The Biological Condition Gradient:

Advances in Science and Application in Region 1

NWQMC

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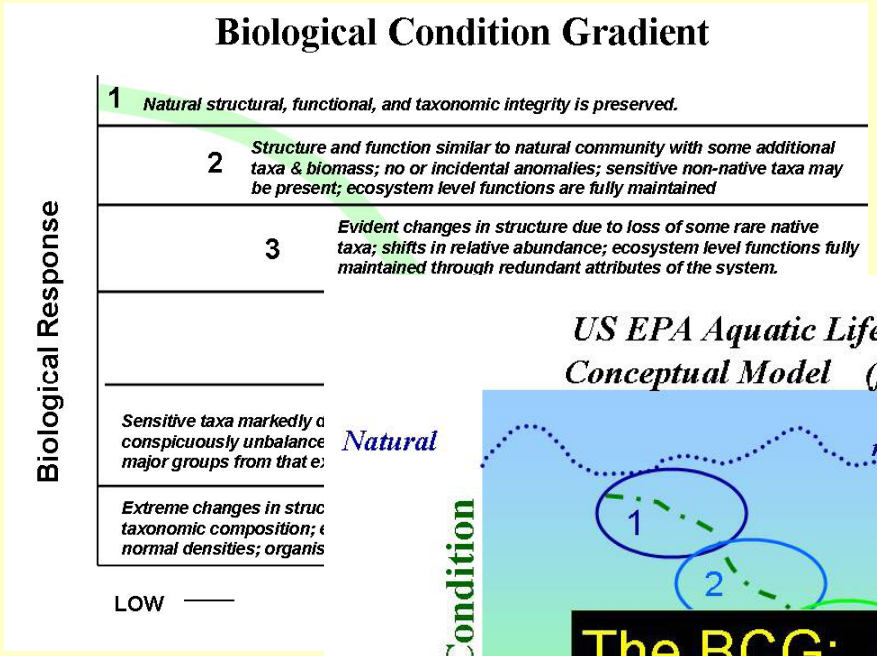
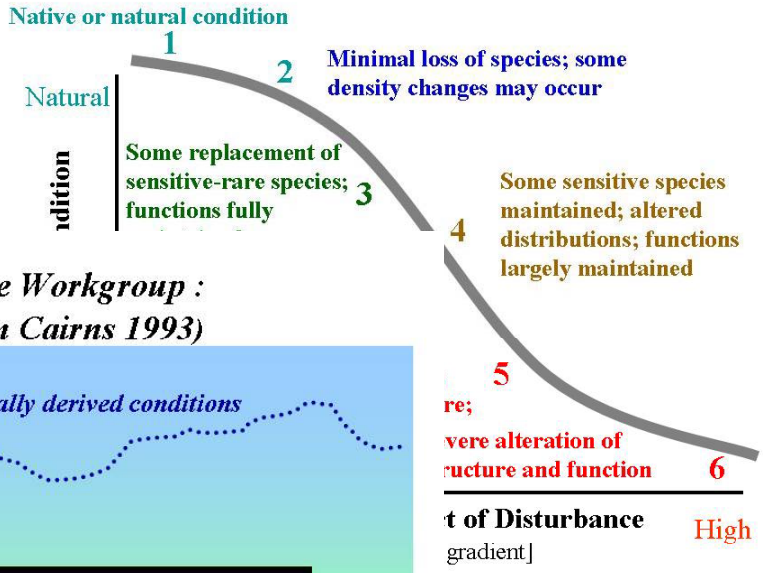
Susan P. Davies

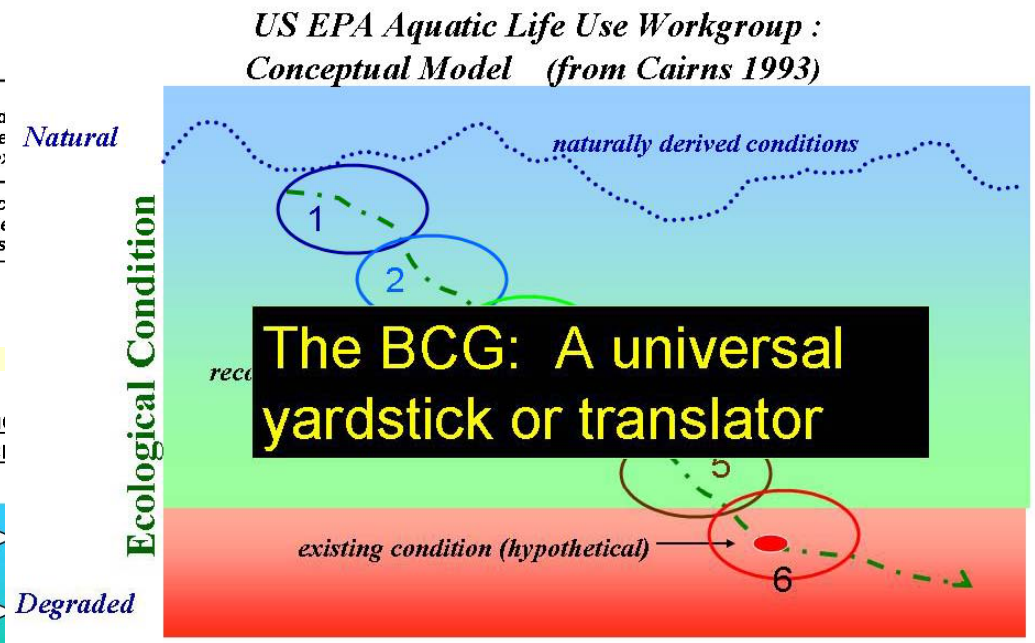
What is "The" BCG?

