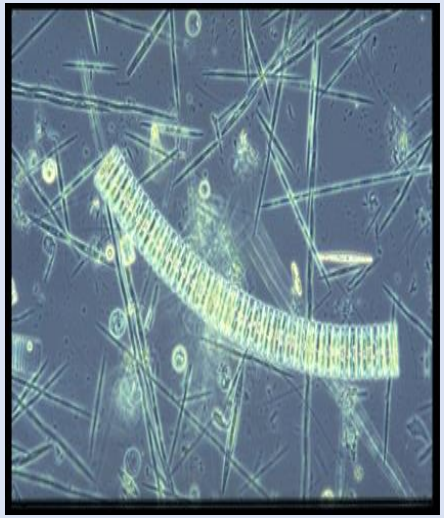
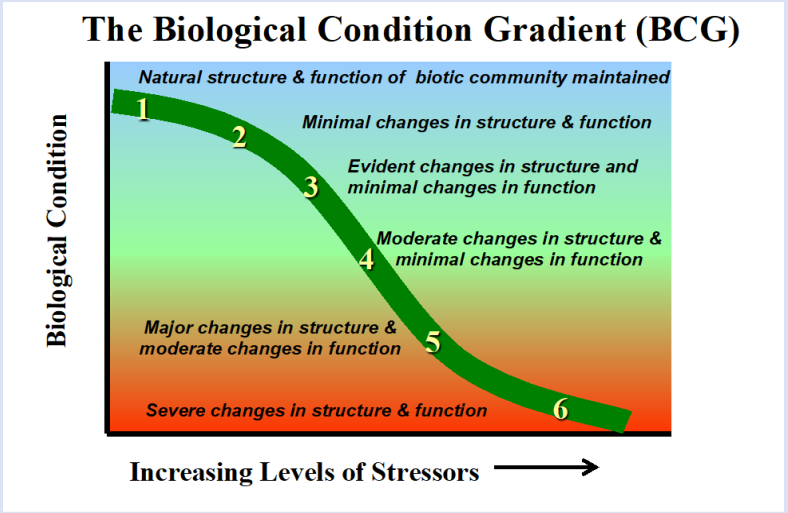
The Biological Condition Gradient

CWA 303d Training Meeting

May 28, 2020

Susan Jackson
USEPA





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Result:

State Best Practices

Practitioners Guide to the Biological Condition Gradient: A Framework to Describe Incremental Change in Aquatic Ecosystems 2016

EPA 842-R-16-001

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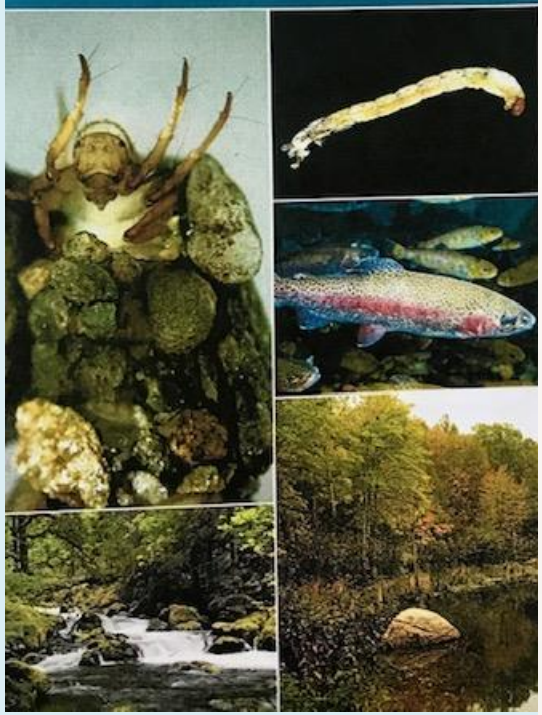
A Practitioner's Guide to the Bi
Condition Gradient: A Framewo
Incremental Change in Aquatic

February 2016



Acknowledgements

Thank you to the following scientists and state, territorial, county and tribal agencies for their leadership and support with development and piloting of the biological condition gradient.* There were additional experts involved for each of the case examples presented in this document.**

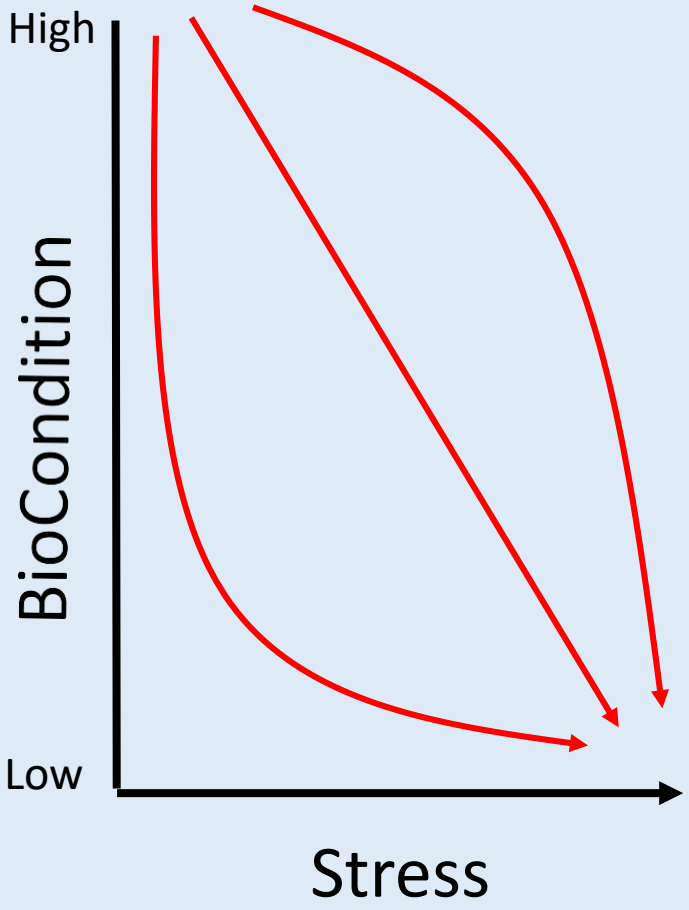
State, Territorial, and Tribal BCG Workgroup Members and Pilots (2000–2015)

Alabama Department of Environmental Management – Lisa Huff
Alabama Geological Survey – Patrick O'Neill
Arizona Department of Environmental Quality – Patti Spindler
California Department of Fish and Game – Jim Harrington
Colorado Department of Public Health and Environment – Robert McConnell, Paul Welsh
Connecticut Department of Energy and Environmental Protection – Chris Bellucci
Florida Department of Environmental Protection – Russ Frydenborg, Ellen McCarron, Nancy Ross
Idaho Department of Environmental Quality – Mike Edmondson
Kansas Department of Health and Environment – Robert Angelo, Steve Haslouer, Brett Holman
Kentucky Department for Environmental Protection – Tom VanArsdall
Maine Department of Environmental Protection – David Courtemanch, Susan Davies, Leon Tsomides, Tom Danielson, Jeanne DiFranco, Beth Connors
Maryland Department of the Environment – Richard Eskin, George Harmon, Matthew Stover
Maryland Department of Natural Resources – Scott Stranko
Minnesota Pollution Control Agency – Will Bouchard, Greg Gross
Mississippi Department of Environmental Quality – Leslie Barkley, Natalie Guerdon
Montana Department of Environmental Quality – Randy Apfelbeck, Rosie Sada
Montgomery County, Maryland, Department of the Environment – Kenneth Mack, Jennifer St John, Keith Van Ness
Narragansett Bay National Estuary Program – Tom Borden, Program Director
New Jersey Department of Environmental Protection – Kevin Berry, Thomas Belton
Nevada Division of Environmental Protection – Karen Vargas
North Carolina Department of Environment and Natural Resources – David Lenat, Trish MacPherson
Ohio Environmental Protection Agency – Jeff DeShon, Dan Dudley
Ohio River Valley Water Sanitation Commission – Erich Emery
Oregon Department of Environmental Quality – Doug Drake, Rick Hafele
Pennsylvania Department of Environmental Protection – Dustin Shull, Gary Walters
Pyramid Lake Paiute Tribe – Dan Mosley
Rhode Island Department of Environmental Management – Chris Deacutis
Texas Commission on Environmental Quality – Mark Fisher, Charles Bayer, William Harrison, Ann Rogers
Upper Mississippi River Basin Association – David Hokanson, Deputy Director
Vermont Department of Environmental Conservation – Doug Burnham, Steve Fisk
Virginia Department of Environmental Quality – Alexander Barron, Larry Willis
Washington State Department of Ecology – Robert Plotnikoff
Wisconsin Department of Natural Resources – Joseph Ball, Edward Emmons, Robert Masnado, Greg Searle, Michael Talbot, Lizhu Wang

What is Biological Condition Gradient (BCG)?

It is a scientific framework for interpreting biological response to anthropogenic stress, based on bioassessments.

Conceptually applicable to all aquatic systems regardless of waterbody type, location, method



BCG CONCEPTUAL MODEL

Levels of Biological Condition

Natural structural, functional, and taxonomic integrity is preserved.

