Landscape and Predictive Tools Methods Guidance

NWQMC Conference

April 25-29, 2010

Denver, Colorado USA

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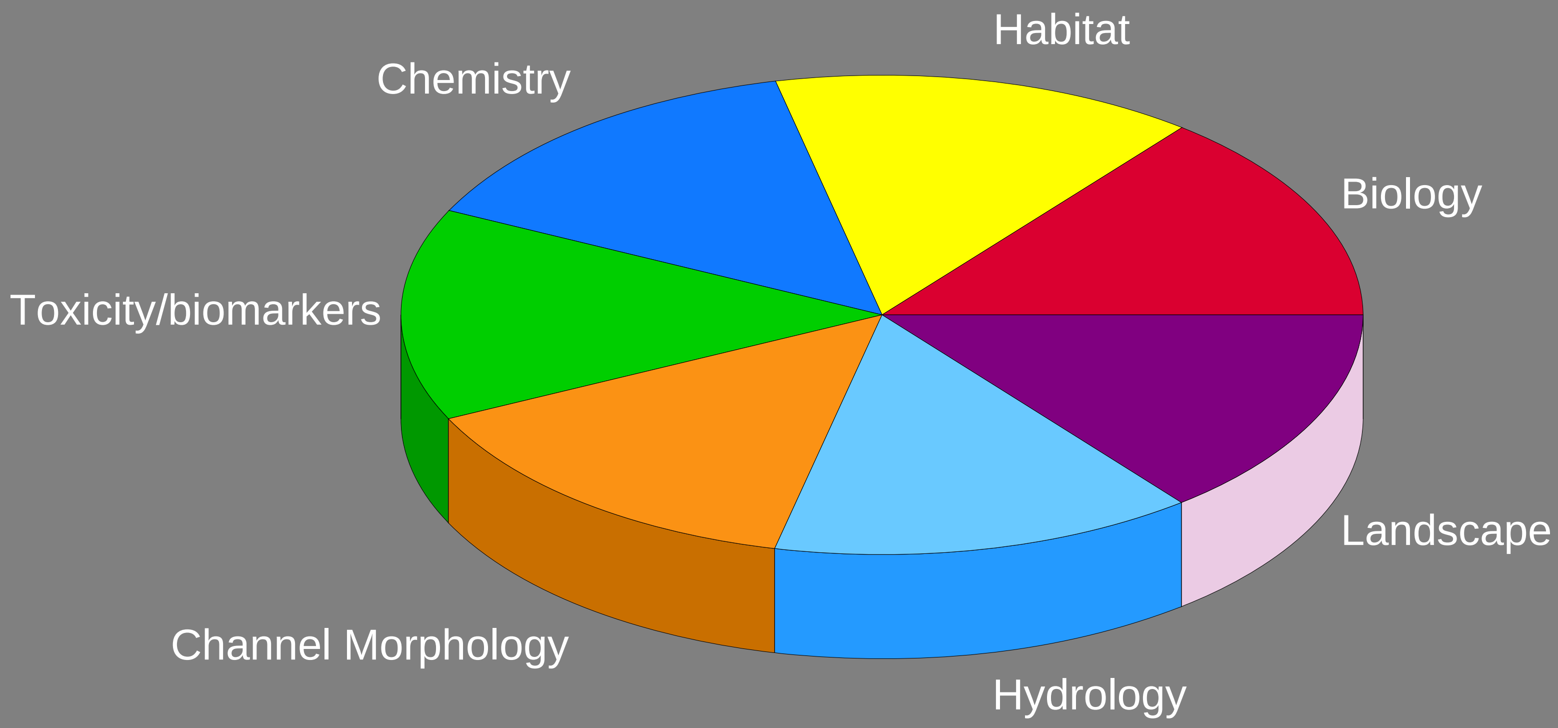
Co-Chair – Landscape and Predictive Tools Steering Committee

Dividing the monitoring pie by technique



Landscape and Predictive Tools Steering Committee

Organized July 2006 – work through meetings and conference calls

Approximately 30 Members Representing:

- EPA Headquarters (OWOW & OST)
- EPA Regions (1, 4, 5, 6, 8 &10)
- EPA ORD (Las Vegas, Corvallis, Cincinnati, Narragansett, RTP)
- States (AL, FL, OR and others)
- Other Agencies (USGS)

Committee Co-Chairs:

- Jim Harrison – EPA Region 4
- Susan Cormier – EPA ORD/Cincinnati
- Ellen Tarquinio – EPA HQ/OWOW
- Don Ebert – EPA ORD/Las Vegas

Mission:

Strengthen and support incorporation of geographic frameworks, and landscape information and tools into Clean Water Act programs

Timeline

2006

Steering Committee formed
Bi-monthly calls
Meeting – Annapolis
Draft Outline developed

2007

Bi-monthly calls continue
Chapter Leads established
1st draft of most Chapters

2008

Bi-monthly calls continue
Writing and Revision Workshop
Region 1 Lab: Boston
Editing and Formatting

2009

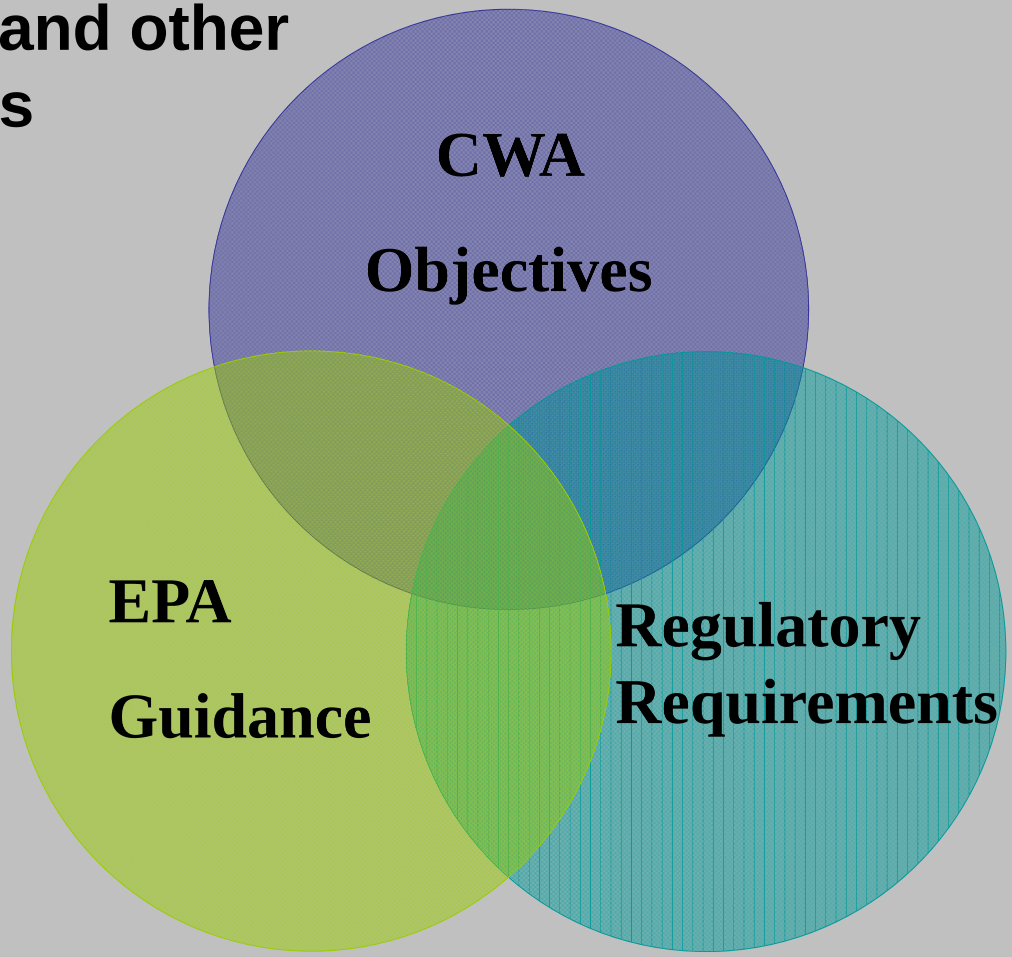
Internal EPA review
Revise for peer review

2010 (Planned)

Peer Review
Revise per peer review comments

Finalize during 2010

Clean Water Act: Monitoring and other Applications



Clean Water Act **Monitoring Objectives**

Establish, review and revise **WQS, TMDL**, and establish **appropriate monitoring methods**. (CWA 303(c), 303(d))

Conduct analyses of the **extent to which all navigable waters attain water quality standards**. (CWA 305(b))

Identify impaired waters. (CWA 303(d)

Determine Abatement and control **priorities** (CWA 402)

Support **implementation of water management programs** (CWA 319, 402, 303, 314)

Evaluate effectiveness of water management programs. (CWA 319, 314, 303, 305, 402) bracket

Regulatory Requirements

40 CFR 130.4

Establish **appropriate methods and procedures** to **monitor the quality of navigable waters and ground waters**

Devices, methods, systems, procedures

- Biological monitoring
- Eutrophic conditions

Compile and analyze data on navigable waters and ground waters

Devices, methods, systems, procedures

- Classification of eutrophic conditions
- Physical, chemical, biological data

Guidance: 10 Elements Document

A. Develop strategy for all water resource types: streams, rivers, lakes, & reservoirs, coastal areas (estuaries), wetlands, groundwater

