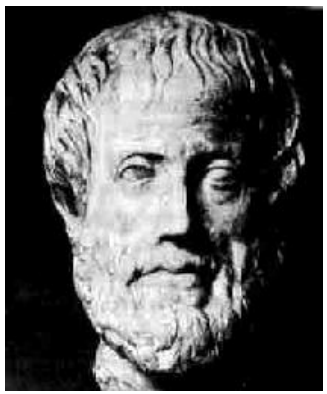
Characterizing, Mapping and Applying Level III and IV Ecoregions in New England for Integrated Ecosystem Assessment and Management

Greg Hellyer
EPA- New England Regional Laboratory

NEAEB – Mapping Session 1A

March 17, 2010

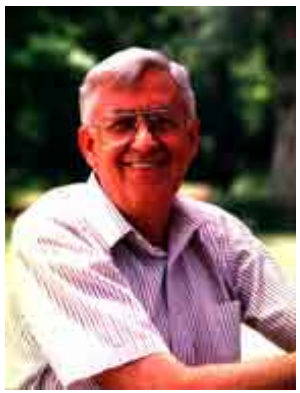
“The whole is more than the sum of its parts”



- Aristotle (~350 B.C.)

Metaphysica 10f-1045a

“Two streams of science – one reductive and certain, and one integrative and uncertain. The first provides the bricks for the edifice, but not the architectural design”



- C.S. (Buzz) Holling

Emeritus Eminent Scholar and Professor in Ecological Sciences at the University of Florida and ‘father’ of concepts of resilience, adaptive management, the adaptive cycle, and panarchy.

Rationale for Ecoregion Project (Single Resource vs. Ecosystem View)

- Federal and state agencies and NGOs have traditionally focused assessment, research, monitoring, and management on single resources (e.g. streams, lakes, wetlands, wildlife, fish, forests, grasslands or agriculture);
- However, an holistic, ecosystem (ecoregional) perspective is needed, given the inextricably interconnected nature of environmental processes and problems; Ecosystems and ecoregions exhibit emergent, non-linear, complex, panarchic* properties;

*"Panarchy is the hierarchy of adaptive cycles that form the basis of ecosystems and social-ecological systems across time/space scales." (www.globaldiversityfund.net/glossary/1/letterp)

Specific Purpose Regions vs. General Purpose Ecoregions

- **Specific Purpose Regions** are based on patterns of one characteristic and spatial associations with causal or reflective geographical phenomena (e.g. alkalinity, soils, or geology regions);

- **General Purpose Ecoregions** are based on spatial coincidence of numerous geographic phenomena affecting or reflecting ecosystem characteristics;

Specific to General Purpose Lake Management Hierarchy

General Purpose

Specific Purpose

Ecoregions

Aggregated Ecoregions
(for specific purposes e.g. biota)

Based on spatial coincidence of numerous geographic phenomena affecting or reflecting ecosystem characteristics

Lake Management Regions

Lake Phosphorus Regions

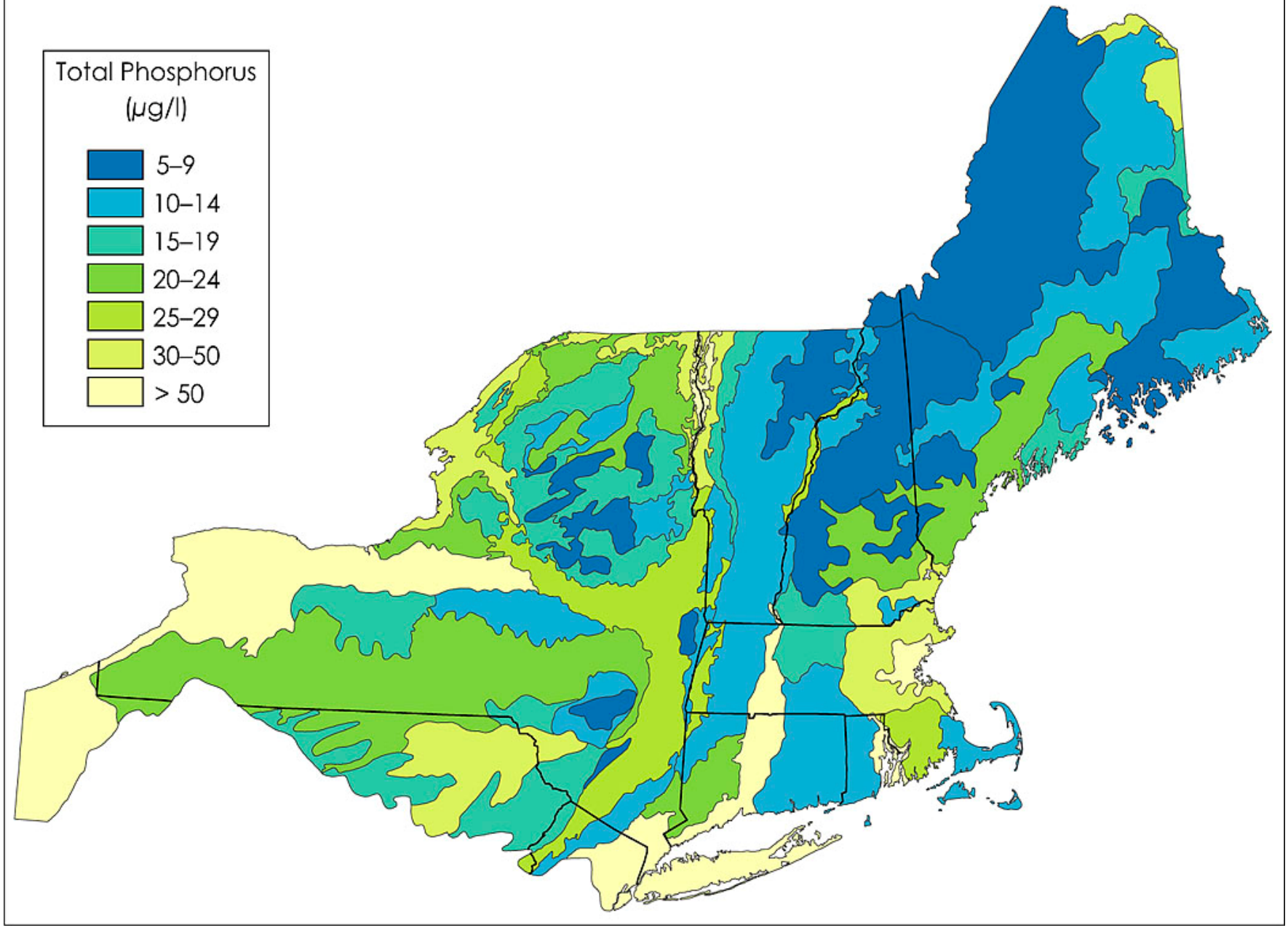
Alkalinity Regions

Nutrient Regions

Based on patterns of one characteristic and the spatial association with causal and reflective geographic phenomena

Source: *Ecoregions, watersheds, basins, and HUCs: How state and federal agencies frame water quality* (Griffith and others 1999)

TOTAL PHOSPHORUS REGIONS FOR THE LAKES IN THE NORTHEASTERN UNITED STATES



Source: (Rohm and others 1995)

Definition of EPA Ecoregions

- Areas of similarity regarding patterns in the mosaic of abiotic and biotic, aquatic and terrestrial ecosystem components, including geology, physiography, vegetation, climate, soils, hydrology, land use, and wildlife, with humans being considered as part of the biota;
- The relative importance of each characteristic varies from one ecological region to another regardless of the hierarchical level.

Omernik, J.M. (1995) *Ecoregions: A spatial framework for environmental* management, in Biological assessment and criteria: tools for water resource planning and decision making, pp. 49-62.

EPA Ecoregions and Ecosystem Management

- Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources;
- Spatial differences in the capacities and potentials of ecosystems and ecoregions stratify the environment by its probable response to disturbance (Bryce and others, 1999).

Bryce, S.A., Omernik, J.M., and Larsen, D.P., 1999, *Ecoregions – a geographic framework to guide risk characterization and ecosystem management*: Environmental Practice, v. 1, no. 3, p. 141-155.

EPA Ecoregions and Ecosystem Management (cont'd)

- EPA ecoregions were not designed to serve a single purpose or to optimally correspond to patterns of specific environmental components such as fish, macroinvertebrates, soils, or vegetation;
- Ecoregions do correspond well to water quality, which integrates multiple environmental factors;

Gallant, A. L., T. R. Whittier, et al. (1989). *Regionalization as a tool for managing environmental resources*: Corvallis, Oregon, US Environmental Protection Agency, EPA/600/3-89/060, 152 p.

Hierarchical Nesting of EPA Ecoregions

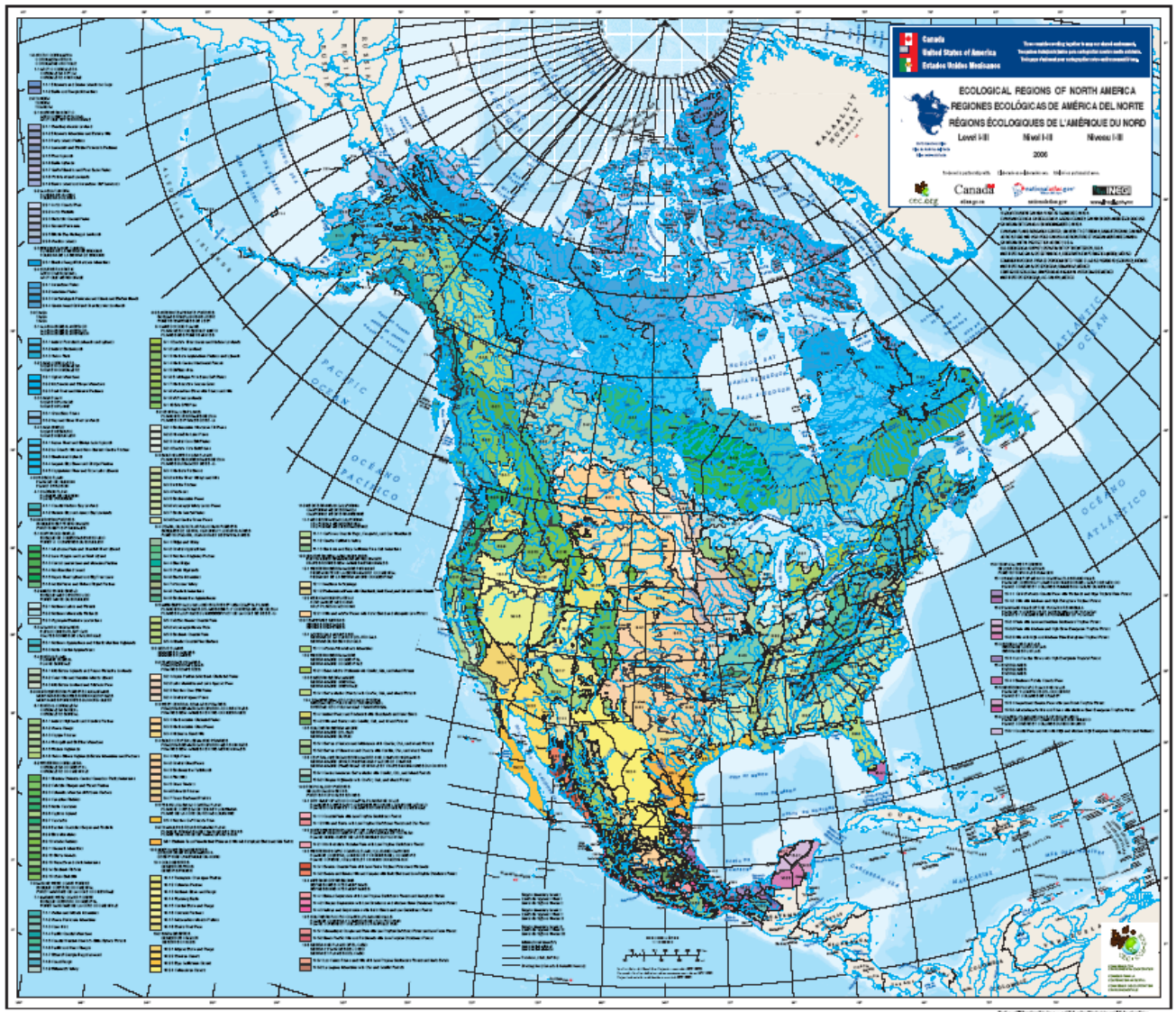
- The four (4) EPA ecoregional hierarchical Levels do not perfectly ‘nest’, given boundary uncertainty and variation at different mapping scales;