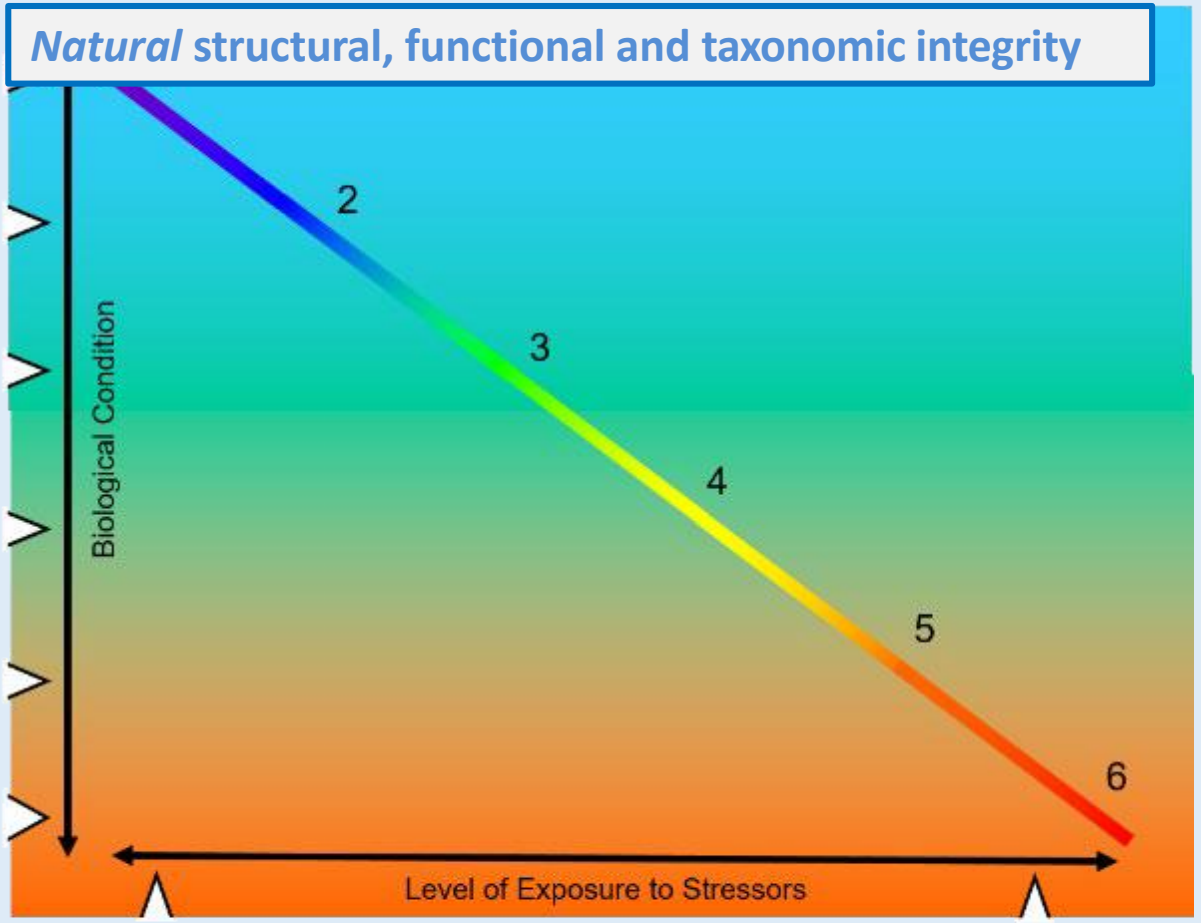
Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.

Moderate changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.

Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.



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

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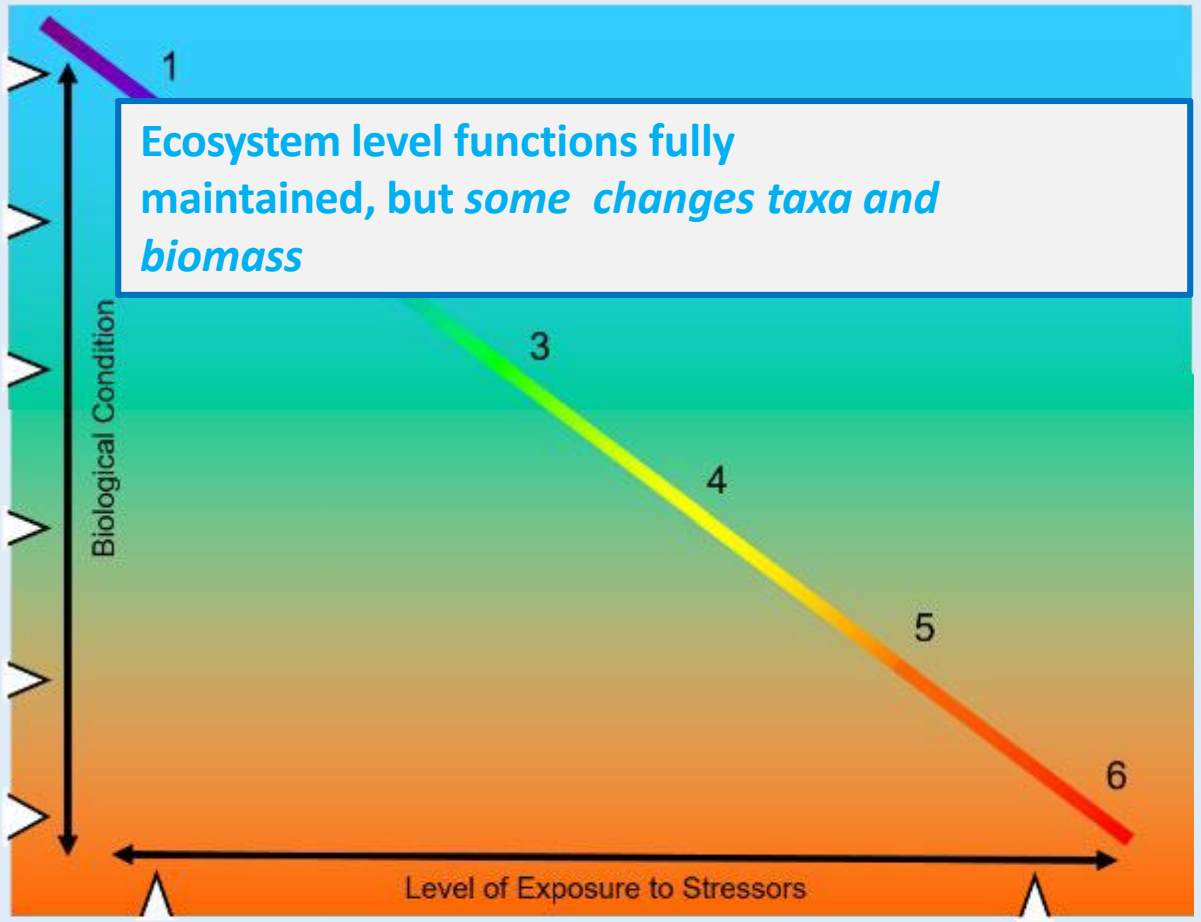

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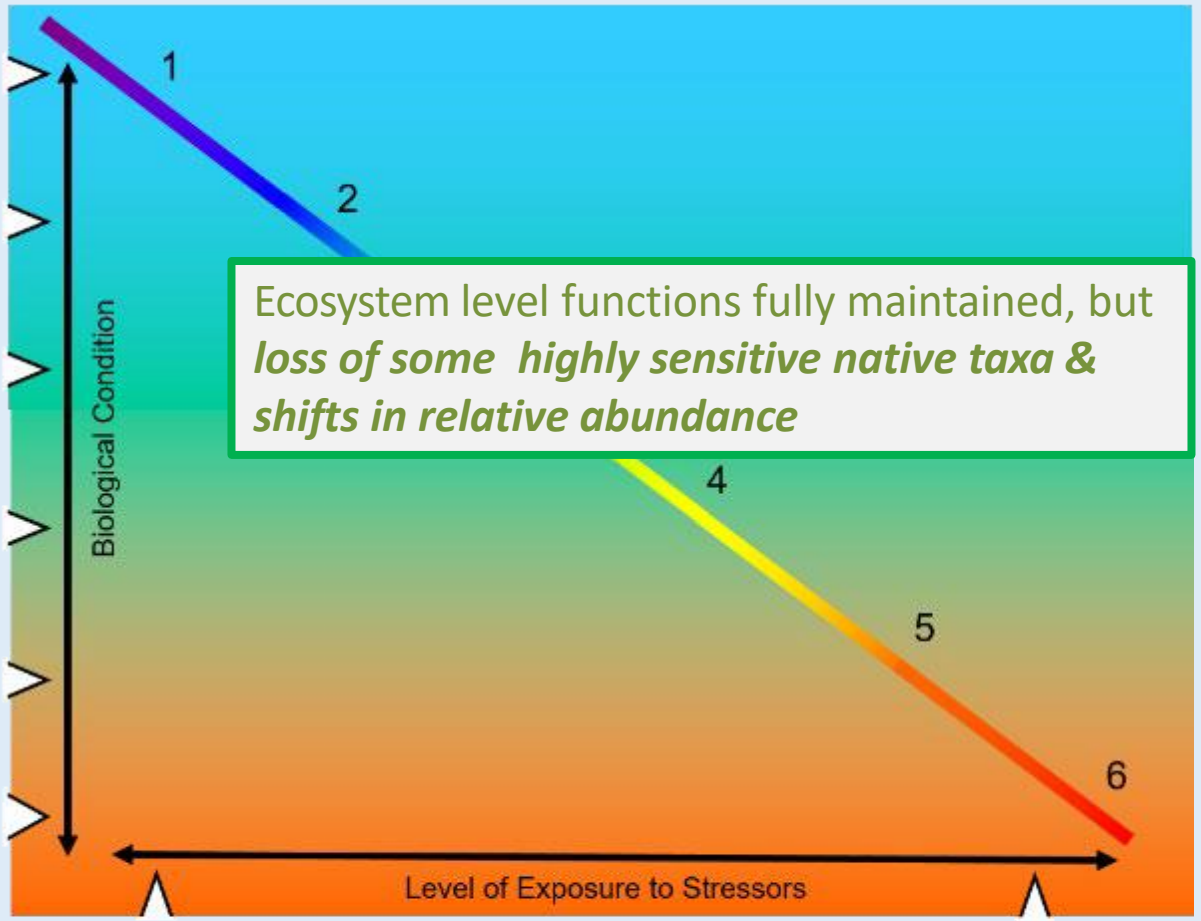