There are *many* BCGs

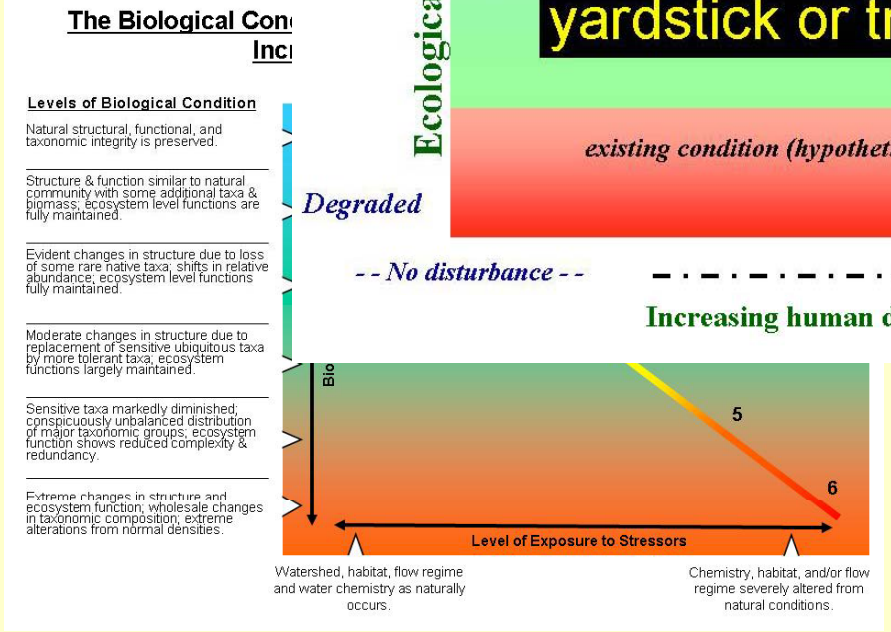
- Generalized conceptual model BCGs
- Waterbody-type specific BCGs
- Assemblage-specific BCGs
- Data-calibration BCGs
- Stressor-Response curve BCGs
- Reach scale BCGs
- Whole estuary BCGs