- For mapping purposes ecoregional Levels are shown hierarchically nested;

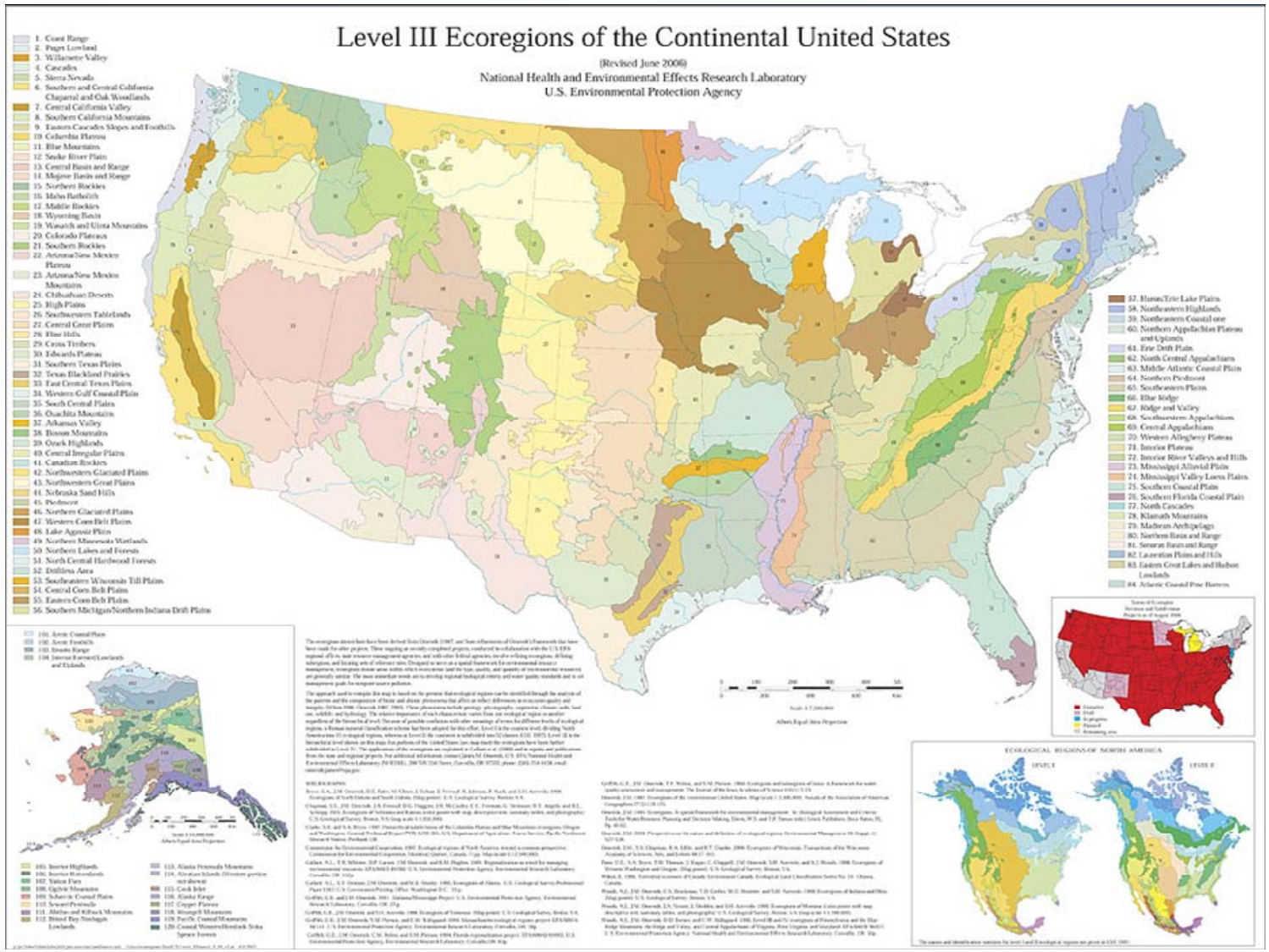
Common 15 Level I Ecoregions of N. America (CEC 1997)

Common 52 Level II Ecoregions of N. America (CEC 1997)

Common 182 Level III Ecoregions of N. America (CEC 1997)

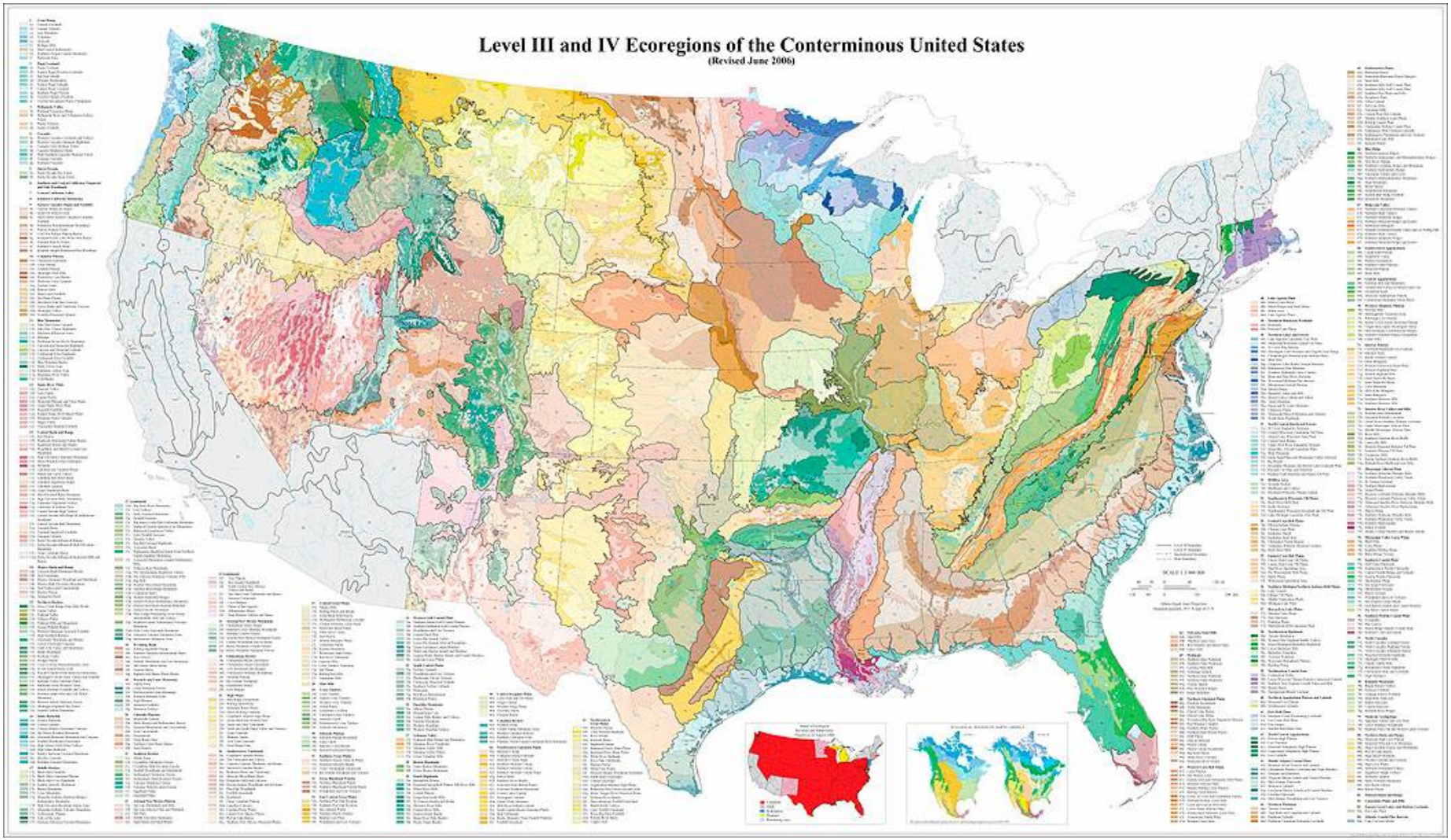


84 Level III Ecoregions of the Lower 48 States (EPA 2006)



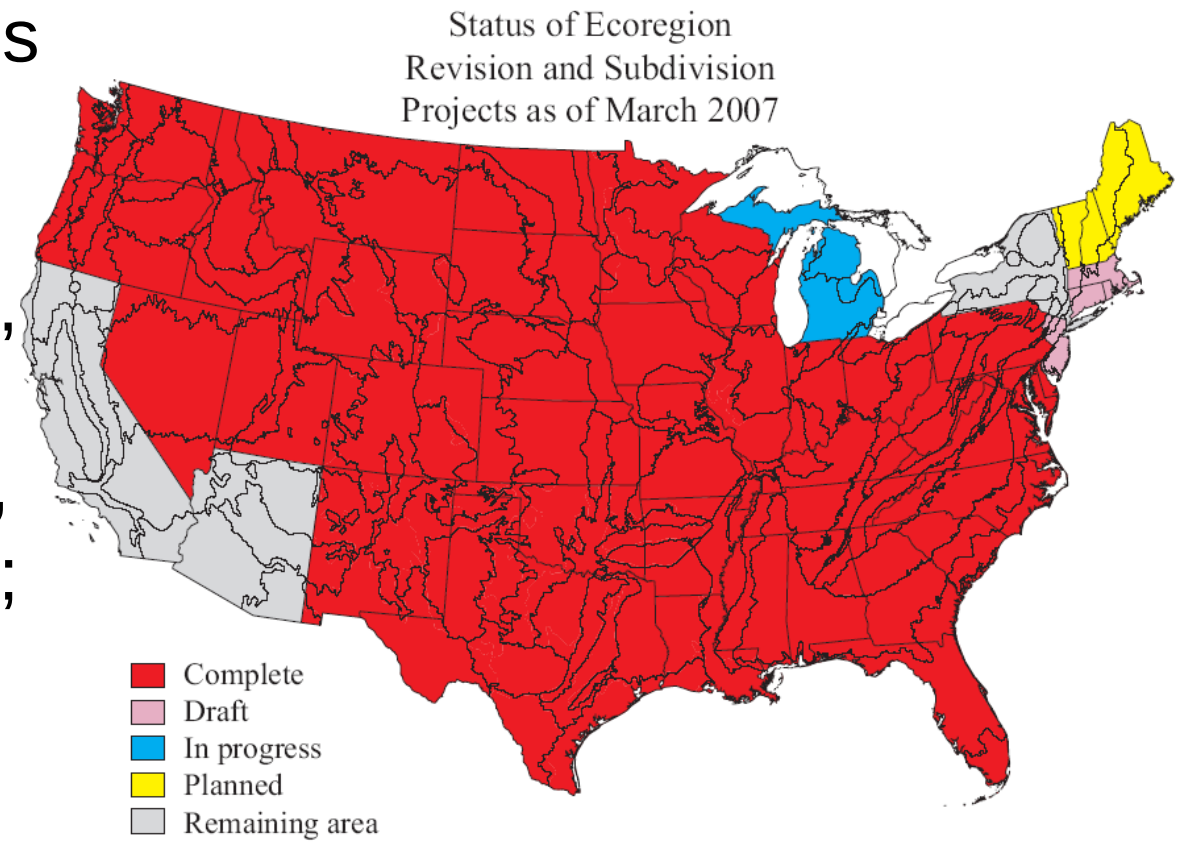
Slightly revised in USEPA (2009)

