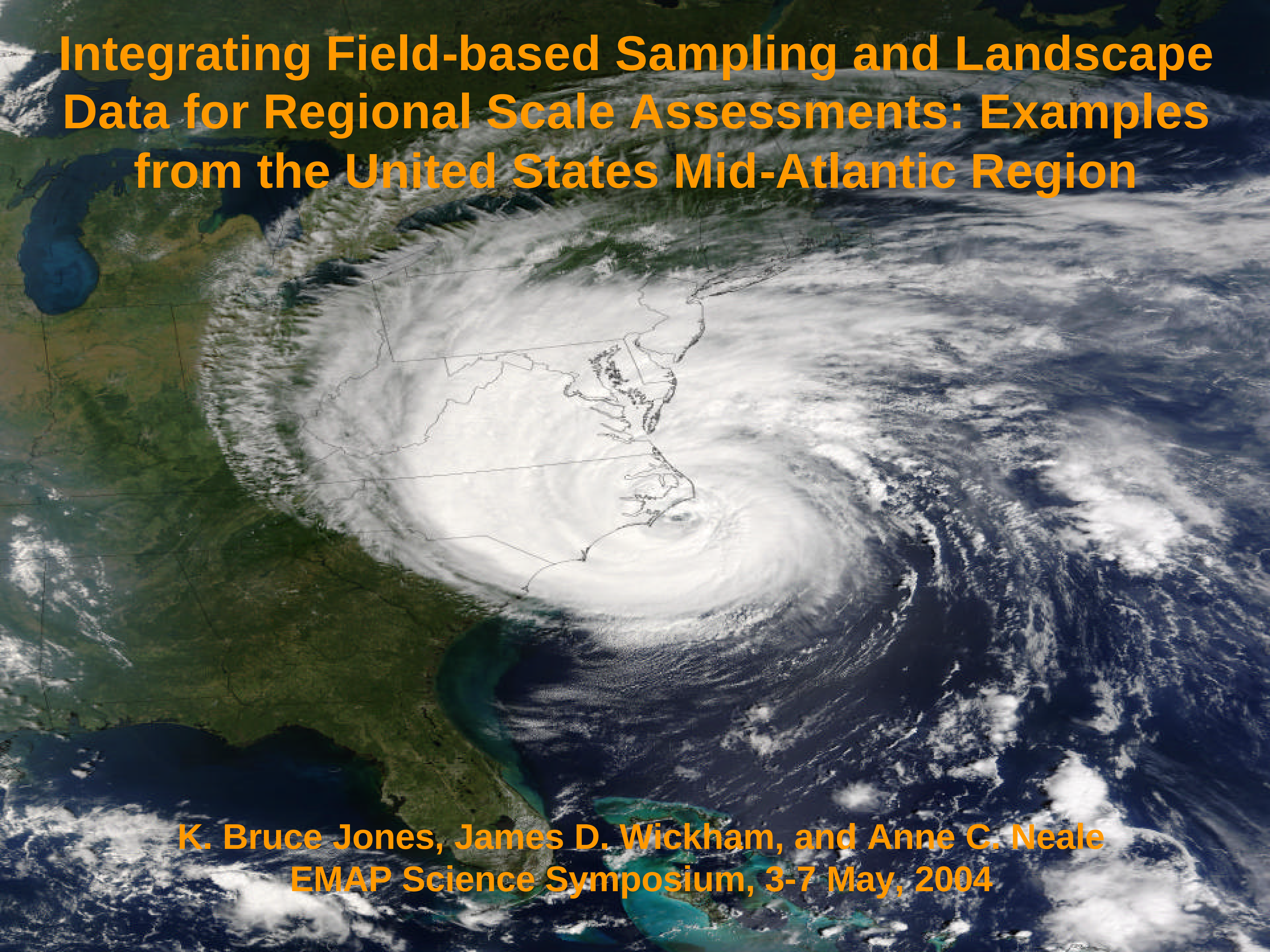
Integrating Field-based Sampling and Landscape Data for Regional Scale Assessments: Examples from the United States Mid-Atlantic Region



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EMAP Science Symposium, 3-7 May, 2004

Presentation Highlights

- Present results of landscape modeling efforts where ecological field data are integrated with measures of landscape conditions at multiple scales.
  - Nitrogen export to streams
  - Breeding birds
  - Integrated bird/nutrient export assessment
- Describe different statistical approaches used to integrate data
- Examples primarily from the mid-Atlantic

Primary Objectives Related to EMAP

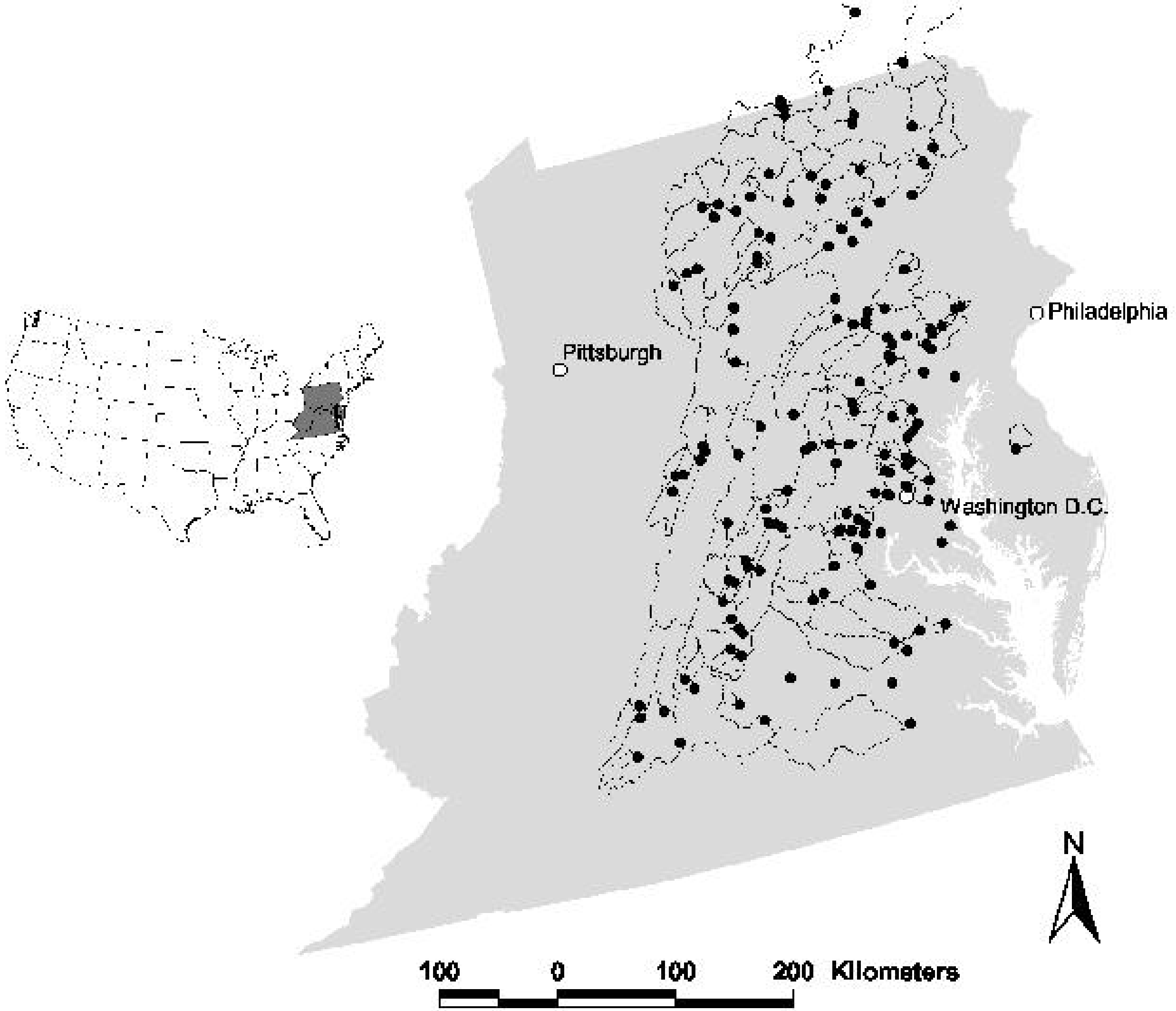
- Evaluate potential causes/factors influencing the condition of ecological resources at a range of scales
- Extend EMAP probability estimates to spatial continuous surfaces and areas not sampled

Models

- Empirical
  - Multiple regression
  - Logistics regression
  - Classification and Regression Tree (CART)
- Baysian
- Combination … rule-based/empirical (integrated assessment of breeding bird habitat suitability and nutrient export

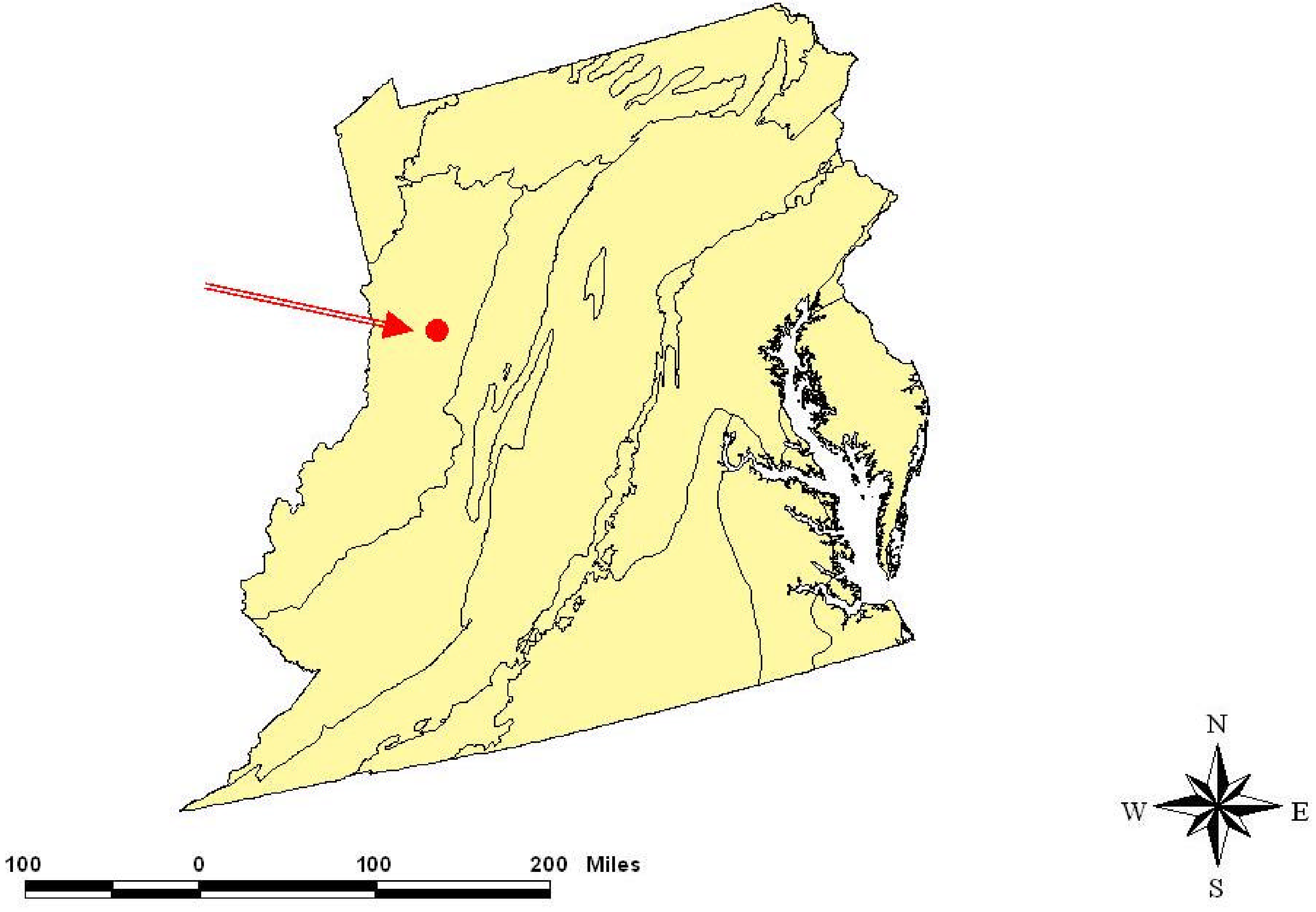
General Approach

- Select specific endpoint of interest
  - Two examples in our studies
    - Nutrients/Sediment in streams as they affect water quality
    - Breeding bird habitats
- Collect/acquire field samples
- Filter data based on selection criteria
- Assemble spatial data at various scales on various units (functional and arbitrary)
- Generate metrics and or measures … pair metrics with individual samples sites in a SAS database
- Conduct statistical analyses