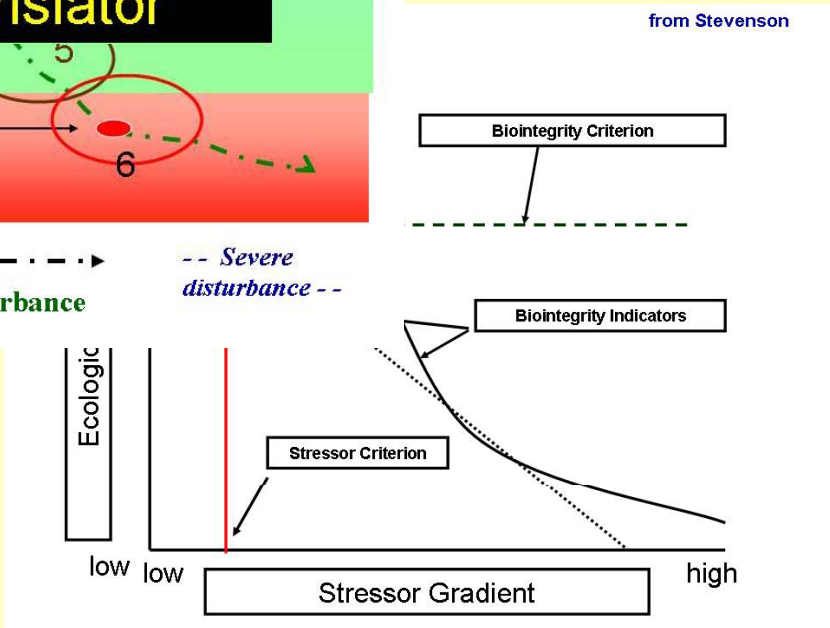






The BCG: A universal yardstick or translator



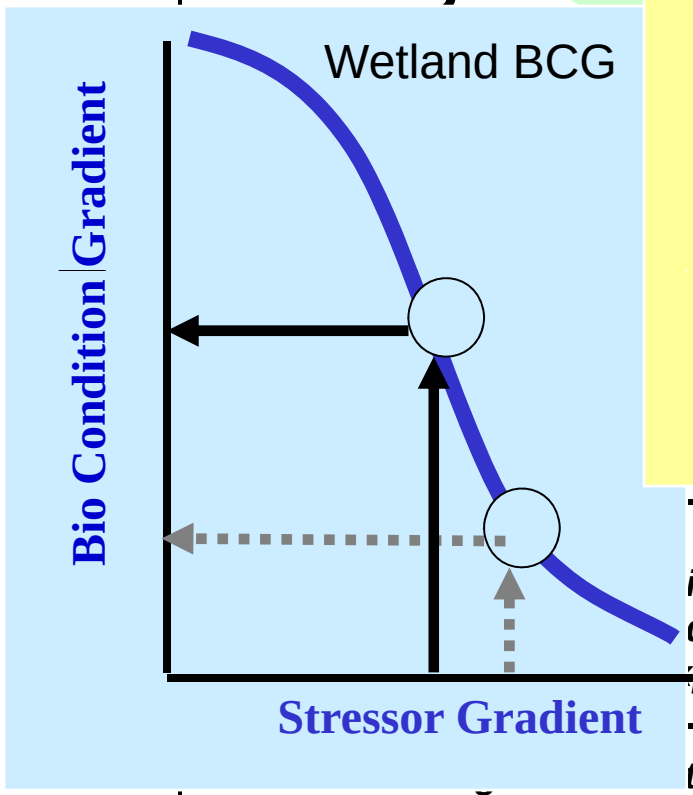


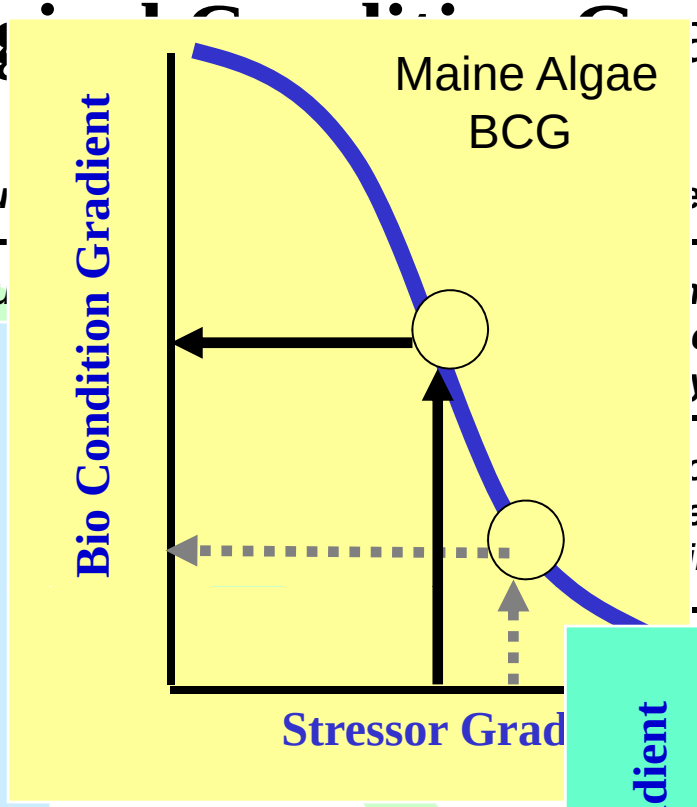
Overview of 10 Attributes

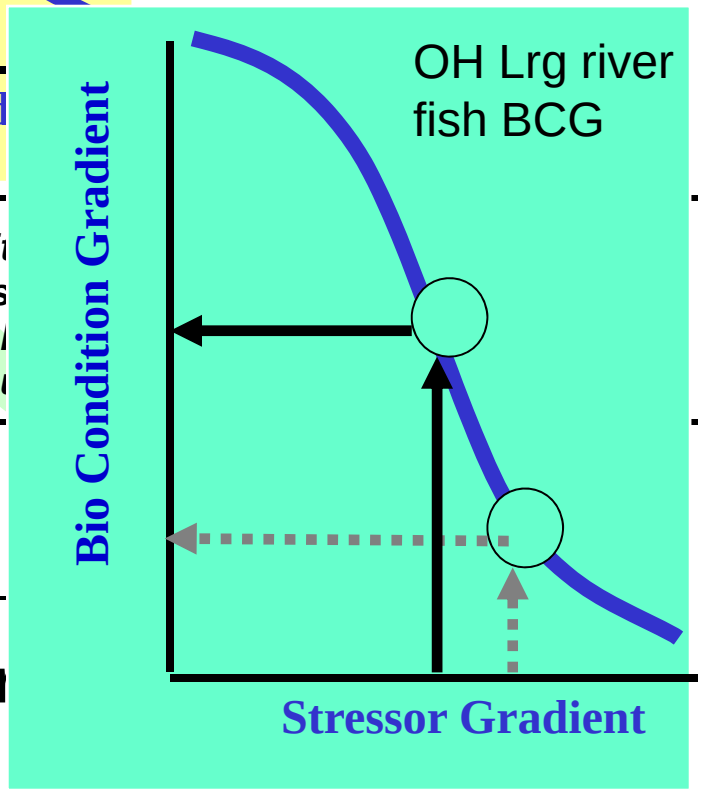
- **Taxonomic composition and tolerance**
  - Attributes I-V
  - *Sensitive-Endemic* thro[illegible]
- **Non-native taxa**
  - Attribute VI
- **Organ[illegible]ition**
  - [illegible]VII
- **[illegible]ystem function**
  - Attribute VIII
- **Physical-biotic interactions**
  - Attributes IX-X

The Y-axis Attributes

Biolog adient







1 *Natural structural, fu eserved.*

Structu

2

munity with some additional ensitive non-native taxa may y maintained

o loss of some rare native ecosystem level functions fully ibutes of the system.

iminished; d distribution of pected; organism

5 *condi stress compl build*

ture; wholesale changes in taxonomic composition; extreme alterations from normal densities; organism condition is often poor;

LOW

Level of Stressor

BCGs to Organize Complexity

- Generalized Conceptual Models
  - Northeastern temperate forested streams
  - Arid west streams
  - Wetland BCG
  - Large River BCG
  - Whole Estuary and sub-habitat BCGs
- Account for all major assemblages
- Describe gradient at different scales
- Includes stressor and response gradients

Data-driven BCGs for a Locale

Focus is on the Y-Axis only and commonly only on Attributes II thru V

- Purpose - fit **real data** to pre-established BCG conceptual model
  - Examples:

    Maine (4); NEWS (2); CT (1); PA (1?); NJ (1?); MN(1?); NAWQA-EUSE data (Bayes-Net model)

  - Usually operates at the reach or “sampling” scale
  - A specific model for a specific place, calibrated using empirical data, expert judgment, and modeling
  - Assemblage-specific (*macroinvertebrate; fish; algae)*
  - Waterbody-type specific (stream, river, wetland, estuary)