B. **Monitoring objectives**

C. Monitoring design

D. Core and supplemental water quality indicators

E. Quality assurance

F. Data management

G. Data analysis & assessment

H. Reporting

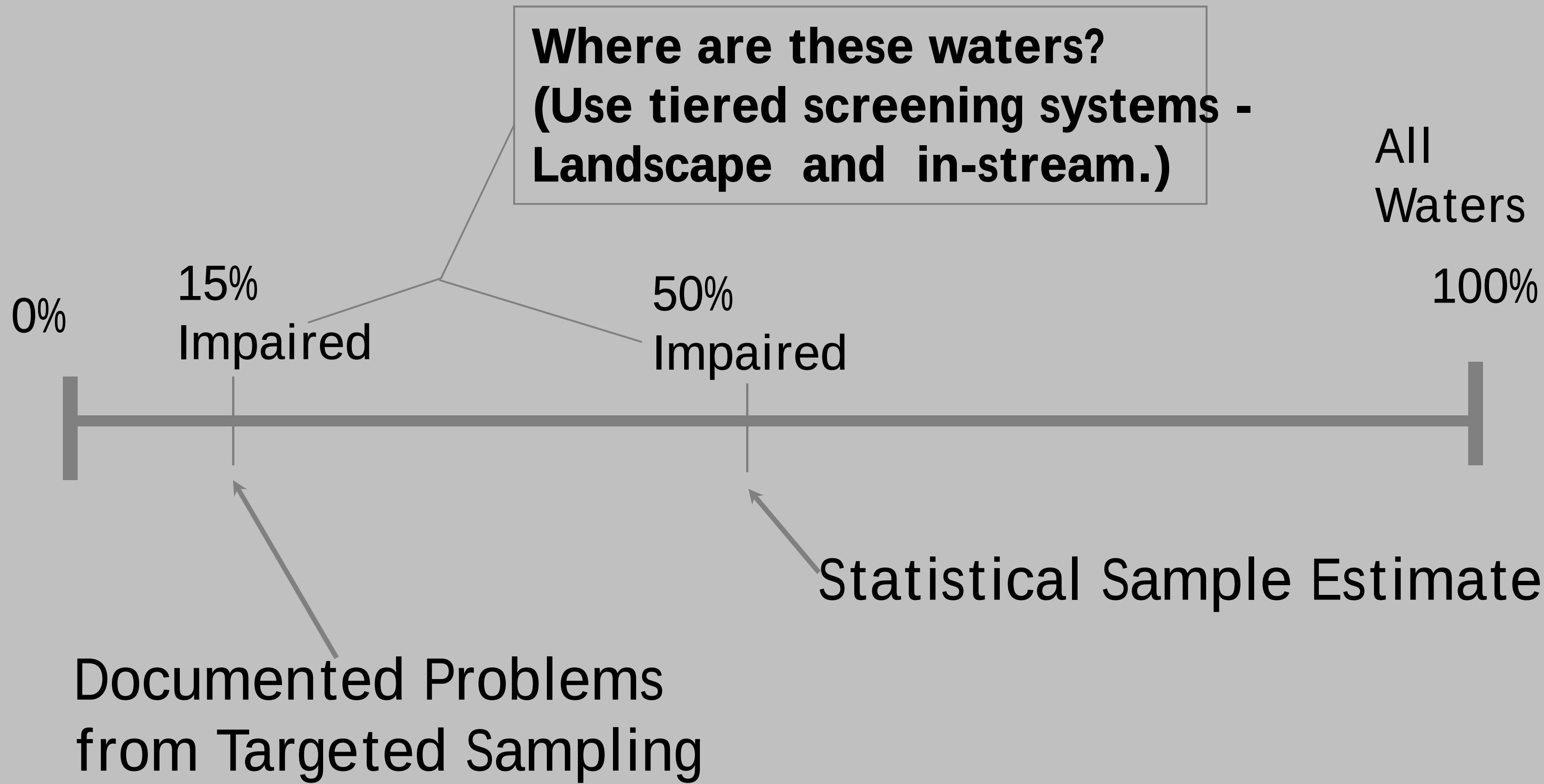
I. Programmatic evaluation

J. General support & infrastructure planning

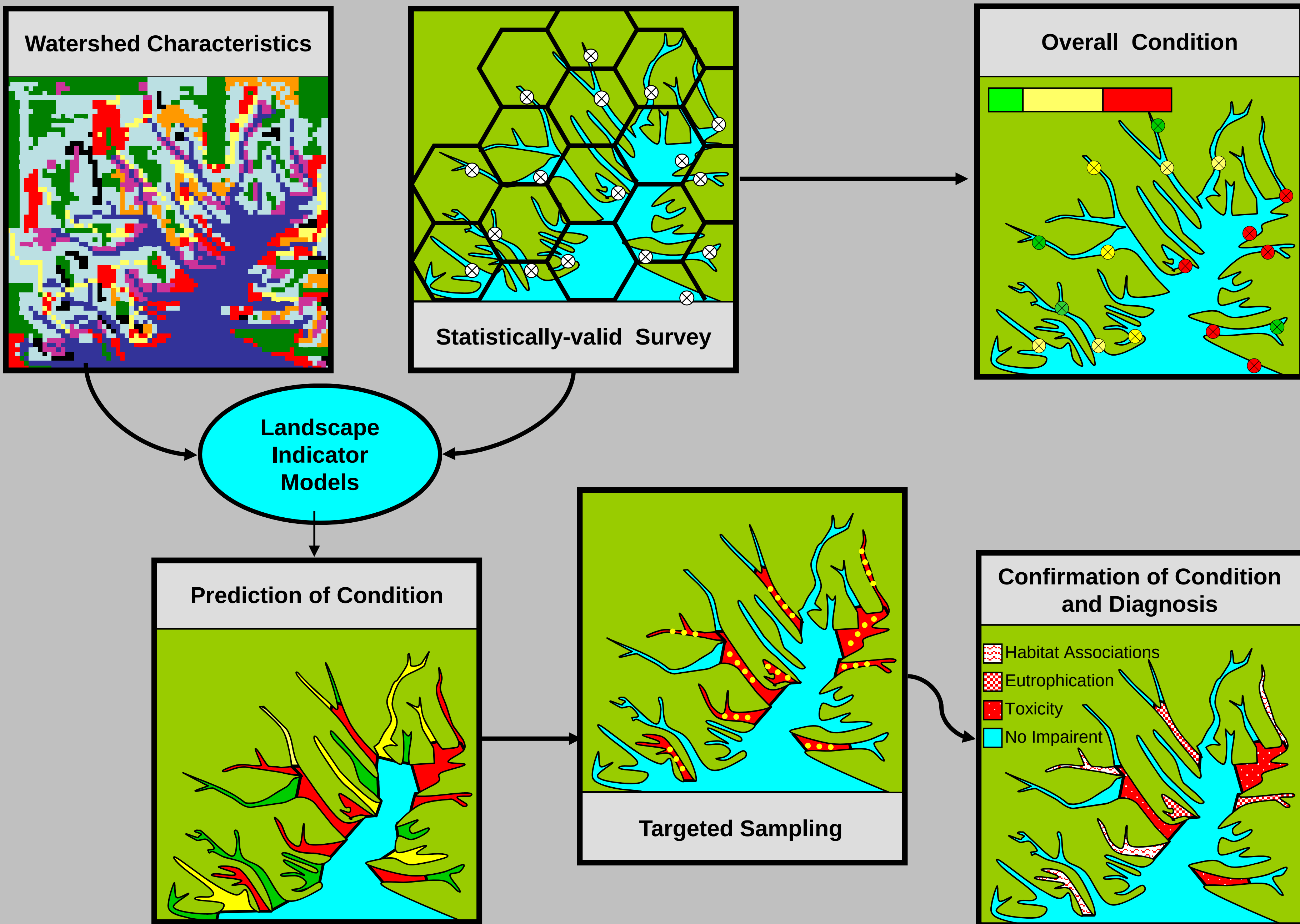
Combination of Tools for Water Monitoring and Assessment Decisions

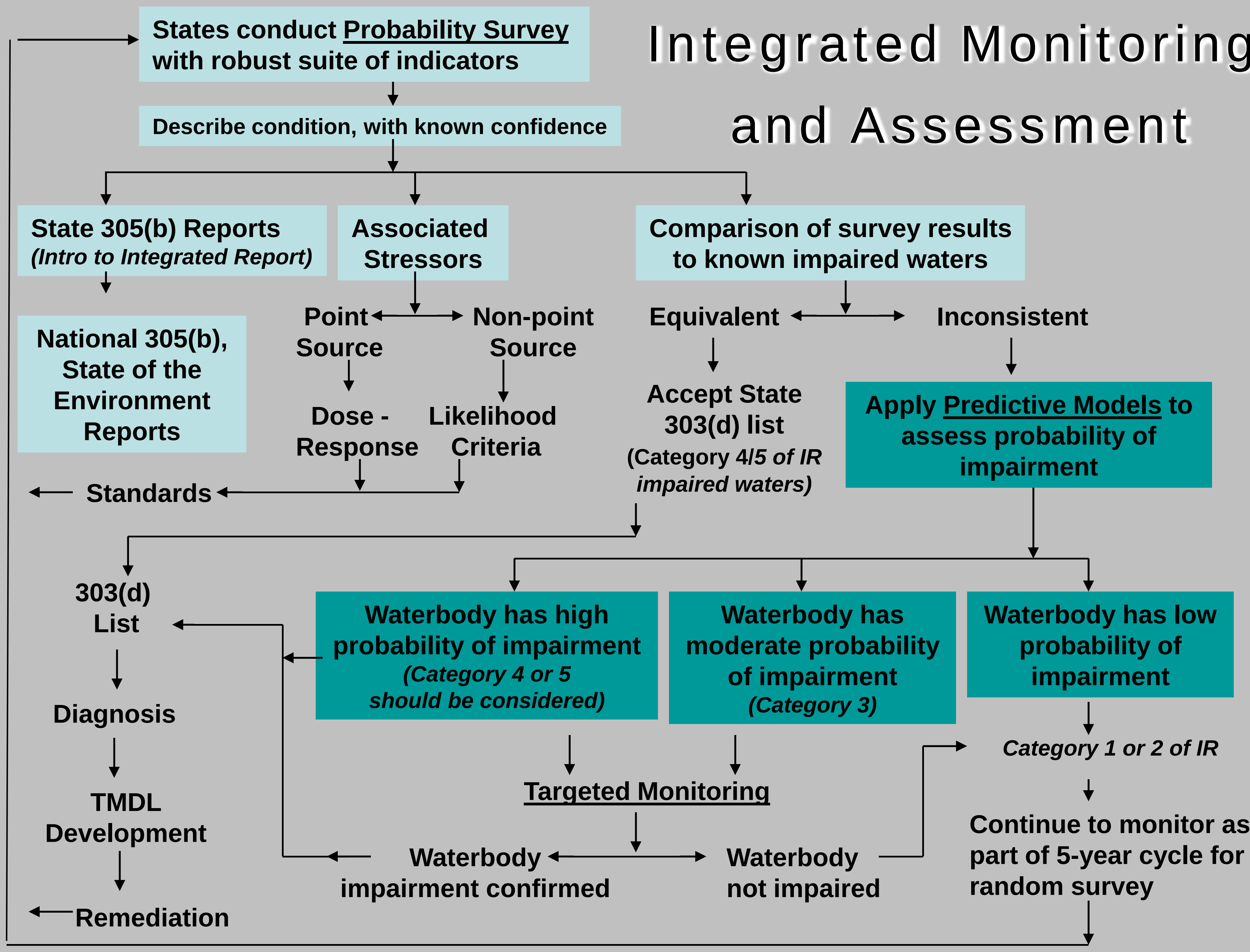
Statistically-valid survey	• Predict proportion of all waters in good or poor condition, with documented confidence • Measure trends in water resource condition and CWA program effectiveness • Support development of new WQS • Prioritize targeted monitoring to specific parameters/stresses
Modeling and landscape analysis	• Determine where water quality is likely impaired • Help identify high quality and reference waters • Predict localized water quality • Prioritize targeted monitoring to specific areas and stresses
Targeted monitoring	• Assess WQS attainment for specific segments • Measure trends at specific sites • Identify sources of pollutants to specific waters • Support development of local management measures (TMDL, NPDES permits, NPS BMPs, WQS) • Assess performance of individual measures

Need for Predictive Screening Systems to Identify Problems



Streamlined Monitoring – Using the Tools Together




Integrated Monitoring and Assessment
States conduct Probability Survey with robust suite of indicators
Describe condition, with known confidence
State 305(b) Reports
(Intro to Integrated Report)
Associated Stressors
Comparison of survey results to known impaired waters
National 305(b), State of the Environment Reports
Point Source
Non-point Source
Equivalent
Inconsistent
Dose - Response
Likelihood Criteria
Accept State 303(d) list
(Category 4/5 of IR impaired waters)
Apply Predictive Models to assess probability of impairment
Standards
303(d) List
Waterbody has high probability of impairment
(Category 4 or 5 should be considered)
Waterbody has moderate probability of impairment
(Category 3)
Waterbody has low probability of impairment
Diagnosis
Category 1 or 2 of IR
Targeted Monitoring
TMDL Development
Continue to monitor as part of 5-year cycle for random survey
Waterbody impairment confirmed
Waterbody not impaired
Remediation

Spectrum of Uses for Landscape and Predictive Tools

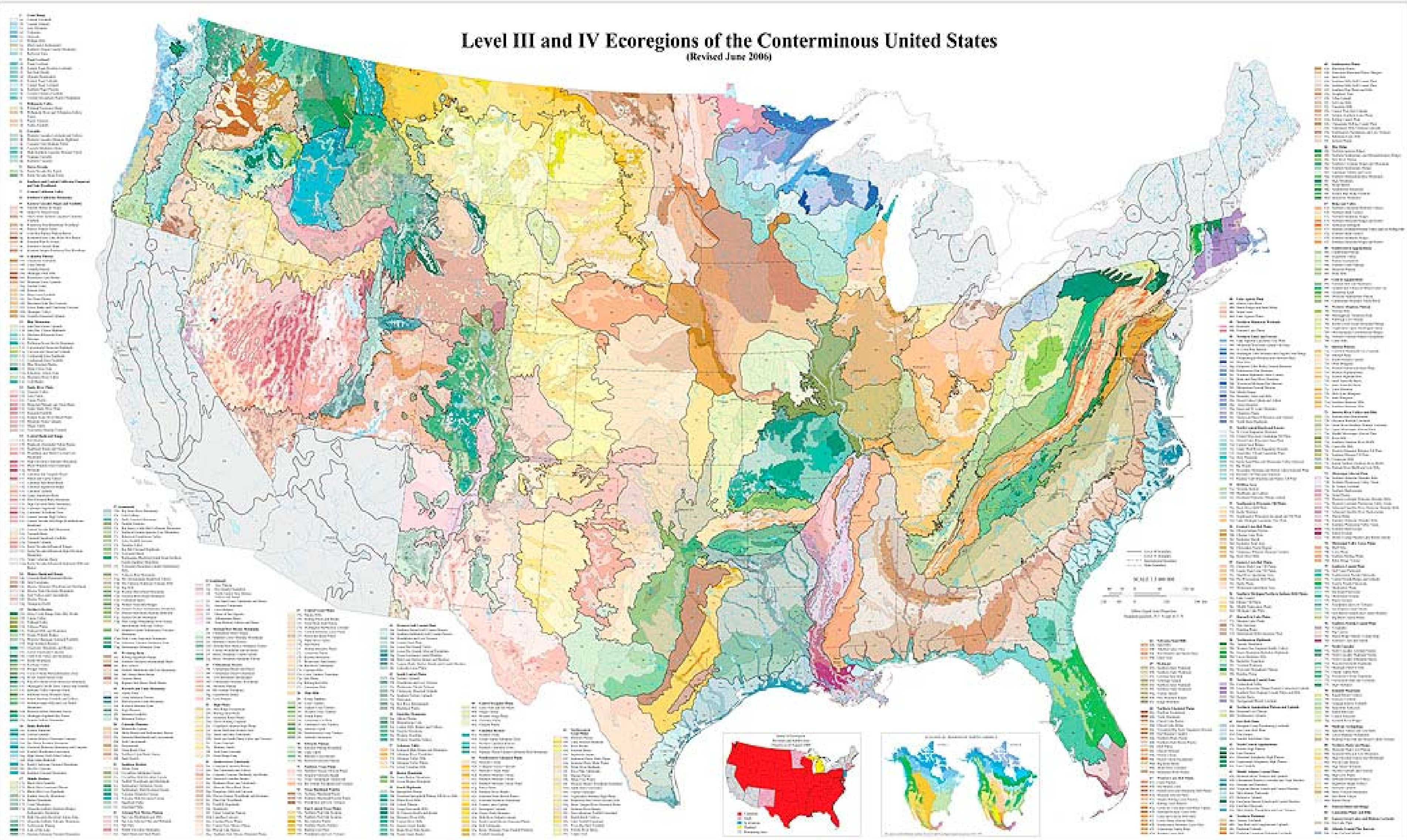
Purpose	***Uses***
Criteria and Standards Development	Identify candidate reference (minimally disturbed, least disturbed) areas Calibrate reference condition at state, multi-state, and national scales Calibrate biological and other condition measures Develop more protective predictive models of biota & biocriteria Define & document human disturbance gradients for Tiered Aquatic Life Uses (TALU) and other purposes
Problem Identification and Prevention	Extrapolate condition estimates to waters lacking in-situ data Identify suspected problem areas Target monitoring to assess likely problems Estimate vulnerability to stress(es) Target areas for prevention or protection
Prioritization and Targeting of Rehabilitation	Assist stressor identification & diagnosis Identify causes and sources Prioritize TMDL and rehabilitation or regulatory efforts Prioritize waters for delisting efforts Estimate recovery potential and target rehabilitation actions
Science, Education and Management	Evaluate landscape stresses and problem causes (pressures) for large areas Assess relative influence of different stresses/pressures and scales (site, watershed/catchment) Relate human disturbance to effects occurring in water bodies (rivers, lakes, wetlands, estuaries) Raise awareness of consequences of local land decisions