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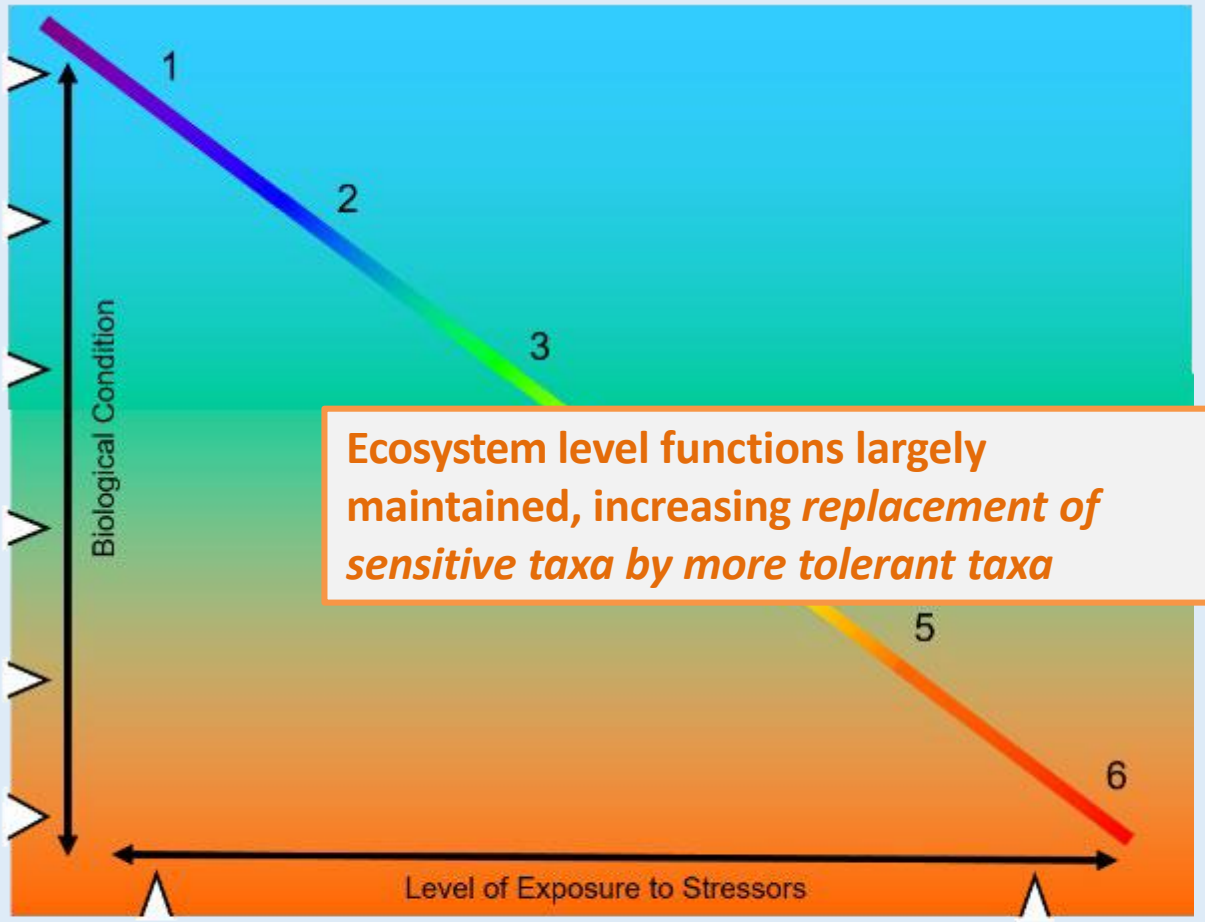

Ecosystem level functions largely maintained, increasing *replacement of sensitive taxa by more tolerant taxa*

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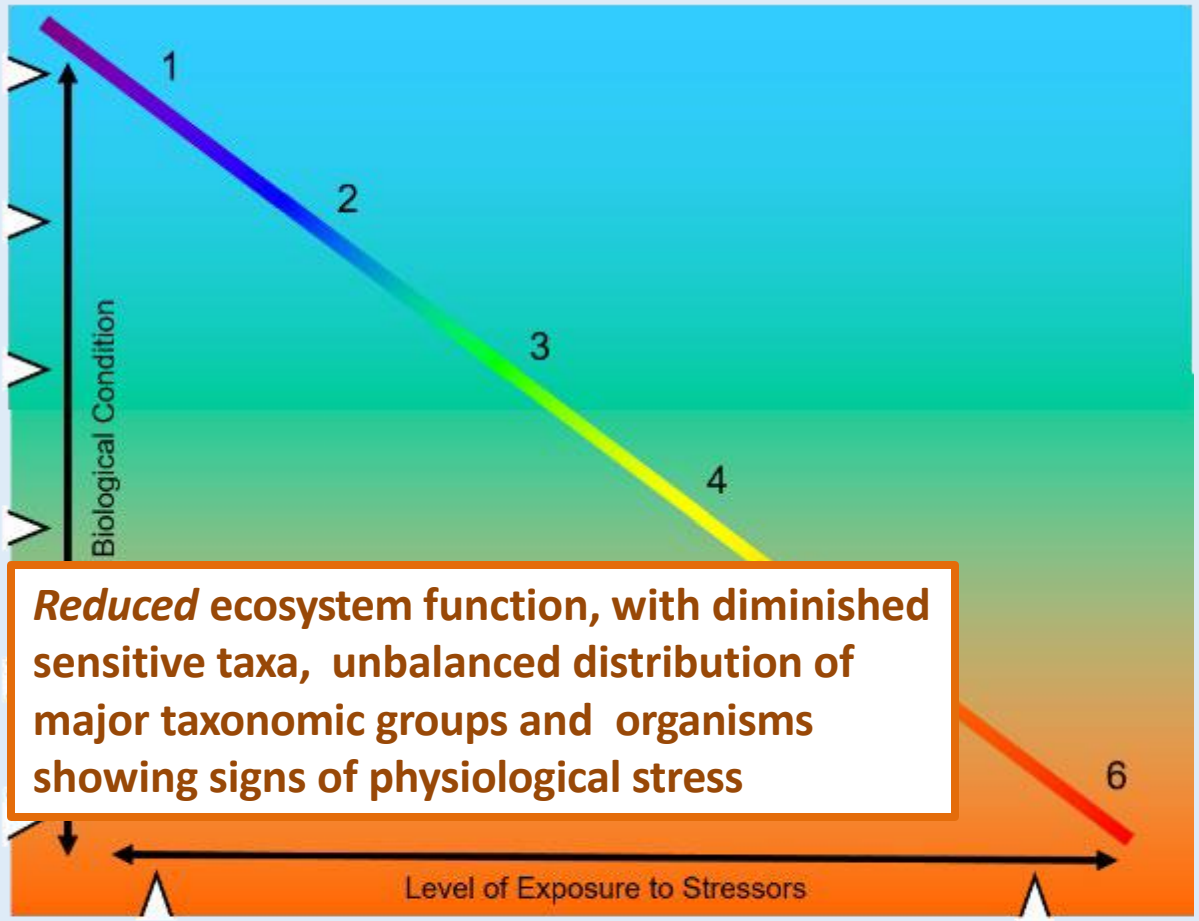

Reduced **ecosystem function, with diminished sensitive taxa, unbalanced distribution of major taxonomic groups and organisms showing signs of physiological stress**

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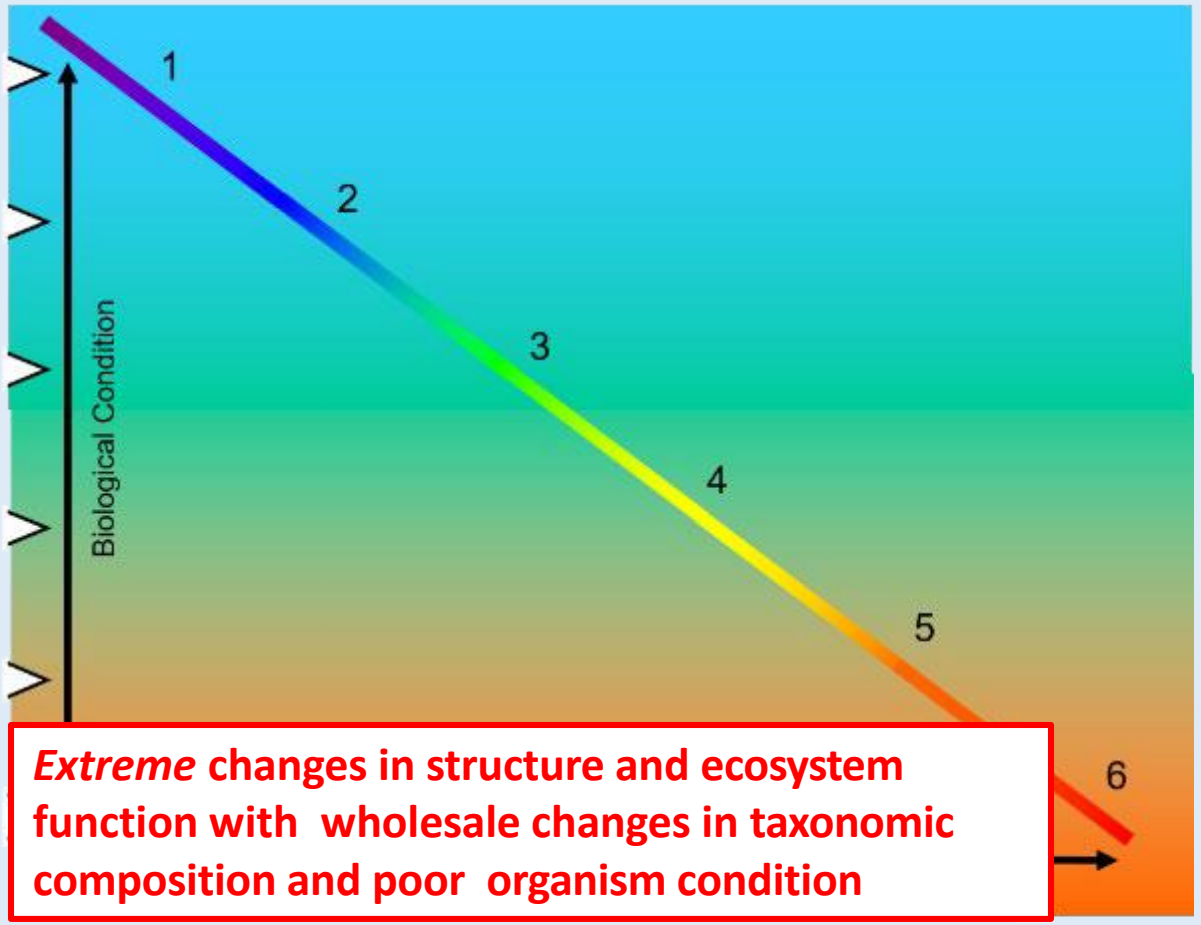