EPA (2006) Level III and IV Ecoregions of Conterminous United States



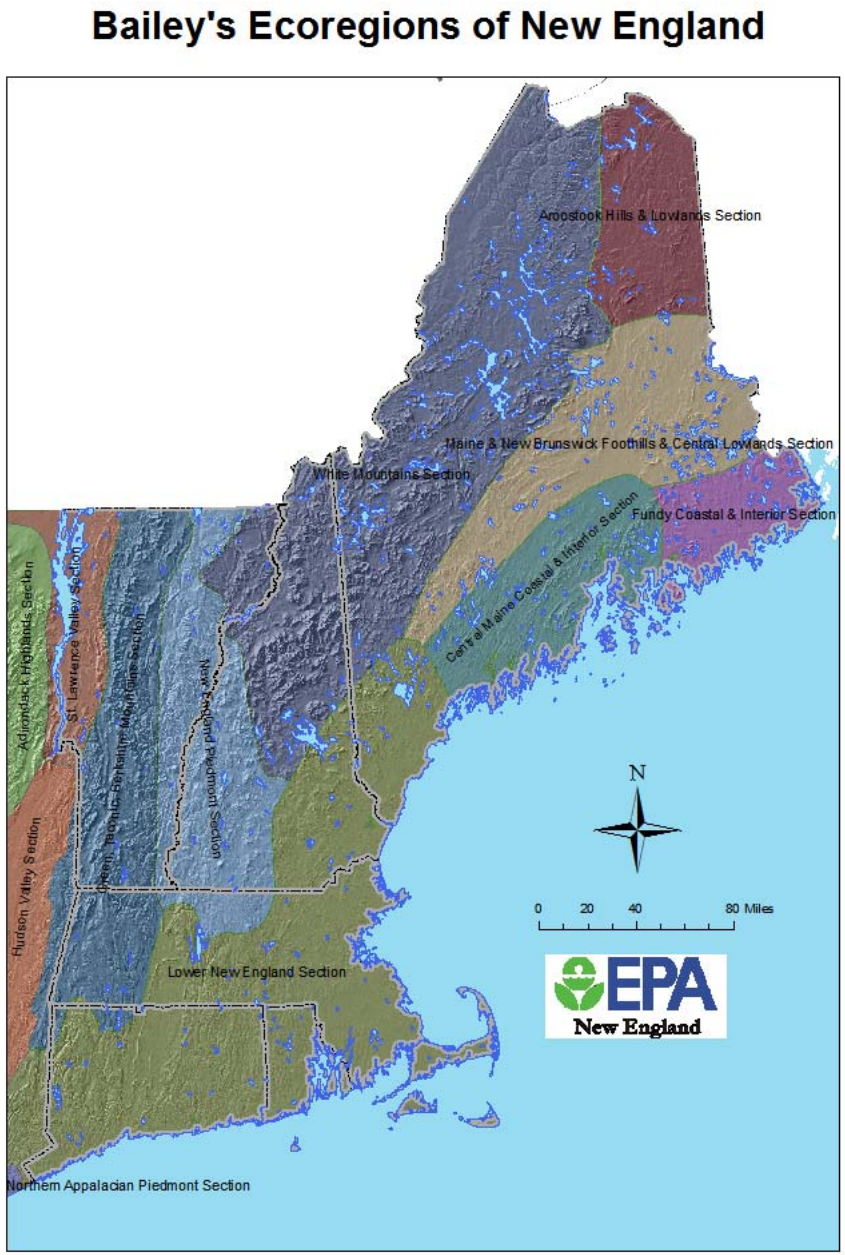
Status of EPA Level IV Mapping in Lower 48 States (March, 2007)

- Level IV ecoregions are mapped for ~85% of the conterminous U.S., but not for the Northeast (NY, NJ, and New England);



Bailey's (1994) Ecoregions of New England (Sections)

- St. Lawrence Valley;
- Green, Taconic, Berkshire Mountains;
- New England Piedmont
- White Mountains;
- Aroostook Hills & Lowland
- Maine & New Brunswick Foothills & Central Lowlands;
- Fundy Coastal & Interior;
- Central ME Coastal & Interior;
- Lower New England;



EPA Level III Ecoregions of New England (2006)

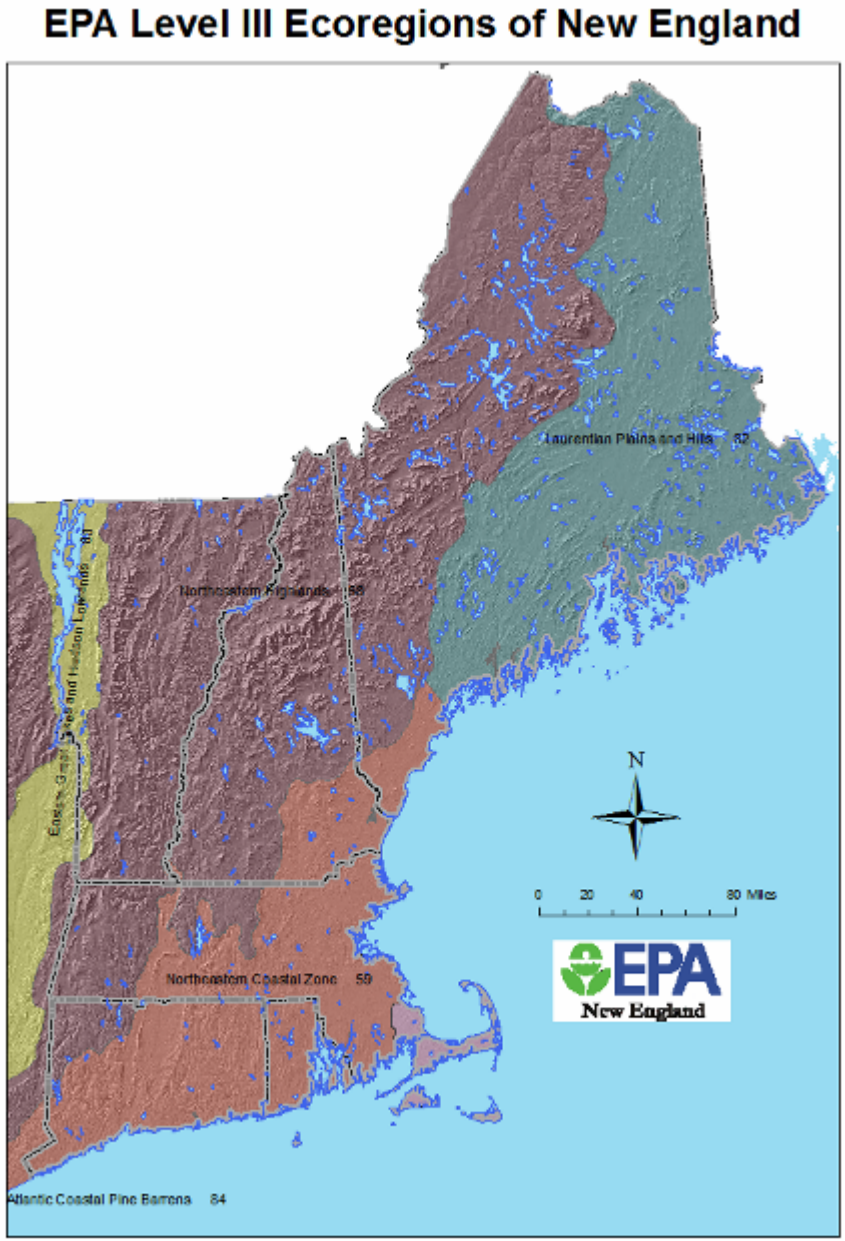
#83 Eastern Great Lakes Hudson Lowlands;

#58 Northeastern Highlands;

#82 Laurentian Plains and Hills;

#59 Northeastern Coastal Zone;

#84 Atlantic Coastal Pine Barrens;

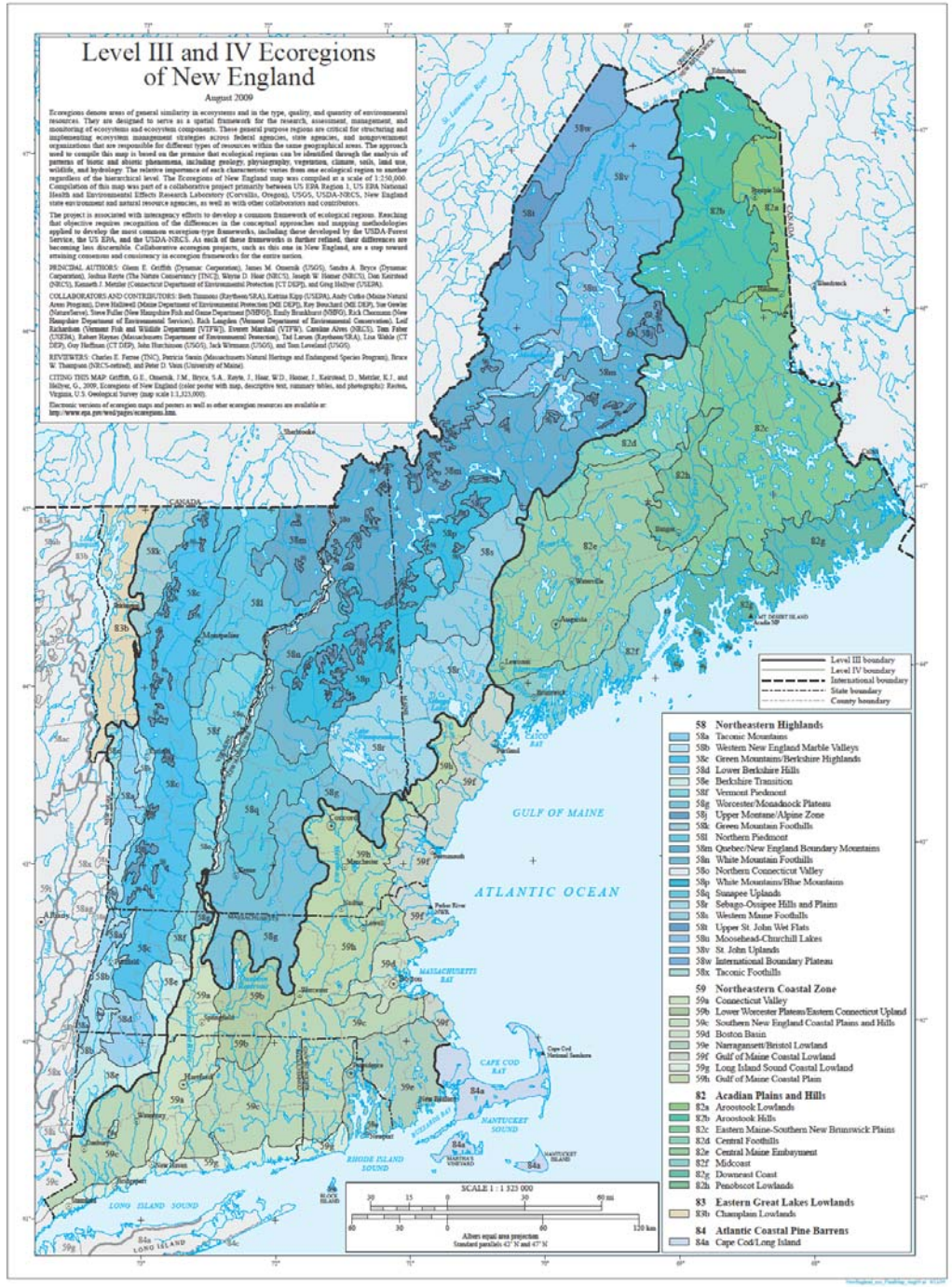


Delineation of EPA Ecoregions

- Ecoregions are not self-evident but require a focused multi-disciplinary discovery of their intrinsic spatial patterns;
- EPA ecoregions are not simply the overlaying of GIS coverages;
- EPA uses a weight-of-evidence approach which identifies congruent aquatic, terrestrial and human landscape patterns;

Level III and IV Ecoregions of New England (2009)

- 5 Level III ecoregions;
- 40 Level IV ecoregions;
- Compiled at a scale of 1:250,000;
- High ecological & landscape diversity



Summary of State & Federal Ecoregional Applications in the Lower 48 States

Some State and Federal Applications of Ecoregions in the Lower 48 States - January 4, 2008 Page 1 of 43
Greg Hellyer, USEPA – New England Regional Lab (hellyer.greg@epa.gov)