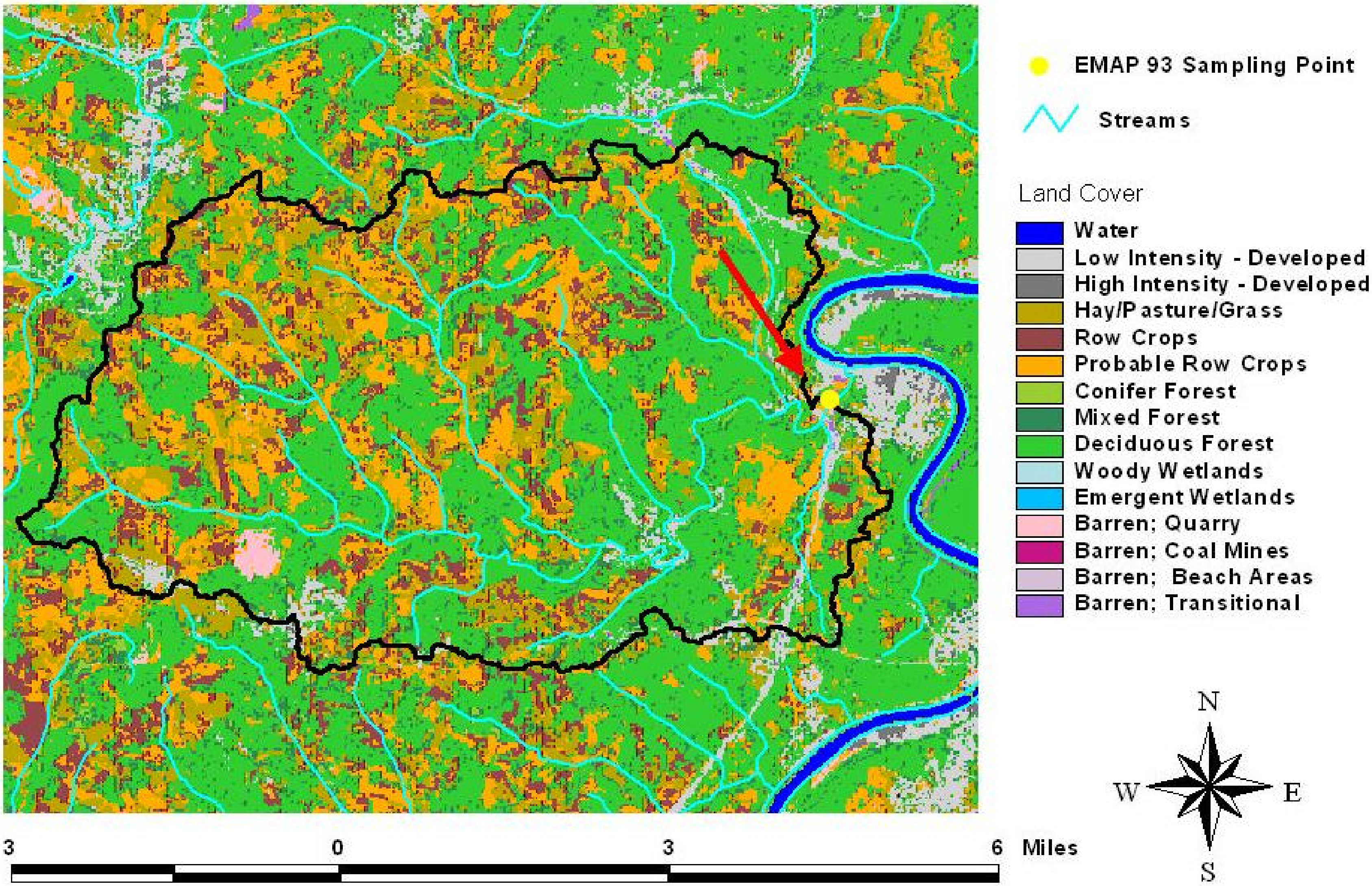


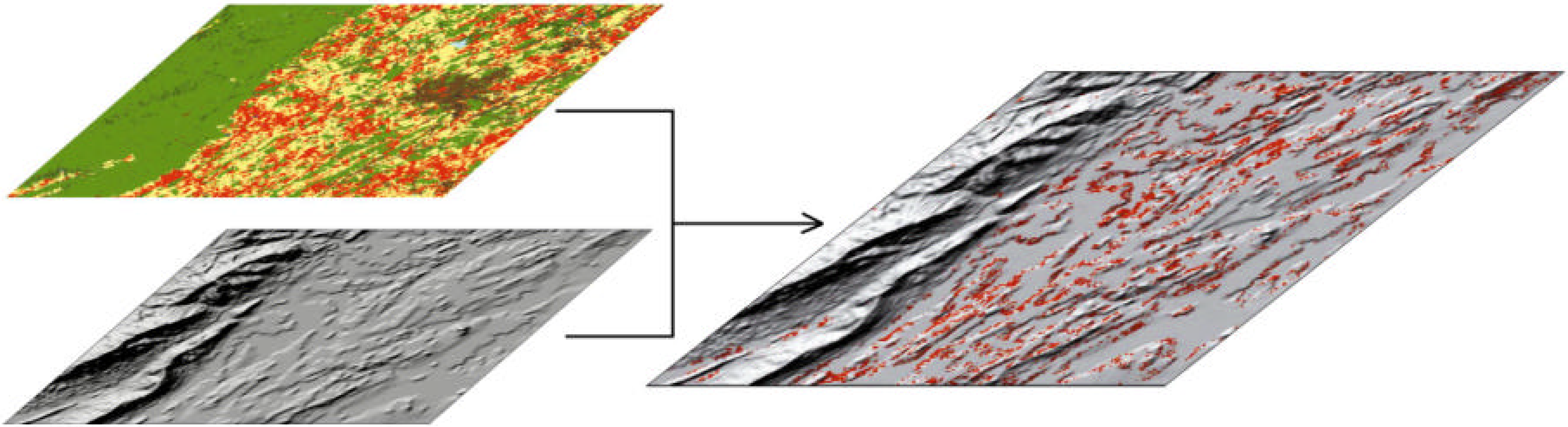
USGS Loading Sample Sites and Associated Watersheds

Location of Example Watershed

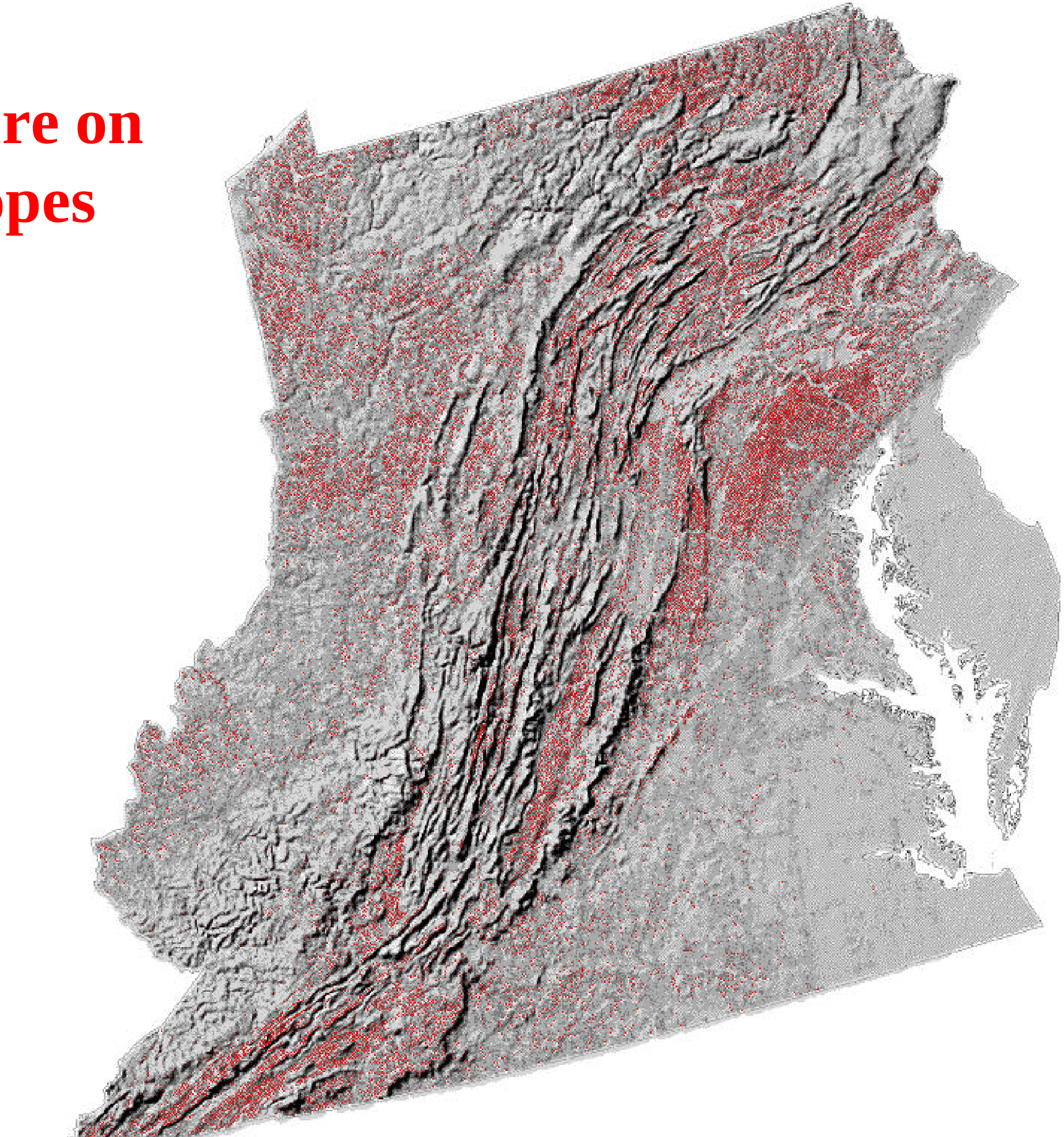


Example Watershed





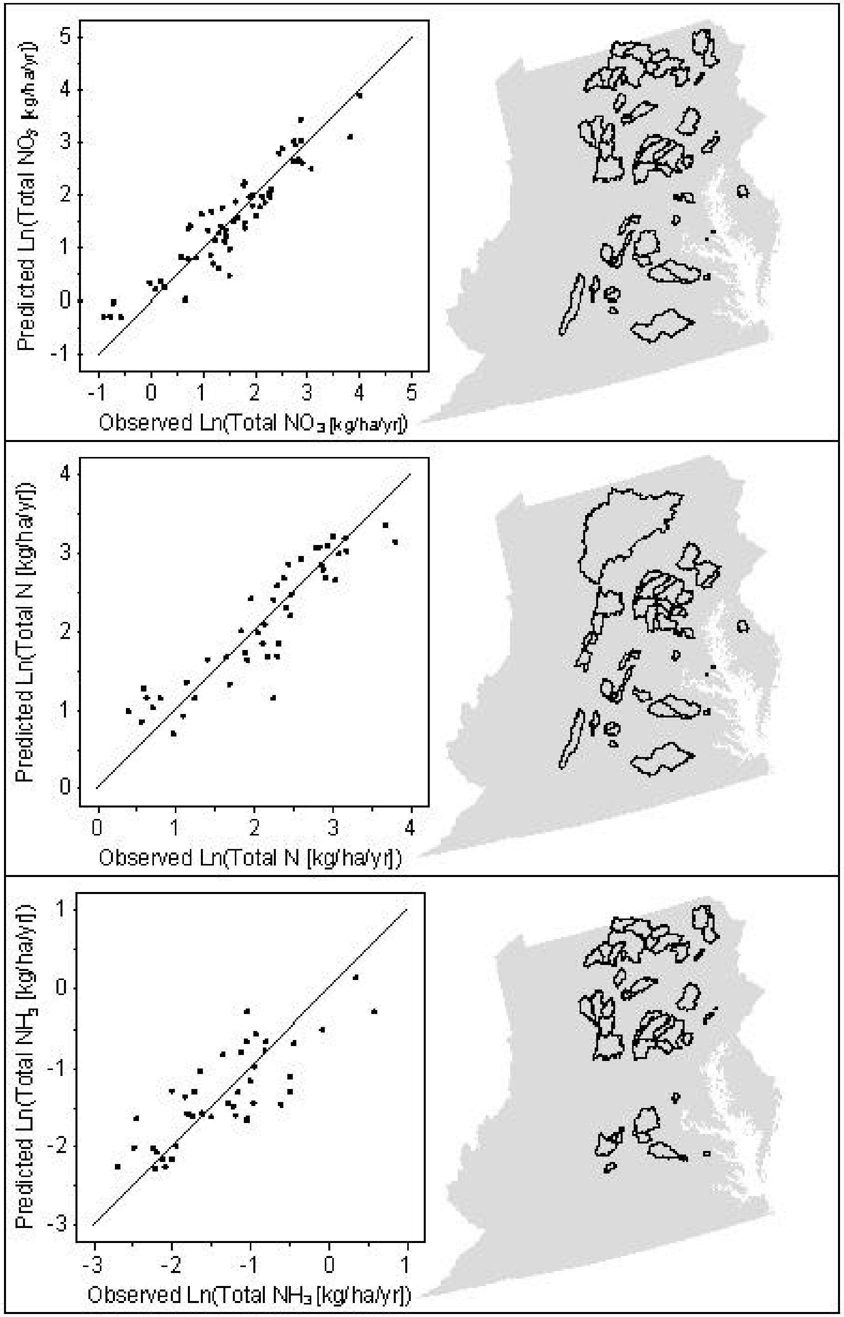
Agriculture on > 3 % Slopes



Landscape Metrics

Mean Riparian agriculture
Riparian forest
Forest fragmentation
Road density
Forest land cover
Agricultural land cover
Agricultural land cover
   on steep slopes
Nitrate deposition
Potential soil loss
Roads near streams
Slope gradient
Slope gradient range
Slope gradient variance
Urban land cover
Wetland land cover
Barren land cover

