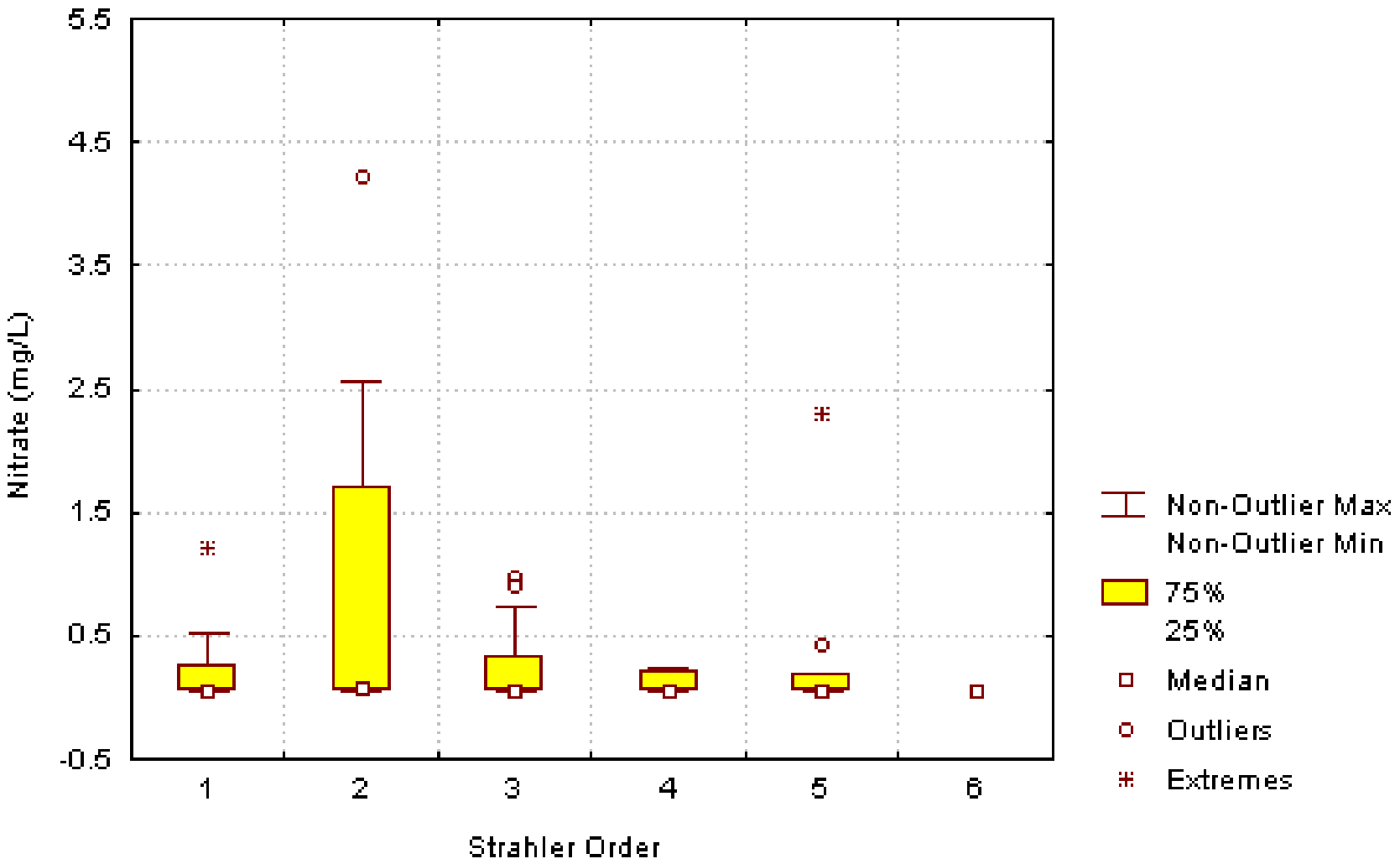


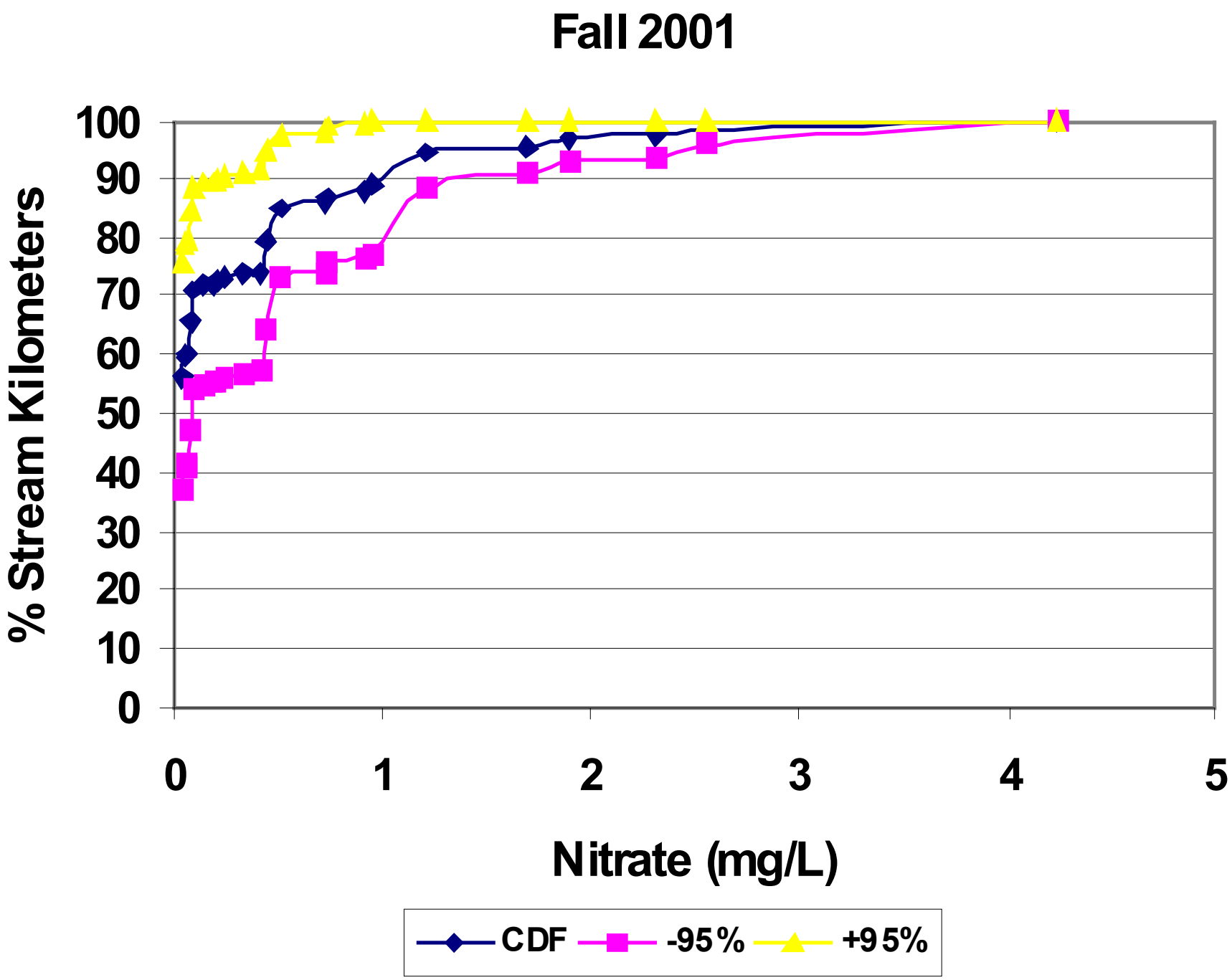
Dissolved Oxygen Fall 2001



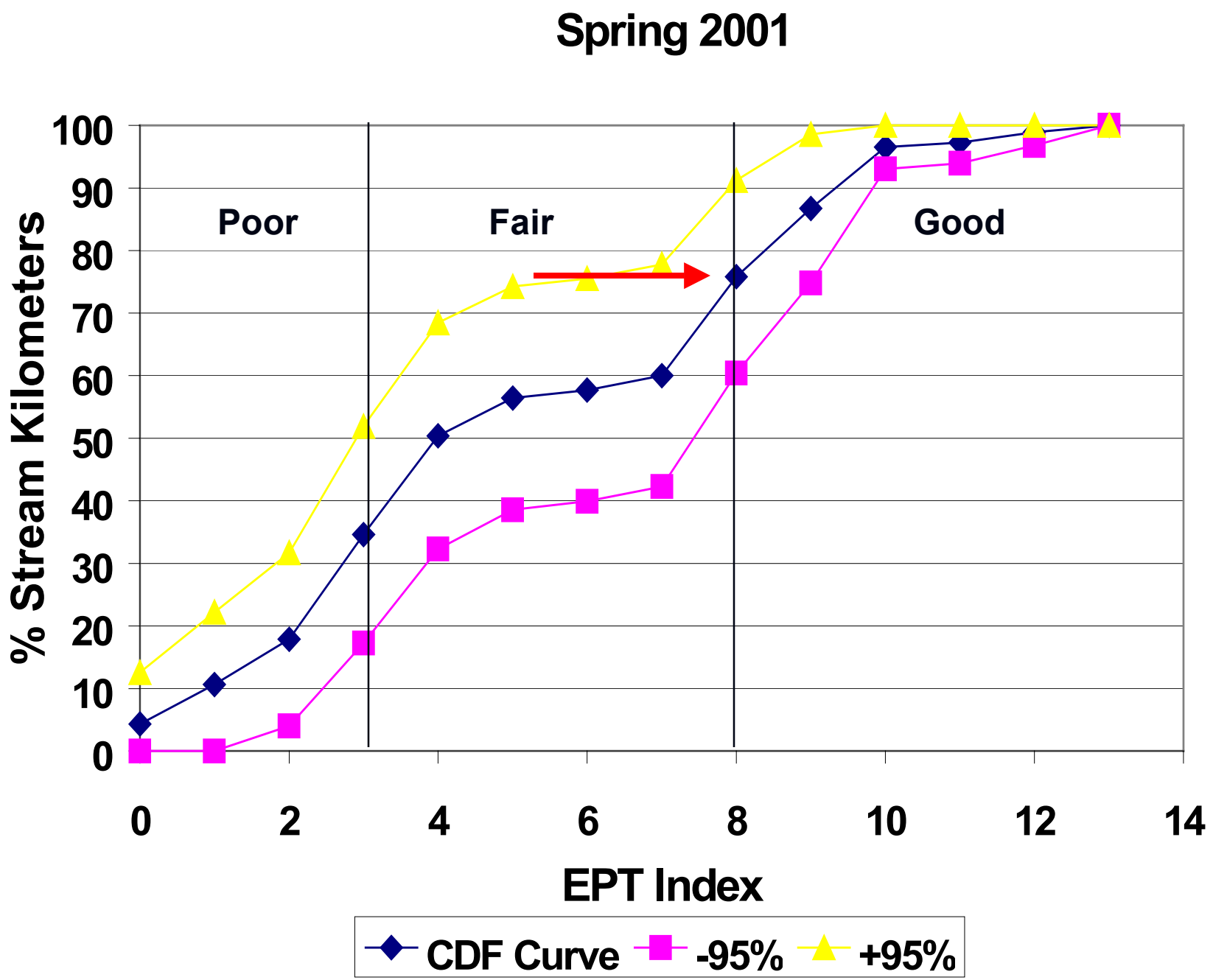

Fall 2001
