The New England Biological Condition Gradient (BCG)

and a

Model of Benthic Condition

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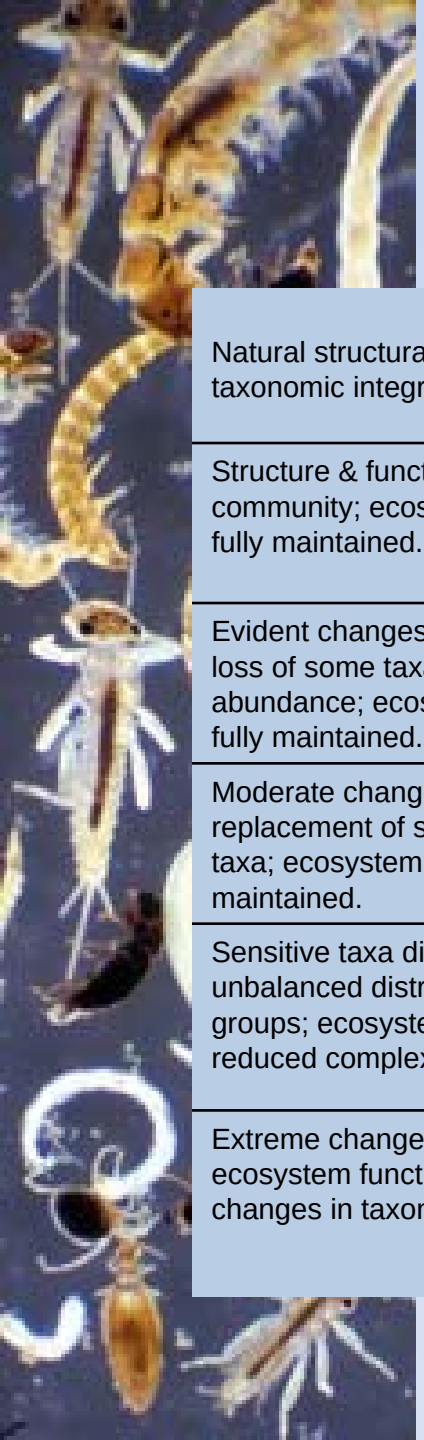
The New England BCG Team

- The Biologists of New England
- EPA
- NEIWPCC
- Tetra Tech colleagues

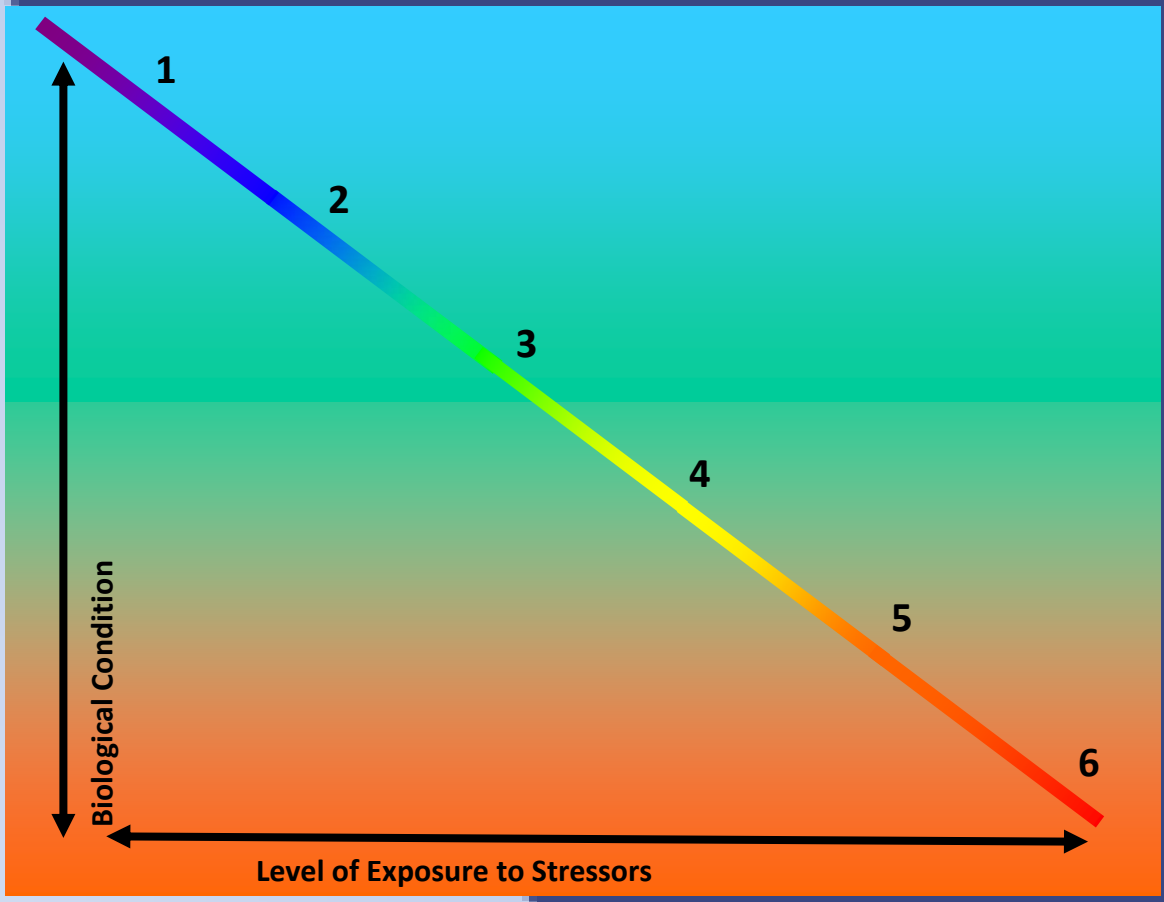
Why build a BCG model?