Multiple Regression

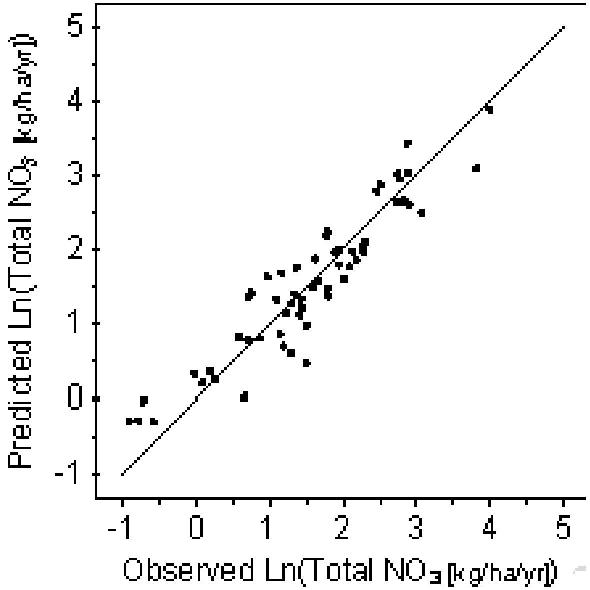


$R^2 = .86$
% Ag
Nitrate Dep
Roads x Streams
% Urban
Riparian Ag

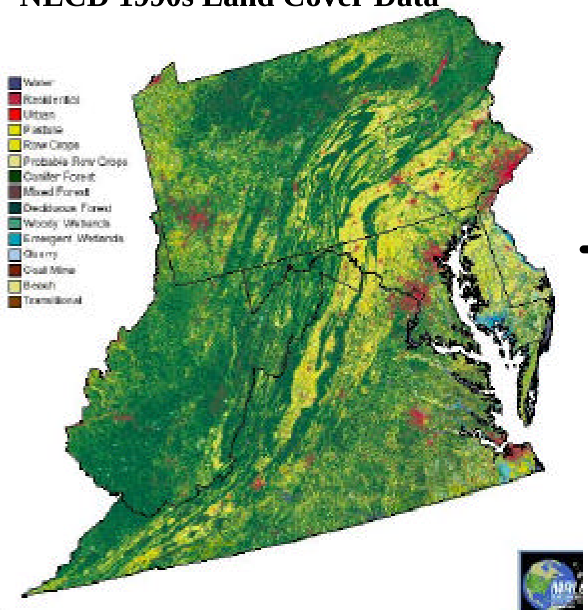
$R^2 = .83$
Riparian Forest
Nitrate Dep

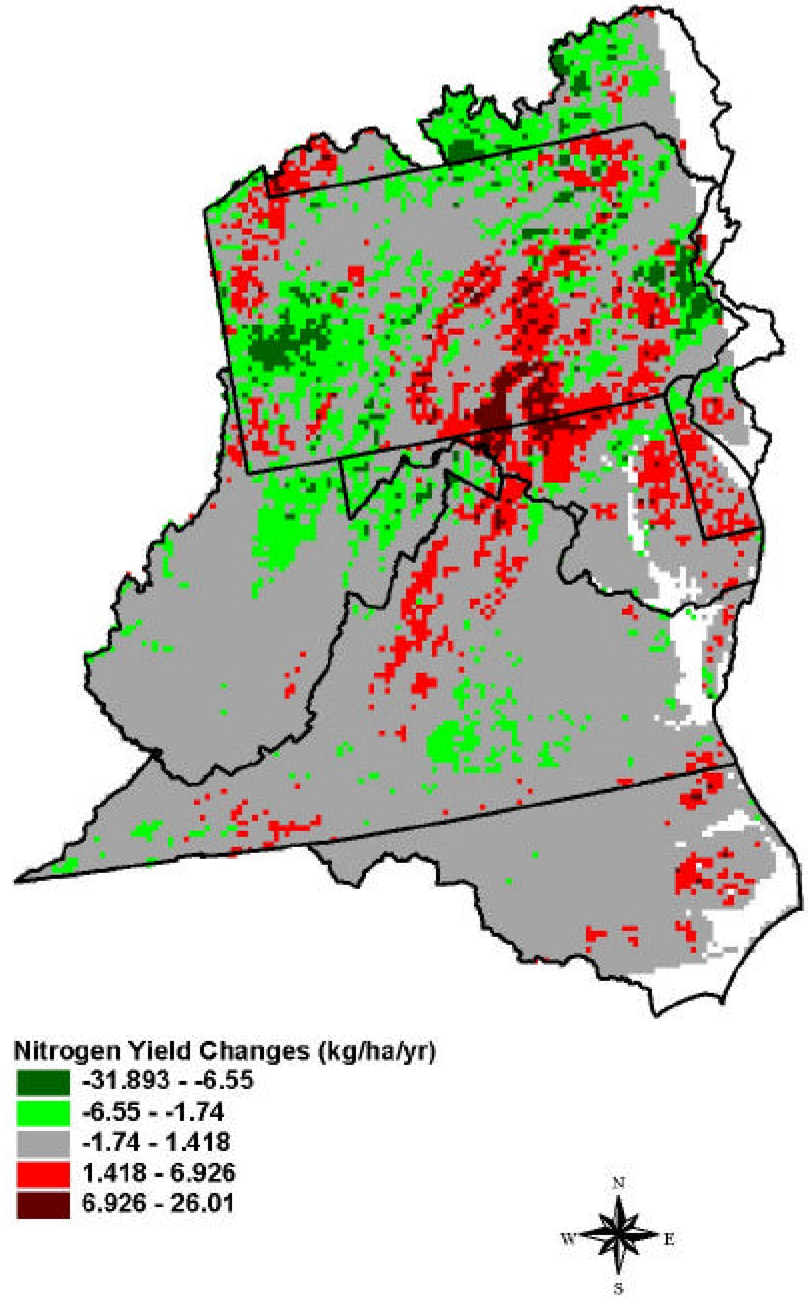
$R^2 = .65$
Road Density
Riparian Forest

Integration to Create a Surface Map of Conditions



NLCD 1990s Land Cover Data



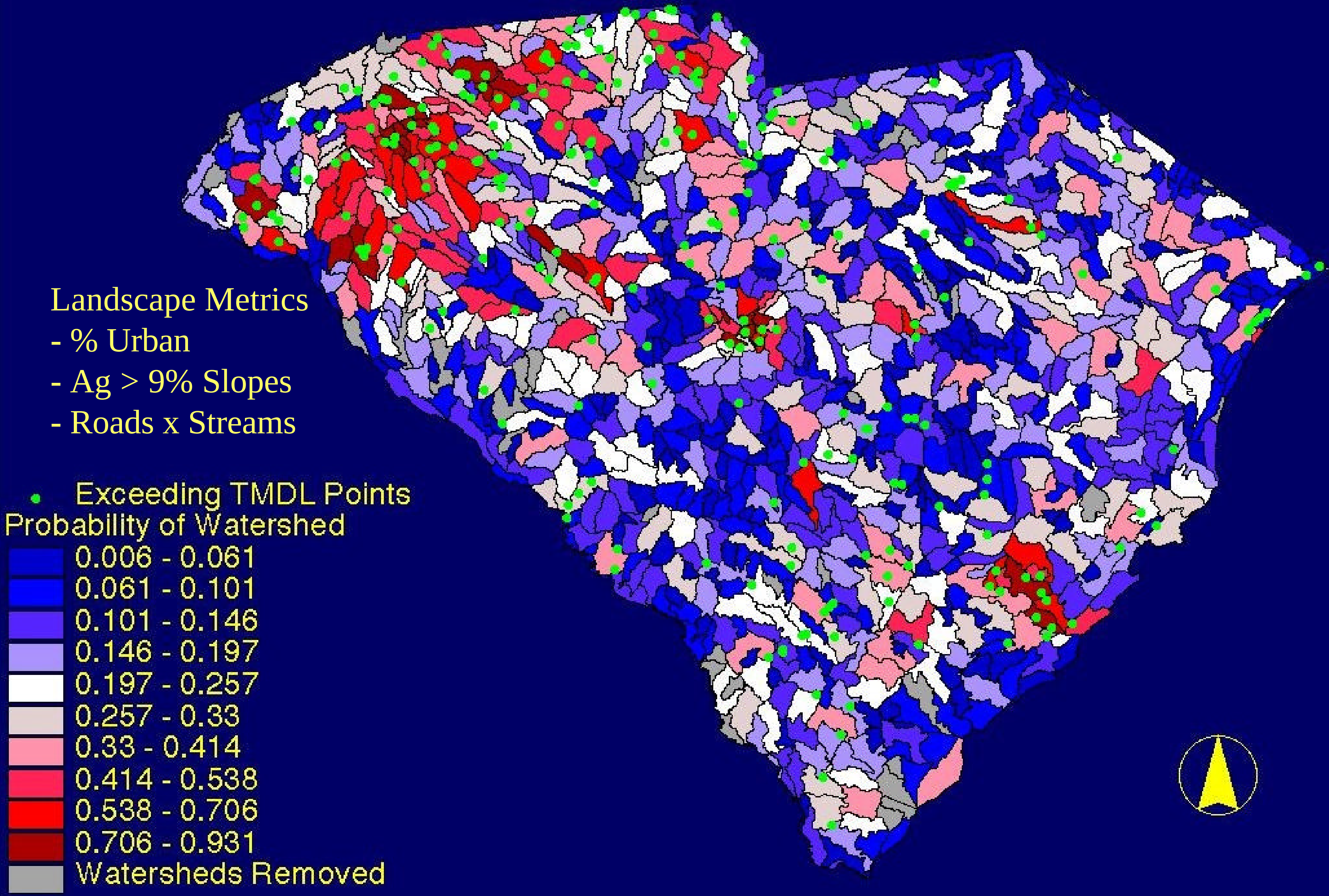


Logistics Regression

- Uses threshold values and provides cross-validation and probabilities of exceeding a threshold (yes/no relative to a dependent variable) based on a set of independent variables (landscape and biophysical variables)
- Useful for evaluating probability of exceeding a TMDL threshold/condition threshold

Logistic Regression Results with Test Points

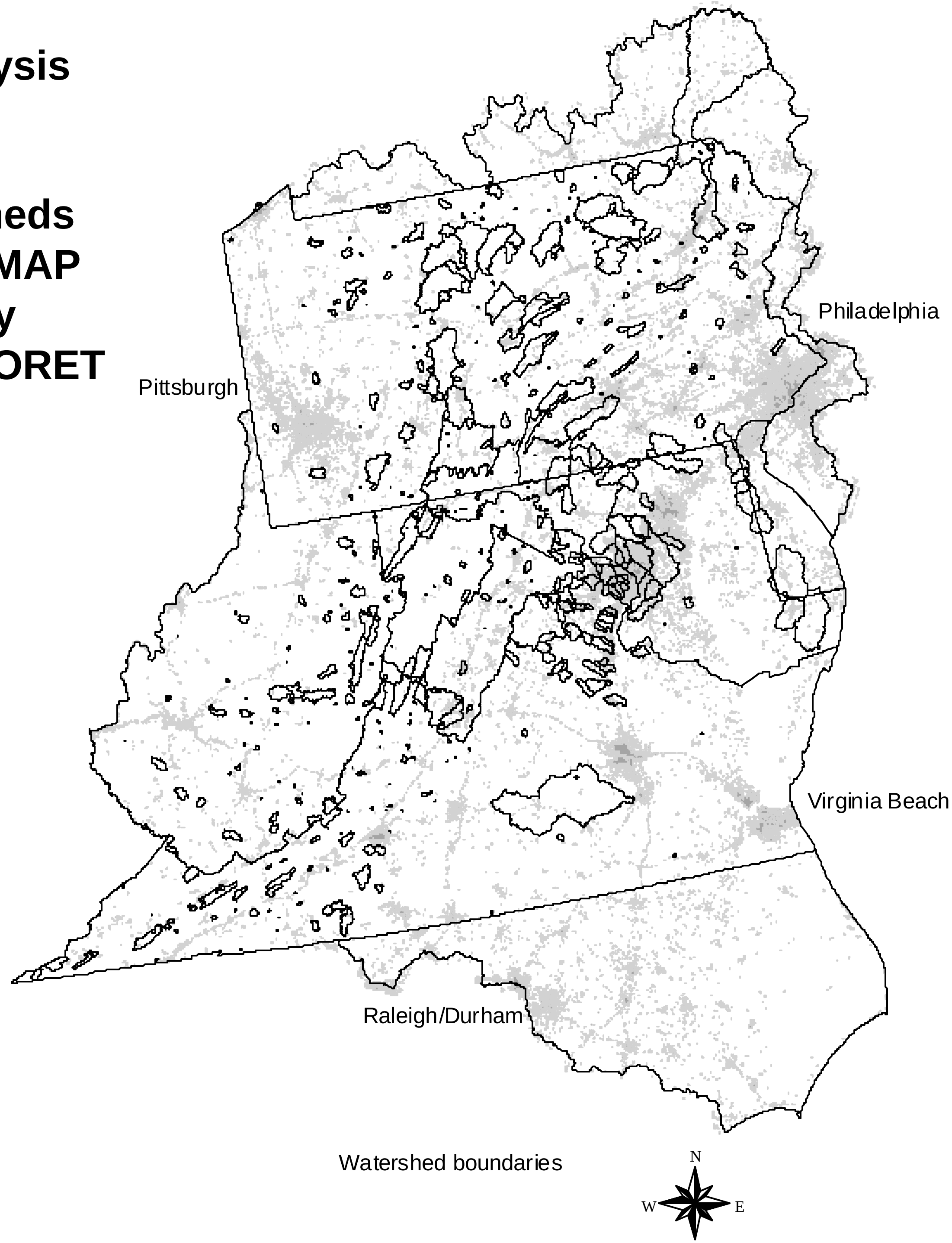
Landscape Metrics
- % Urban
- Ag > 9% Slopes
- Roads x Streams