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Key Components

- The Biological Condition Gradient (BCG) has two key components – Attributes and Levels.
  - **Levels** are the discrete levels of biological condition across a stressor-response curve
    - Example: Level 1 =natural; Level 6 = completely degraded
  - **Attributes** are measurable components of a biological system (Karr and Chu 1999)
    - Example: species composition such as number and proportion of sensitive and tolerant taxa; presence of disease

QUANTIFY GRADIENT - Attributes

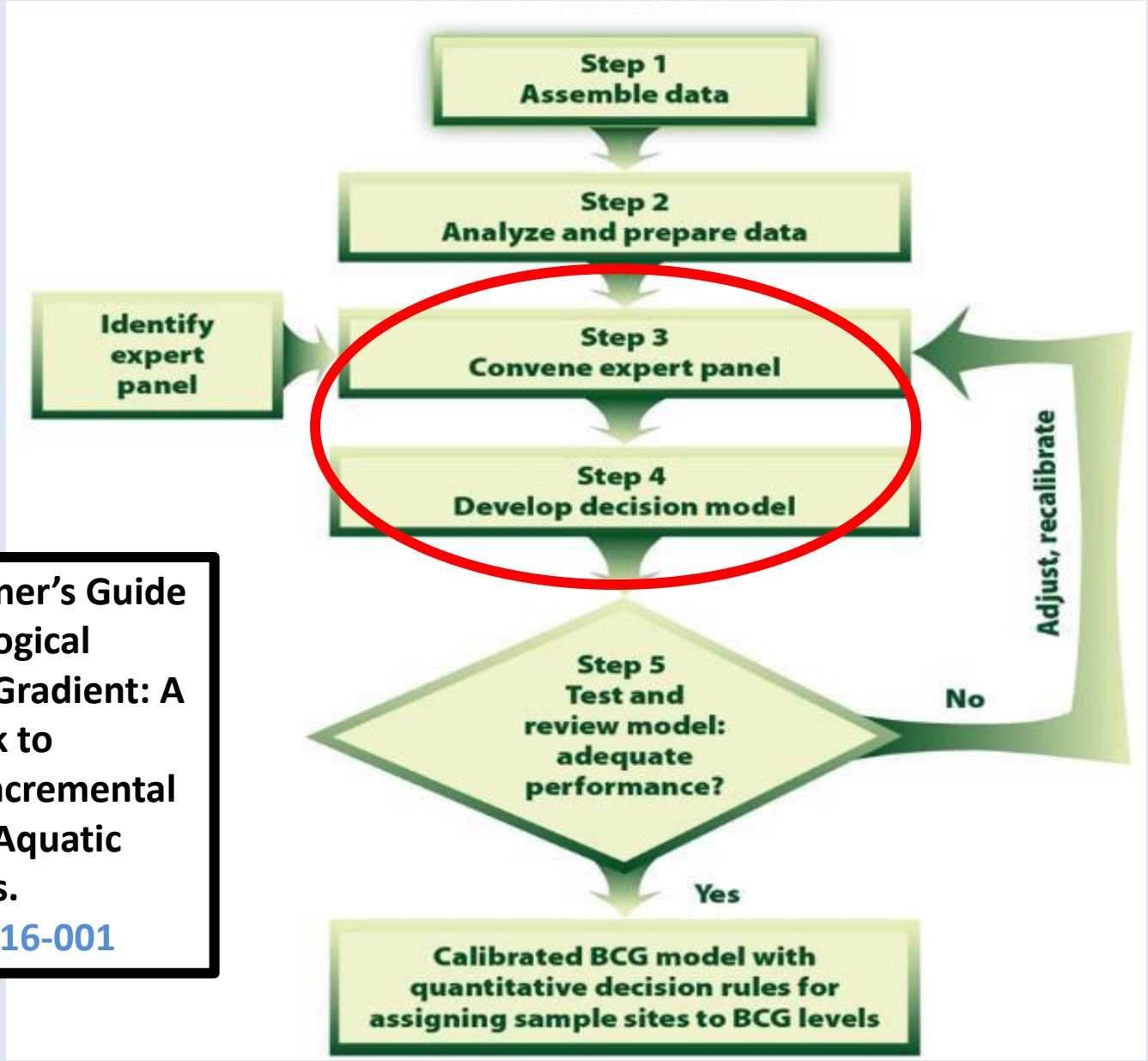
Stream, River, Coral Reef

- Taxa sensitivity/tolerance
- Organism Condition (e.g. disease, tumors etc)
- Presence of native/non native species

Estuaries: Work in Progress

- Above plus exploring measures of:
  - habitat mosaic
  - connectivity
  - ecosystem function

BCG Process



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EPA 842-R-16-001

Quantitative Model Development

Iterative process:

- **conceptual model**
- **site data across stress gradient**
- **expert elicitation & panel consensus**
- **metric testing to replicate expert consensus**

Example: Data Worksheet

Example of a fish worksheet that was used when making BCG level assignments for stream sites in Illinois.

ExerciseID	Samp1072	Best		Assigned Level	Reasoning
Collection Date	08-10-1999	Median			
Collection Method	1ES	Worst			

BCG Attribute	Number of Taxa	Number of Ind	Pct Taxa	Pct Individs
I	0	0	0%	0%
II	0	0	0%	0%
III	1	1	8%	2%
IV	10	46	83%	94%
V	1	2	8%	4%
VI	0	0	0%	0%
NA	0	0	0%	0%
Total	*12*	*49*	*100%*	*100%*

BCG Attribute	Species Common Name	Count
IV	creek chubsucker	4
III	spotted sucker	1
IV	golden shiner	4
IV	blackspotted topminnow	8
IV	grass pickerel	4
IV	flier	1
IV	warmouth	1
IV	bluegill	10
IV	longear sunfish	6
IV	redear sunfish	3
IV	pirate perch	5
V	yellow bullhead	2

StationID	
Waterbody Name	
Reference Status	
Level III Ecoregion	71
Level IV Ecoregion	71n
Fish Region	12
Ecological Drainage Unit	Ohio River
Drainage Area (mi2)	26.11
Slope	0.00
Stream Width (ft)	23.0
Stream Depth (ft)	0.7
Pct Imperviousness	
LULC - Pct Urban	
LULC - Pct Forest	
LULC - Pct Agriculture	
Dissolved Oxygen	
Alkalinity	
pH	
Conductivity	
Nitrogen, Total	
QHEI	
Gradient	
Pct Fines	13.0
Alteration	
Alteration Assessment	
Structure	

We ask the experts to …

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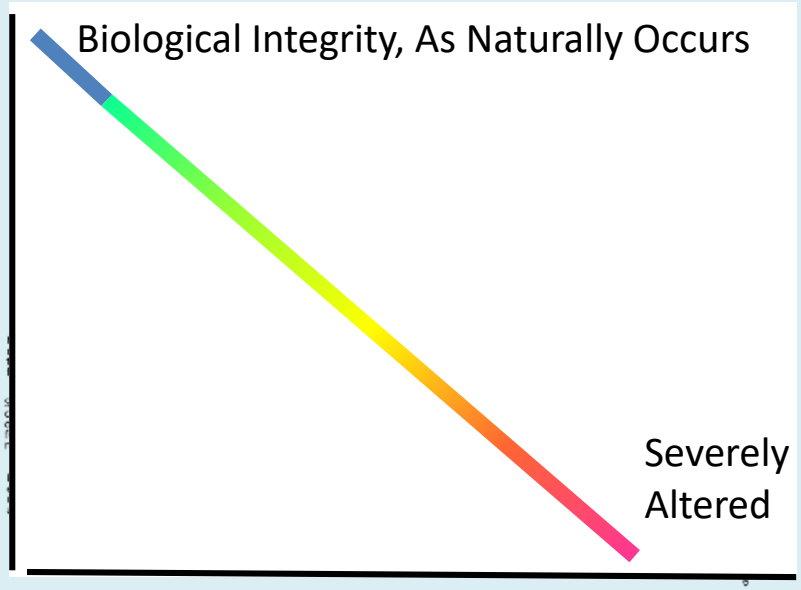
Experience and Knowledge