- The BCG is a universal assessment scale
- It allows regionwide assessments and comparisons on a level playing field
- It is another assessment tool for the States to consider

The Biological Condition Gradient



1	Natural structural, functional, and taxonomic integrity is preserved.
2	Structure & function similar to natural community; ecosystem functions fully maintained.
3	Evident changes in structure due to loss of some taxa; shifts in relative abundance; ecosystem functions fully maintained.
4	Moderate changes in structure due to replacement of sensitive ubiquitous taxa; ecosystem functions largely maintained.
5	Sensitive taxa diminished; unbalanced distribution of taxonomic groups; ecosystem function shows reduced complexity.
6	Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition.



Watershed, habitat, flow regime and water chemistry as naturally occurs.

Chemistry, habitat, and/or flow regime severely altered from natural conditions.

BCG Development Timeline

2000-2003: General BCG Conceptualization

2004: Development of NJ Decision Model (MMI Calibrated on BCG)

2005: PA BCG ratings (No MMI)

2004: Development of NE Decision Criteria Model 1 (NEWS MMI)

- NEWS data – Sampled 2000-2001 – 70 sites, additional state sites
- Emphasis on CT sites and sampling methods

2006: Revised NJ MMI to include low gradient BCG

2006: Development of CT Decision Criteria Model (CT MMI)

2009: Development of NE Decision Criteria Model 2 (NEIWPCC MMI)

- Emphasis shifted to all participating states and state methods
- WSA sites with multiple sampling methods
  - Sampled 2004/2005 – 44 sites, relatively high gradient

2009-10: Development of fish and invert BCGs for Minnesota

- Calibration of MMIS to BCGS

BCG MMI Development Process

1. Review taxa and assign attributes of tolerance and frequency
2. Review sample taxa lists and categorize into BCG tiers
   * State crews rate state samples
3. Determine rules that relate taxa occurrence and abundance, taxa attributes, and BCG tiers
4. Translate rules into a non-linear mathematical model

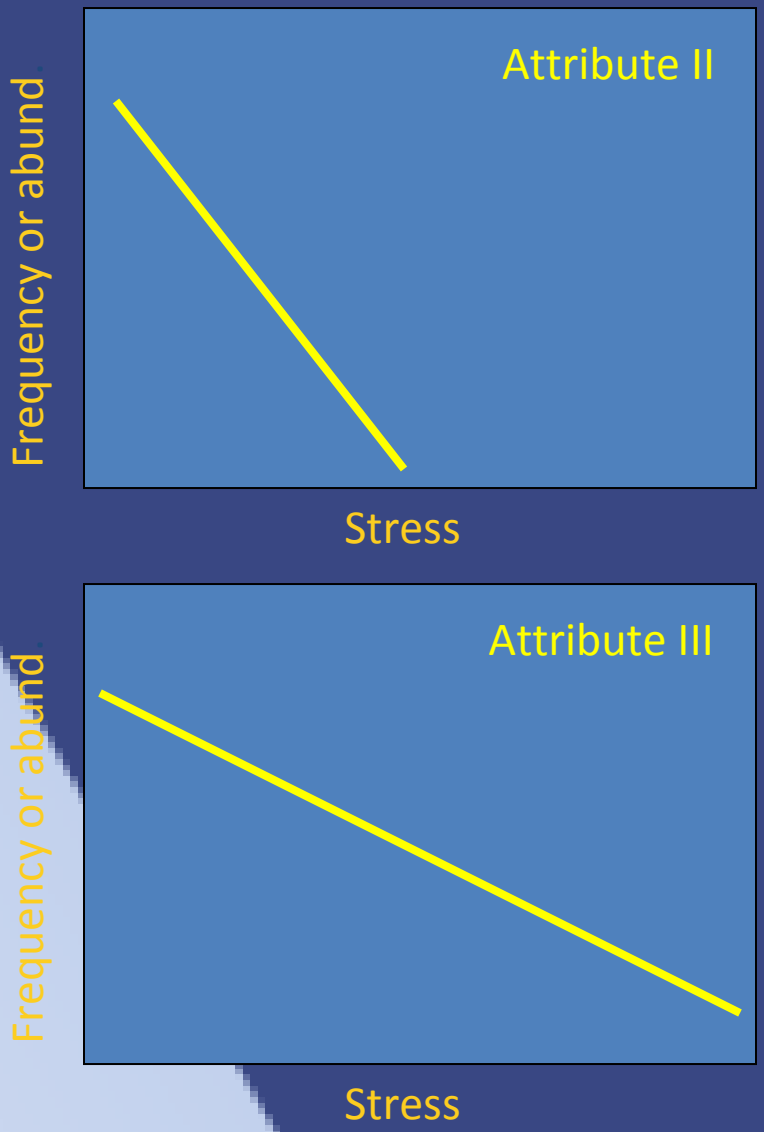
Expert Panel Conferences

Taxa Attributes

1. Historically documented, sensitive, long-lived, regionally endemic taxa
2. Highly sensitive or specialist taxa
3. Sensitive and common taxa
4. Taxa of intermediate tolerance
5. Tolerant taxa
6. Non-native taxa
7. Organism condition
8. Ecosystem Function
9. Spatial and temporal extent of detrimental effects
10. Ecosystem connectance

