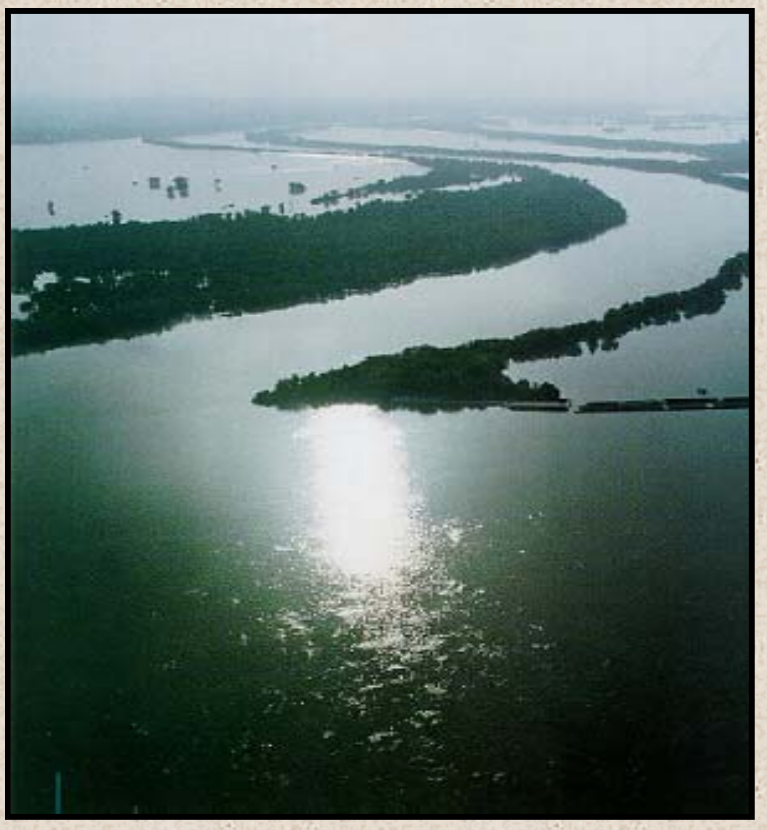
Upper Missouri River



← Then

Now →

Bank Stabilization

Floodplain Wetlands

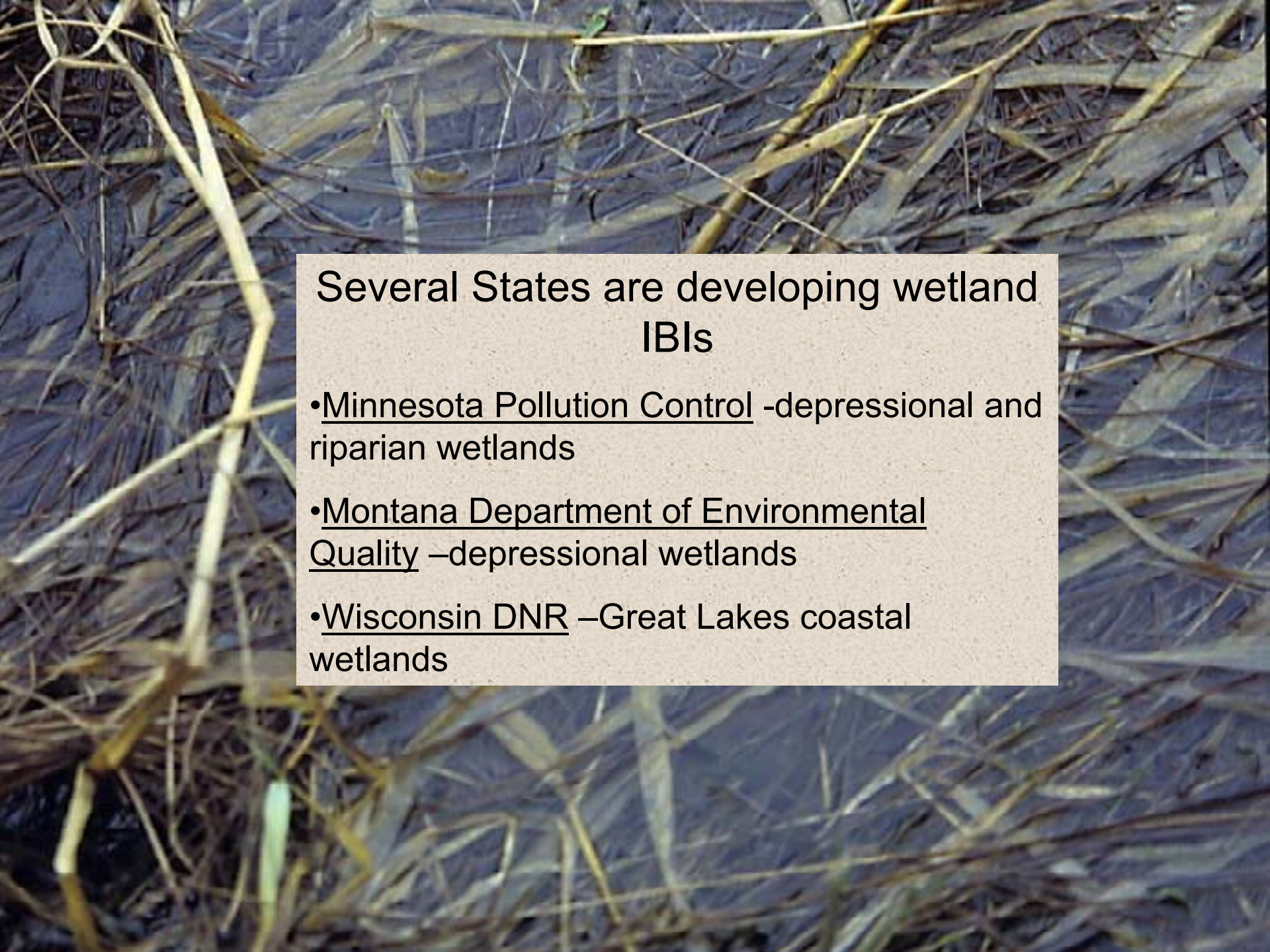
Emergent
(26 acres/mile)

Forested
(4 acres/mile)