Classification and Regression Tree Study

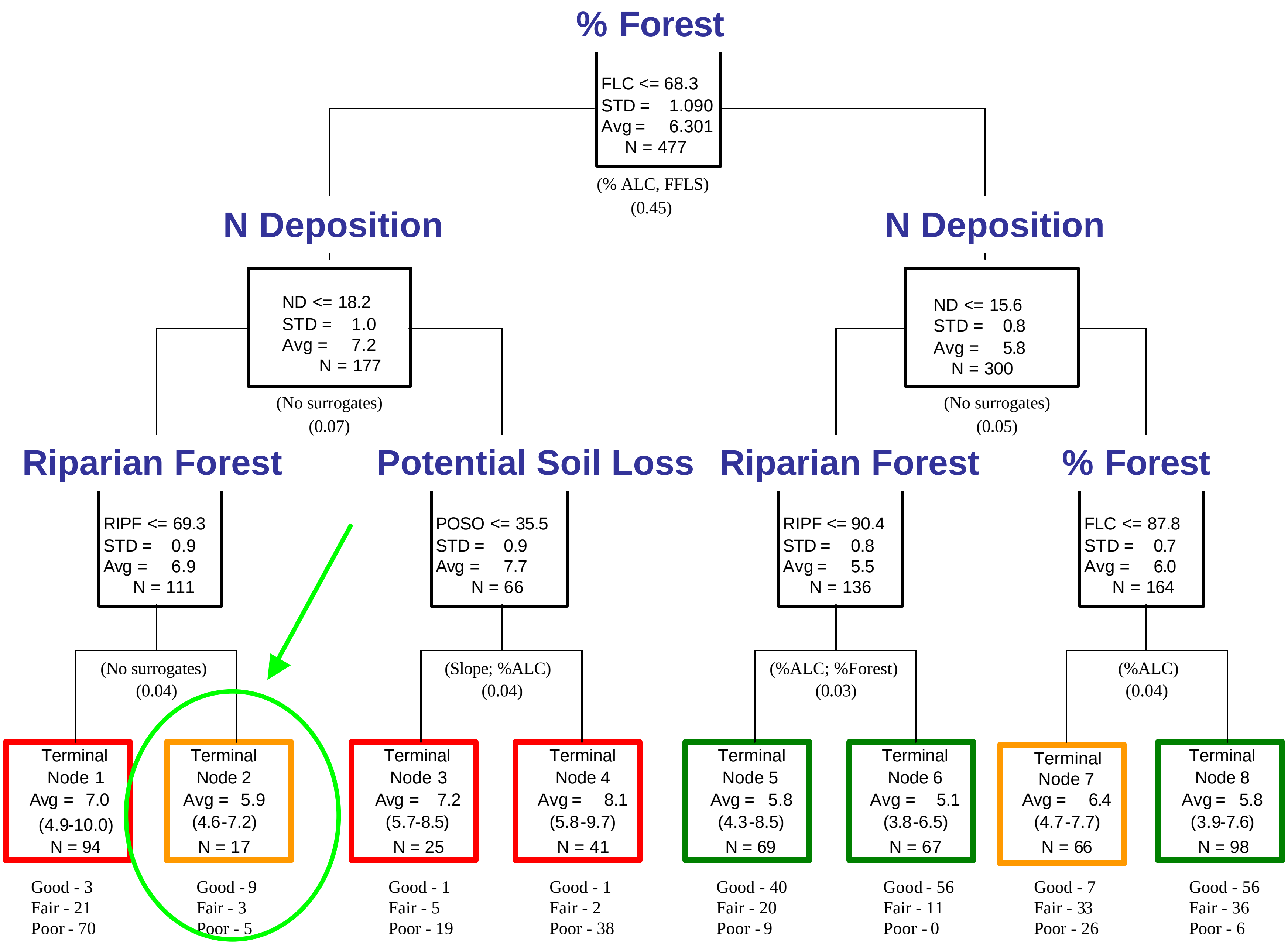
CART Analysis

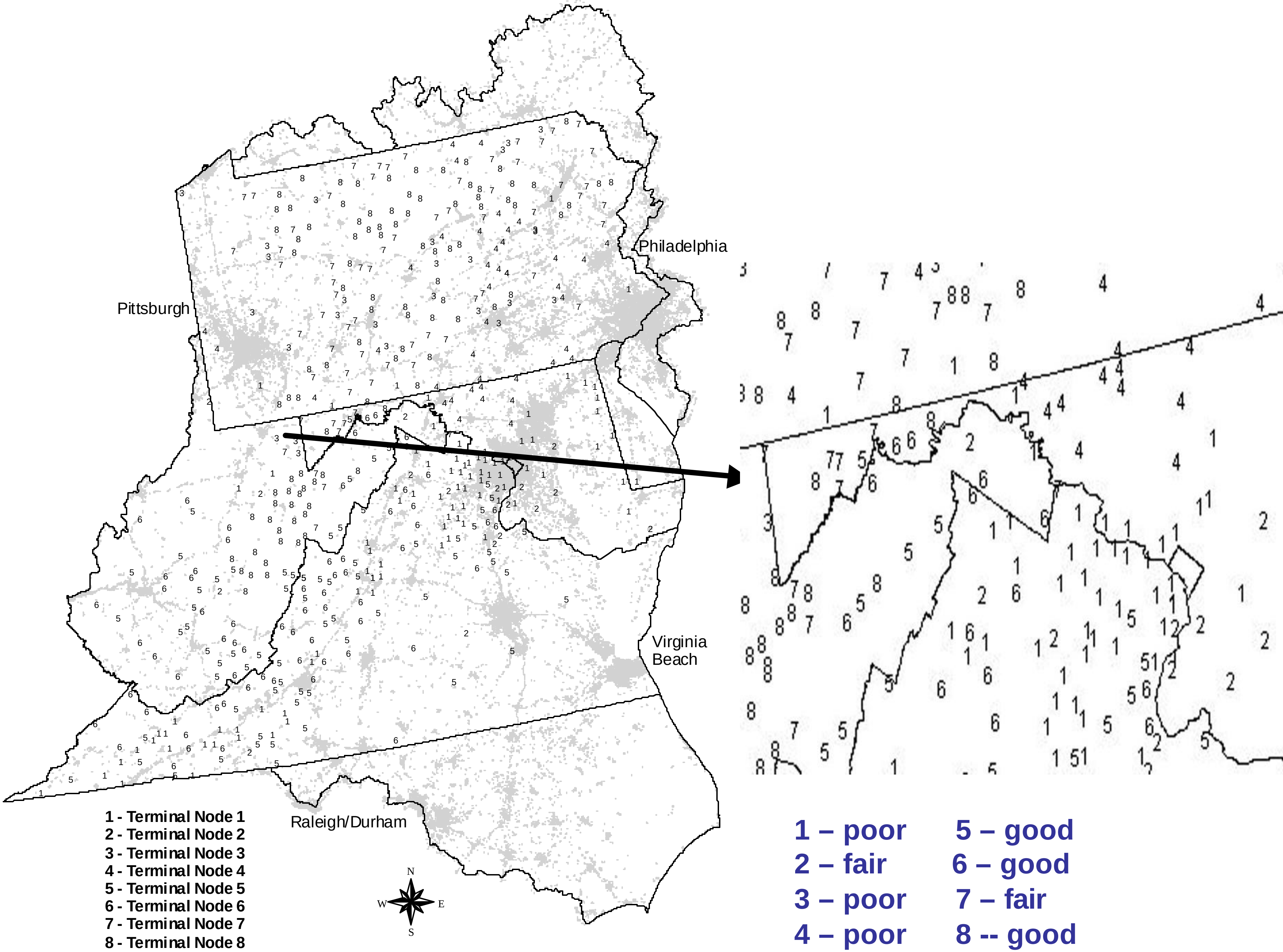
477 Watersheds Based on EMAP and carefully selected STORET sites

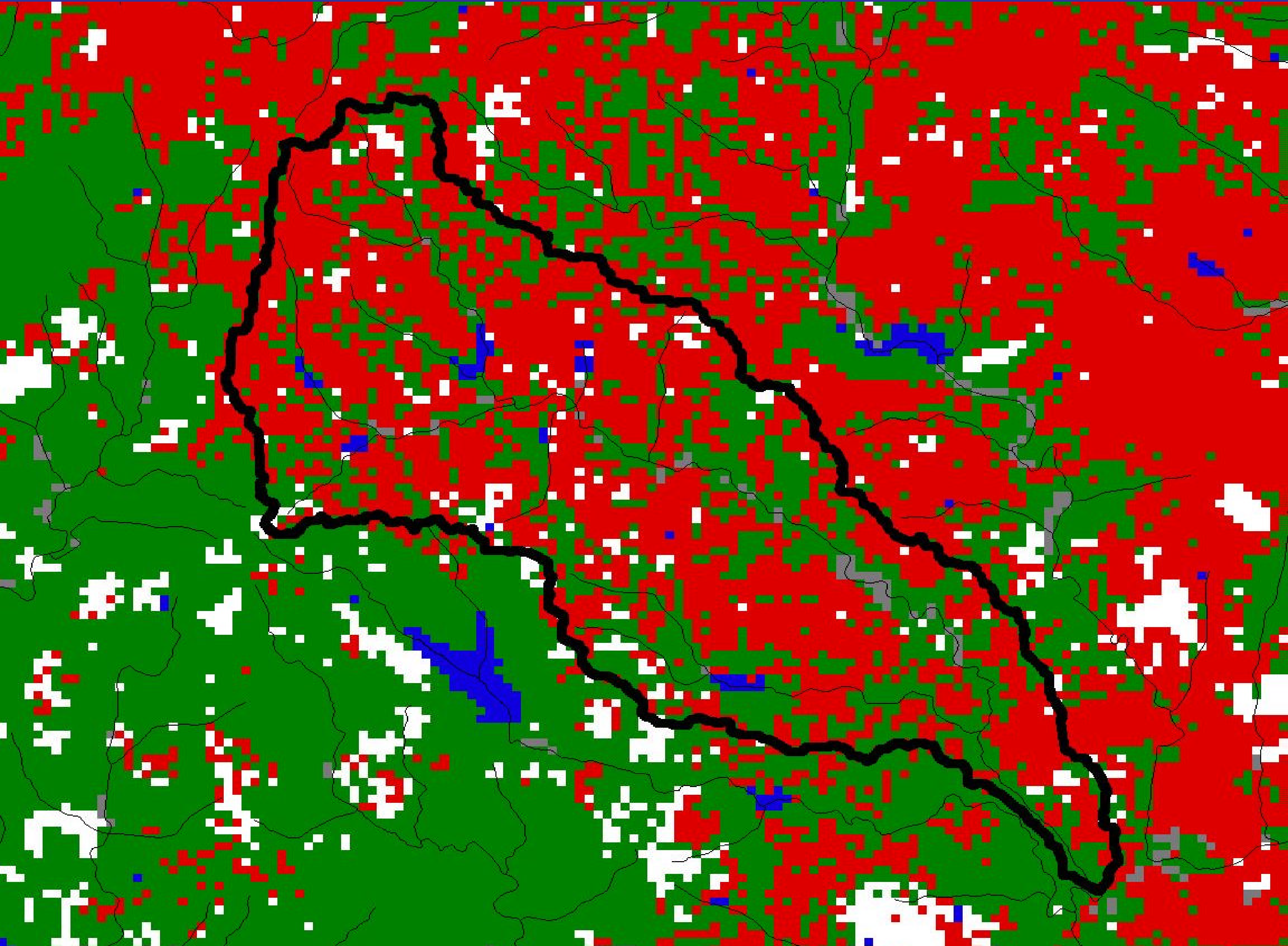


Watershed boundaries

CART Analysis – N concentration in MAIA Streams




Pittsburgh
Philadelphia
Virginia Beach
Raleigh/Durham
1 - Terminal Node 1
2 - Terminal Node 2
3 - Terminal Node 3
4 - Terminal Node 4
5 - Terminal Node 5
6 - Terminal Node 6
7 - Terminal Node 7
8 - Terminal Node 8
N
W
E
S
1 – poor
2 – fair
3 – poor
4 – poor
5 – good
6 – good
7 – fair
8 -- good



