The Biological Condition Gradient

By Susan P. Davies

and

USEPA Aquatic Life Use Support Workgroup

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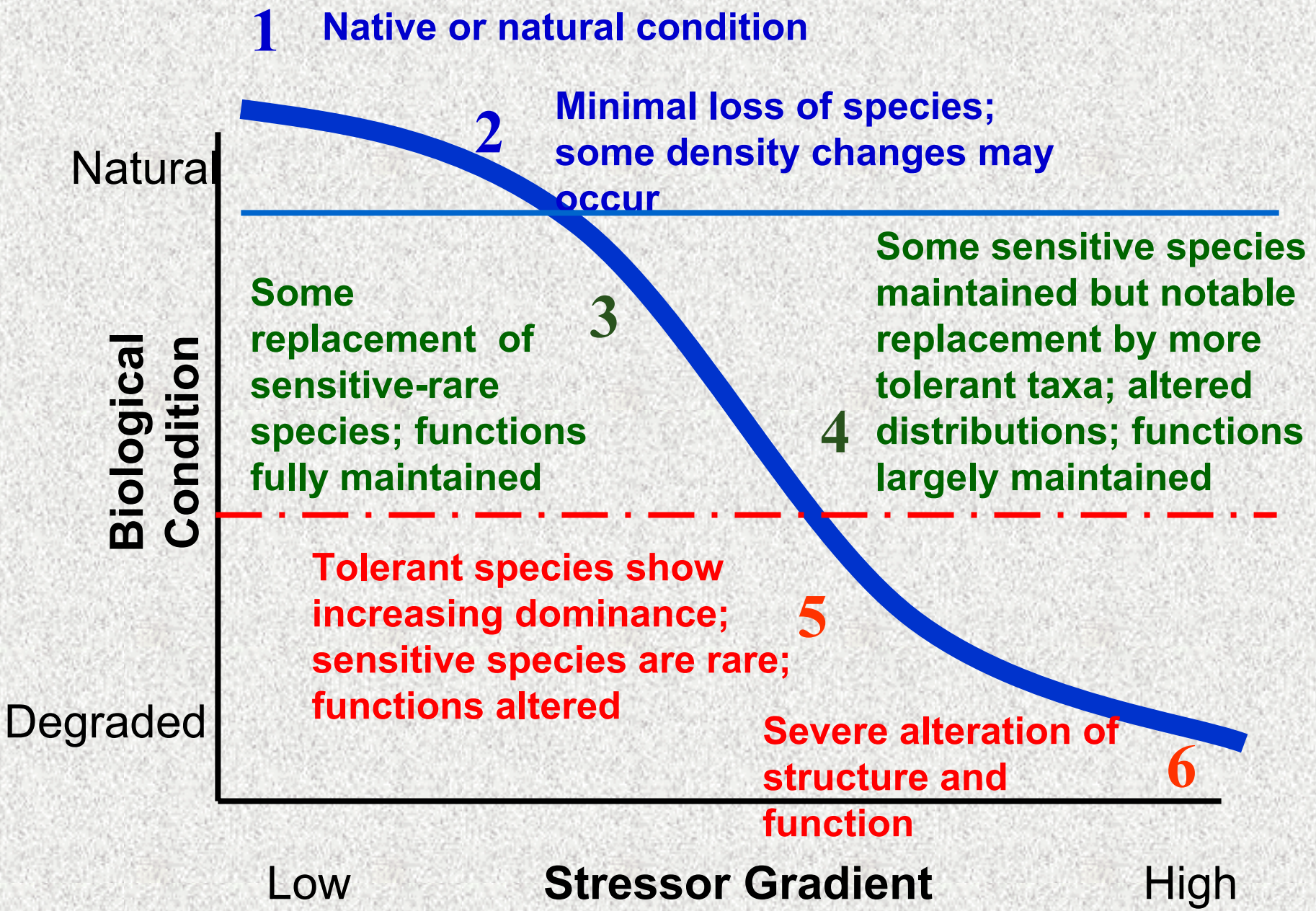
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Minimal loss of species; some density changes may occur
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Some replacement of sensitive-rare species; functions fully maintained
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Tolerant species show increasing dominance; sensitive species are rare; functions altered
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Degraded
Severe alteration of structure and function
6
Low
Stressor Gradient
High

2001 ALUS Meeting Data Exercise

33 biologists from 21 states

six BioAxis categories

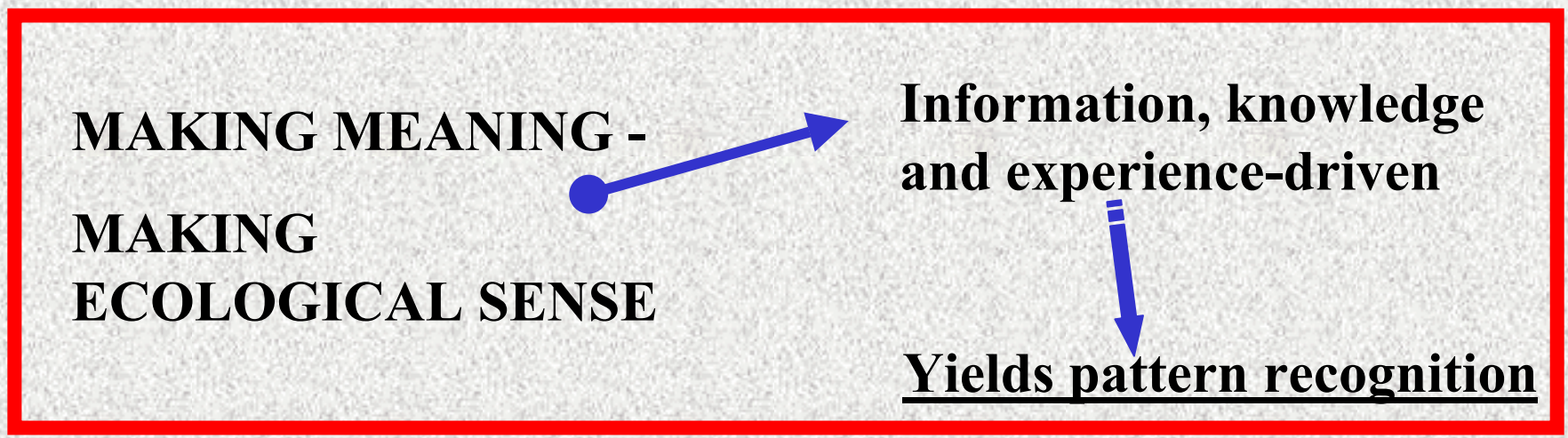
82% concurrence !

four regions of the U.S.

74 stream samples

Purpose

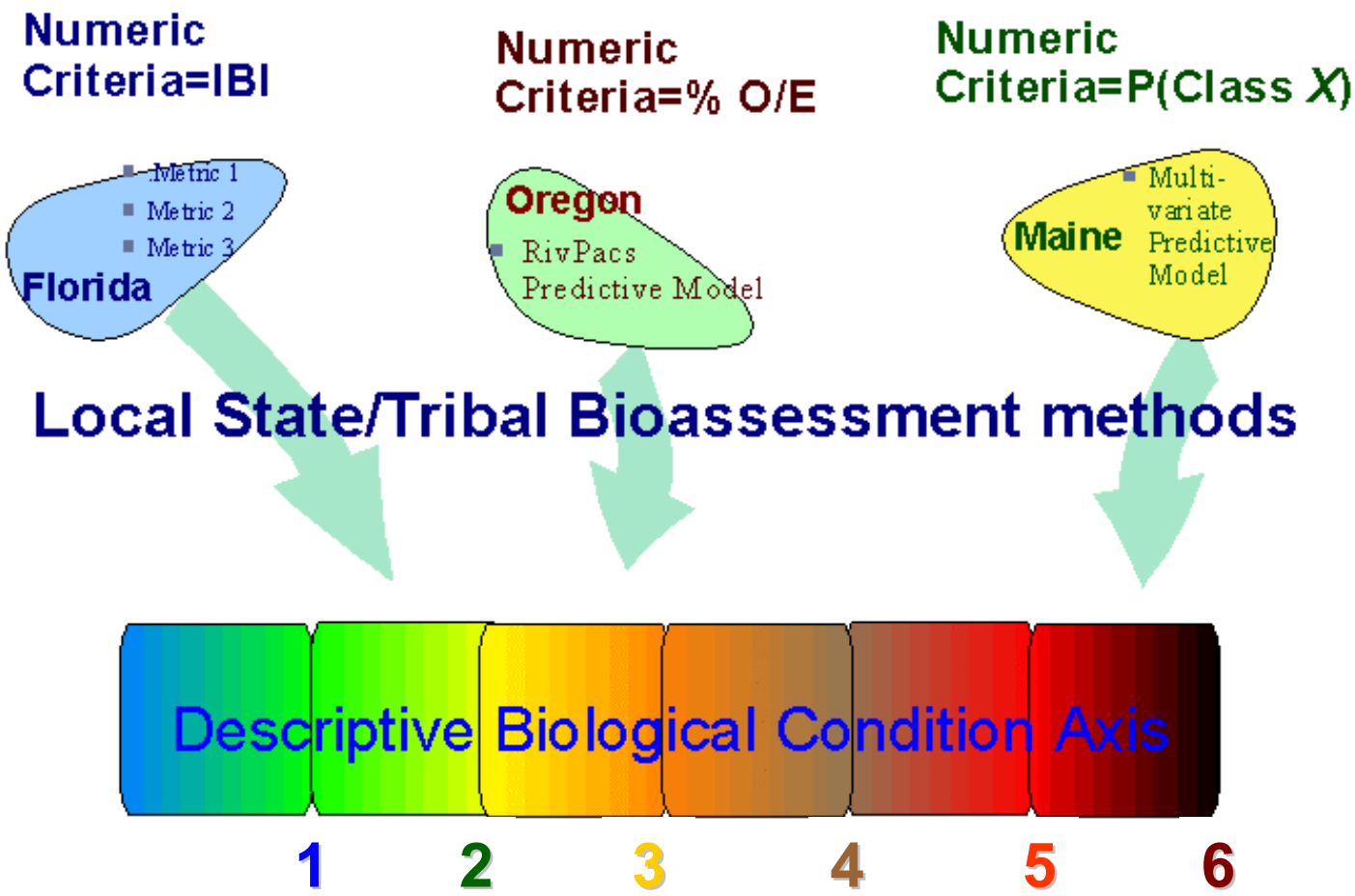
- To disclose and document current bioassessment observations and interpretations
  - **Enable hypothesis testing**
  - **Highlight emerging research needs**
  - **Build upon areas of consistent interpretation**
  - **Disclose discrepancies in interpretation and explain or resolve through research**