Rate sites along gradient of disturbance

Assign to BCG level

Describe logic for assignment

HO #2 and #3

Quantitative Model Development

<u>In a snapshot</u>:

1) **Narrative rules, logic documented**

2) **Test metrics that measure narrative rules**

3) **Suite of metrics = numeric decision rules**

4) **Test that the decision rules replicate expert knowledge**

BCG complements existing IBIs

Take Home Message:

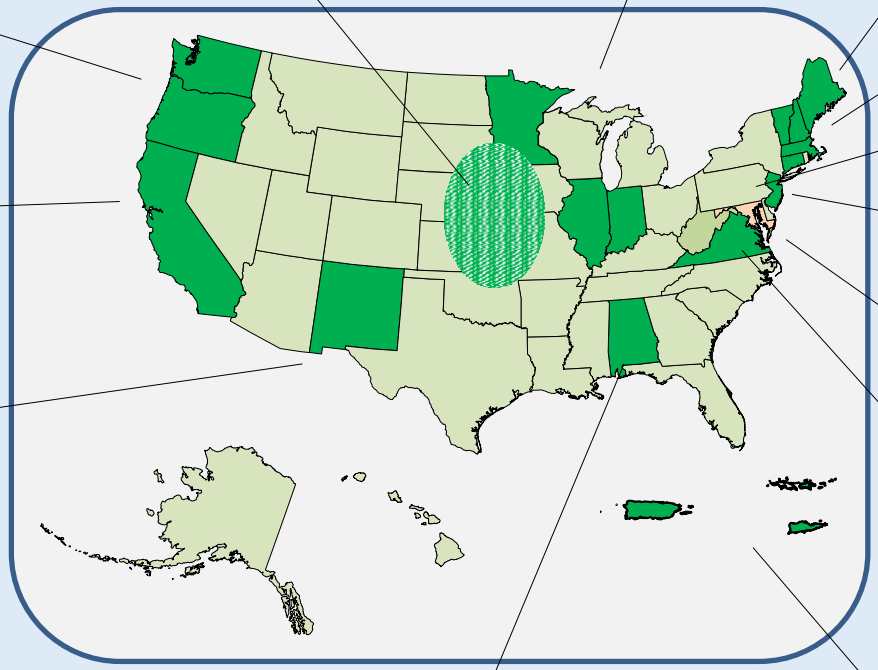
BCG is a tool in a larger "toolbox" of biological indicators and methods

It is a state, territorial or tribal program decision on how to adapt and use

Compa **a**
streams

Compar
subecor PRV)

BCG: Work to date*



Maine, Connecticut, Vermont Streams – NE BCG (benthic &/or fish)

Narragansett and Massachusetts Bay (habitat mosaic)

Pennsylvania stream (benthic BCG metrics)

New Jersey streams (benthic, fish, diatoms)

Montgomery County, MD Streams (benthic, fish)

Virginia streams/Appalachian Mtn Ecoregions (benthic, fish)

Puerto Rico and USVI coral reef (benthic, fish)

Alabama: streams (benthic, fish)

New Mexico Rio Grande River (benthic, fish)

California streams (benthic, diatoms)

Maritime NW Pacific Region - Washington/Oregon (benthic)

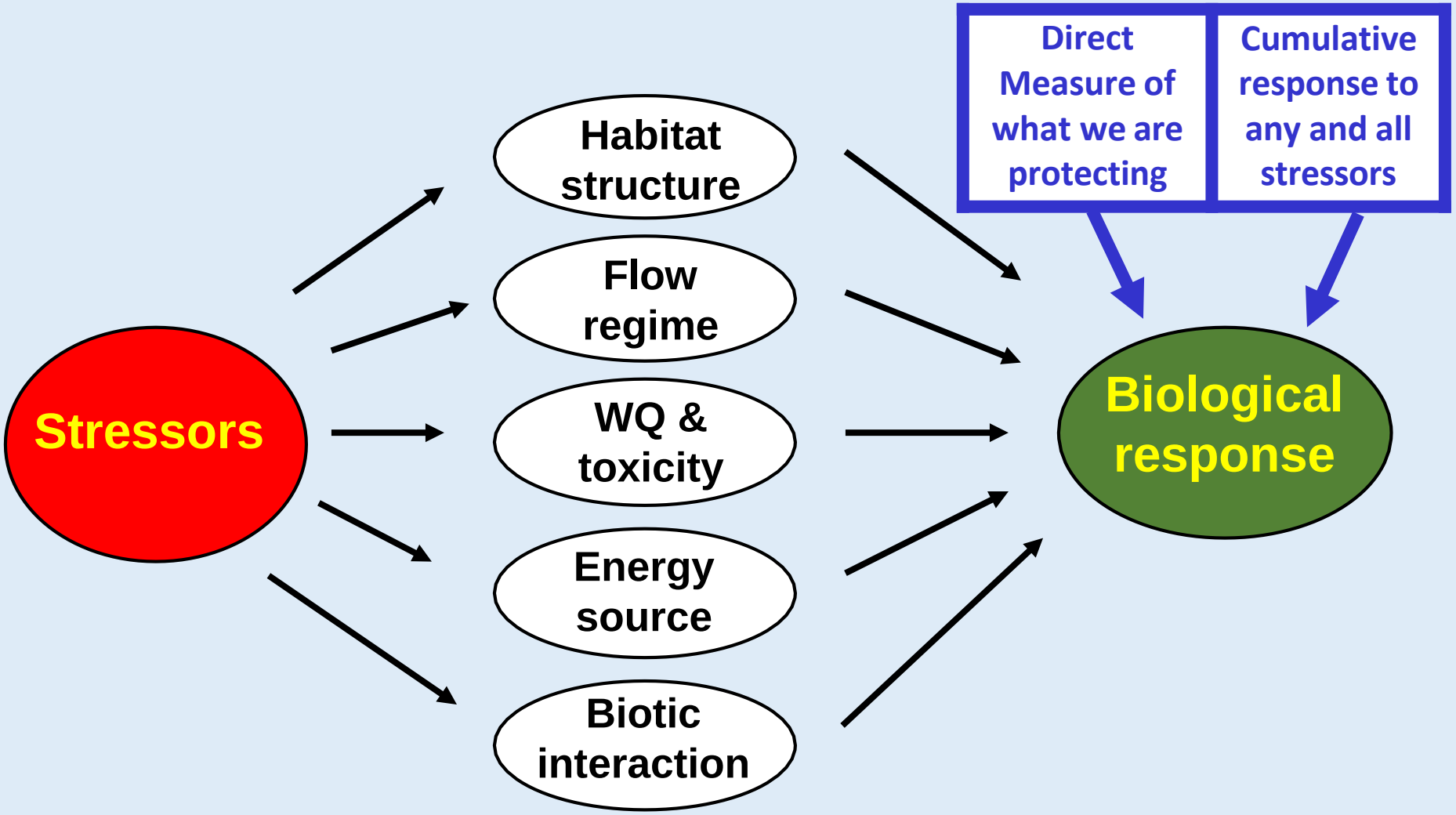
Central Great Plains (benthic, fish)

Minnesota, Illinois, Indiana streams (benthic &/or fish)

*BCG development and/or application in progress.

What can the BCG be used for?

What does biology tell you?



What does the BCG add?