% Stream Kilometers
100
90
80
70
60
50
40
30
20
10
0
400 cfu Standard
0
1000
2000
3000
4000
5000
6000
Fecal Coliform Bacteria (cfu/100mL)
CDF Curve
-95%
+95%

Nitrate-N by Stream Order

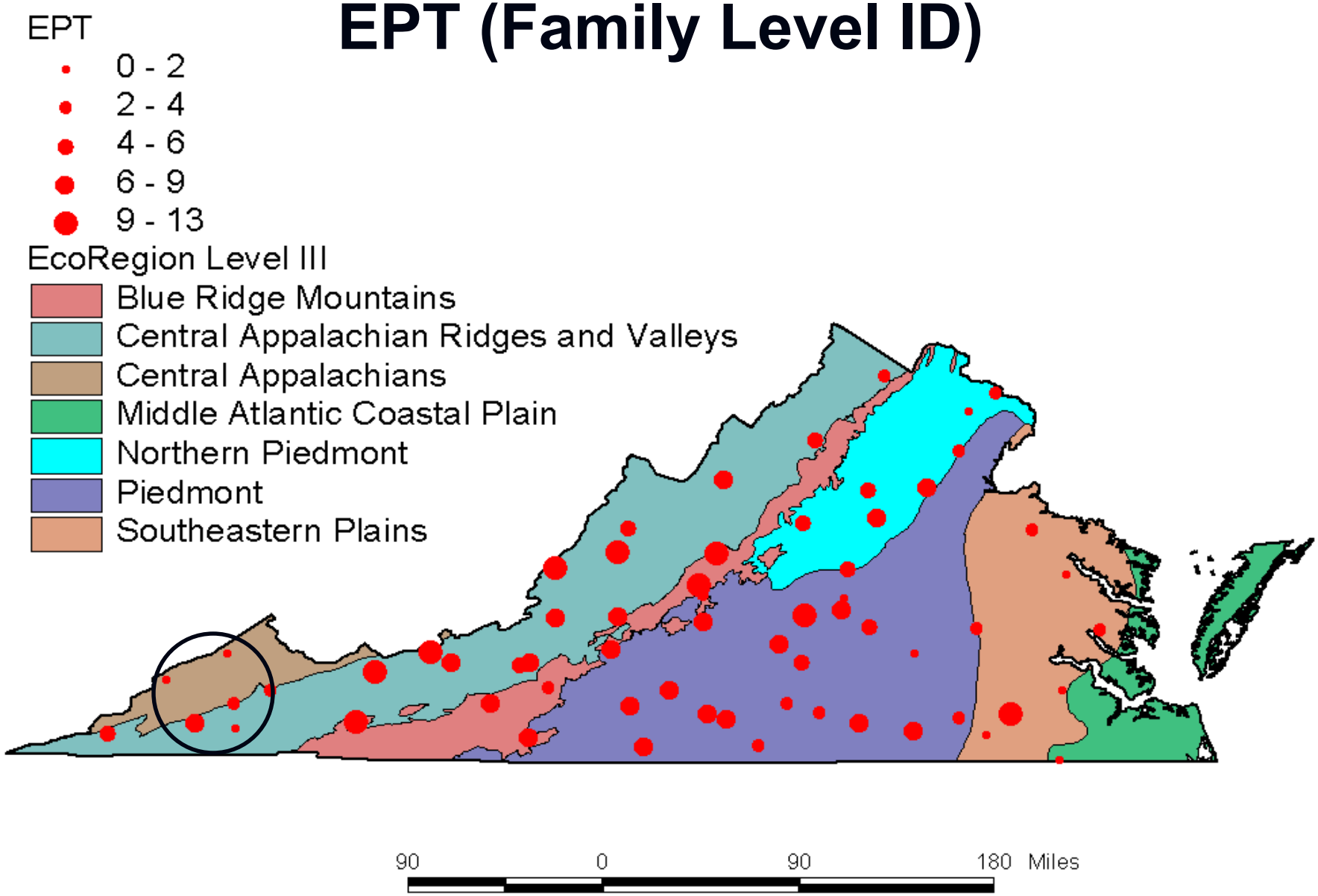



Fall 2001
% Stream Kilometers
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Nitrate (mg/L)
CDF
-95%
+95%