OBSERVATION & MEASUREMENT
Methods-driven
Yields data
MAKING MEANING -
MAKING ECOLOGICAL SENSE
Information, knowledge and experience-driven
Yields pattern recognition
REGULATORY CONTROL AND ACTION-FORCING
Socially and legally-driven
Yields rules for fairness and balance

Characteristics

- A conceptual model
  - *not a scientific hypothesis*
- A common observational scale
  - *not a roadmap*
- A heuristic (tool for learning and communication)
  - *not a formula*
- A quality gradient
  - *not a "classification of data"*

ALUS Tiers Provide Consistency

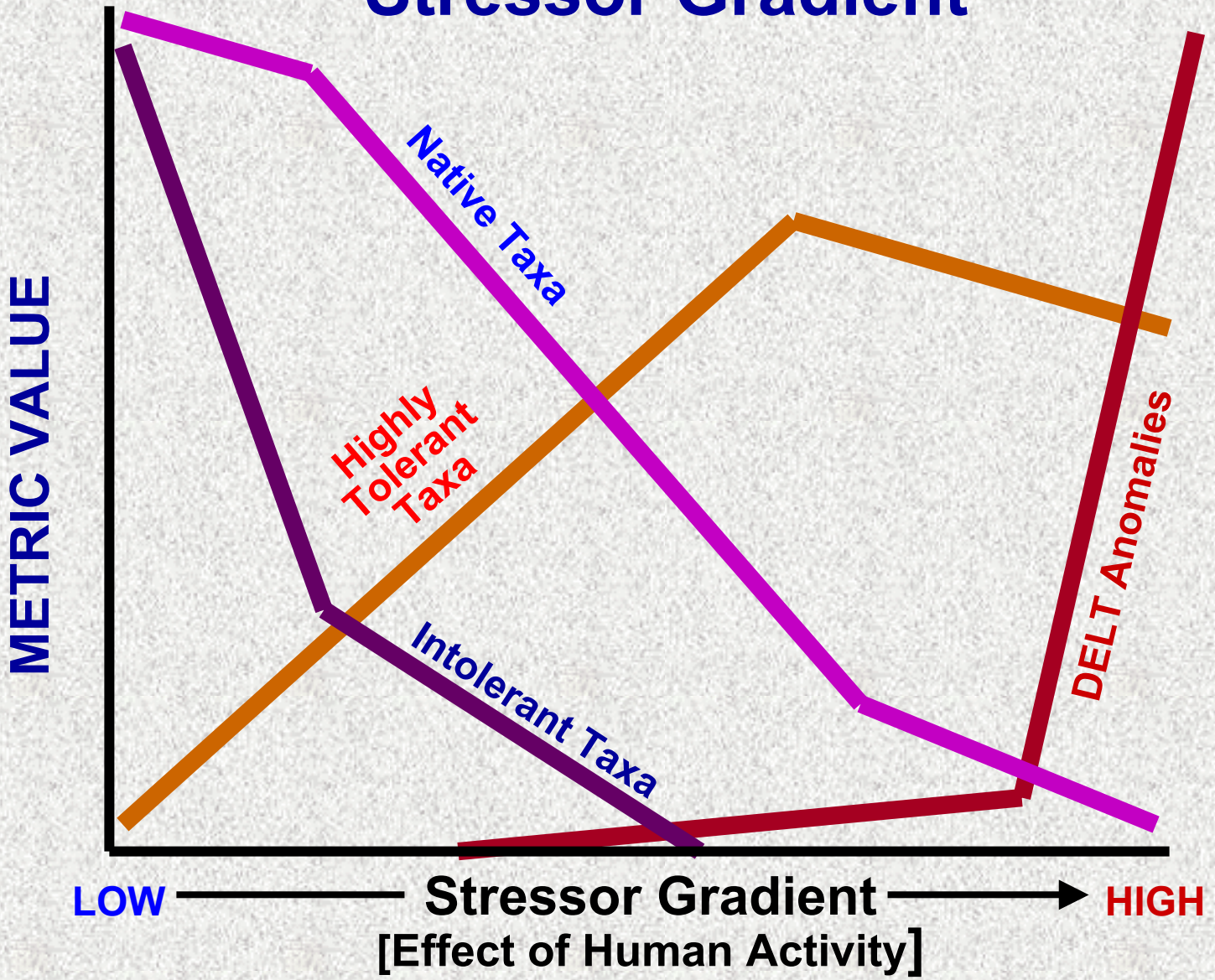


Susan P. Davies, MDEP

Overview of the Attributes

- **Taxonomic composition and tolerance**
  - Attributes I-V
  - *Regionally Endemic* through *Tolerant*
- **Non-native taxa**
  - Attribute VI
- **Organism condition**
  - Attribute VII
- **Ecosystem function**
  - Attribute VIII
- **Physical:Biological interactions**
  - Attributes IX and X
  - Expands the interpretation to larger spatio-temporal scales
  - Provides linkage to the “Disturbance Axis”
  - Informs the management perspective (e.g., prioritization)

Fish Metric Behavior Along the Stressor Gradient

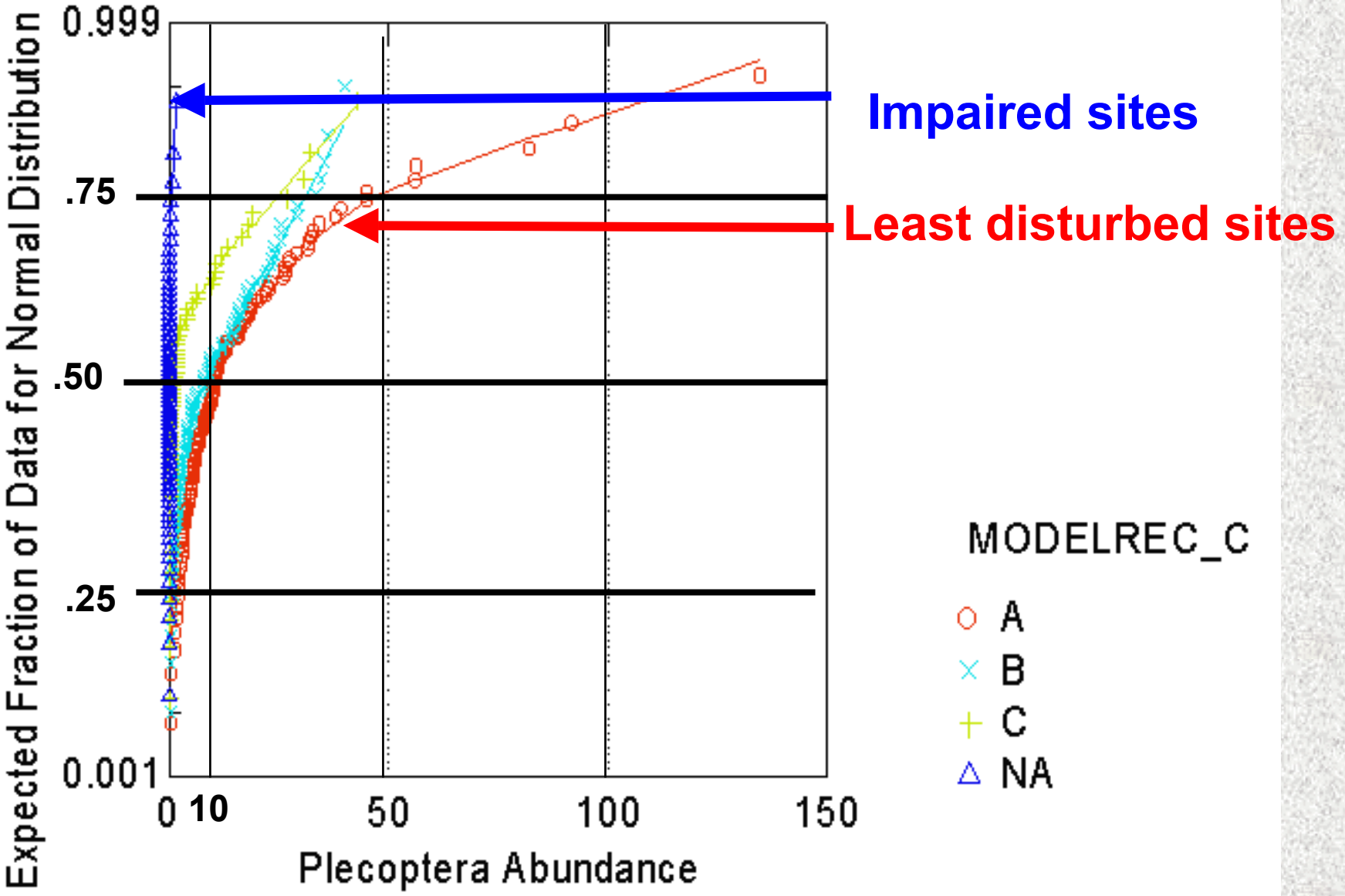


Courtesy of Chris Yoder, CABB

Overview of Attributes

- **I - Historically documented, sensitive, long-lived, regionally endemic taxa**
  - documented presence prior to CWA
  - unique life history requirements
  - may be a listed RTE or Special Concern species
  - ex: **Brook Floater mussel; Bull trout**
- **II - Sensitive - rare or specialist taxa**
  - may require special habitats;
  - intolerant of disturbance in environmental conditions
  - naturally low densities;
  - commonly k-strategists (slow development, longer lifespan, stable population density over time)
  - ex: ***Taeniopteryx*; Slimy sculpin**

