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Advancing State and Tribal Programs

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# Index 101

## *Multimetric Concepts*

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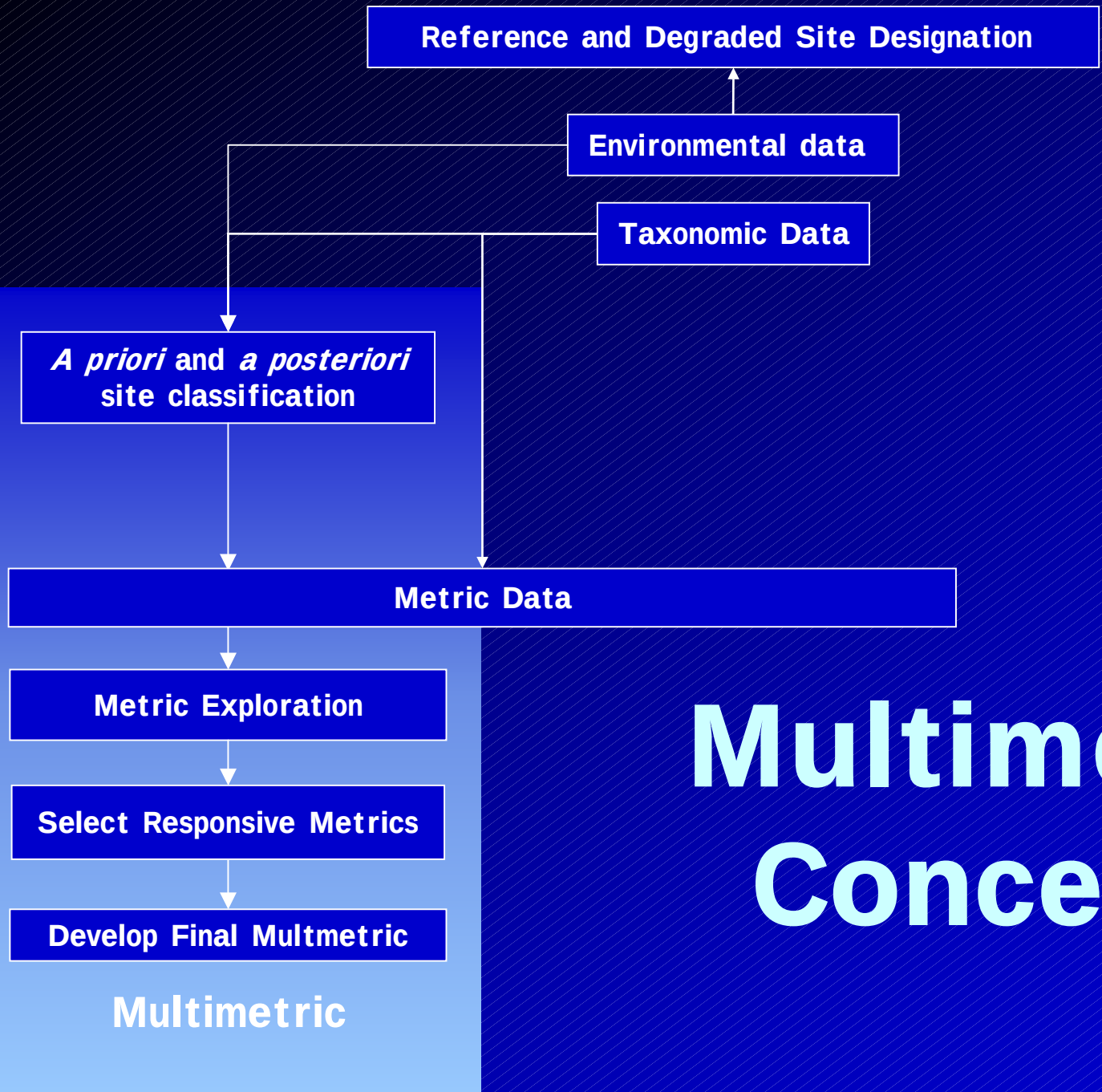



# Multimetric Concepts

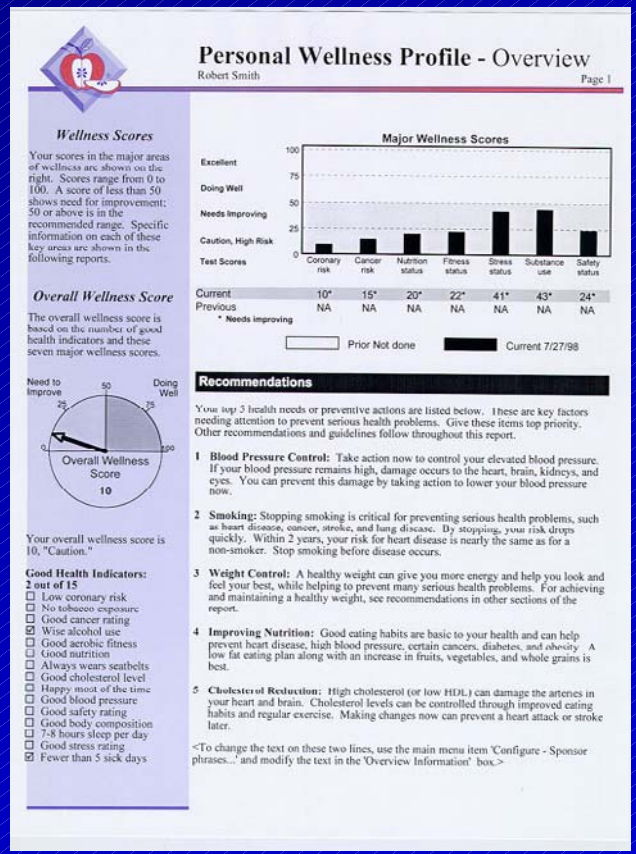
# Basic Steps

- Reference/Degraded Criteria
- Classification
  - Reducing variability
- Metric Exploration
  - Incorporating broad ecological information
  - Identifying discriminatory metrics
  - Avoiding redundancy
- Developing the “multi”-metric
  - Testing combinations of metrics

# A medical metaphor

- Have you ever taken a “wellness” test?

- **They ask a lot of questions based on common “indicators” = “metrics”**



**Personal Wellness Profile** - Overview

Robert Smith — Page 1

*Wellness Scores*

Your scores in the major areas of wellness are shown on the right. Scores range from 0 to 100. A score of less than 50 shows need for improvement; 50 or above is in the recommended range. Specific information on each of these key areas are shown in the following reports.