Baysian Landscape Models

Nitrogen Export
kg/ha/yr

Forest	Urban	Agriculture
0.1	5.0	3.2
0.1	5.0	4.8
0.2	5.0	5.0
0.7	5.1	5.0
2.2	5.4	5.8
2.5	6.7	9.1
2.5	7.9	9.6
2.6	9.6	9.8
3.0	9.6	11.9
3.7	12.0	14.0
4.4	16.3	20.0
7.6	18.0	20.6
12.2	28.0	22.3
		23.5
		33.3

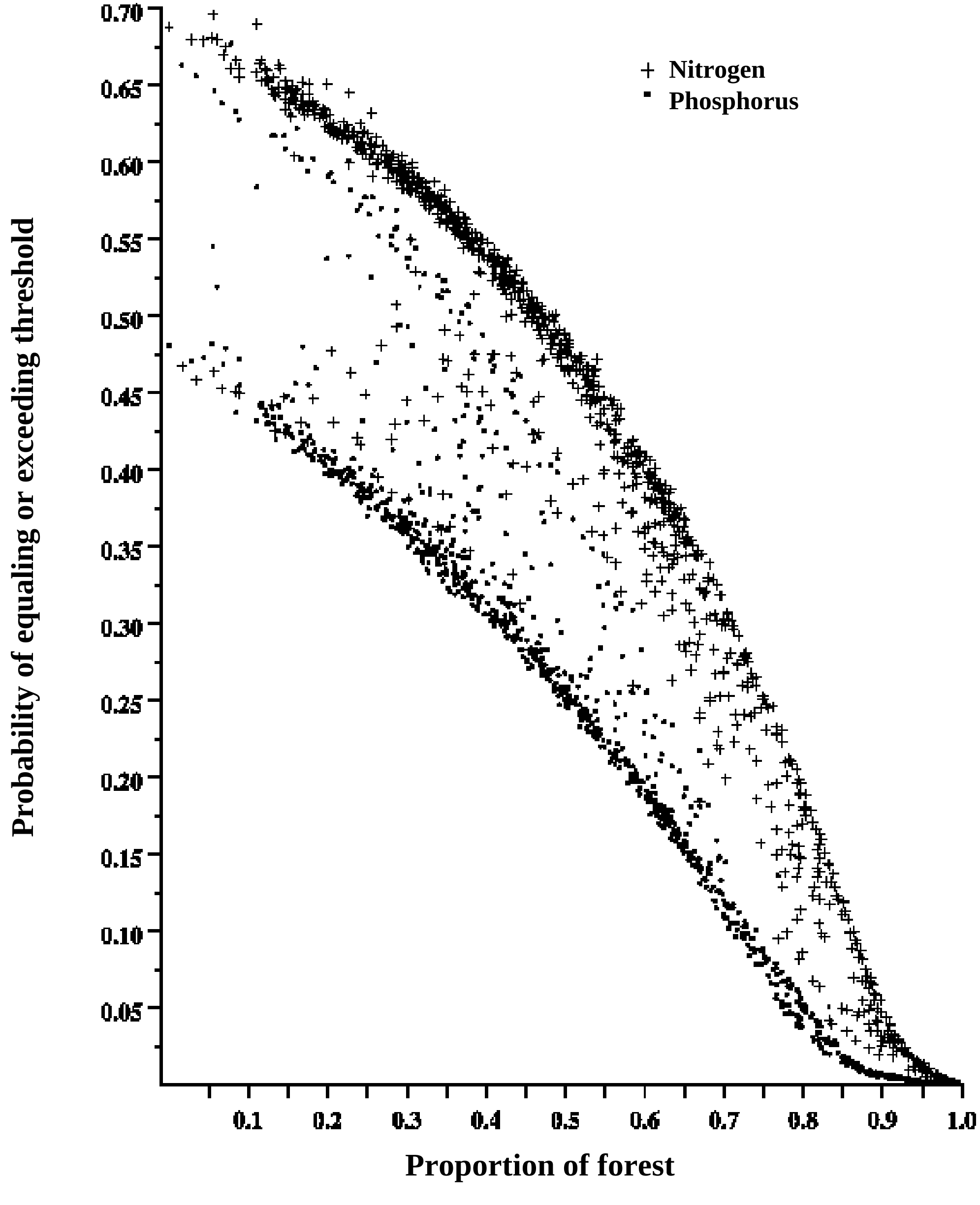
Source: Frink (*JEQ*, 1991, 20:717)

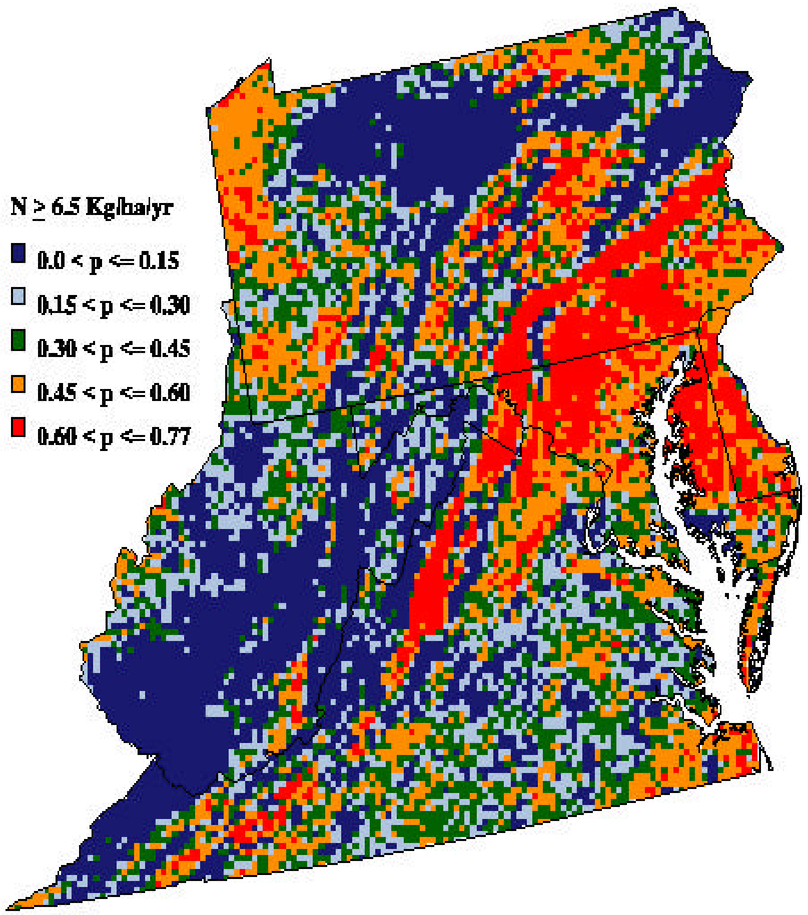
Land-Cover	WS (ha)	N/P	# of Obs.	Min	Q_{25}	Q_{50}	Q_{75}	Max
Agriculture	40-8000	N	30	2.1	6.6	11.1	20.3	53.2
Urban	4-4800	N	19	1.5	4.0	6.5	12.8	38.5
Forest	7-47000	N	21	1.4	1.9	2.5	3.3	7.3
Agriculture	40-8000	P	27	0.08	0.49	0.91	1.34	5.40
Urban	4-4800	P	24	0.19	0.69	1.10	3.39	6.23
Forest	7-47000	P	62	0.01	0.04	0.08	0.22	0.83

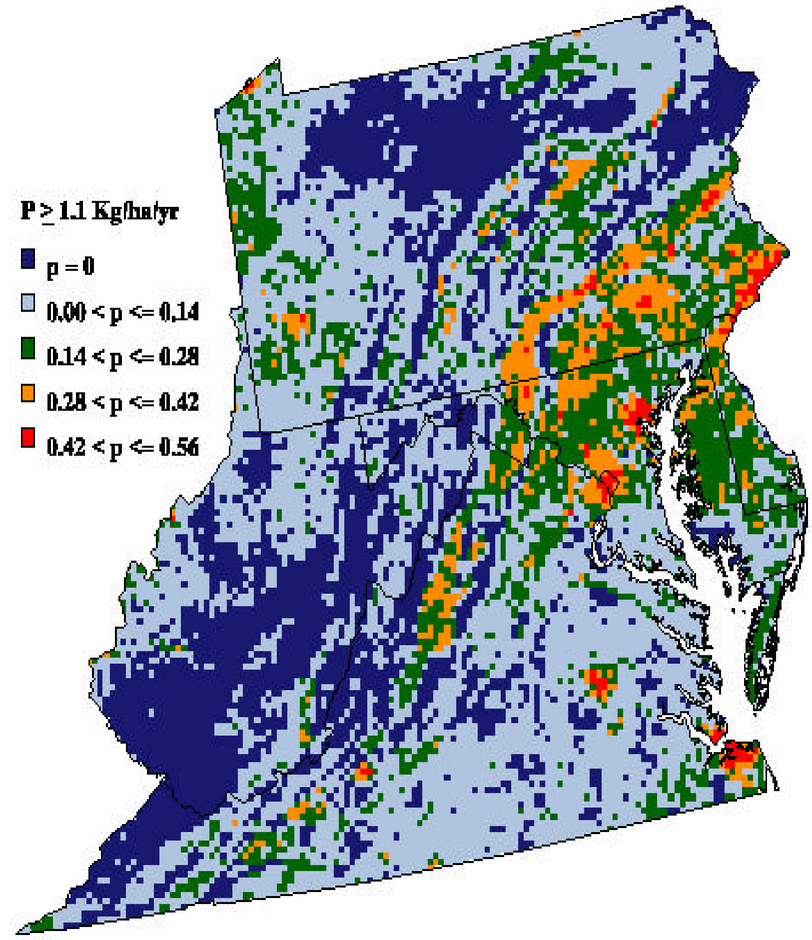
$$N, P = \sum_{i}^{n} (C_i * A_i)$$

	N	P
Threshold	7.0	0.8

Risk: # of iterations / 10000 >= 7.0 or 0.8


+ Nitrogen
▪ Phosphorus
Probability of equaling or exceeding threshold
Proportion of forest
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

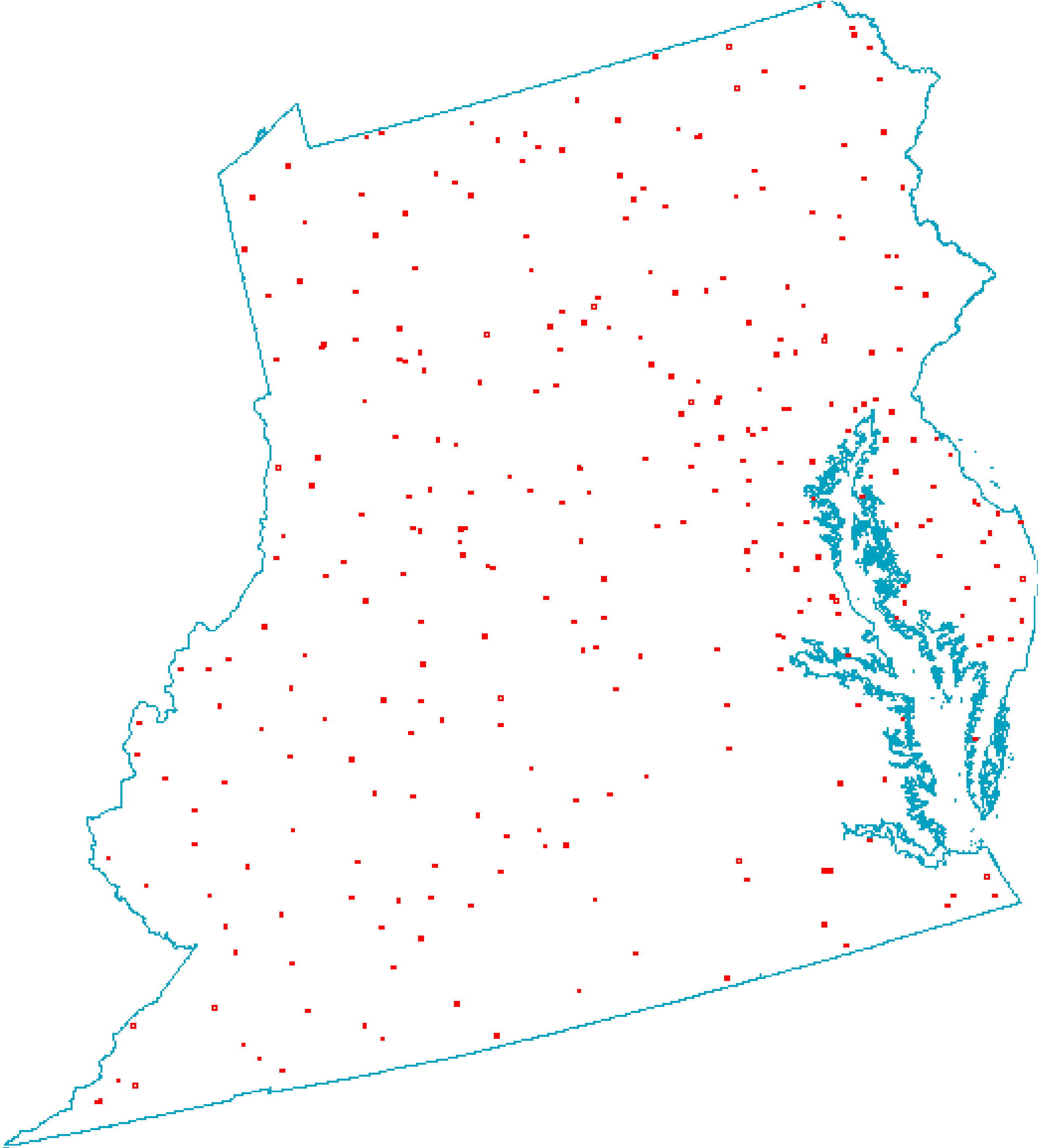

N ≥ 6.5 Kg/ha/yr
0.0 < p <= 0.15
0.15 < p <= 0.30
0.30 < p <= 0.45
0.45 < p <= 0.60
0.60 < p <= 0.77