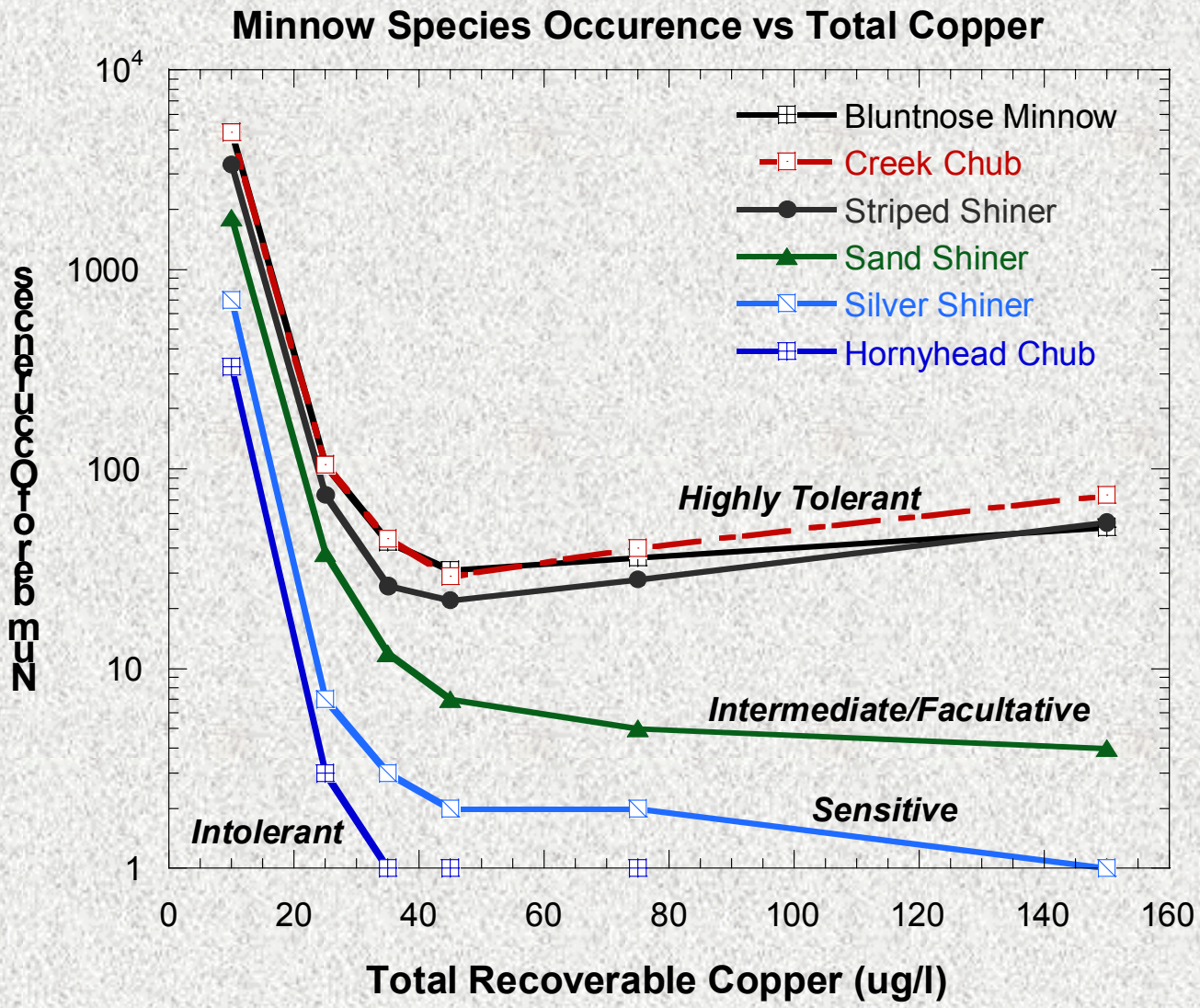
Maine Macroinvertebrate Monitoring Data



Overview of Attributes (cont.)

- **III - Sensitive - ubiquitous taxa**
  - ordinarily common and abundant
  - broader range of thermal and habitat tolerance; mild pollution loads have a negative effect on populations;
  - ex: ***Acroneuria*; Baetidae; Ephemerellidae; Brook trout**
- **IV - Taxa of intermediate tolerance**
  - may have generalist feeding strategies
  - densities commonly increase in response to nutrient enrichment
  - may be r-strategists (early colonizers with rapid turnover times and boom/bust populations)
  - ex: **Hydropsychidae; Polycentropodidae; Common shiner**

Ohio Fish Monitoring Data



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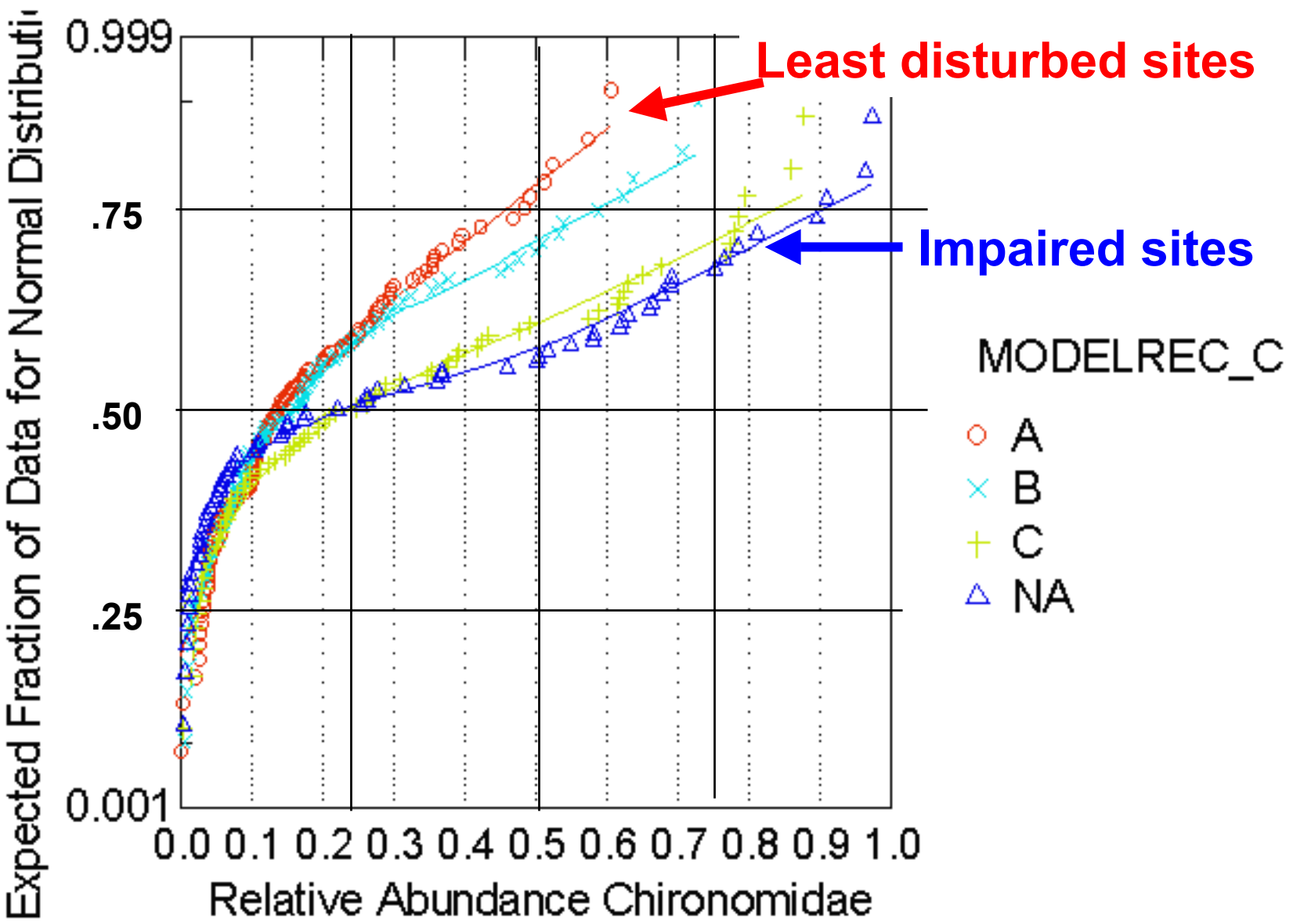


Overview of Attributes (cont.)

- **V - Tolerant Taxa**
  - often tolerant of a broad range of environmental conditions
  - often r-strategists or opportunist taxa; densities may increase greatly in absence of competition and predation
  - ex: **leeches; gastropods; white sucker**
- **VI - Non-native taxa**
  - species that do not naturally occur in a given locale or ecosystem
  - ex: ***Corbicula*; zebra mussels; rudd**
- **VII - Organism condition**
  - DELT anomalies and parasites of fish;
  - evidence of reproduction; sex ratios; biomass of YOY
- **VIII - Ecosystem function**
  - respiration, primary and secondary production

Overview of Attributes (cont.)