State or Federal Agency	Some Applications of Ecoregions
LOWER 48 STATES	
Alabama	River and Stream Level IV Ecoregional Reference Sites 216.226.179.150/fieldops/monitoring/surfacestrategies/riverstream.htm#Core
Alabama	Alabama's Draft 2008 Section 303(d) List of Impaired Waters and Comments on Alabama's Draft Assessment and Listing Methodology www.adem.state.al.us/PublicNotice/Aug/8Meth.htm
Alabama	Alabama's Water Quality Assessment and Listing Methodology www.adem.state.al.us/PublicNotice/Aug/Meth.pdf
Alabama	Water Quality Standards www.adem.state.al.us/waterdivision/WQuality/305b/2006/2006%20AL%20IWQMAR%20Ch1%20(Water%20Quality%20Standards).pdf
Alabama	1998 305(b) Report to Congress 216.226.179.150/waterdivision/wquality/305b/1998/1998.htm
Alabama	2004 Integrated Water Quality Monitoring & Assessment Report 216.226.179.150/waterdivision/wquality/305b/2004report/2004.htm
Alabama	319 Reporting 216.226.179.150/education%20div/nonpoint%20program/npsgrant/fy04%20and%20future%20year%20proposal%20workplan%20template%20%28rev.3%2D22%2D04%29.doc
Alabama	2006 Integrated Water Quality Monitoring and Assessment Report 216.226.179.150/waterdivision/wquality/305b/WQ305bReport.htm
Arizona	Associating wildlife with different ecoregions for management www.azgfd.gov/w_c/cwcs_format.shtml

I compiled 43 page annotated draft summary of State & Federal Ecoregional Applications in the Lower 48 States

Some State, Federal & NGO Ecoregional Applications in Lower 48 States (see poster)

- Monitoring of aquatic biota (e.g. fish, benthic macroinvertebrates, zooplankton, periphyton, algae);
- Identifying reference conditions and developing indices of ecological health and integrity (e.g. Index of Biological Integrity - IBI, Index of Biological Wellness - IBW, Tiered Aquatic Life Uses - TALU, Biological Condition Gradient - BCG, and Water Quality Index - WQI);

Some Examples of Ecoregional Applications

- Developing narrative and numeric biological criteria, water quality criteria and standards, and nutrient criteria for streams, rivers, lakes, reservoirs and wetlands;
- Development and monitoring of TMDLs;
- 305(b)/303(d) and Integrated Reporting;
- Basin assessment, facilities permitting and waste management;
- Statistical and spatial/geographic assessment and modeling (e.g. REMAP/ EMAP data: wadeable streams, lakes and ponds, large rivers and wetlands);

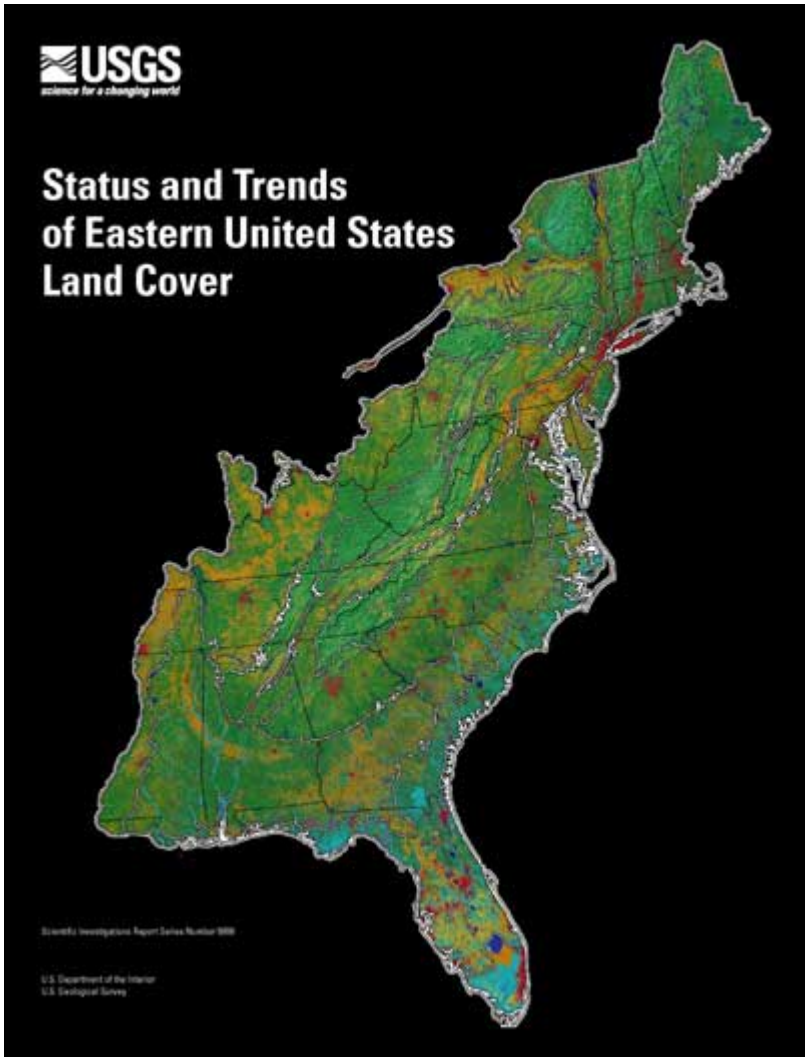
Some Examples of Ecoregional Applications (cont'd)

- Large-scale monitoring of aquatic communities; Ecosystem assessment of watersheds;
- Identifying Target Fish Communities (TFC) and fisheries restoration goals;
- Assessment and classification of streams, rivers, and lakes;
- Development of state Comprehensive Wildlife Conservation Strategies (CWCS);
- Identifying critical habitat to preserve biodiversity;

Some Examples of Ecoregional Applications (cont'd)

- Park land acquisition and planning; Conservation and recreational planning for birds, fish and aquatic communities;
- Wetland protection including planning, permitting, mitigation and determining reference conditions;
- Land cover status and trends; Assessing urbanization; Highway and road planning; Bacterial source tracking;

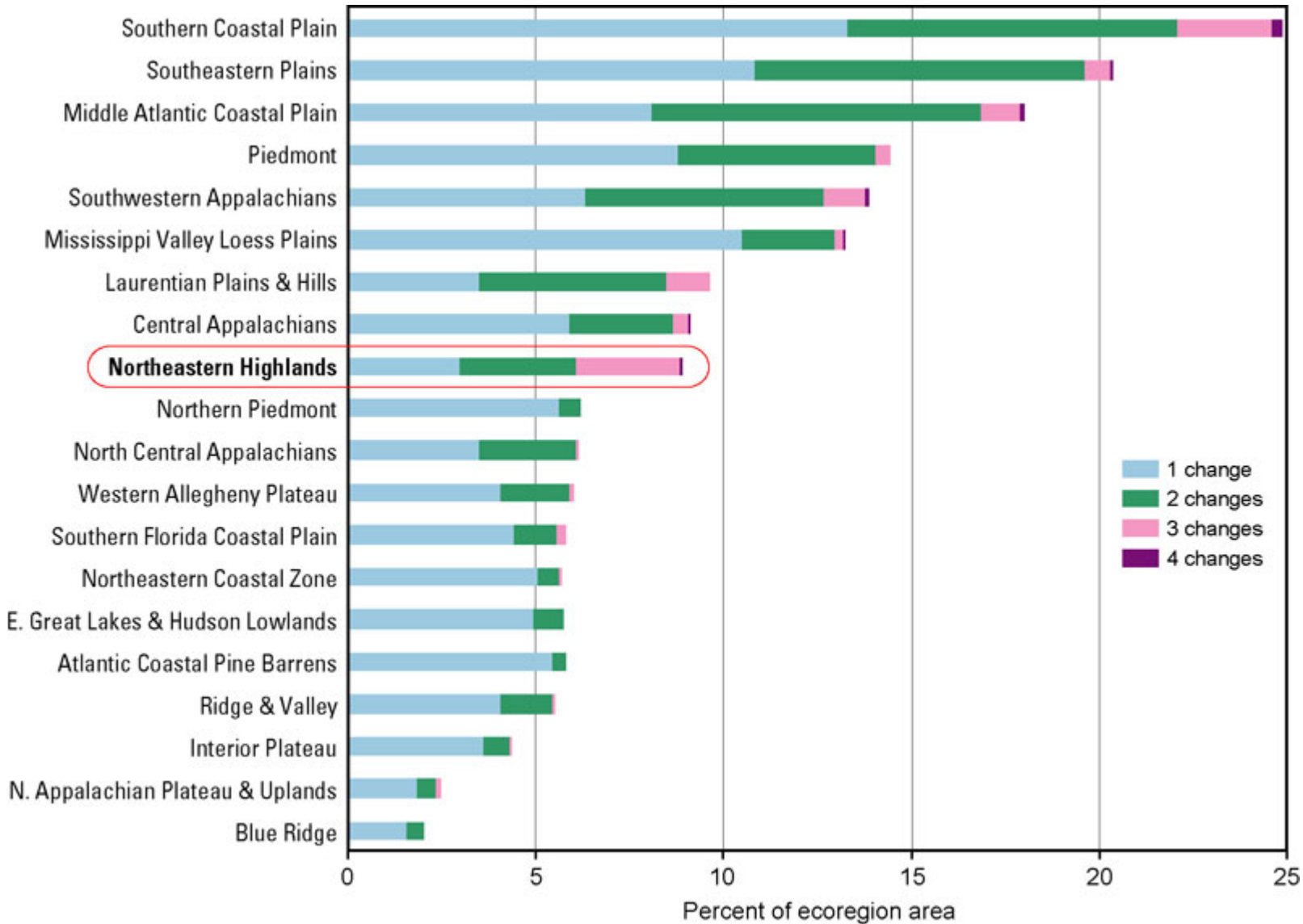
Status and Trends of Eastern United States Land Cover



1) Where is change occurring;
2) What land cover types are changing;
3) Types of transformation occurring;
4) Rates or amounts of land change;
5) Driving forces and proximate causes of change;

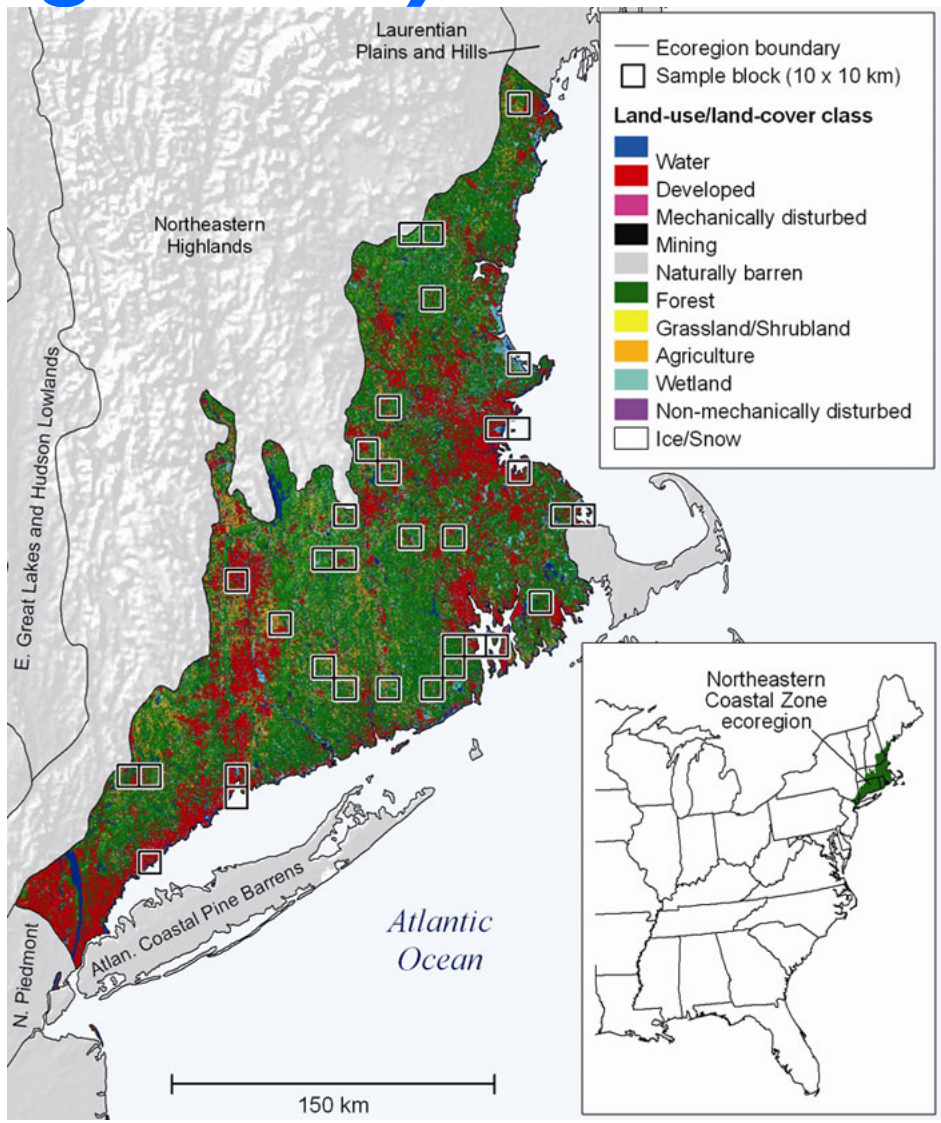
Source: http://edc2.usgs.gov/LT/coverpage.php