Examples from Region I-States, EPA, and USGS

Advances in Science and Management Applications

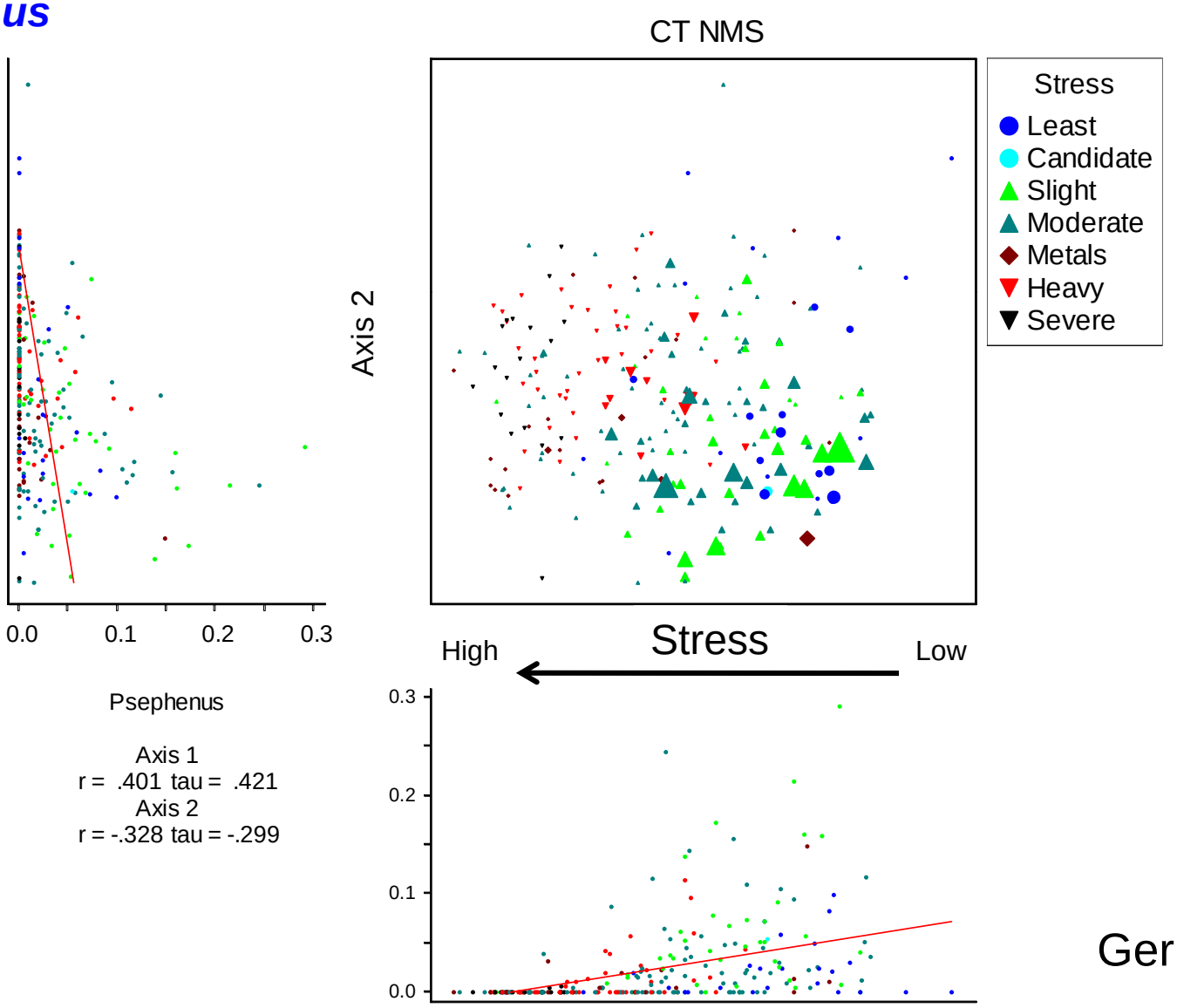
New England Wadeable Streams and WSA

- EPA, 4 states,TetraTech, NEIWPCC
- Calibrated a Regional Scale and State scale BCG from probability-design data
- Developed a BCG-based decision model
- Analyzed X and Y axis data for evidence of Tier 1 sites
- Conducted a 6-way methods comparison study (*4 states+NEWS+WSA methods*)
- BCG-based site assessment results reported in federal 305b reports

SUB-SESSION 9-2

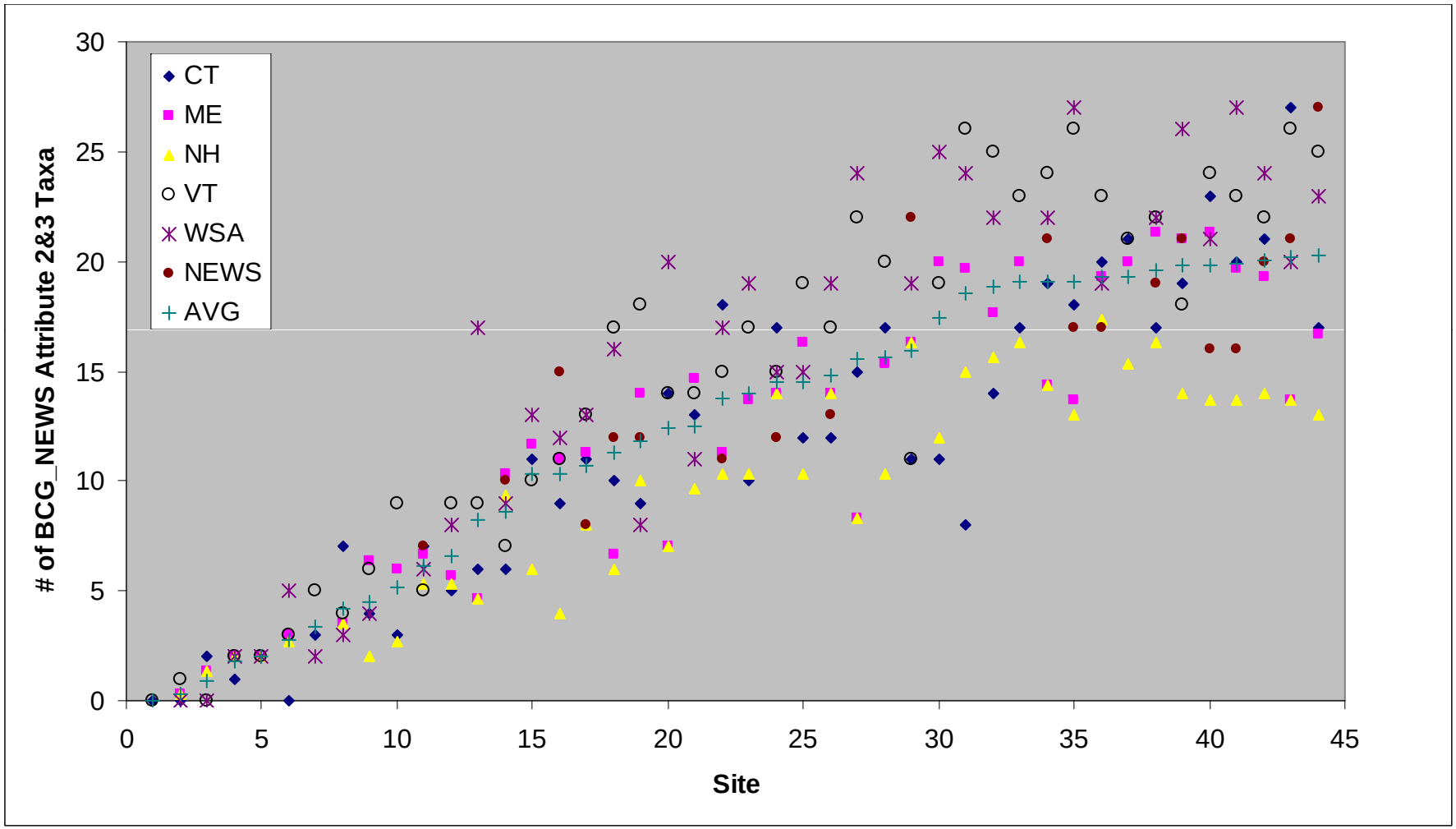
New England Wadeable Streams and WSA
Attribute assignments-*empirical information **and** expert opinion*