Emergent Wetlands

← Reference

Impaired →



Several States are developing wetland IBIs

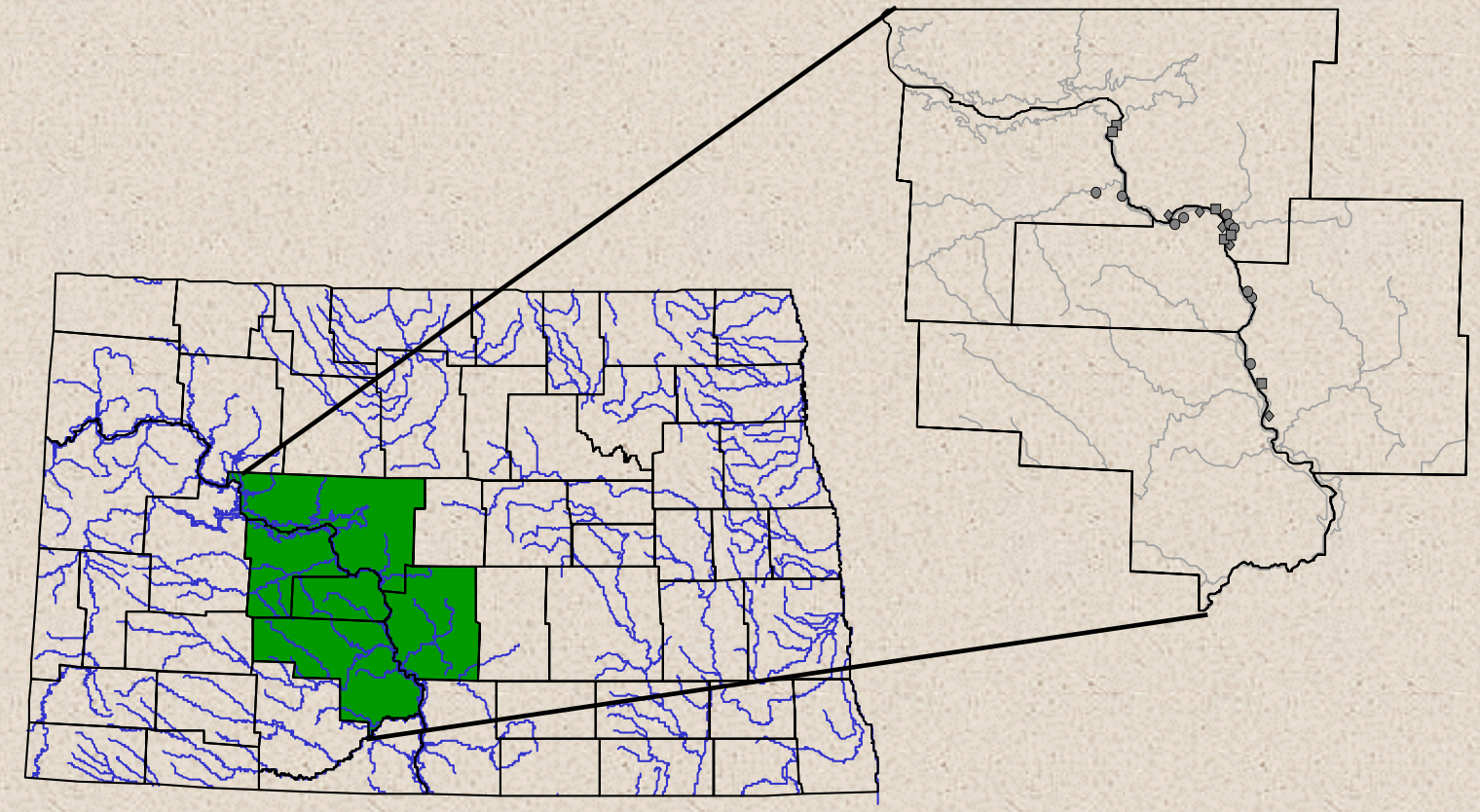
- Minnesota Pollution Control -depressional and riparian wetlands
- Montana Department of Environmental Quality –depressional wetlands
- Wisconsin DNR –Great Lakes coastal wetlands

Research Objectives

Upper Missouri River – US EPA Regional Environmental Assessment and Monitoring Program (REMAP)

1) Develop a multimetric Index of Biotic Integrity for emergent, floodplain wetlands of the upper Missouri River basin
2) Evaluate the biological condition of floodplain wetlands of the upper Missouri River

Study Area



59 Wetlands
(22 PEMA)
(37 PEMC)

Biological Data

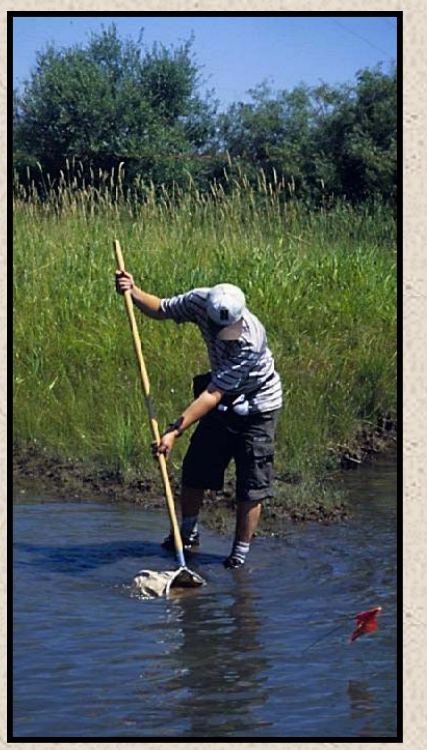
Vascular plants

Periphyton composition

Soft-bodied algae

Macroinvertebrates

Sediment characteristics



Physical Data

Water quality (35 variables)