Overall Spatial Change in all Eastern U.S. Ecoregions

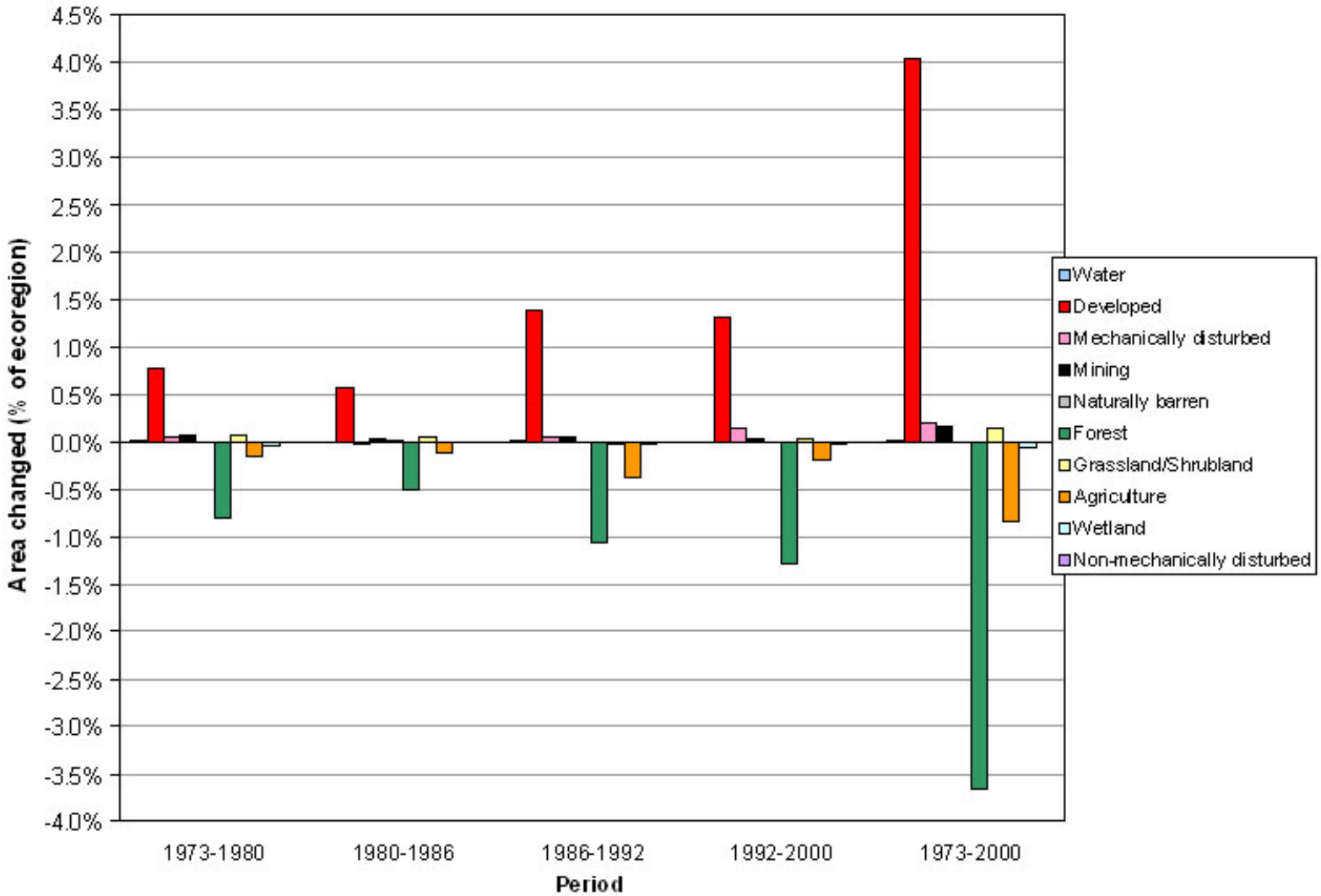


Northeastern Coastal Zone (Ecoregion 59)

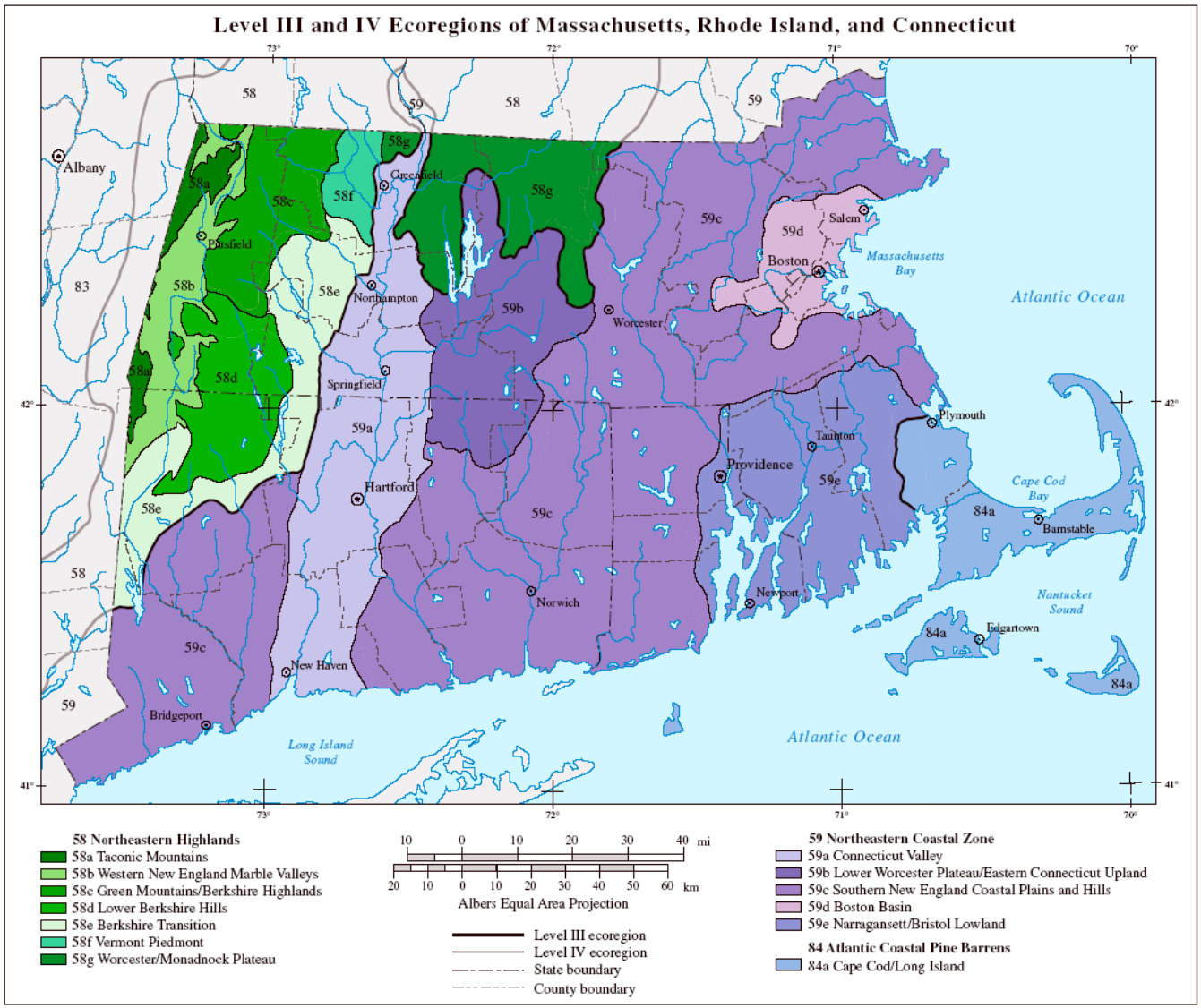
- The Northeastern Coastal Zone's Land Cover Trends sample blocks (the black hollow 10 km x 10 squares) overlay the USGS 1992 National Land Cover Database;



Estimated Net Percentage Change by Land Cover Class (Ecoregion 59)



Level III & IV Ecoregions - MA, RI, CT (1994)



- Landscape & process changes required updating of MA;
- CT & RI never endorsed project & products;

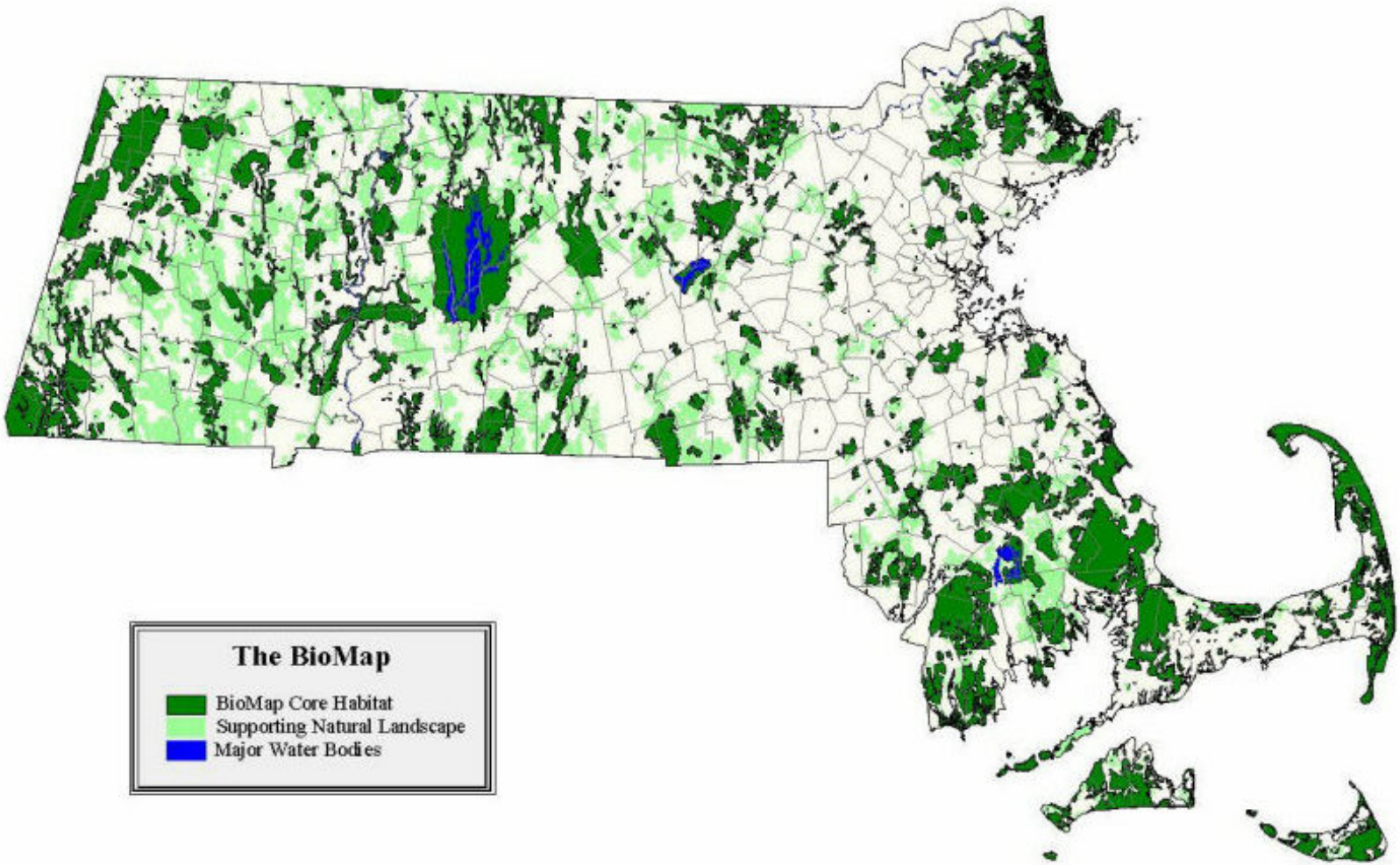
MA Use of Level IV Ecoregions

- MADEP found EPA's Level IV mapping extremely informative in selecting reference streams for biological assessment (TetraTech 2001);
- This furthered development of biological criteria for the state's streams and small rivers, through sampling of their fish and benthic macroinvertebrate communities;

MA Use of Level IV Ecoregions (cont'd)

- In 2001, the MA Natural Heritage and Endangered Species Program (MANHESP) completed BioMap;
- BioMap was designed to identify and protect Massuchusett's biodiversity by including "adequate representation from each of the 13 ecoregions" identified by EPA;

MANHESP BioMap



MA Use of Level IV Ecoregions (cont'd)

- BioMap identified Core Habitat and supporting natural landscapes, most critical for protection and maintenance of biodiversity.