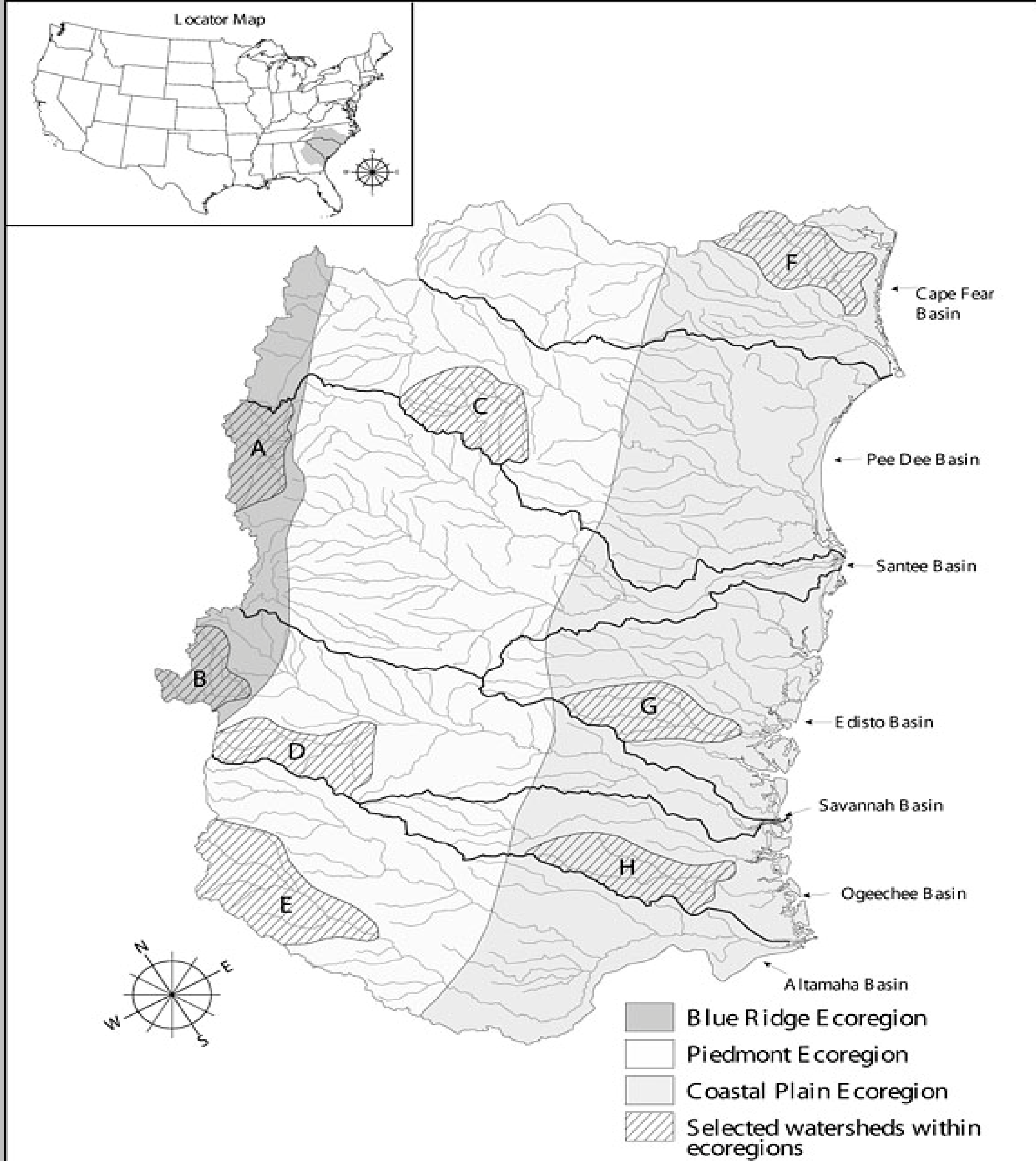
Preliminary Analysis Steps and Factors

Preliminary Analysis Steps	*Factors to Consider*
Problems/questions (See Slide 17: Spectrum of Uses for Landscape and Predictive Tools)	Criteria and Standards Development Problem Identification and Prevention Prioritization and Targeting of Rehabilitation Science, Education and Management
Areas of interest	Scales Geographic Frameworks Appropriate areas for analysis and extrapolation
Pressure/stress/response parameters of interest	Landscape Habitat/channel/geomorphology Chemistry Hydrology Biology Others
Available data	Geographic Frameworks/Classifications Landscape Ambient stress/response - Gradient of sites covering full range of stress(es) - Probability survey data: biological response and stressors - Before/After and Control/Impact (BACI) designs
Data quality objectives	Are existing data sufficient to answer questions with required power?
Exploratory analysis	Simple GIS & statistical approaches Describe stress and response gradients Derive simple stress/response relationships (if needed/possible)
Evaluate results	Identify gaps Plan next steps

Spatial Scales and Geographic Frameworks

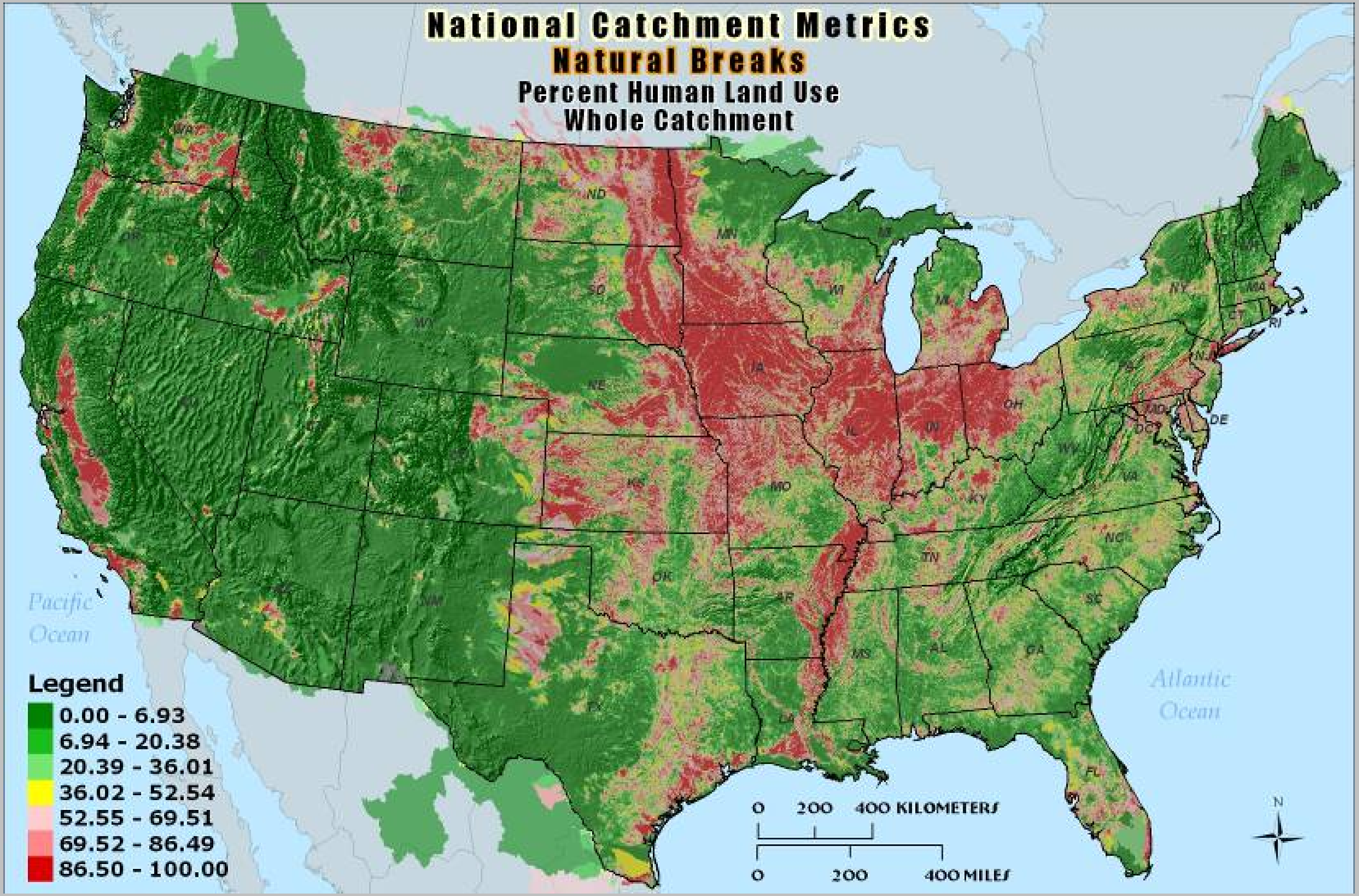
- Ecoregions (levels 4, 3 and 2)
- Watersheds (catchments, 14, 12, 11, 10 & 8 digit HUC’s)
- Hydrologic Landscapes
- Political and other boundaries (city, county, regions, state, EPA region, nation)


Level III and IV Ecoregions of the Conterminous United States
(Revised June 2006)


Locator Map
A
B
C
D
E
F
G
H
Cape Fear Basin
Pee Dee Basin
Santee Basin
Edisto Basin
Savannah Basin
Ogeechee Basin
Altamaha Basin
N
E
S
W
Blue Ridge Ecoregion
Piedmont Ecoregion
Coastal Plain Ecoregion
Selected watersheds within ecoregions

Resolutions of Landscape and In-Situ Data (examples)

- MODIS ~ 1 hectare
- Landsat ~ 30 meters (NLCD 1993 & 2000)
- SPOT ~ <10 meters
- Air Photo ~ <3 meters
- In-situ measurements such as channel, riparian and habitat factors (usually point or reach)
- Classifications, continuous and “direct” remote sensed data (chl a, temp, lidar, etc.)

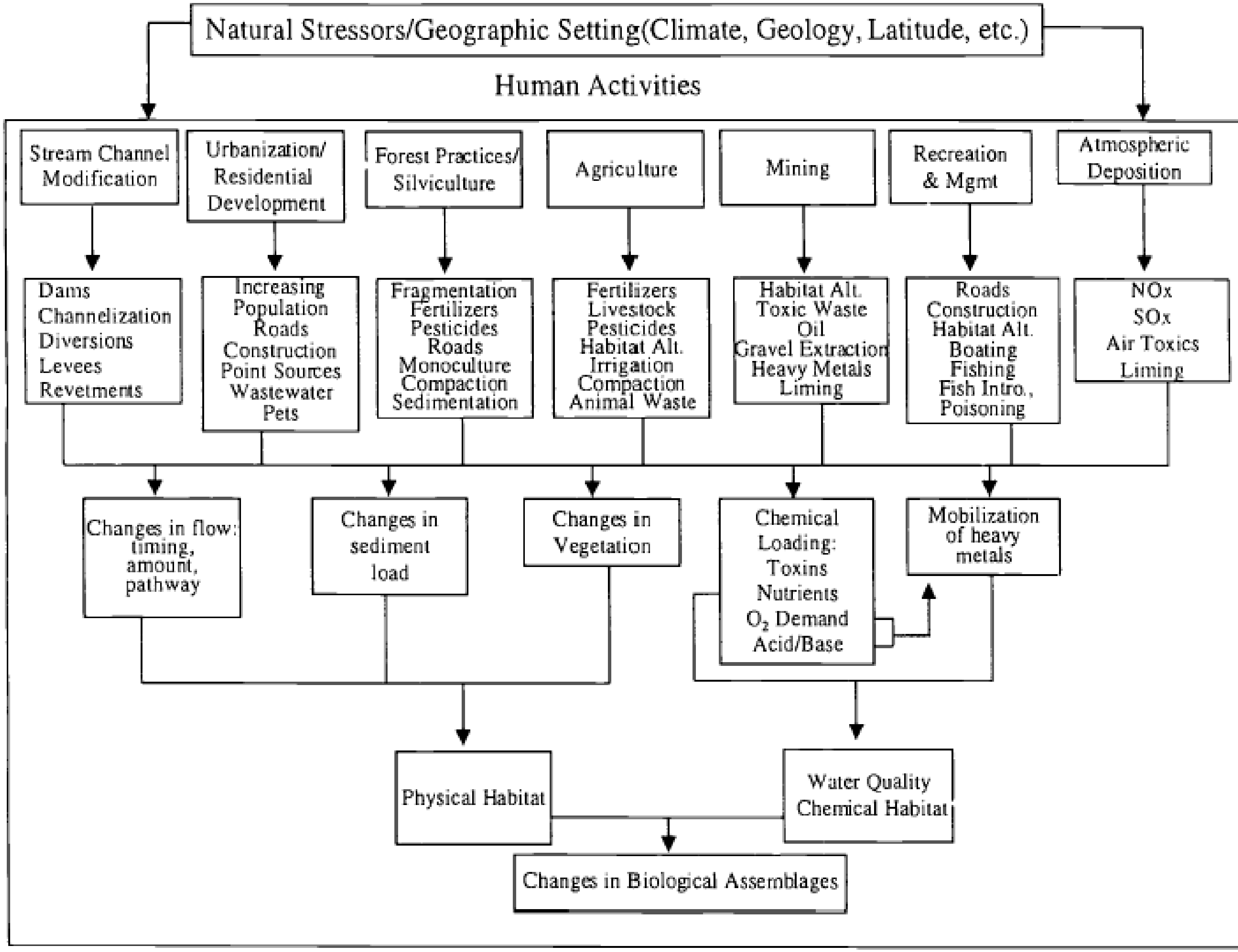

National Catchment Metrics
Natural Breaks
Percent Human Land Use
Whole Catchment
Pacific Ocean
Atlantic Ocean
Legend
0.00 - 6.93
6.94 - 20.38
20.39 - 36.01
36.02 - 52.54
52.55 - 69.51
69.52 - 86.49
86.50 - 100.00
0 200 400 KILOMETERS
0 200 400 MILES
N
DE