- **VIII - Ecosystem Function**
  - processes required for normal performance of a biological system
  - may be applied to any level of biological organization
  - Not commonly measured directly by state/tribal programs
  - **Examples**:
    - **Individual**- % organisms with …(anomalies, disease, parasites, etc.)
    - **Population**- fecundity, age class distributions, sex ratios, presence/absence
    - **Community**- structural composition and complexity
    - **Ecosystem**- Primary and secondary production, P/R, immigration and emigration, trophic complexity, resource leakage

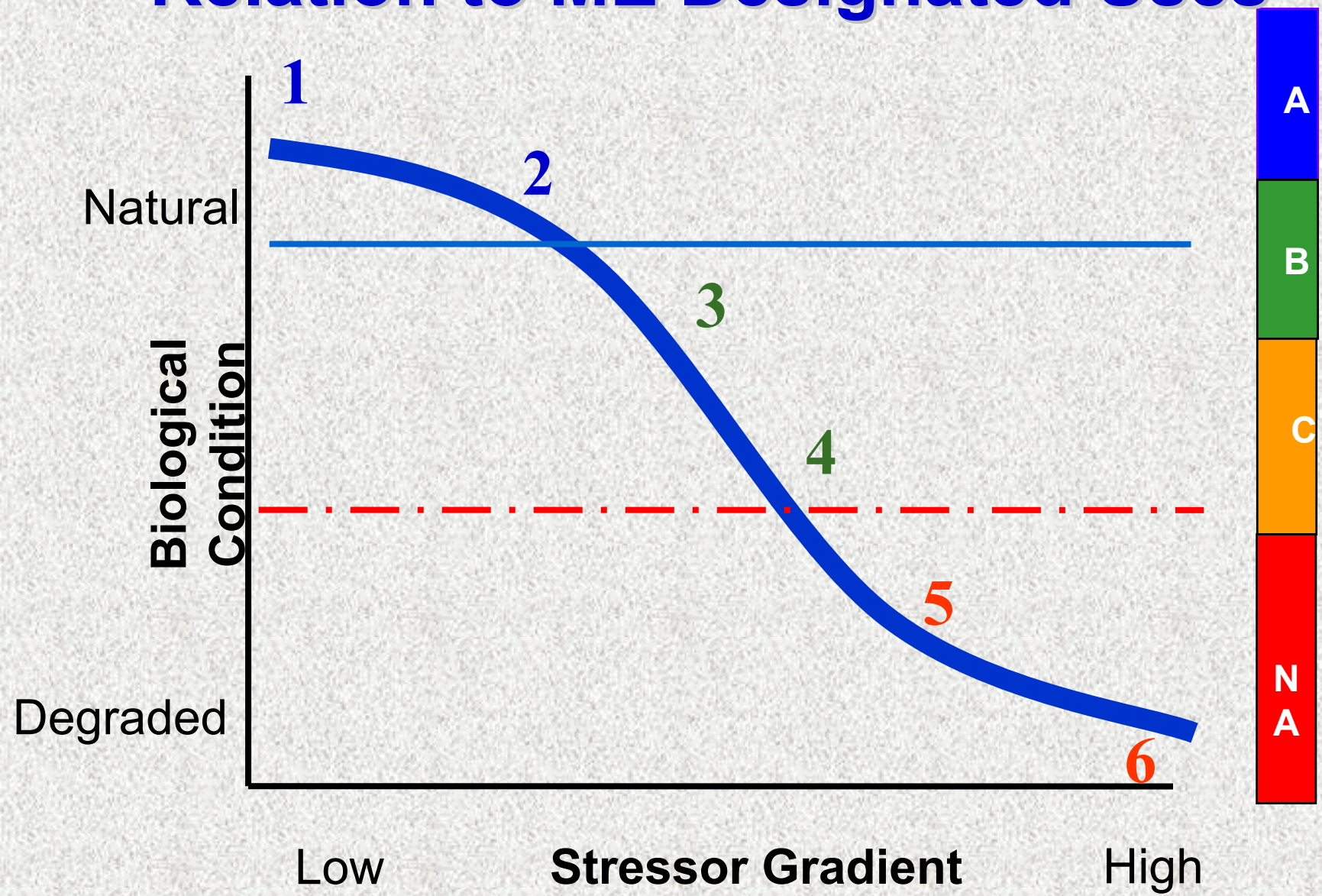
Overview of Attributes (cont.)

- **IX - Spatial and temporal extent of detrimental impacts**
  - near-field to far-field range of observable effects of human disturbance *(extent increases with increased severity of disturbance)*
  - patchy islands or periods of **unsuitable** conditions, within generally suitable conditions, progressing to patchy islands or periods of **suitable** conditions within generally degraded conditions
  - expands the scale perspective beyond the reach
  - linkage to the stressor-axis - (physical:biological interactions)
  - linkage to the management axis- (level of urgency or severity; ameliorating influences like BMPs)

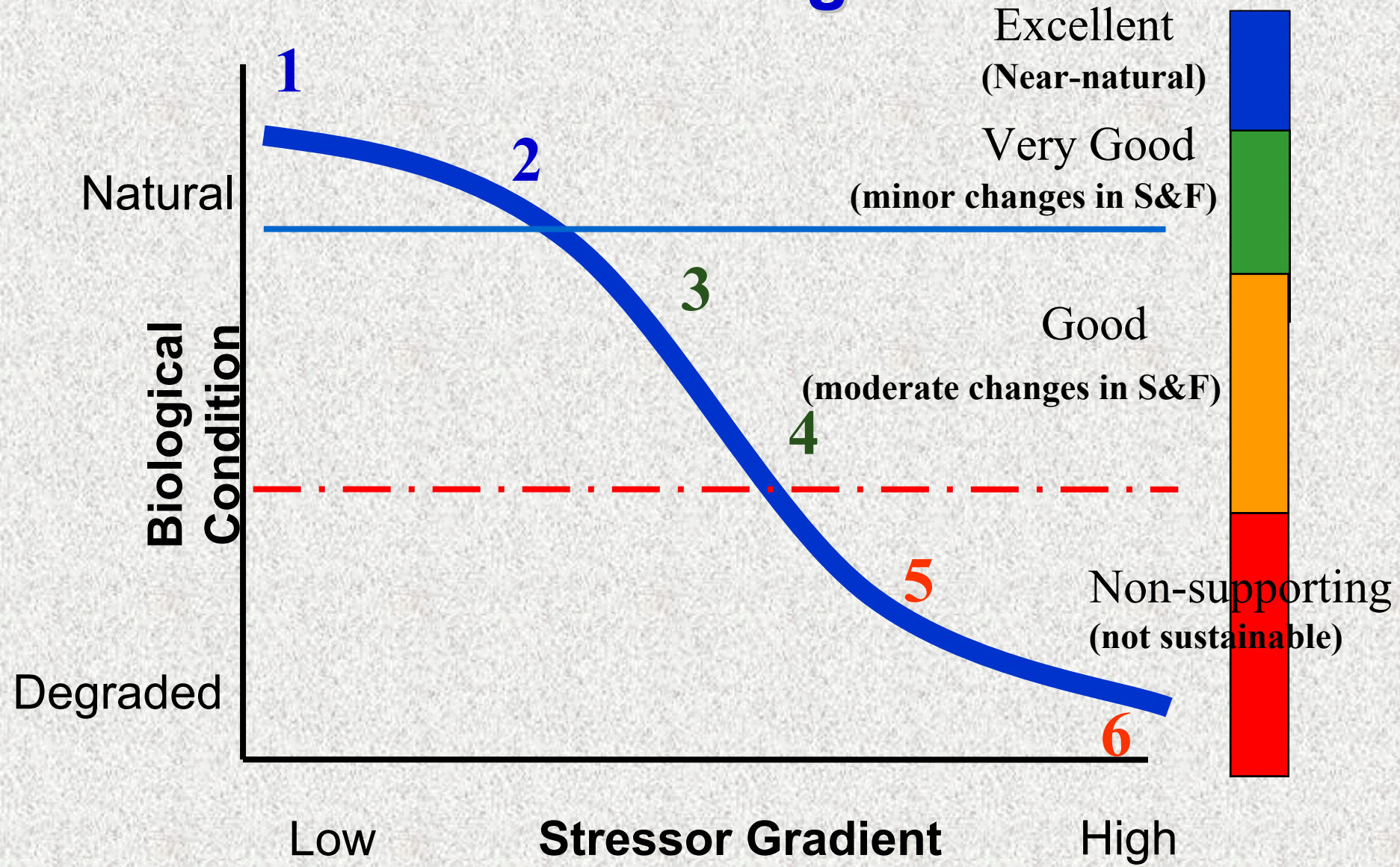
Overview of Attributes (cont.)

- **X - Ecosystem Connectance**
  - access or linkage (in space/time) to materials, locations, and conditions required for maintenance of interacting populations of aquatic life;
  - the opposite of fragmentation;
  - necessary for meta-population maintenance and natural flows of energy and nutrients across ecosystem boundaries
  - informs the management perspective- recovery potential, recruitment and maintenance of populations into a restored environment