*Overall Wellness Score*

The overall wellness score is based on the number of good health indicators and these seven major wellness scores.

Need to Improve / Doing Well

Overall Wellness Score 10

Your overall wellness score is 10, "Caution."

**Good Health Indicators: 2 out of 15**

- ☐ Low coronary risk
- ☐ No tobacco exposure
- ☐ Good cancer rating
- ☑ Wise alcohol use
- ☐ Good aerobic fitness
- ☐ Good nutrition
- ☐ Always wears seatbelts
- ☐ Good cholesterol level
- ☐ Happy most of the time
- ☐ Good blood pressure
- ☐ Good safety rating
- ☐ Good body composition
- ☐ 7-8 hours sleep per day
- ☐ Good stress rating
- ☑ Fewer than 5 sick days

**Major Wellness Scores**

Excellent / Doing Well / Needs Improving / Caution, High Risk / Test Scores

| | Coronary risk | Cancer risk | Nutrition status | Fitness status | Stress status | Substance use | Safety status |
|---|---|---|---|---|---|---|---|
| Current | 10* | 15* | 20* | 22* | 41* | 43* | 24* |
| Previous | NA | NA | NA | NA | NA | NA | NA |

* Needs improving

Prior Not done — Current 7/27/98

**Recommendations**

Your top 5 health needs or preventive actions are listed below. These are key factors needing attention to prevent serious health problems. Give these items top priority. Other recommendations and guidelines follow throughout this report.

1 **Blood Pressure Control:** Take action now to control your elevated blood pressure. If your blood pressure remains high, damage occurs to the heart, brain, kidneys, and eyes. You can prevent this damage by taking action to lower your blood pressure now.

2 **Smoking:** Stopping smoking is critical for preventing serious health problems, such as heart disease, cancer, stroke, and lung disease. By stopping, your risk drops quickly. Within 2 years, your risk for heart disease is nearly the same as for a non-smoker. Stop smoking before disease occurs.

3 **Weight Control:** A healthy weight can give you more energy and help you look and feel your best, while helping to prevent many serious health problems. For achieving and maintaining a healthy weight, see recommendations in other sections of the report.

4 **Improving Nutrition:** Good eating habits are basic to your health and can help prevent heart disease, high blood pressure, certain cancers, diabetes, and obesity. A low fat eating plan along with an increase in fruits, vegetables, and whole grains is best.

5 **Cholesterol Reduction:** High cholesterol (or low HDL) can damage the arteries in your heart and brain. Cholesterol levels can be controlled through improved eating habits and regular exercise. Making changes now can prevent a heart attack or stroke later.

<To change the text on these two lines, use the main menu item 'Configure - Sponsor phrases...' and modify the text in the 'Overview Information' box.>

# Reference/Degraded Criteria

- What is healthy?
- Need two groups for building models

**HEALTHY REFERENCE**

**Non-smoker**
**Low Stress**
**Exercise 5d/week**
**Healthy Diet**

**UNHEALTHY DEGRADED**

**2 packs/day**
**High Stress**
**No exercise**
**High Fat Diet**

# Classification

- The first few questions always deal with age, gender, etc.
- Expectations differ for different groups.

# Metric Exploration

- One indicator doesn't get it done...
- Likely explored a lot of indicators
- Explored relationship of indicators to illness – developed those that were good at discriminating healthy from unhealthy folks.

# Developing a ‘multi’-metric

- Finally identified those indicators that consistently discriminated healthy individuals from unhealthy.
- Doctors now use an array of these to measure your “wellness”
- Individual indicators used for diagnosing particular problem areas

# How it works – reference criteria

- Reference/Degraded Criteria
  - Reference sites are used to build classifications
  - Reference and Degraded used to select metrics and test final index
  - Abiotic variables are used
  - Likely need to test a few approaches
  - May need to stratify later

# Reference Sites

- The primary function of reference conditions is as a measurement standard
- To be useful, a measurement standard must account for natural variability
  - undisturbed, natural
  - best of available
  - representative of class

# Reference and Degraded Criteria

- Reference sites (must meet all)
  - No discharges within prescribed distance
  - Better than state water quality standards
  - Land use: no direct disturbances
  - Habitat typical for region; good riparian zone
- Stressed sites (meets one or more)
  - Fails water quality or sediment standards
  - Severe habitat impairment
  - Severe nonpoint sources; erosion

# Maryland Reference Criteria (must meet all)

- pH $ 6.0
- ANC $ 50Feq/l
- dissolved oxygen $ 4.0 ppm
- Nitrate-N # 4.2 mg/l
- Urban land use # 20% of catchment
- Forested land cover $25% of catchment
- Remoteness rating “optimal” or suboptimal”
- Aesthetics rating “optimal” or “suboptimal”
- Instream habitat rating “optimal” or “suboptimal”
- Riparian buffer width $ 15m
- No channelization
- No point source discharges

# Maryland Stressed Criteria (meets any one)

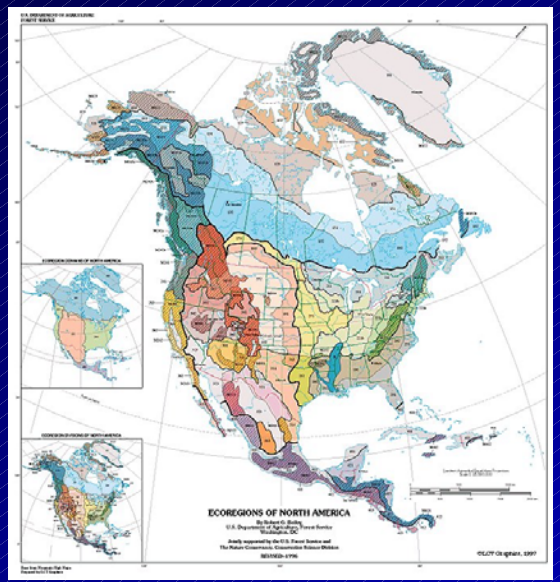
- **pH # 5.0 *and* ANC # 0 Feq/l**
- **dissolved oxygen # 2.0 ppm**
- **Nitrate-N $ 7.0 mg/l and DO # 2.0 ppm**
- **Urban land use > 50% of catchment area and instream habitat rating "poor"**
- **Instream habitat rating "poor" and bank stability rating "poor"**
- **Channel alteration rating "poor" and instream habitat rating "poor"**