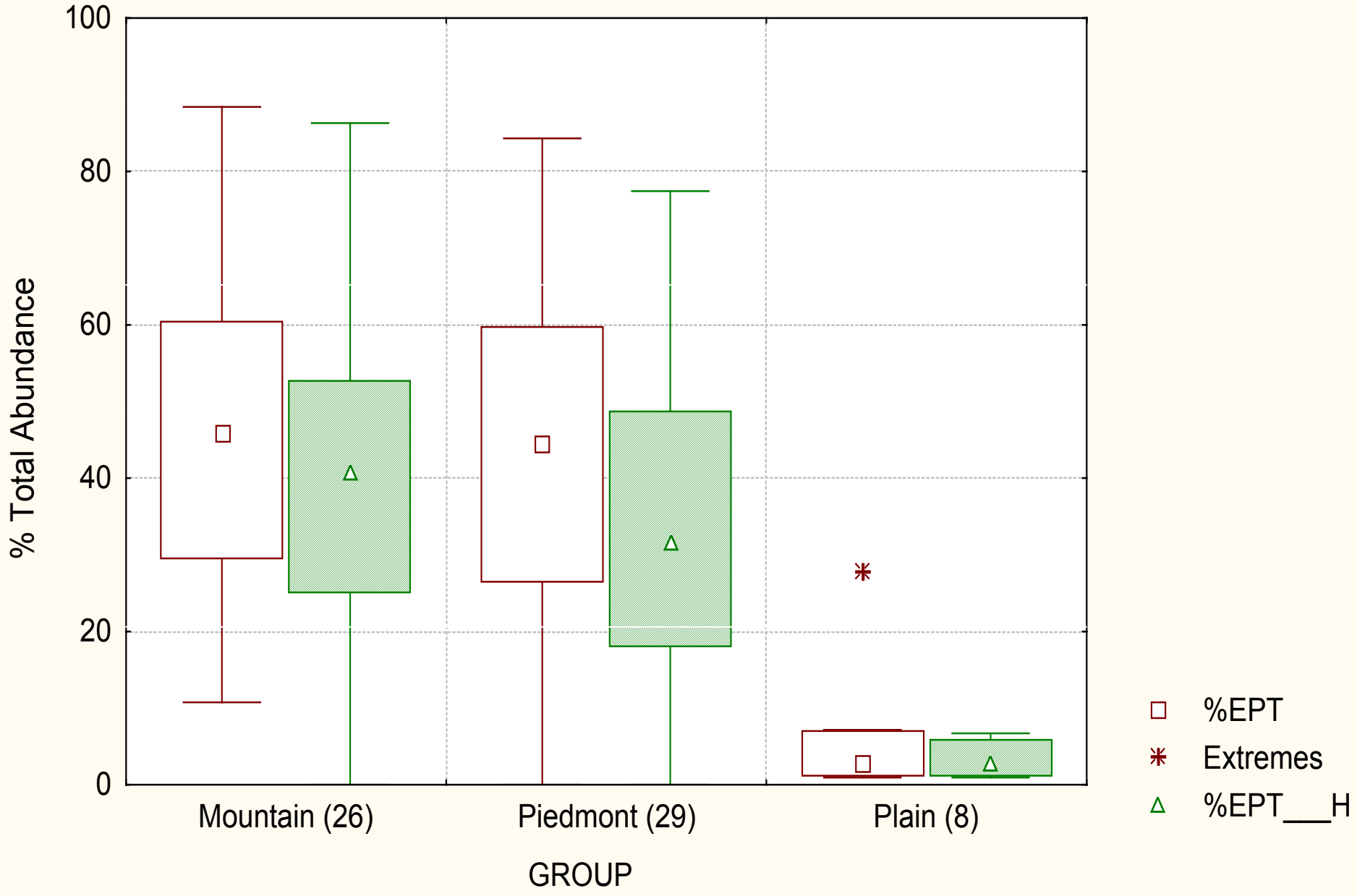
Biomonitoring Results


Spring 2001
% Stream Kilometers
100
90
80
70
60
50
40
30
20
10
0
Poor
Fair
Good
0
2
4
6
8
10
12
14
EPT Index
CDF Curve
-95%
+95%

EPT (Family Level ID)