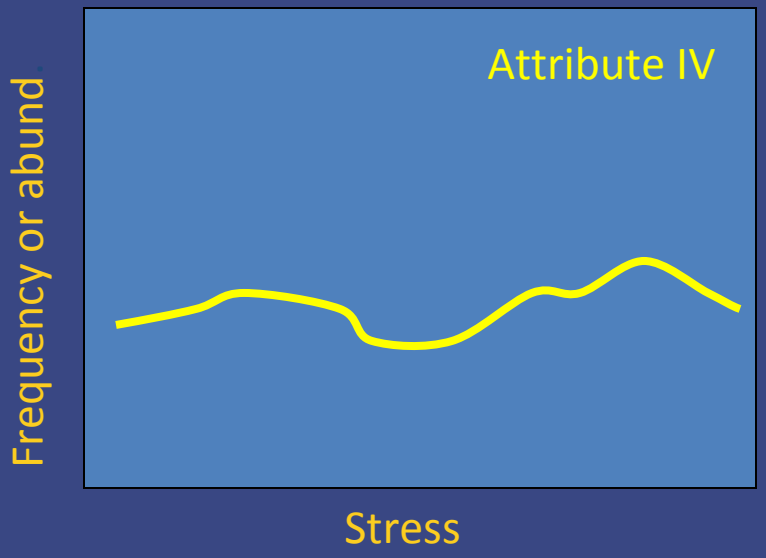
Sensitive Taxa

- Attribute I: rare-endemic taxa – are they necessarily sensitive?
- Attribute II: Highly sensitive taxa: optimum in best sites, narrow tolerance. First to disappear
- Attribute III: Intermediate - sensitive taxa: Sensitive but more tolerant: optimum in best sites, but also occur in poorer sites