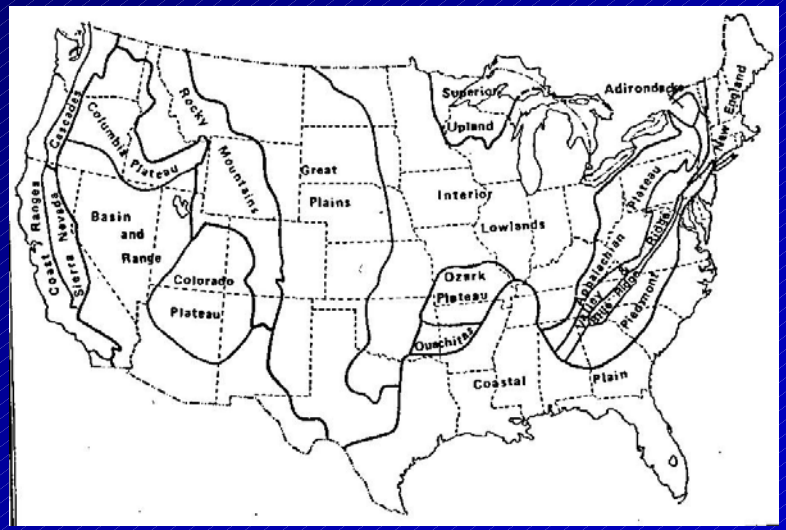
# Classification

- Classification
  - Comparing like to like
  - Way of apportioning variability
  - Models calibrated to each “class”
- *A priori* - existing
- *A posteriori* – derive from your data

# *A priori* classification

- Ecoregions



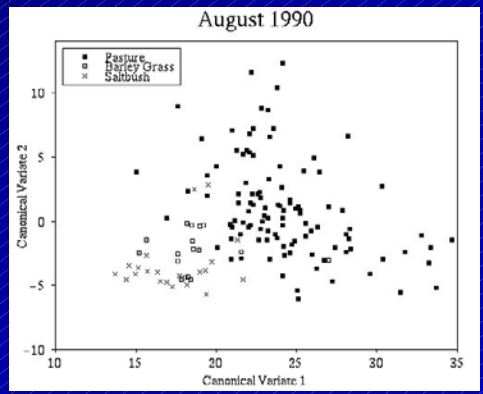

- Physiographic provinces

# *A posteriori* classification

**Physical and Chemical Data**

| STRM_ID | ALTD | ANC | ANSUM | CA | CATSUM | CL |
|---|---|---|---|---|---|---|
| MD10S | 10 | 154 | 4787.3 | 27.2 | 4665.4 | 7.9 |
| MD11S | 5 | 153 | 5314.5 | 237.5 | 5219.8 | 10.2 |
| MD11S | 8 | 286 | 10374.9 | 357.3 | 10712.8 | 42.9 |
| MD12S | 6 | 391 | 8300.6 | 409.2 | 8429.9 | 5.4 |
| MD15S | 30 | 412 | 14993.8 | 568.8 | 14879.7 | 66.3 |
| MD55S | 12 | 246 | 6547.2 | 327.3 | 6655.7 | 16.6 |
| MD56S | 19 | 895 | 12759.1 | 728.5 | 13778.1 | 24.2 |
| MDR02S | 8 | 789 | 13107 | 908.2 | 12481.2 | 8.4 |
| MDR03S | 3 | 149 | 5095 | 25.2 | 5567.2 | 6.0 |
| MDT02S | 30 | 968 | 14774.9 | 668.7 | 13983.6 | 29.0 |
| PA00S | 3 | 3534 | 7080.5 | 3568 | 6668.6 | 14.9 |
| PA01S | 28 | 2370.6 | 28600.8 | 1801.4 | 28683.4 | 32.5 |
| PA50S | 9 | 1740 | 23408.6 | 1791.4 | 23847.3 | 15.0 |
| PA50S | 10 | 195 | 4129.9 | 242.5 | 3970.7 | 2.1 |
| PA50S | 151 | 164 | 1631.1 | 107.3 | 1911.7 | 1.9 |
| PA51S | 12 | 194 | 8494.8 | 323.4 | 8852.9 | 36.3 |
| PA51S | 5 | 968 | 4104.8 | 190.1 | 417.4 | 15.1 |
| PA51S | 8 | 315 | 6557.9 | 265 | 6481.6 | 5.0 |
| PA51S | 22 | 662 | 2492.9 | 128.7 | 2558.6 | 3.2 |
| PA51S | 6 | 531 | 12146 | 488.5 | 13660.8 | 56.3 |
| PA52S | 9 | 773 | 11018 | 568.9 | 11046.1 | 11.6 |
| PA52S | 21 | 118 | 5597.8 | 176.6 | 6025.8 | 27.4 |
| PA53S | 14 | 240 | 6142.1 | 405.2 | 5940.8 | 9.1 |