Parameters/stresses

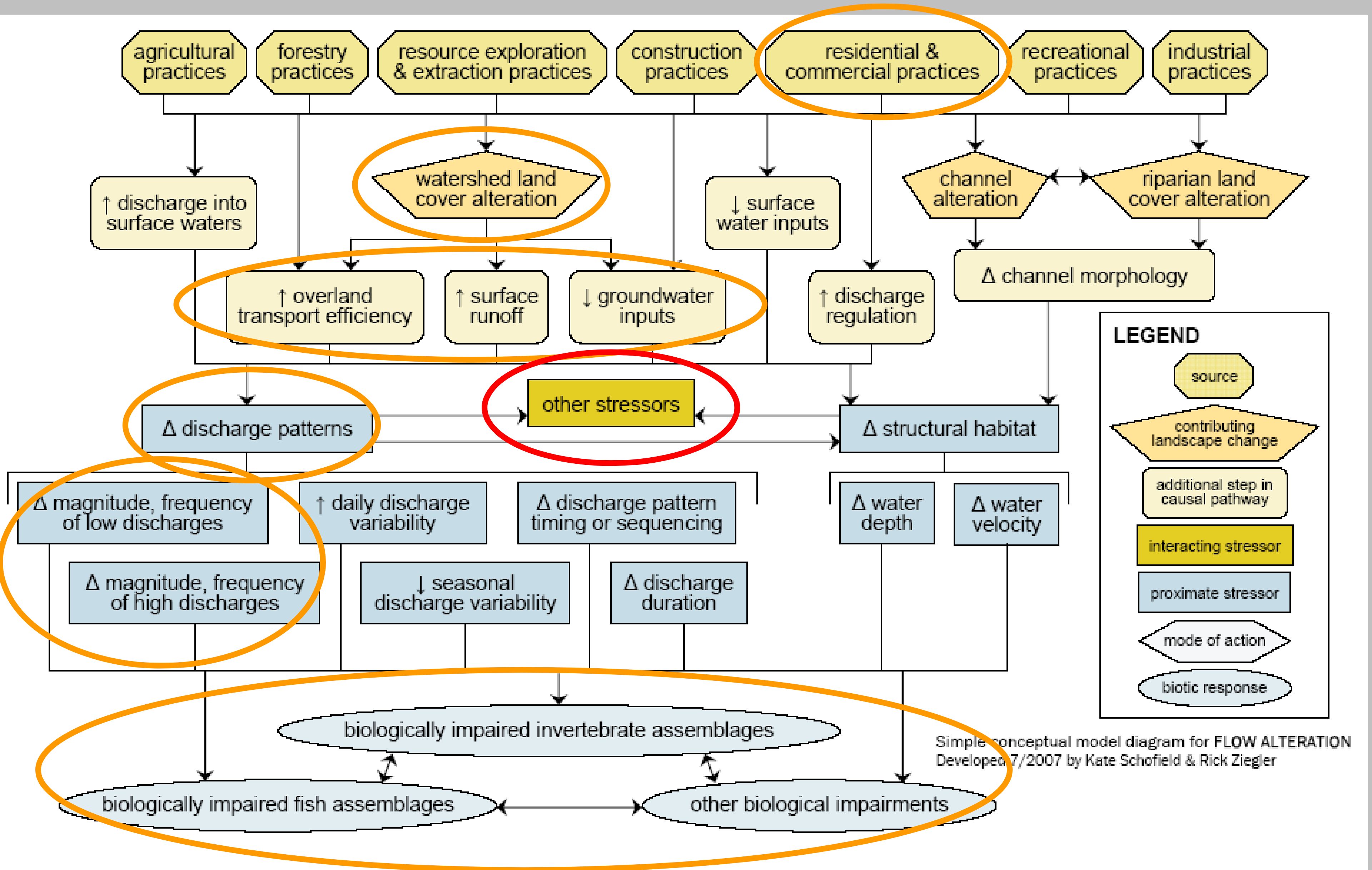
- Nutrients
- Sediment
- Bacteria
- Imperviousness/hydrology
- Riparian/habitat/large wood/channel
- Chemicals/biocides/etc
- Others

Conceptual Models

Bryce, Larsen, Hughes, and Kaufmann



Flow Conceptual Model



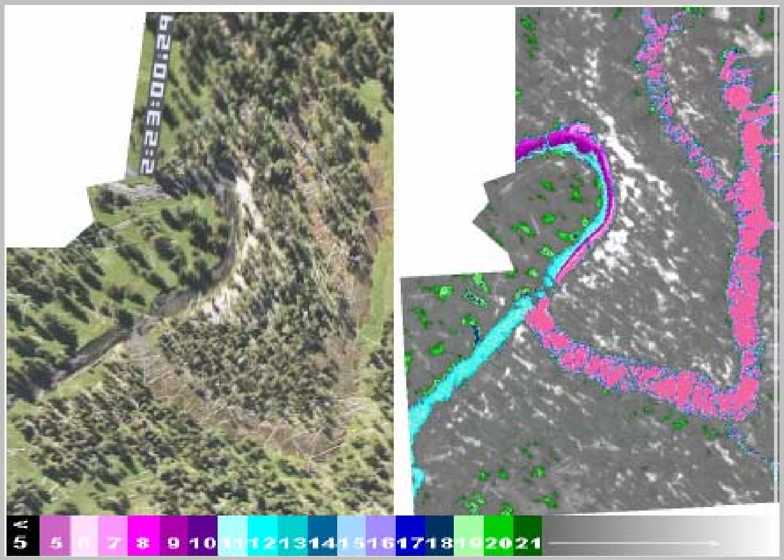
Data and analysis methods for one, many and “all” stresses

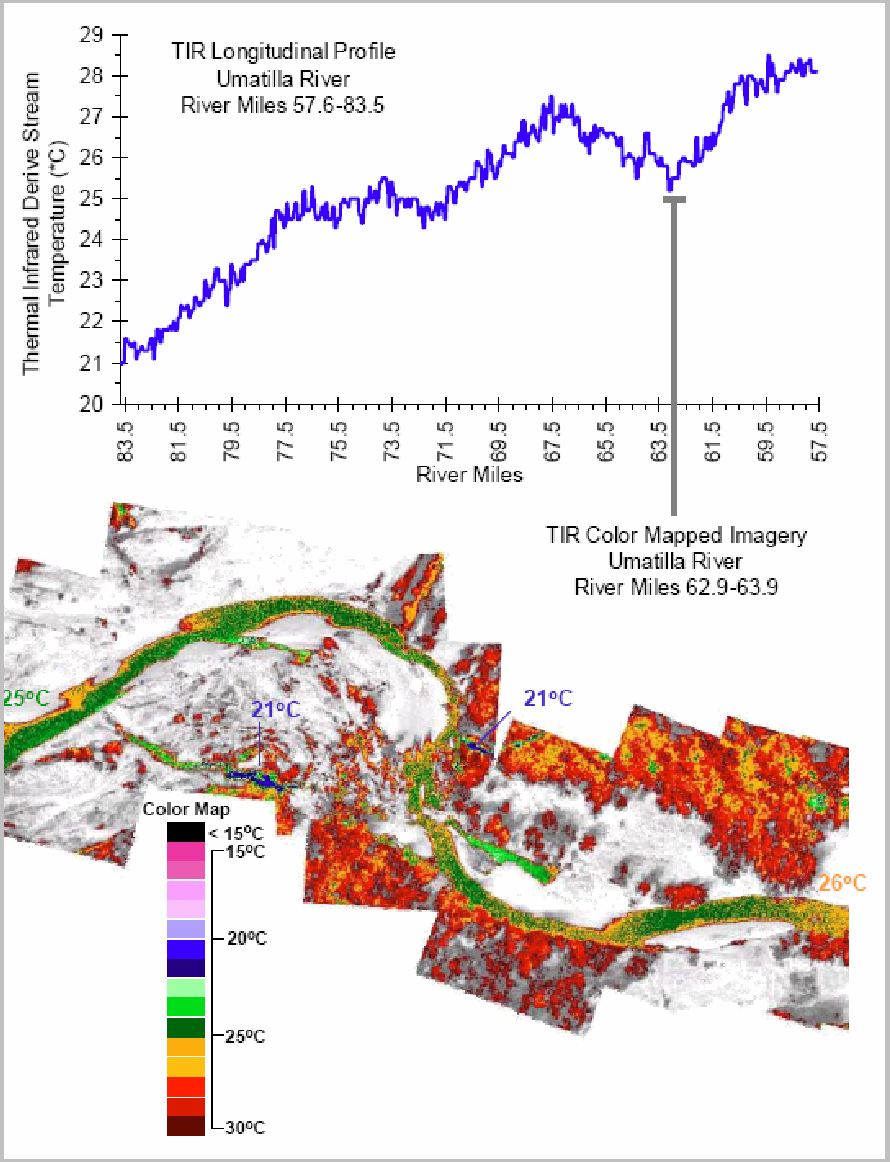
- Single predominant stress (descriptive/relative risk, simple regression)
- Multiple factors (empirical/multiple regression)
- Multiple factors (multivariate/process models)
- “Universal” stress measures (LDI, U-Index, N-Index, etc.)