P ≥ 1.1 Kg/ha/yr
p = 0
0.00 < p <= 0.14
0.14 < p <= 0.28
0.28 < p <= 0.42
0.42 < p <= 0.56

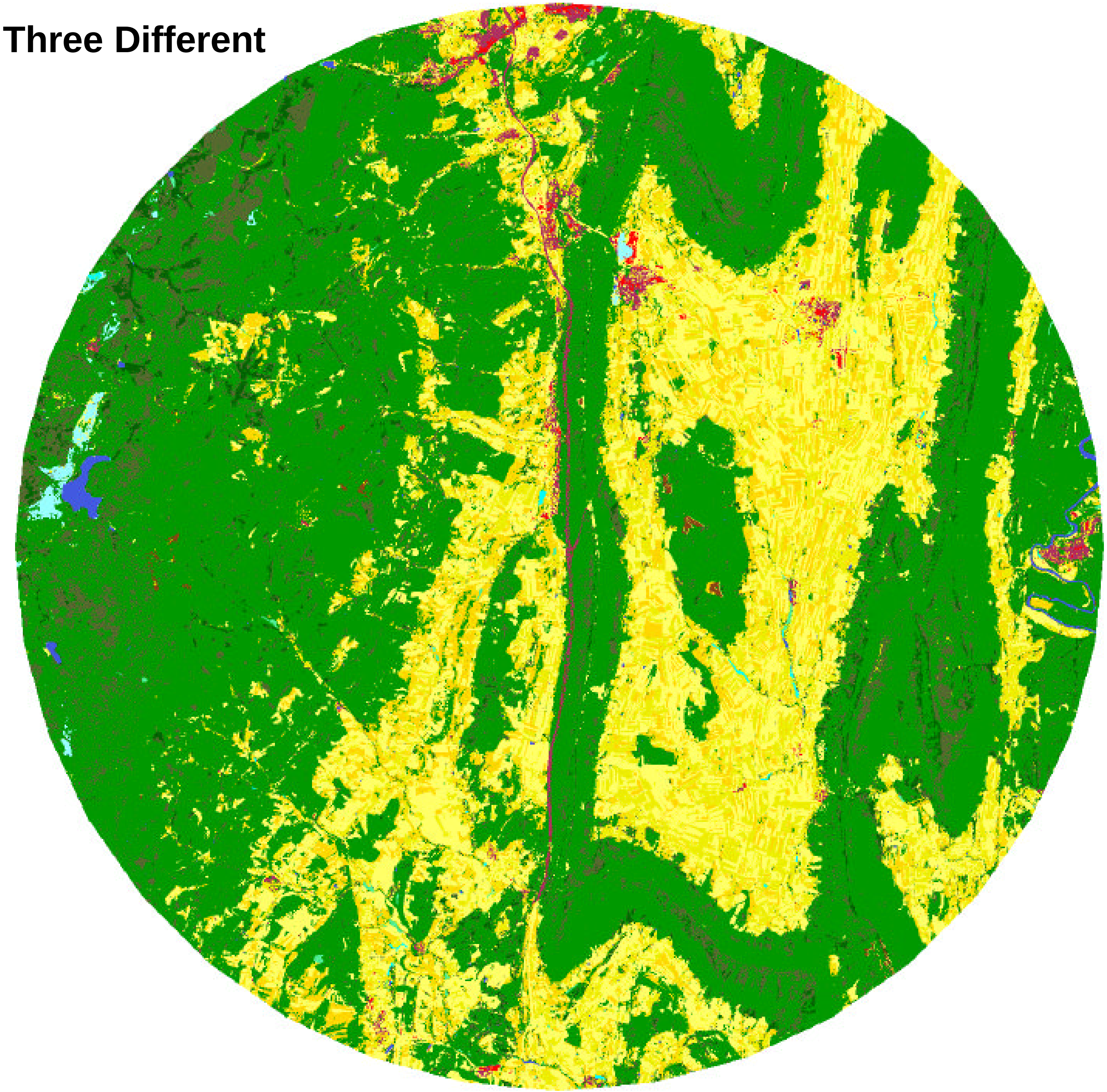
Birds and Landscape Condition

MAIA BBS Study

- Compare landscape metrics to breeding bird guild structure based on O'Connell et al
- 182 BBS transects
- Center point of route
- Circular support area at three different scales
- Bird data from BBS routes of highest quality

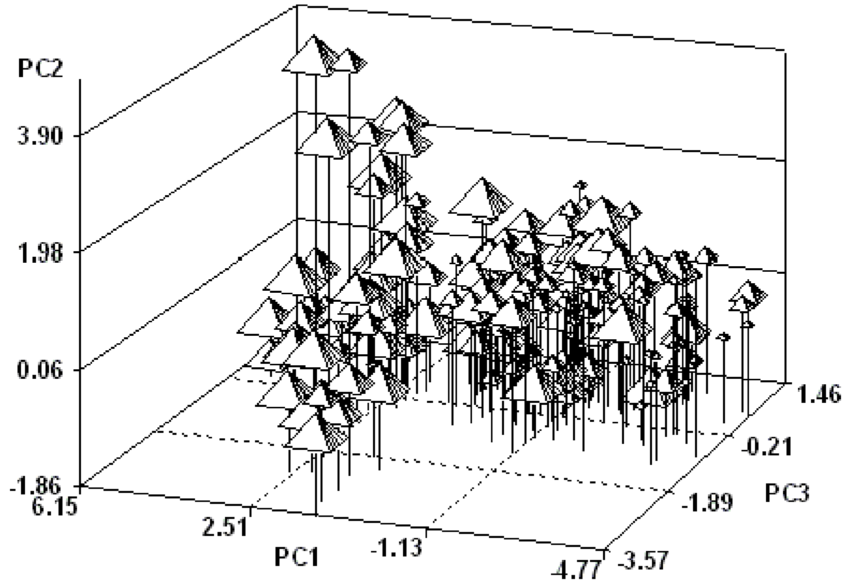


Looked at Three Different Scales

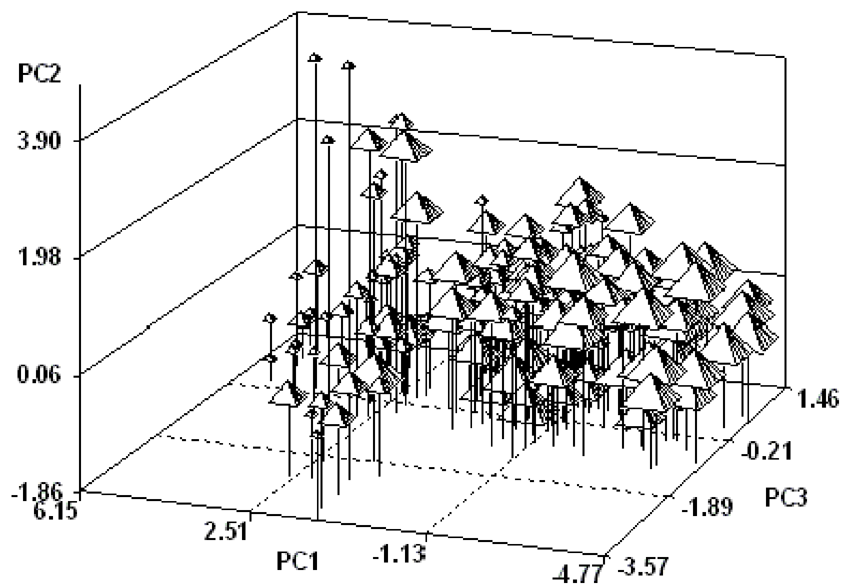


Results of MAIA BBS Study

- Generalists
  - Forest edge (30% of variation) +
  - Forest fragmentation (2% of variation) -
  - Only one guild > 40% of variation
    - Exotic (46%)
- Specialists
  - Forest edge (44% of variation) -
  - Forest @ 3 scales (2% of variation) +
  - Two guilds > 40% of variation
    - Interior forest obligate (53%)

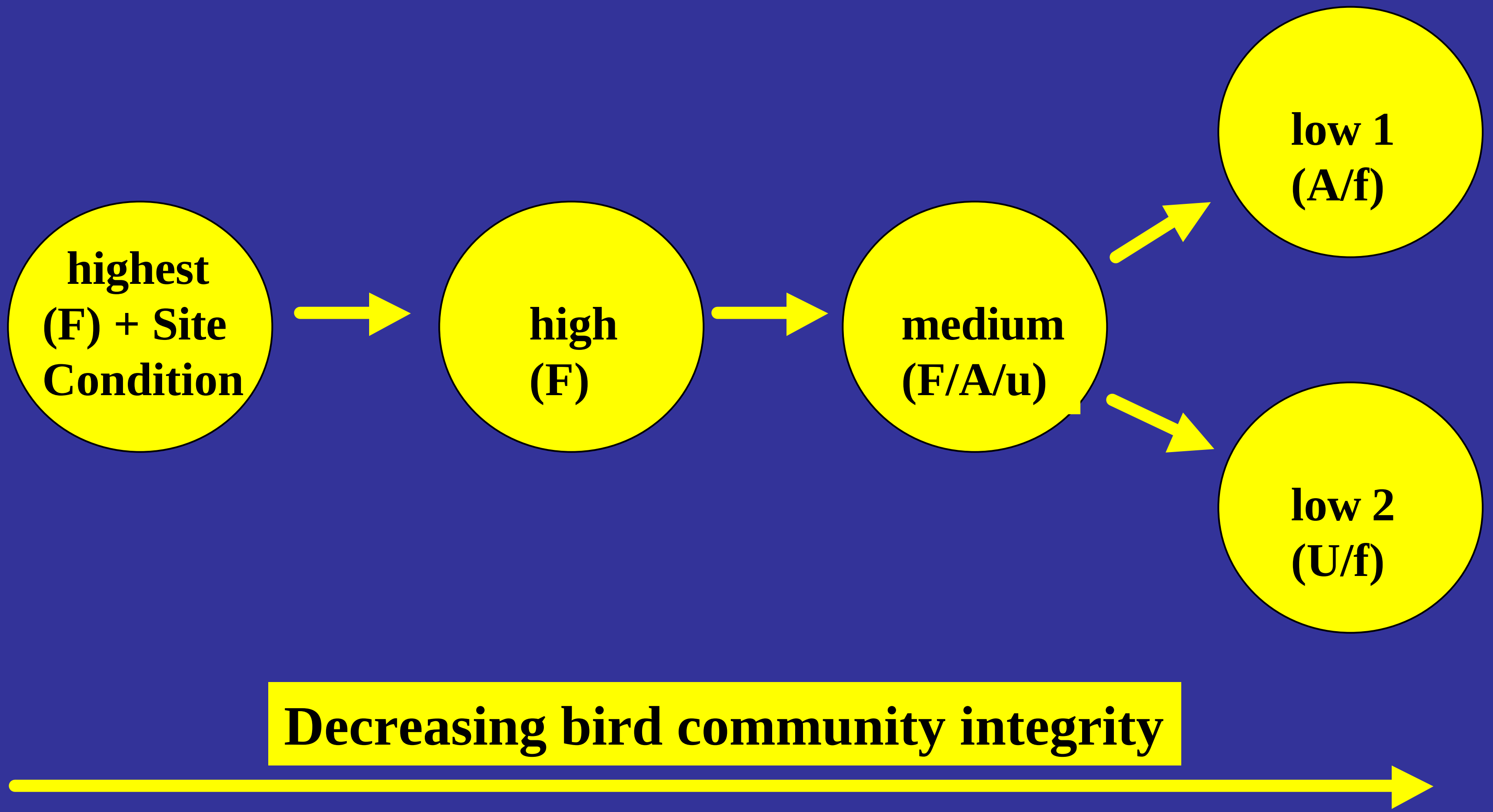


Generalists (A)