Psephenus



Gerritsen et al

New England Wadable Streams Methods Comparison



J Stamp, TetraTech

Benefits

- Fostered exchange of ecological knowledge among states and EPA
- Uncovered hidden biases and revealed limits of fact-based biological understanding
- Produced a common language to communicate assessment outcomes (calibrated BCG model)

Estuary BCG:
Region 1
At. Ecol. Div. and Off. Ecosyst. Protect.
plus several national and state estuary programs

- Progress conceptualizing and calibrating a BCG for estuaries

"E-BCG"

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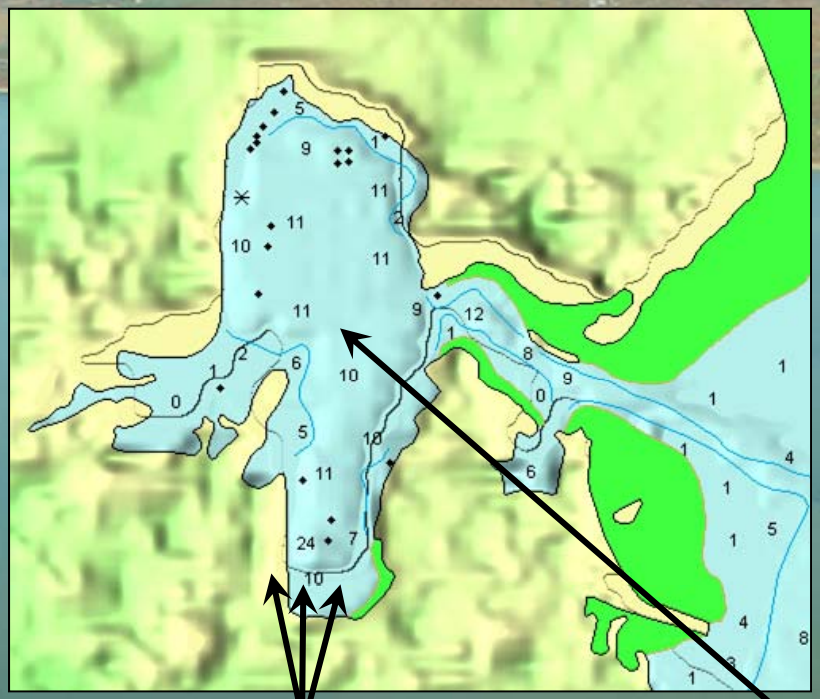

What scale?

What biological indicators?

Consider habitat mosaic?

Consider single habitat?

How to put it all together?