Direct Measure of what we are protecting

Cumulative response to any and all stressors

Stressors

Habitat structure

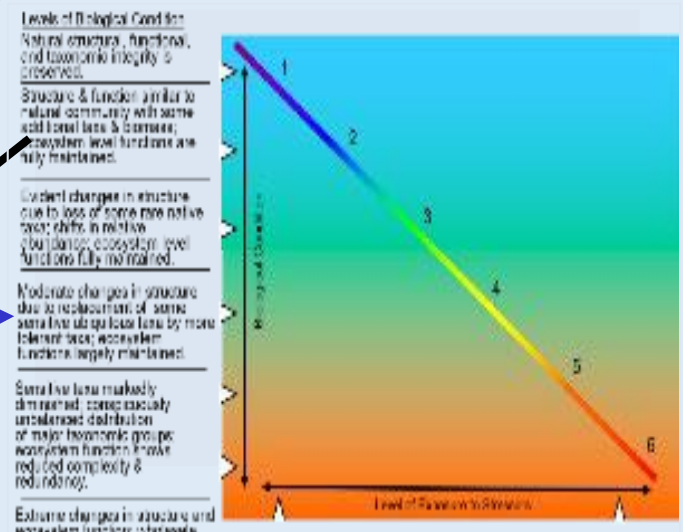
Flow regime

WQ & toxicity

Energy

Biological response

Interpret condition relative to undisturbed, natural expectations



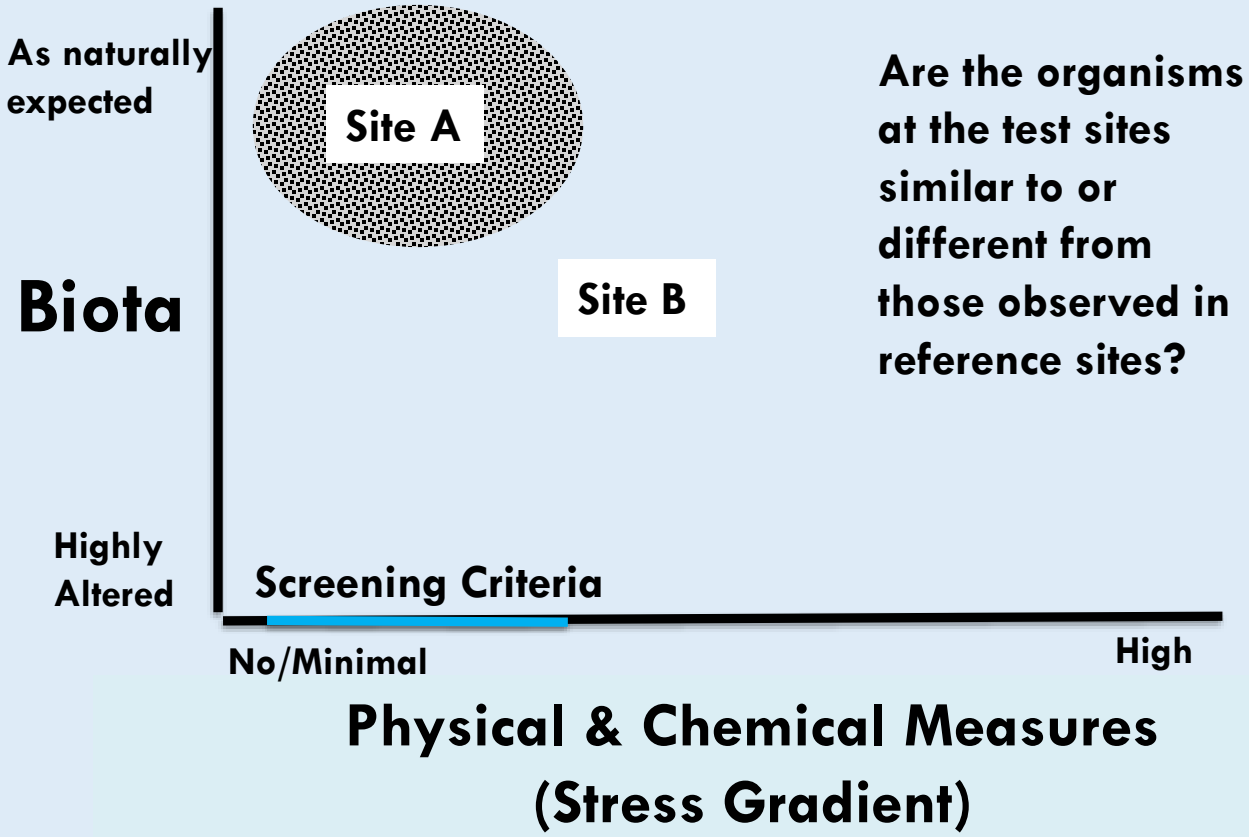
Reference Sites As A Benchmark

What is reference condition?

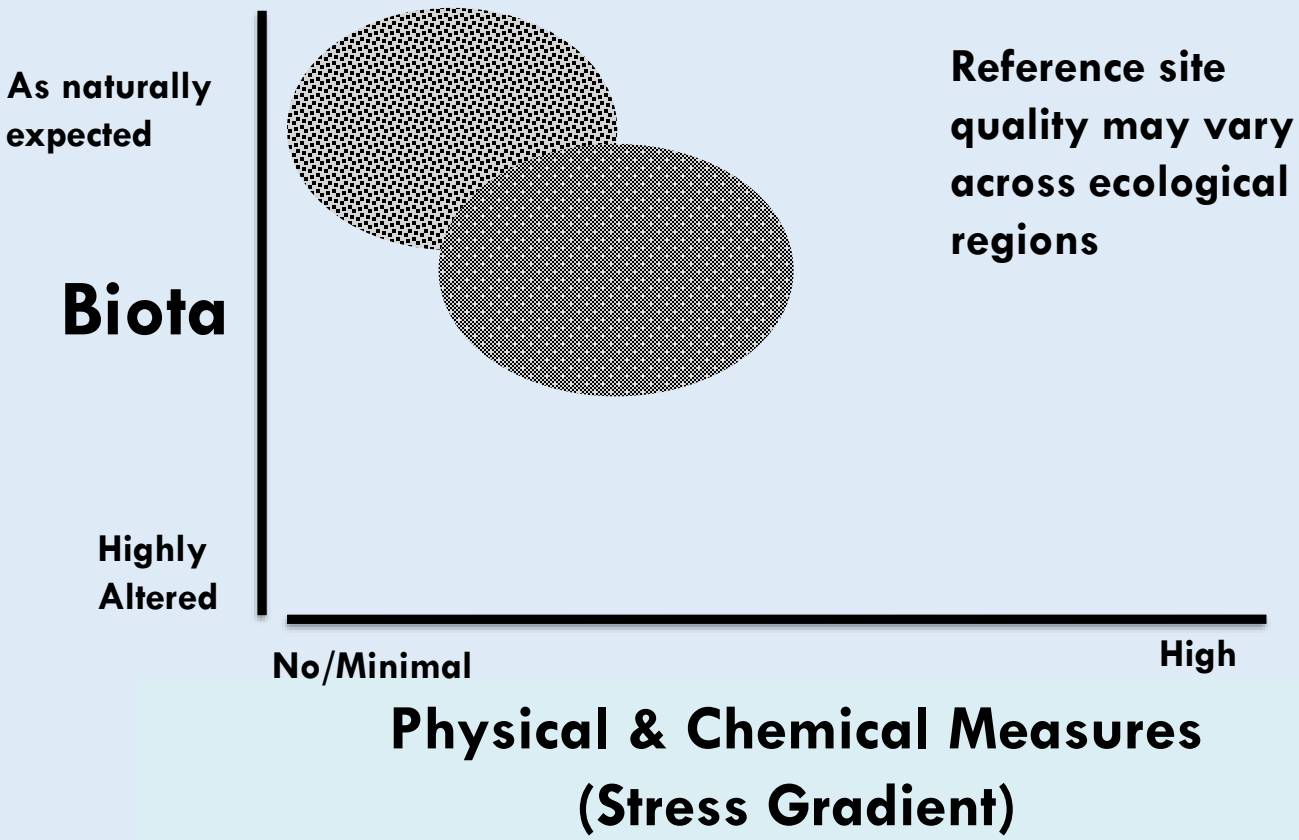
The biological expectation for a given water body type (e.g., streams) in a given region (e.g., Northern Lakes and Forest Ecoregion) that would occur with no or minimal human disturbance.

This is what will be used as a benchmark to compare streams to determine their condition.