Size

Elevation

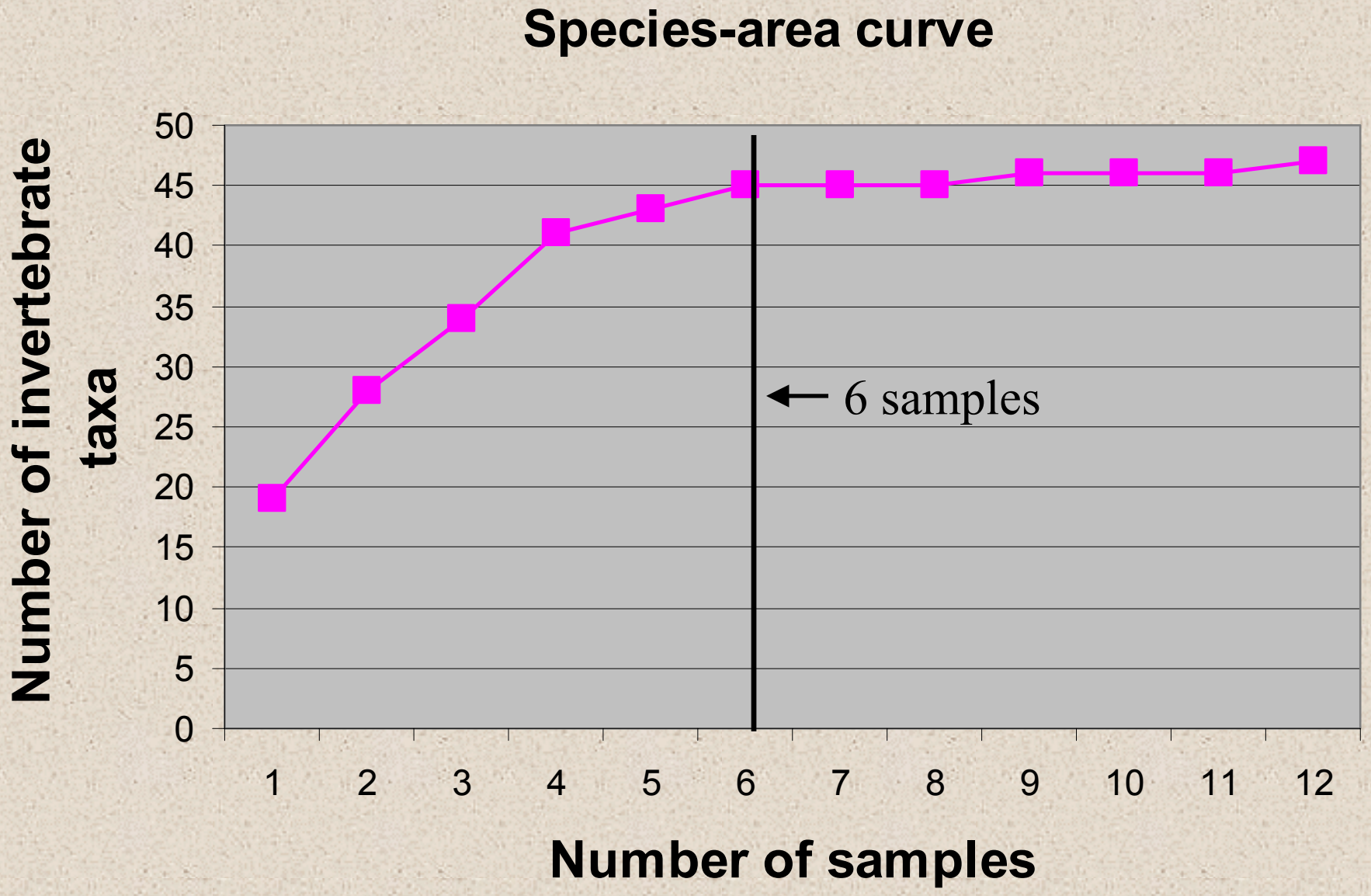
Distance to river's edge

Outline

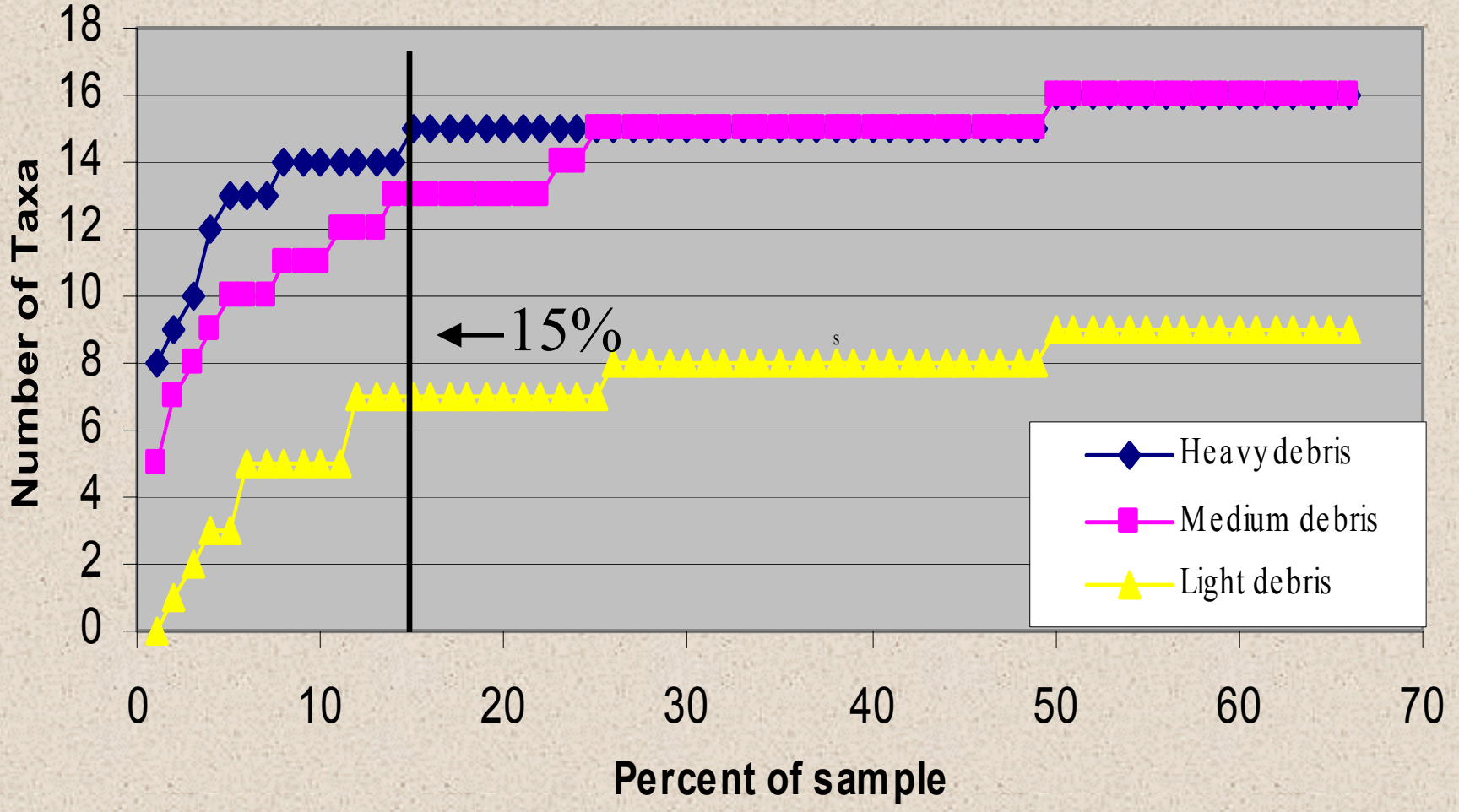
- Sampling methods
  - Species-area curves
  - Sub-sampling
- Metric development
  - Box plots
  - Discriminant Analysis
  - Randomization Test
- IBI Scoring Criteria
  - Temporal variation
  - Spatial variation

Sampling Methods – PEMC Wetlands

- **Reference** (n=6) vs. **Impaired** (n=6)
- **Randomly** selected wetlands (n=16; EMAP Protocol)
- Each wetland divided into 6 quadrants. Ten 1-m sweep samples collected in each quadrant (6 samples/wetland).
- Re-sampled wetlands for intra- (n=11) and inter- (n=5) year variation
- Taxonomy, abundance, and biomass estimates of invertebrates

