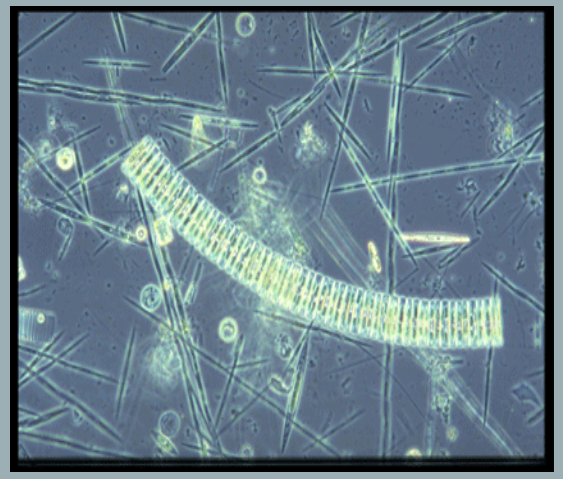
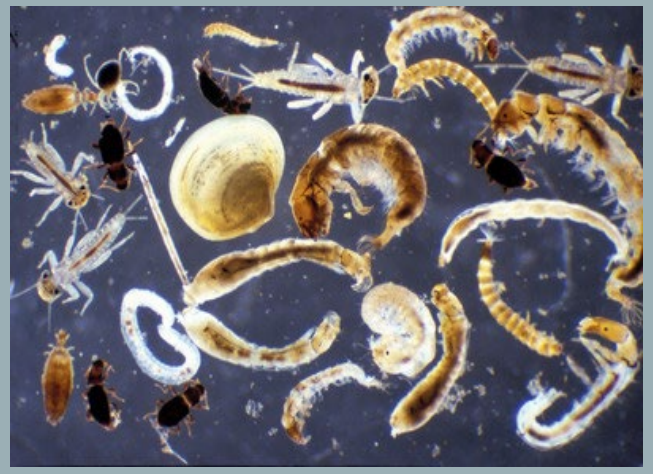


BIOLOGICAL CRITERIA

Water Quality Standards Academy June 2024

The views expressed in this presentation are those of the author[s] and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

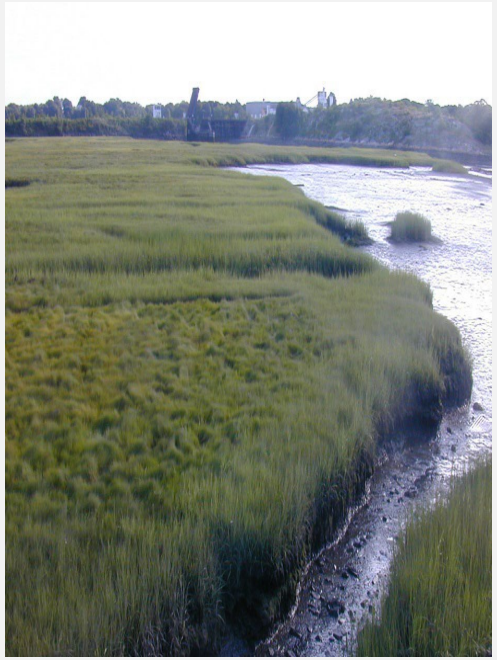
This Presentation does not:

- Impose any binding requirements
- Determine the obligations of the regulated community
- Change or substitute for any statutory provision or regulatory requirement
- Change or substitute for any Agency policy or guidance
- Control in any case of conflict between this discussion and statute, regulation, policy, or guidance

CWA SECTION 101

Objective

To restore and maintain the chemical, physical, and *biological integrity* of the nation's waters.



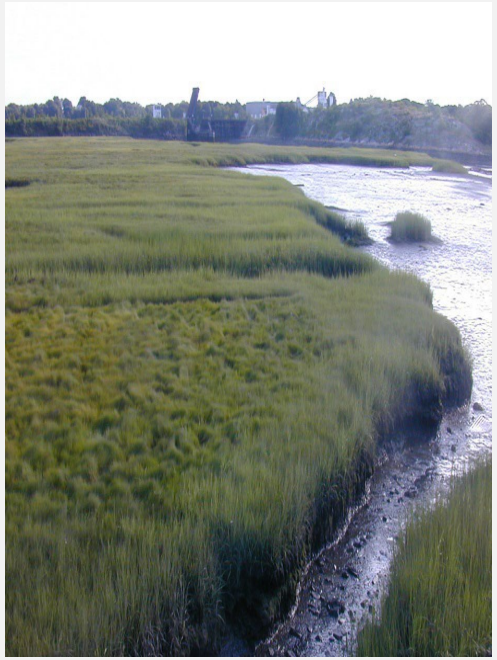
CWA SECTION 101

Objective

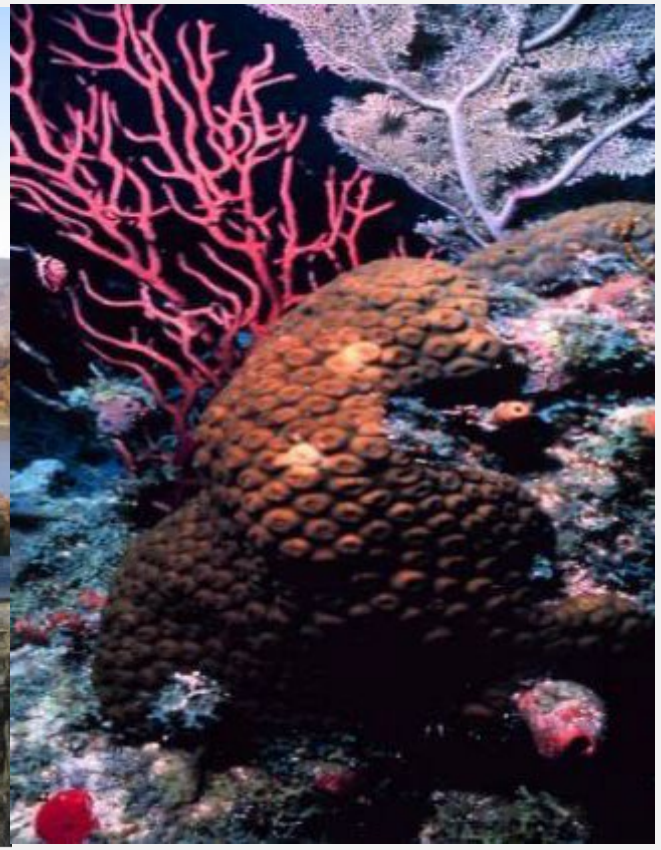
To restore and maintain the chemical, physical, and *biological integrity* of the nation's waters.

101(a)(2) Goal

Protection and propagation of fish, shellfish, and wildlife …

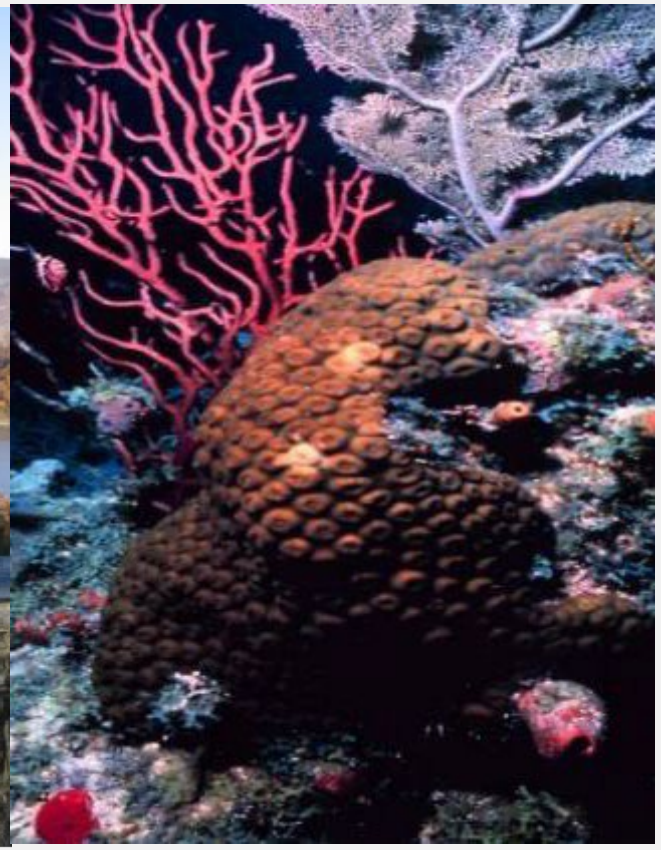






BIOLOGICAL INTEGRITY

The capability [of an aquatic ecosystem] to support and maintain a balanced, integrated, adaptive community of organisms having a composition and diversity comparable to that of the natural habitats of the region (adapted from Frey 1977)



classification

BIOLOGICAL INTEGRITY

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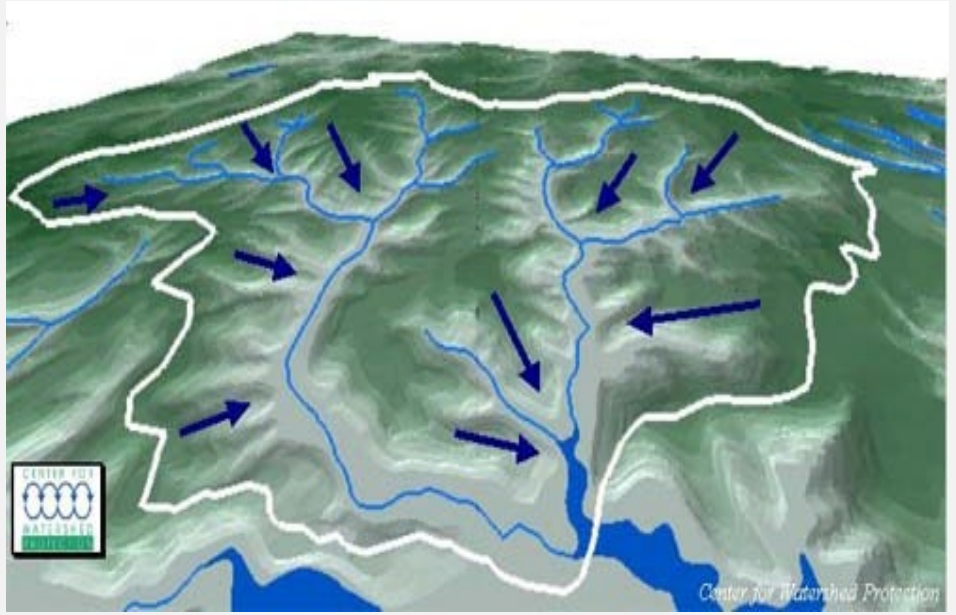
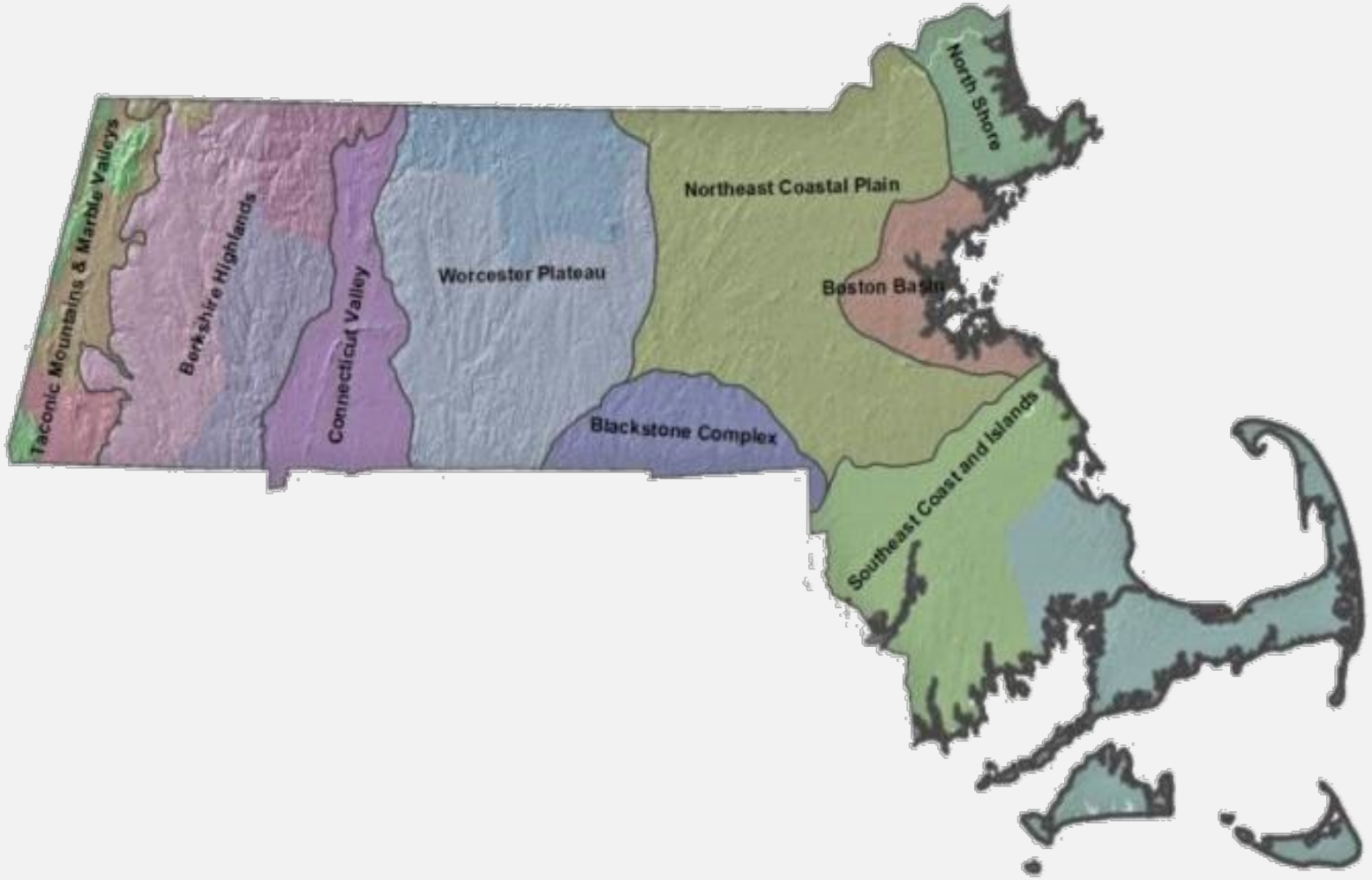
WATERBODY CLASSIFICATION

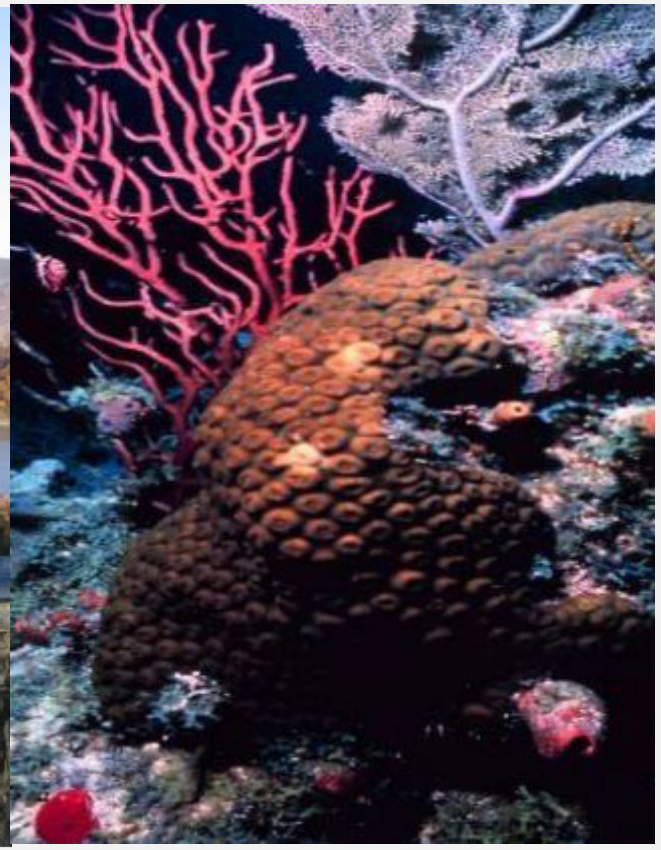
- Biota vary naturally in different environments.
- Classification of waterbodies allows you to compare waterbodies with similar biological expectations.
- Some ways to classify waterbodies are by aquatic resource type and ecological region.



ECOREGIONS

Ecoregions: areas of relative ecosystem homogeneity. They are based on soils, geology, elevation, climate, and other factors.





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REFERENCE SITES AS A BENCHMARK

What is reference condition?

- The biological expectation for a given waterbody type in a given region that would occur with no or minimal human disturbance.

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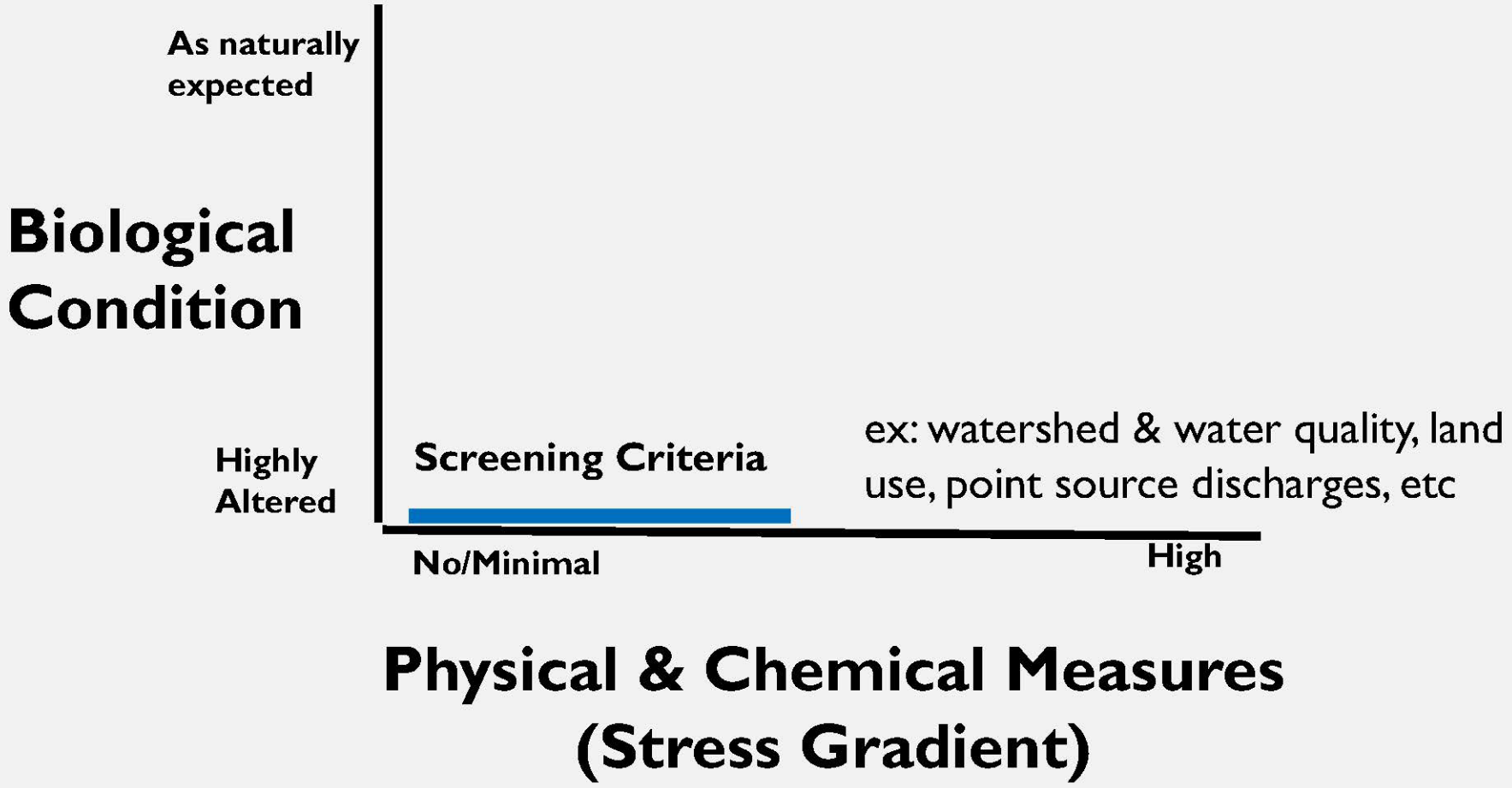

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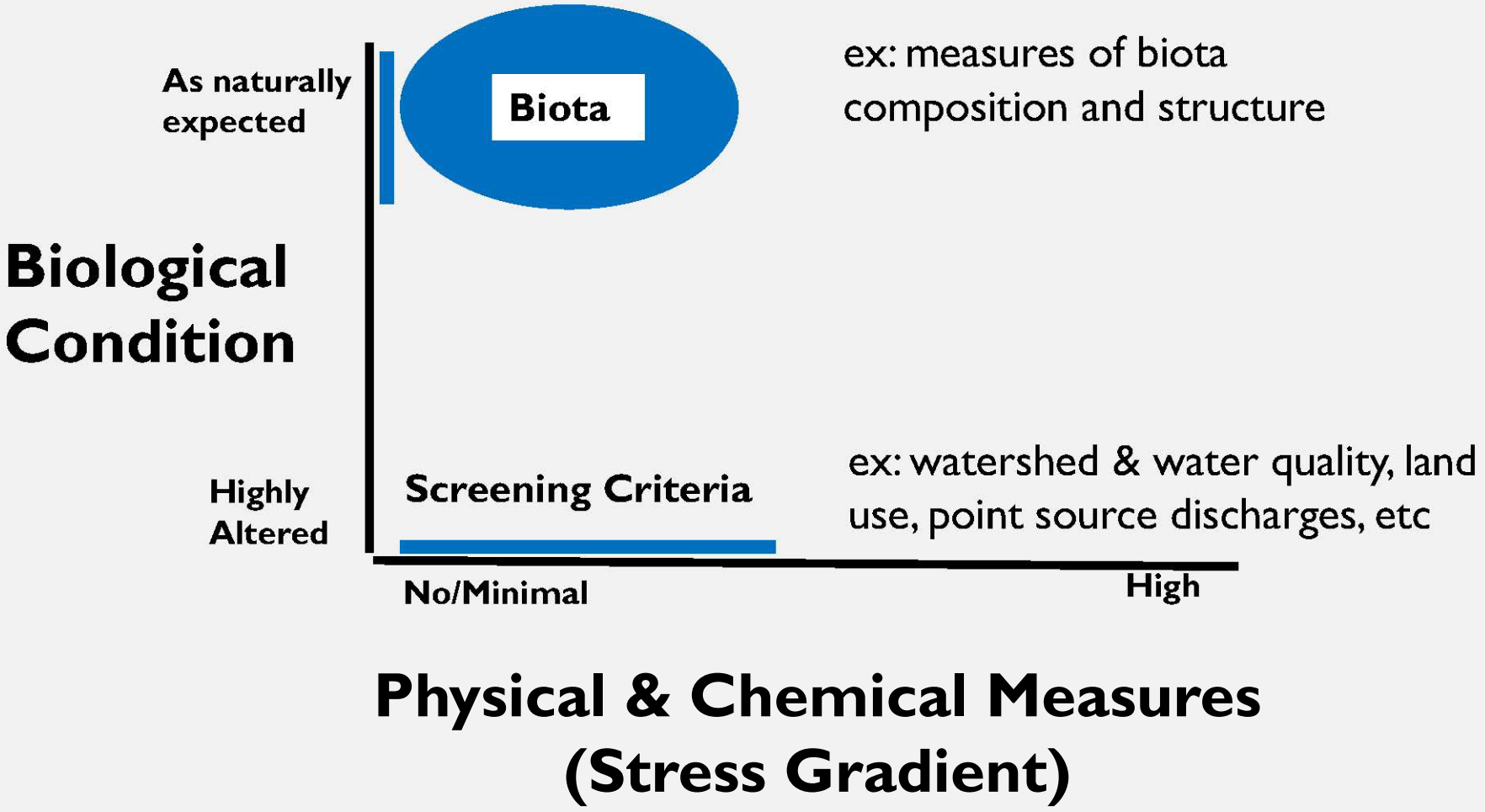