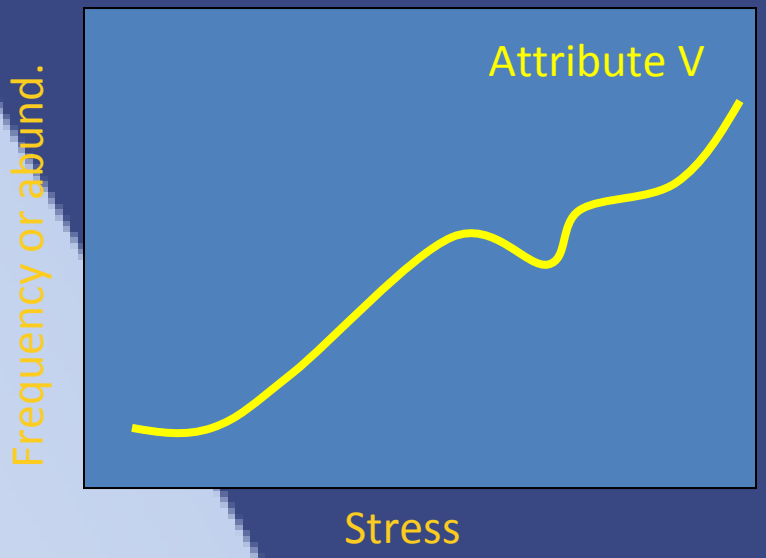


Tolerant Taxa

- Attribute IV: intermediate tolerance, found anywhere

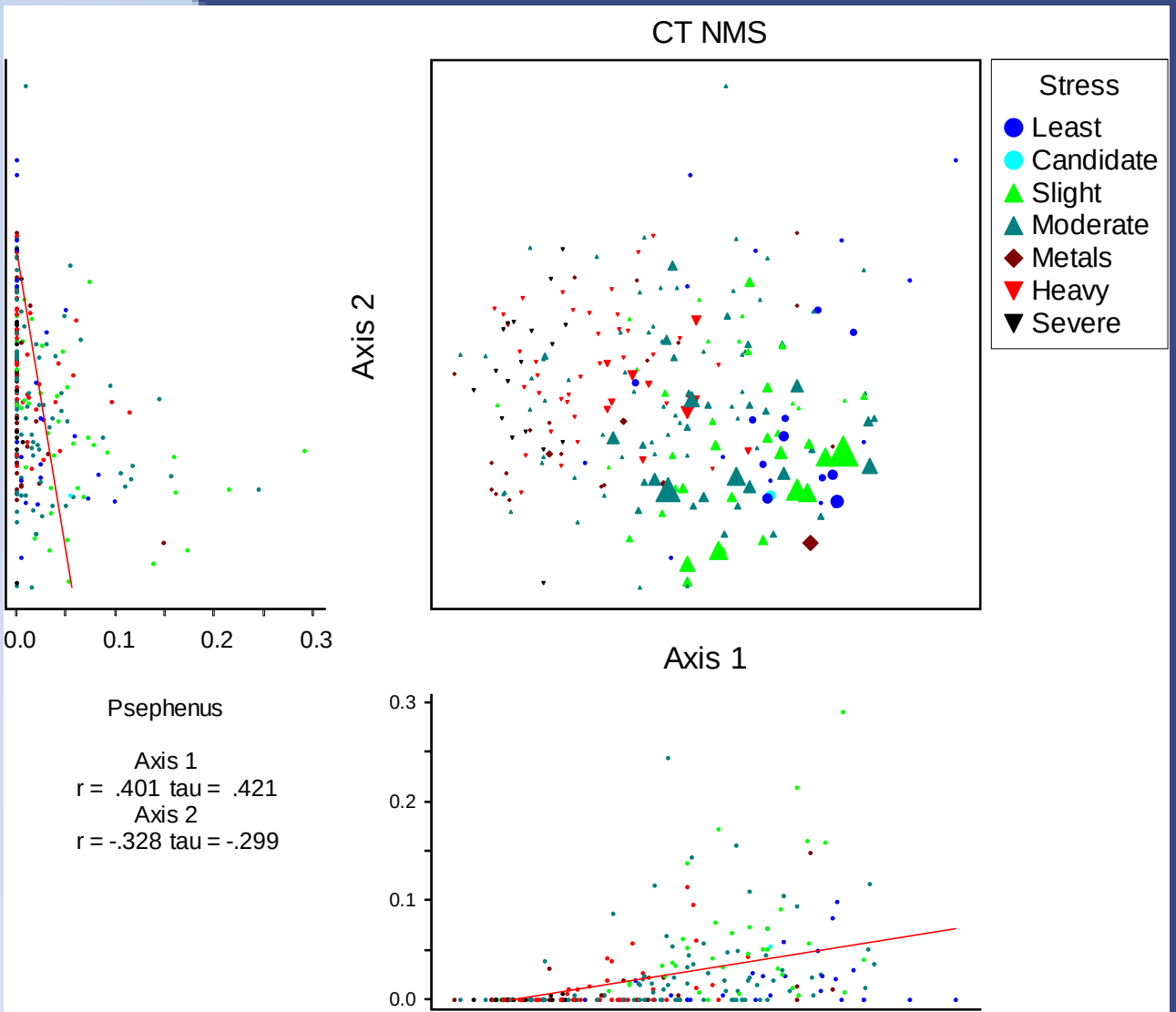


- Attribute V: tolerant taxa; optimum in worst sites, broad tolerance. Last survivors



Taxa Attribute Assignment: empirical information **and** expert opinion

Psephenus: Attribute 3 taxon in CT



Assign sites to BCG levels

- Panel members assign sites to BCG levels using species composition information
- Best sites are not necessarily Level 1!
  - contrast to reference condition
- In this exercise, all assignments were done individually
- Capture critical information for decisions in conference