Defining Reference Condition - I



Defining Reference Condition - II



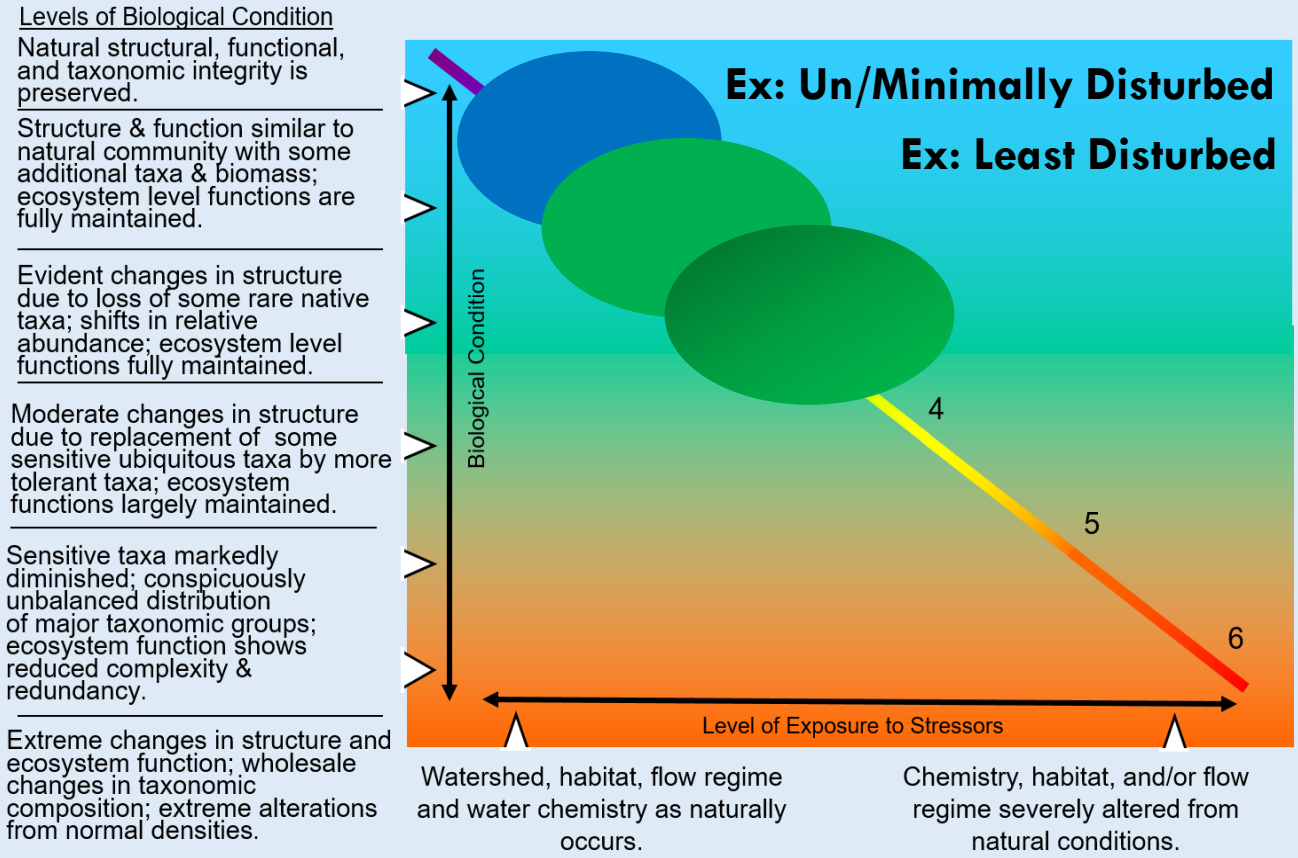
Reference Sites As A Benchmark

Least Disturbed Condition

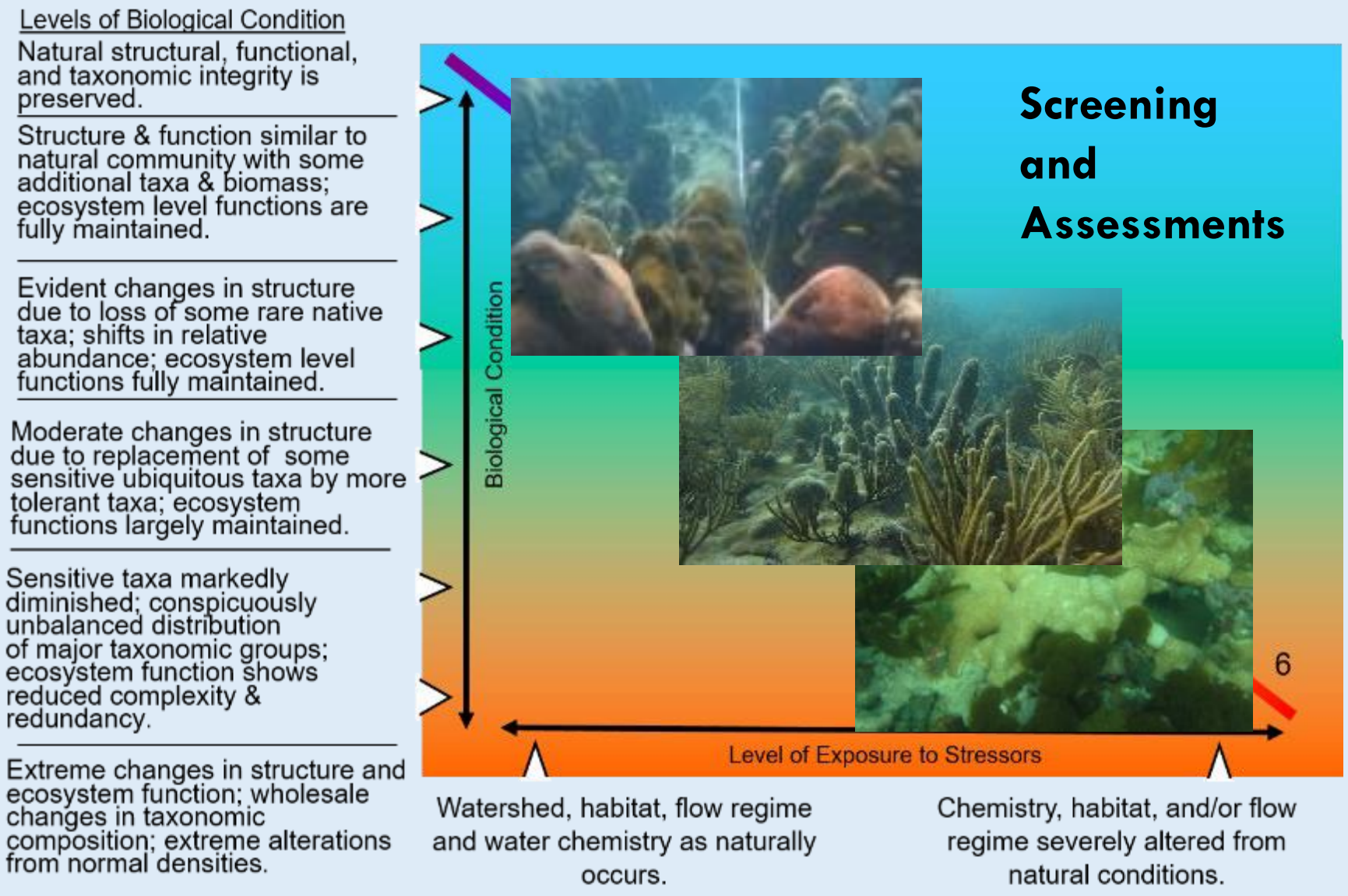
The best available* existing conditions with regard to physical, chemical and biological characteristics.

* Lowest level of anthropogenic disturbance within class and/or region

Biological Condition Gradient: Provides Context



Potential Applications



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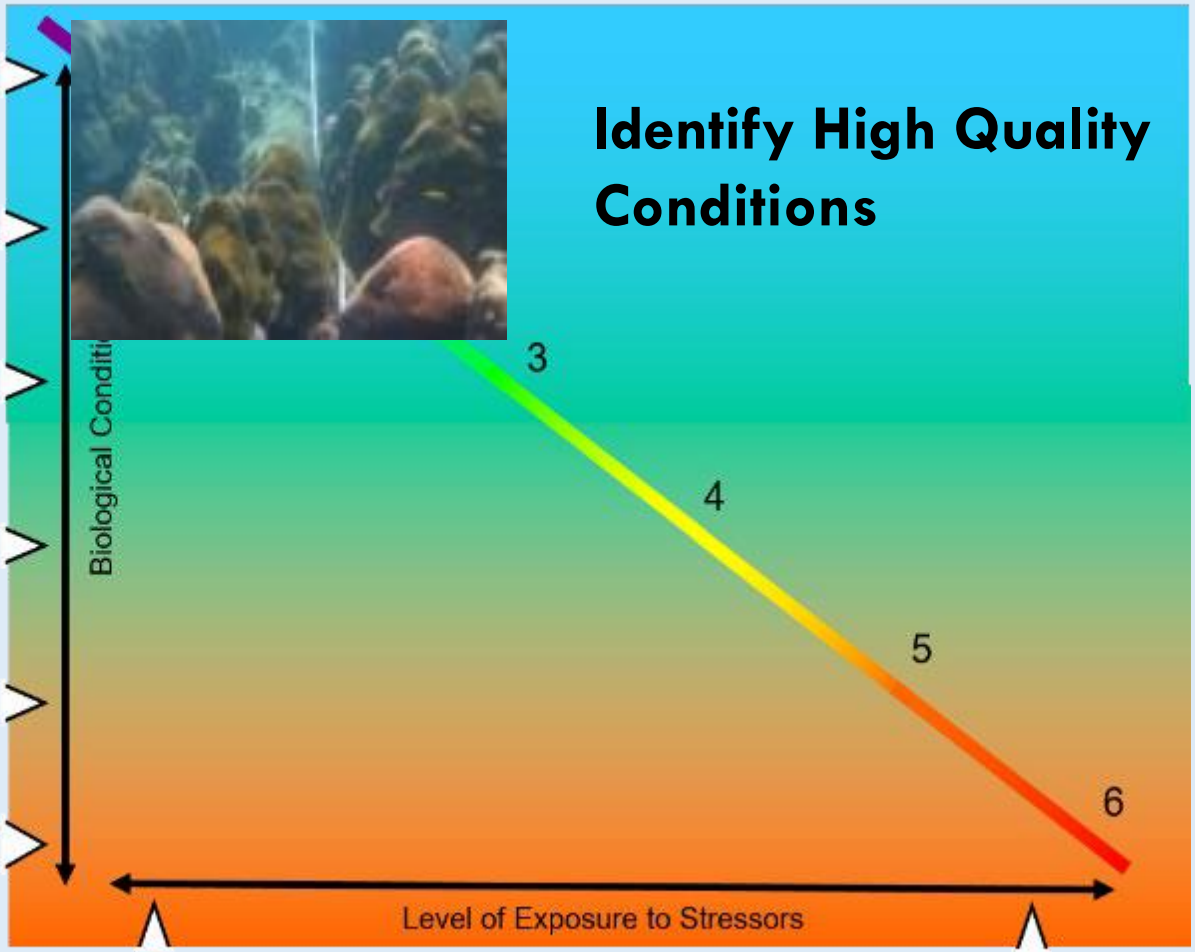