**Ordination**
**Cluster Analysis**
**Etc.**




**Classes or Groups**

**Highlands**

**Piedmont**

**Plains**

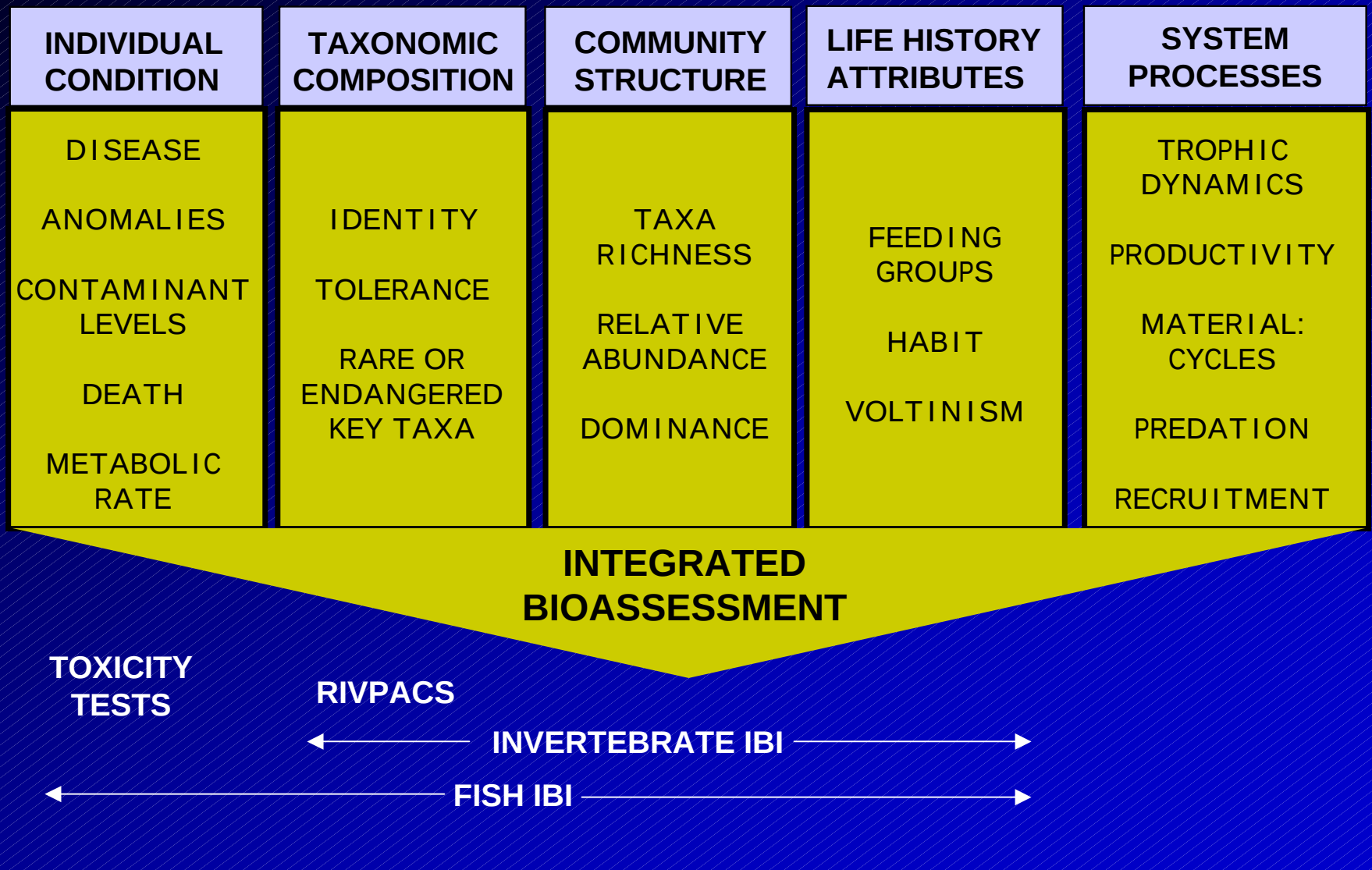
# Confirmation

- Univariate tests
- MANOVA
- Other Ordination
- Similarity analysis

# Metric Exploration

- Incorporating broad ecological information
- Identifying discriminatory metrics
- Avoiding redundancy