- MANHESP Living Waters project furthered this goal focusing on protection of MA freshwater biodiversity;

***Our Irreplaceable Heritage: Protecting Biodiversity in Massachusetts* (1998);**

- From 1950 to 2000, the population of MA increased 28%, area of developed land increased 200%;
- Compared development rates in two MA ecoregions: Connecticut River Valley and the Worcester Plateau; development often follows geology and topography;
- Recommended that MA identify “an equitable distribution of biologically viable conservation lands at all topographic elevations and across all ecoregions” (MA CWCS 2005);

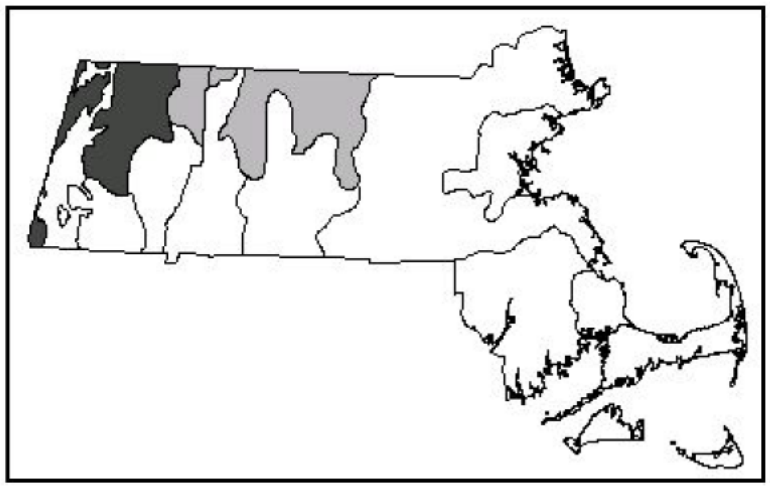
***Classification of the Natural Communities of Massachusetts* (2001)**

- "Sub-ecoregions … are particularly useful for statewide ecological inventory and assessment activities, including vegetation classification" (Swain and Kearsley 2001);
- "In the vegetation classification, each community description is accompanied by a sub-ecoregion line map showing the sub-ecoregion boundaries";

Source: *Classification of the Natural Communities of Massachusetts* (Swain and Kearsley 2001)

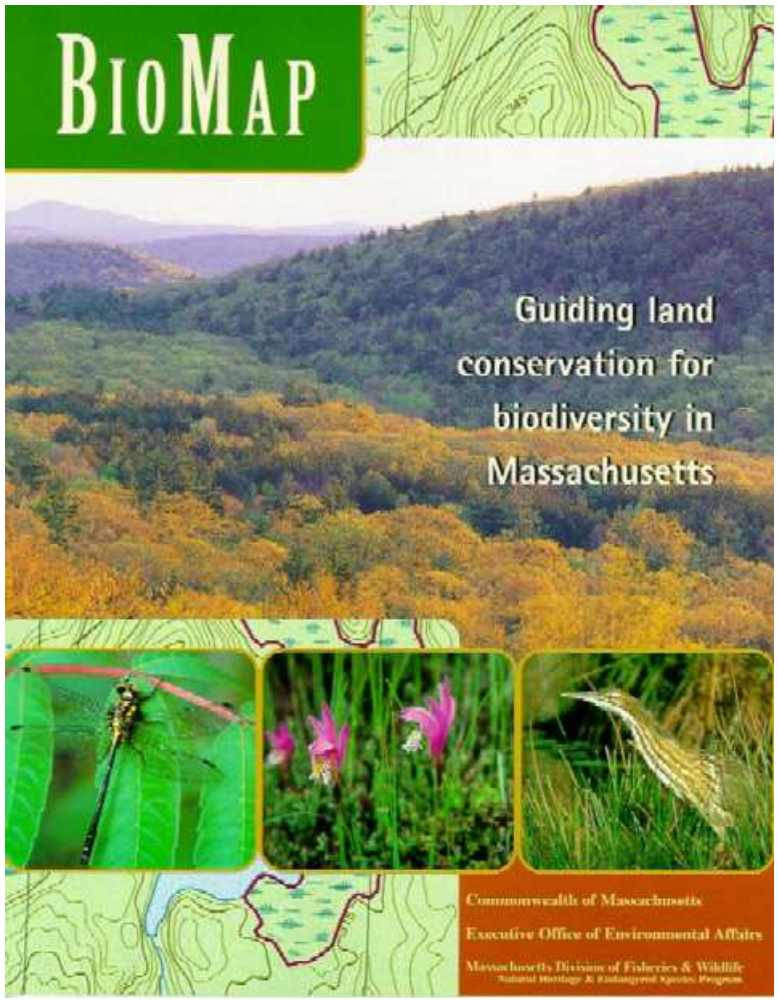
Level IV Ecoregions and MA Natural Community Classification

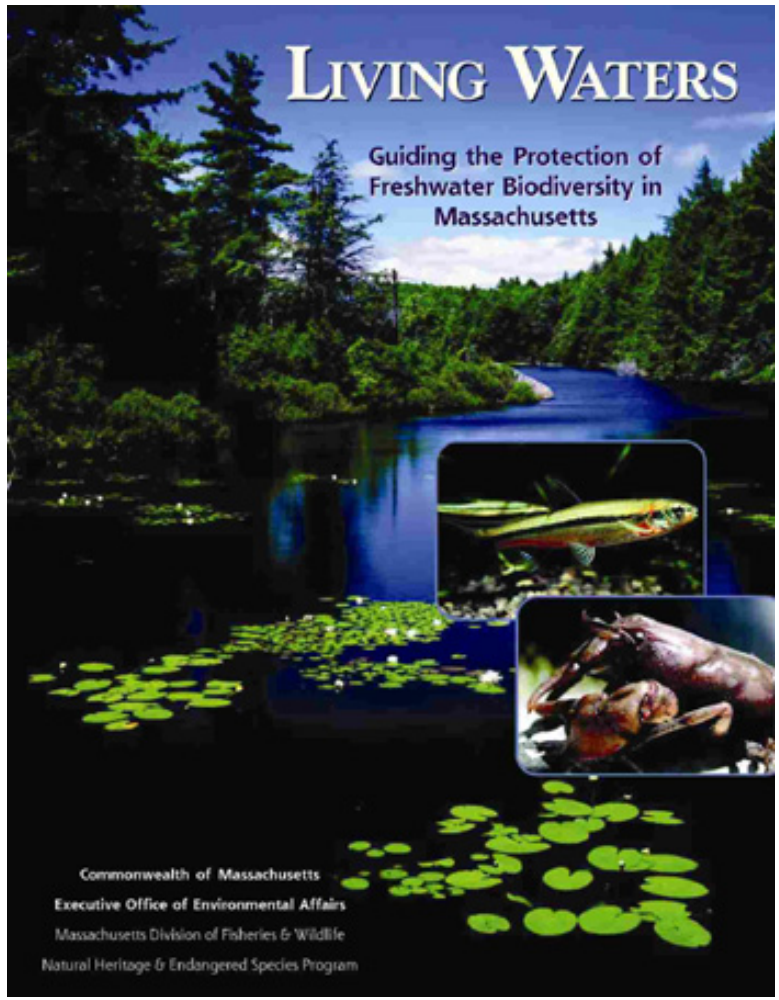
- Level IV ecoregions in which community type is known to occur shaded ***dark gray;***
- Level IV ecoregions with probable occurrences shaded in ***light gray***;
- Level IV ecoregion in which community is not believed to occur is left ***white*** (Swain and Kearley 2001)



Spruce-Fir Boreal Swamp - Forested wetlands of Berkshire Highlands and north-central Massachusetts dominated by red spruce and balsam fir.

MANHESP BioMap and Living Waters Ecoregional Publications





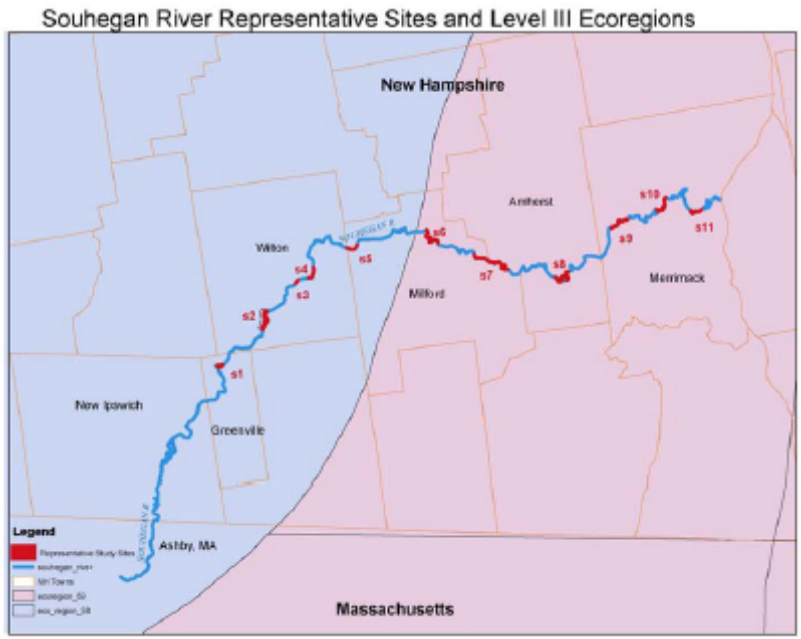
Source: http://www.mass.gov/dfwele/dfw/nhesp/nhpubs.htm

S. New England Target Fish Community (TFC) Development

- “Define the fish community that is appropriate for a natural river in southern New England” (Bain and Meixler 2000);
- Maintain biological integrity defined as “a balanced, integrated, adaptive community” (Karr, 1991);
- Identify impaired community using sampling and metrics and set fisheries management goals based on reference rivers and habitats;

Target Fish Community (TFC) Development in MA, CT & NH

- Applied Bain and Meixler's (2000) TFC to Upper and Lower Souhegan R. (NH), Lamprey R. (NH), Charles R. (MA), Ipswich R. (MA) and Quinebaug R. (MA/CT);



Souhegan R. Representative Sites and Level III Ecoregions

MADEP Applications of TFC

- TFC shows MA river fish communities are being impacted by water quality and quantity and habitat alteration;
  - Fisheries-Based Watershed Management Plans;
  - Coldwater Fishery Resource (CFR) Designations;
  - Water Quality Standards (DEP);
  - USGS Publications;
  - State Wildlife Grants;
  - Sustainable Forestry;
  - NFHI/EBT Joint Venture;