The Estuary BioCondition Gradient

	Scale and Attribute	Potential Metrics and Description
STRUCTURE	***Whole Estuary:*** **Waterbody-Scale Structure and Compositional Complexity**	Metrics of biological structure or composition along the natural estuarine gradient, e.g., integrative planktonic community composition or biotope mosaics, recognizing also loss of habitat area or total absence of habitats due to human activities. Examples include phytoplankton or zooplankton community measures, presence/quantity of sensitive or susceptible biotopes, metrics of whole-system biotope mosaics, integrative epifaunal measures across multiple habitat types, etc.
	Single Habitat: **Habitat-Scale Structure and Compositional Complexity**	Measures within a single habitat of community structure or composition, habitat extent, vegetation or faunal density, organism size, patchiness, etc, recognizing also total or partial loss of habitat area due to human activities. Examples include benthic macroinvertebrate indices for soft-sediment areas, presence/quantity of sensitive or susceptible taxa, fish community indices for specific habitats, wetland vegetation indices.
CONDITION	***Whole Estuary:*** **Waterbody-Scale Community or Biotope Condition**	Measures of condition along the estuarine gradient including incidence/severity of system-wide disease outbreaks, measures or indices of biotope health or condition, HABs, resiliency of estuary to withstand perturbations.
	Single Habitat: **Habitat-Scale Species or Organism Condition**	Metrics of organism condition within a single habitat, e.g., fish tumors, seagrass "health", epiphitization, summary metrics or indices of "health" or condition; shellfish bed disease, etc. Examples include seagrass condition indices, fish pathology indices, integrative wetland condition indices.
FUNCTION	***Whole Estuary:*** **Waterbody Function**	Measures of energy flow, trophic linkages, and material cycling among habitats; measures of functional attributes along the natural estuarine gradient. These can also be characterized by proxies or snapshot metrics that correlate to functional measures. Examples include P/R ratios, benthic:pelagic production ratios, indices of system metabolism, measures of production such as Chl-a concentrations, macroalgal biomass.
	Single Habitat: **Habitat Function**	Measures of energy flow, trophic linkages, and material cycling within a single habitat. These may be characterized by proxies or snapshot metrics that correlate to functional measures.
CONNECTIVITY	***Whole Estuary:*** **Waterbody Connectivity**	Metrics of exchanges or migrations of biota to/from adjacent waterbodies, e.g., between the estuary and the larger waterbody/coastal ocean, or between the estuary and the river. These analyses recognize that the important within-waterbody measures may be primarily affected by factors existing outside the boundaries of the waterbody. Proxies (such as measures of habitat isolation, habitat edge, or fragmentation) may be used.
	Single Habitat: **Habitat Connectivity**	Metrics of exchanges or migrations of biota to/from adjacent habitats within the estuary. Proxies may be used, e.g., structural measures of habitat connectance, fragmentation, extent of edge, etc.
NON-NATIVES	***Whole Estuary:*** **Non-Native Taxa in Waterbody**	Estimated numbers of species/individuals or biomass of invasives or non-natives in the estuary or waterbody; measures of the effects of invasives/non-natives estuary-wide.
	Single Habitat: **Non-Native Taxa in Habitat**	Estimated numbers of species/individuals or biomass of invasives or non-natives in a habitat; measures of the effects of invasives/non-natives in a habitat.

<u>Five attributes</u>:
structure,
function,
condition,
connectivity,
non-native species

<u>Two scales</u>:
whole estuary,
single habitat

Cicchetti et al 2009

Benefits

- Advancing the ability to address issues of observational and management scale
- Addressing higher scale, “cross-cutting” BCG Attributes VIII (Function), IX (Scale) and X (Connectance)
- Explicitly incorporating habitat factors and habitat-forming biota.

USGS-NAWQA and Duke University

plus State and NGO partners

Effects of Urbanization on Stream Ecosystems (EUSE)

Bayesian Network BCG Model

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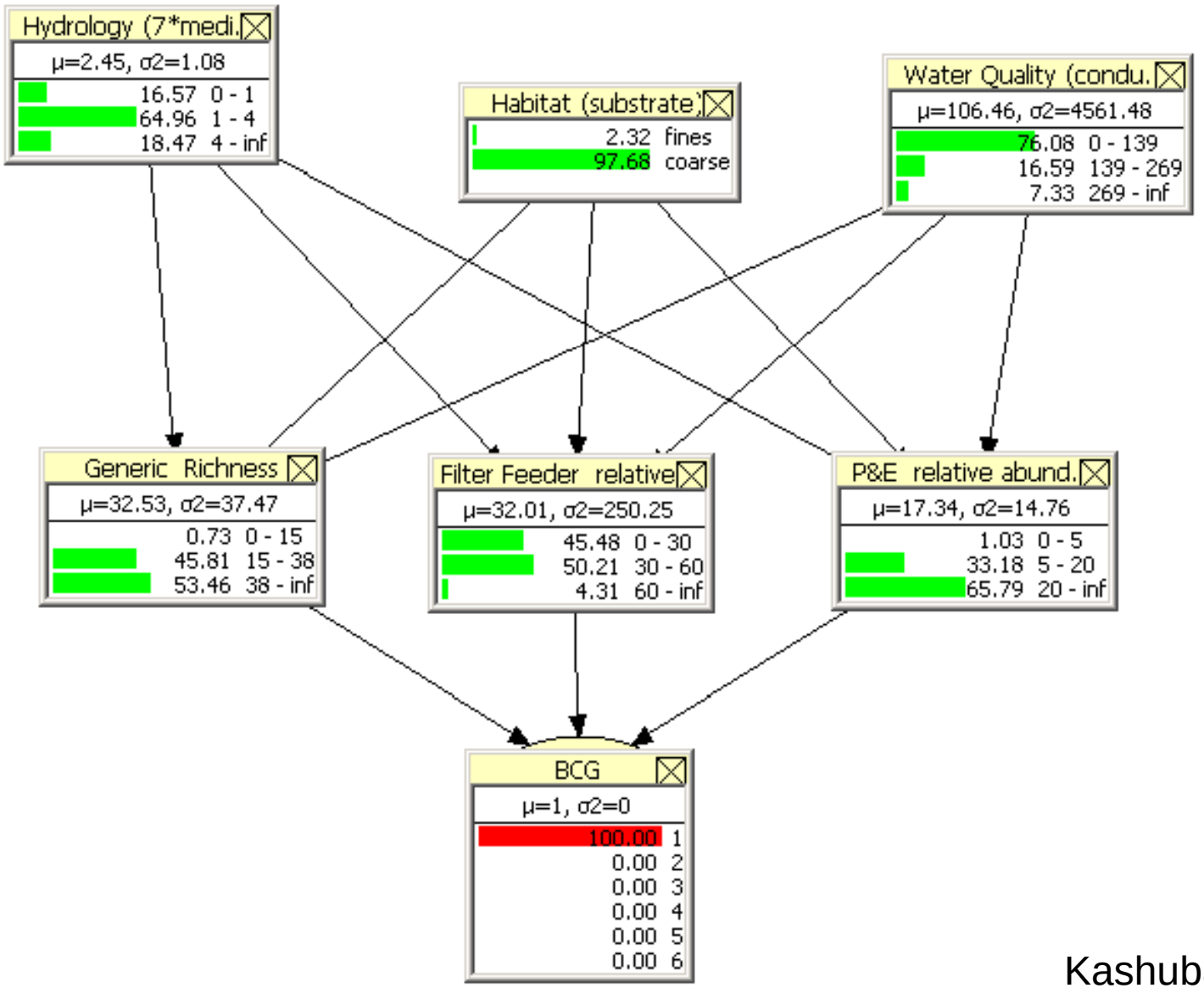
Bayes-Net Diagnostic probabilities