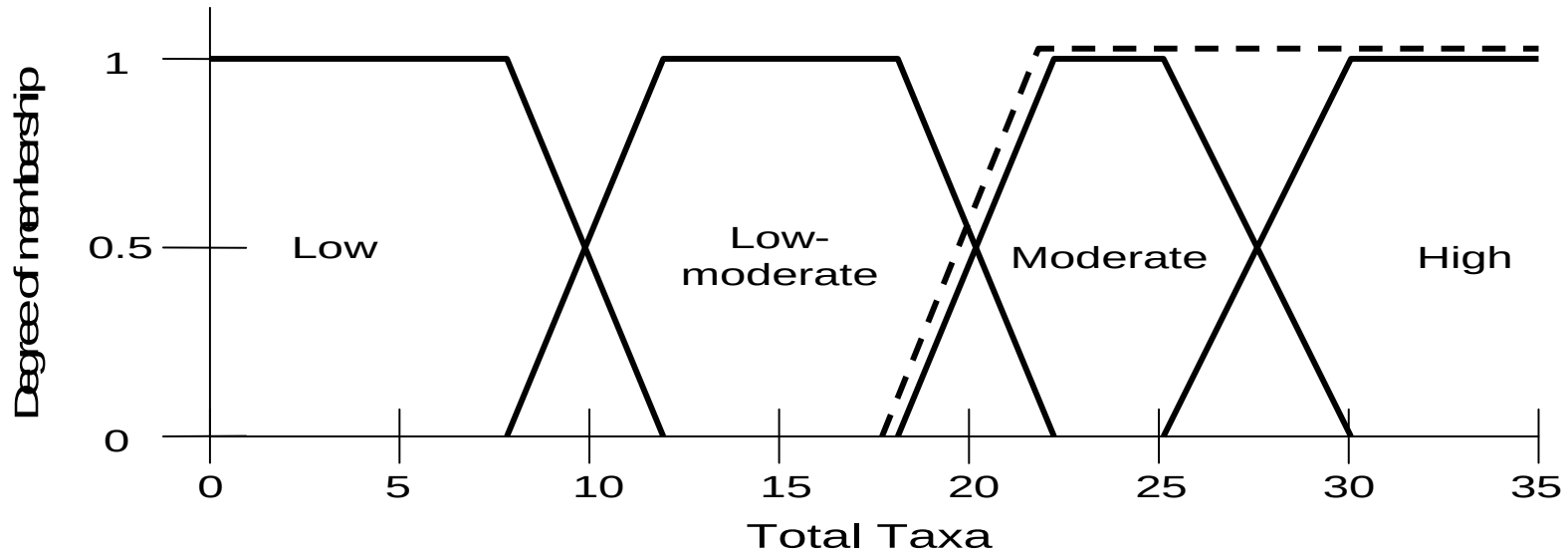
Example site data

TALU_SampID	HA03	Level	Area (km²)	19.06
StationID	AN0018	5	Pct Urban	13.98
Station Name	Culvers Ck		Pct Agr	1.59
WMA	1		Pct Forest	48.40
Gradient	High		Pct Wetlands	18.16
CollDate	10/13/1992		Total Habitat Score	Not Scored
BCG Attribute	FinalID	Individuals	Order	Family (Tribe)
4	*Crangonyx pseudogracilis*	8	Amphipoda	Gammaridae
3	*Stenonema smithae*	3	Ephemeroptera	Heptageniidae
3	*Nigronia serricornis*	2	Megaloptera	Corydalidae
4	*Argia*	1	Odonata	Coenagrionidae
4	*Cheumatopsyche*	45	Trichoptera	Hydropsychidae
5	*Hydropsyche betteni*	43	Trichoptera	Hydropsychidae

Mathematical Set Theory

- Mapping of non-linear numerical data to management categories
- Expert system that explicitly replicates the consensus best professional judgment (BPJ) of biologists in assigning sites to the BCG
- The final assessment tool allows systematic assessment of sample taxa lists, drawing on the opinions of the regional experts
- States and regions can incorporate the tool into their databases and biocriteria programs

Rule Diagram



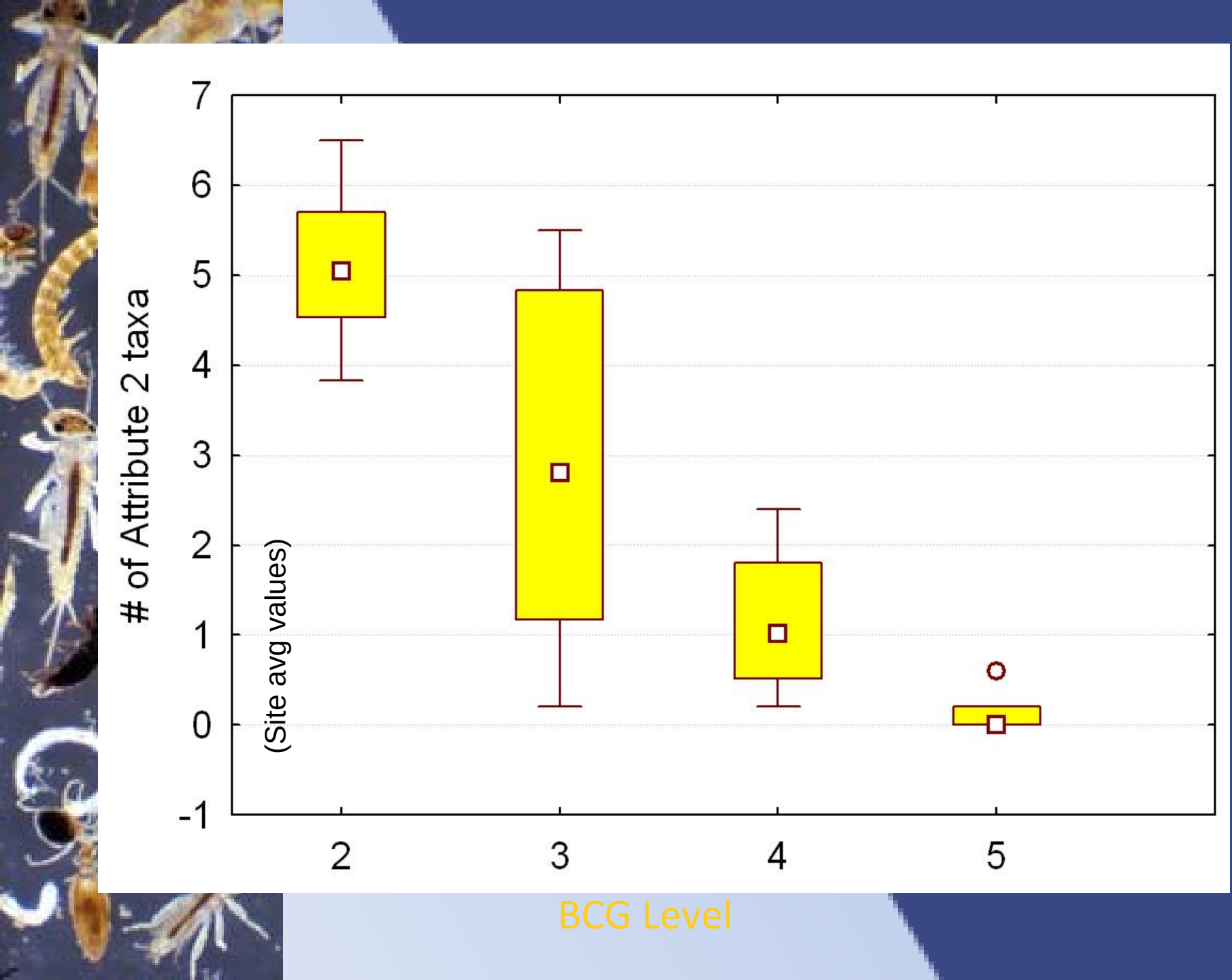
- Rules are developed for all attribute-based metrics
- Rules are combined with “AND” or “OR”