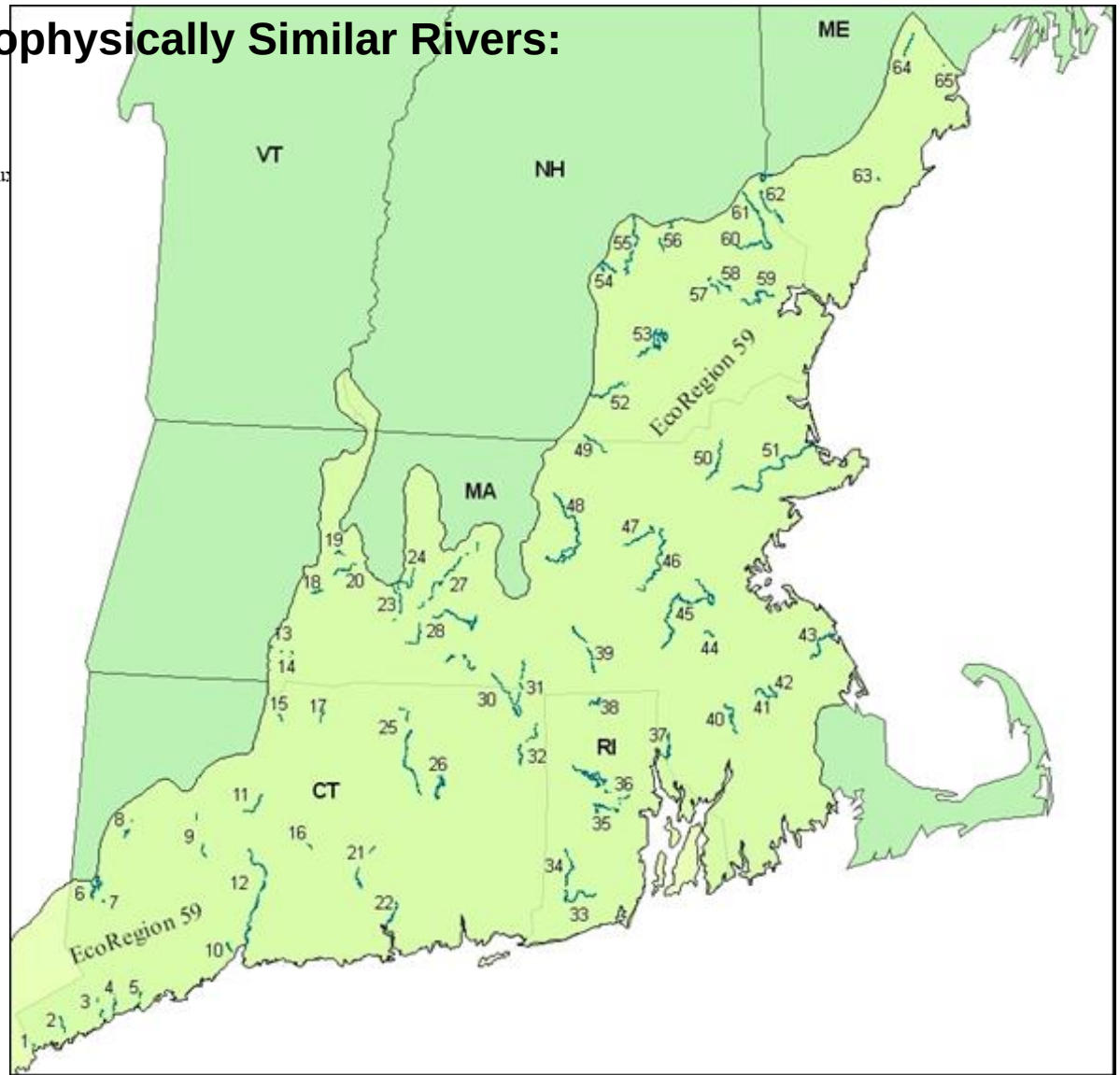
Source: *Restoring Massachusetts Rivers: Habitat and Fluvial Fish* (Todd Richards, MADFW) http://www.mass.gov/dfwele/river/pdf/flowconfrichards.pdf

65 Potential Lamprey River Reference Rivers in EPA Level III Ecoregion 59

- **Zoogeographically & Geophysically Similar Rivers:**

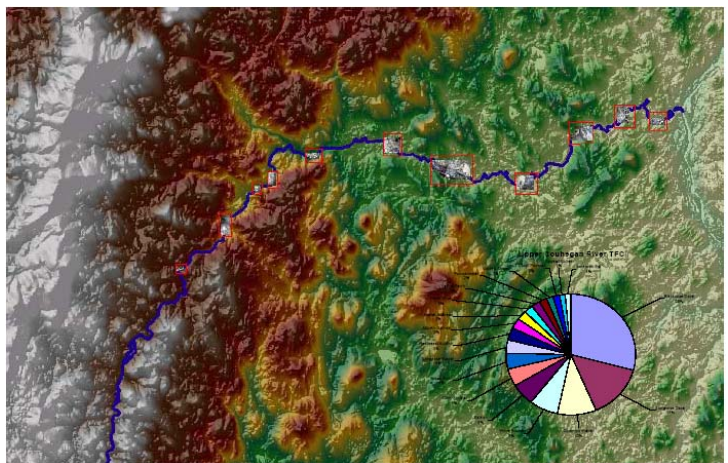
Key:

1. Byram River
2. Rippowan River
3. Norwalk River
4. Saugatuck River
5. Mill River
6. Upper Still River
7. Still River
8. Shepaug River
9. Naugatuck River
10. West River
11. Farmington River
12. Quinnipiac River
13. Little River
14. Munn Brook
15. West Branch Farmington River
16. Mattabesset River
17. Stony Brook
18. Manhan River
19. Mill River
20. Fort River
21. Salmon River
22. Eightmile River
23. Swift River
24. East Branch Swift River
25. Willimantic River
26. Shetucket River
27. Ware River
28. Quaboag River
29. Upper Quinebaug River
30. Quinebaug River
31. French River
32. Fivemile River
33. Pawcatuck River
34. Wood River
35. South Branch Pawtu
36. Pawtuxet River
37. Ten Mile River
38. Branch River
39. Blackstone River
40. Mill River
41. Town River
42. Taunton River
43. North River
44. Neponset River
45. Charles River
46. Sudbury River
47. Assabet River
48. Nashua River
49. Nissitissit River
50. Shawsheen River
51. Ipswich River
52. Souhegan River
53. Cohas Brook
54. Turkey River
55. Soucook River
56. Suncook River
57. Mile Brook
58. North River
59. Lamprey River
60. Isinglass River
61. Cocheco River
62. Salmon Falls River
63. Kennebunk River
64. Pleasant River
65. Piscatagua River

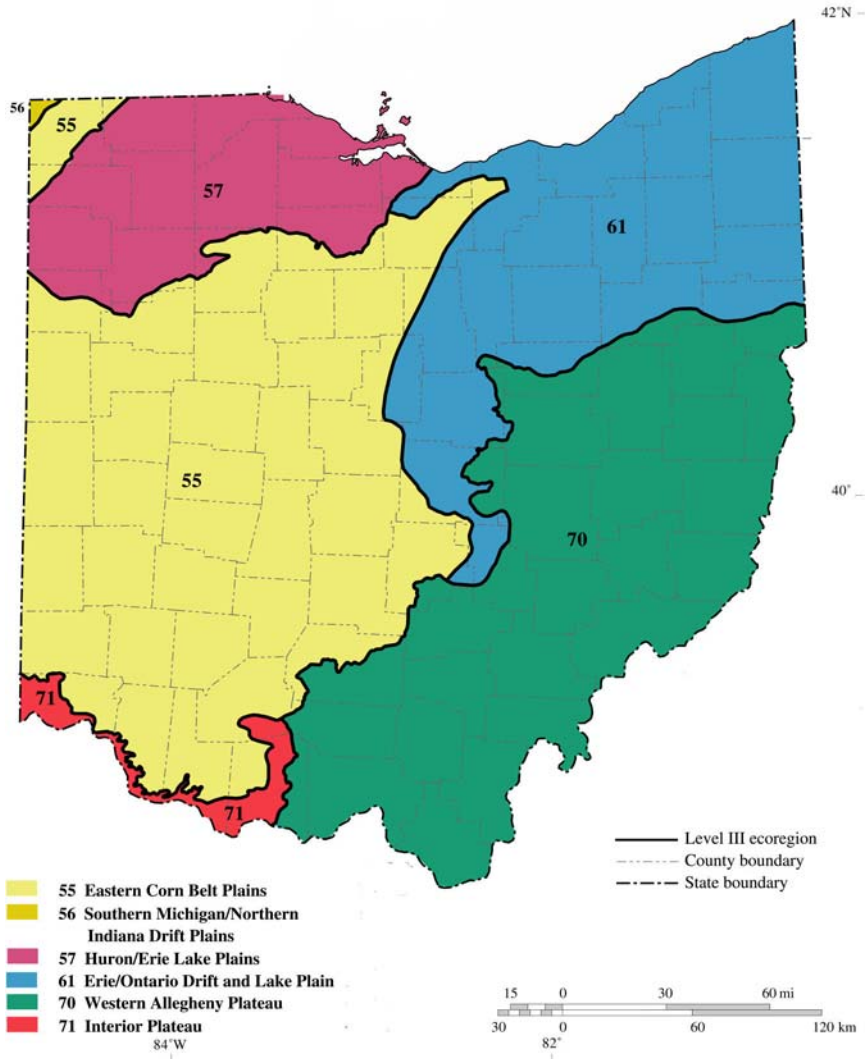


TFC for Upper and Lower Souhegan River, NH

- For the Souhegan River “[D]etermination of the zoogeographic similarity of areas is based on an analysis of geology, physiography, vegetation, climate, soils, land use, wildlife and hydrology to identify ecologically similar regions, or Ecoregions” (Legros 2005);

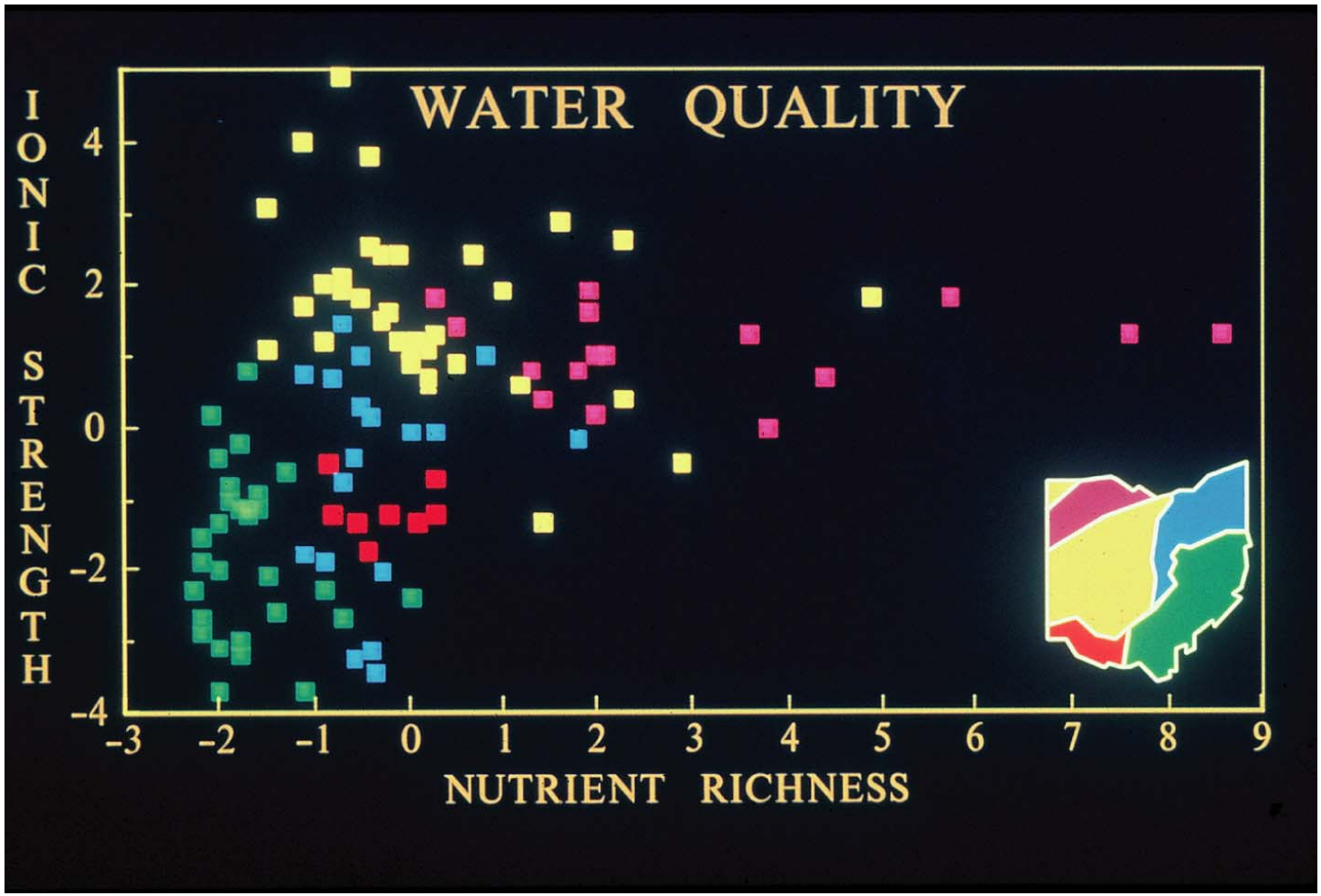


Six Level III Ohio Ecoregions



Level III ecoregion water sampling sites cluster with similar chemical concentrations (i.e. ionic strength and nutrient richness) in the following graph (Griffith et al. 1999)