Case Study/Example Highlights

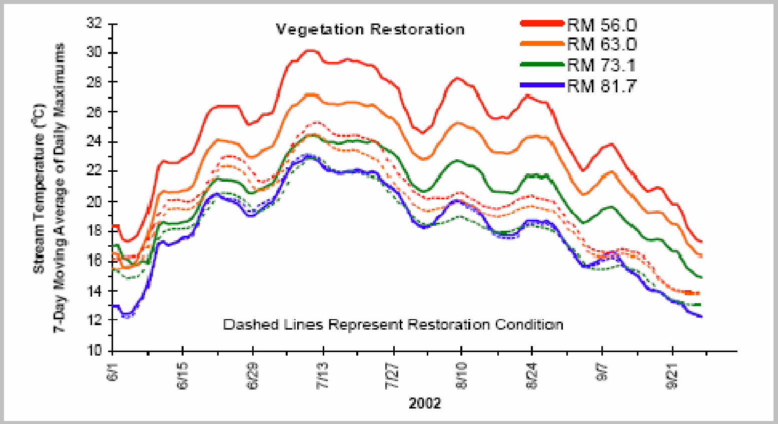
Temperature

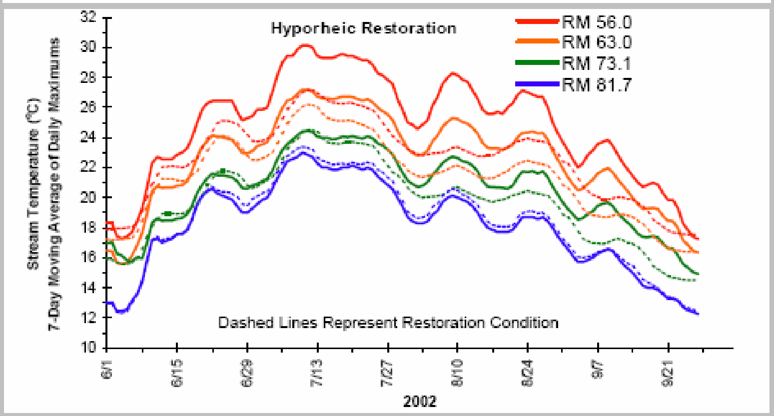
Thermal Infrared Derived Temperatures

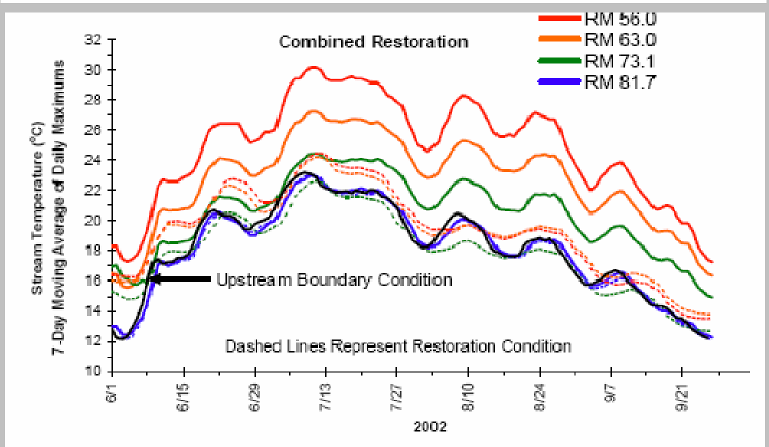


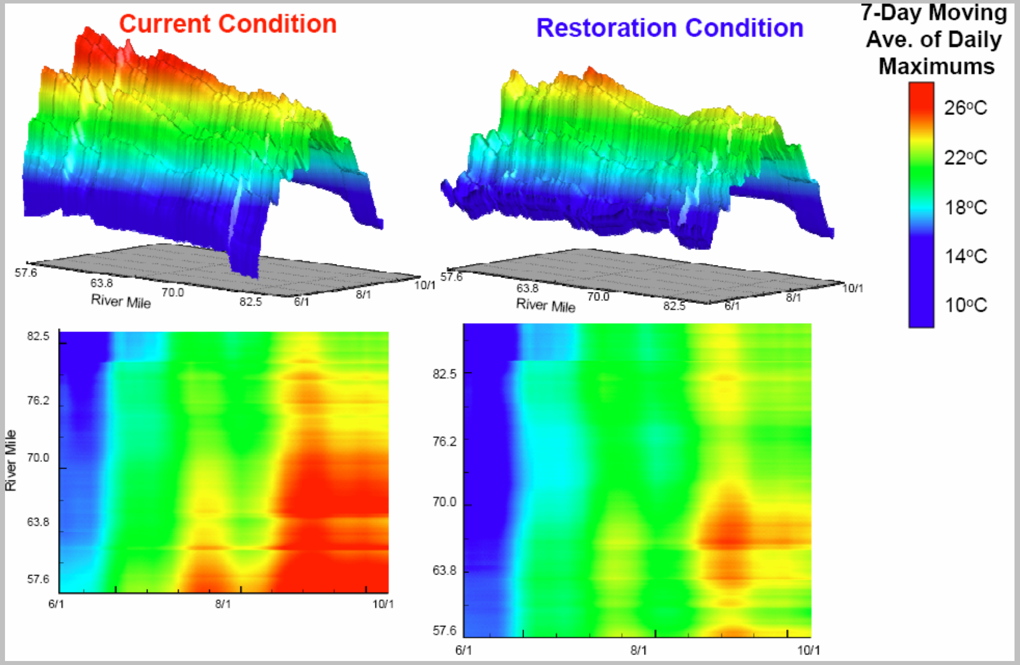


Temperature Restoration Modeling

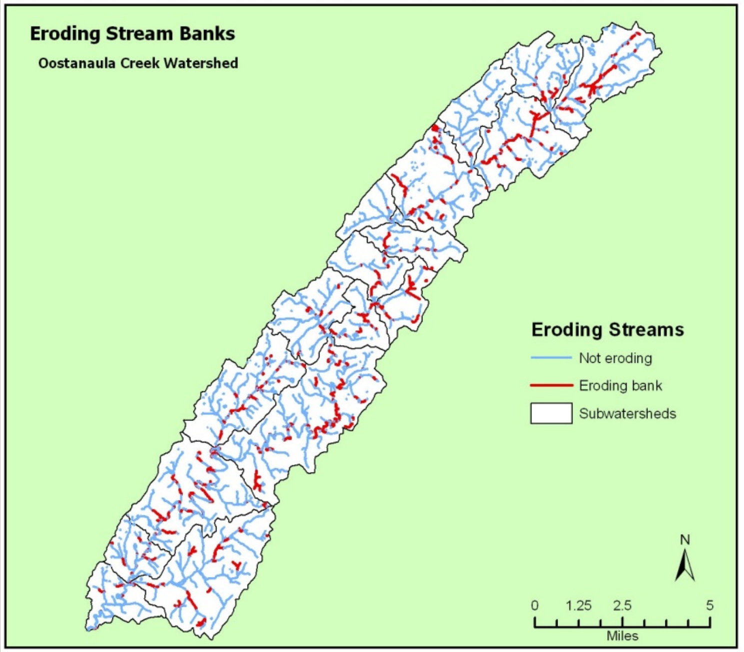


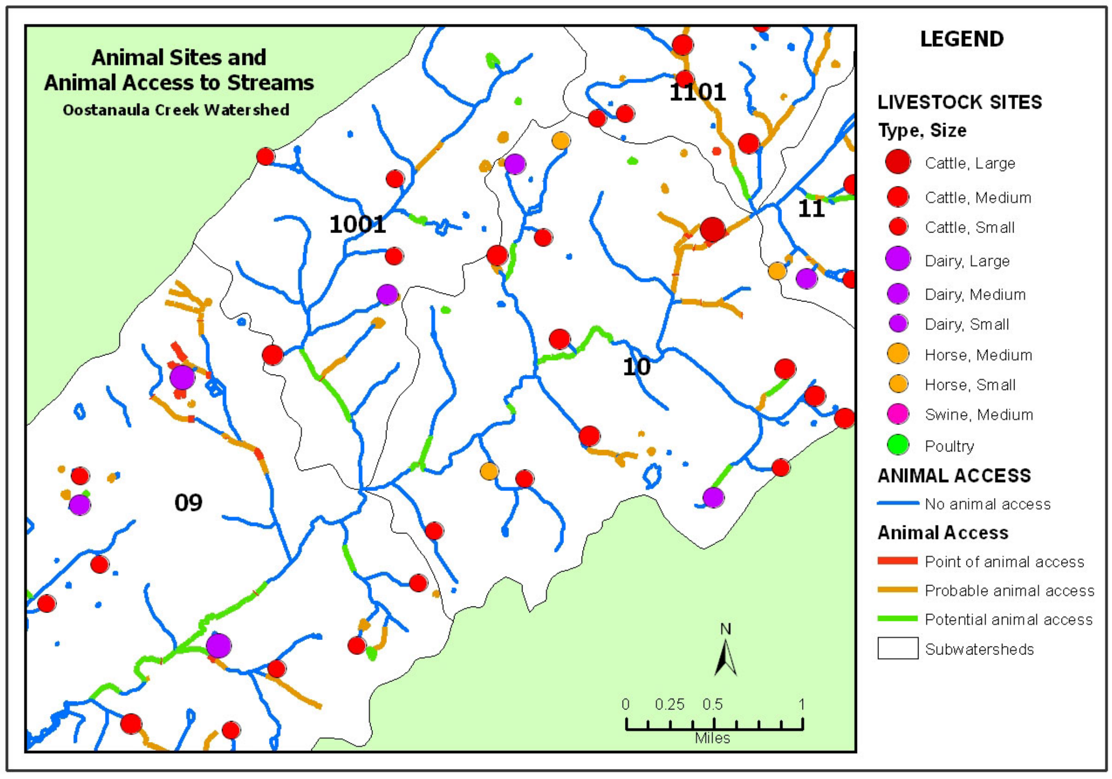




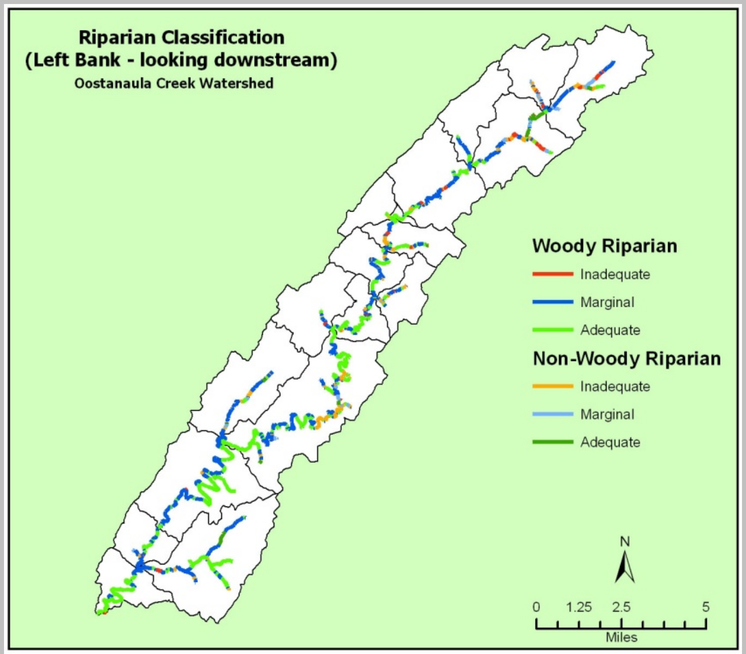


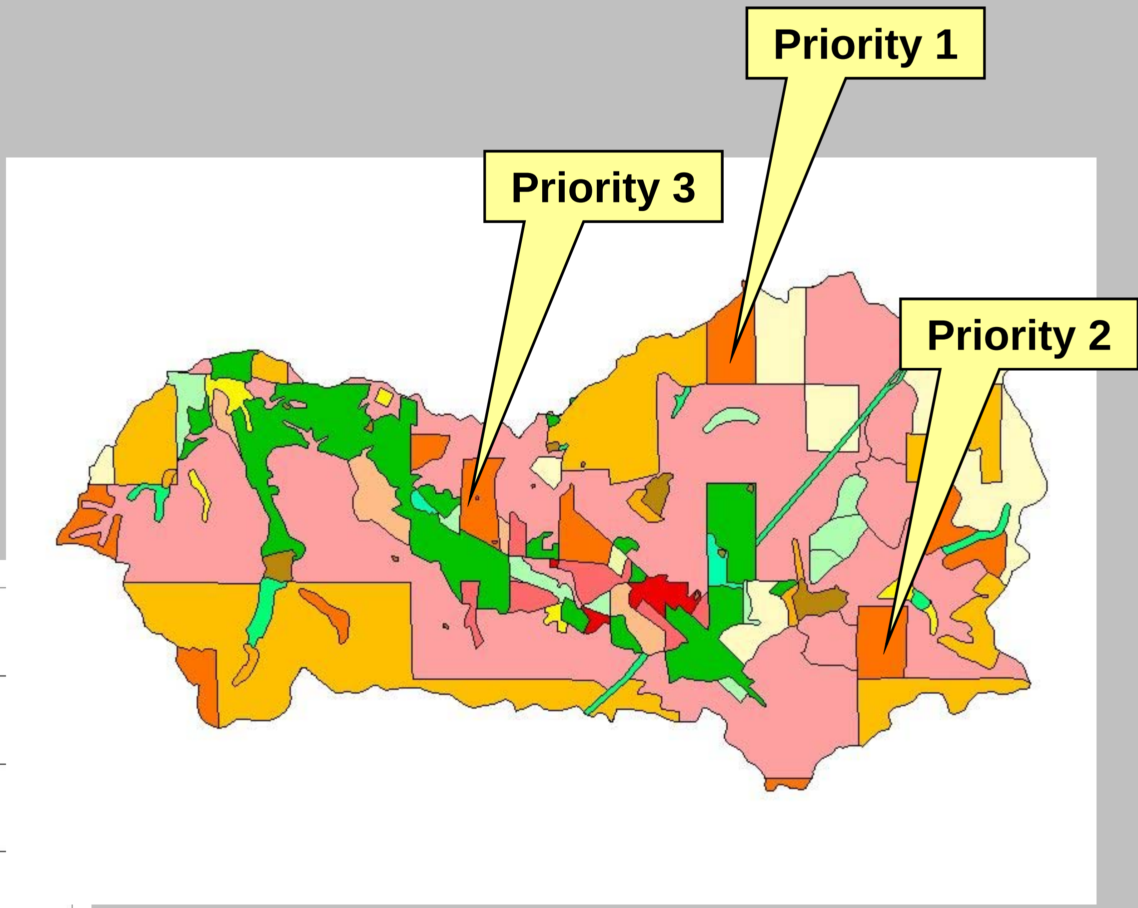
TVA's Integrated Pollutant Source Identification (IPSI) System

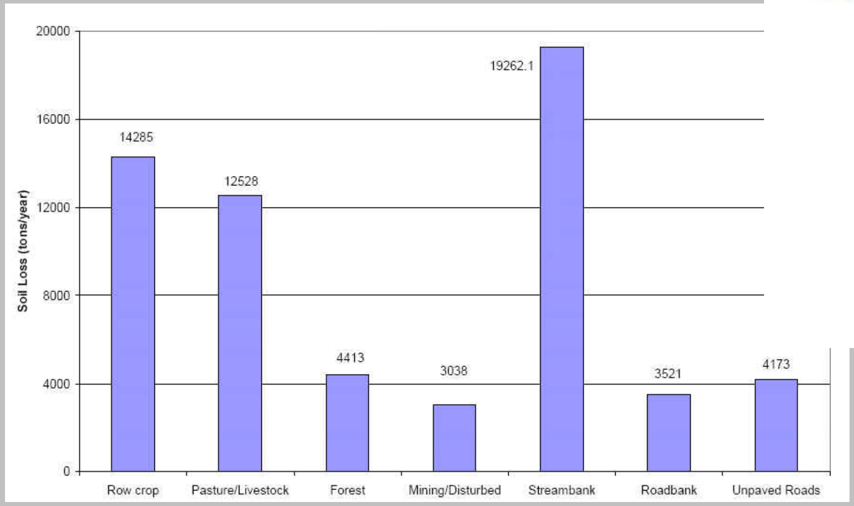




TVA/IPSI(cont.)