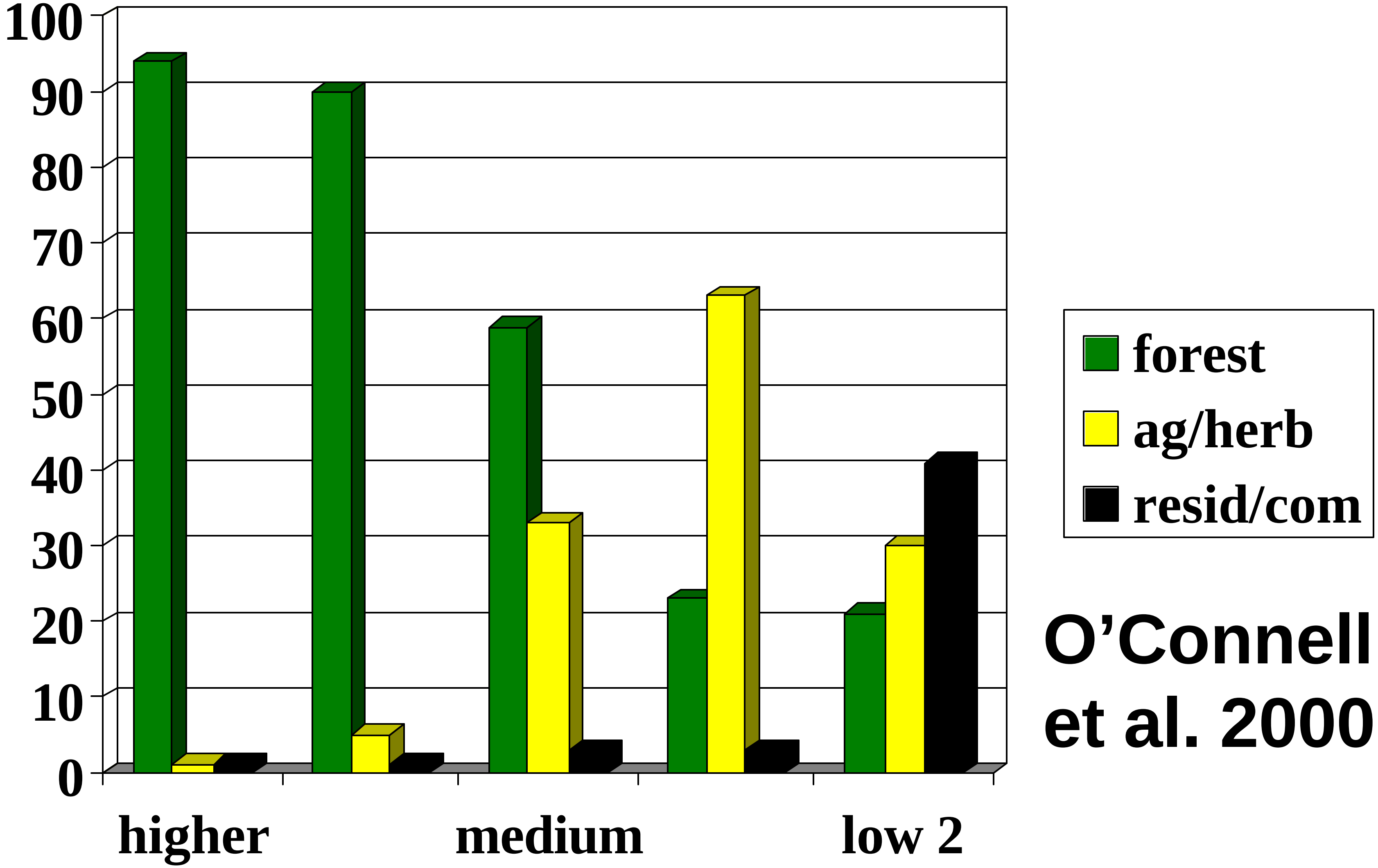


Specialists (B)

Bird Community Integrity



Percent Land Cover Type by BCI Grouping

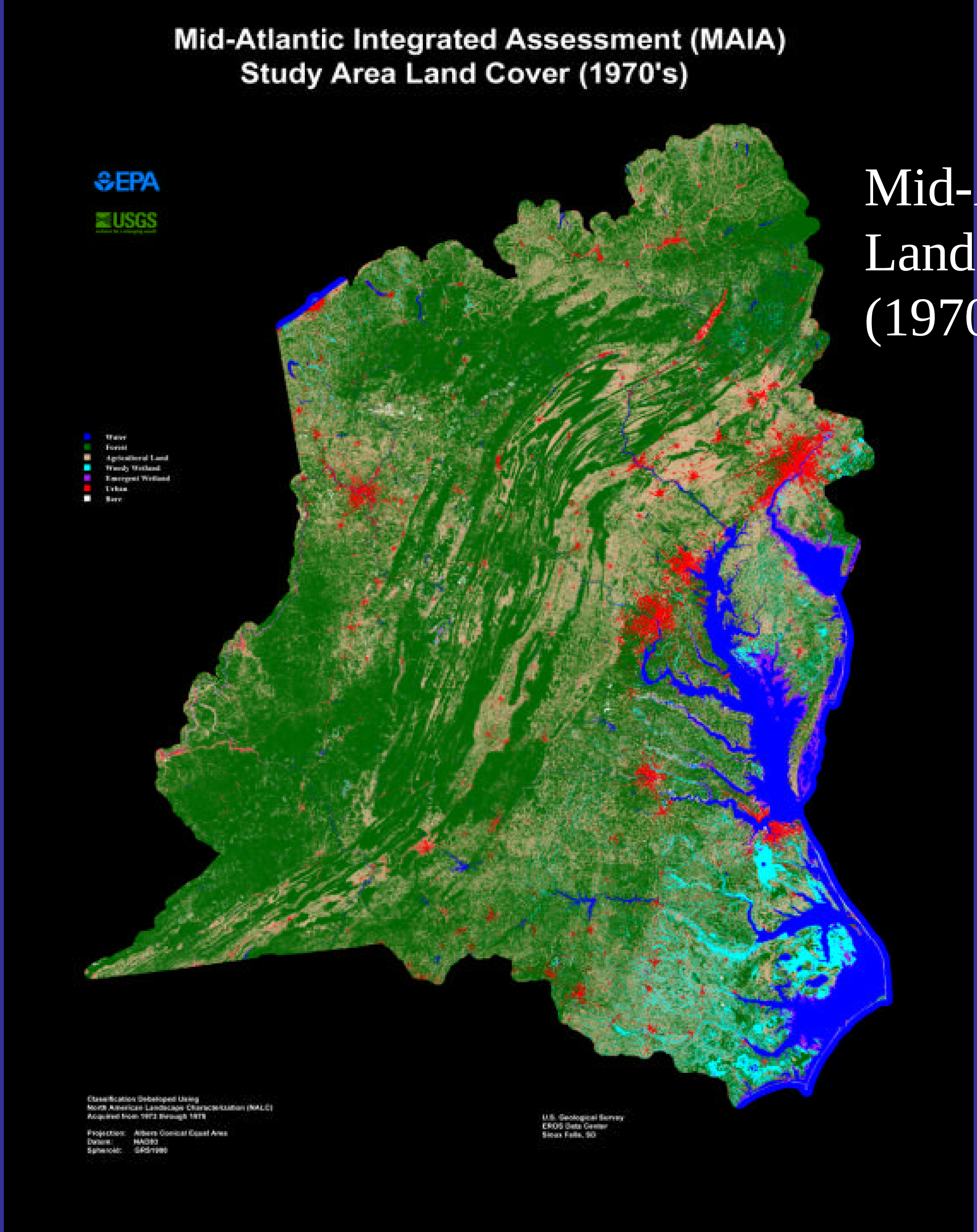


O'Connell et al. 2000

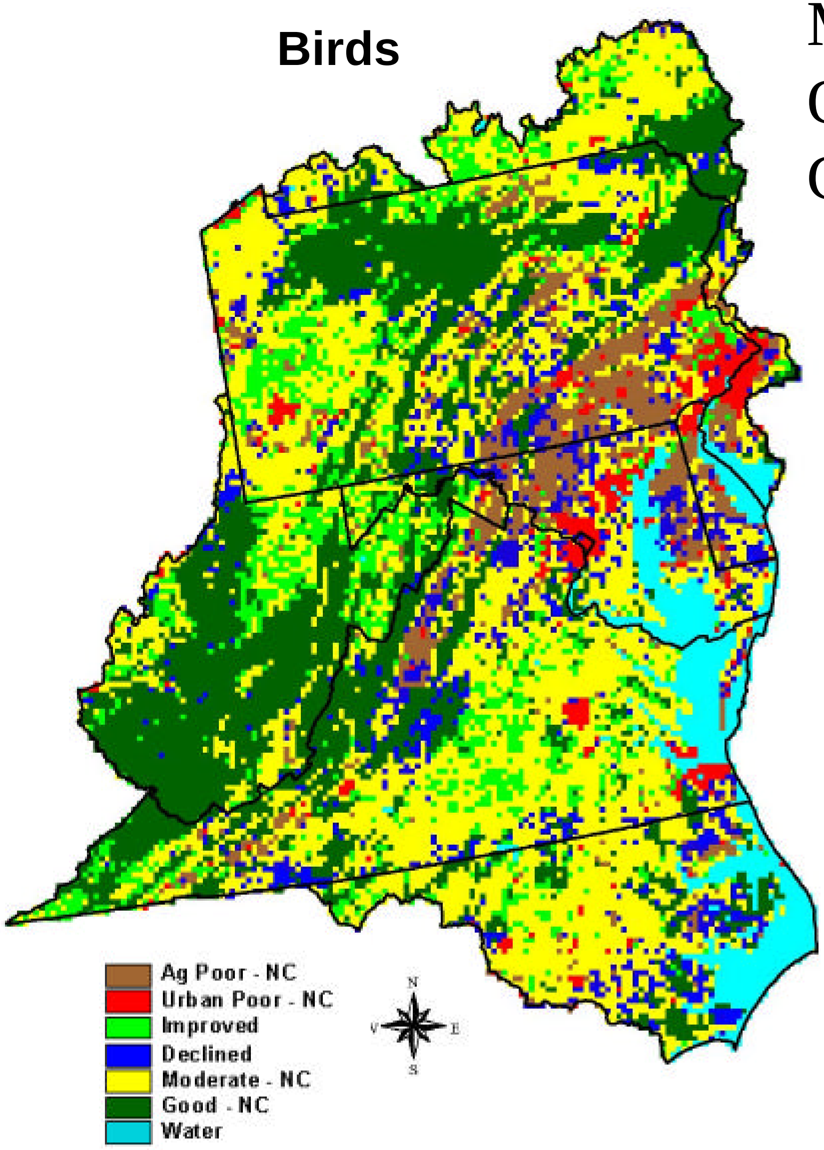
CROSS-VALUE INTEGRATION

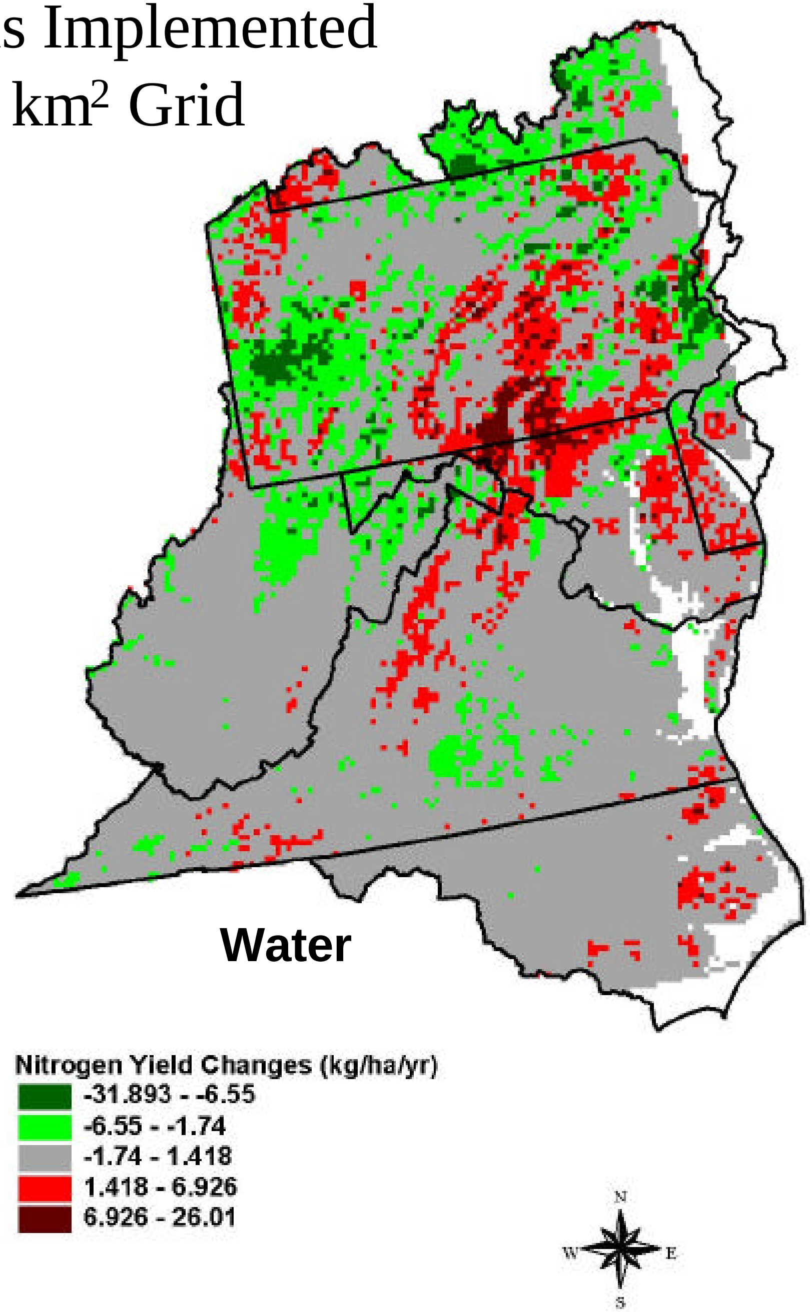
An example related to landscape change

Mid-Atlantic Landscape Change (1970s-1990s)