Kashuba

Benefits

- Model can assist in diagnosis of causes of biological impairment
- Model can provide insight into the likely biological results of various BMP options
- Model ground-truths (and/or corrects) biologists' expert opinions

Some State Examples

Danielson-Maine Algae Monitoring and Nutrient Criteria Goals

- **Determine ecologically meaningful tiered *algal biocriteria***
- **Determine ecologically meaningful tiered *nutrient criteria***
- **Develop a tiered decision framework that incorporates:**
  - **nutrient concentration limits**
  - ***and* ecological response variables (aesthetics, DO- diurnal change, etc)**

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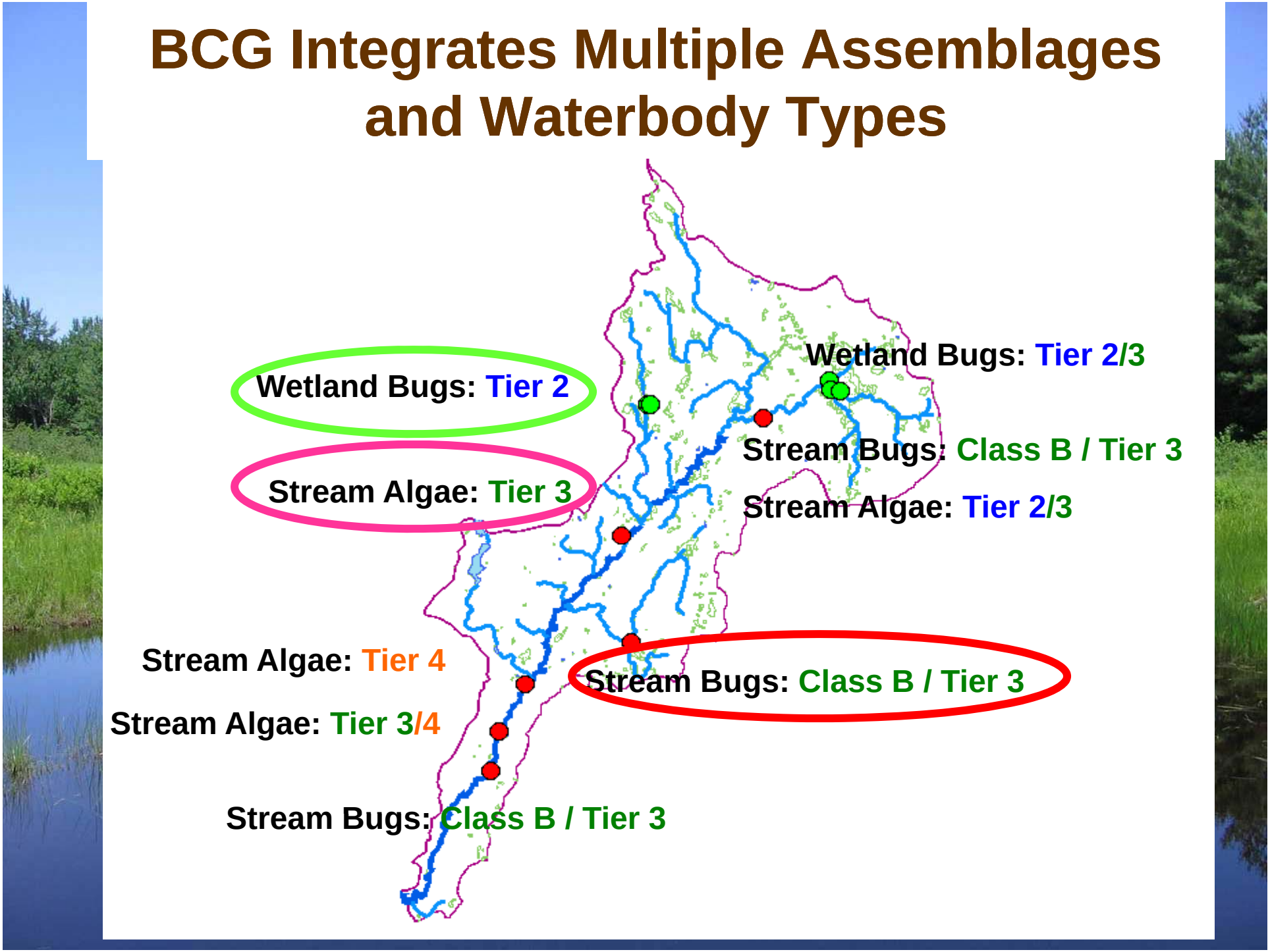
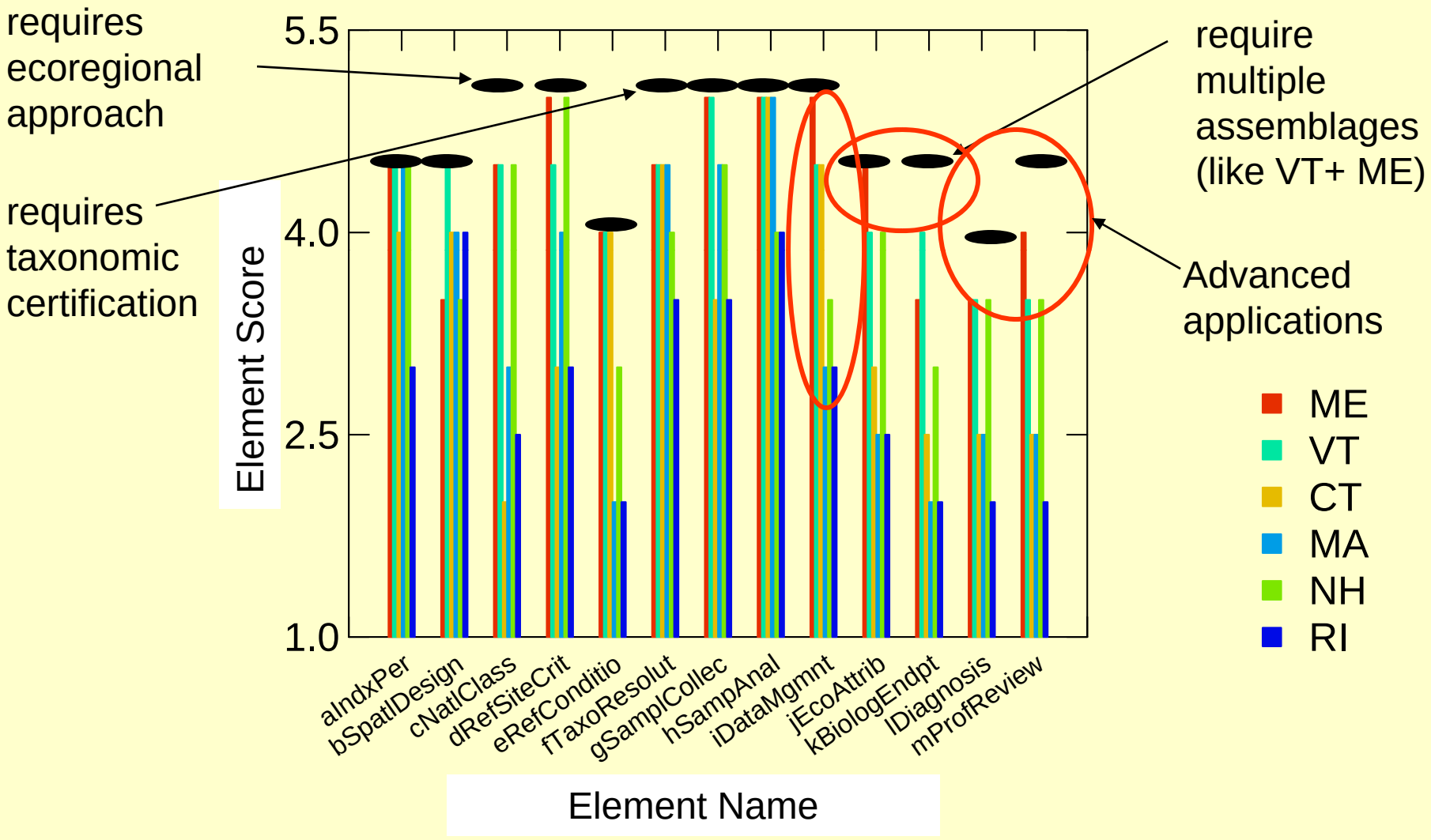
BCG Integrates Multiple Assemblages and Waterbody Types