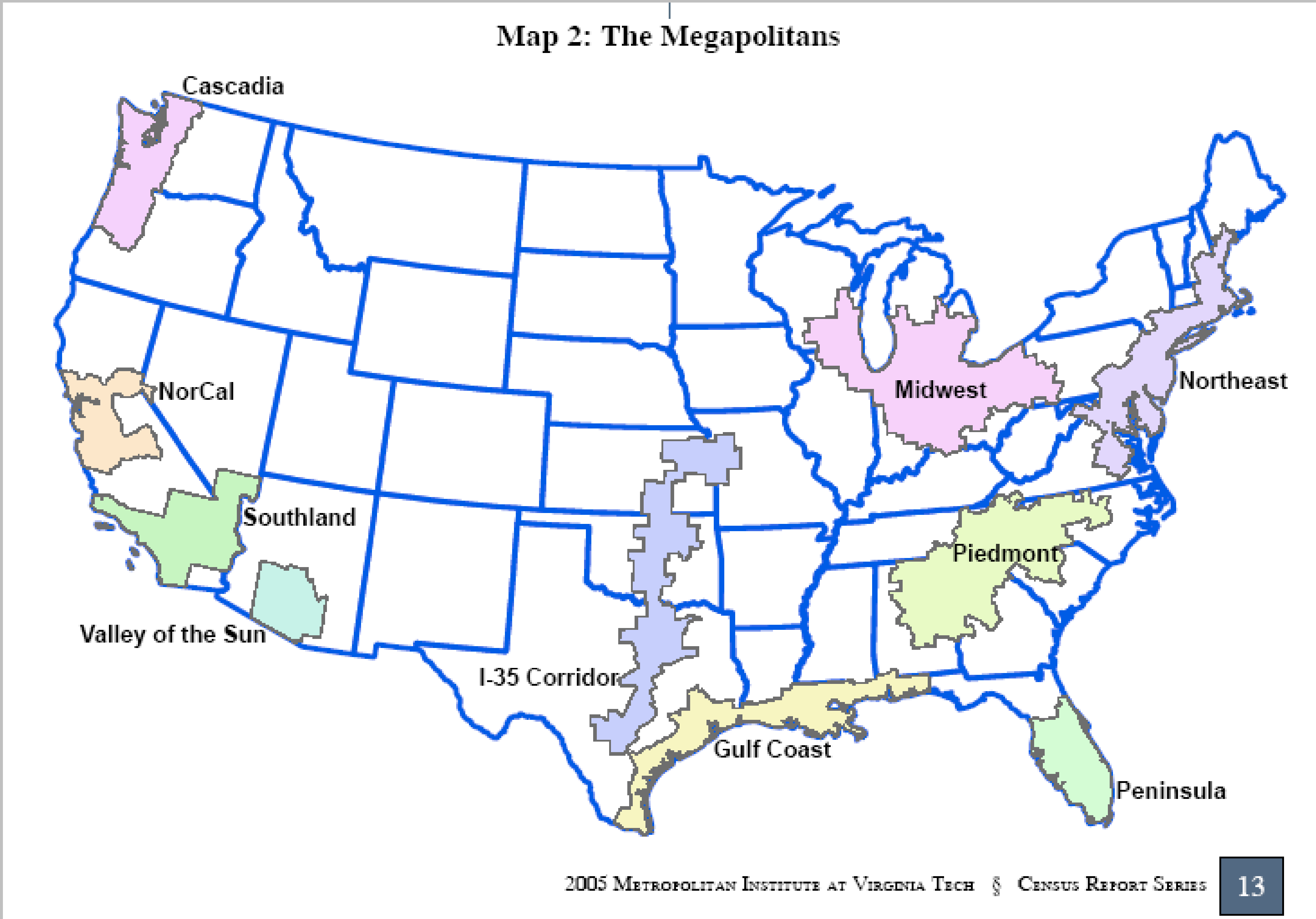




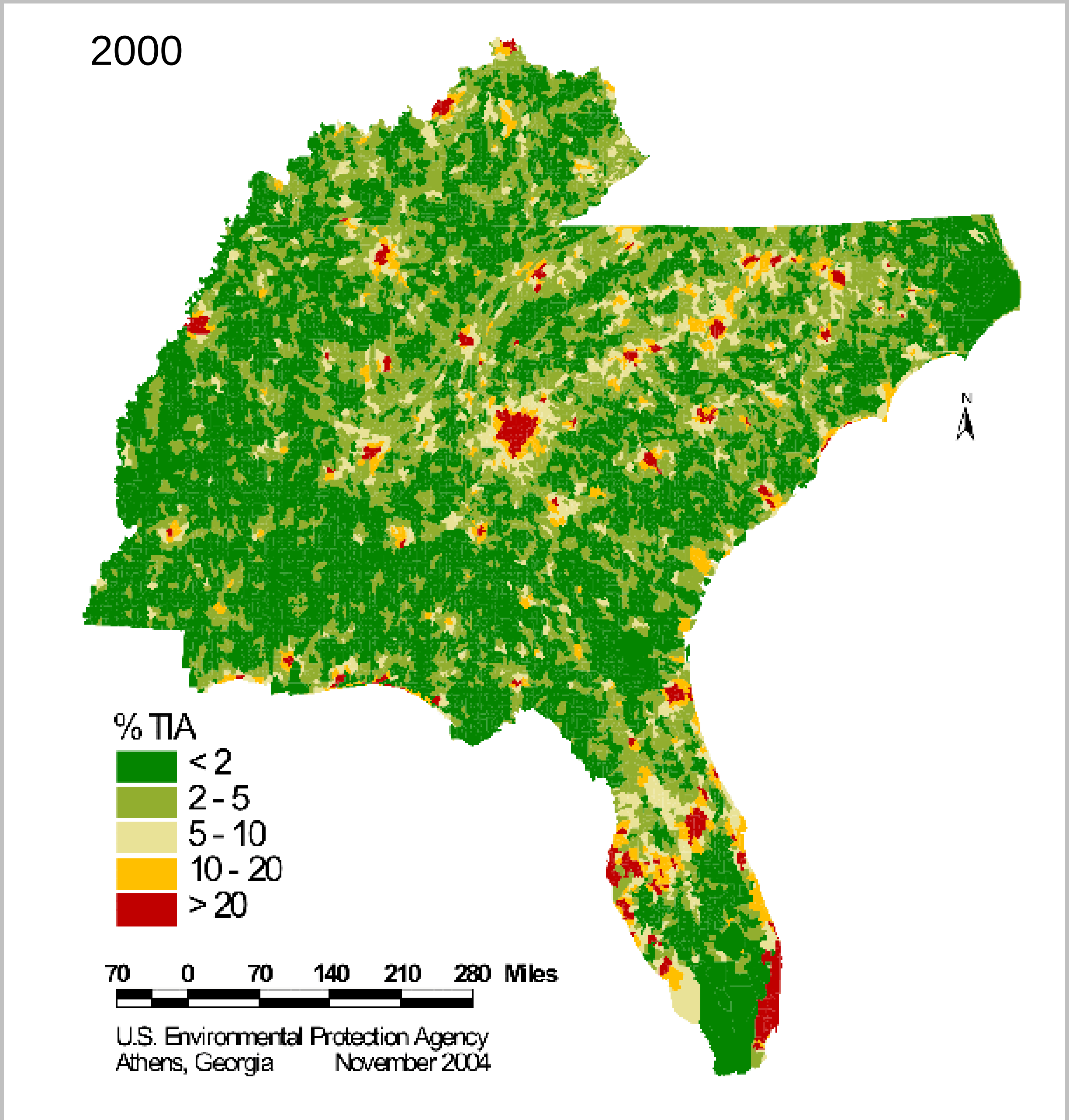
Detailed Analysis Steps and Factors

Detailed Analysis Steps	Factors to Consider
Refine Basis of Analysis	Problems/questions Areas/scales of interest Geographic frameworks Pressure/stress/response parameters of interest
Identify analysis methods and data requirements	GIS analyses Statistical approaches
Refine data quality objectives	Develop QAPP/SOP/Study Plan Peer review (if desired/needed)
Gather additional site and landscape data to fill gaps	Gradient of sites covering full range of stress(es) Probability Survey data
Derive landscape stress/disturbance factors	Delineate watershed boundaries and buffers for sites Watershed Riparian Buffer Proximity Buffer Other appropriate landscape factors
Apply analysis methods	Describe stress and response gradients Reduce number of variables (if needed) Derive robust stress/response relationships
Extrapolate stress/response models to area of interest	Estimate response for areas lacking in-situ data
Evaluate power of results	Balance false negative vs. false positive
Refine analyses if needed	Go back to Refine Basis of Analysis
Report results	Peer review (if needed or desired) Other reviews Publish results
Make decisions using analysis results	Targeting and Priorities Other critical water quality monitoring/management decisions