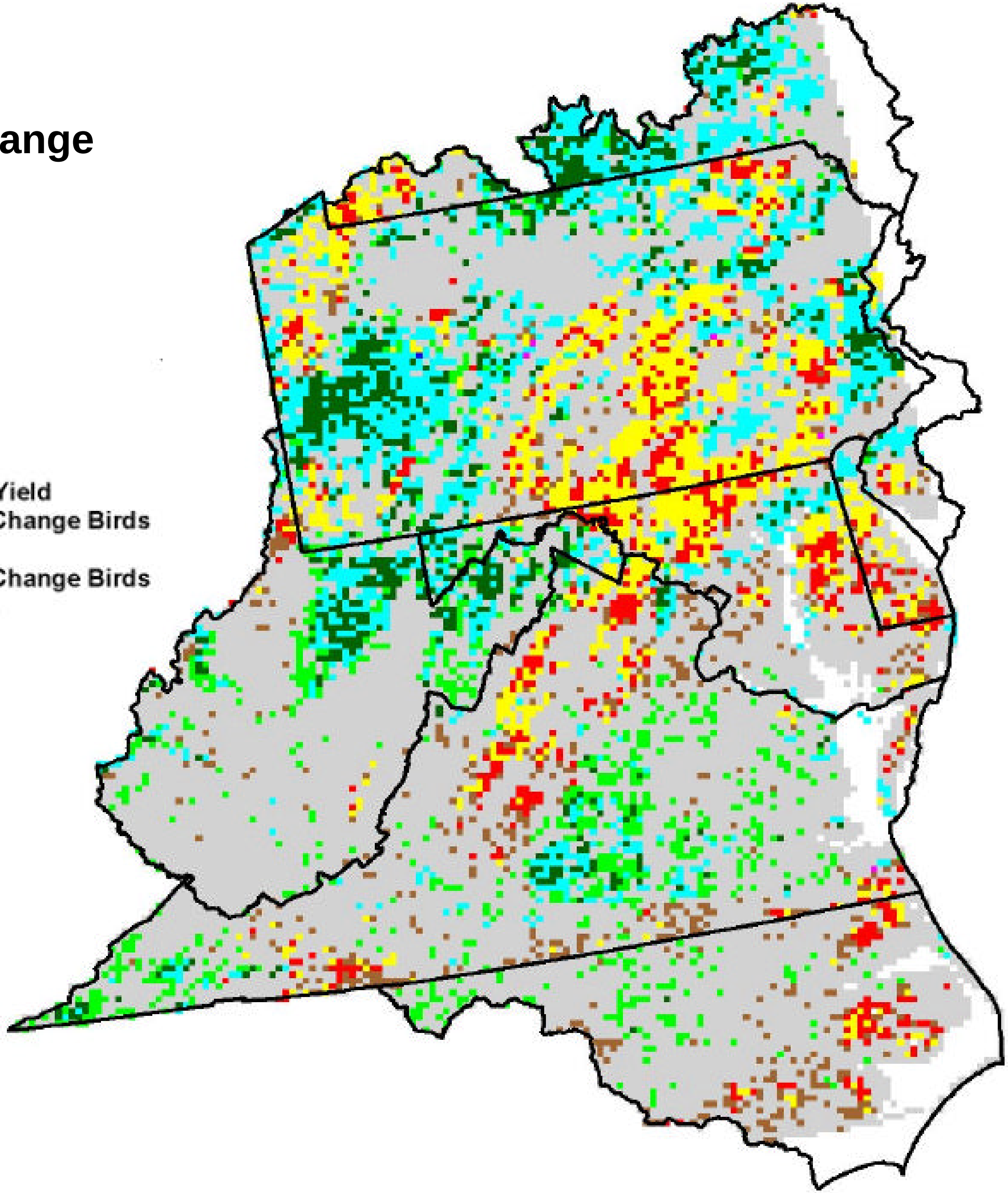


Models Implemented On 25 km^2 Grid Cells



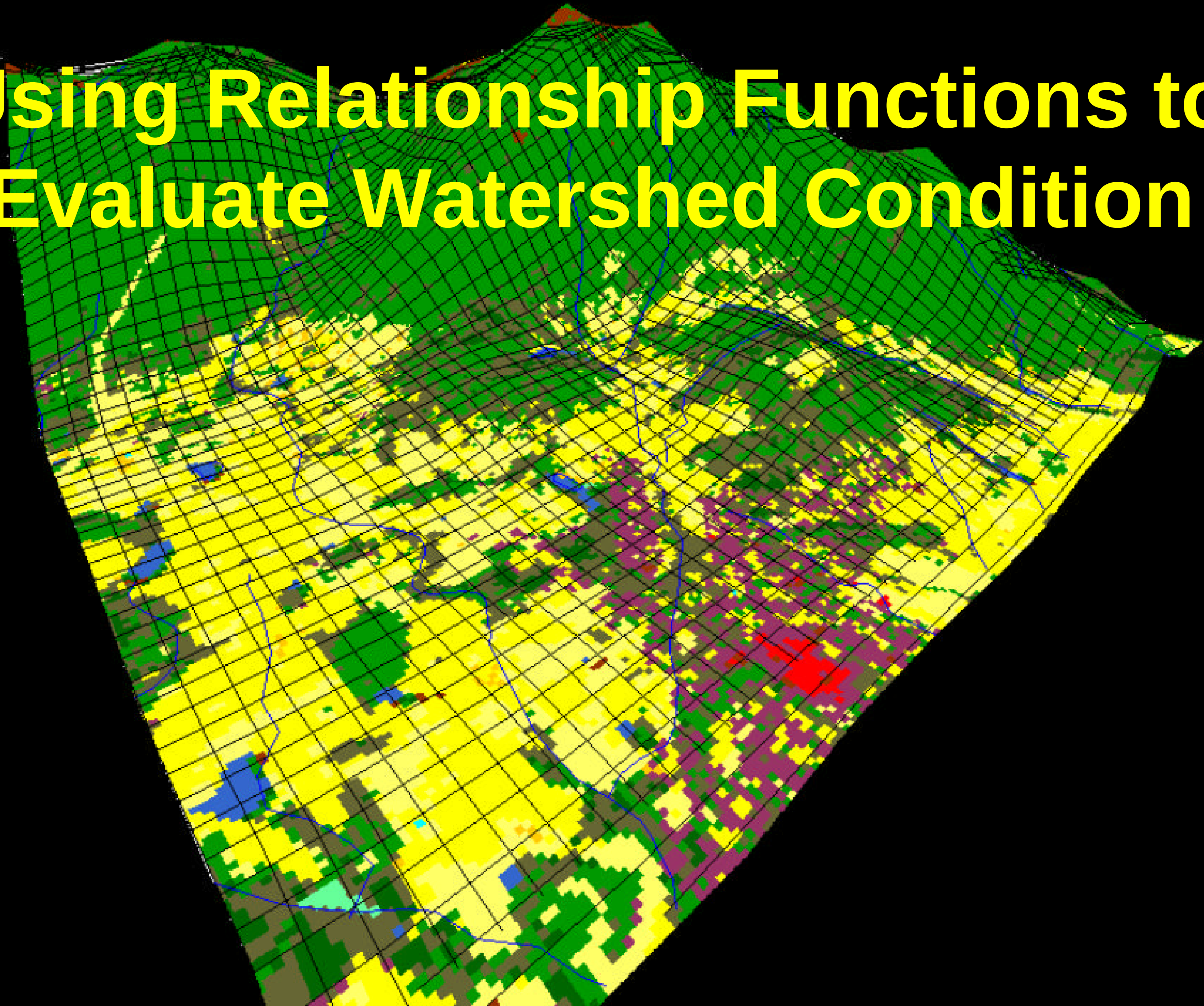


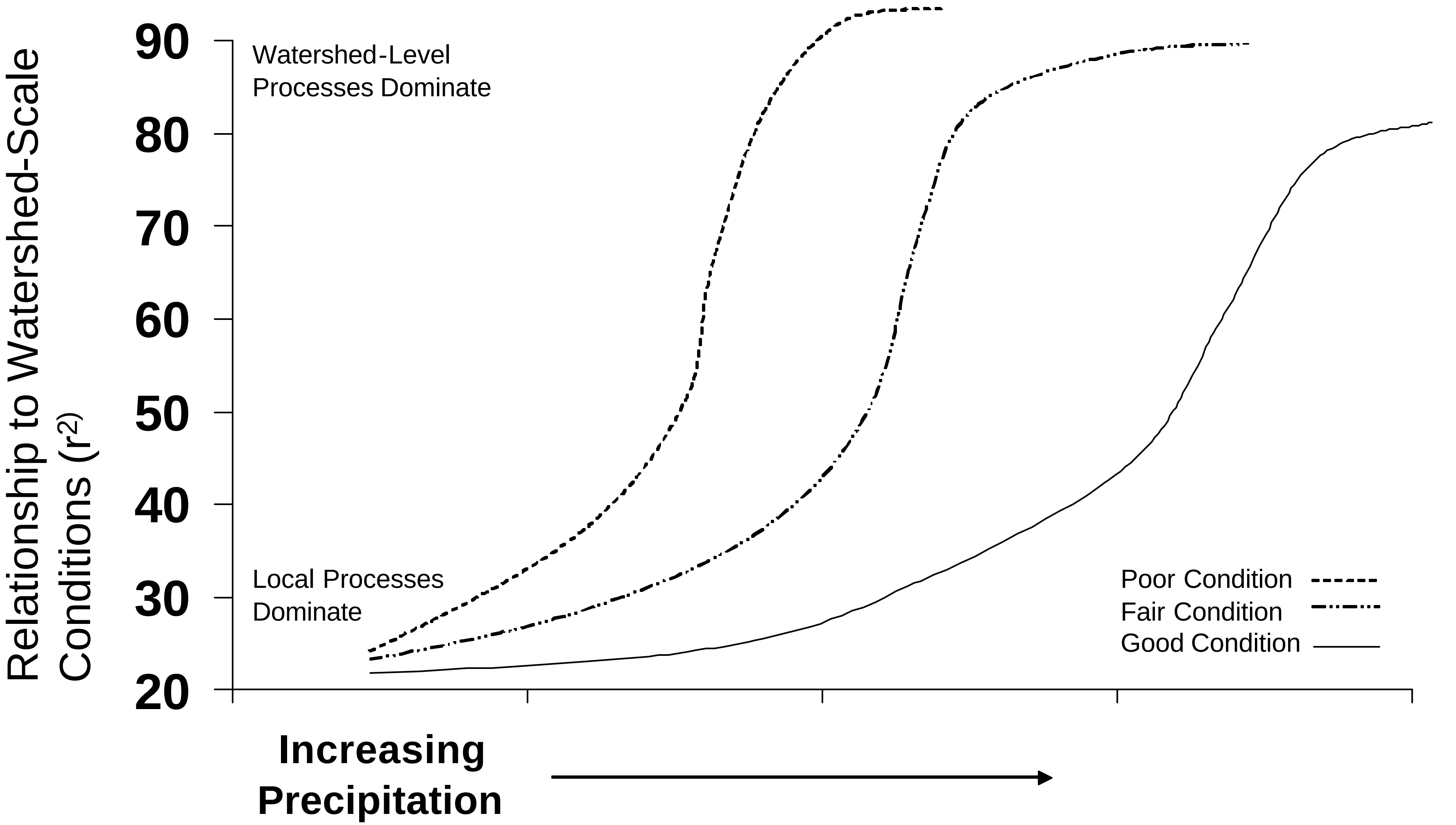
1970s to 1990s Change



25 km² grid cells

Using Relationship Functions to Evaluate Watershed Condition





Relationship to Watershed-Scale Conditions (r^2)
90
80
70
60
50
40
30
20
Watershed-Level Processes Dominate
Local Processes Dominate
Poor Condition
Fair Condition
Good Condition
Increasing Precipitation


The End
THE
LITTLE
RASCALS
.NET