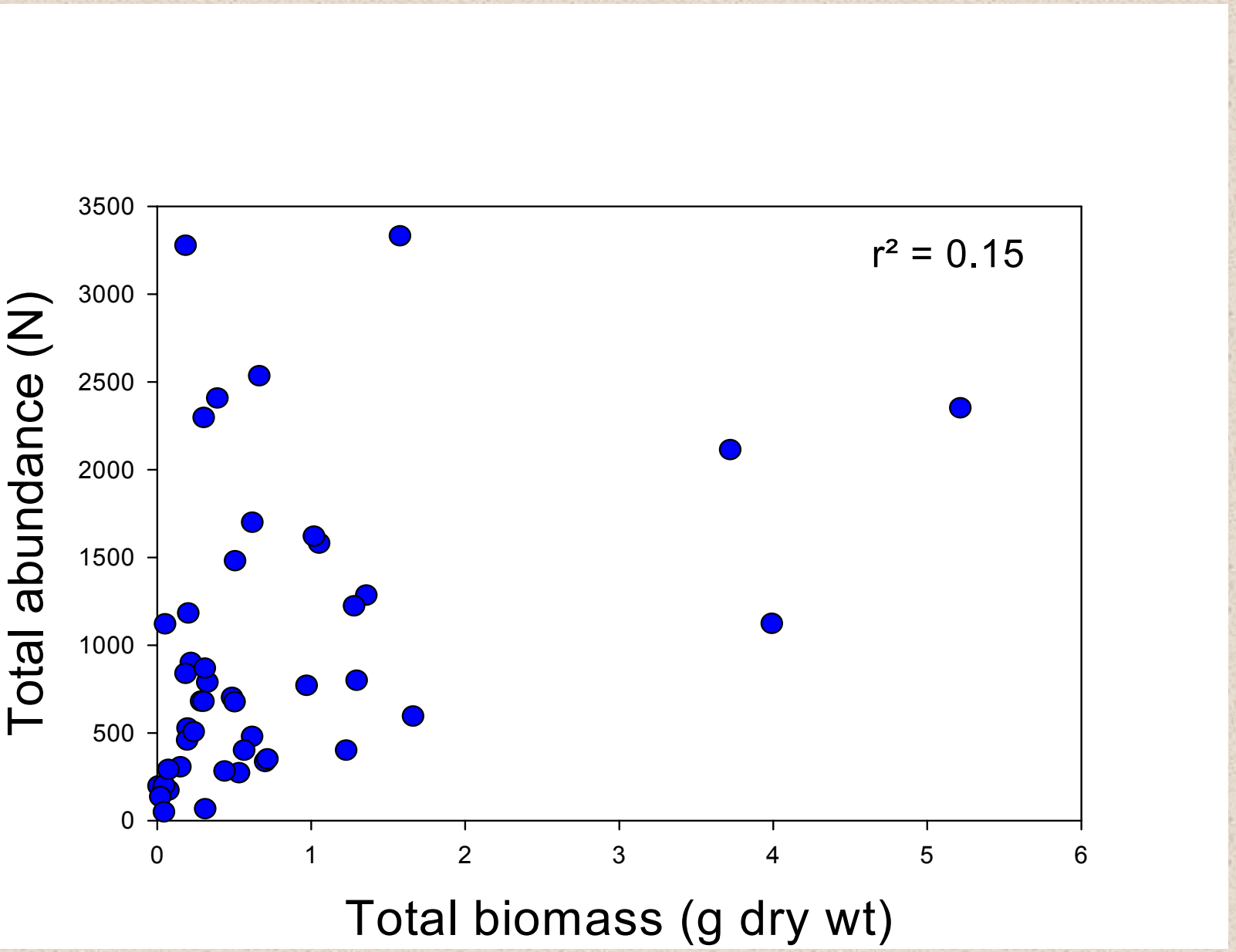

Species-area curve
Number of invertebrate taxa
50
45
40
35
30
25
20
15
10
5
0
6 samples
1
2
3
4
5
6
7
8
9
10
11
12
Number of samples

Invertebrate sub-sampling



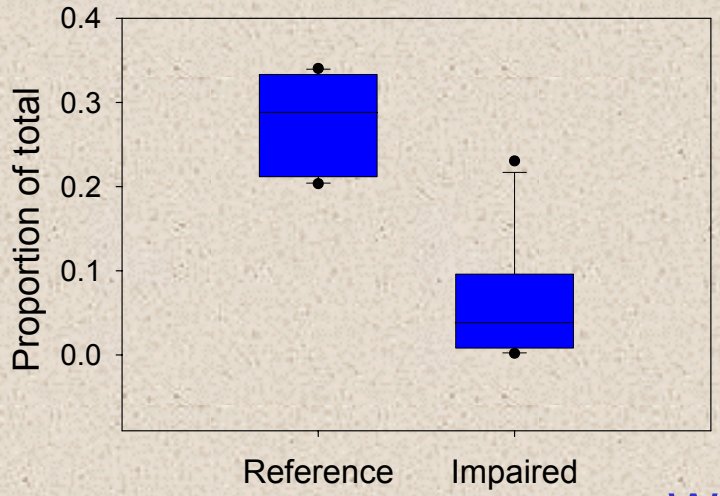
Metric Development

- Tested a total of 83 possible metrics
- Metrics consisted of:
  - Taxa Richness
    - Total taxa, total taxa by Order, Shannon- Wiener Index
  - Proportional abundance
    - By Order, Family, feeding group, habitat guild, voltinism
  - Proportional biomass
    - By Order, Family, feeding group, habitat guild, voltinism


r² = 0.15
Total abundance (N)
Total biomass (g dry wt)
3500
3000
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6

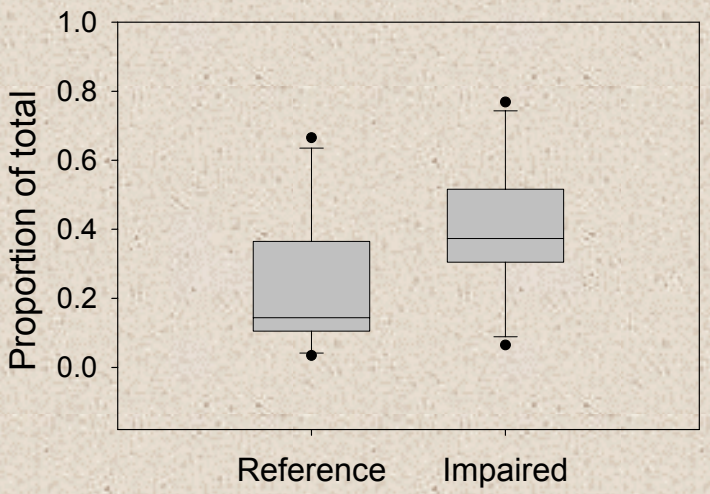
Strong separation

Proportional abundance of Chironomidae



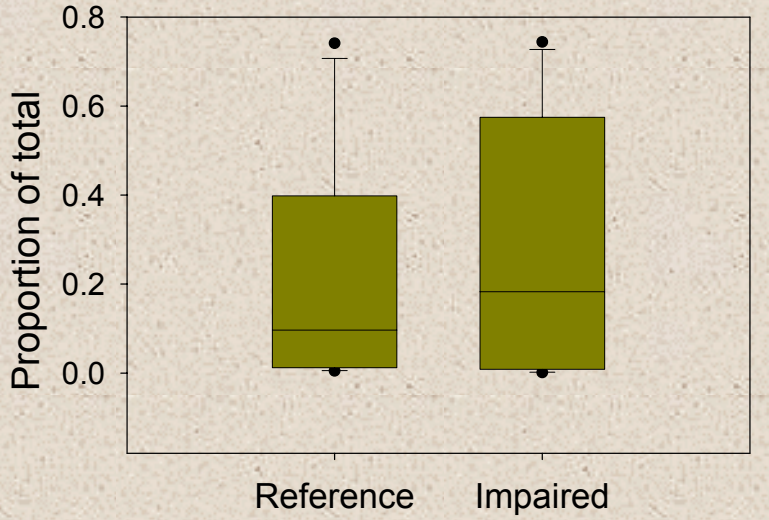
Moderate separation

Proportional biomass of swimmer taxa



Weak separation

Proportional abundance of oligocheates



Least Overlapping Metrics (t-test; P<0.10)

Taxa Richness

1) Ephemeroptera Tricoptera and Odonata (ETO) taxa
2) Odonata taxa

Proportional Abundance

3) Coenagrionidae
4) Chironomidae
5) Culicidae
6) Dytiscidae
7) Lymnaeidae
8) Coleoptera
9) Gastropods
10) Filterers
11) Scrapers
12) Climbers
13) Swimmers

Proportional Biomass

14) Culicidae
15) Dytiscidae
16) Libellulidae
17) Diptera
18) Odonata
19) Filterers
20) Collector gatherers
21) Predators
22) Sprawlers
23) Multivoltine
24) Univoltine
25) Total biomass