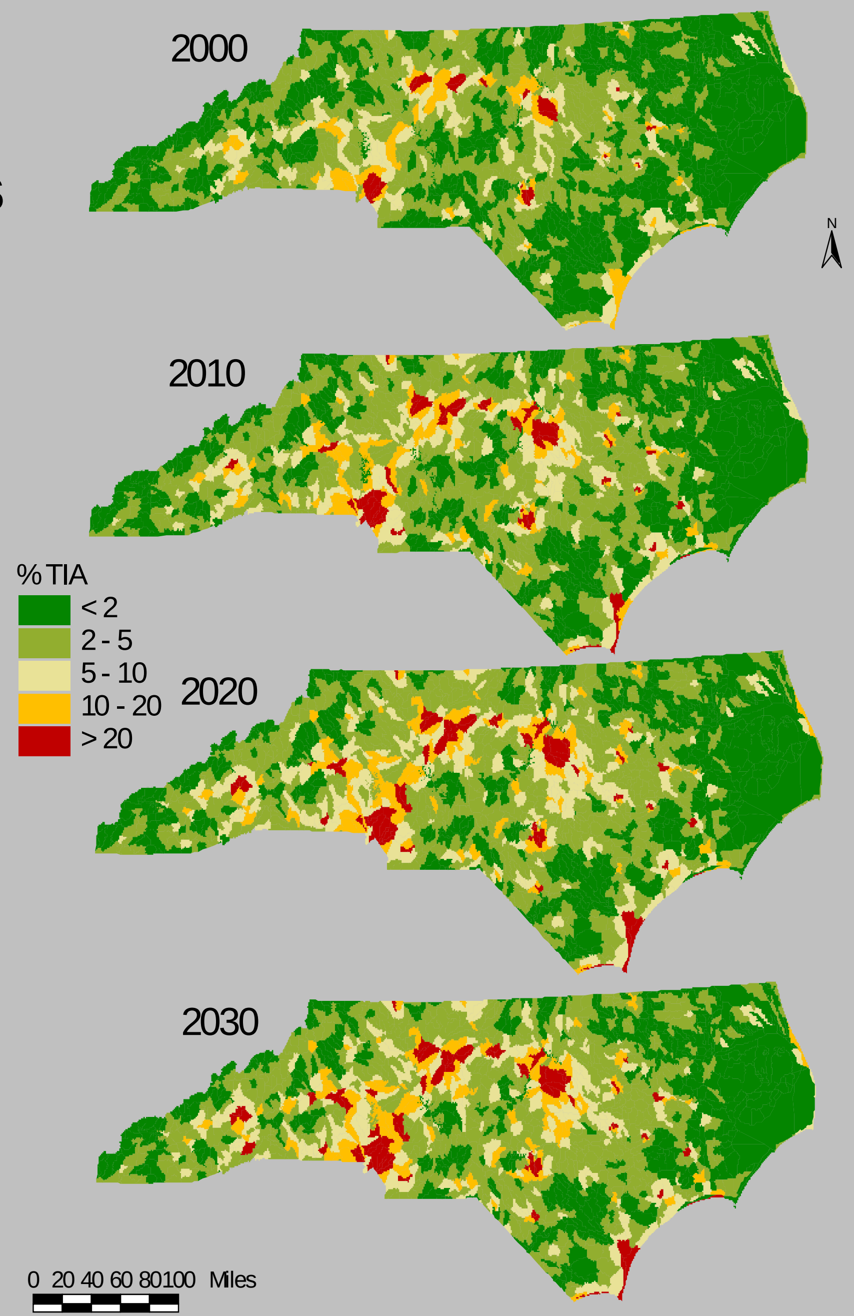
Megalopolis Grows



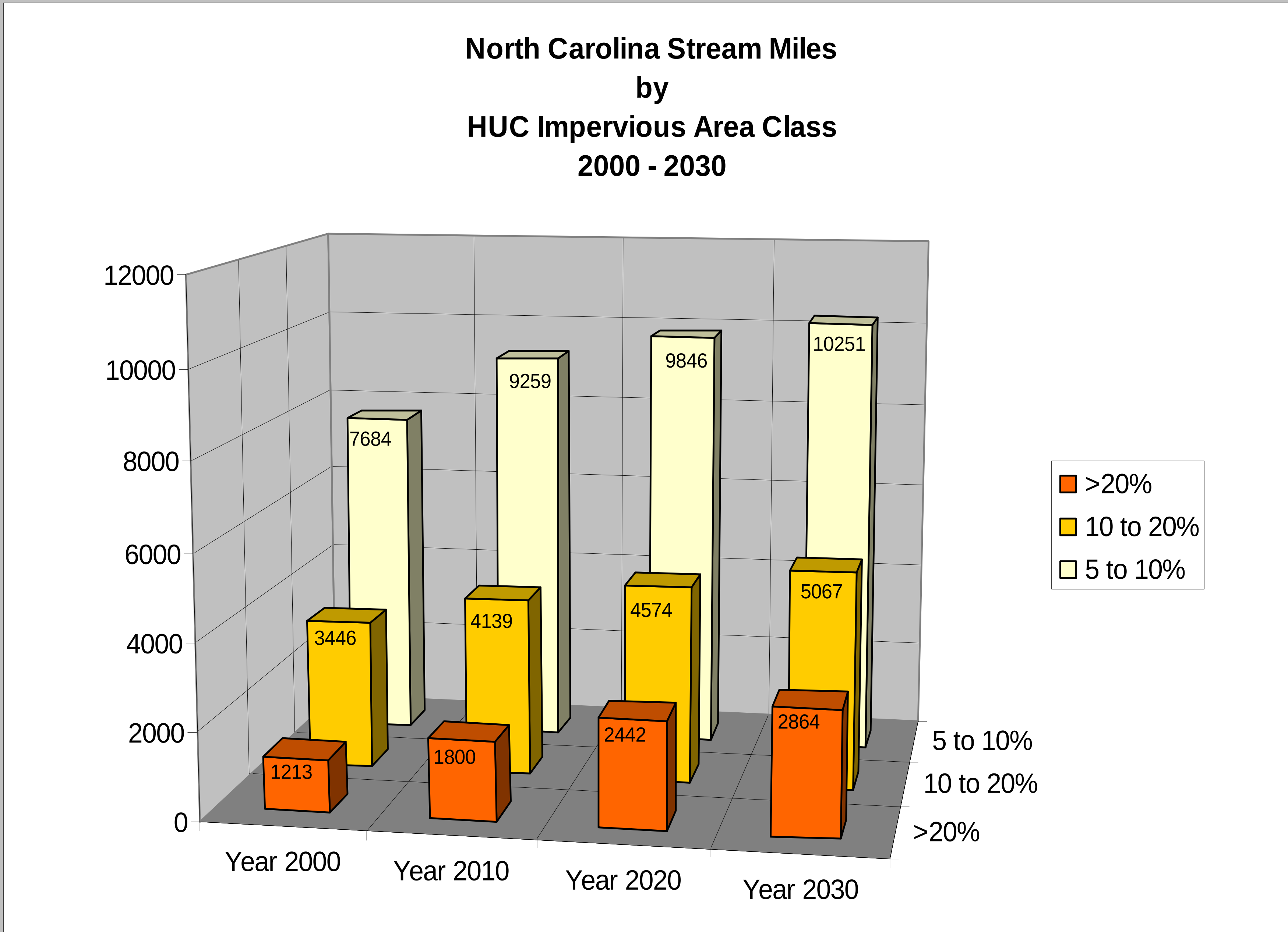
EPA Region 4 Year 2000 Estimated Total Impervious Area (TIA) ~1,700 12 Digit HUC's



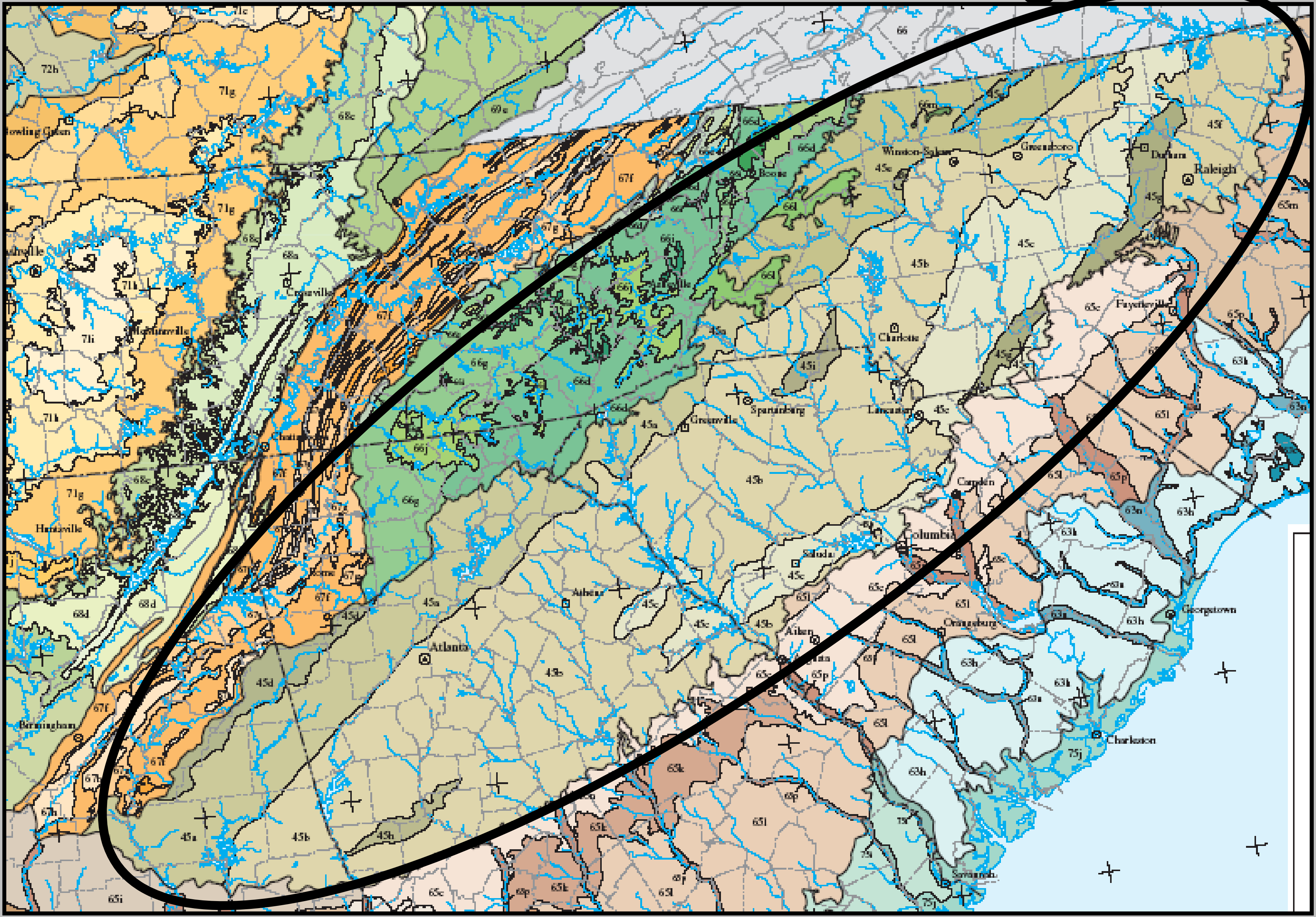
North Carolina Future Projections of TIA



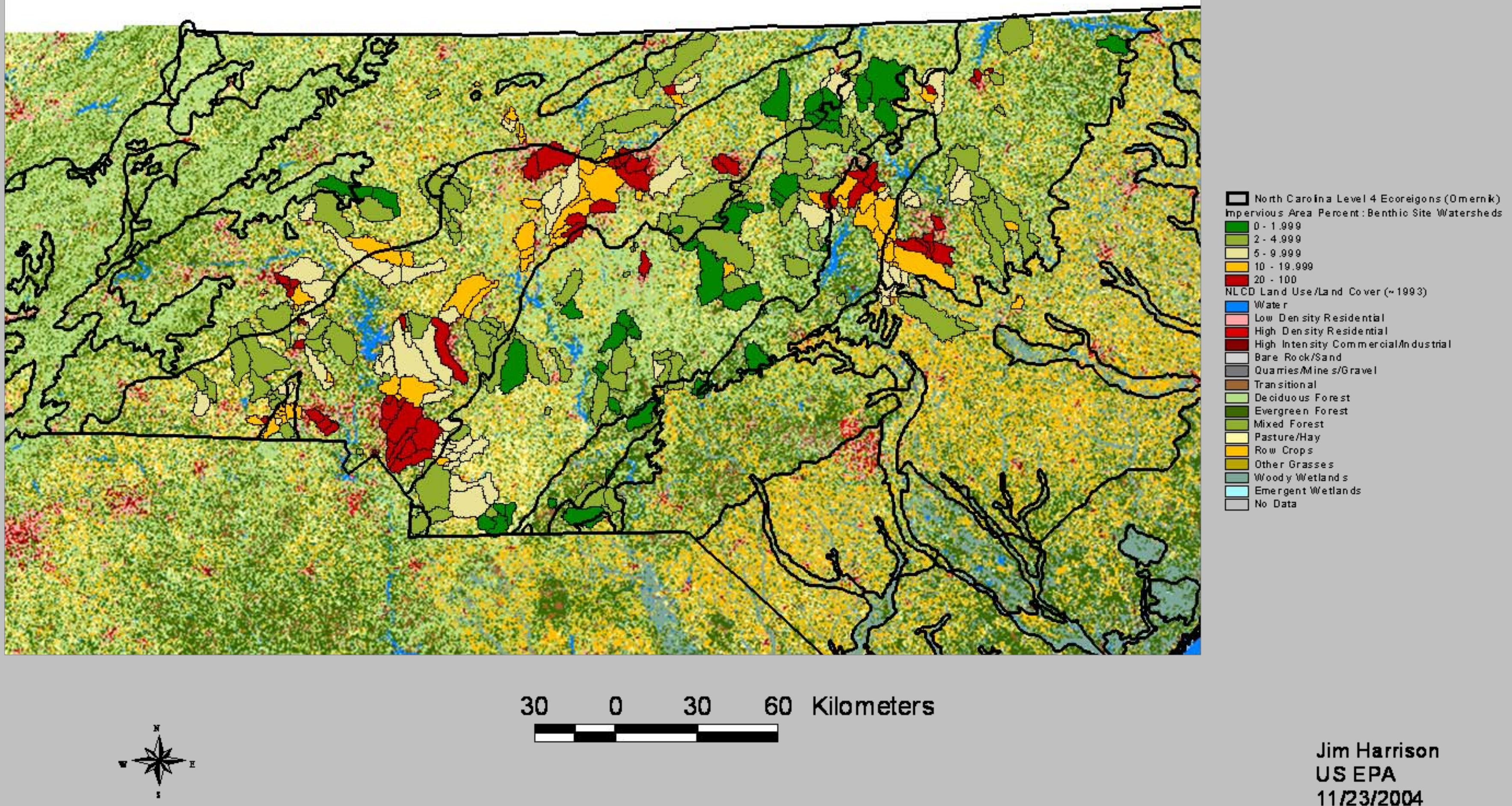
U.S. Environmental Protection Agency Athens, Georgia November 2004


North Carolina Stream Miles
by
HUC Impervious Area Class
2000 - 2030
12000
10000
8000
6000
4000
2000
0
7684
9259
9846
10251
3446
4139
4574
5067
1213
1800
2442
2864
Year 2000
Year 2010
Year 2020
Year 2030
5 to 10%
10 to 20%
>20%
>20%
10 to 20%
5 to 10%

Piedmont Level 4 Ecoregions

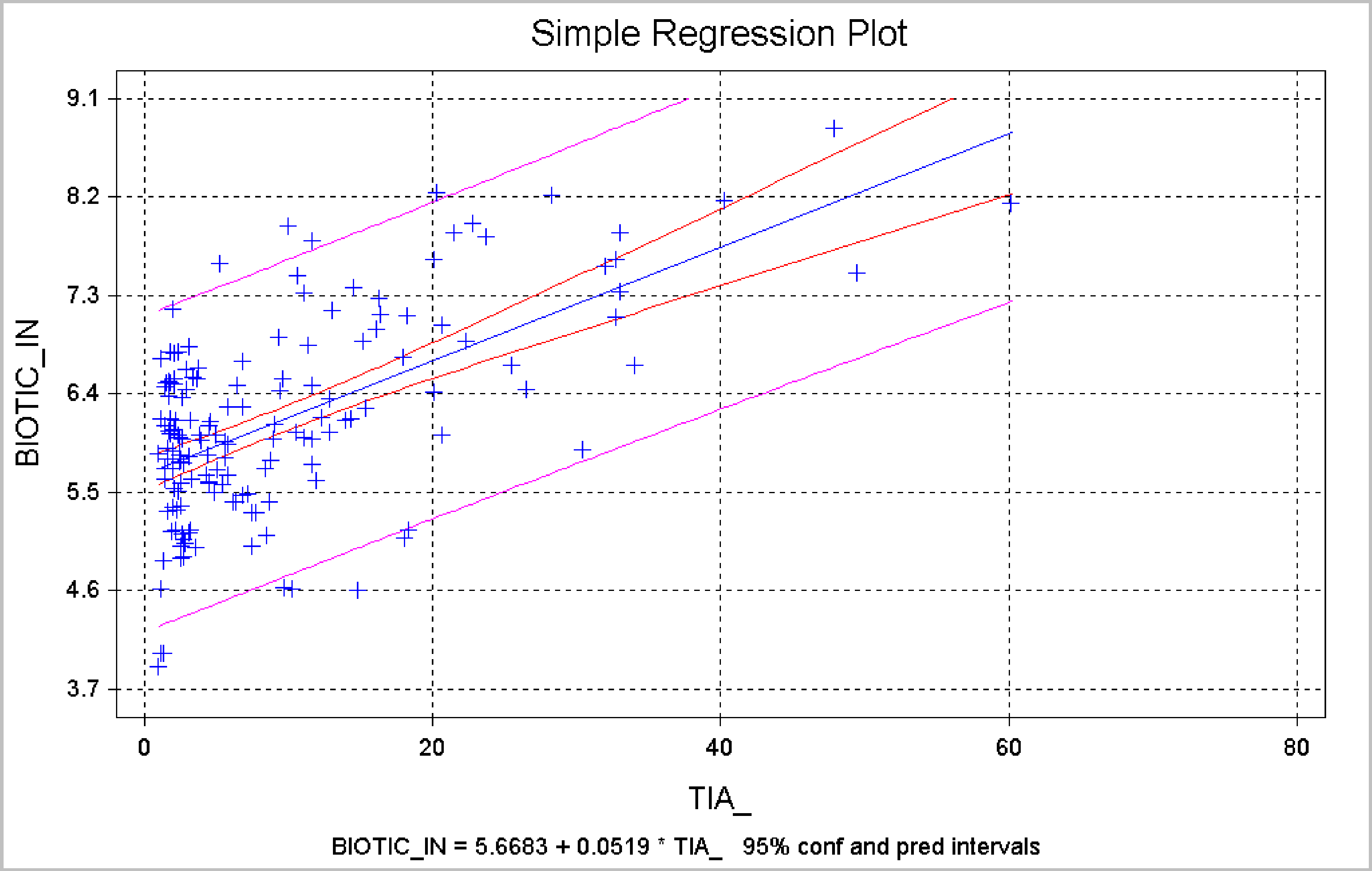


Impervious Area Percent
Multiple Data Source (MDS) Method
North Carolina Piedmont
Benthic Site Watersheds
(317 sites - some watersheds overlap)