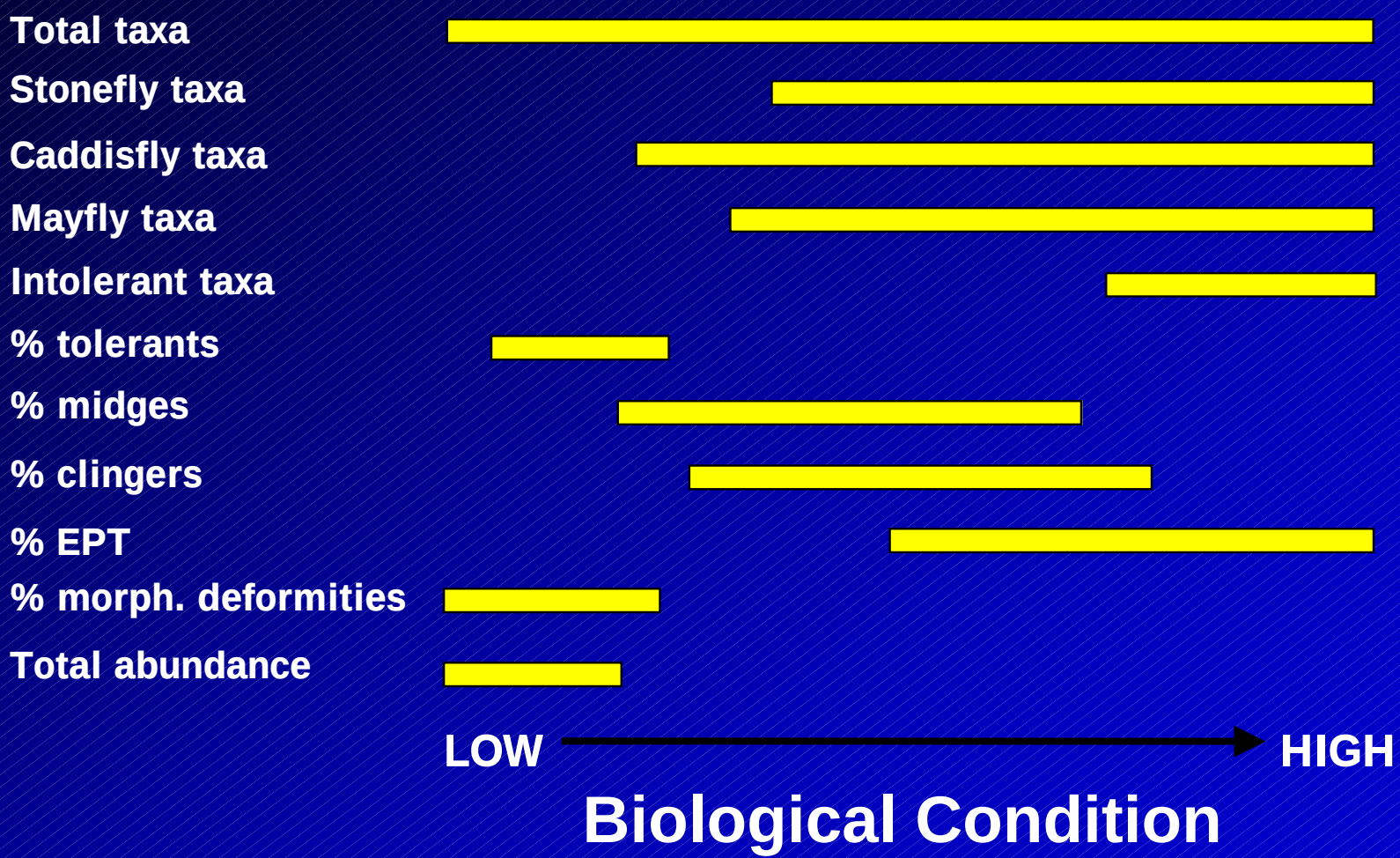
# Metric Exploration



# Ideal Multimetric Composite

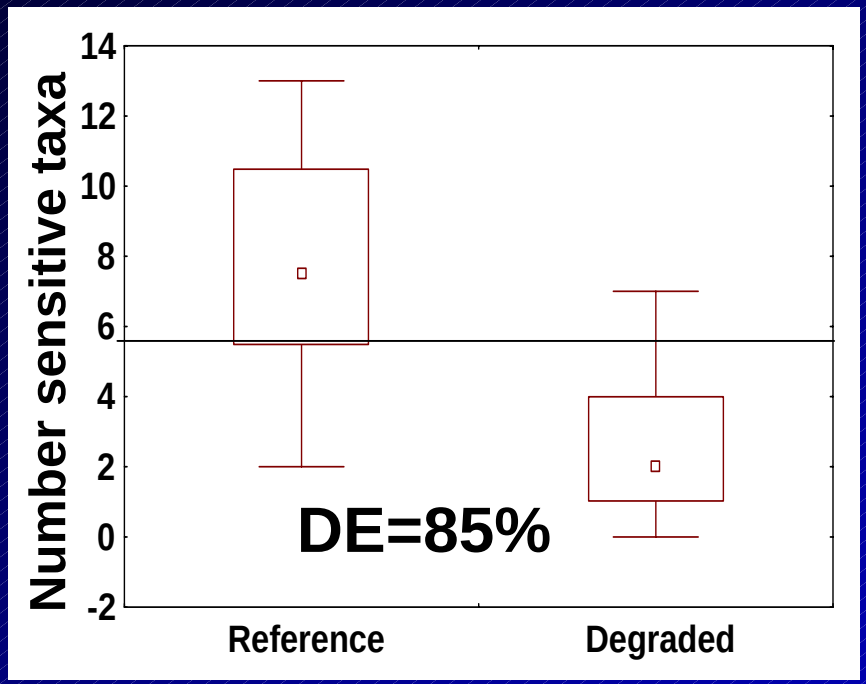
- Multiple organizational levels
- Addresses structure and function
- Broad sensitivity
- Broad range of habitats, niches
- Metric characteristics
  - Responsive to stressors
  - Low natural variability
  - Interpretable (understanding of ecology)
  - Cost-effective to measure