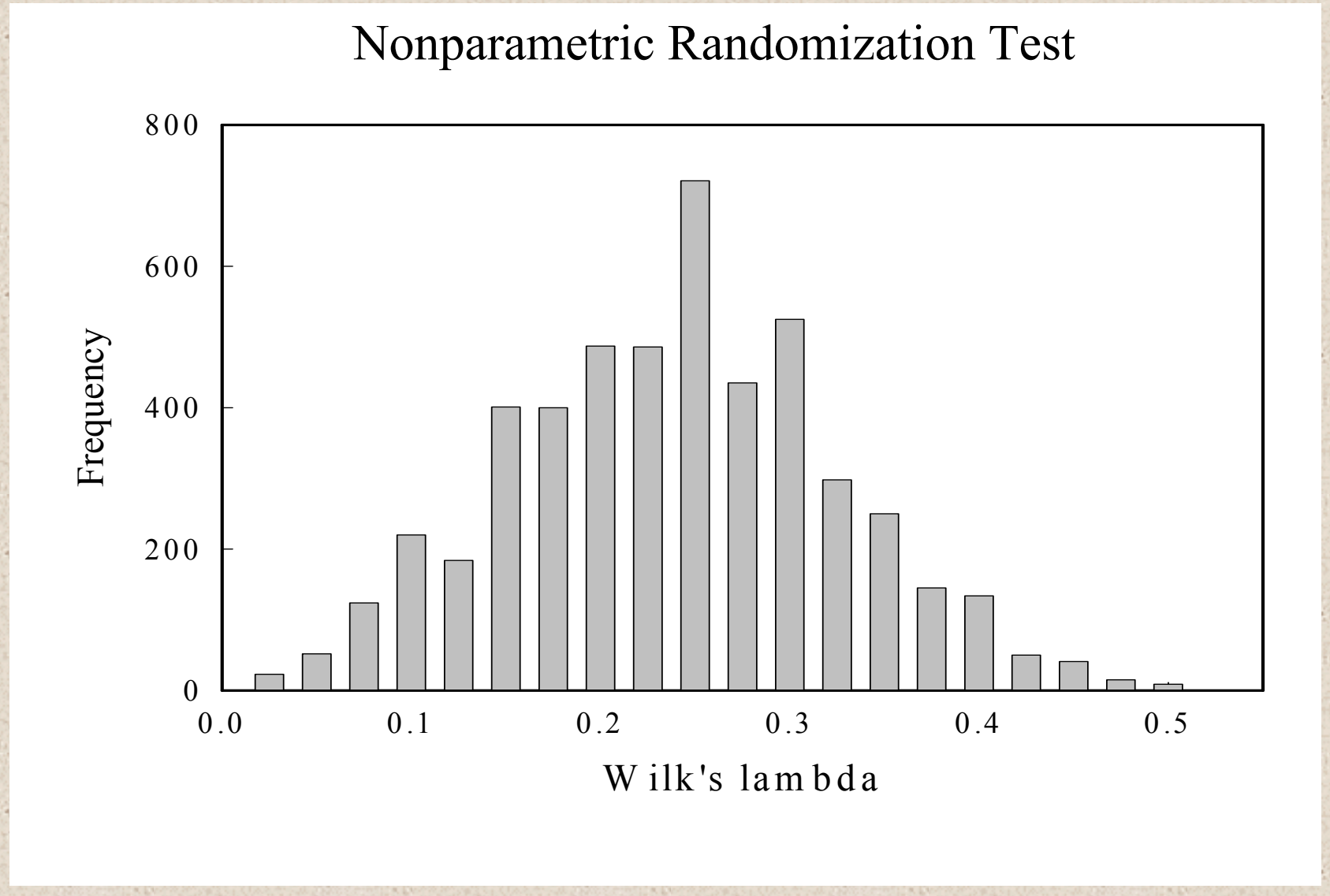
Stepwise Discriminant Function Analysis

- Yields variables (i.e., metrics) that best discriminate reference and impaired sites from our data.
  - Nonparametric Randomization test
  - Apparent vs. Actual Re-classification rate

Randomization Procedure

- Combine metric data from wetland samples
- Randomly sort data into ‘n’ new samples equal in size to the original data
- Calculate a test statistic based on the new samples
- Repeat steps 2 and 3 a large number of times (e.g. 5,000)

From these data, a probability distribution of the randomized test statistic is generated



Observed value: Wilk’s lambda = 0.01

IBI Metrics	Response to impairment
Proportional abundance of Chironomidae	Decrease
Proportional abundance of scraper taxa	Decrease
Proportional biomass of Culicidae	Increase
Proportional biomass of Diptera taxa	Increase
Proportional biomass of filterer taxa	Increase
Proportional biomass of multivoltine taxa	Increase

Related Studies

- Proportional abundance of Chironomidae
  - Gernes and Helgen (1999)
- Proportional abundance of scraper taxa
  - Burton et. al. (1999)
- Proportional biomass of Culicidae, Diptera, filterer taxa and multivoltine taxa
  - Adamus (1996)

IBI Score

- Each metric was scored following the procedure by Minns et. al. (1994).

  Metrics decreasing with impairment were scored (range 1-10):

  (Raw metric/Max value)x 10= Metric Score

  Metrics increasing with impairment were scored (range 1-10):

  10- ((Raw metric/Max value)x 10)= Metric Score

  Overall IBI was computed (range 1-100):

  (Sum of all metrics for a site / N_m) x 10 = Overall IBI

  where **N_m** is the number of metrics

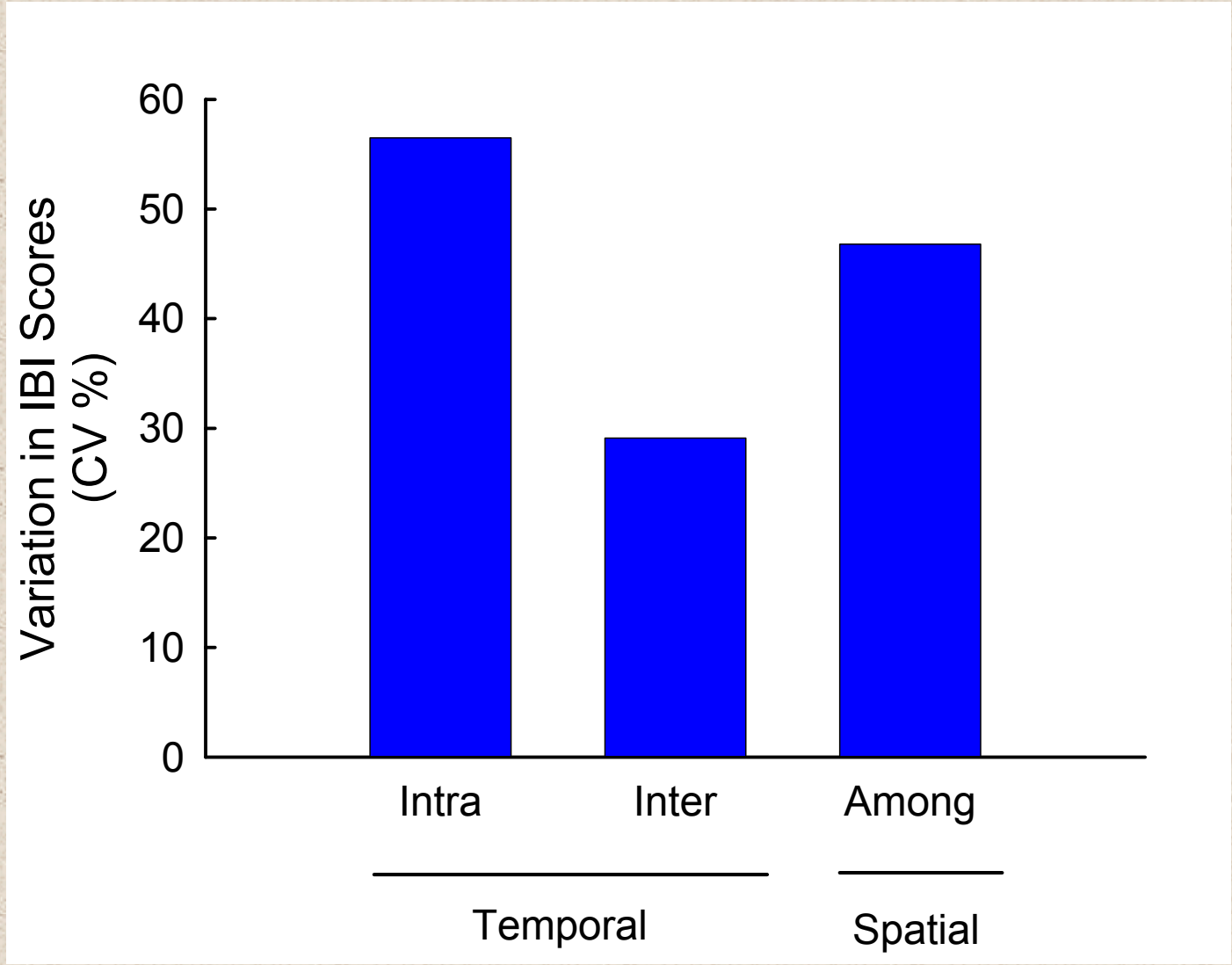
Qualitative IBI Condition Ranges	
Very Poor	>0-20
Poor	>20-40
Fair	>40-60
Good	>60-80
Excellent	>80-100