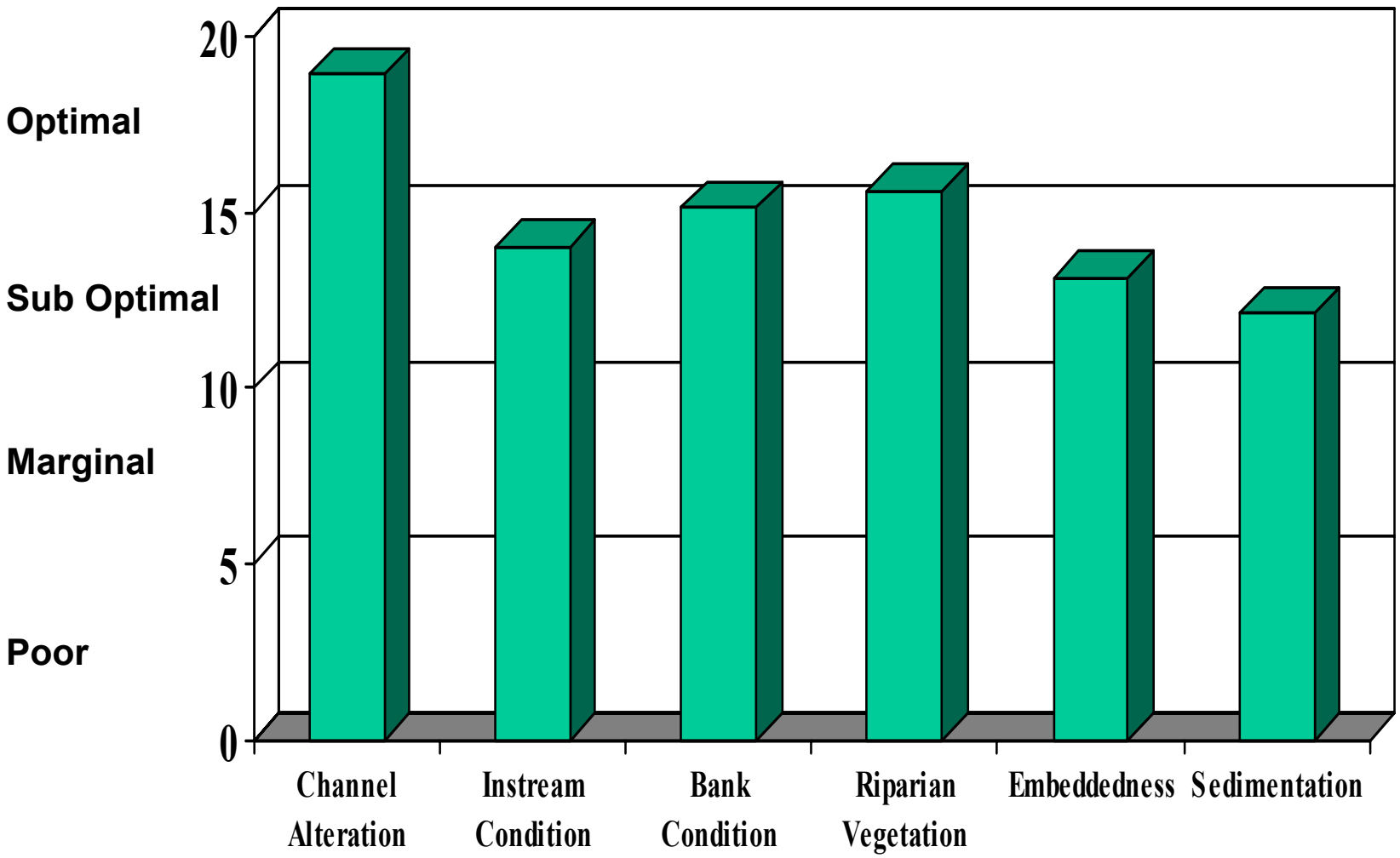


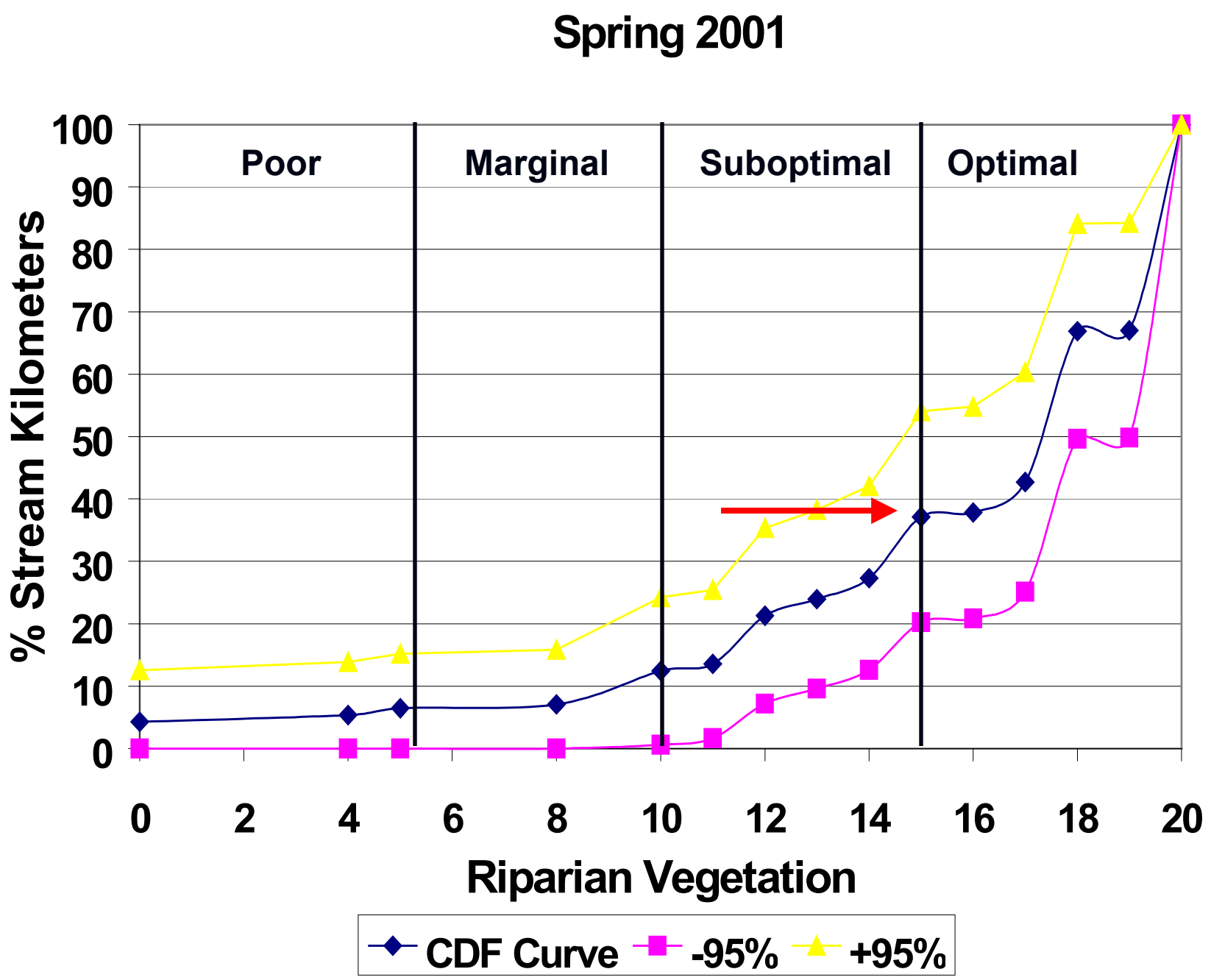
%EPT and %EPT-H

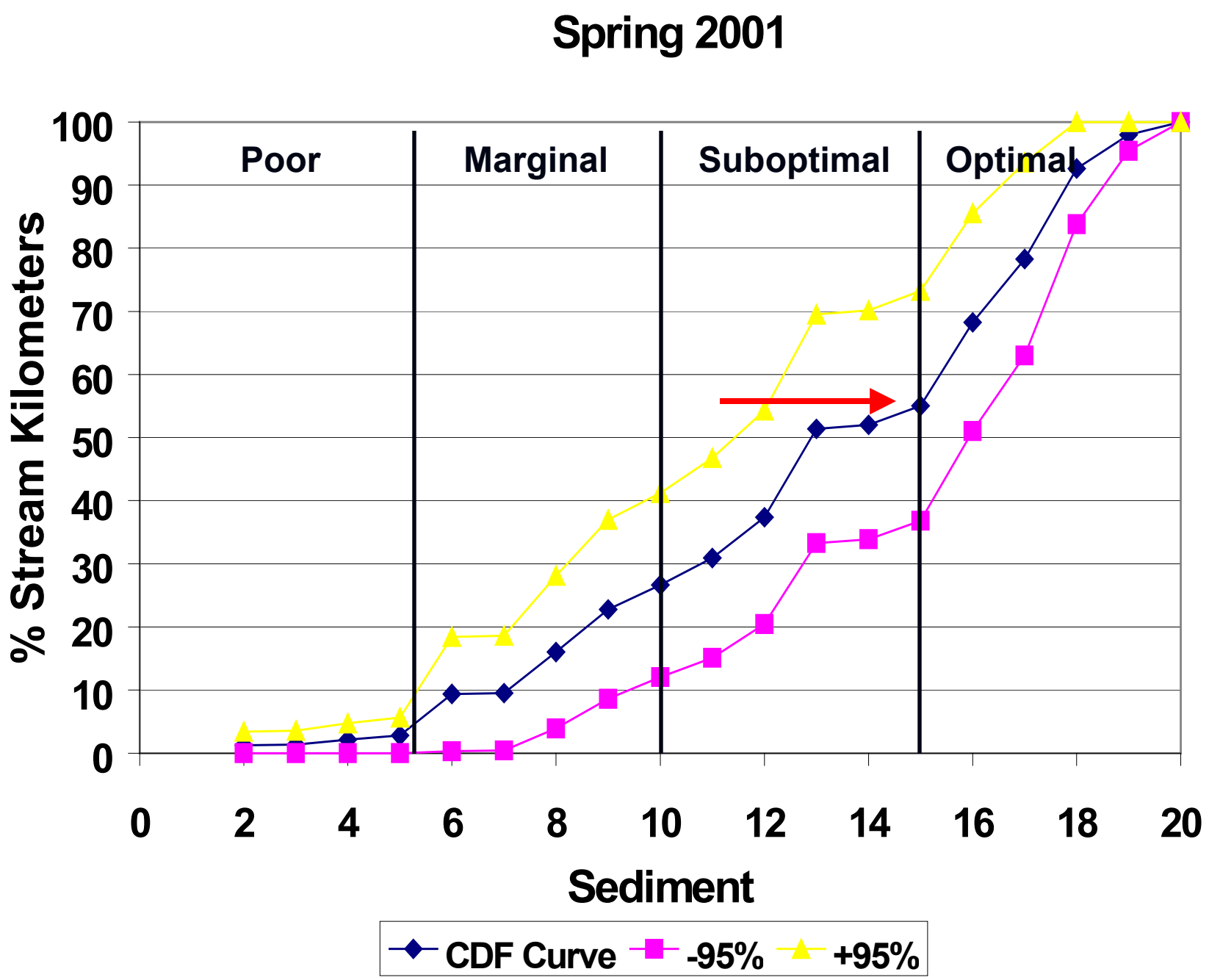

100
80
60
40
20
0
% Total Abundance
Mountain (26)
Piedmont (29)
Plain (8)
GROUP
%EPT
Extremes
%EPT___H