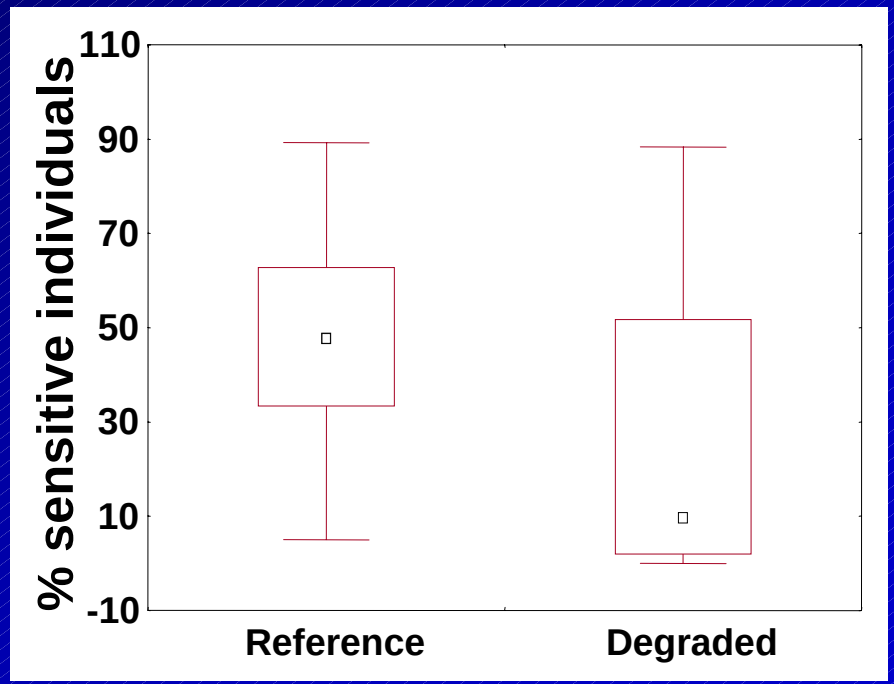
# Different responsiveness



# Testing metrics – reference vs degraded approach

Metric Responses

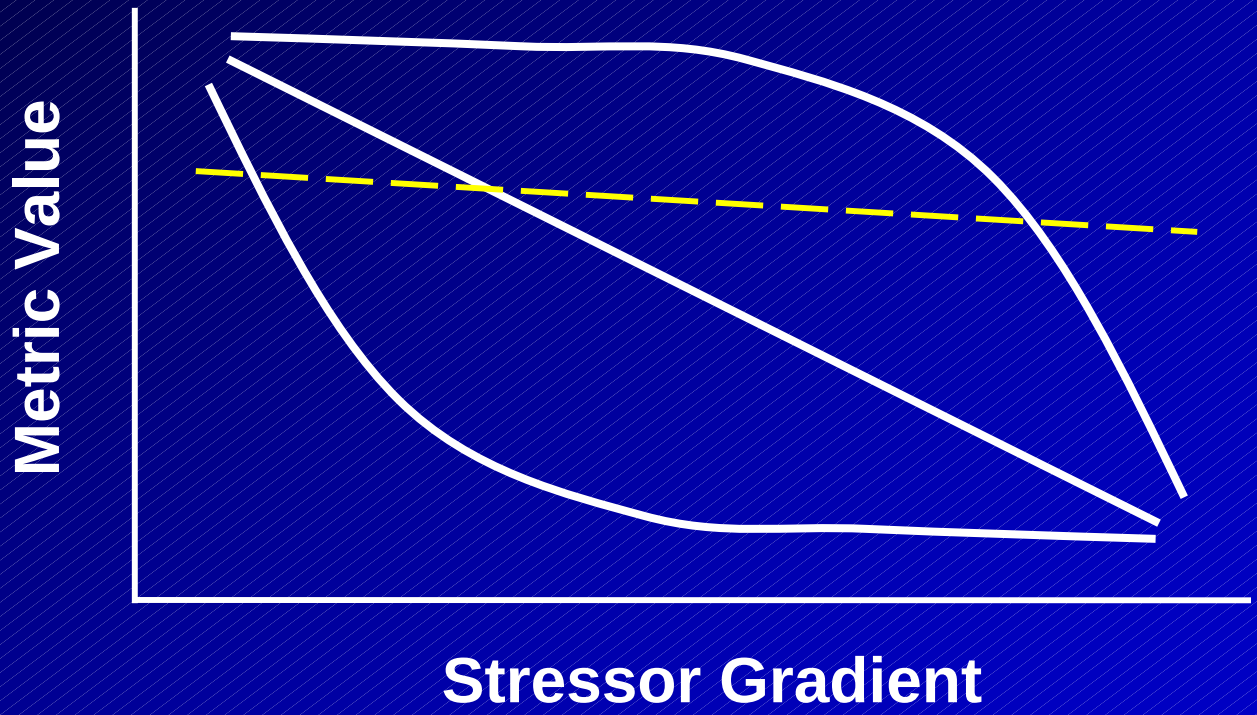



**Strong** **Weak**

**Discrimination Efficiency = percent degraded < 25$^{th}$ percentile reference**

# Testing metrics – gradient approach



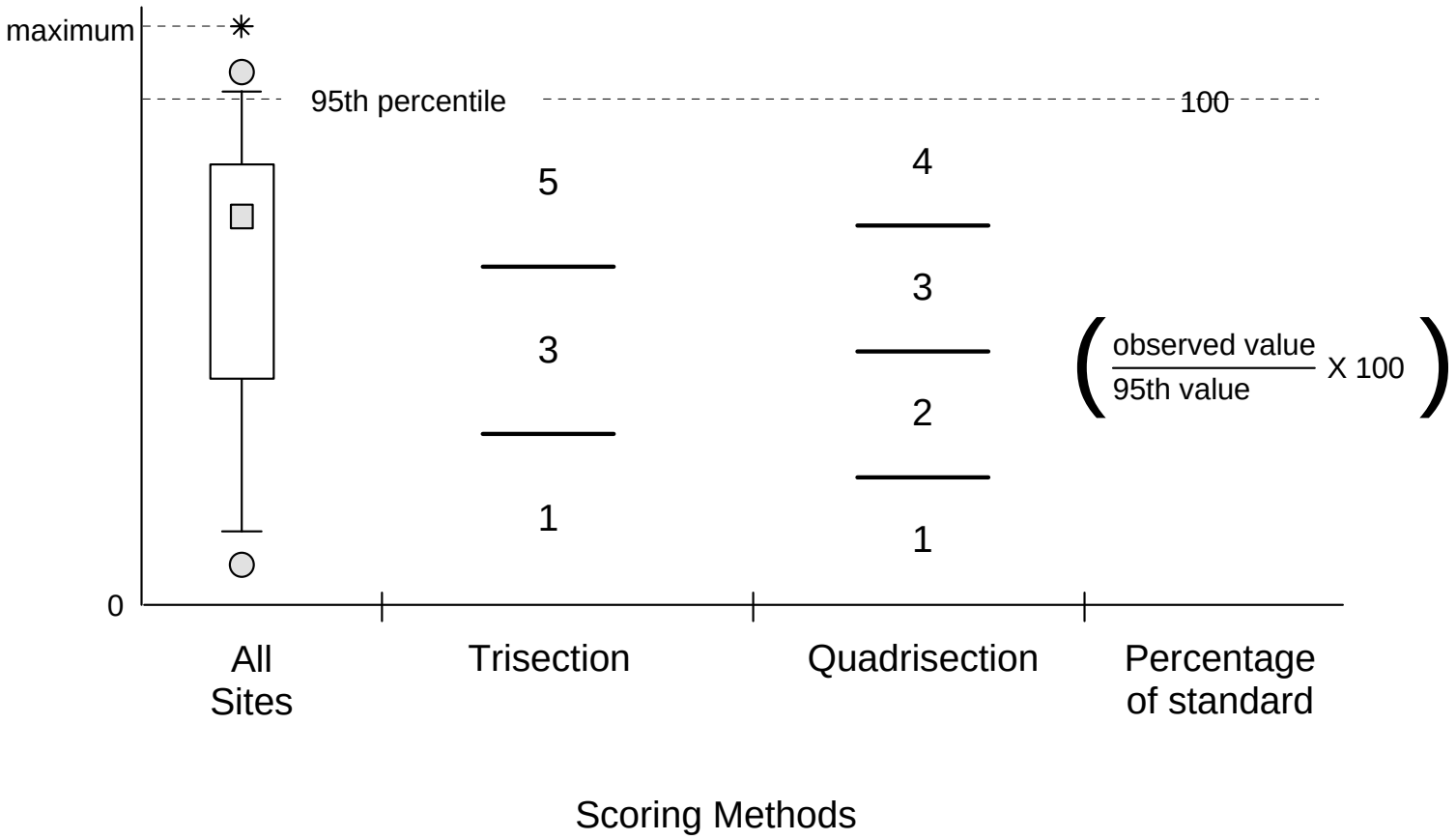
# Avoid redundancy

- Avoid metrics that are components of others
  - E.g. % EPT and % Ephemeroptera
- Correlation analysis – avoid highly correlated metrics in same multimetric
  - r>0.7 is a good start