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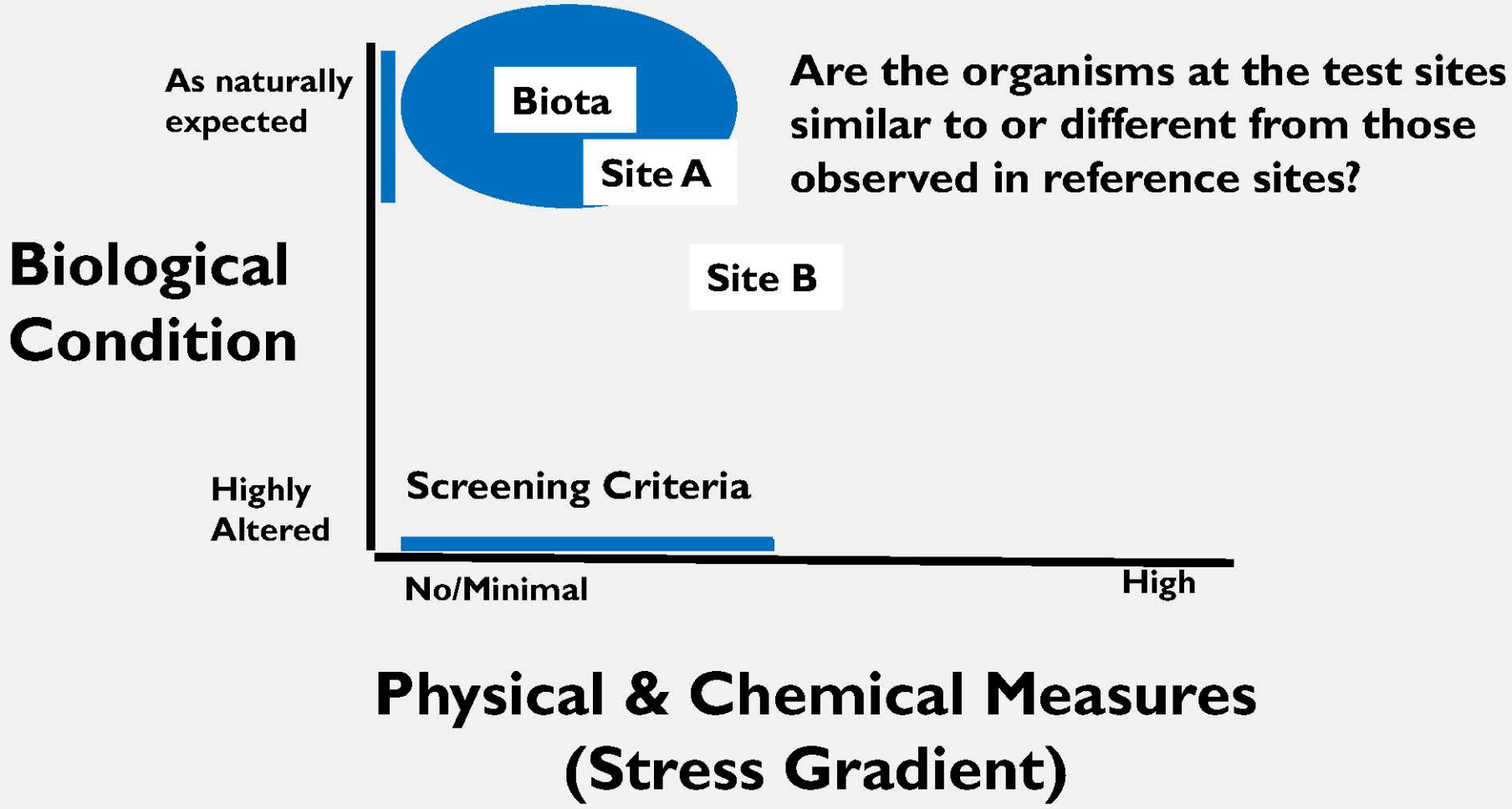

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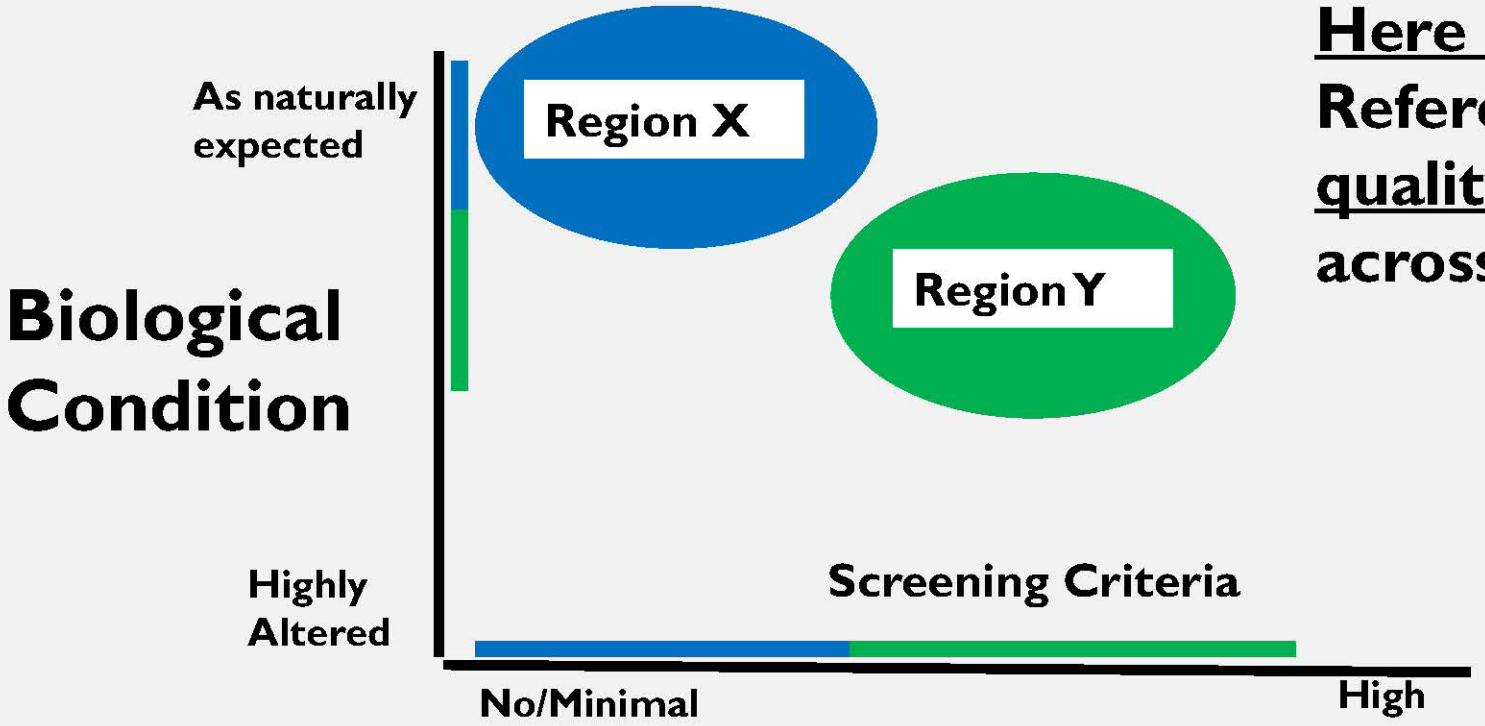

Here is the hitch:
Reference site quality may vary across regions

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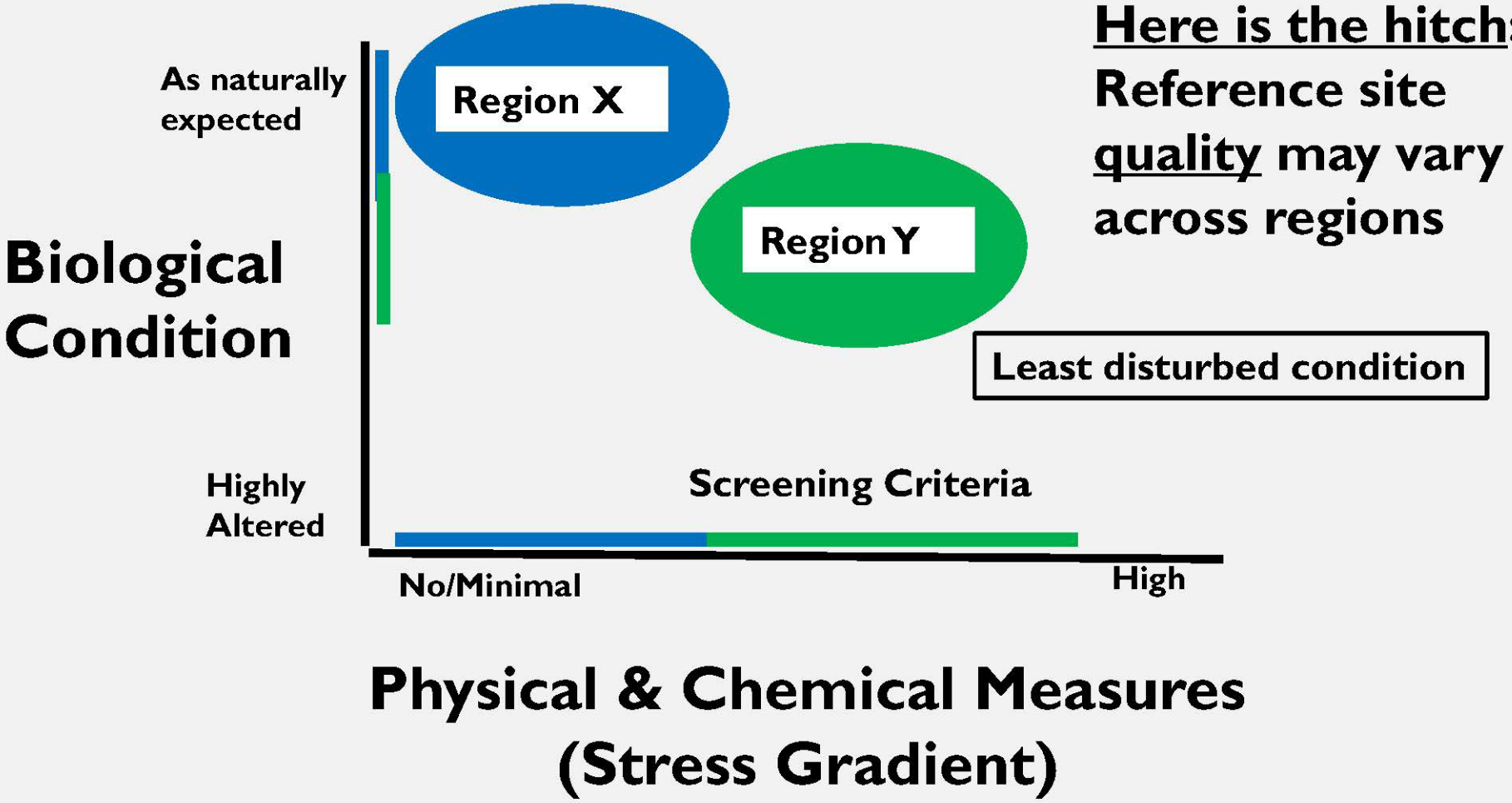

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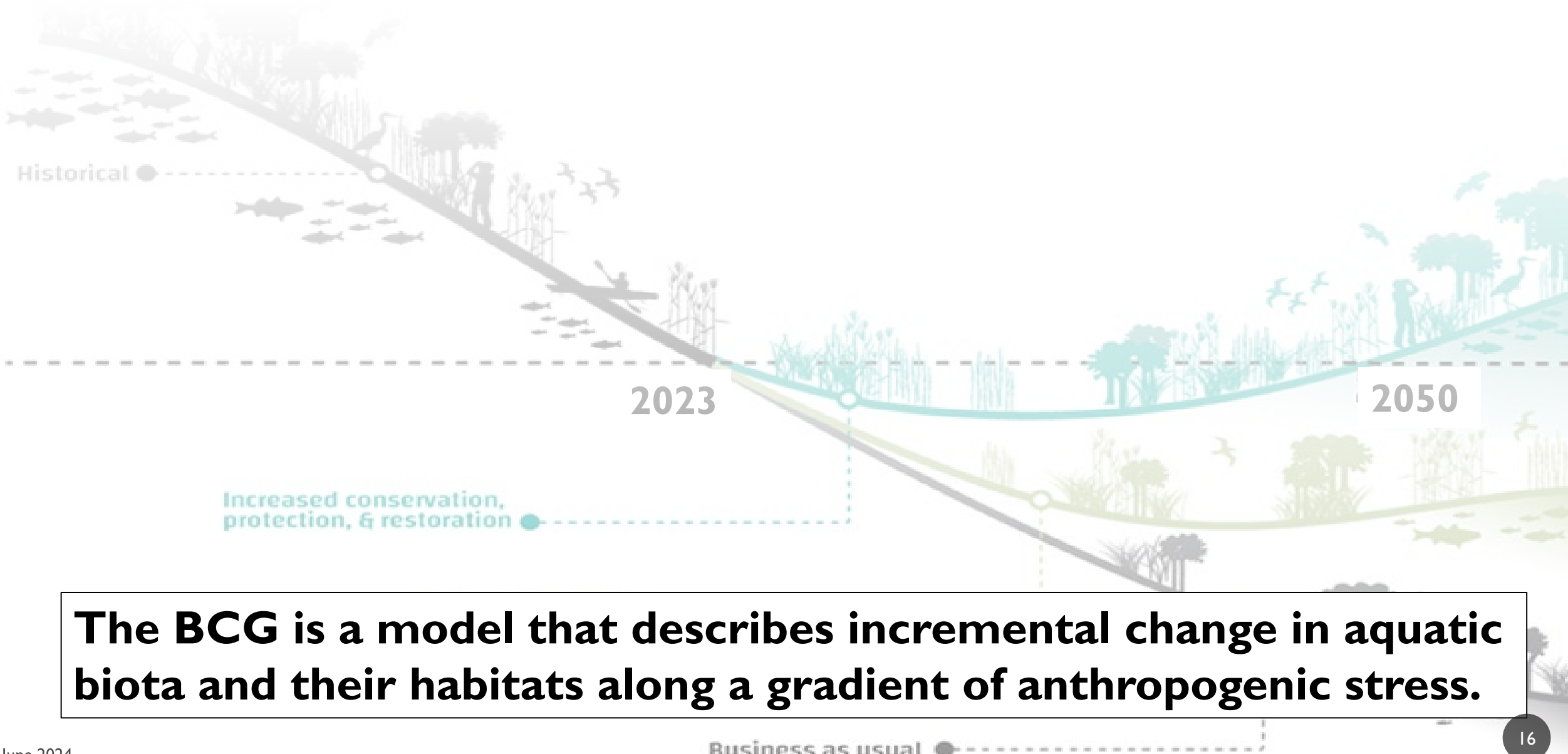
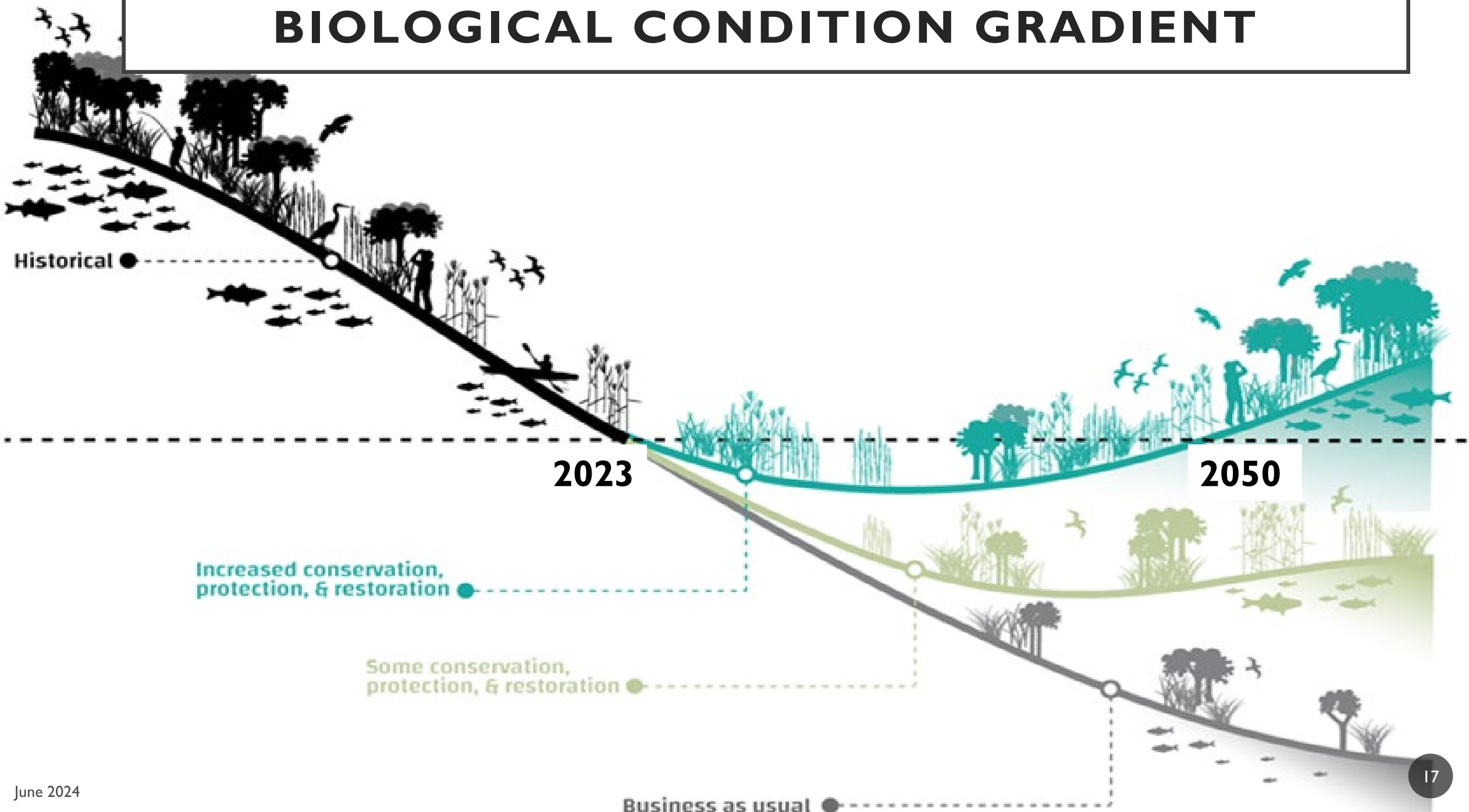
Least disturbed condition

BIOLOGICAL CONDITION GRADIENT



The BCG is a model that describes incremental change in aquatic biota and their habitats along a gradient of anthropogenic stress.

BIOLOGICAL CONDITION GRADIENT



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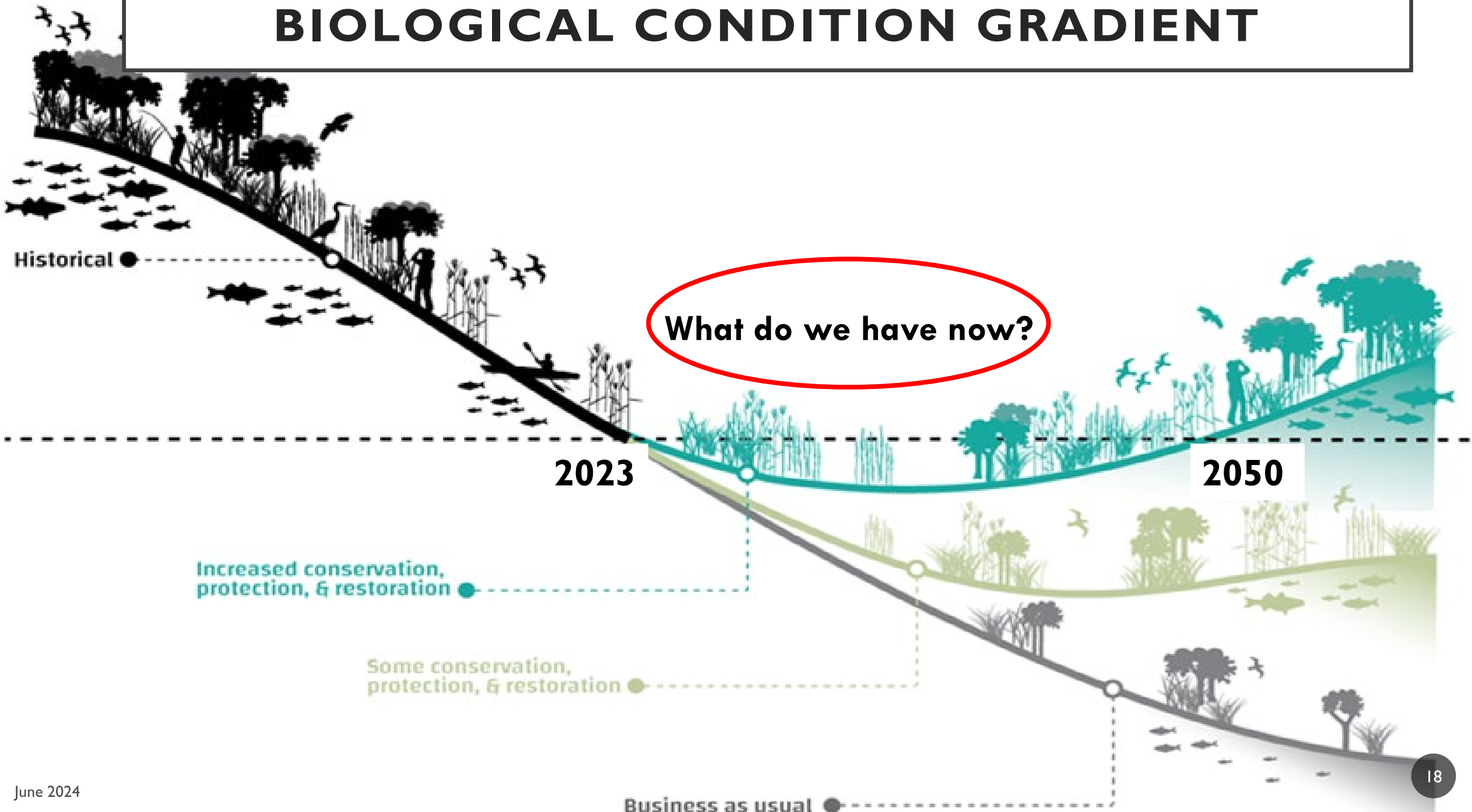