Habitat Results

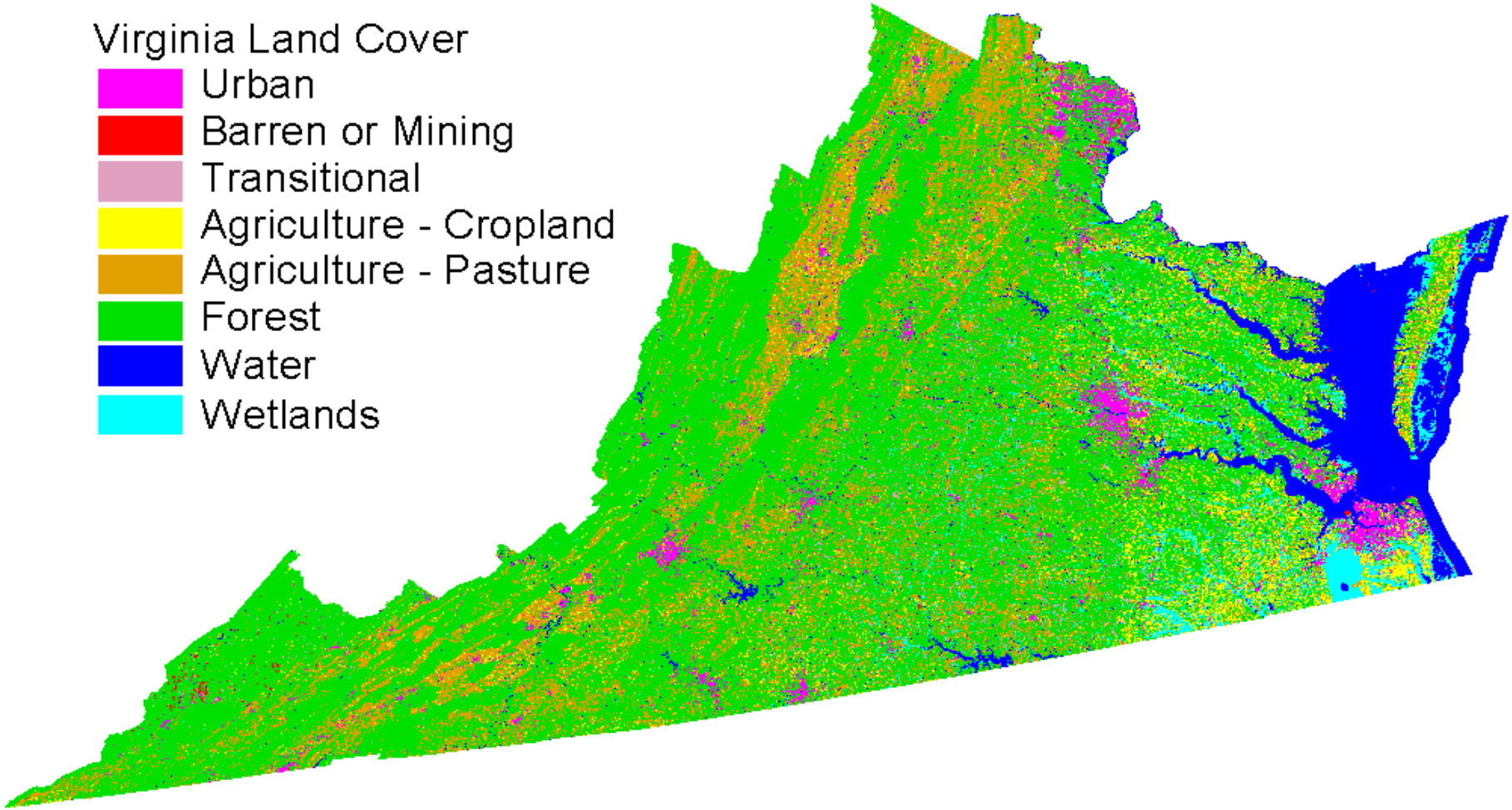
Statewide Averages of Select RBP Habitat Parameters