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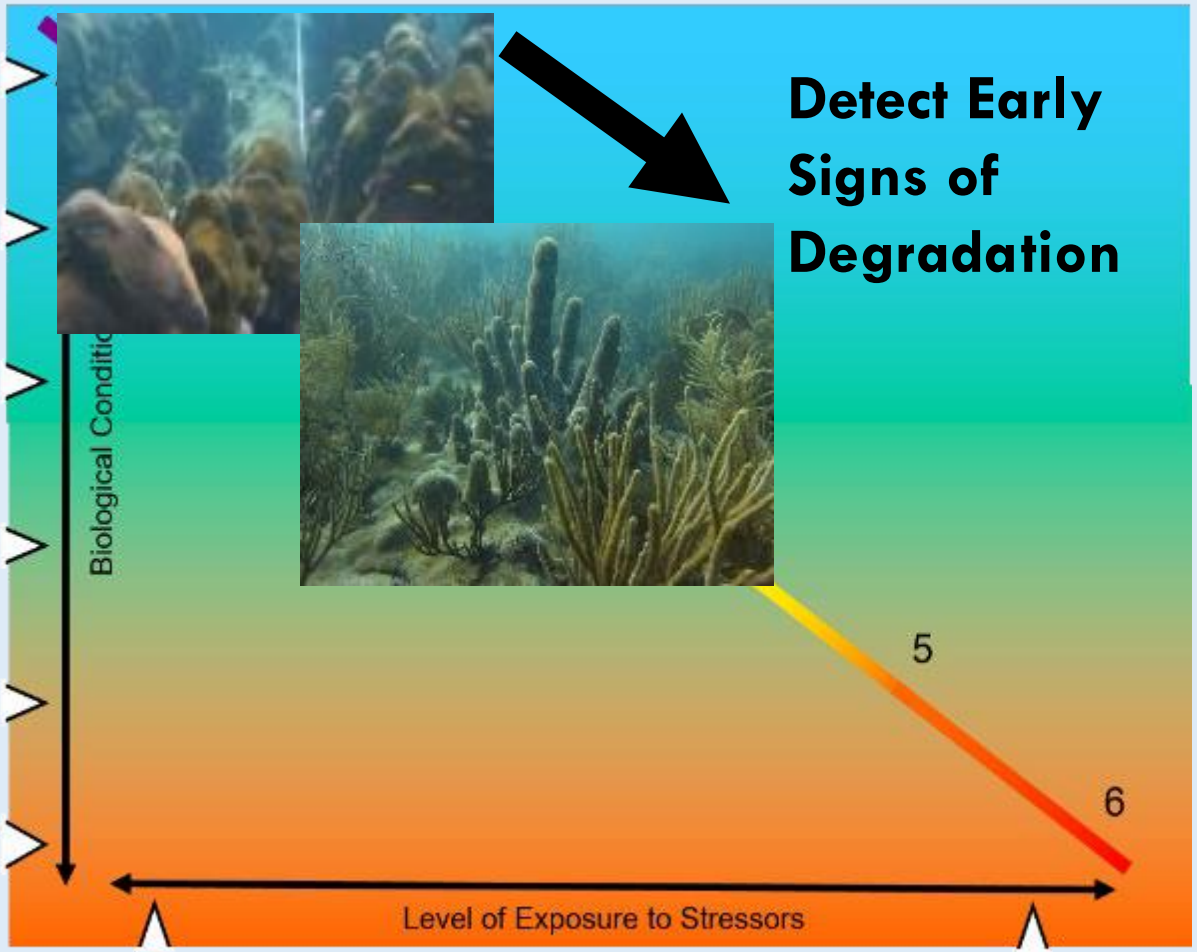

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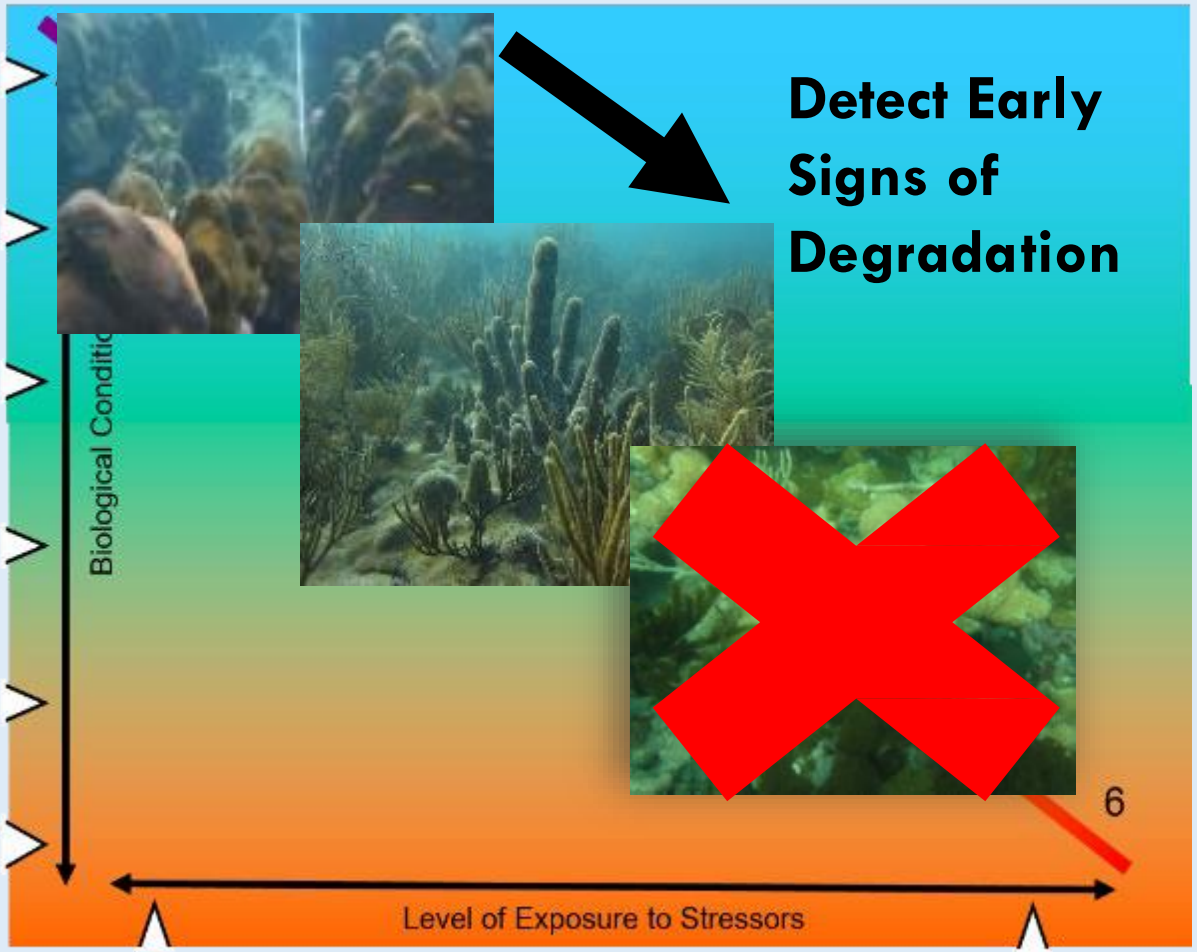

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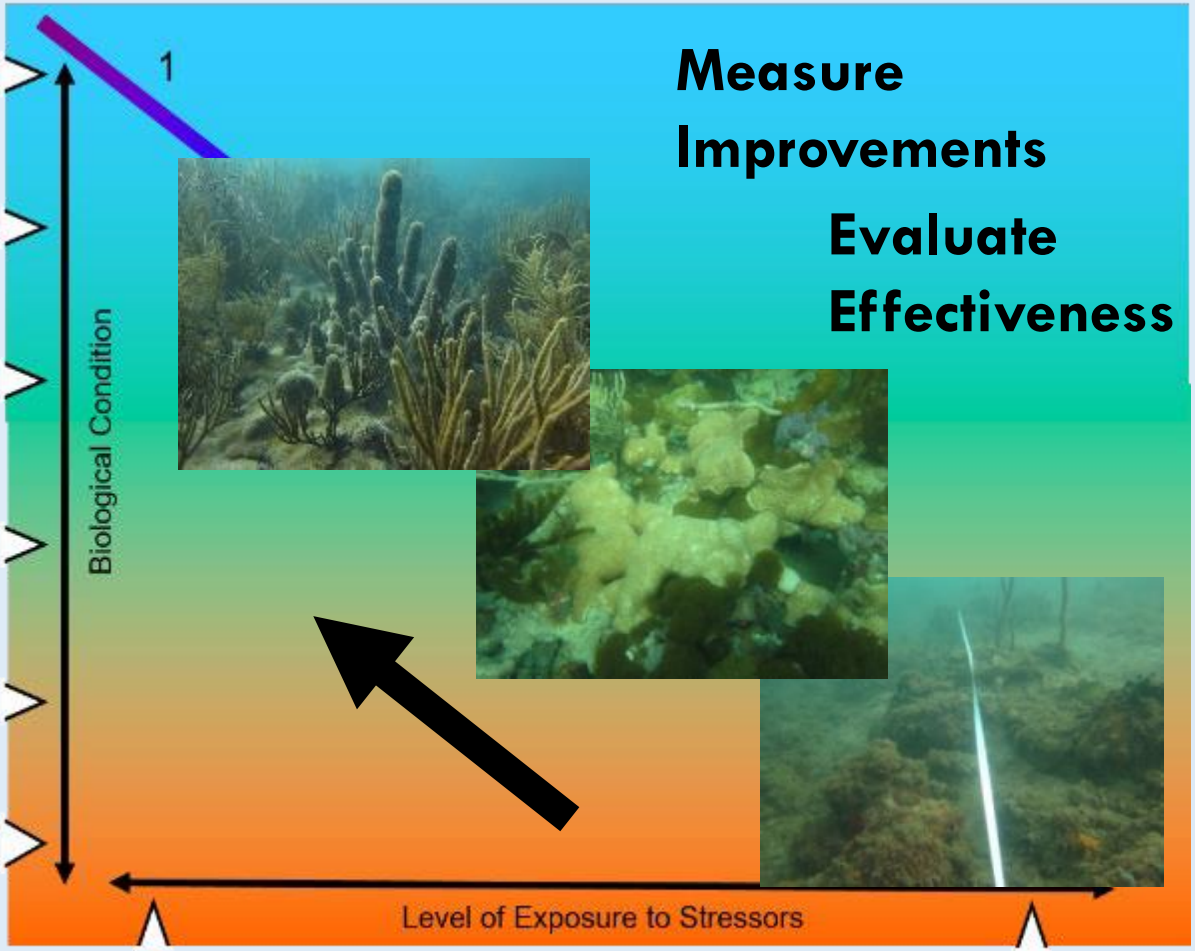

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In sum, the BCG can be used to help:

- Assess biological condition
- Identify high quality waters
- Set protection and restoration targets
- Track incremental progress
- Develop biological criteria and detailed ALU descriptions

Thank You!

Questions?

Susan Jackson
jackson.susank@epa.gov