Reg. 1 Critical Elements Evaluations



C. YODER, MBI

Defining Biocriteria Thresholds- ***partnership of science and policy***

- a public policy task
  - Requires weighing socio-economic and environmental costs and benefits
  - Requires transparency
  - Requires public participation
- a technical task
  - Requires knowledge of the strengths and limitations of the science
  - Requires local knowledge of biological potential and reference conditions
- credible bioassessment programs make it possible

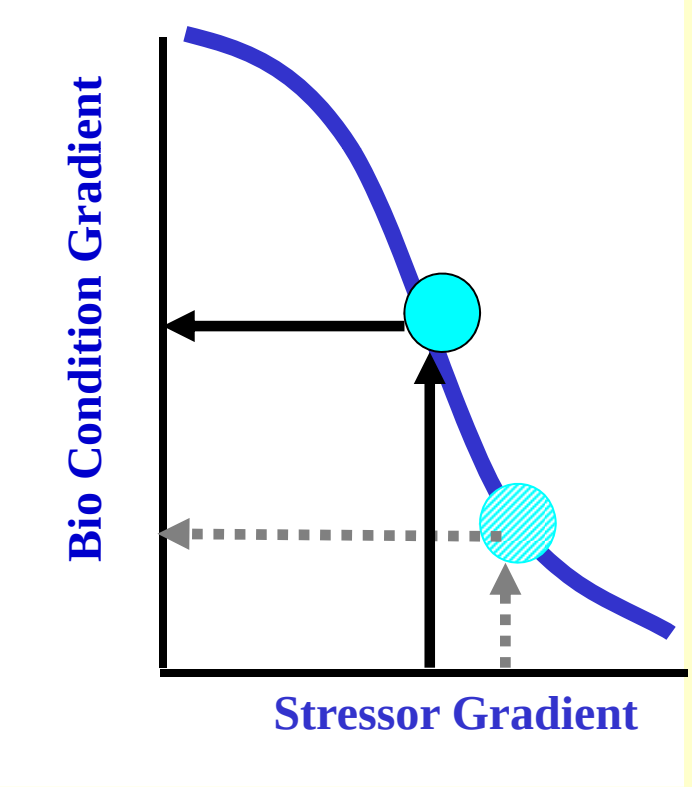
The Northeast Water Program Managers' TALU Pilot

- Program managers from six Region 1States, plus New York
- Sponsored by NE Interstate Commission (NEIWPCC); supported by EPA
- A "learning pilot"
- Engage water program managers in benefits of incorporating biological information in WQS, planning, and management

The Science behind Water Quality Goals

SCIENCE → **GOALS**

Biological Condition Gradient



A Scientific Model

Class A/AA	***"as naturally occurs"***
	BCG Tier 1-2
Class B	***"support all indigenous species; no detrimental change"***
	BCG Tier 2-3
Class C	***"support indigenous fish (salmonids); maintain structure and function"***
	BCG Tier 3-4

Water Quality Standards Framework (ex: Maine)