Site	Score	Condition
IMP1C	40	Poor
IMP2C	42	Fair
IMP3C	37	Poor
IMP4C	32	Poor
IMP5C	27	Poor
IMP6C	37	Poor
REF1C	88	Excellent
REF2C	84	Excellent
REF4C	77	Good
REF5C	70	Good
REF6C	99	Excellent
REF7C	83	Excellent

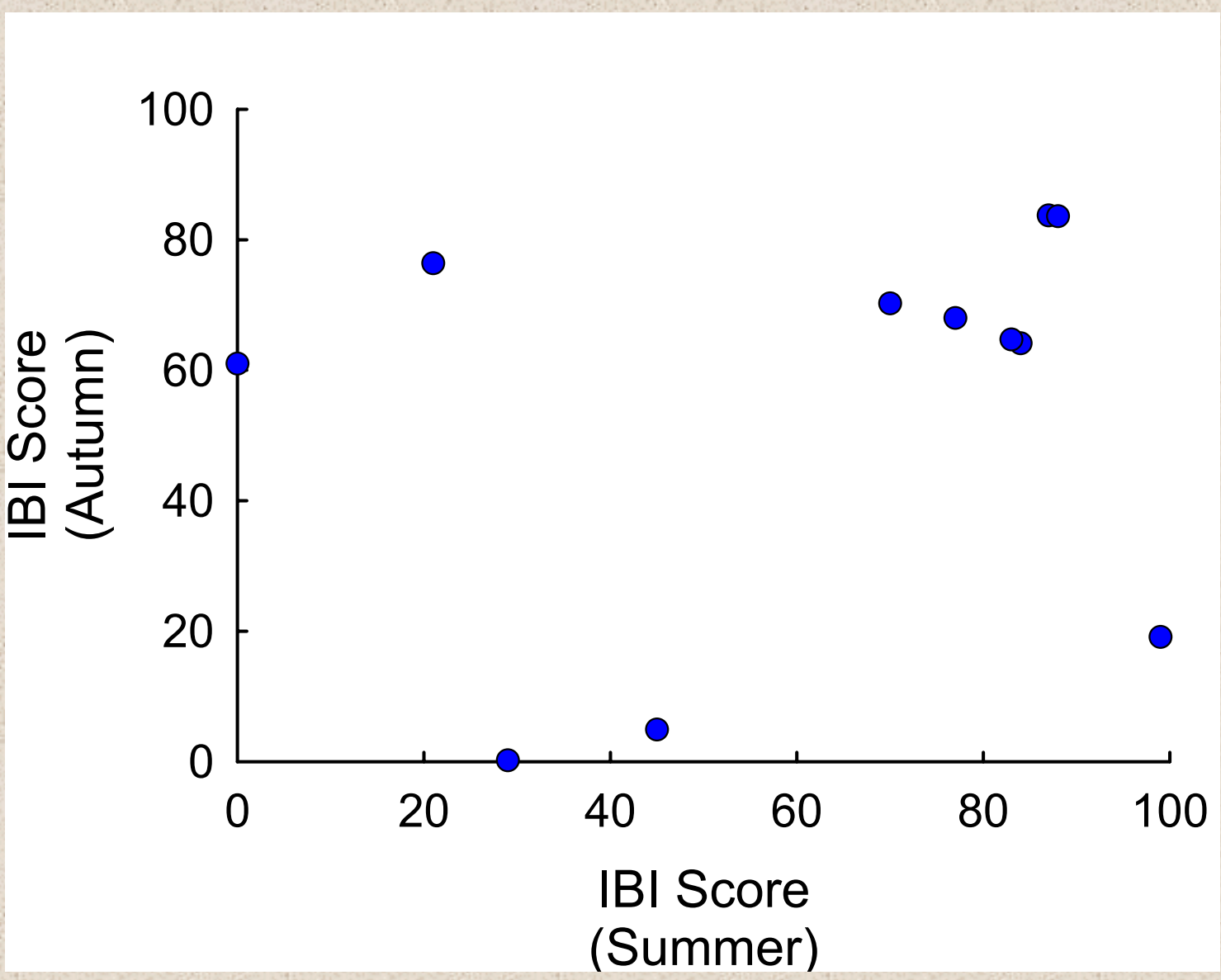
Sensitivity analysis

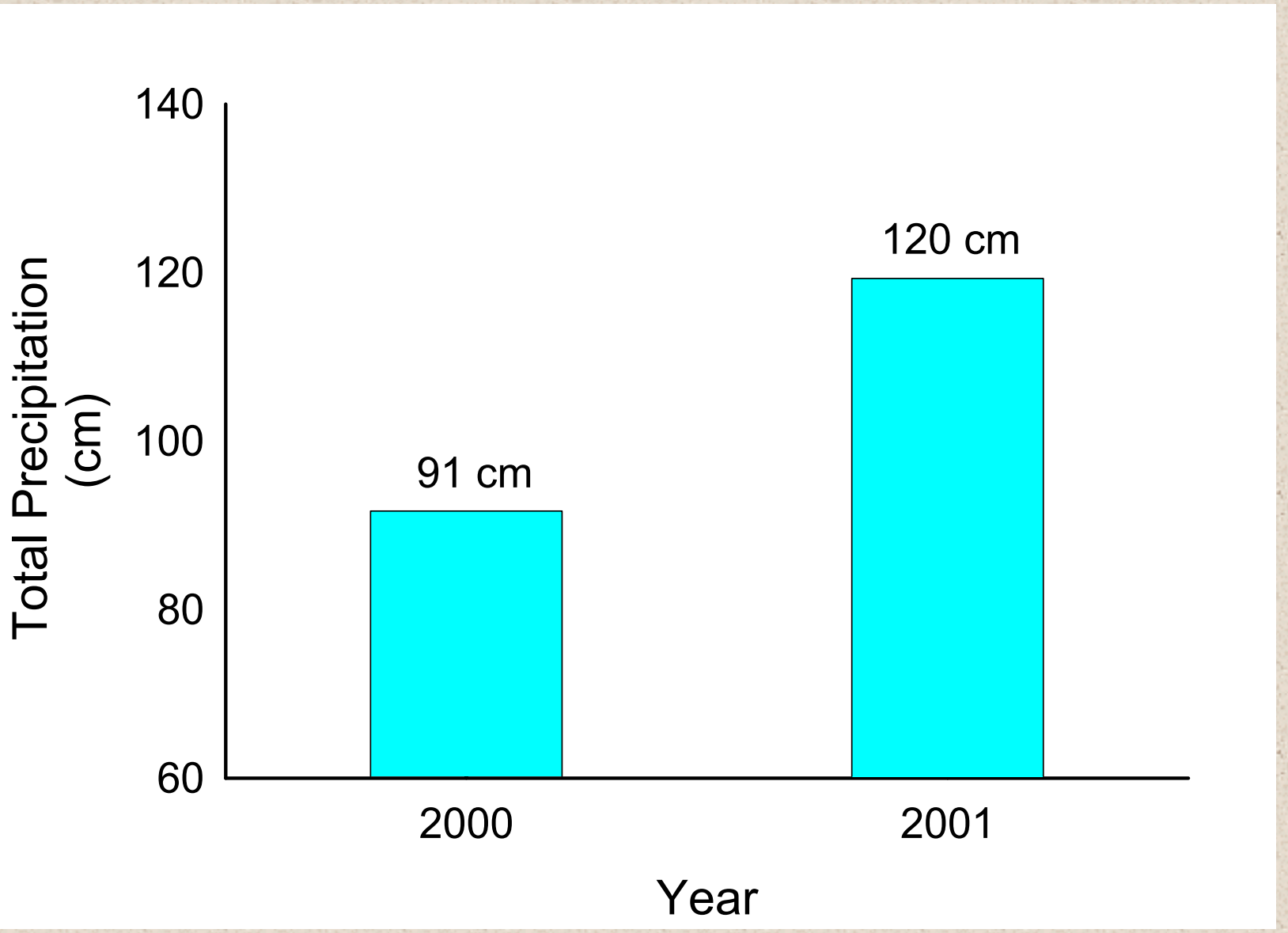
- Sensitivity of a metric is based on computing a reduced IBI and comparing it to the overall IBI (Minns et. al. 1994).
  - **Reduced IBI =10 x (N_m x IBI/10 – Test metric)/(N_m-1)**
    where **N_m** is the number of metrics in overall IBI
- The IBI was found to be most sensitive to:
  - proportional abundance of scraper taxa
  - proportional biomass of filterer taxa