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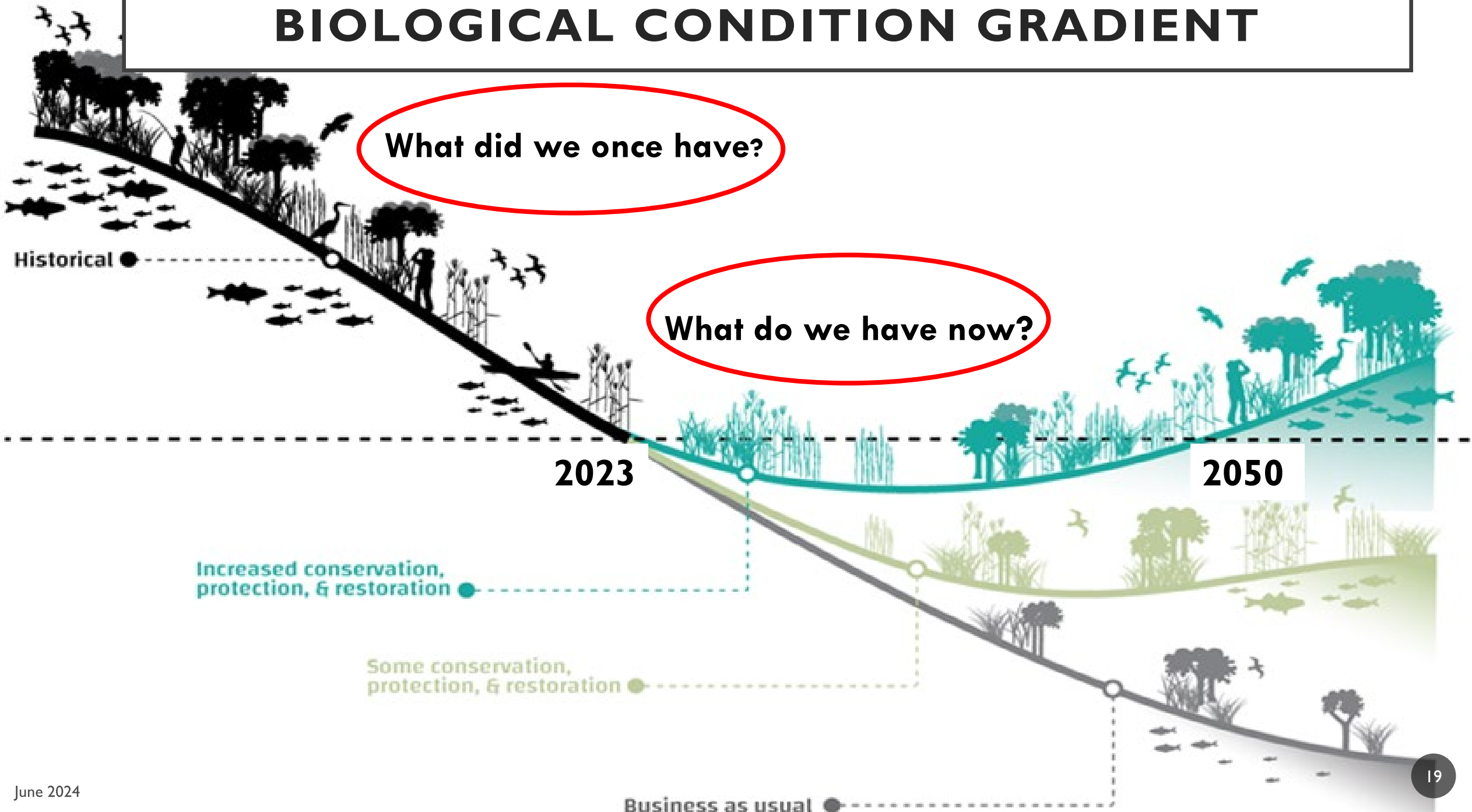

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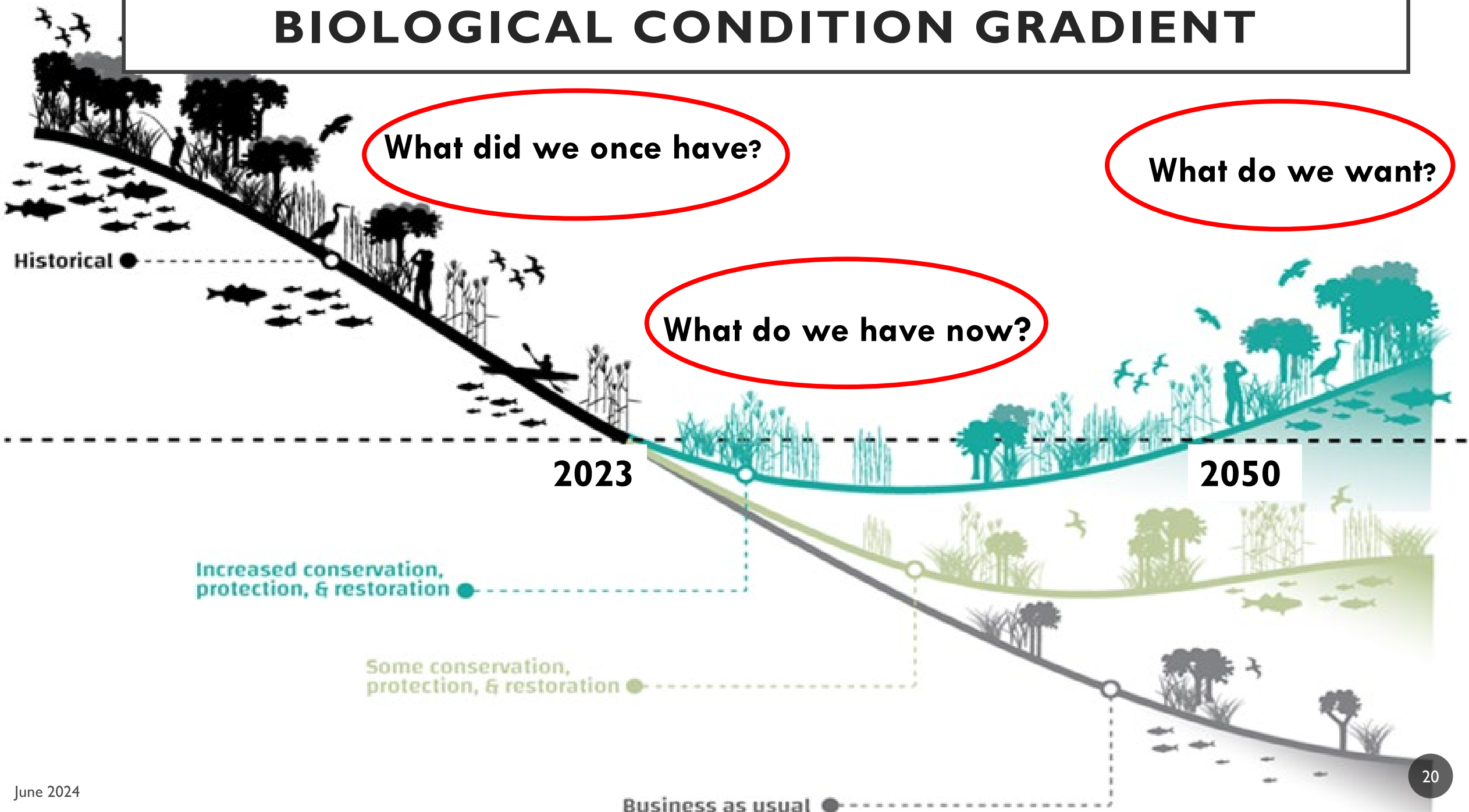
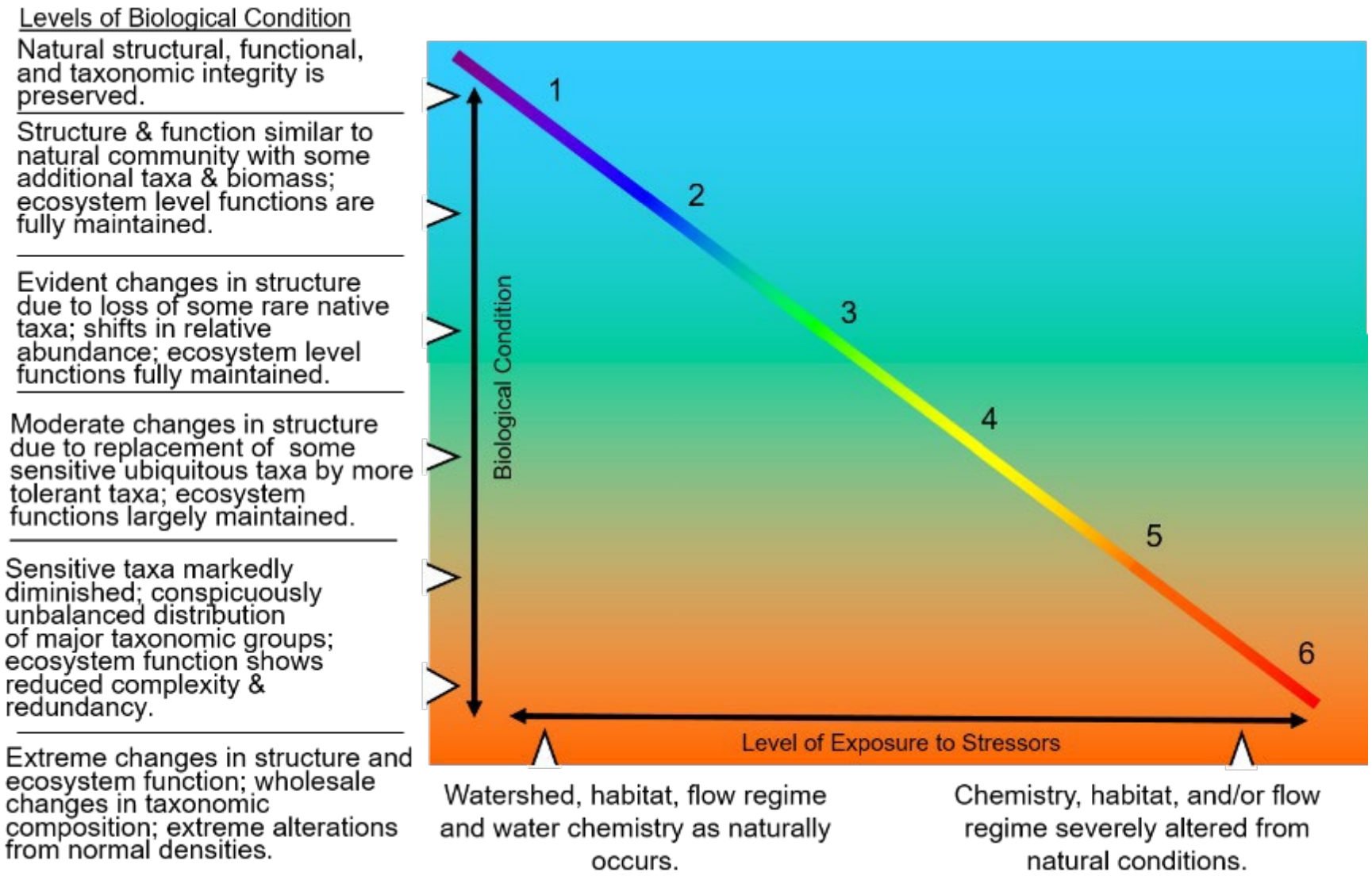


BCG CONCEPTUAL MODEL

There are 6 levels of condition defined along the stressor gradient, each defining a shift in biotic or habitat condition with increasing stress. From condition comparable to biological integrity …



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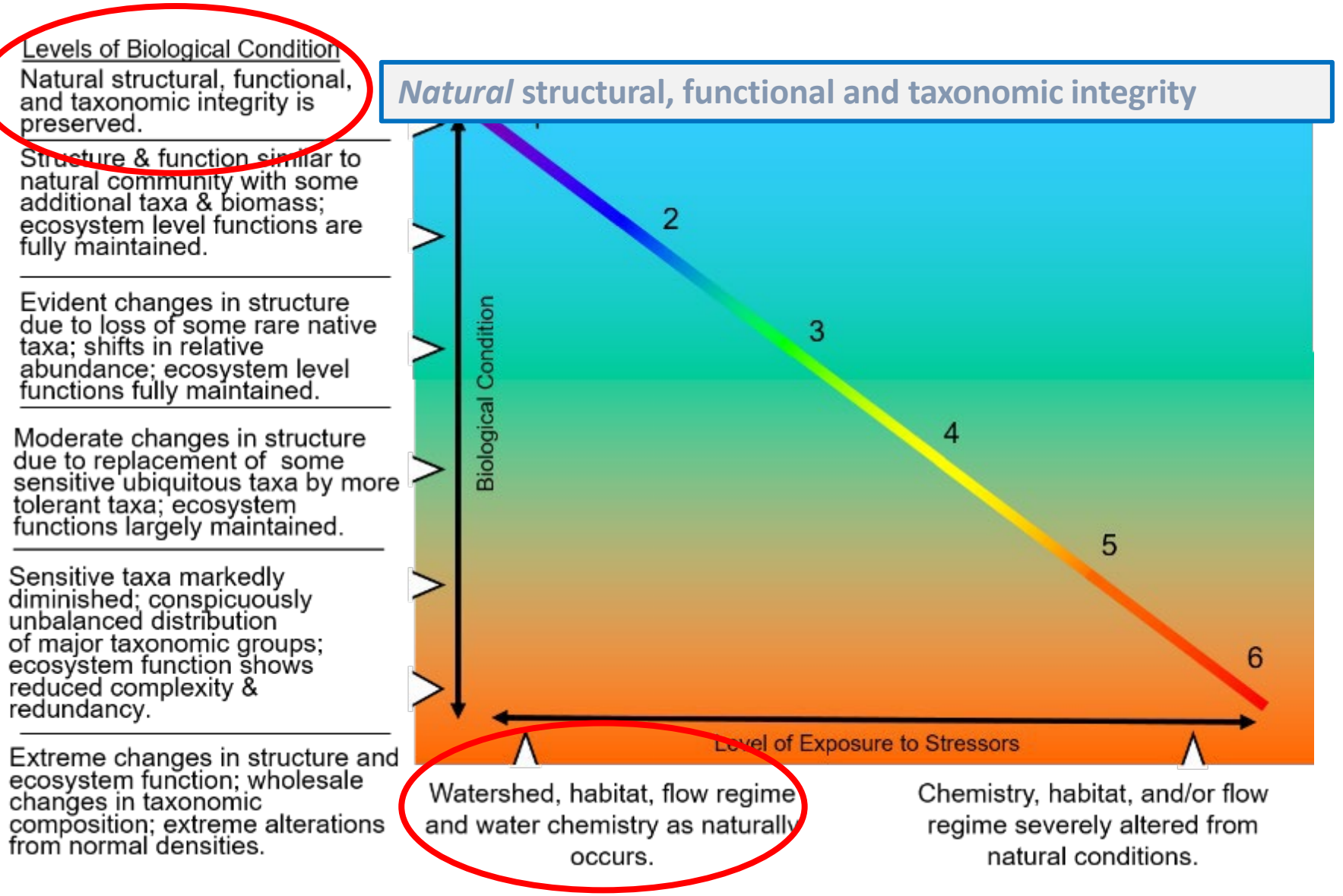

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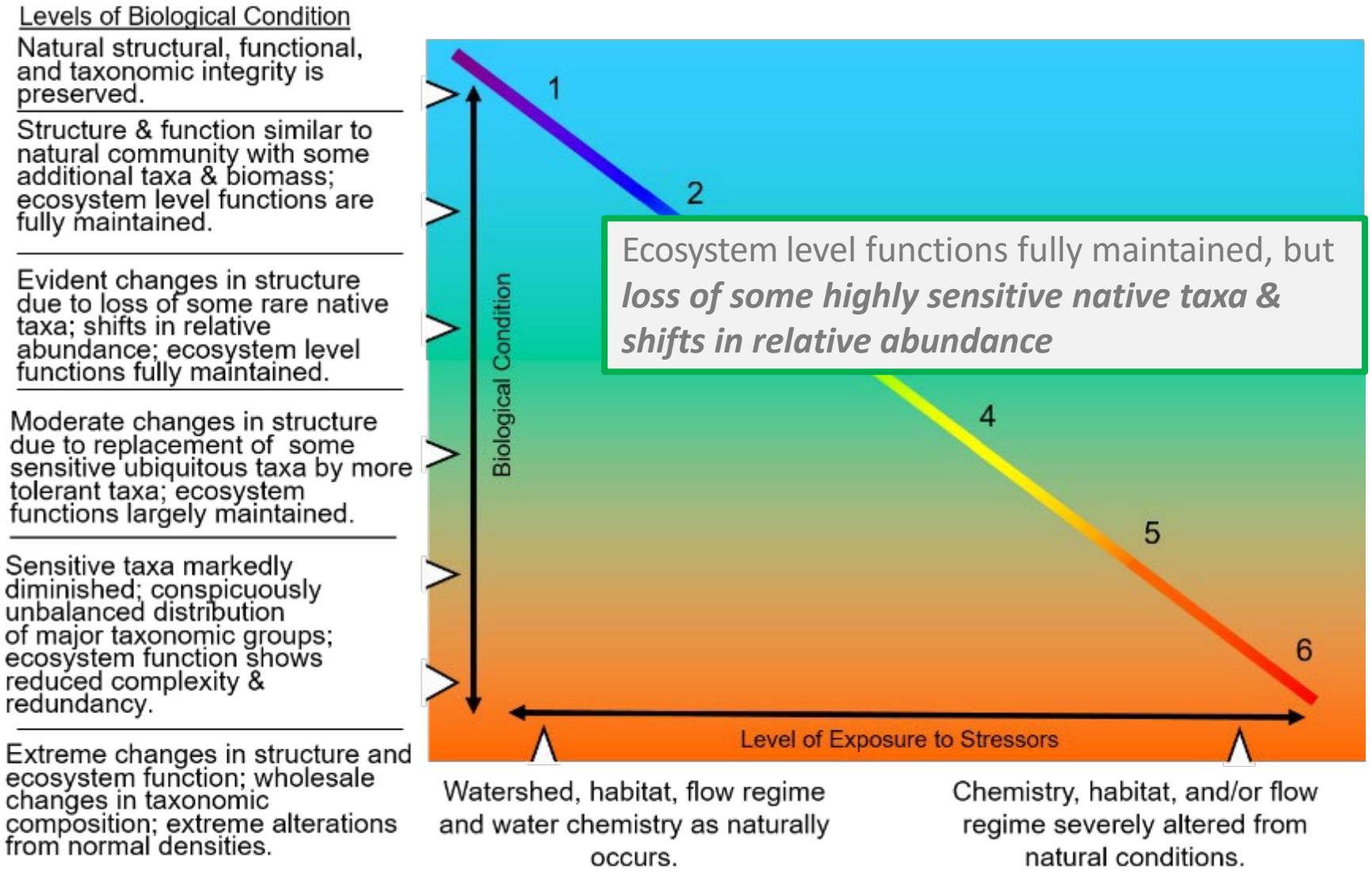
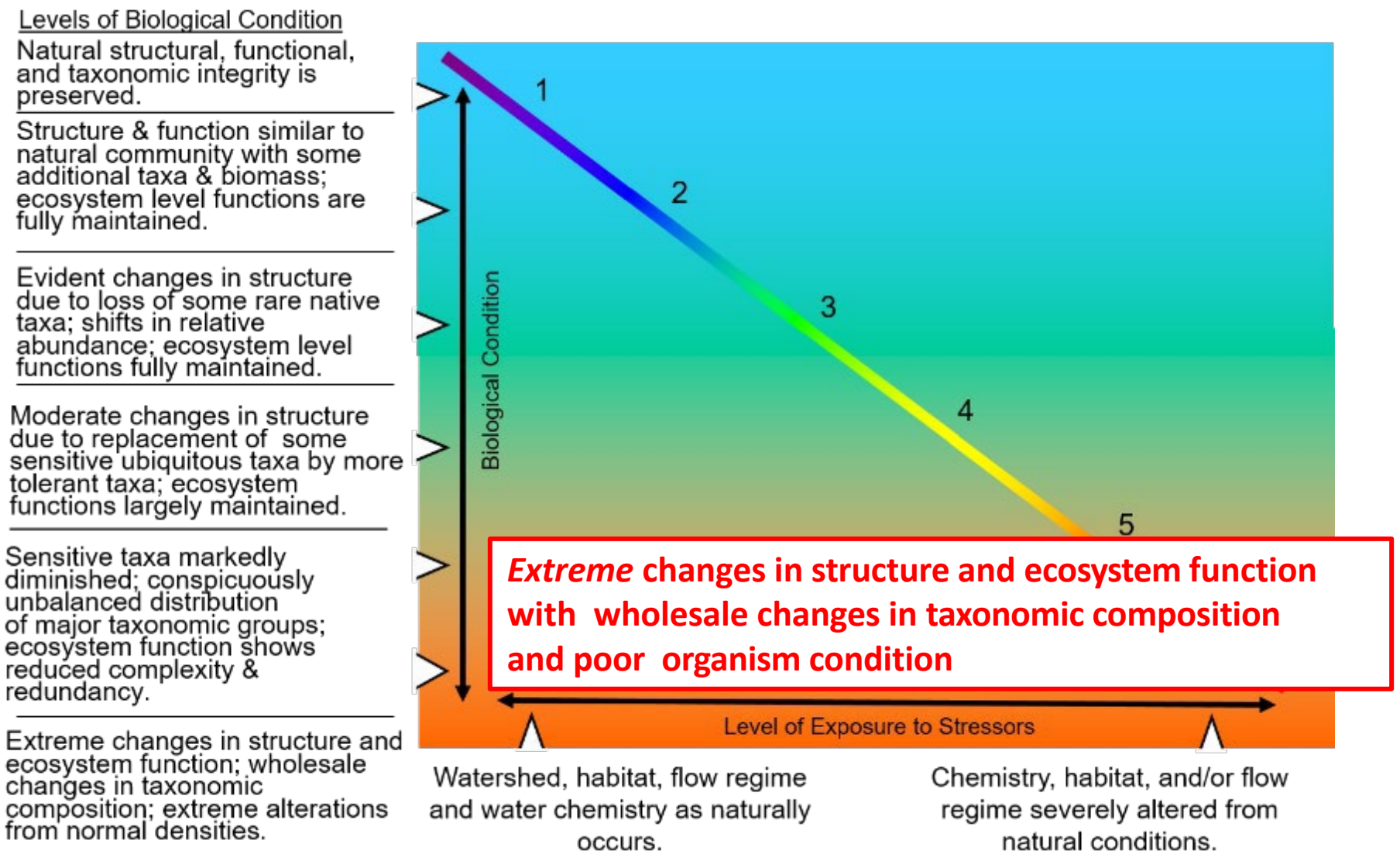


BCG CONCEPTUAL MODEL

… to a condition that is severely altered.