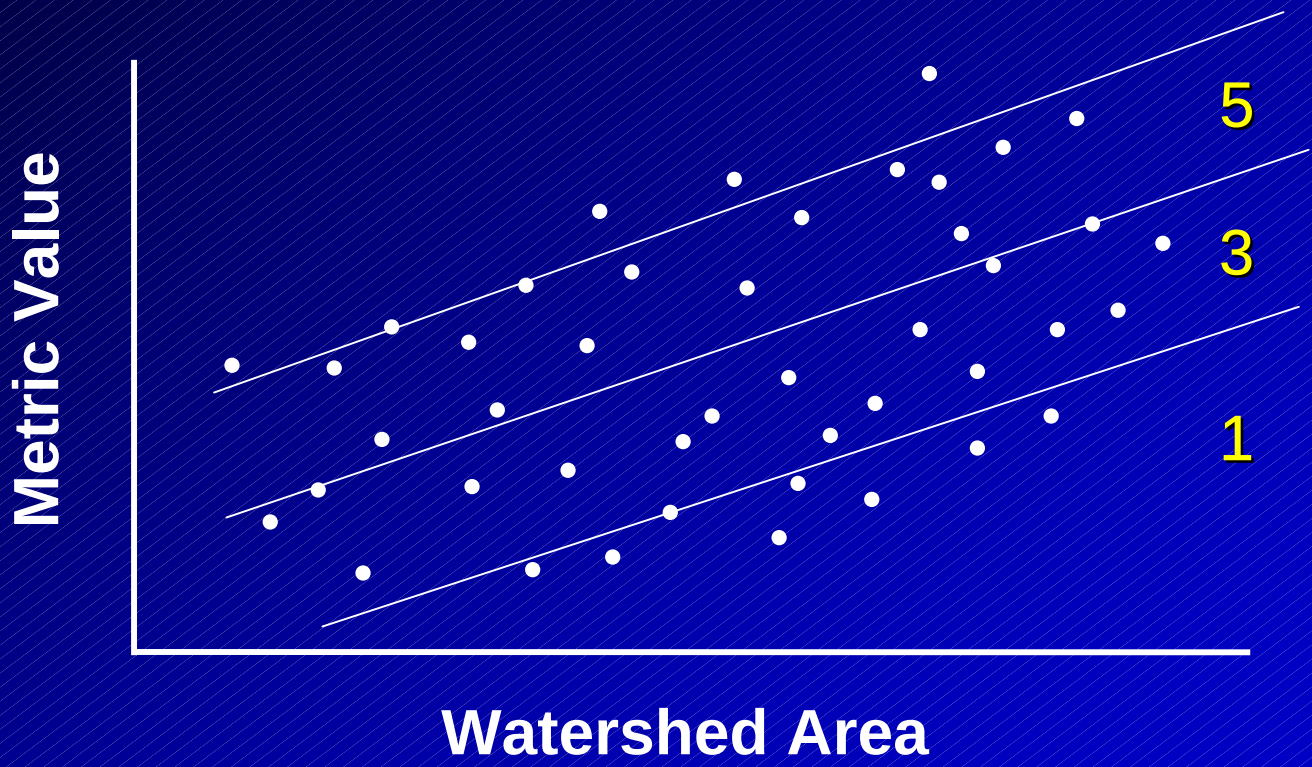
# Delete Metrics

- Obscure ecological meaning
- Weak response to stressors
- Limited ecosystem relevance
- Redundancy to other metrics

# Metric Standardization



# Metric Standardization



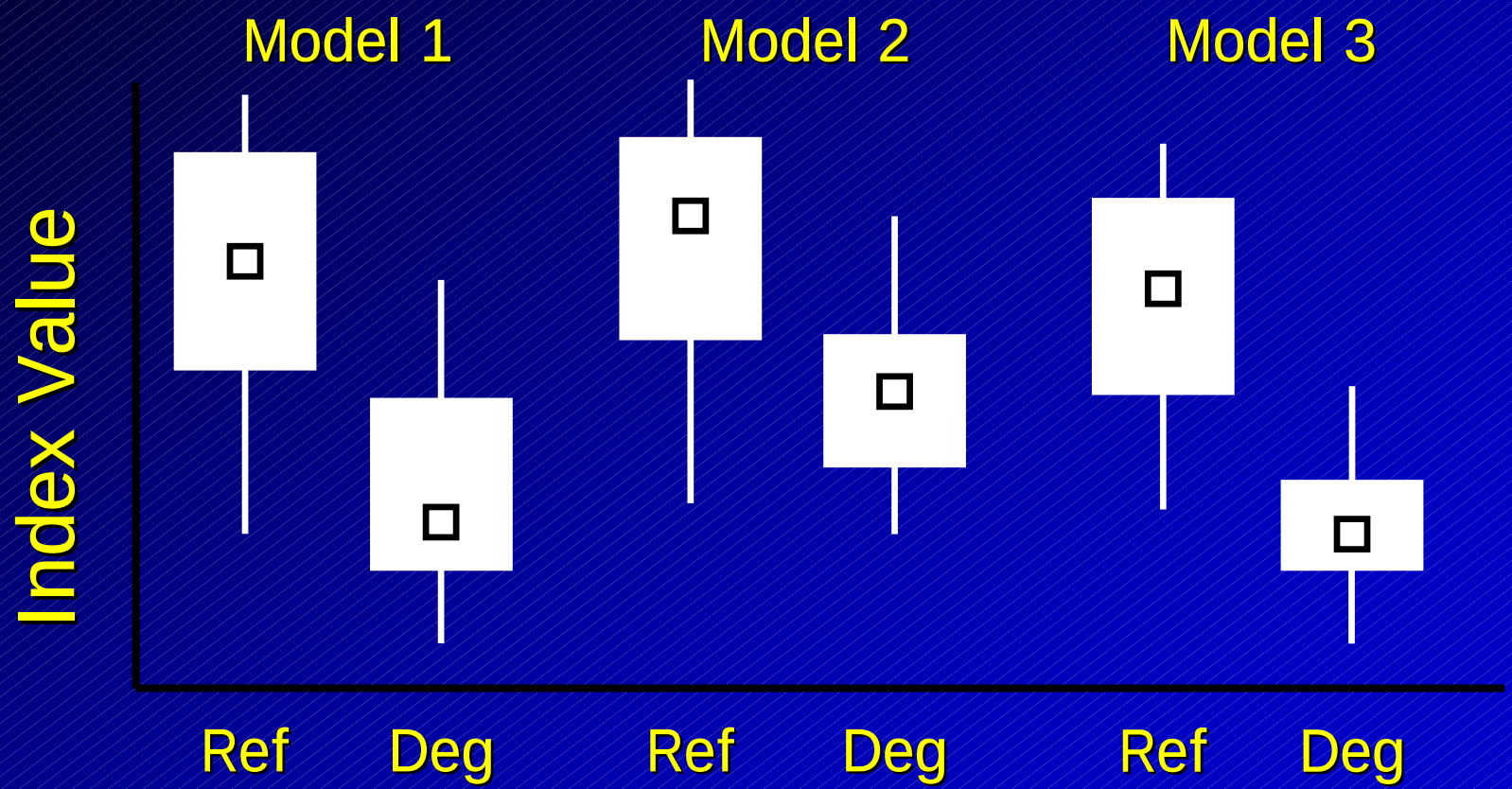
# Assembling Metrics

- Use sum or average of standard scores of metrics to get final multimetric score
- Test several combinations for overall discrimination efficiency