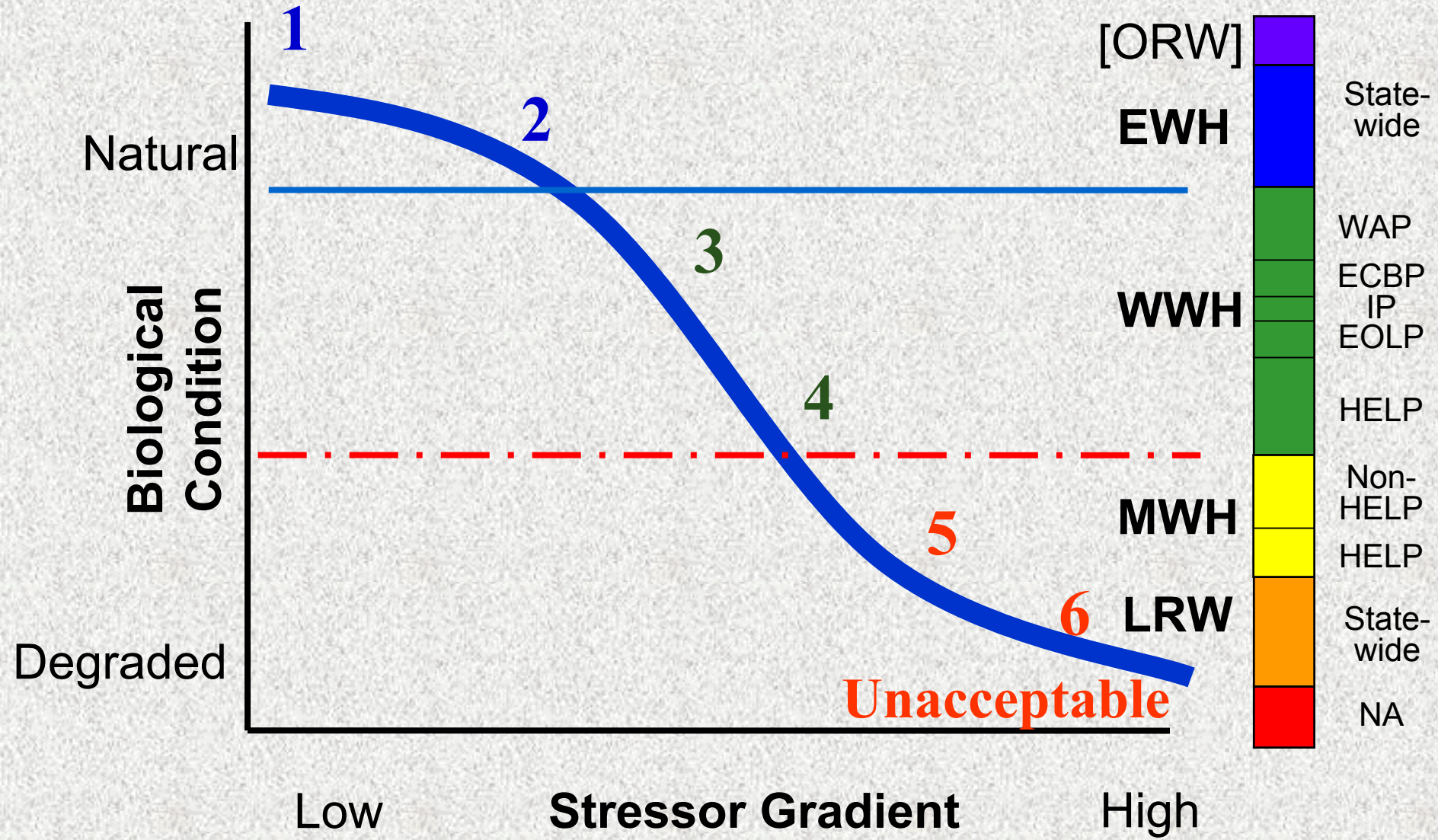
Relation to ME Designated Uses

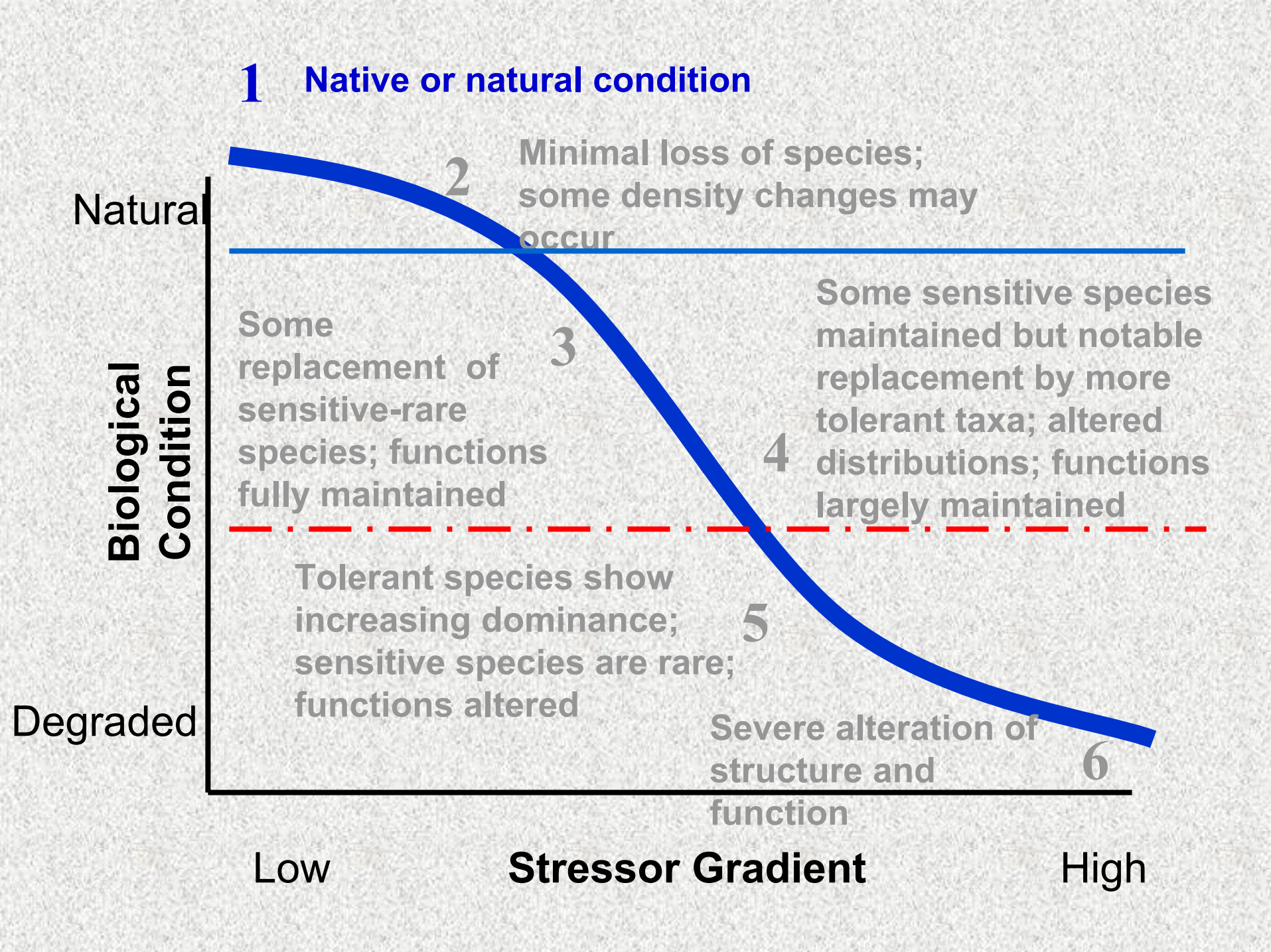


Relation to VT Designated Uses



Relation to OH Designated Uses

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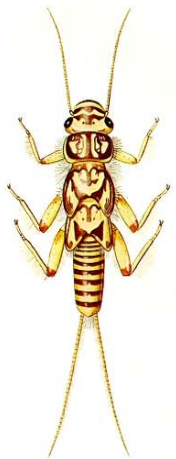
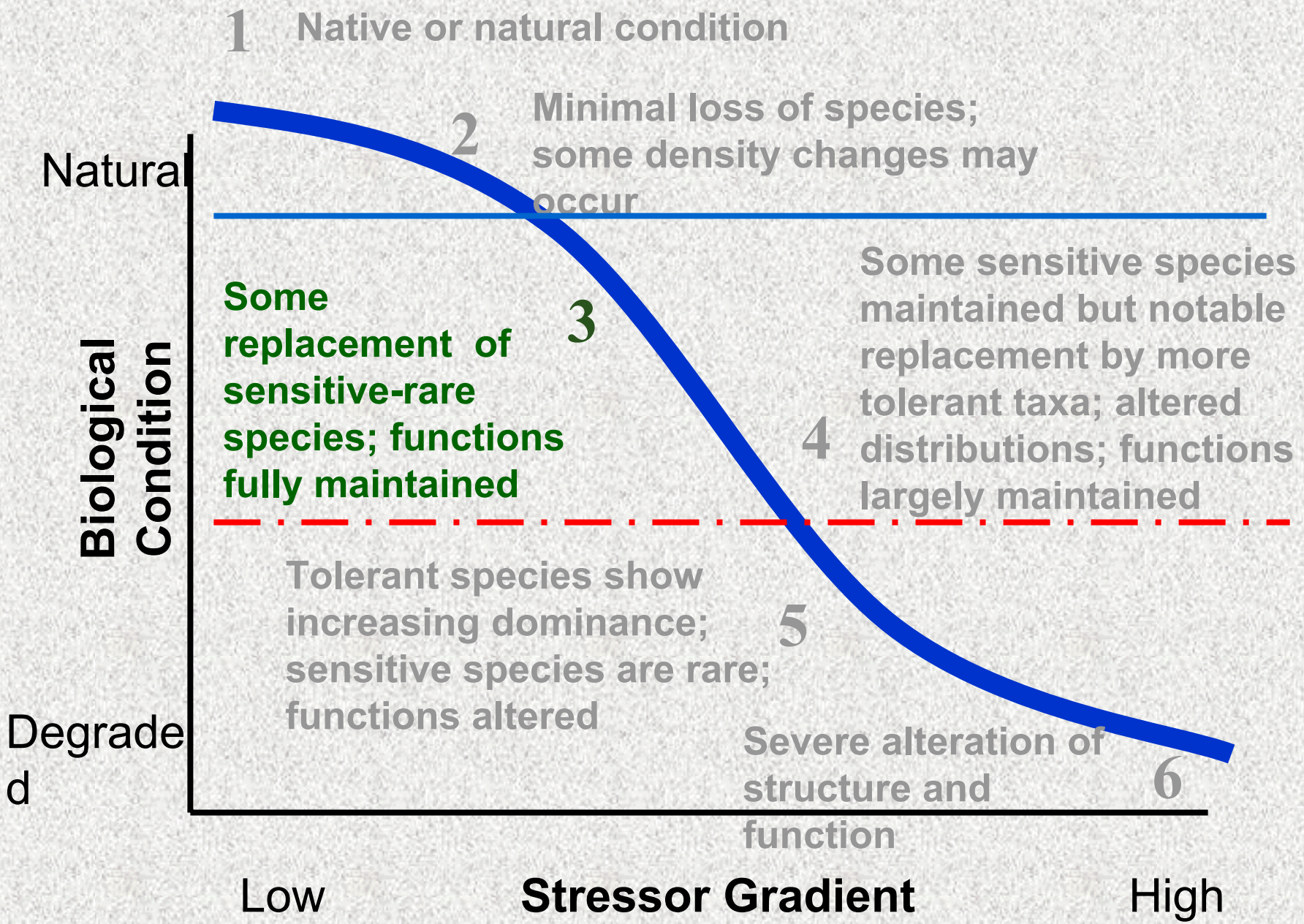