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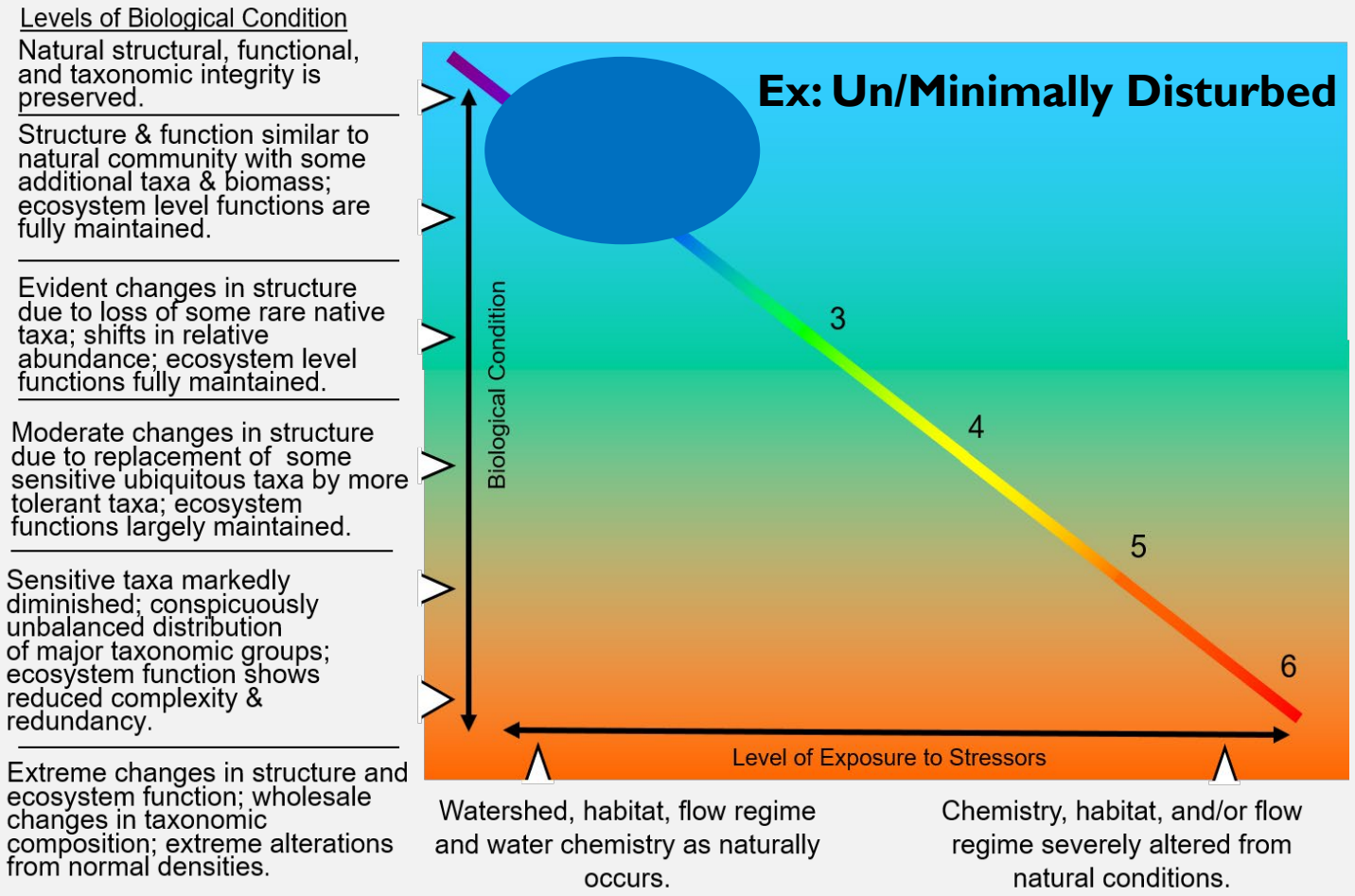

https://www.epa.gov/wqc/practitioners-guide-biological-condition-gradient-framework-describe-incremental-change-aquatic

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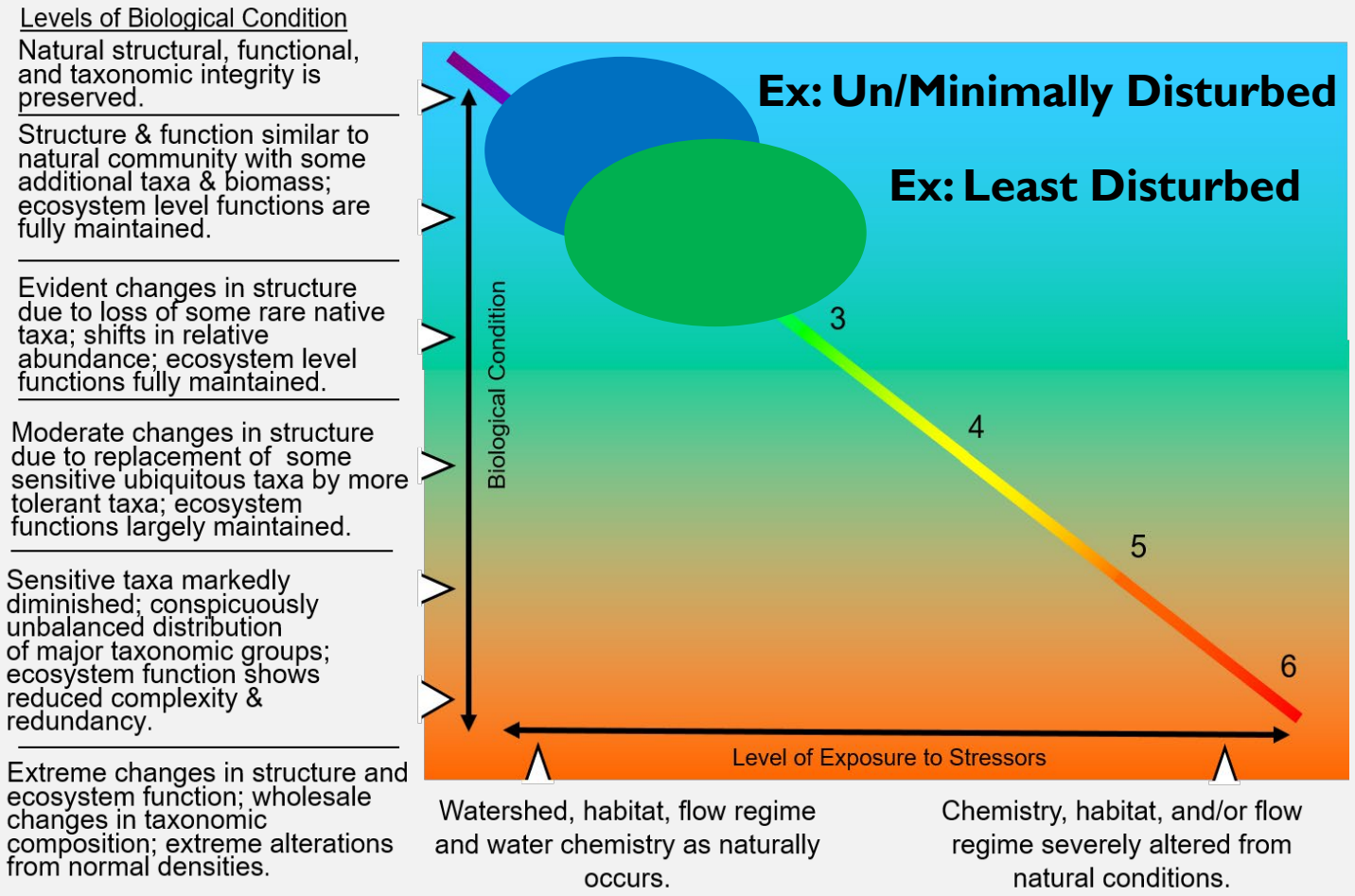

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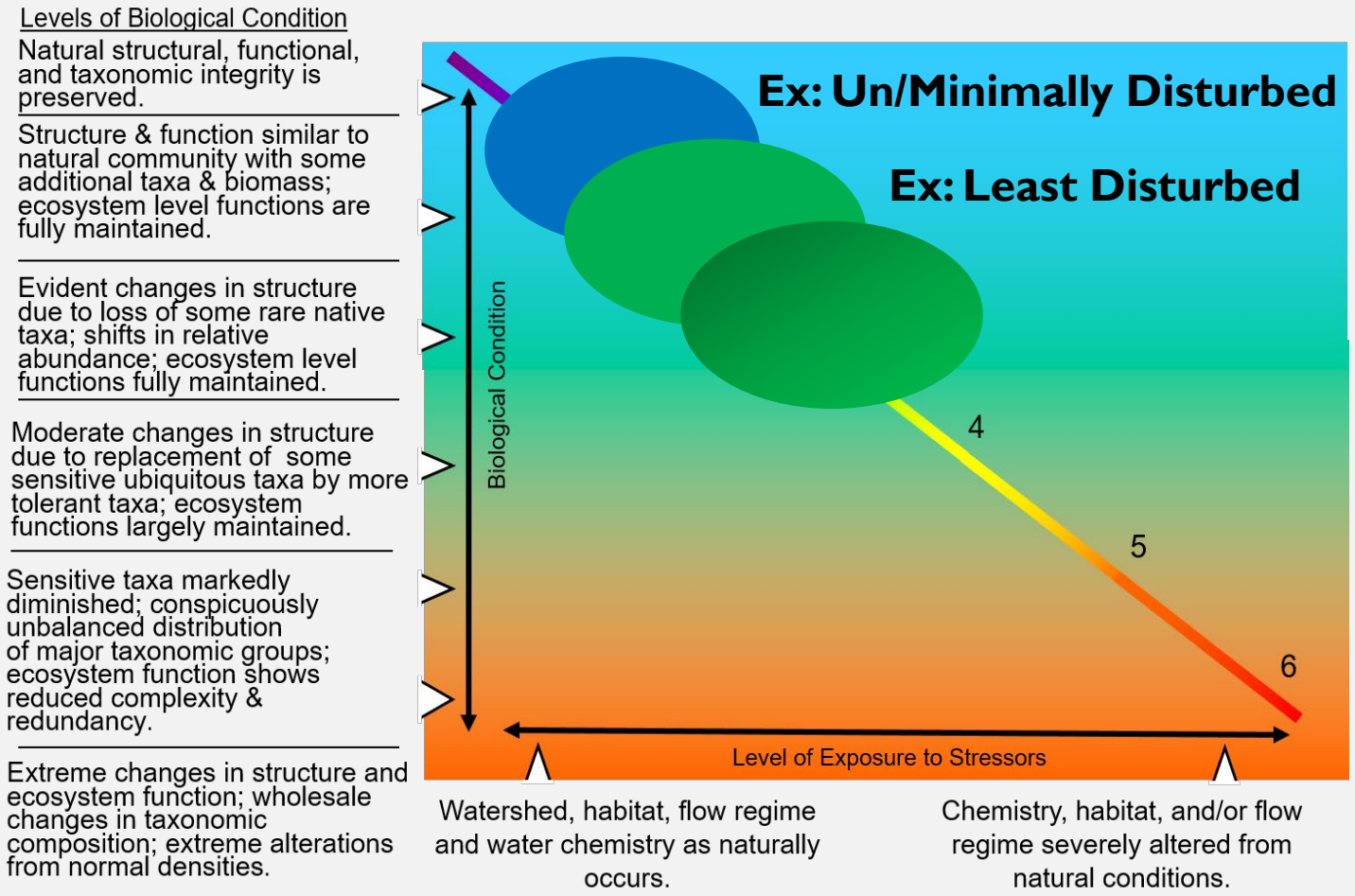

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quantitative measures

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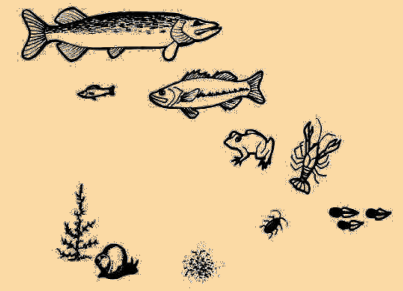
Benthic Macroinvertebrates
Fish
Diatoms



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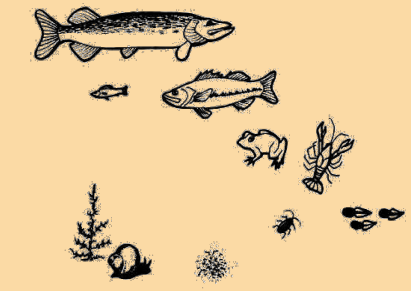
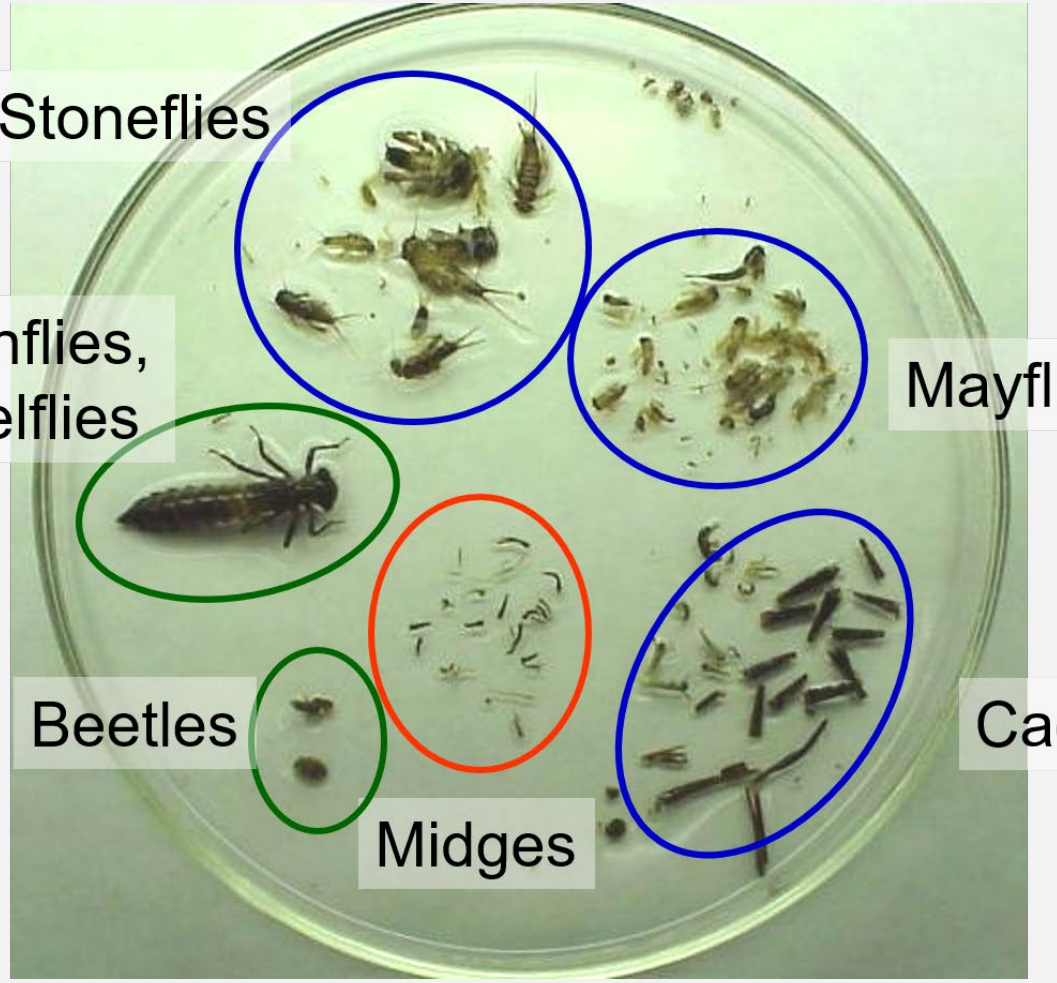
Fish
Diatoms
Amphibians
Birds
Aquatic Macrophytes



EX: BENTHIC MACROINVERTEBRATES

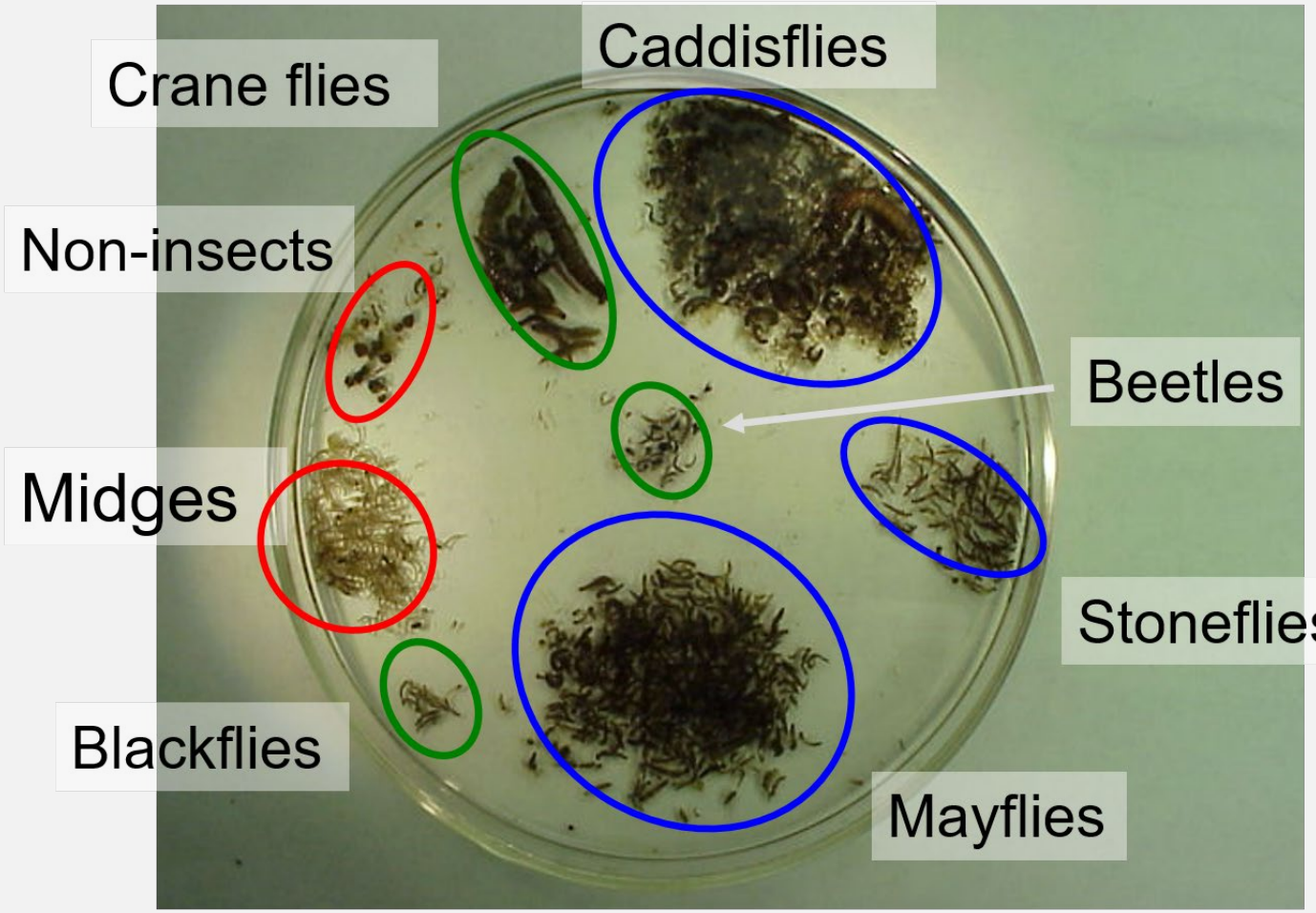
- Animals without backbones, living in or on the sediments for one or more life stages
- Large enough to be seen by the unaided eye.
- Are susceptible to degradation of water quality and habitat, and therefore serve as good indicators of environmental conditions.

UNDISTURBED/MINIMALLY DISTURBED STREAM



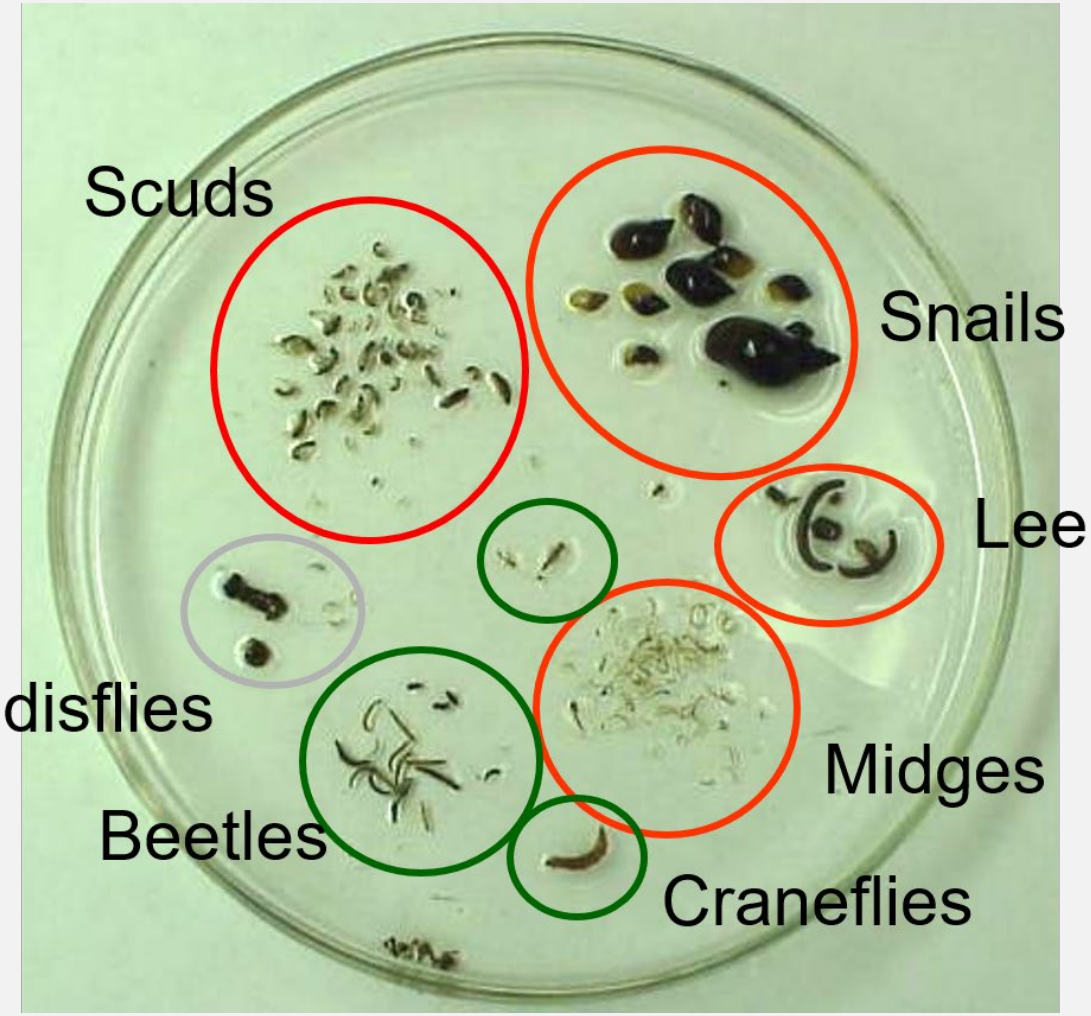
Courtesy of Susan Davies, ME DEP

NUTRIENT ENRICHED STREAM



Courtesy of Susan Davies, ME DEP

DRAINAGE FROM A SHOPPING MALL PARKING LOT



1 inch

Courtesy of Susan Davies, ME DEP

BIOLOGICAL CONDITION GRADIENT

Levels of Biological Condition

Natural structural, functional, and taxonomic integrity is preserved.

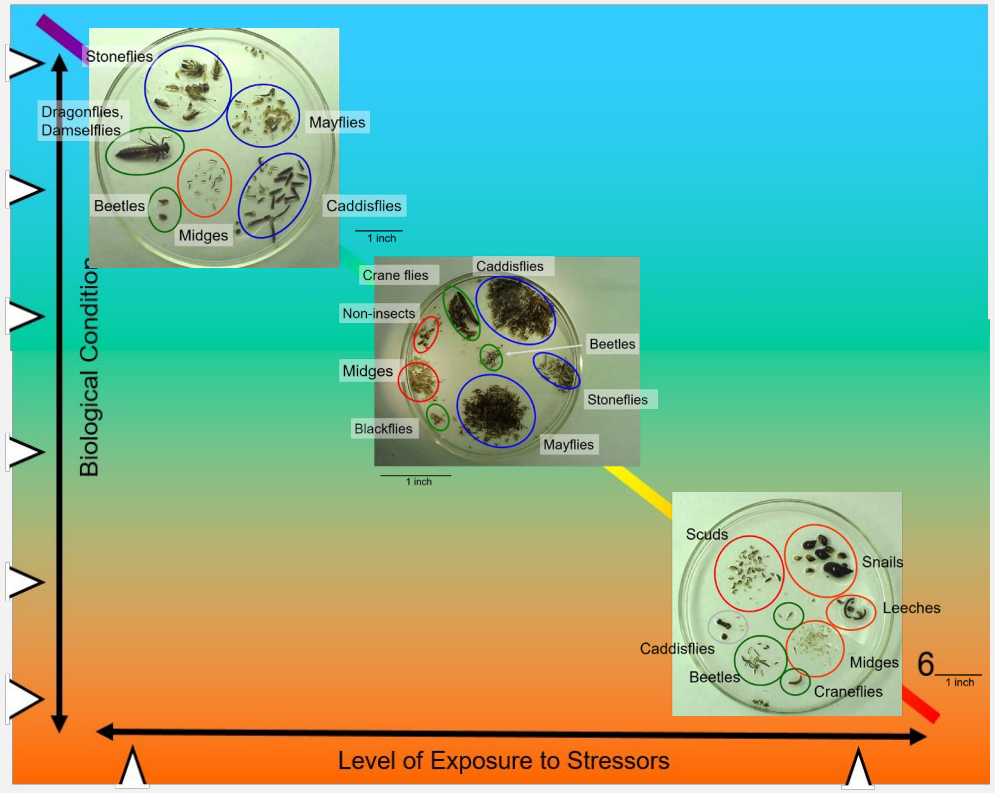
Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

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.