# Assembling multimetrics

| Metric | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Ephemeroptera taxa | X | X | X |
| Plecoptera Taxa | | X | X |
| Trichoptera Taxa | | X | X |
| Insect taxa | X | | |
| Non-insect taxa | X | | |
| % Ephemeroptera | X | | |
| % Ephemeroptera less Baetid | | X | |
| % Trichoptera Less Hydropsyche | | X | X |
| %Oligochaeta | X | | |
| % scrapers | X | X | X |
| BCI CTQA | | X | X |
| HBI | X | X | |
| % 5 dominant | X | X | |

# Compare Discrimination Efficiencies




**DE =** **80%** **74%** **98%**

# Different classes may have different indexes

- **Coastal Plain metrics**
  - Total taxa
  - EPT taxa
  - % mayflies
  - % Tanytarsini
  - Beck's Biotic Index
  - Scraper taxa
  - % clingers
- **Non-Coastal Plain metrics**
  - Total taxa
  - EPT taxa
  - % mayflies
  - % Tanytarsini
  - Ephemeroptera taxa
  - Diptera taxa
  - Intolerant taxa
  - % tolerant individuals
  - % collectors

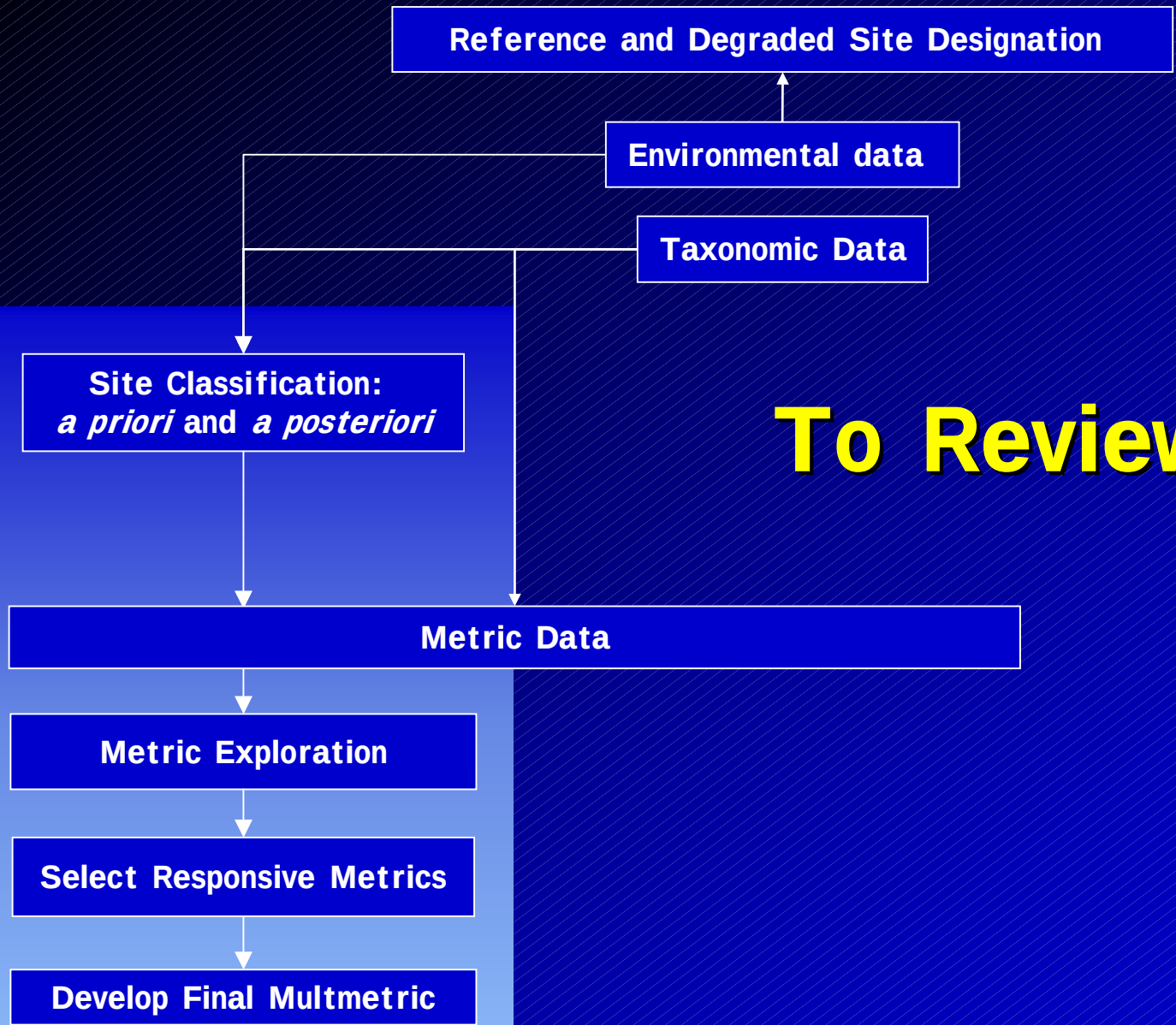
# Or may be the same, but use different standardized scores or threshold values

95th Percentile of Reference Site Values

| Metric | Class I | II | III | IV |
|---|---|---|---|---|
| Total Taxa | 20 | 34 | 32 | 36 |
| EPT Taxa | 6 | 10 | 12 | 15 |
| Diptera Taxa | 8 | 12 | 12 | 15 |
| % Tolerant | 19 | 9 | 8 | 6 |
| % Scrapers | 12 | 20 | 23 | 20 |
| % Clingers | 55 | 60 | 63 | 65 |

# Always test any model

- Use an independent dataset with reference and degraded sites
  - Same year set aside
  - Newly collected data
  - Test discrimination efficiency
  - Should match model building DE
  - No strict rule




**To Review...**

**Multimetric**