Temporal and Spatial Variation in IBI Scores



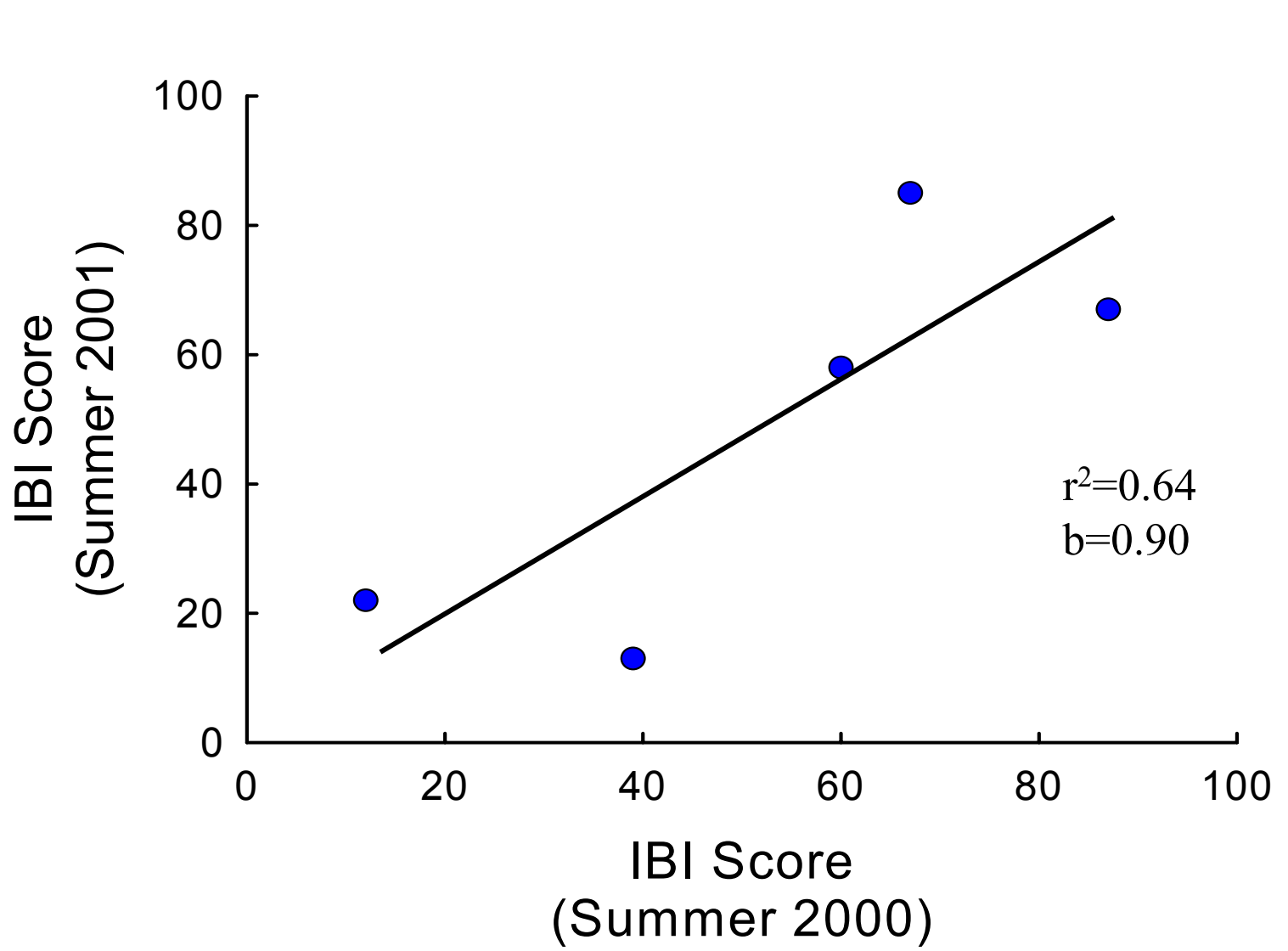
Within-Year Variation



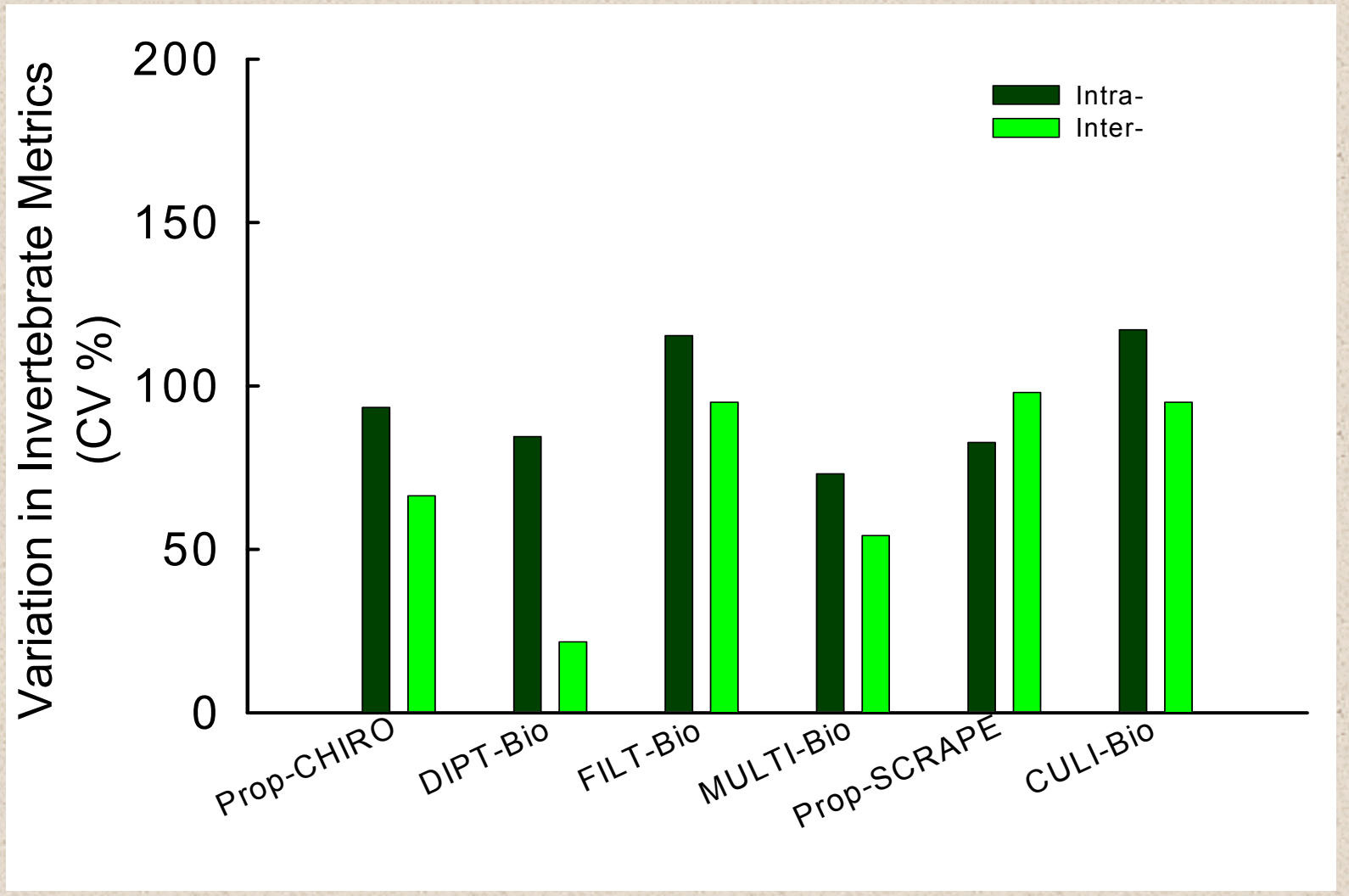


Source: National Climatic Data Center, NOAA

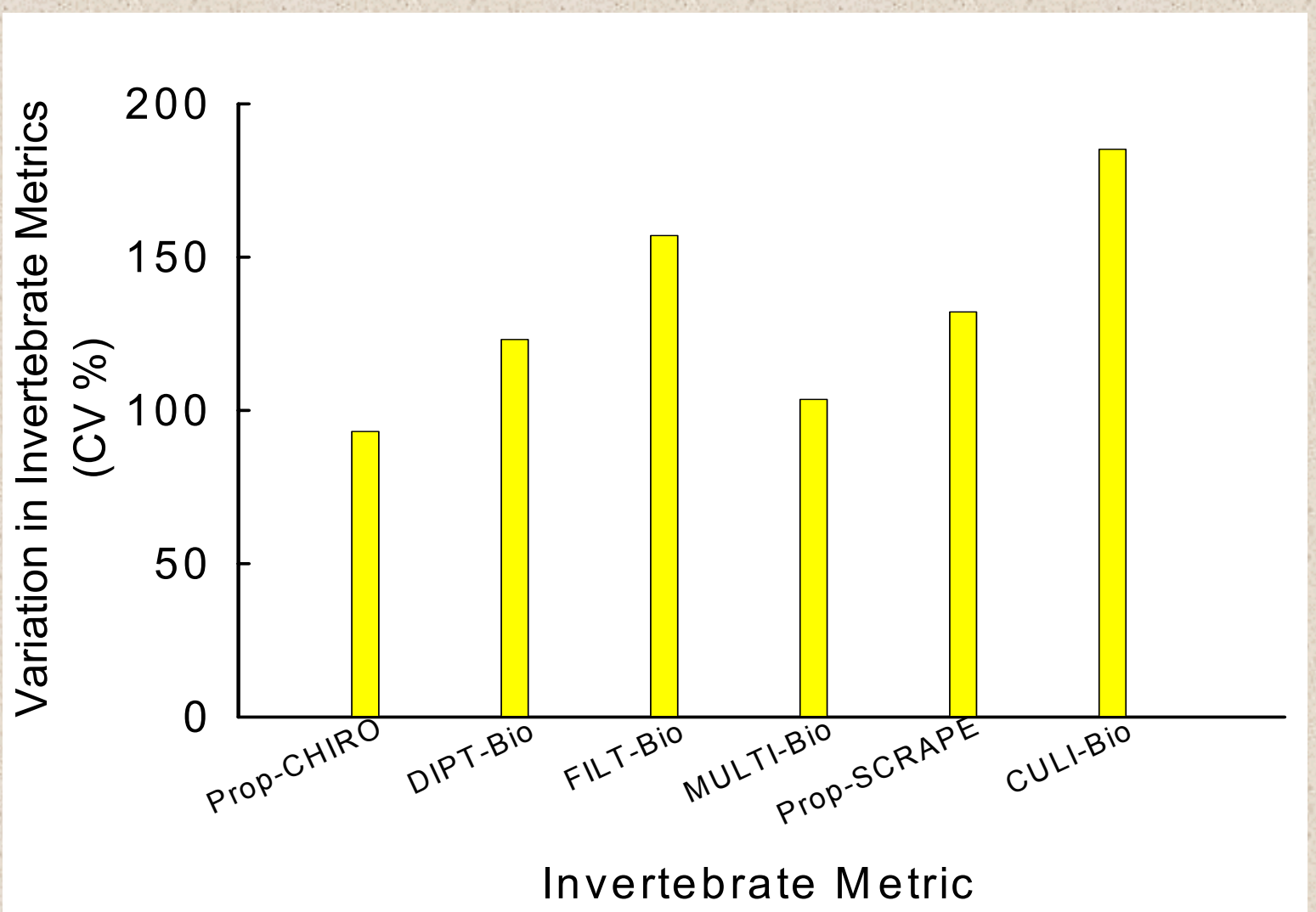
Between-Year Variation



Temporal Variation



Spatial Variation



Synopsis

- Species-area curves were useful for determining minimum sample sizes.

- Nonparametric, discriminant function analysis was a robust method for identifying metrics.

- In general, invertebrate biomass was a better indicator of disturbance than abundance estimates.

- Seasonal variation in invertebrate composition has important implications for usefulness of IBI.

- Invertebrate metrics were robust to natural (i.e., year-to-year) variation.

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"...to protect human health and to safeguard the natural environment..."

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