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

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

https://www.epa.gov/wqc/practitioners-guide-biological-condition-gradient-framework-describe-incremental-change-aquatic

INDICATOR SELECTION

- Attribute: any measurable component of a biological system.
- Metric: attribute that shows a quantitative change in value along a gradient of human influence.
- Multimetric index: a number that integrates several biological metrics to express a site's condition or health (ex. Index of Biological Integrity)

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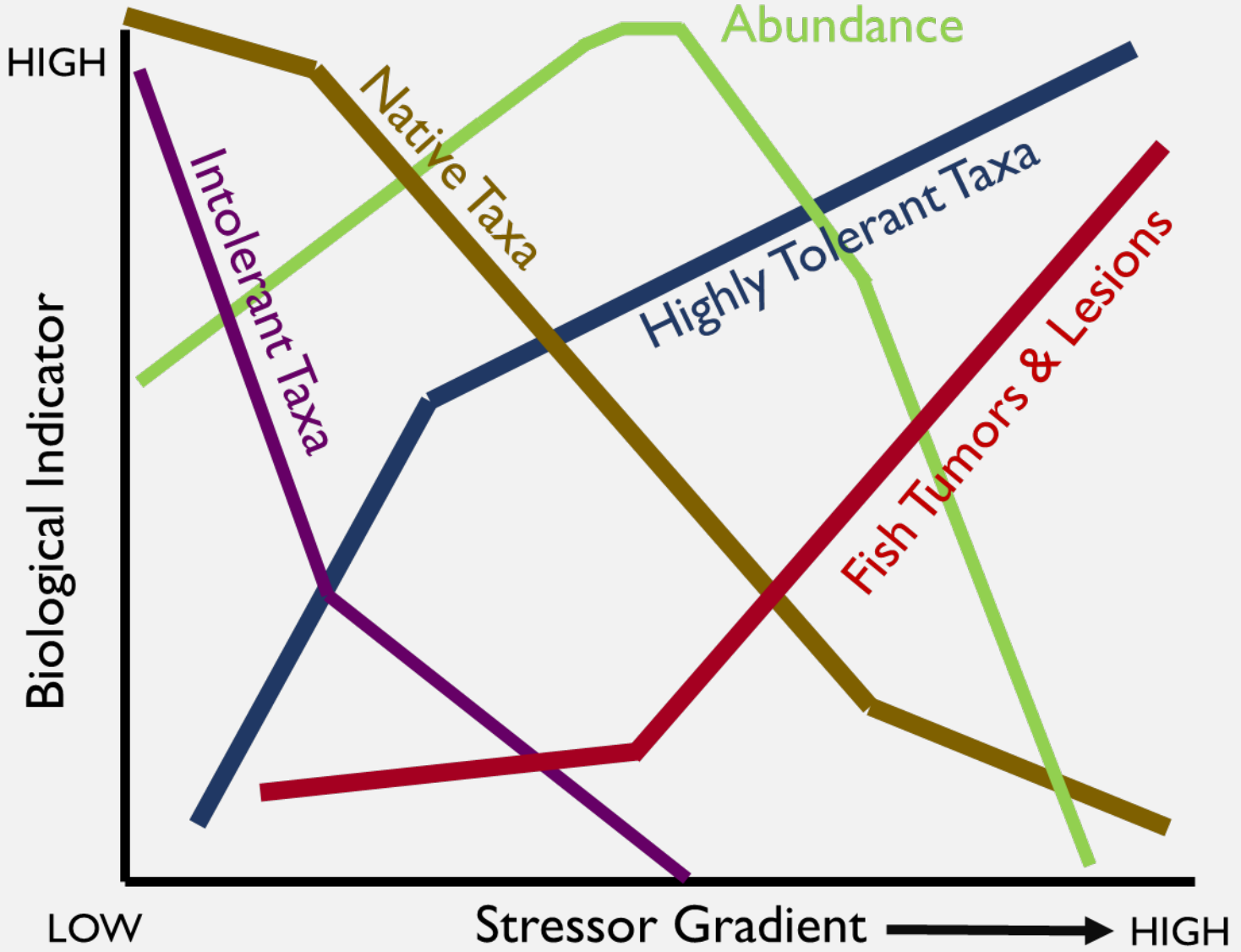
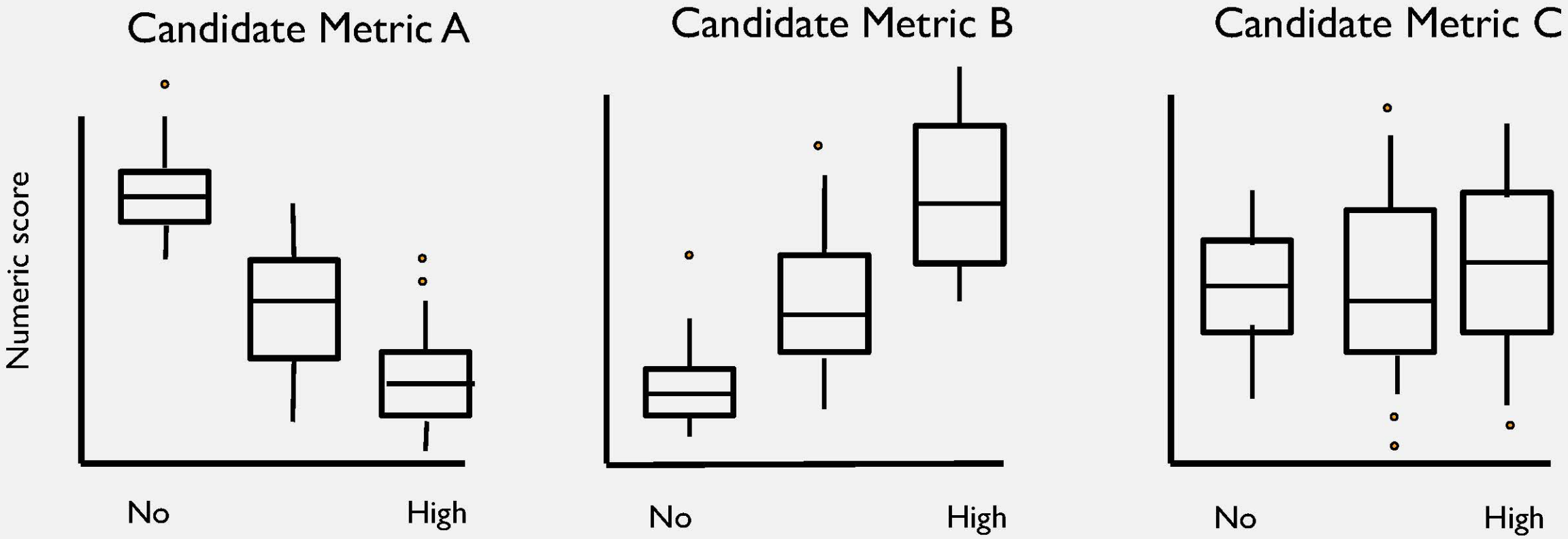
BIOLOGICAL INDICATOR GRAPH (1)

Biological Indicator: Response Along the Stressor Gradient



Modified original courtesy of Chris Yoder, CABB

INDICATOR SELECTION: BOX PLOTS



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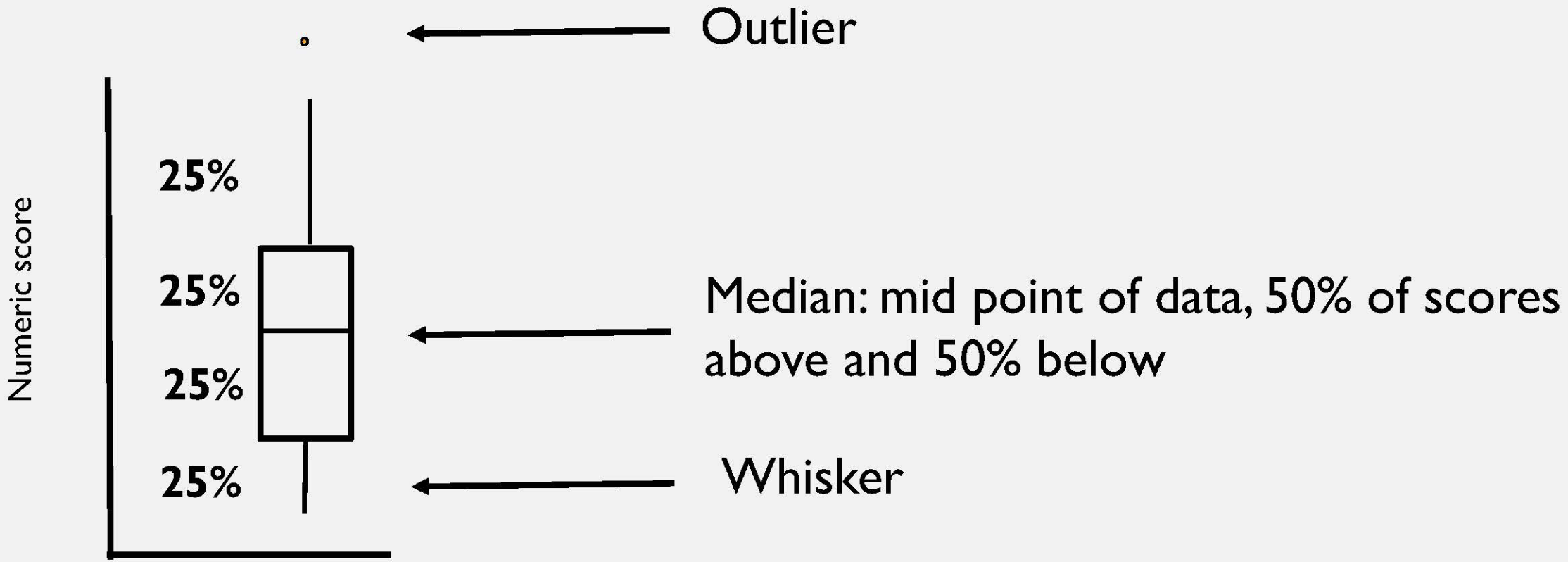

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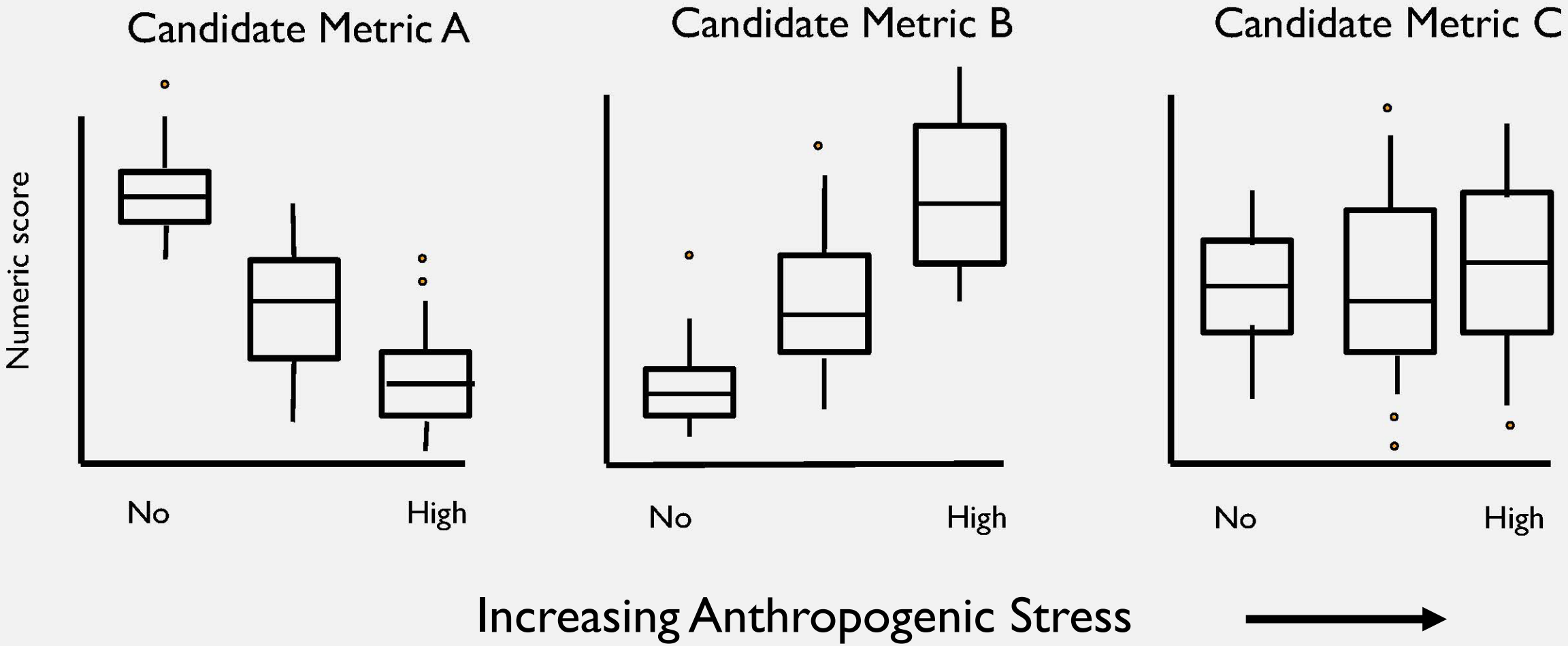

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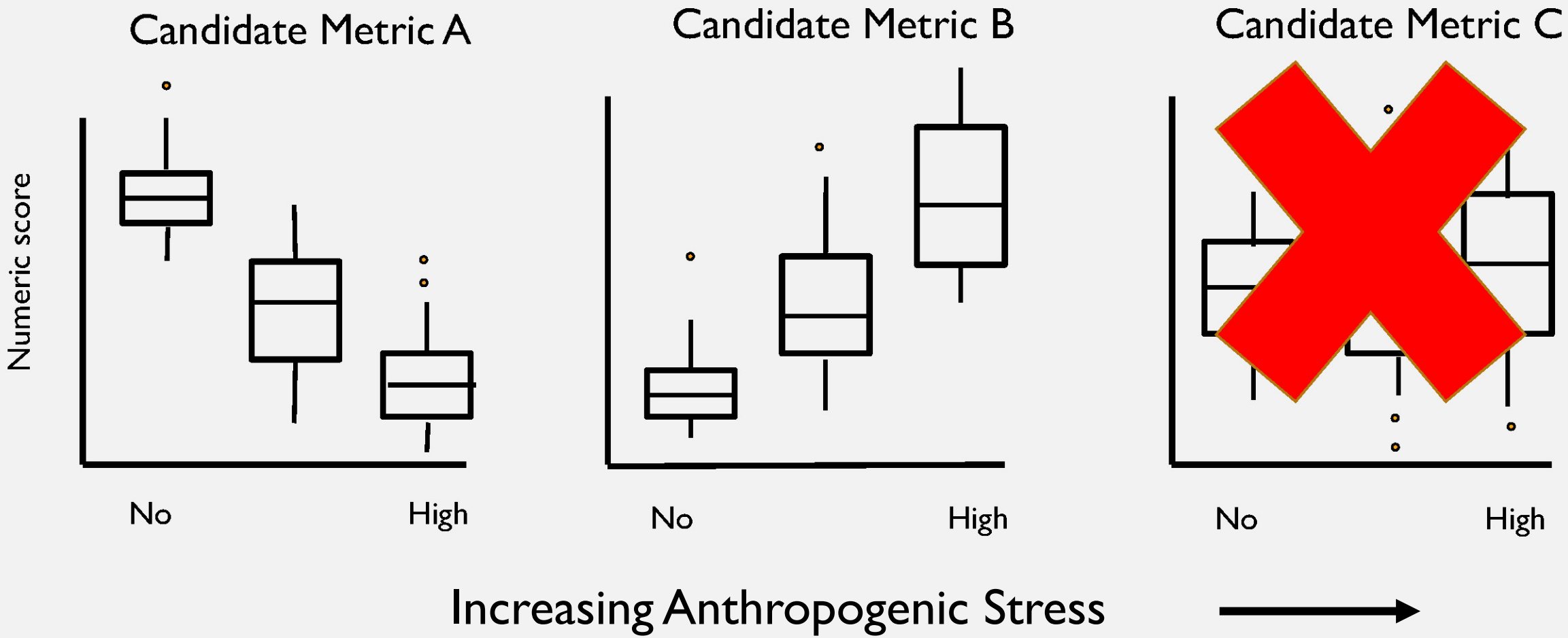

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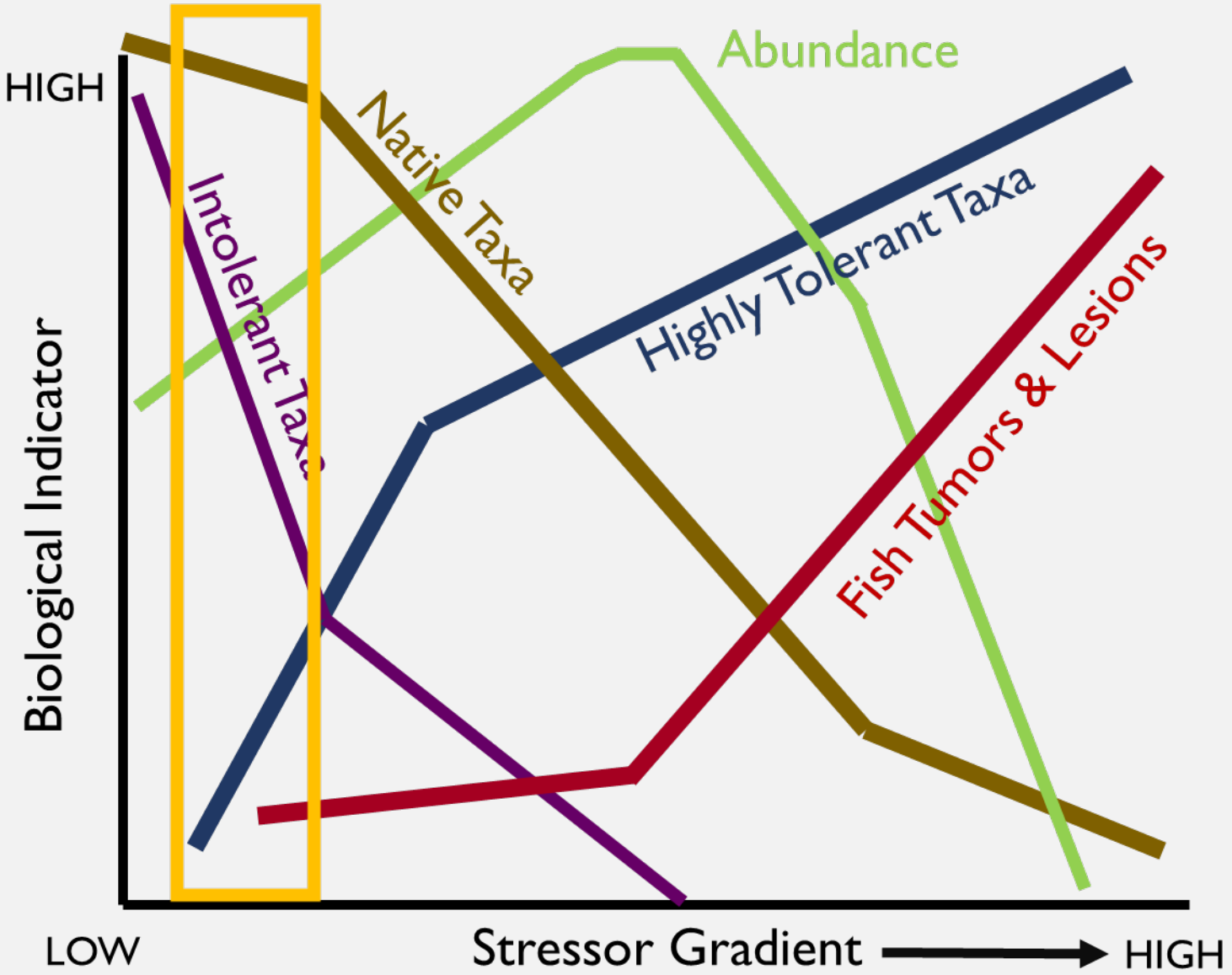

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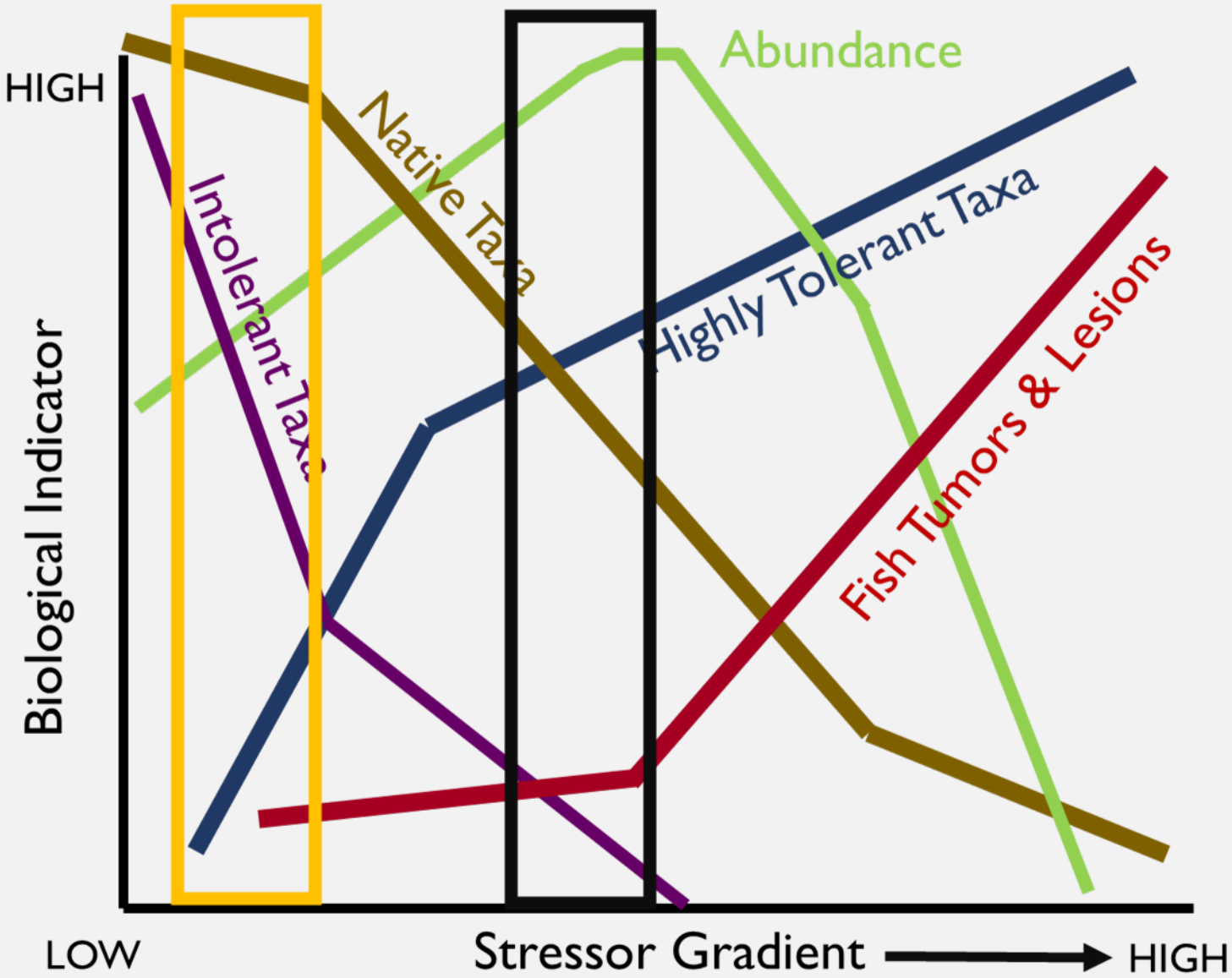