Correspondence between Ohio Level III Ecoregions and Water Quality Spatial Pattern



Water Chemical Composition Differs between Level III Ohio Ecoregions

- The previous graph shows “..results of two principal components analyses of median stream values of ionic strength variables (conductivity, alkalinity, calcium, magnesium, and total hardness), and nutrient richness variables (total phosphorus; nitrate-, nitrite-, ammonia-, and Kjeldahl nitrogen; and total organic carbon) collected from the reference watersheds”(Griffith et al. 1999).

EPA-NE/NEIWPCC State Workshop – Spring, 2010

- EPA-NE and NEIWPCC are organizing a New England/New York state workshop for Spring, 2010 to illustrate how some states, such as Tennessee, have applied ecoregions in their water programs;
- Hope to have expert(s) from TN attend and continue as consulting resources for New England and New York state water programs interested in exploring ecoregional applications;

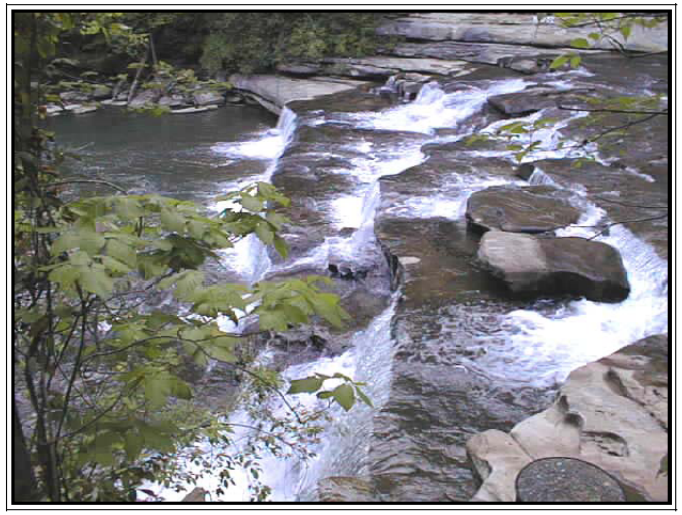
Some Tennessee (TN) Ecoregionally Based Reports

DEVELOPMENT OF REGIONALLY-BASED NUMERIC INTERPRETATIONS OF TENNESSEE'S NARRATIVE BIOLOGICAL INTEGRITY CRITERION

Tennessee Department of Environment and Conservation
Division of Water Pollution Control
7th Floor L & C Annex
401 Church Street
Nashville, TN 37243-1534

Numeric Biological Integrity Criterion

2006 305(b) Report
The Status of Water Quality in Tennessee



Division of Water Pollution Control
Tennessee Department of Environment and Conservation

2006 305(b) Report

Some TN Ecoregionally Based Reports (cont'd)

REGIONAL CHARACTERIZATION OF STREAMS IN TENNESSEE WITH EMPHASIS ON DIURNAL DISSOLVED OXYGEN, NUTRIENTS, HABITAT, GEOMORPHOLOGY AND MACROINVERTEBRATES

Tennessee Department of Environment and Conservation
Division of Water Pollution Control
7th Floor L&C Annex
401 Church Street
Nashville, TN 37243-1534

Wadeable Stream Assessment

PROBABILISTIC MONITORING OF STREAMS BELOW SMALL IMPOUNDMENTS IN TENNESSEE

Tennessee Department of Environment and Conservation
Division of Water Pollution Control
7th Floor L&C Annex
401 Church Street
Nashville, TN 37243-1534

Probabilistic Monitoring

Some TN Ecoregionally Based Reports (cont'd)

DEVELOPMENT OF REGIONALLY-BASED pH CRITERIA FOR WADEABLE STREAMS

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Division of Water Pollution Control
7th Floor L&C Annex
401 Church Street
Nashville, TN 37243-1534

Devmt of Wadeable Stream pH Criteria

HABITAT QUALITY OF LEAST-IMPACTED STREAMS IN TENNESSEE

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Division of Water Pollution Control
7th Floor L&C Annex
401 Church Street
Nashville, TN 37243-1534

Habitat Quality of Reference Streams

Some TN Ecoregionally Based Reports (cont'd)

DEVELOPMENT OF REGIONALLY-BASED INTERPRETATIONS OF TENNESSEE'S NARRATIVE NUTRIENT CRITERION

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Division of Water Pollution Control
7th Floor L & C Annex
401 Church Street
Nashville, TN 37243-1534

Narrative Nutrient Criteria

TENNESSEE'S PLAN FOR NUTRIENT CRITERIA DEVELOPMENT

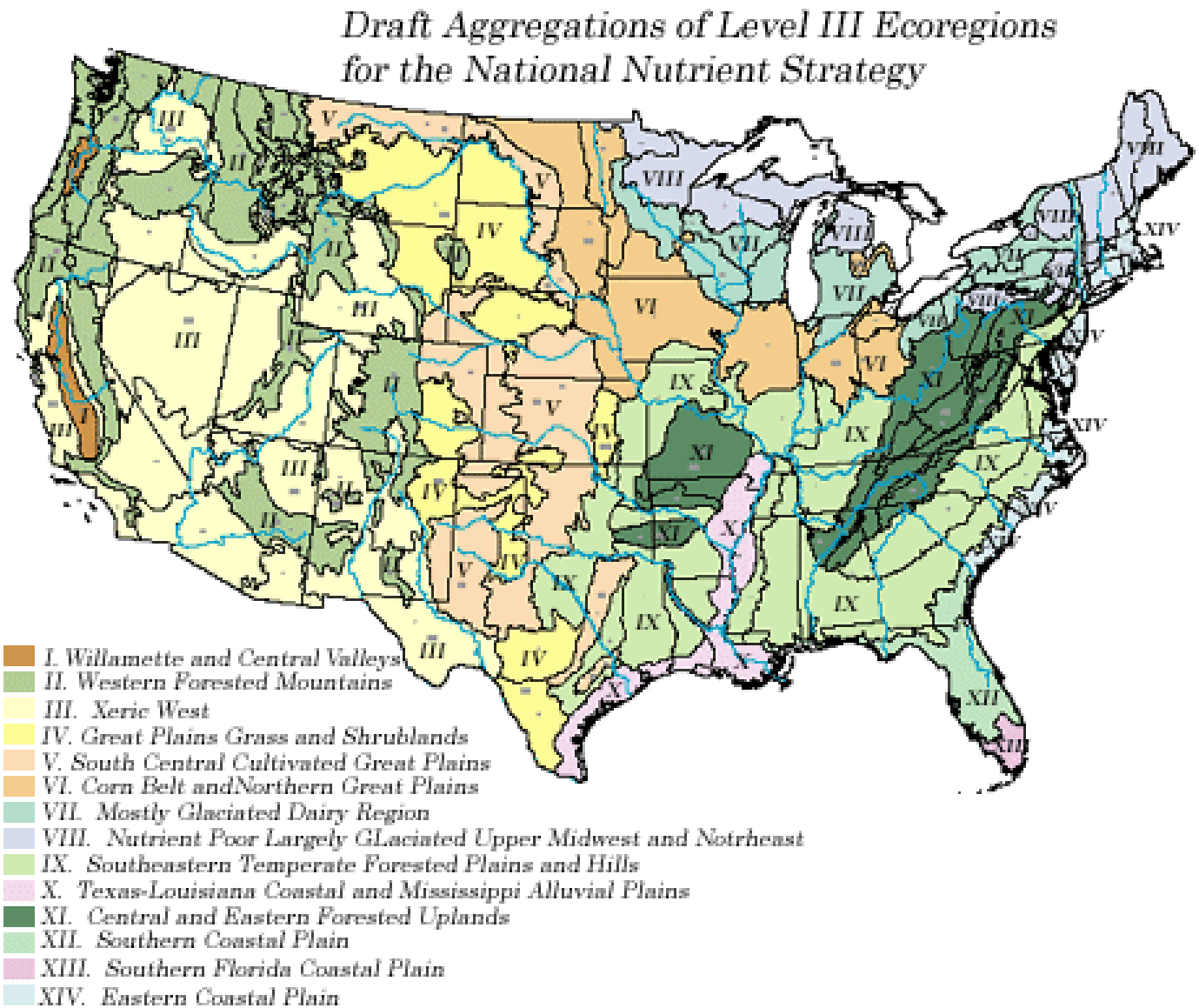
Revised October, 2004

DEC
Environment & Conservation

Planning and Standards Section
Division of Water Pollution Control
Tennessee Department of Environment and Conservation
7th Floor, L & C Annex
401 Church Street
Nashville, Tennessee 37243-1534

Nutrient Criteria Development

EPA's 14 Nutrient Ecoregions (2003)



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“Ecoregions of New England” - Endorsing Agencies and NGOs

- EPA-New England
- USGS
- NRCS
- CTDEP
- RIDEM
- MADEP
- ME Dept of Conservation
- MEDEP
- NHDES
- NH Fish and Game
- VTDEC
- VT Fish & Wildlife
- The Nature Conservancy

Saving the Last Great Places

Ecoregions of New England – Principal Authors

- Glenn E. Griffith (Dynamac Corporation)
- James M. Omernik (USGS; EPA-retired)
- Sandra A. Bryce (Dynamac Corporation)
- Joshua Royte (The Nature Conservancy)
- Wayne D. Hoar (NRCS)
- Joseph W. Homer (NRCS),
- Don Keirstead (NRCS)
- Kenneth J. Metzler (CTDEP)
- Greg Hellyer (EPA-New England)

Agency Principal Collaborators & Contributors

- ***Katrina Kipp*** , Diane Switzer, Tom Faber, Lynne Hamjian & Tony Olsen (USEPA)
- Caroline Alves (NRCS)
- Andy Cutko (ME Natural Areas Program)
- Dave Halliwell and Roy Bouchard (ME DEP)
- Sue Gawler (NatureServe)
- Mark Anderson (TNC)
- Steve Fuller and Emily Brunkhurst (NHFG)
- Rick Chormann (NHDES)
- Rich Langdon (VTDEC)
- Leif Richardson, Everett Marshall & Eric Sorensen (VTFW)
- Lisa Wahle and Guy Hoffman (CT DEP)
- Robert Haynes and Pat Swain (MADEP)
- John Hutchinson, Jack Wittmann & Tom Loveland (USGS)

(My sincere apologies that not all those involved can be directly acknowledged)

“Ecoregions of New England” - Poster Peer Reviewers

- Charles E. Ferree (TNC)

- Patricia Swain (MA Natural Heritage and Endangered Species Program)

- Bruce W. Thompson (NRCS-retired) and

- Peter D. Vaux (University of Maine)