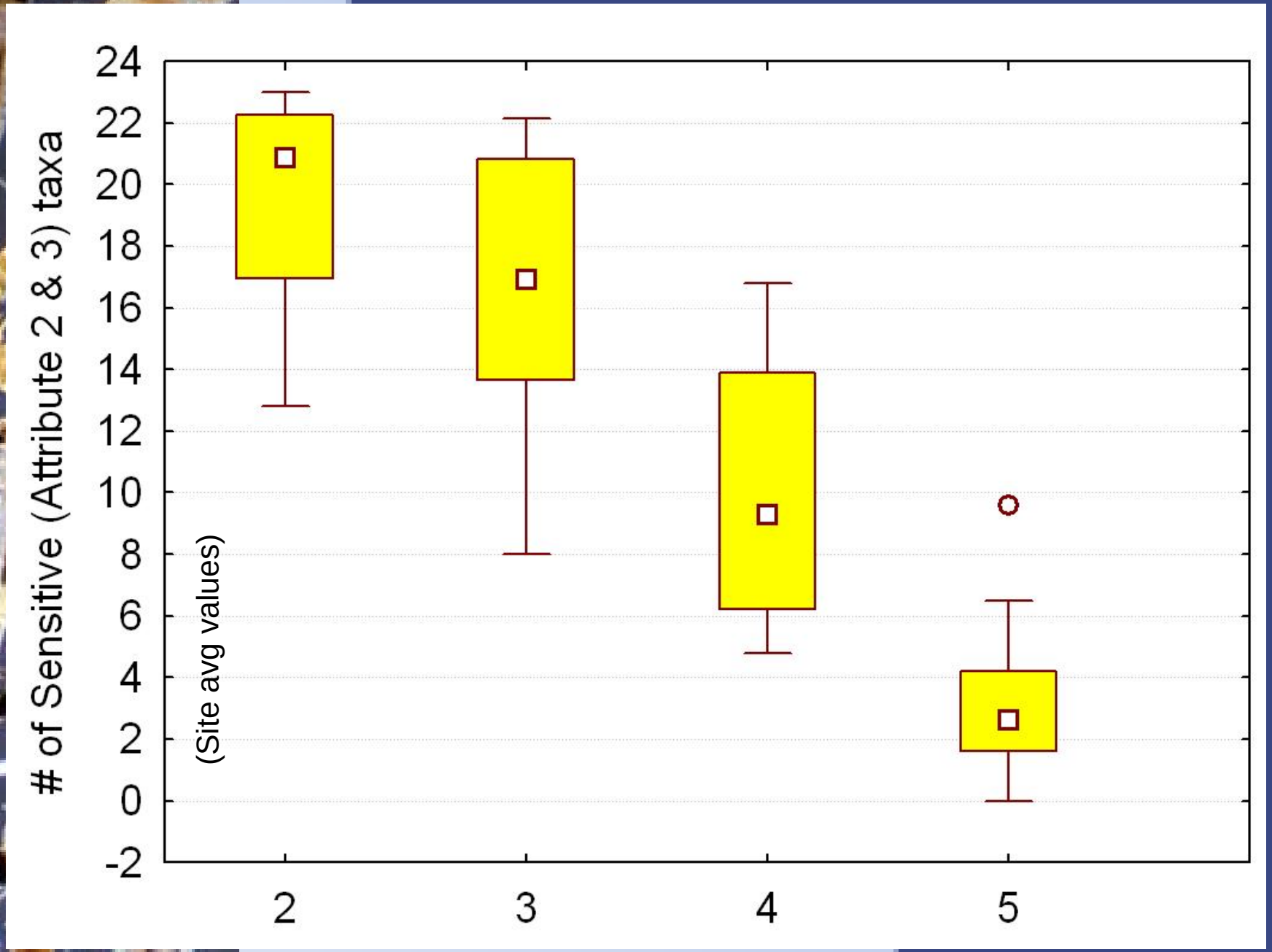
A BCG-BASED NEW ENGLAND MMI FOR ALL STATE METHODS

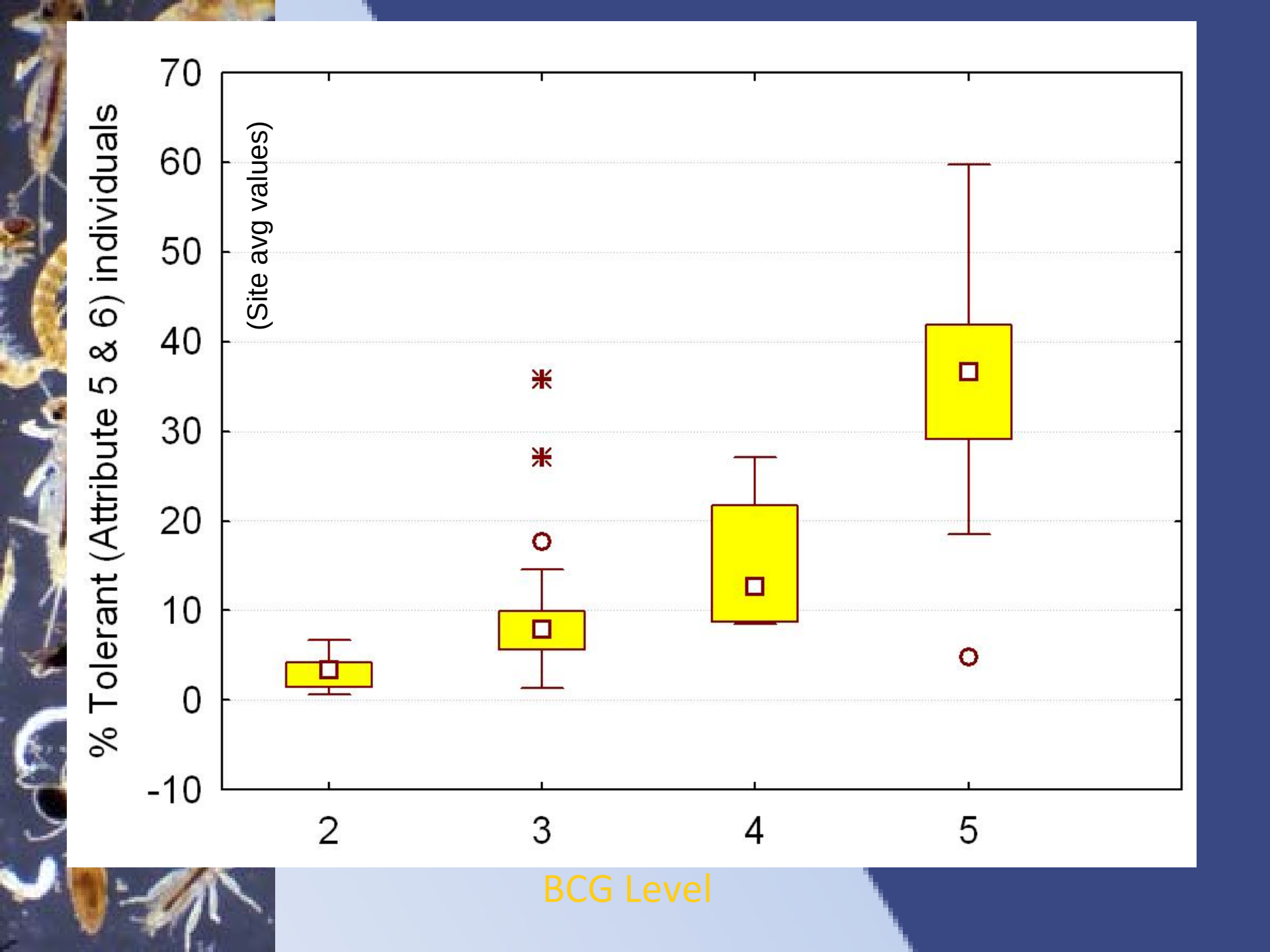
Ranges of attribute metrics

Attributes	Group assigned BCG level (nominal)			
	BCG 2 (n=9)	BCG 3 (n=20)	BCG 4 (n=6)	BCG 5 (n=9)
0 General	Richness 17 - 82	Richness 25 - 97	Richness 15 - 88	Richness 10 - 65
I Endemics				
II Highly sensitive taxa	# Taxa 1 - 12 % of taxa 2.5 – 35%	# Taxa 0 - 13 % of taxa 0 - 23%	# Taxa 0 - 6 % of taxa 0 – 22%	# Taxa 0 - 2 % of taxa 0 – 6%
III Intermediate Sensitive taxa	# Taxa 6 - 27 % of taxa 23 – 61%	# Taxa 4 - 27 % of taxa 8 – 47%	# Taxa 4 - 22 % of taxa 8 – 40%	# Taxa 0 - 12 % of taxa 0 – 25%
II + III All sensitive taxa	# Taxa 12 - 37 % of taxa 31 – 83% % of indiv. 16 – 80%	# Taxa 7 - 38 % of taxa 16 – 67% % of indiv. 5 – 76%	# Taxa 5 - 27 % of taxa 12 – 60% % of indiv. 2.4 –45%	# Taxa 0 - 12 % of taxa 0 – 25% % of indiv. 0 – 21%
IV Intermediate Tolerant taxa	% of indiv. 13 – 71%	% of indiv. 7.5 – 89%	% of indiv. 17 – 77%	% of indiv. 5 – 89%
V Tolerant taxa	% of indiv. 0.7 – 41%	% of indiv. 2.2 – 65%	% of indiv. 2.5 –73%	% of indiv. 7 – 95%