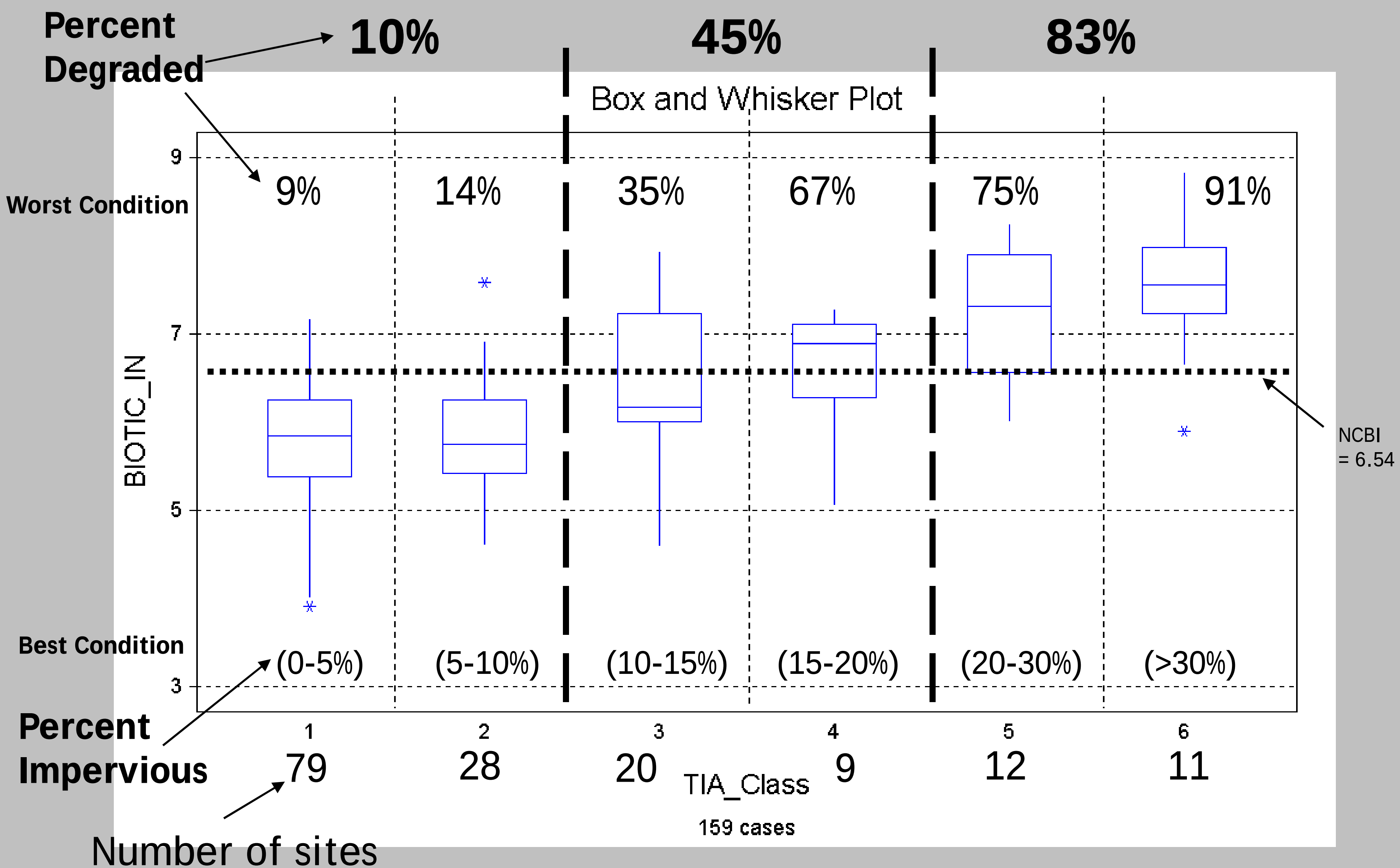


Jim Harrison
US EPA
11/23/2004

159 Piedmont Sites



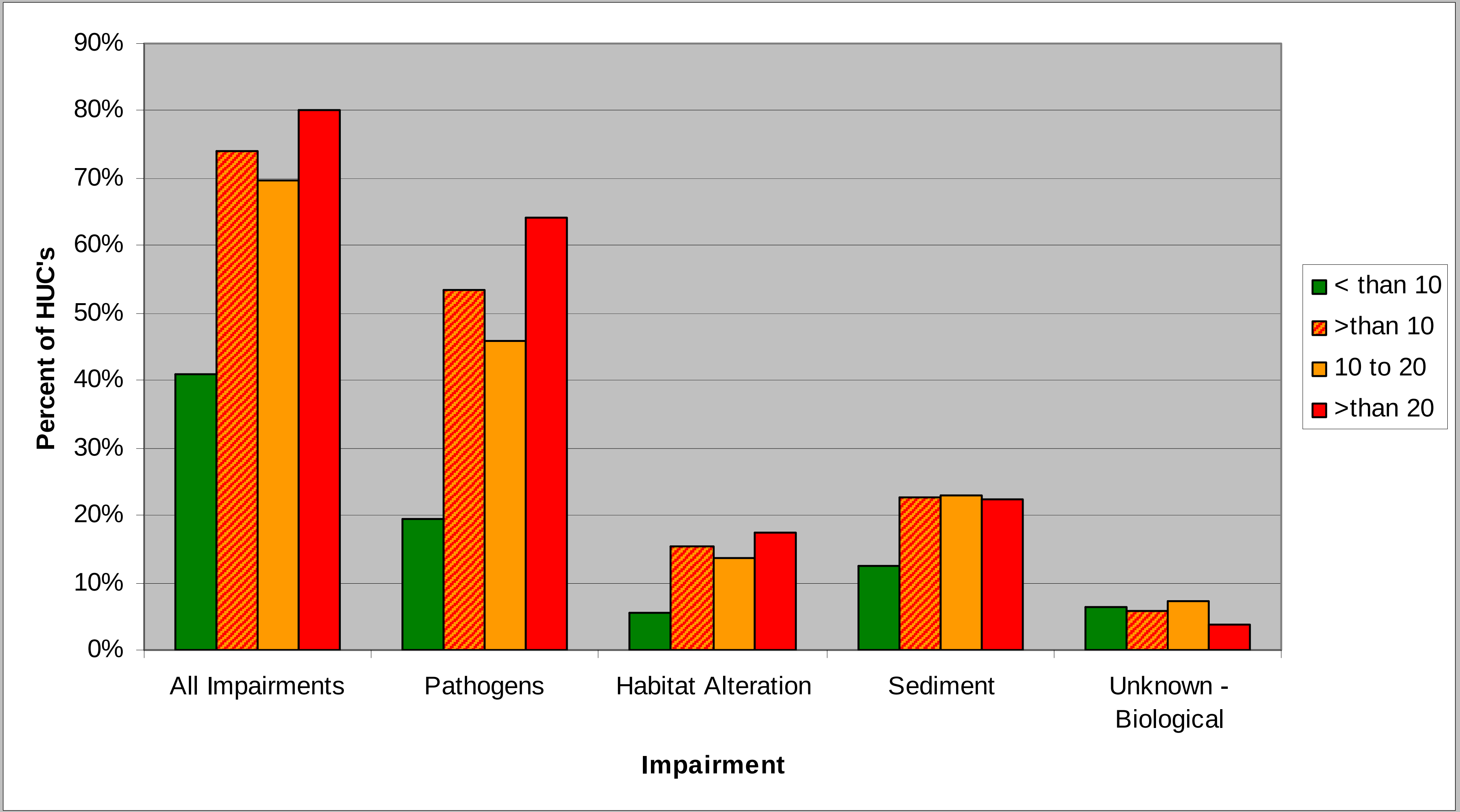
Percent Degraded (NCBI > 6.54: < fair) vs. Total Impervious Area



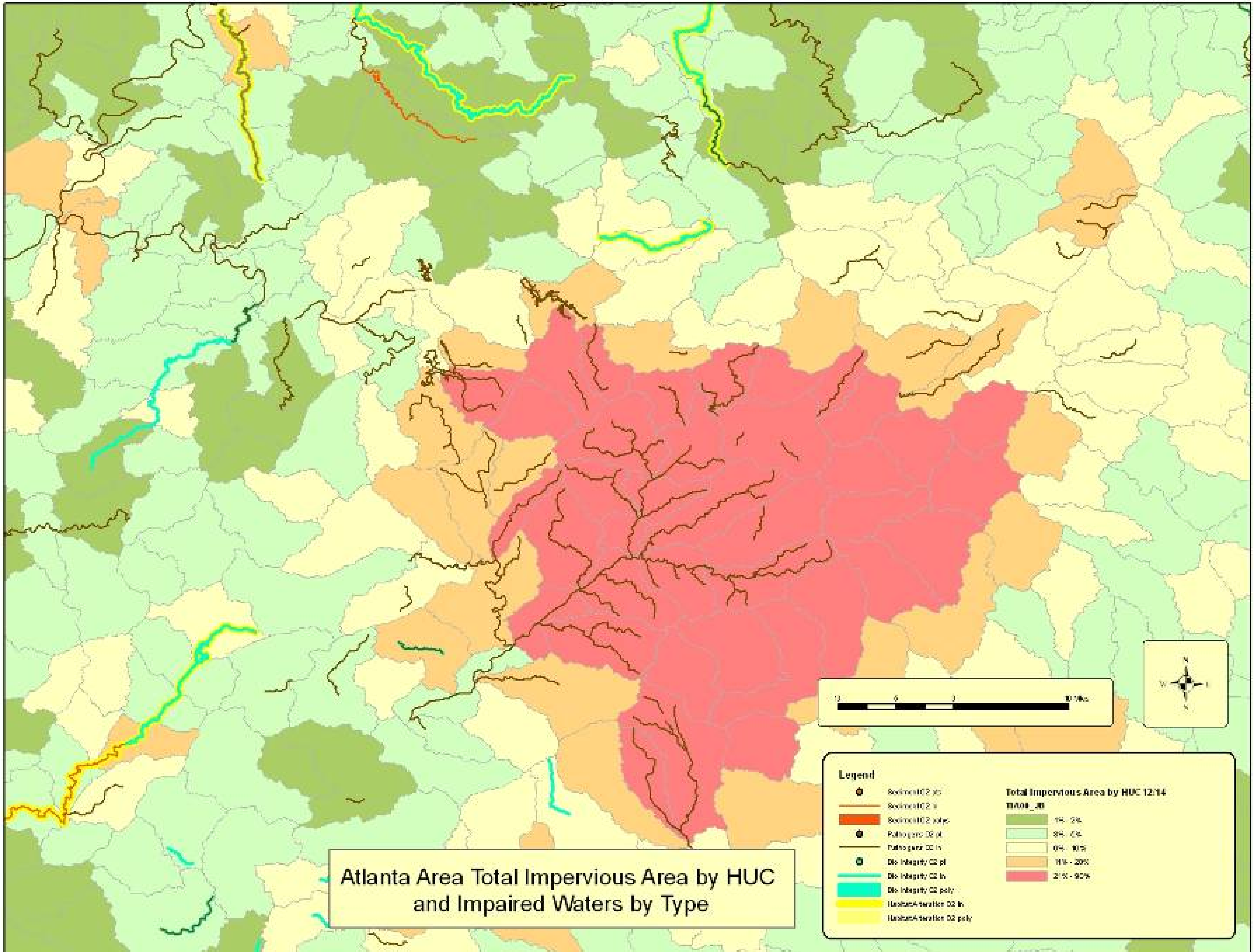
Relative Risk

%TIA Range	% Degraded	Relative Risk
<5	9	1.0
5-10	14	1.5
10-15	35	3.9
15-20	67	7.4
20-30	75	8.3
>30	91	10.1

Percent of Region 4 HUCs Within Impervious Area Ranges Having Specific Impairments



*Based on 2002 Section 303(d) Impaired Waters lists and year 2000 estimated impervious area.
Analysis by Jon Becker and Jim Harrison



*Based on 2002 Section 303(d) Impaired Waters lists. Map by Jon Becker

Why Use Landscape and Predictive Tools?

- Systematic priority setting
- Comprehensive targeting of problems and monitoring efforts
- Improve efficiency of limited monitoring resources
- Monitor smart – from ad hoc/BPJ to scientifically sound basis
- Focus on measuring results – keep score on what's really important

End

- Thank you !
- Contact Information

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  - Harrison.jim@epa.gov
  - 404-562-9271

- Questions/comments?