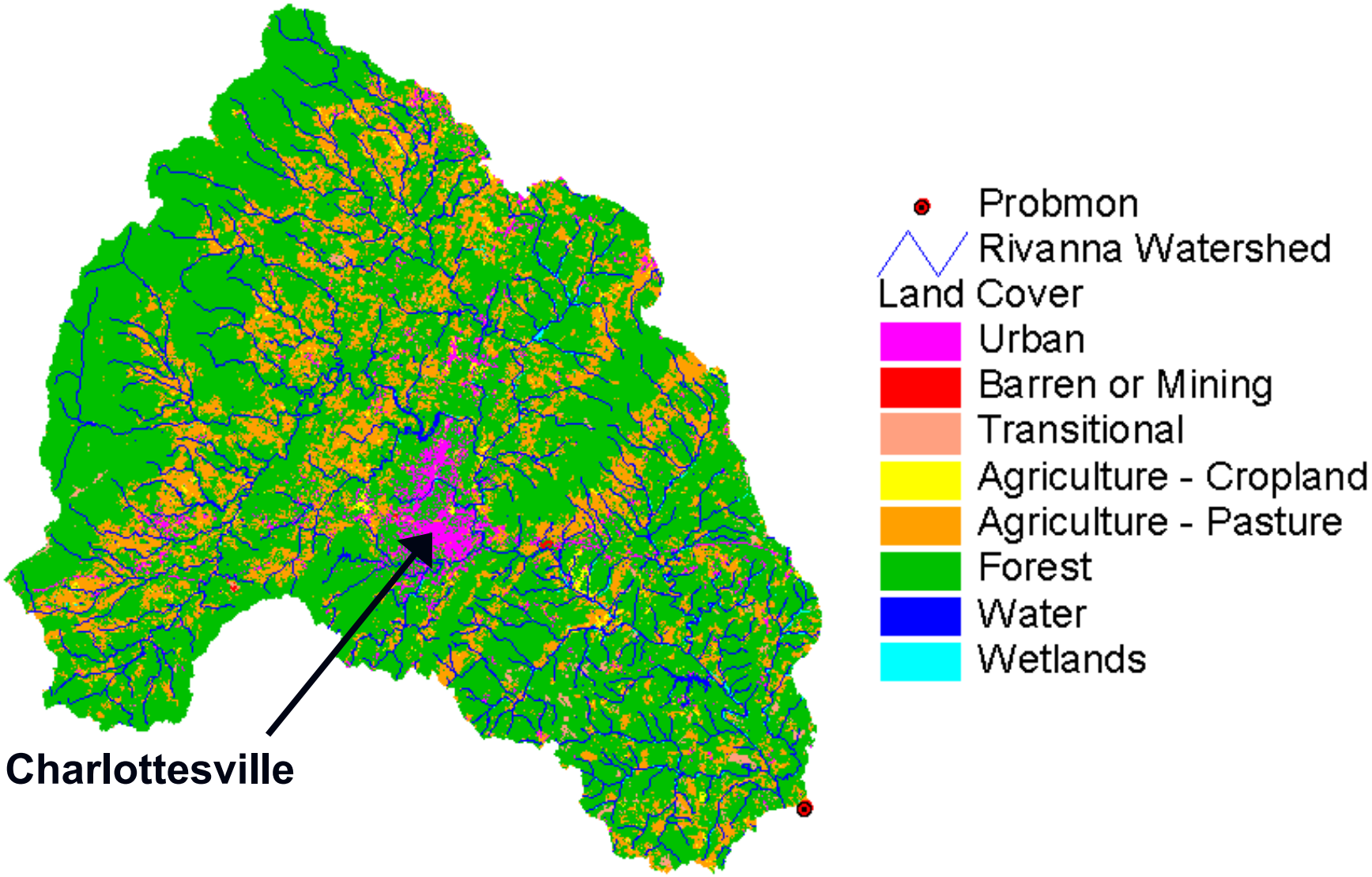

Spring 2001
Poor
Marginal
Suboptimal
Optimal
% Stream Kilometers
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
Riparian Vegetation
CDF Curve
-95%
+95%


Spring 2001
Poor
Marginal
Suboptimal
Optimal
% Stream Kilometers
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
Sediment
CDF Curve
-95%
+95%

Land Cover Results



Rivanna River Land Cover



Land Cover for Central Appalachian Ridges and Valleys Ecoregion Stations

Station	Stream Order	River Basin	% Open Water	% Urban	% Agriculture	% Forest	% Wetland	% Other	Total Square Miles	Hectares
1BDRI000.21	1	Shen	0.53	6.87	29.35	**62.81**	0.34	0.08	14.57	4144.65
6BXDJ000.15	1	Tenn	0.00	0.00	8.32	**91.68**	0.00	0.00	0.21	55.08
1BBVR000.84	2	Shen	0.14	0.22	33.61	**65.60**	0.18	0.24	1.72	444.86
1BCPL002.83	2	Shen	0.03	0.05	**78.17**	21.25	0.48	0.02	5.08	1314.82
2-OGL005.53	2	James	0.00	0.00	1.84	**97.95**	0.00	0.20	1.69	438.57
2-CWP053.78	3	James	0.22	0.03	13.90	**85.32**	0.18	0.35	28.88	7480.80
4ARNF015.50	3	Roanoke	0.03	0.67	26.33	**72.95**	0.00	0.01	48.07	12448.41
6BLWS003.88	3	Tenn	0.25	0.02	8.77	**87.12**	0.00	3.85	1.97	509.29
9-WFC044.15	3	New	0.16	0.00	**50.74**	48.80	0.30	0.00	38.68	10018.06
2-CWP023.28	4	James	0.32	0.09	12.22	**86.87**	0.21	0.29	49.97	12942.24
2-JOB001.02	4	James	0.33	0.01	12.22	**93.21**	0.14	0.21	13.09	3391.14
4ARNF009.01	4	Roanoke	0.05	2.21	21.74	**75.25**	0.01	0.74	76.46	19803.05
9-WFC010.66	4	New	0.08	0.39	19.56	**79.45**	0.15	0.36	207.11	53638.70
2-LMC001.15	5	James	0.10	3.04	37.00	**59.68**	0.01	0.17	7.62	1973.26
6BPOW156.57	5	Tenn	0.20	2.13	4.27	**90.38**	0.13	2.88	36.64	9488.38
9-WLK024.17	5	New	0.12	0.31	23.12	**76.20**	0.03	0.22	192.95	49971.62

Theoretical reference site matrix for the Central Appalachian Ridges and Valleys Ecoregion.

Land Cover	**Include if**
Urban	< 8%
Agriculture	< 35%
Barren/Mining	< 2%
Physical Habitat Data	**Include if**
Sedimentation	> 15
Riparian Zone	> 15
% Habitat	> 75 %
Chemical Data	**Include if**
Nitrate	< 0.1 mg/L
Total Phosphorus	< 0.02 mg/L

Summary

- Probabilistic Sampling Design
  - Site selection
  - Statewide coverage
- Data Analysis
  - Estimates general water quality of all non-tidal streams
- Future Applications
  - Correlate water quality to land cover
  - Develop reference conditions

Acknowledgements

EPA: Tony Olsen, Corvallis Office, for assistance and support with random site selection, weighting, and CDF Curve generation

Private Landowners across the state of Virginia for allowing DEQ field staff to access ProbMon sites

DEQ: G. Brown, R. Daub, D. Schmidt, M. Shaver, C. Staten, E. Cumbow, L. Sparks, F. Kaurish, T. Silvia, W. Harlan, C. Davey, D. Wolfram, J. Howell, A. Wazlak, M. Titman, R. Turner, M. Richardson, R. Anderson, A. Barren, D. Lazarus

http://www.deq.state.va.us
ANY QUESTIONS?