Ranges include individual sample results


# of Attribute 2 taxa
(Site avg values)
7
6
5
4
3
2
1
0
-1
2
3
4
5
BCG Level


# of Sensitive (Attribute 2 & 3) taxa
(Site avg values)
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
2
3
4
5
BCG Level


% Tolerant (Attribute 5 & 6) individuals
(Site avg values)
70
60
50
40
30
20
10
0
-10
2
3
4
5
BCG Level

Model Development

- Observe differences in attribute values across BCG rankings
- Develop rules for each metric
- Apply rules in combination
- Test model performance
- Confirm with workgroup
  - Validity of rules, combinations, and site results
- Repeat as needed

BCG Rules

Attribute	Level 2	Level 3
0 General	2.1 Total taxa > (19-23) 2.2 count > (50–55%) of target	3.1 Total taxa > (19–23) 3.2 count > (50–55%) of target
II *Highly sensitive taxa*	2.3 % Taxa II > (10 – 15%)	May be absent
III *Sensitive taxa*	2.4 % Taxa (II+III) > (40–50%) 2.5 % Indiv (II + III) > (30–40%)	3.3 % Taxa (II+III) > (25 – 30%) 3.4 % Indiv (II+III) > (30–40%)
IV *Intermediate tolerant taxa*	(no rule)	(no rule)
V *Tolerant taxa* (all)	2.6 % Indiv V < (15–20%)	3.5 % Indiv V < (40–50%)
Combining Rule	2.1, 2.2, 2.3, 2.4 and (2.5 or 2.6) Total taxa (rule 2.1) allowed to fail if all other rules succeed	Fails any level 2 rules 2.2-2.6, and meets 3.1, 3.2, 3.3, and (3.4 or 3.5)

BCG Rules (cont.)

Attribute	Level 4	Level 5
0 General	4.1 Total taxa > (17–21) 4.2 count > (50–55%) of target	5.1 Total taxa > (8–12) 5.2 count > (50–55%) of target
II *Highly sensitive taxa*		
III *Sensitive taxa*	4.3 % Taxa (II+III) > (15 – 25%) 4.4 % Indiv (II+III) > (10–20%)	
IV *Intermediate tolerant taxa*	(no rule)	(no rule)
V *Tolerant taxa* (all)	4.5 % Indiv V < (65–75%)	
Combining Rule	Fails any level 2 rules 2.2–2.6 and fails level 3 rules 3.3–3.5 and 4.1, 4.2, 4.3, and (4.4 or 4.5)	Fails level 2 rules 2.2–2.6, and level 3 rules 3.2–3.5 and level 4 rules 4.2–4.5, and 5.1 and 5.2

NEIWPCC, NEWS and CT Rules

Attribute	Level 2	Level 3
0 General	Total taxa > (19-23) (30-35) (25-30) Count > (50–55%) of target (45-55%) (50–60%)	Total taxa > (19–23) (20-25) (19–23) Count > (50–55%) of target (45-55%) (50–60%)
II *Highly sensitive taxa*	% Taxa (II) > (10 – 15%) Taxa (II) > (2-4) (3–5)	May be absent
III *Sensitive taxa*	% Taxa (II + III) > (40–50%) (35 – 40%) (45–55%) Individuals (II + III) > (30–40%) (35-40%) (30–40%)	Taxa (II + III) > 10-12 (8–10) % Taxa (II + III) > (25 – 30%) (30 – 40%) Individuals (II + III) > (30–40%) (30-50%) (30–40%)
IV *Intermediate tolerant taxa*	(no rule)	(no rule)
V *Tolerant taxa* (all)	Individuals (V) < (15–20%) (10-20%) (10–15%)	Individuals (V) < (40–50%) (20-30%) (40–50%)
Additional Rule	[E taxa > 2]	

NEIWPCC, NEWS and CT Rules

Attribute	Level 4	Level 5
0 General	Total taxa > (17–21) (20-25) (17–21) Count > (50–55%) of target (45-55%) (50–60%)	Total taxa > (8–12) (8-12) (8–12) Count > (50–55%) of target (50–55%) (50–60%)
II *Highly sensitive taxa*	(no rule)	(no rule)
III *Sensitive taxa*	Taxa (II + III) > (8-12) (3–5) % Taxa (II + III) > (15 – 25%) (20 -30%) Individuals (II + III) > (10–20%) (10-20%) (10–20%)	Failure of Tier 4 rules
IV *Intermediate tolerant taxa*	(no rule)	(no rule)
V *Tolerant taxa* (all)	Individuals (V) < (65–75%) (40 - 50%) (65–75%)	Failure of Tier 4 rules
Additional Rule	[E taxa > 0]	Individuals (Va) < Individuals (V)

NEIWPCC BCG MMI Performance

- In 68% of cases, the MMI predicted the same BCG level as the majority expert opinion
- In 91% of cases, the MMI predicted a BCG level within one level of the majority expert opinion (the minority opinion)
- Performance may vary by State

All model performances

Model	Exact match (%)	Exact or minority match (%)	N
NEWS	55.7	73.1	218
Connecticut	67.4	85.3	218
CT model on CT assessments*	72.5	87.5	40
NEIWPCC	68.3	90.8	218

* This is an independent test of the CT model