ME Example ALUS Tier 1

Intact watershed

- **Generic Richness**
  - Total = 51
  - EPT = 25 (49%)
  - Mayfly = 8
  - Stonefly = 6
  - Caddisfly = 11
  - Midges = 10
- **Abundance**
  - Total = 312
  - Mayfly = 157
  - Stonefly = 57

- **II - Sensitive- rare, specialist**
  - Taeniopteryx 48
  - Epeorus 13
  - Hexatoma 8
  - Probezzia 8
  - Isoperla 7
  - Pteronarcys 1
  - Capniidae 1
  - Chloroperlidae 1
  - Glossosoma 1
  - Brachycentrus 1
- **III - Sensitive - ubiquitous, generalist**
  - Ephemerella 127
  - Acentrella 13
  - Stenonema 8
- **IV - Intermediate tolerance, opportunistic**
  - Hydropsyche 24
  - Cheumatopsyche 5
- **V - Tolerant Taxa**
  - Polypedilum 8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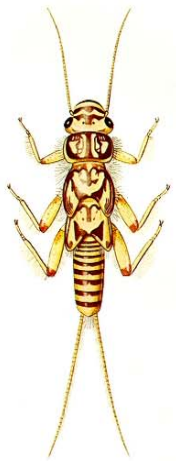
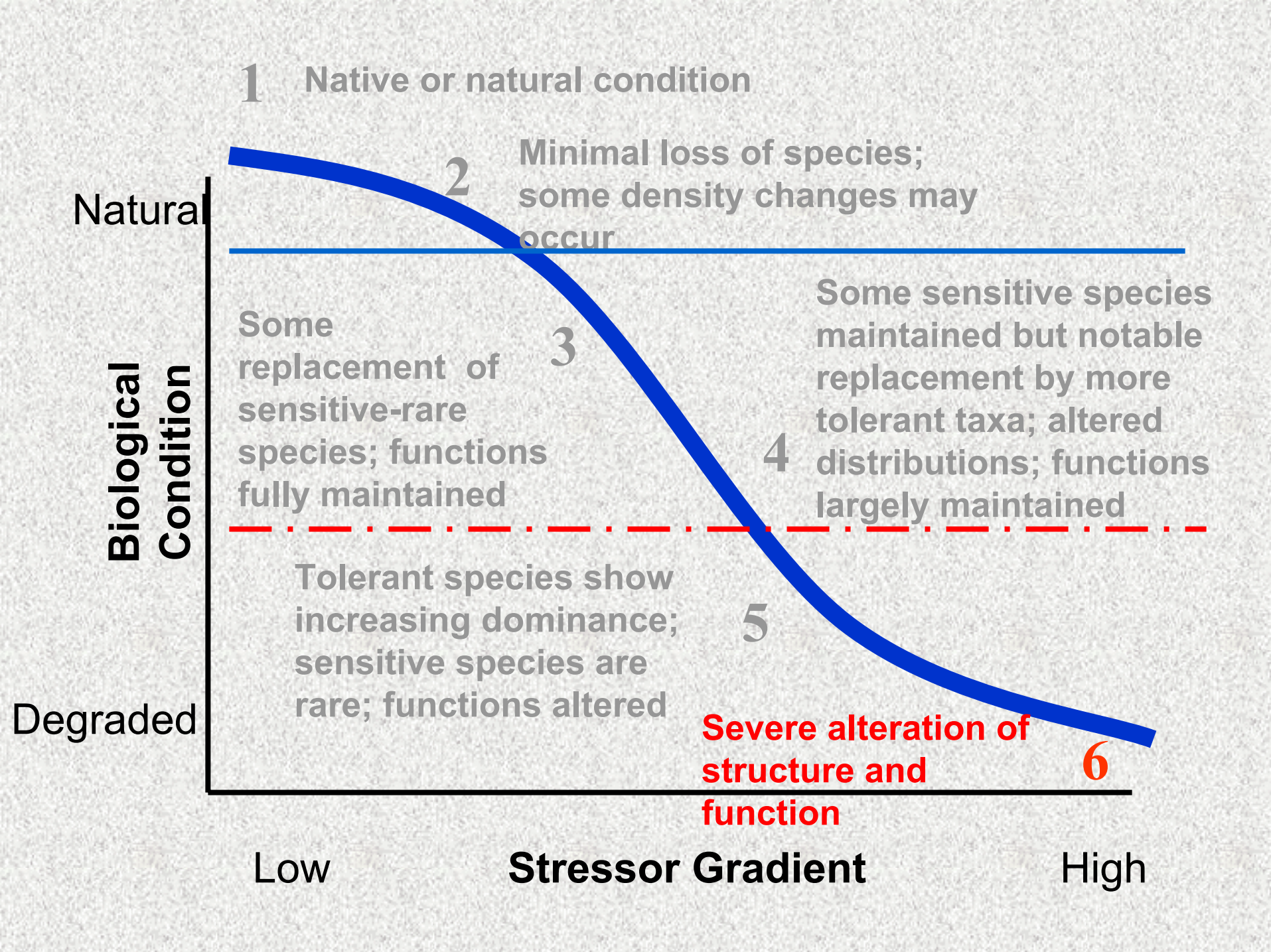


ME Example ALUS Tier 3

Agricultural NPS

- **Generic Richness**
  - Total = 58
  - EPT = 21 (36%)
  - Mayfly = 7
  - Stonefly = 1
  - Caddisfly = 13
  - Midges = 12
- **Abundance**
  - Total = 835
  - Mayfly = 220
  - Stonefly = 16

- **II - Sensitive- rare, specialist**
  - Serratella 8
  - Leucrocuta 5
- **III - Sensitive - ubiquitous, generalist**
  - Baetis 127
  - Ephemerella 67
  - Acroneuria 16
  - Acentrella 6
  - Stenonema 5
- **IV - Intermediate tolerance, opportunistic**
  - Simulium 203
  - Hydropsyche 92
  - Rheotanytarsus 62
  - Chimarra 40
- **V - Tolerant Taxa**
  - Cricotopus 33
  - Polypedilum 32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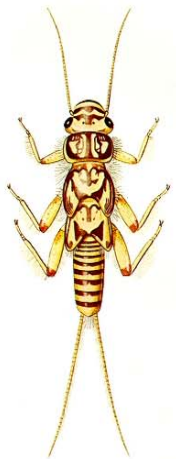


ME Example ALUS Tier 6

Toxic discharge

- **Generic Richness**
  - Total = 8
  - EPT = 0 (0%)
  - Mayfly = 0
  - Stonefly = 0
  - Caddisfly = 0
  - Midges = 3
  - Snails= 2
- **Abundance**
  - Total = 74
  - Mayfly = 0
  - Stonefly = 0
  - Snail= 52

- **II - Sensitive- rare, specialist**
  - none
- **III - Sensitive - ubiquitous, generalist**
  - none
- **IV - Intermediate tolerance, opportunistic**
  - none
- **V - Tolerant Taxa**
  - Helisoma 48
  - Thienemannimyia 16
  - Physa 4
  - Cricotopus 2
  - Ablabesmyia 1
  - Helobdella 1

Summary of 2001 Group Consensus

- **Tiers 1& 2 meet CWA biointegrity goal**
- **Tiers 3 & 4 meet Interim Goal**
  - S&F maintained by replacement and redundancy;
  - some sensitive taxa still supported
  - balanced distribution of major groups
- **Tiers 5 & 6 do not meet the Interim Goal**
  - loss of function
  - sensitive taxa lost
  - hyperdominance or 'unnatural' distributions
- **High importance attributes should be retained (function, connectance, etc) even if not well-assessed now**.

SP Davies, MDEP

Summary of Outstanding Issues

- Should non-native taxa be allowed in Tier 1?
- How can we create a “crosswalk” between the Biocondition Gradient and the Endangered Species Act?
- How can Attribute VIII, Ecosystem Function, be made clearer and more useful?
- How do we transition from ***describing what we see*** to ***establishing management thresholds***?