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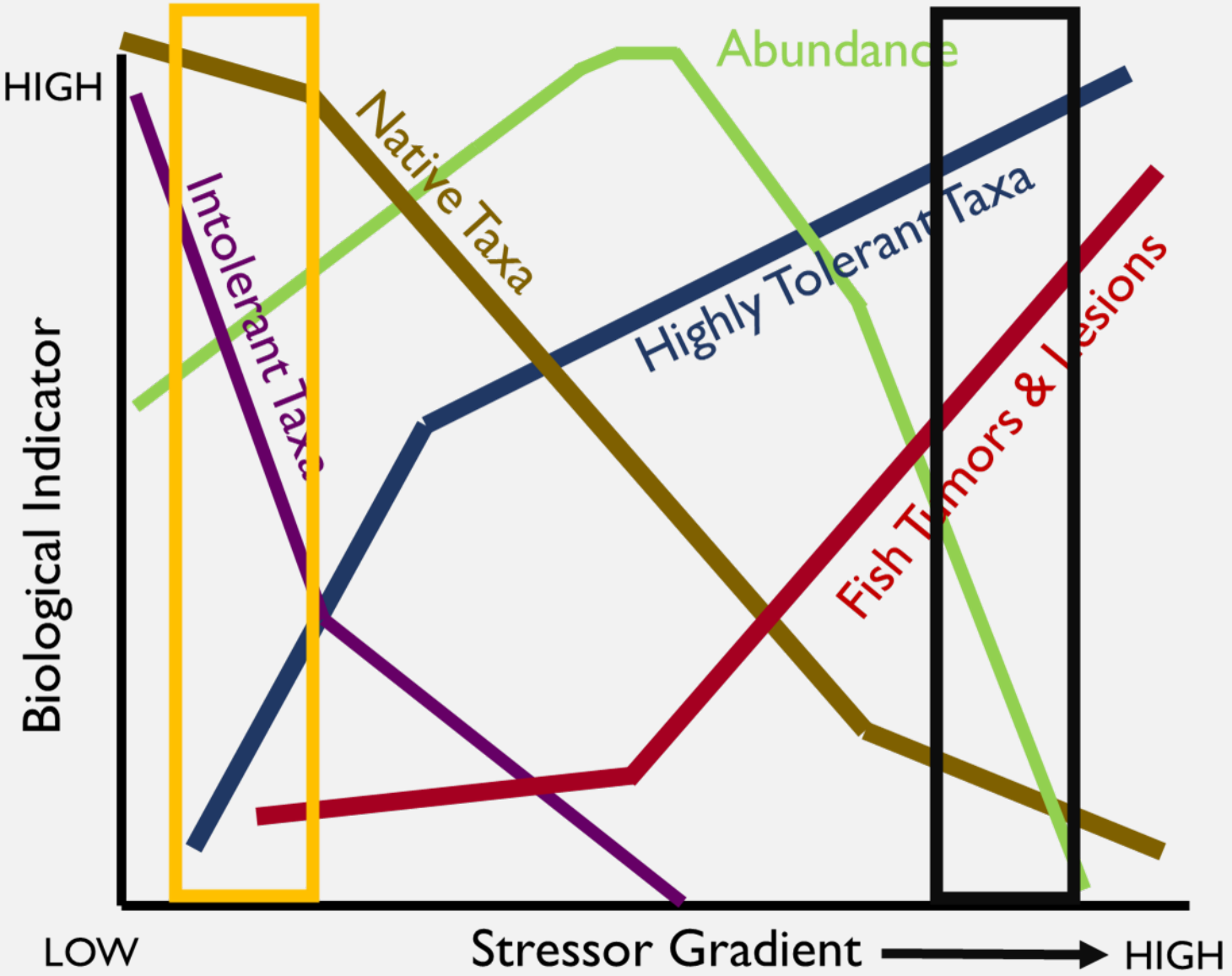


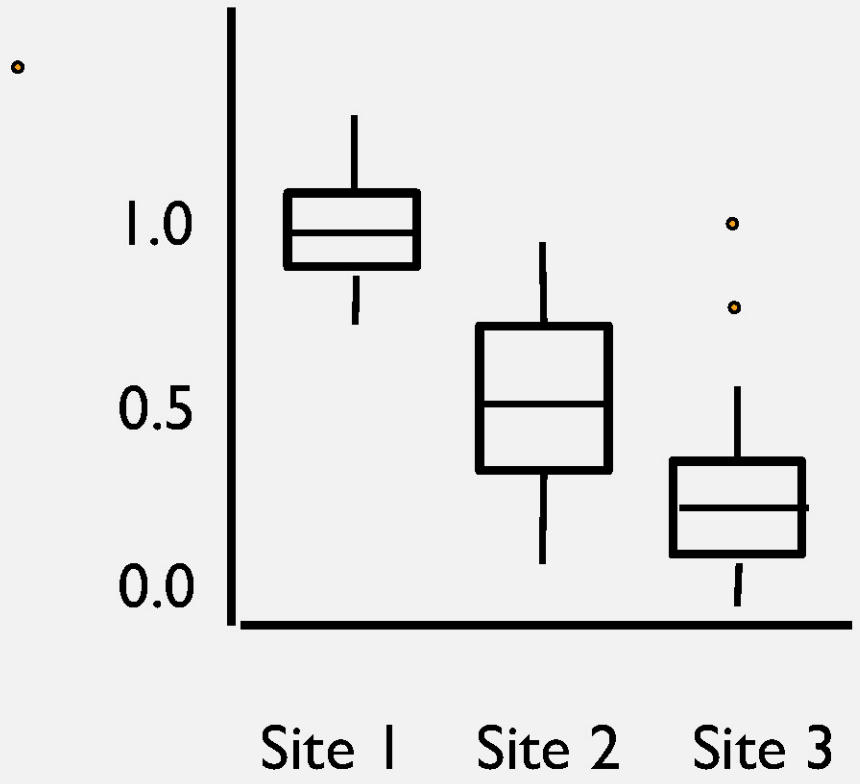
Modified original courtesy of Chris Yoder, CABB

INDICATOR SELECTION - CONTINUED

Mathematical models are increasingly used to assess the expected biological conditions or taxa at a site.

- Linear discriminant model (e.g. Maine)
- River Invertebrate Prediction and Classification System (RIVPACS) (e.g. Utah)

RIVPACS PREDICTIVE MODELING: OBSERVED/EXPECTED



O/E = Observed over Expected Taxa Occurrence and Abundance

E = Reference based

O/E = 1.0 biological diversity as expected

O/E = 0.5 loss of 50% of expected taxa

O/E = 0.3 loss of 70% of expected taxa

O/E ALLOWS A STANDARDIZED ASSESSMENT ACROSS DIFFERENT STREAM TYPES WITH NATURALLY DIFFERENT LEVELS OF BIODIVERSITY

O = 7
E = 10

O = 21
E = 30

Both sites have lost 30% of their biodiversity

TECHNICAL IMPLEMENTATION: BIOASSESSMENTS

Bioassessments are evaluations of the biological condition of a waterbody using surveys of the structure and function of a community of resident biota.

Invertebrate community bioassessment using a Surber sampler

Invertebrate community bioassessment using a kicknet

Fish community bioassessment

RECAP: DEVELOPING BIOCRITERIA

1. Select standardized, consistent biological protocols.
2. Classify waterbodies into similar groups or classes.
3. Identify reference sites in each class.
4. Characterize reference condition.
5. Evaluate metrics and/or predictive model for biological response along full gradient of stress.
6. Develop and test index and/or predictive model.
7. Establish threshold.

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RECAP: DEVELOPING BIOCRITERIA

1. Select standardized, consistent biological protocols.
2. Classify waterbodies into similar groups or classes.
3. Identify reference sites in each class.
4. Characterize reference condition.
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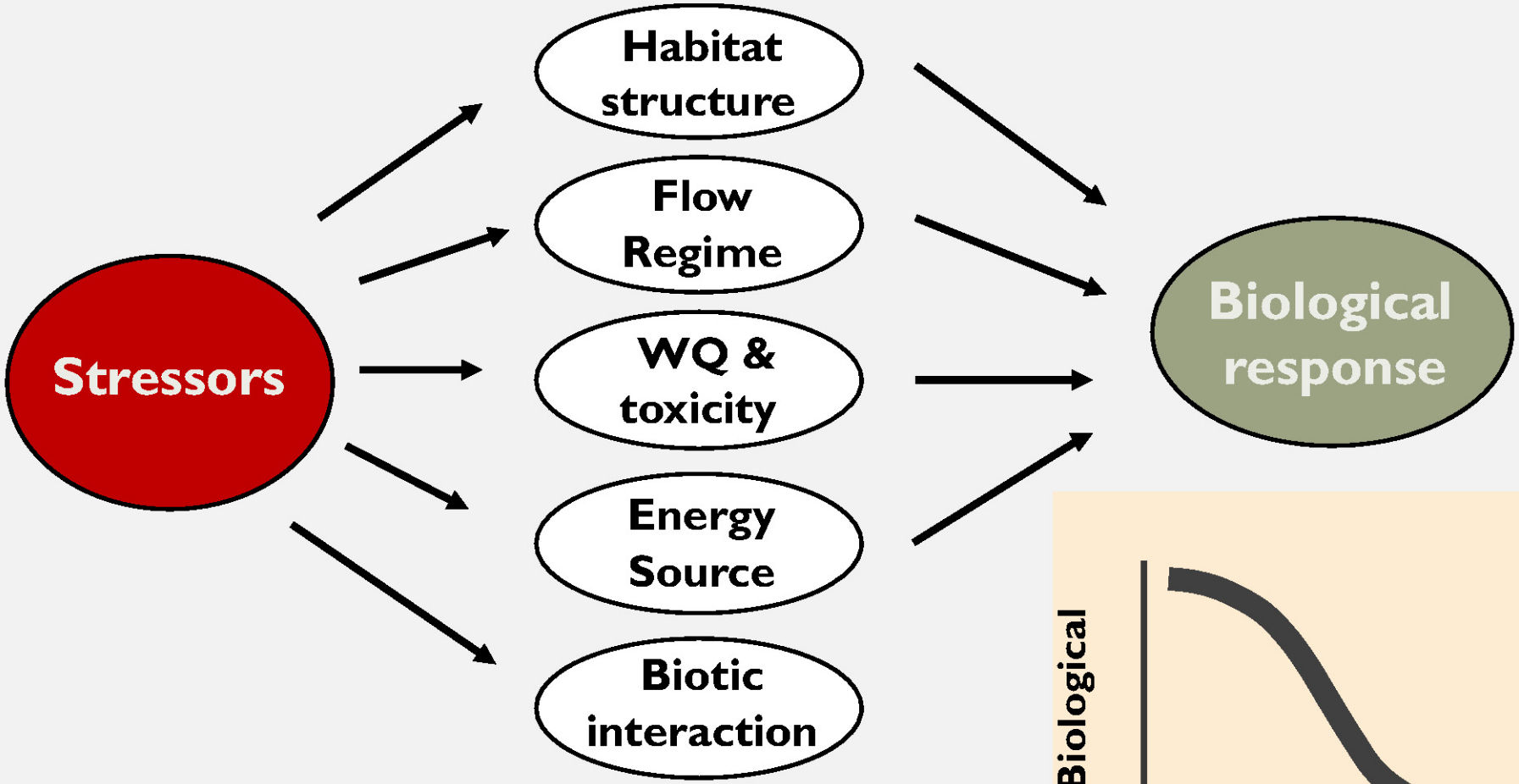
APPLICATION

WHAT DOES BIOLOGICAL INFORMATION ADD?



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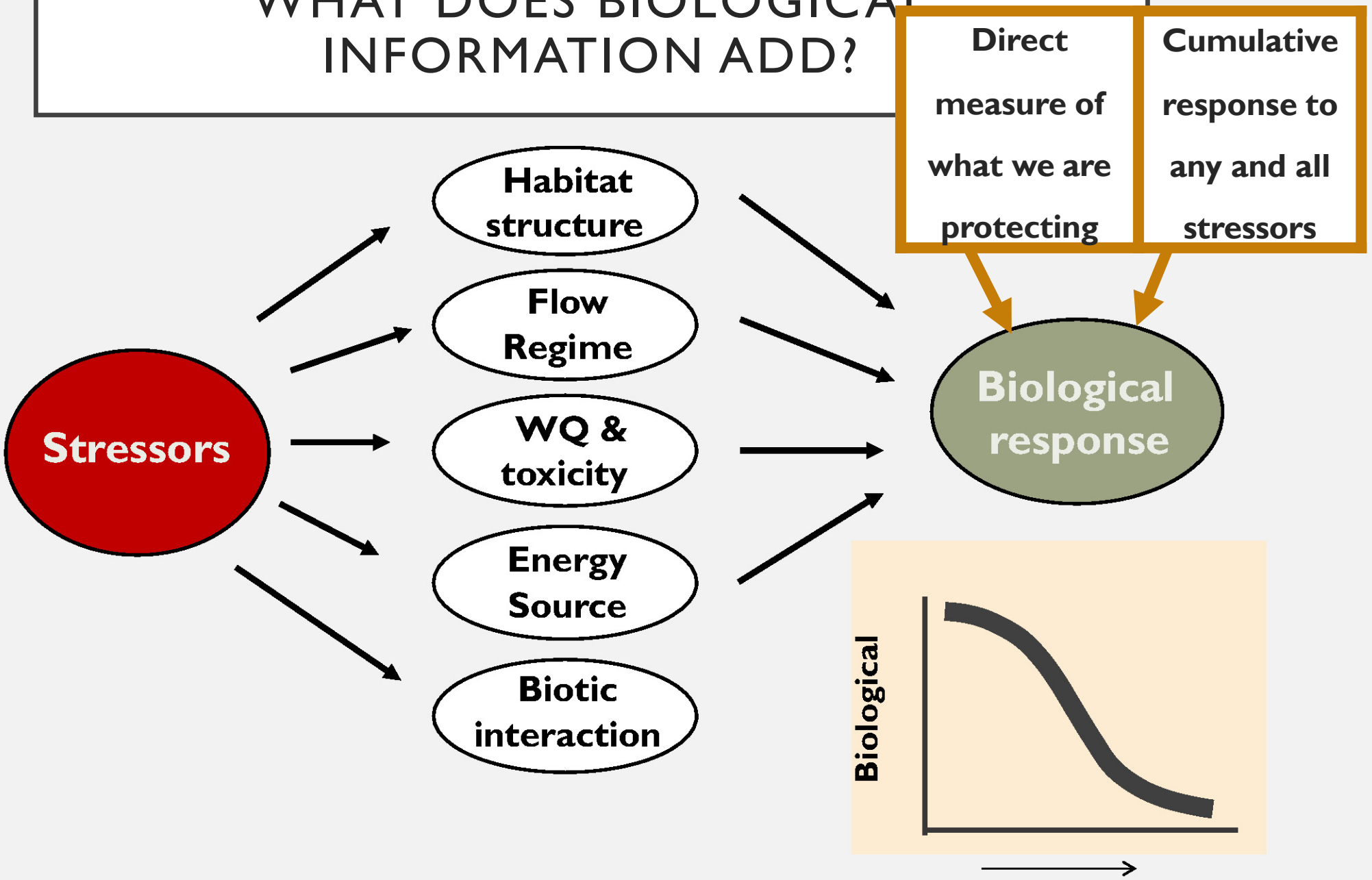
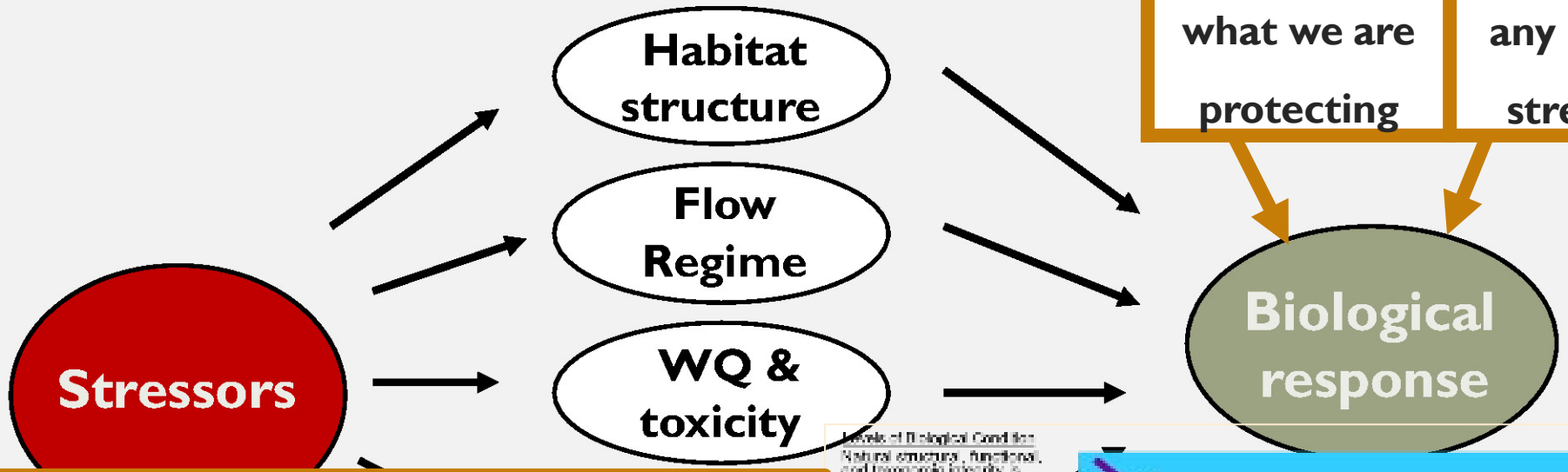
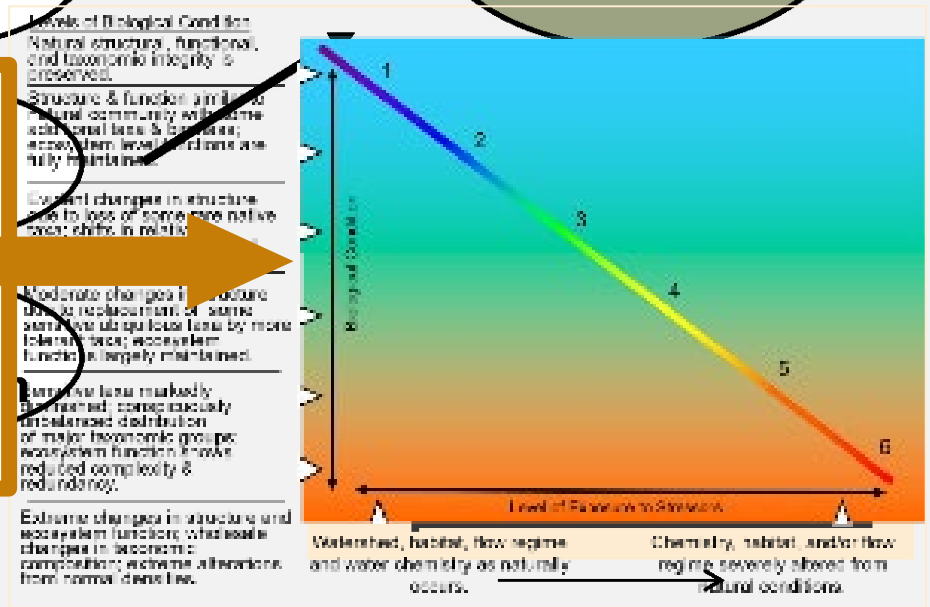


WHAT DOES BIOLOGICAL INFORMATION ADD?

Direct	Cumulative
measure of what we are protecting	response to any and all stressors



BCG:
Interpret incremental change in context of CWA



HOW IS BIOLOGICAL INFORMATION INCORPORATED INTO WQS?

AQUATIC LIFE USES AND BIOCRITERIA

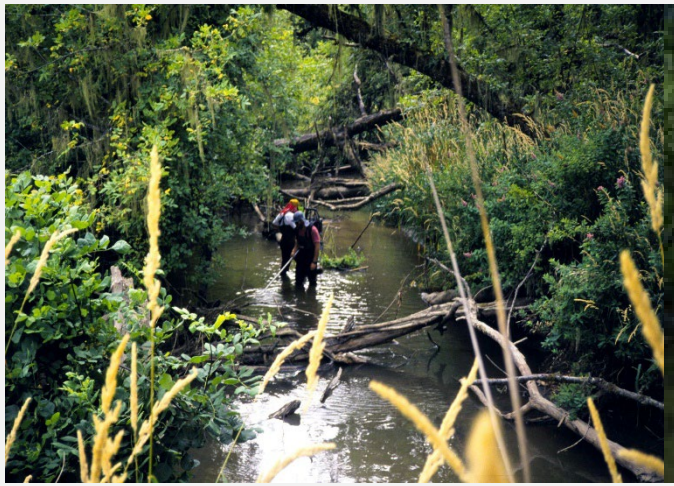
- Management Goals ideally developed for protection and restoration of aquatic life
  - General description of the expected biological characteristics of a waterbody
- Narrative descriptions/quantifiable thresholds

designated aquatic life uses

biocriteria

NARRATIVE BIOLOGICAL CRITERIA

Narrative Biocriteria - Written statement describing the structure and/or function of aquatic communities in a waterbody that support a given designated ALU (e.g., "as naturally occurs," "balanced community of taxa," lists of expected taxa and/or verbal description of type of aquatic community expected).



NUMERIC BIOLOGICAL CRITERIA

- Written statement describing the structure and/or function of aquatic communities in a waterbody that support a given designated ALU and with method for quantification cited.
- Specific quantitative measures (e.g., metrics) of desired level of biological condition for a given ALU designated.



EXAMPLE: DESIGNATED ALU

Minimal changes in structure of the biotic community - native taxa are maintained with some changes in biomass and/or abundance.

EXAMPLE: NARRATIVE BC

Narrative BC for cool-cold water streams (MW)

Overall taxa richness and density is as naturally occurs (e.g., moderate to high levels). Most sensitive taxa and native taxa are present and make up a significant fraction of the total richness and abundance.

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(e.g., *Ephemeroptera: Paraleptophlebia; Plecoptera: Acroneuria, Isoperla, Paragnetina; Trichoptera: Brachycentrus, Chimarra*).

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Numeric BC	Cool Water	Cold Water
# Total taxa	≥ 14 (11 – 16)	≥ 20 (16 – 24)
% Most sensitive taxa (Att I + II)	> 10% (7 – 13%)	> 5% (3 – 7%)
% Most sensitive individuals (Att I & II)	-	> 8% (6 – 10%)
% Sensitive taxa (Att II + III)	>30% (25 – 35%)	> 30% (25 – 30%)
% Sensitive individuals (Att II + III)	>30% (25 – 35%)	> 30% (25 – 30%)
% Most dominant tolerant taxa (Att V)	< 5% (3 – 7%)	-
% Sensitive EPT taxa (Att I + II + III)	> 10% (7 – 13%)	> 10% (7 – 13%)

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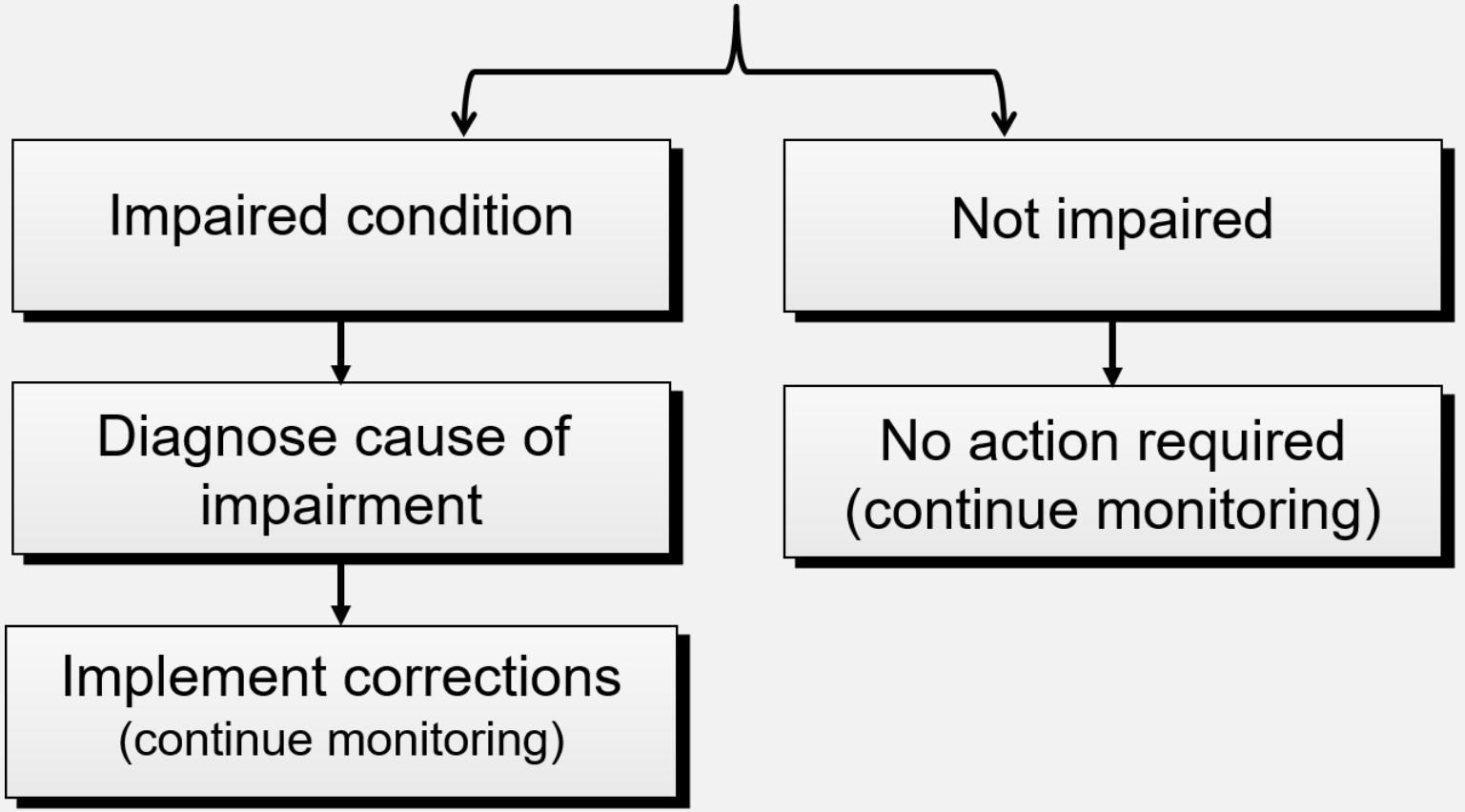
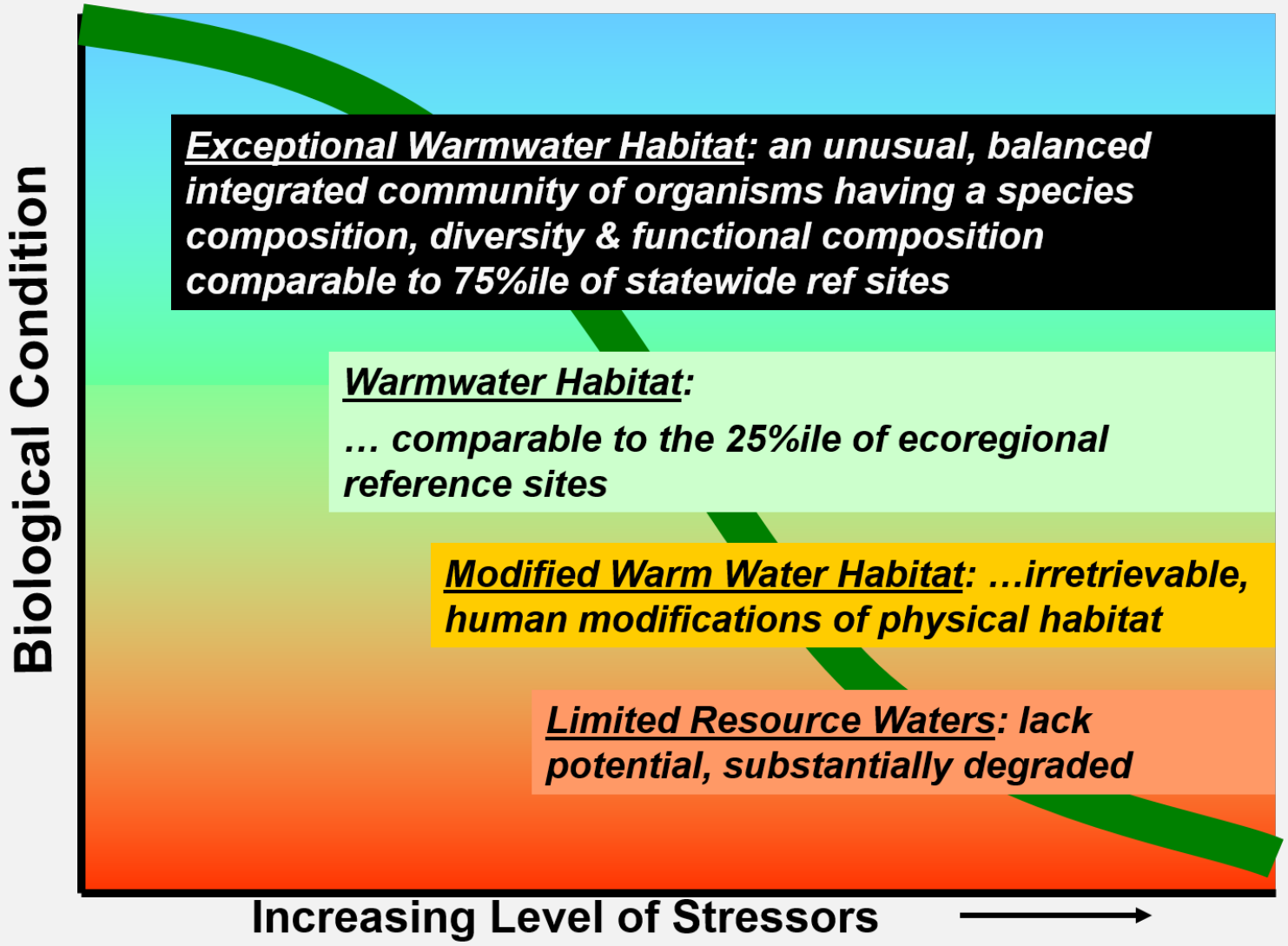
APPLYING BIOLOGICAL CRITERIA

Sample test sites and compare biocriteria

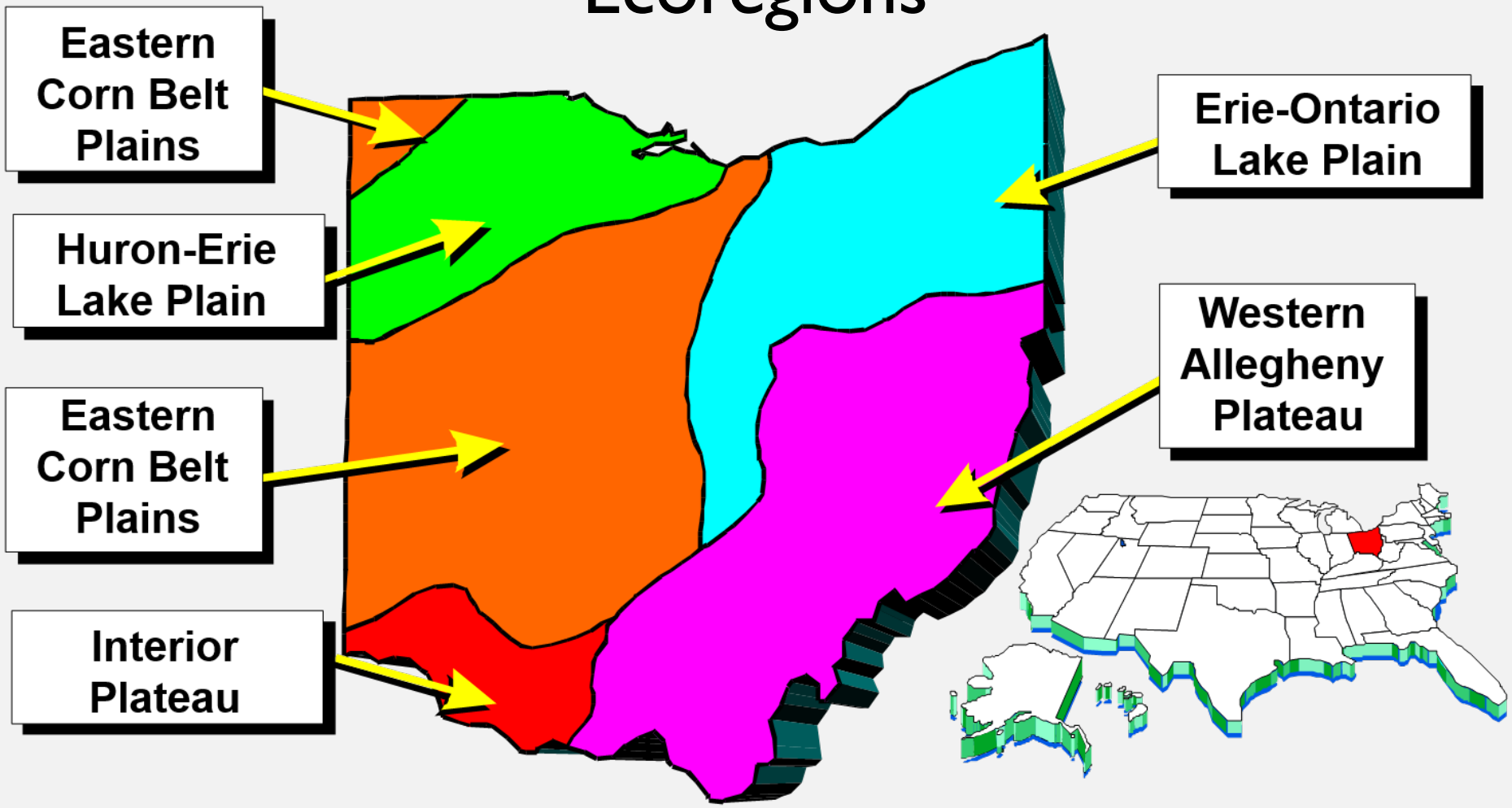


EXAMPLE: OHIO BIOLOGICAL STANDARDS



OHIO: CLASSIFICATION

Ecoregions



OHIO BIOLOGICAL CRITERIA

Benthic Invertebrates and Fish

Huron Erie Lake Plain (HELP)

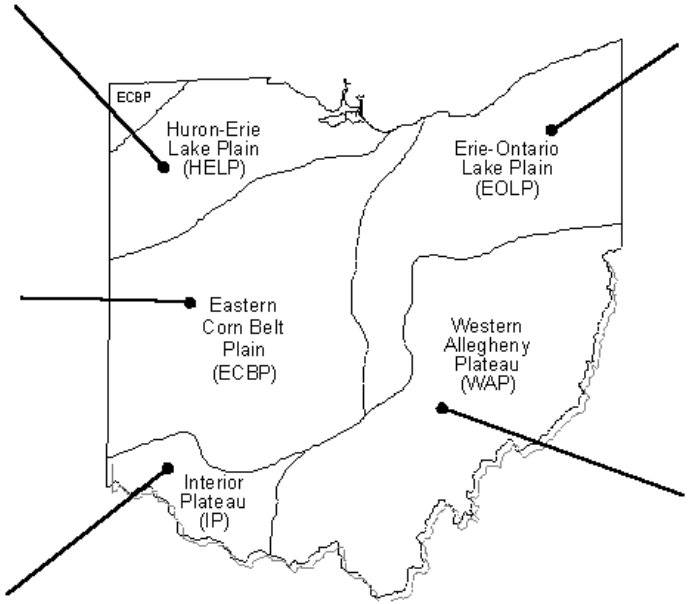
Use	Size	IBI	MIwb	ICI
WWH	H	28	NA	34
	W	32	7.3	34
	B	34	8.6	34
MWH-C	H	20	NA	22
	W	22	5.6	22
	B	20	5.7	22
MWH-I	B	30	5.7	NA

Eastern Corn Belt Plains (ECBP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	36
	W	40	8.3	36
	B	42	8.5	36
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Interior Plateau (IP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	30
	W	40	8.1	30
	B	38	8.7	30
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA



Statewide Exceptional Criteria

Use	Size	IBI	MIwb	ICI
EWH	H	50	NA	46
	W	50	9.4	46
	B	48	9.6	46

Erie Ontario Lake Plain (EOLP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	34
	W	38	7.9	34
	B	40	8.7	34
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Western Allegheny Plateau (WAP)

Use	Size	IBI	MIwb	ICI
WWH	H	44	NA	34
	W	44	8.4	34
	B	40	8.6	34
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-A	H	24	NA	30
	W	24	5.5	30
	B	24	5.5	30
MWH-I	B	30	6.6	NA

ASSESSMENTS & 303d LISTING

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.

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

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

MEASURE GOALS AND SITE STATUS RELATIVE TO CWA

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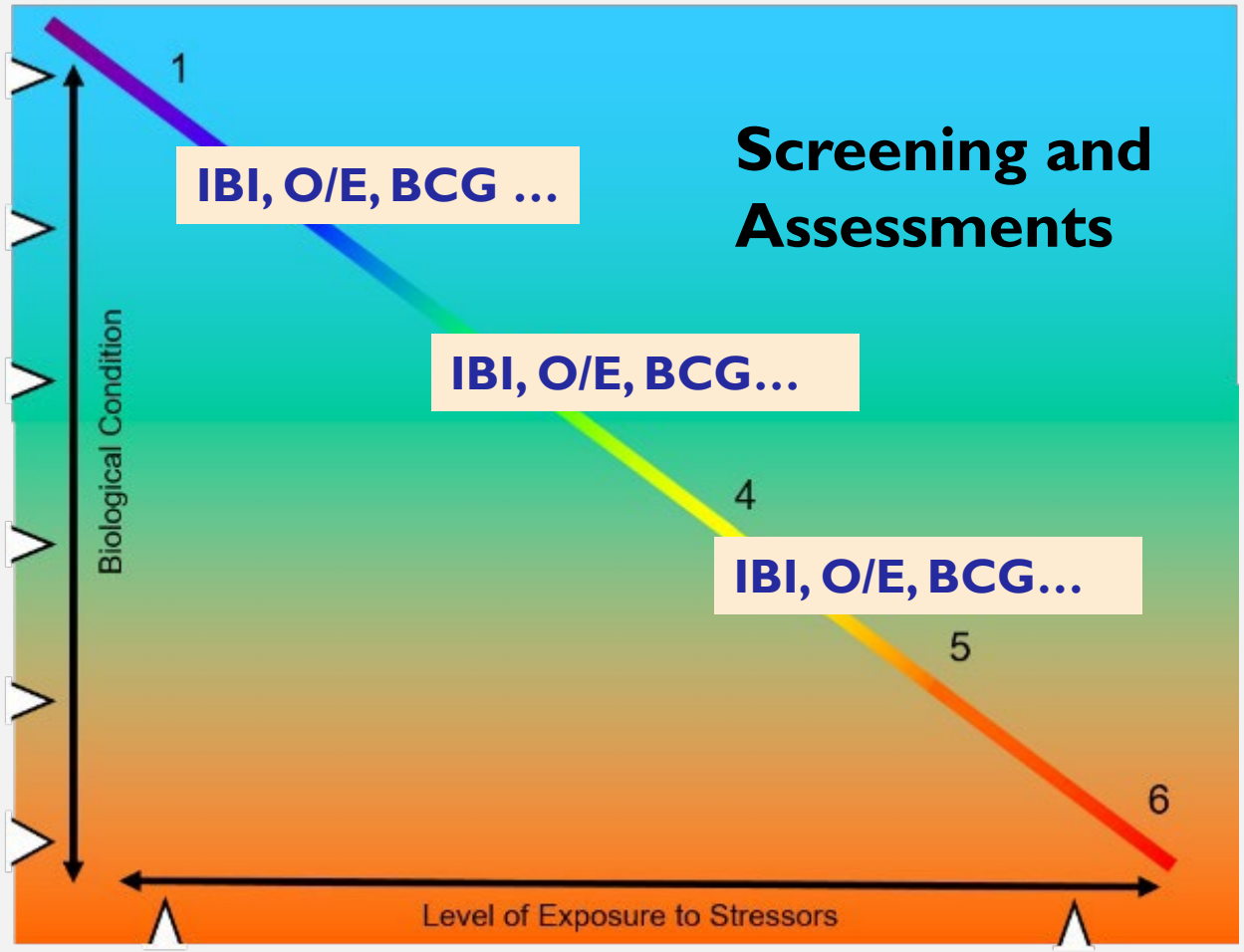

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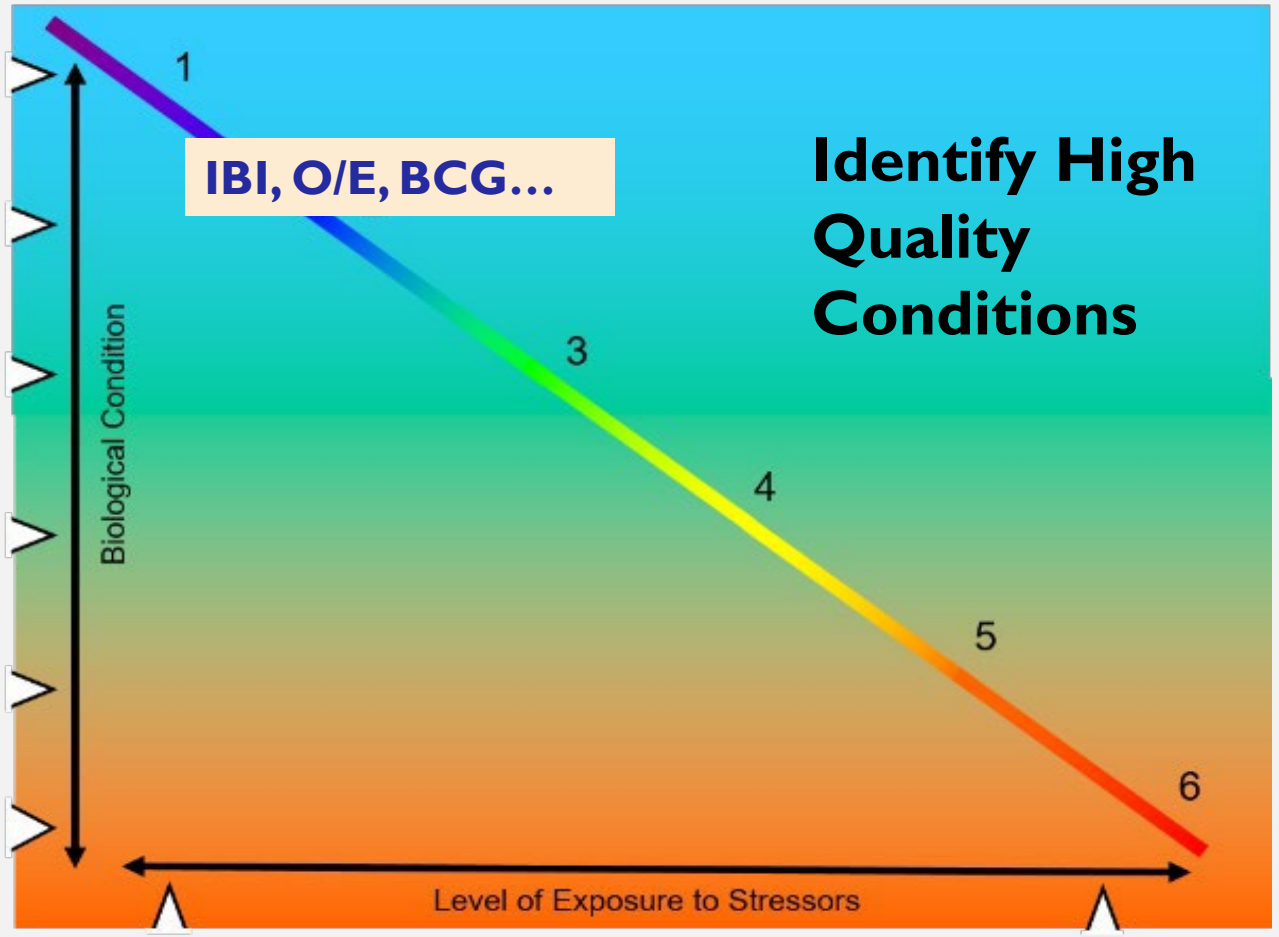

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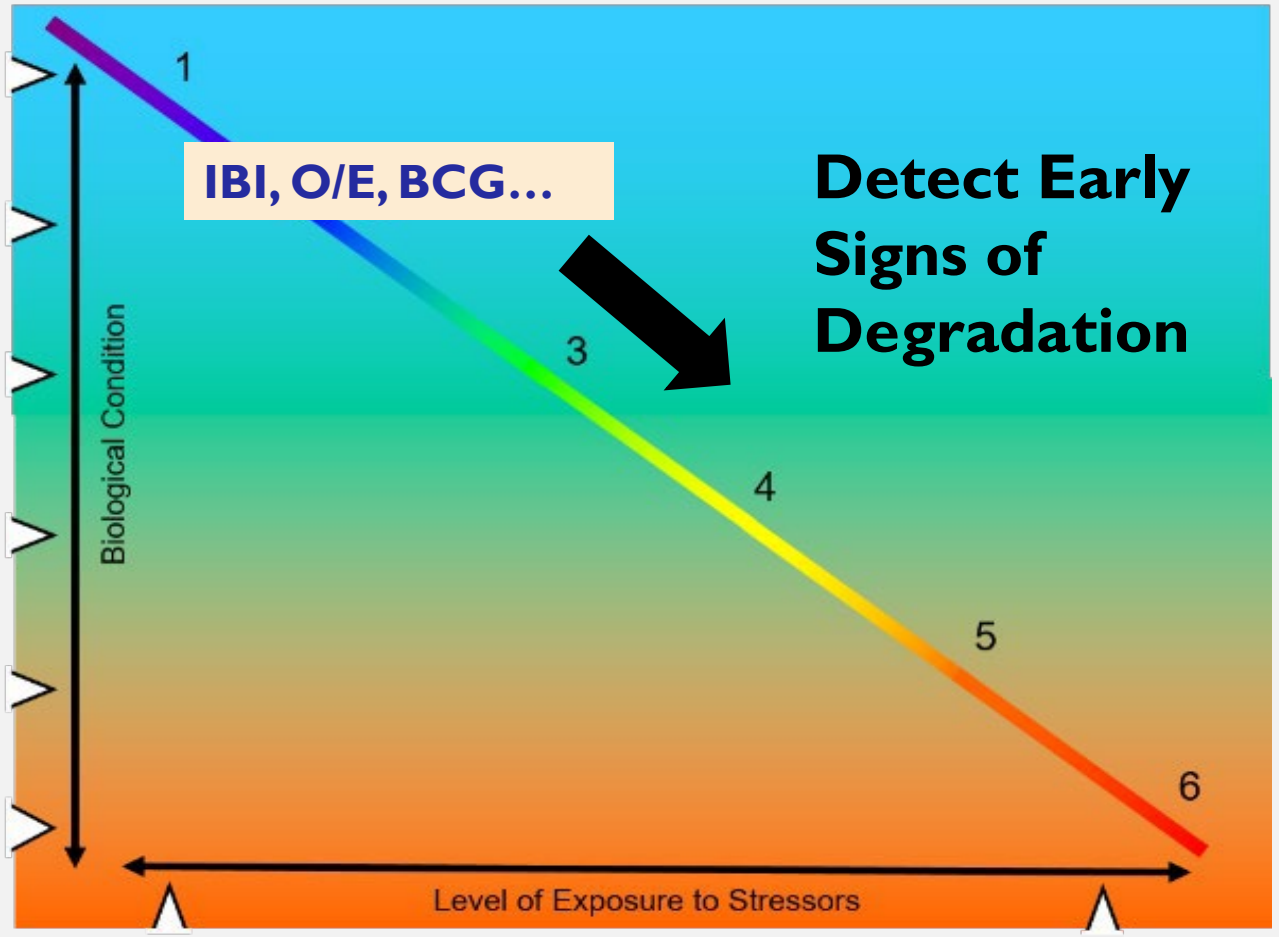