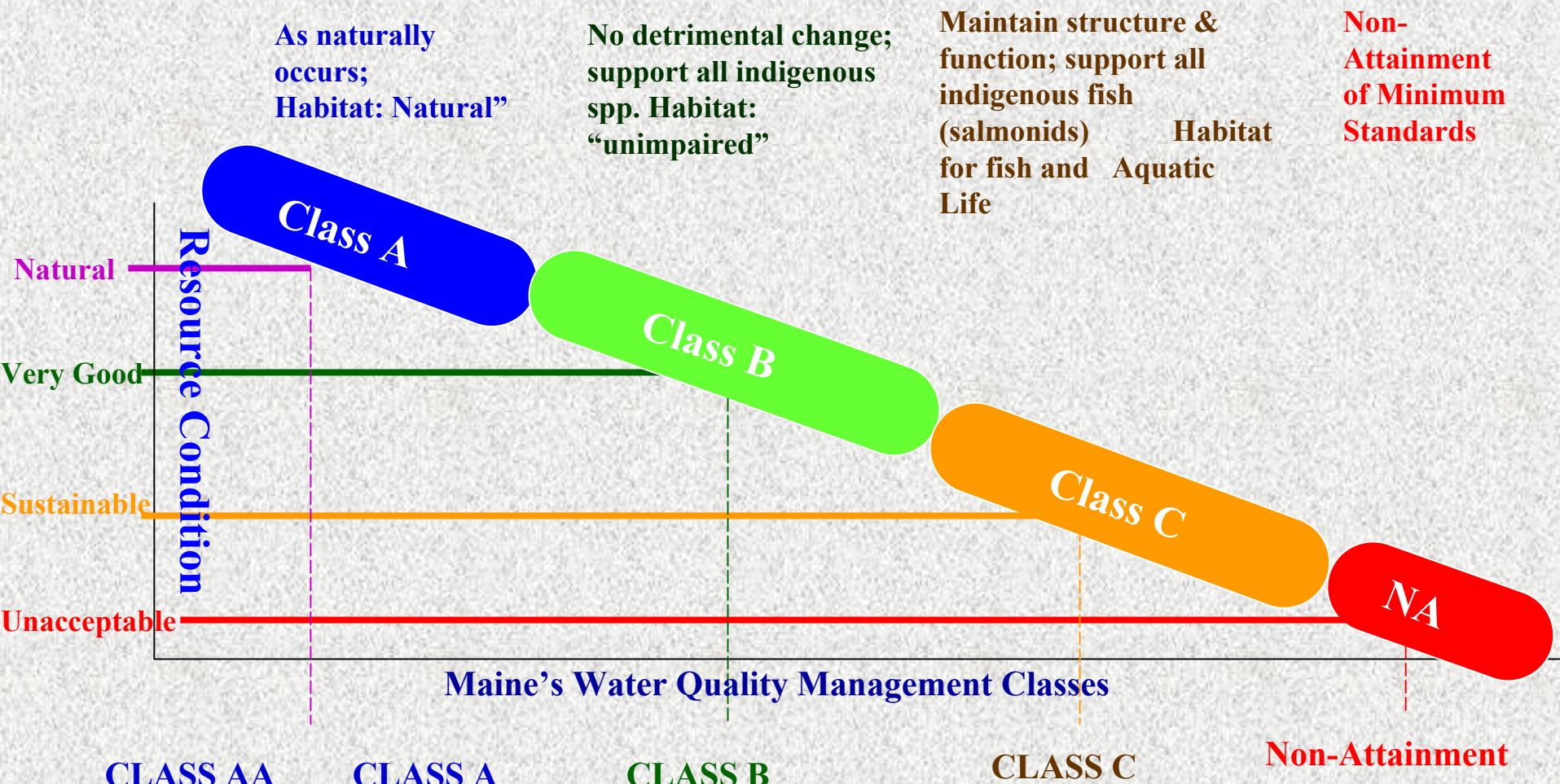
Conclusions

- **Near-universal interpretive Gestalt exists among biologists**
  - based on First Principles of Ecology, independent of methods
  - highly internalized and under-communicated
- **Disclosure and documentation provides an important tool for learning, communication, and management**



Additional supporting slides

Maine's Aquatic Life Management Classes



CLASS AA

Zero Discharge; No hydrologic alteration

CLASS A

No alternatives; D/C Equal to or Better; hydro allowed

CLASS B

D/C with ample dilution; DO: 7ppm/75% saturation; 9 ppm for salmonid spawning; Bacteria: 64/100 mil- in the Summer

CLASS C

DO: 5 ppm/60% Sat.; Water Quality sufficient to ensure salmonid spawning/survival; Bacteria:142/100 mil

Non-Attainment

Maine Tiered Uses Based on Measurable Ecological Values

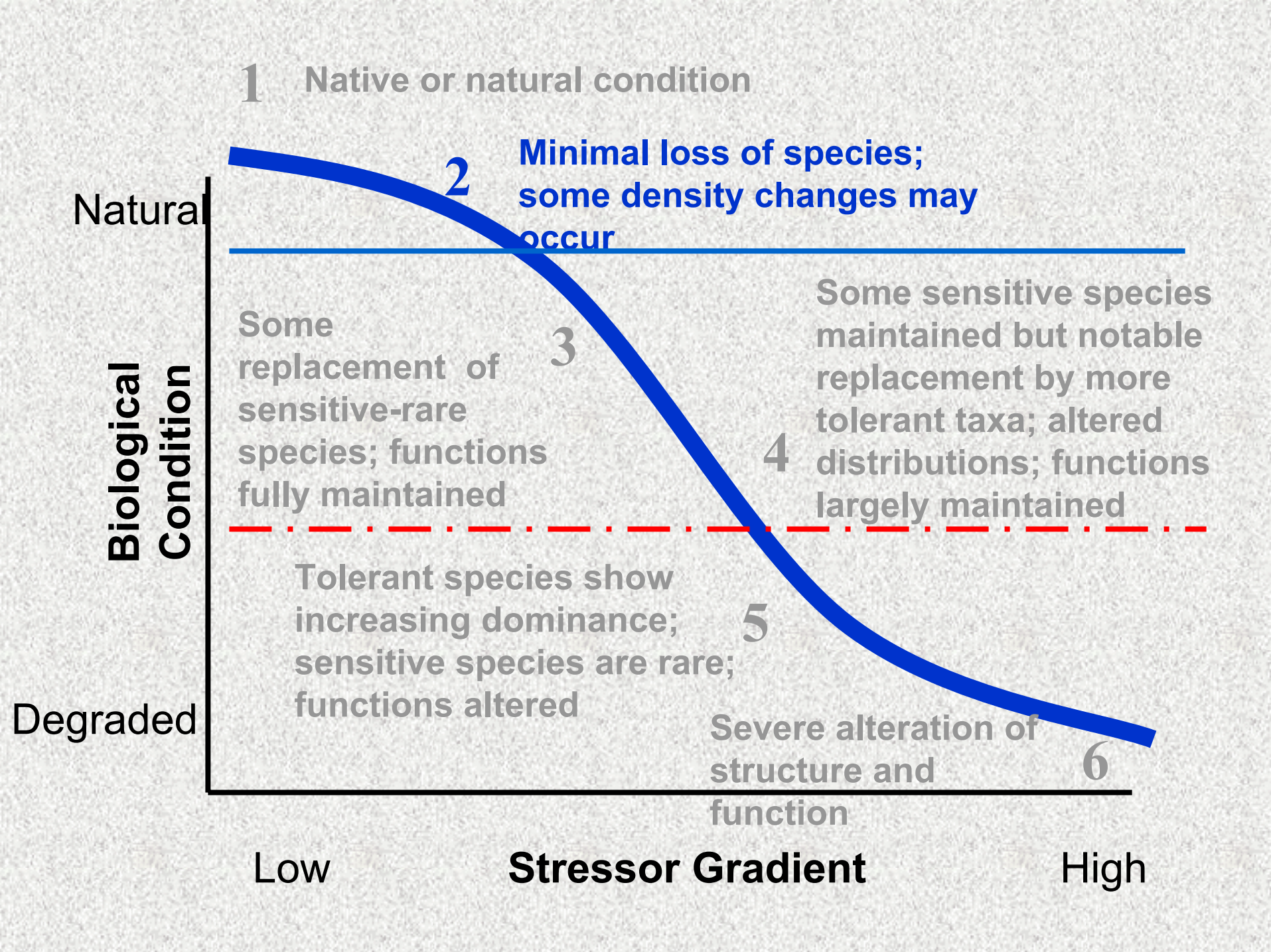
Narrative Standard	Ecological Value	Quantifiable Measures
CLASS A *natural*	Taxonomic and Numeric Equality ; Presence of Indicator Taxa	Similarity, Richness, Abundance, Diversity; EPT, Indicator Taxa, Biotic Index
CLASS B *unimpaired, maintain indigenous taxa*	Retention of taxa and numbers; Absence of hyperdominance; Presence of sensitive taxa	Community loss; Richness; Abundance; diversity; equitability; evenness; EPT; Indicator Taxa, Biotic Index
CLASS C *maintain structure*	Resistance, Redundancy; Resilience; Balanced Distribution	Richness; Diversity; Equitability; Evenness
and function	Energy Transfer; Resource assimilation; Reproduction	Trophic groups; Richness; abundance; community loss; fecundity; colonization rate

Future Needs- *Definitions*

- Clear operational definitions of terms used in the BioCondition Gradient are ultimately dependent on clarifying multiple, specific contexts
- **ecoregion context**
- **taxonomic context**
- **stressor context**
- **sampling methods context**
- **level of effort context**
- **regulatory context**

Conclusion:

States and tribes need to refine the definitions in order for them to have a clear and specific meaning within in a given state program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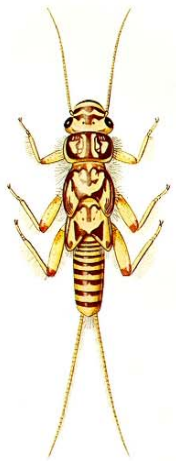
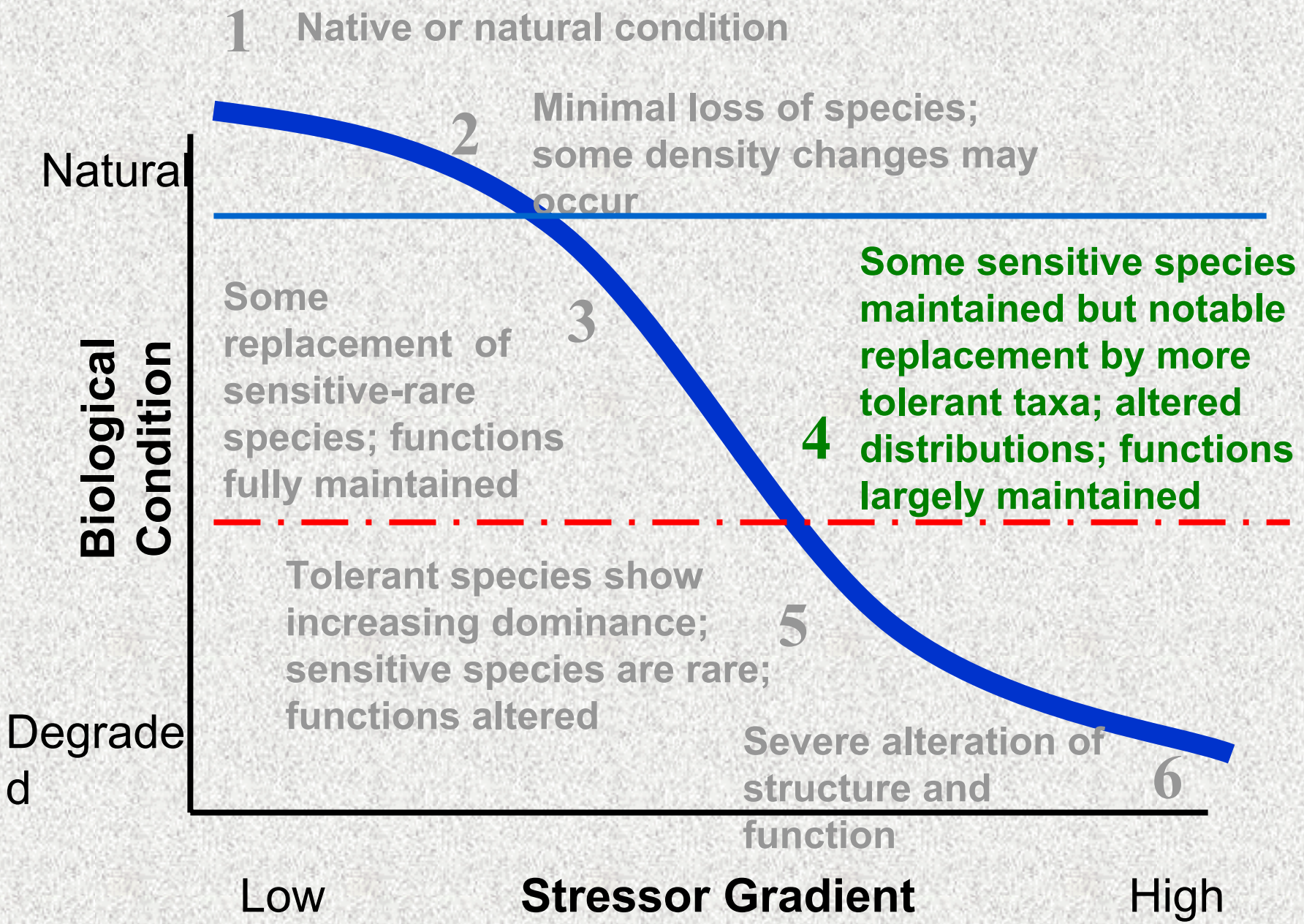


ME Example ALUS Tier 2

- **Generic Richness**
  - Total = 62
  - EPT = 26 (42%)
  - Mayfly = 9
  - Stonefly = 2
  - Caddisfly = 15
  - Midges = 19
- **Abundance**
  - Total = 585
  - Mayfly = 77
  - Stonefly = 18

- **II - Sensitive- rare, specialist**
  - Psilotreta 8
  - Serratella 6
  - Leucrocuta 5
  - Promoresia 4
  - Brachycentrus 1
- **III - Sensitive - ubiquitous, generalist**
  - Helicopsyche 159
  - Isonychia 37
  - Acroneuria 17
  - Stenonema 17
  - Baetis 7
- **IV - Intermediate tolerance, opportunistic**
  - Rheotanytarsus 54
  - Hydropsyche 52
  - Cheumatopsyche 11
- **V - Tolerant Taxa**
  - Polypedilum 8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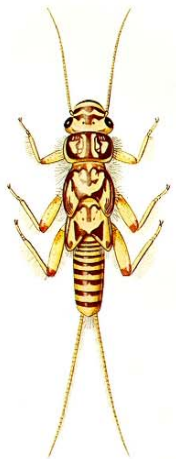
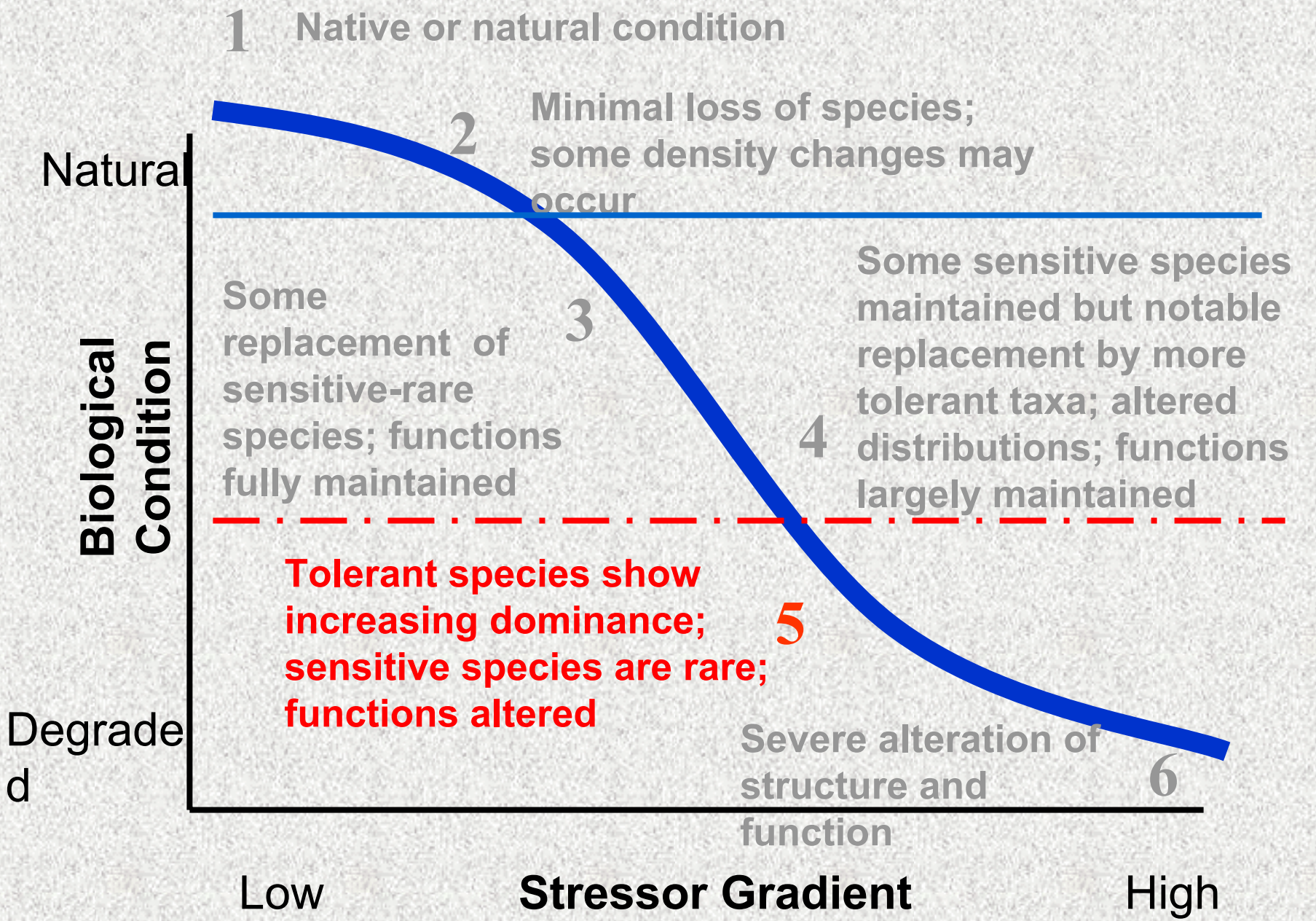


ME Example ALUS Tier 4

- **Generic Richness**
  - Total = 48
  - EPT = 12 (25%)
  - Mayfly = 6
  - Stonefly = 1
  - Caddisfly = 5
  - Midges = 21
- **Abundance**
  - Total = 2470
  - Mayfly = 295
  - Stonefly = 4

- **II - Sensitive- rare, specialist**
  - Serratella 1
- **III - Sensitive - ubiquitous, generalist**
  - Tricorythodes 107
  - Stenonema 101
  - Baetis 59
  - Acroneuria 4
- **IV - Intermediate tolerance, opportunistic**
  - Cheumatopsyche 896
  - Hydropsyche 245
  - Microtendipes 141
  - Simulium 12
- **V - Tolerant Taxa**
  - Cricotopus 469
  - Polypedilum 84
  - Physella 45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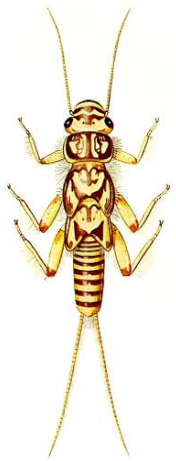

ME Example ALUS Tier 5

- **Generic Richness**
  - Total = 33
  - EPT = 2 (6%)
  - Mayfly = 0
  - Stonefly = 0
  - Caddisfly = 2
  - Midges = 15
- **Abundance**
  - Total = 2780
  - Mayfly = 0
  - Stonefly = 0

- **II - Sensitive- rare, specialist**
  - none
- **III - Sensitive - ubiquitous, generalist**
  - none
- **IV - Intermediate tolerance, opportunistic**
  - Rheotanytarsus 1199
  - Cheumatopsyche 484
  - Hydropsyche 205
  - Rheocricotopus 62
  - Tvetenia 9
- **V - Tolerant Taxa**
  - Isopoda 412
  - Hayesomyia 185
  - Polypedilum 40

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