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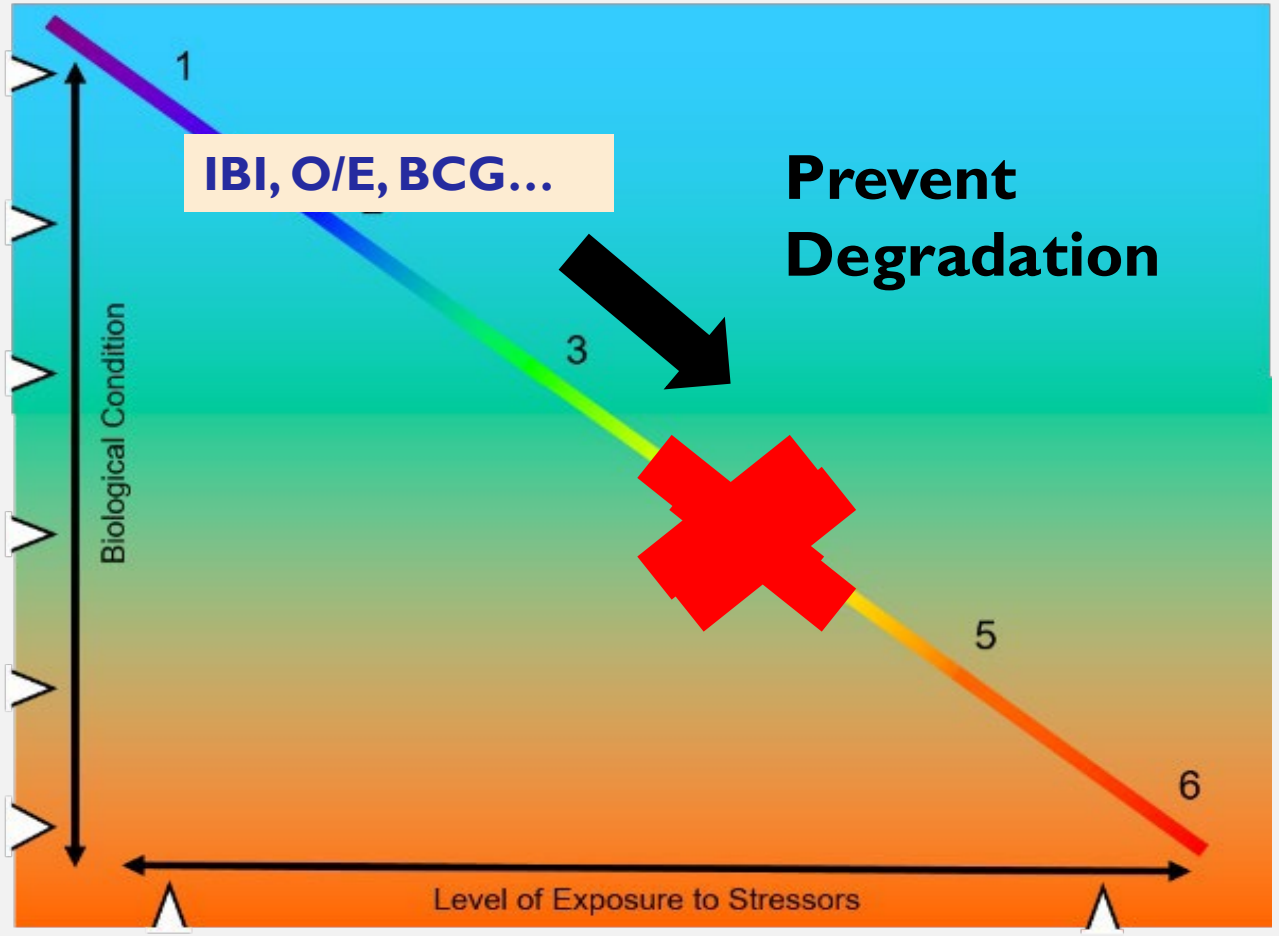

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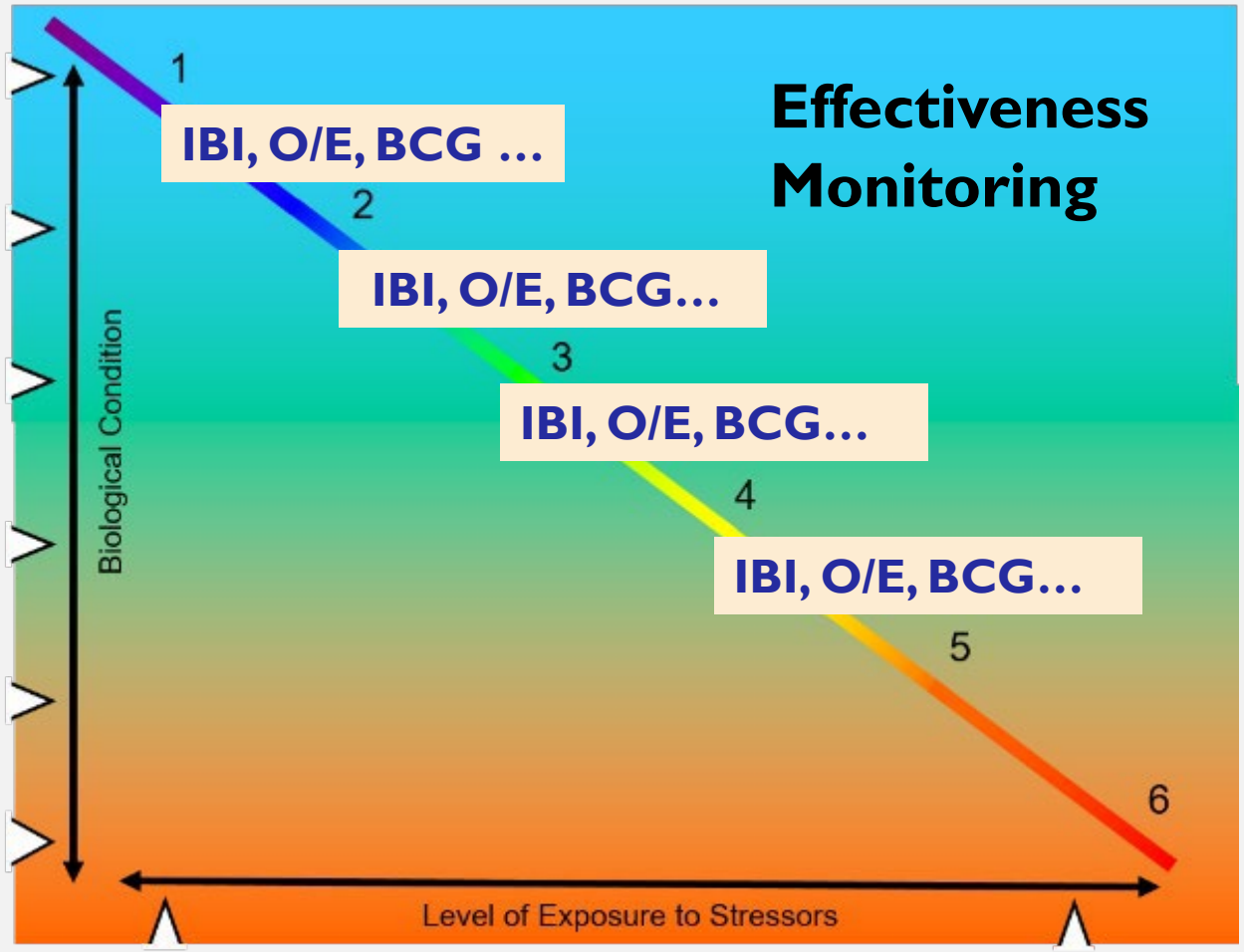

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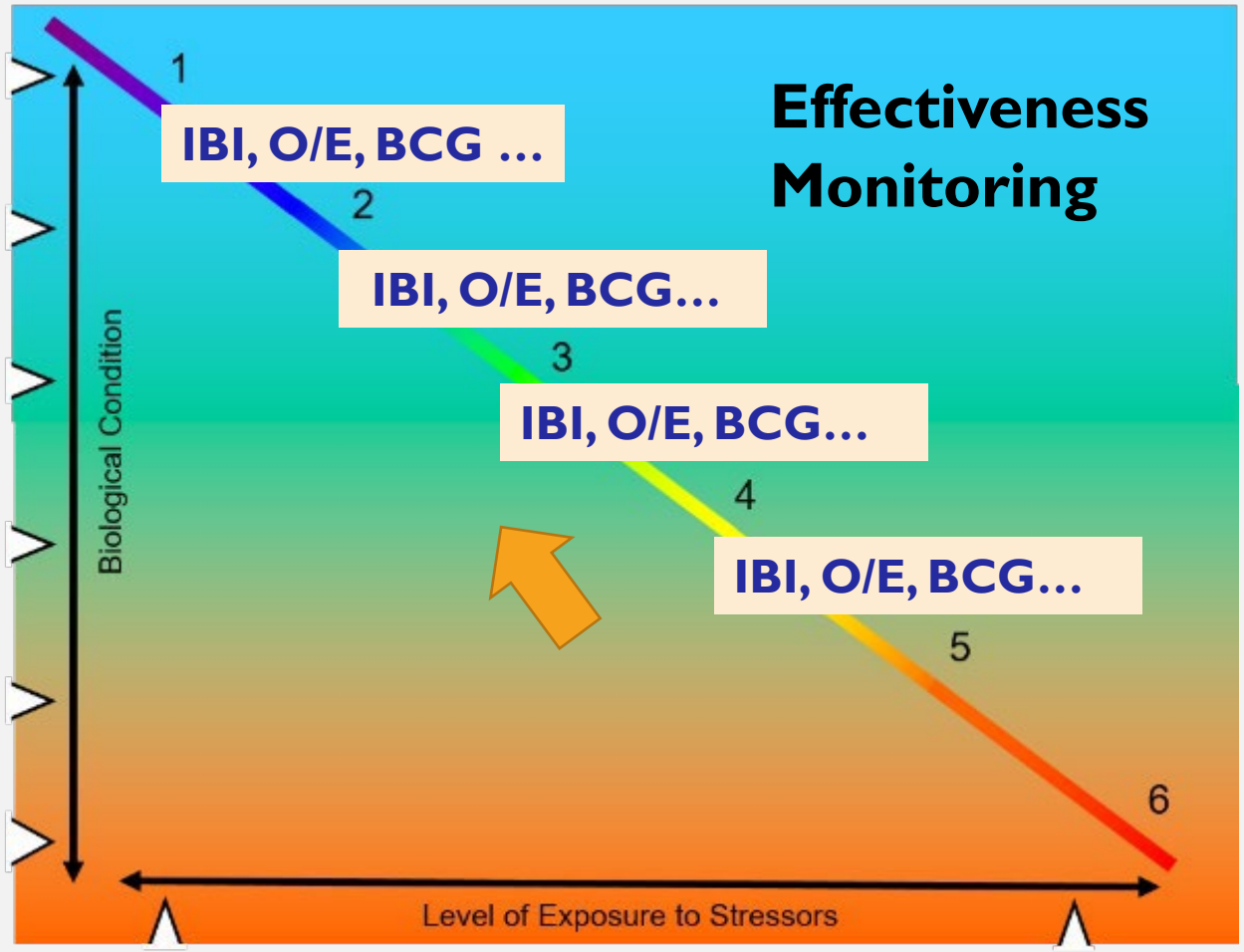

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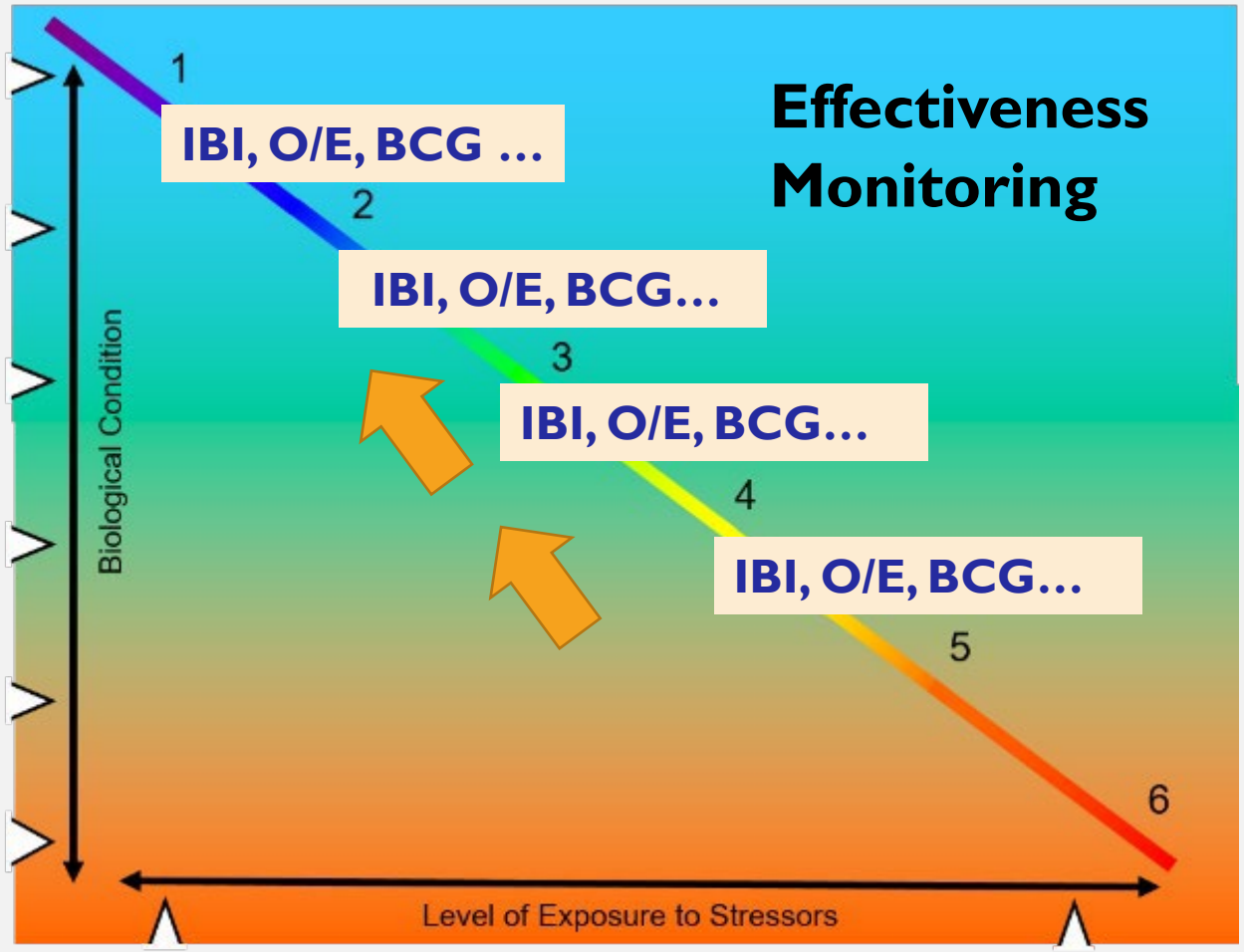

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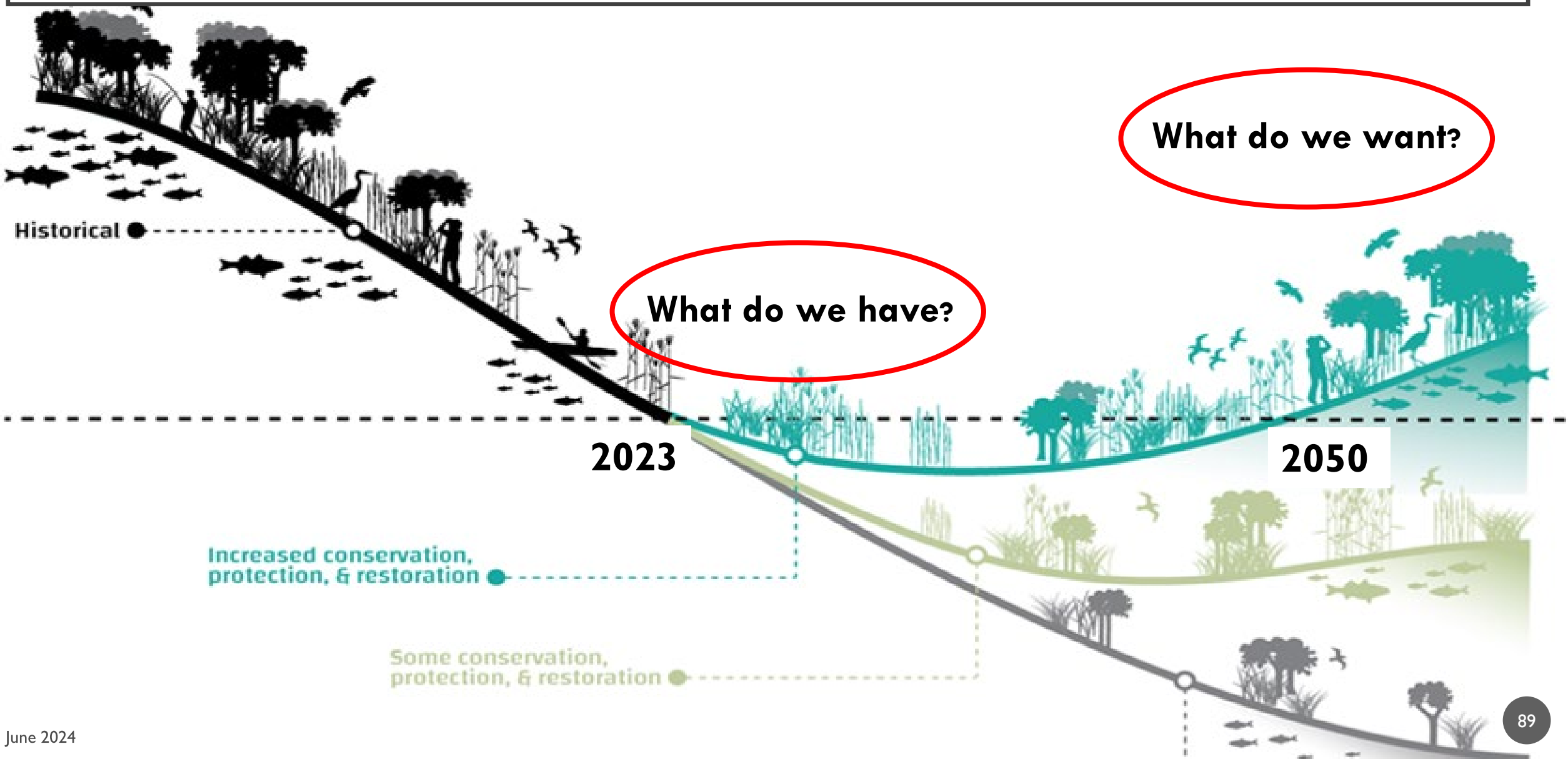
PAIRING BIOLOGICAL CONDITION WITH ECOSYSTEM SERVICES



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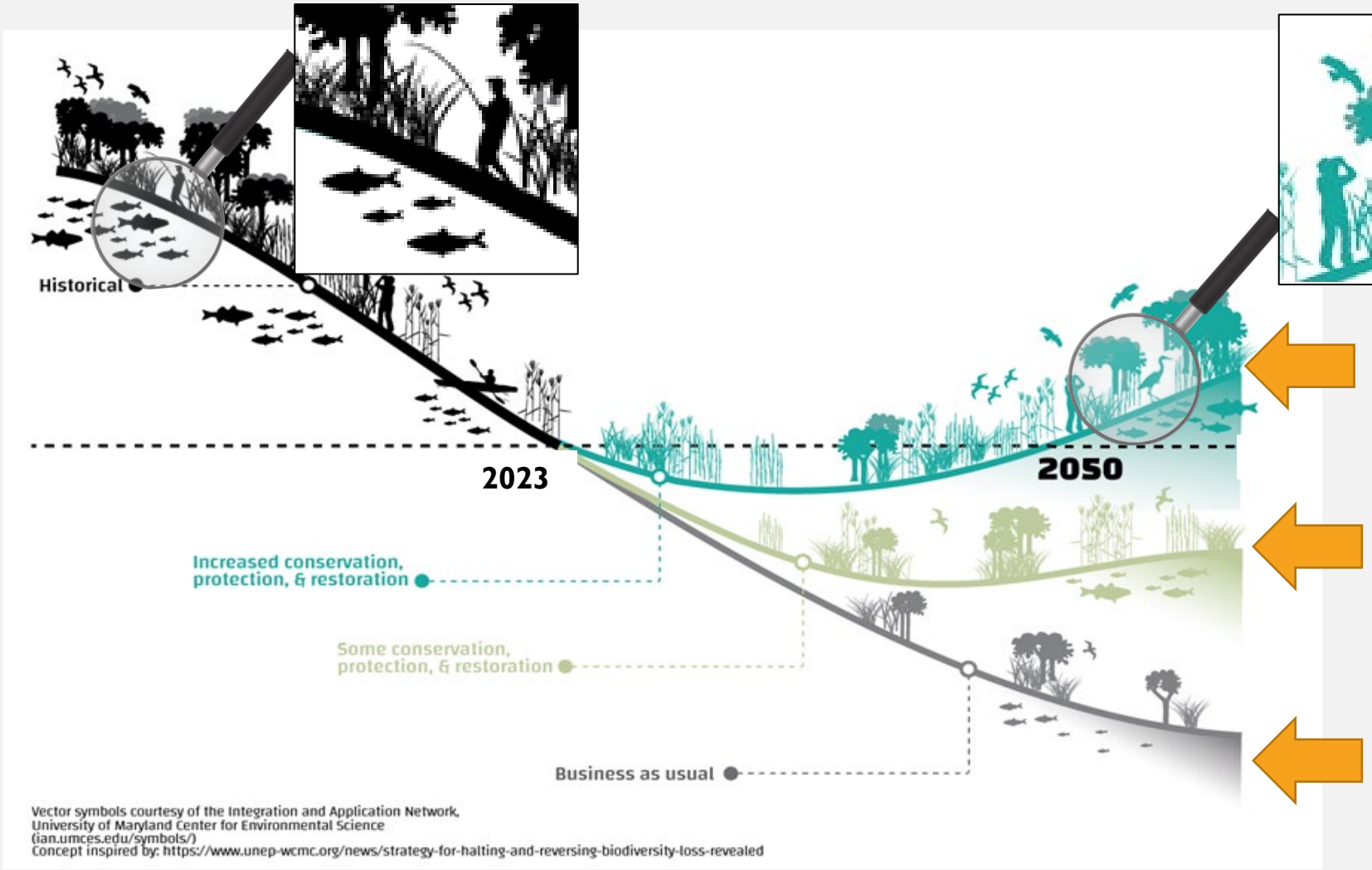

Identify the most relevant ecosystem services and quantify them along levels of biological or habitat condition.

EX: biodiversity, recreation, fisheries, service industry, property values, city or county tax income

ANY QUESTIONS?

Micah Bennett

US EPA Region 5 – Water Division

Bennett.Micah@epa.gov

filling in for

Susan Jackson

US EPA Biological Criteria Program

Jackson.Susank@epa.gov

ADDITIONAL INFORMATION

EPA Biological Criteria

https://www.epa.gov/wqc/biological-water-quality-criteria

Summary Info: Stream bioassessment and biocriteria programs

https://www.epa.gov/wqc/information-bioassessment-and-biocriteria-programs-streams-and-wadeable-rivers

A process for creating multimetric indices for large-scale aquatic surveys (stanford.edu)

Stoddard, J.L., Herlihy, A.T., Peck, D.V., Hughes, R.M., Whittier, T.R. and Tarquinio, E., 2008. A process for creating multimetric indices for large-scale aquatic surveys. *Journal of the North American Benthological Society*, *27*(4), pp.878-891.

Introduction to Rivpaks Modeling John Van Sickle
https://archive.epa.gov/emap/archive-emap/web/pdf/vansickleoe.pdf

RIVPACS Models for Predicting the Expected Macroinvertebrate Fauna and Assessing the Ecological Quality of Rivers
https://www.researchgate.net/publication/223518277_RIVPACS_Models_for_Predicting_the_Expected_Macroinvertebrate_Fauna_and_Assessing_the_Ecological_Quality_of_Rivers