# Normative Flow Project

## Hydrologic and Biological Indicators of Flow Alteration in Puget Sound Lowland Streams

King County DNRP

May 25, 2005

# Project Team

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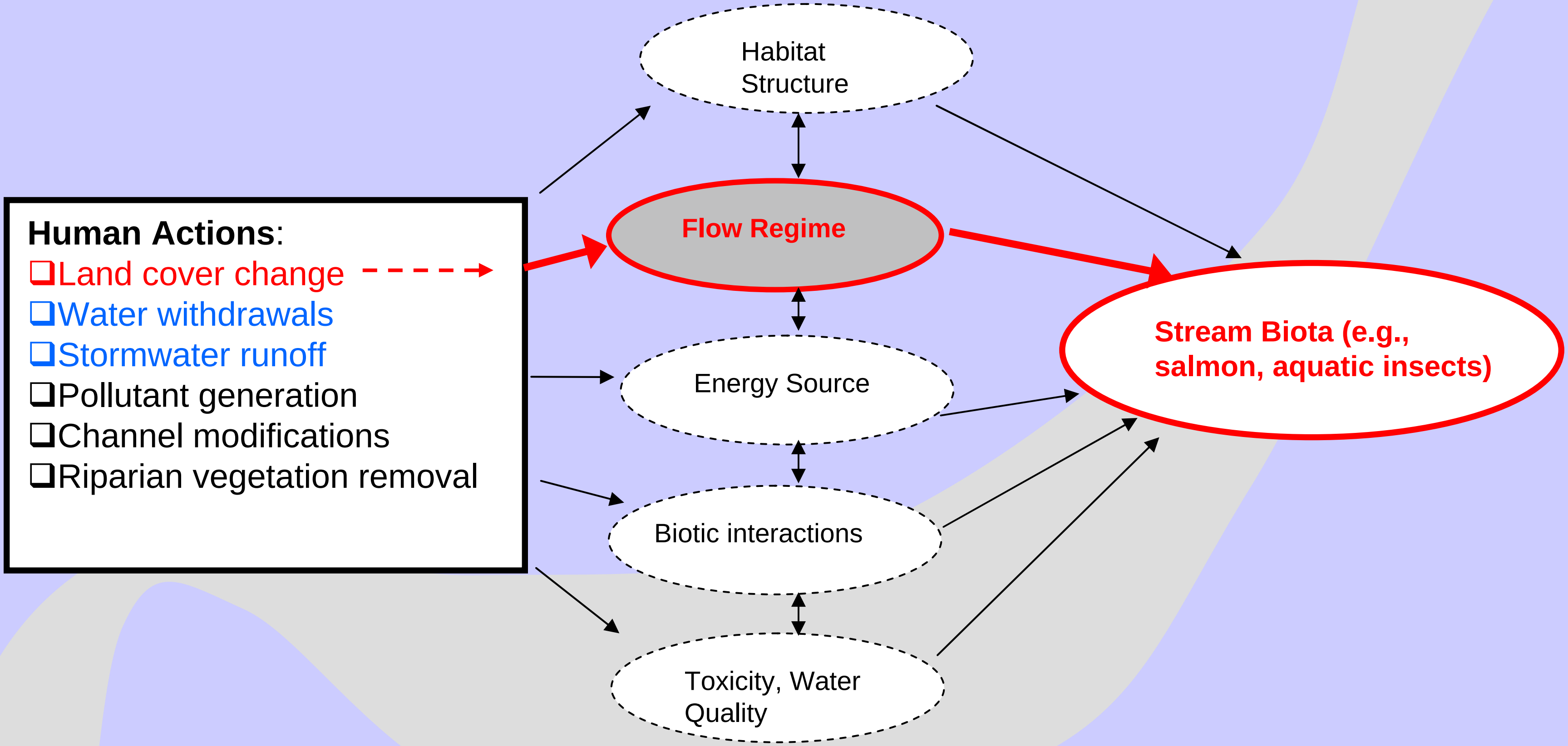
# Outline of Presentation

- **Goals/Rationale for Indicator Approach**
- **Development/Initial Testing of Indicators**
- **Results**
- **Conclusions and Next Steps**

# Goal of Streams  Analysis




Adapted from Karr and Yoder 2004

# Approach and Steps….

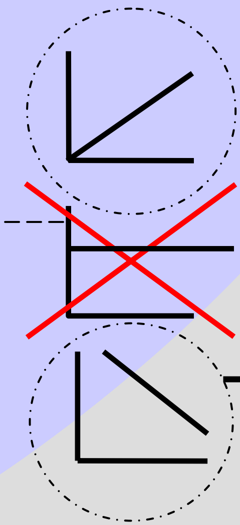
- ❑Conceptual Framework
- ❑Literature Review
- ❑Science Review Team (SRT)

**Potential Indicators & Metrics of Flow Alteration**

- ❑Anthropogenic
- ❑Hydrologic
- ❑Biological

**Test Sub-set of Metrics using Existing Data**

- ❑ HSPF & gage flow data
- ❑ B-IBI benthic macroinvertebrate data



**Potential Metrics – with Relationships:**

- ❑Validation
- ❑Protocols
- ❑Guidance

**Poor Metrics – weak or no relationships**

***Not considered further***

**Sub-set without data for testing**

***Not considered further***

# Predictions about flow-biology relationships

1. biotic integrity ➔ negatively correlated with flow alteration;

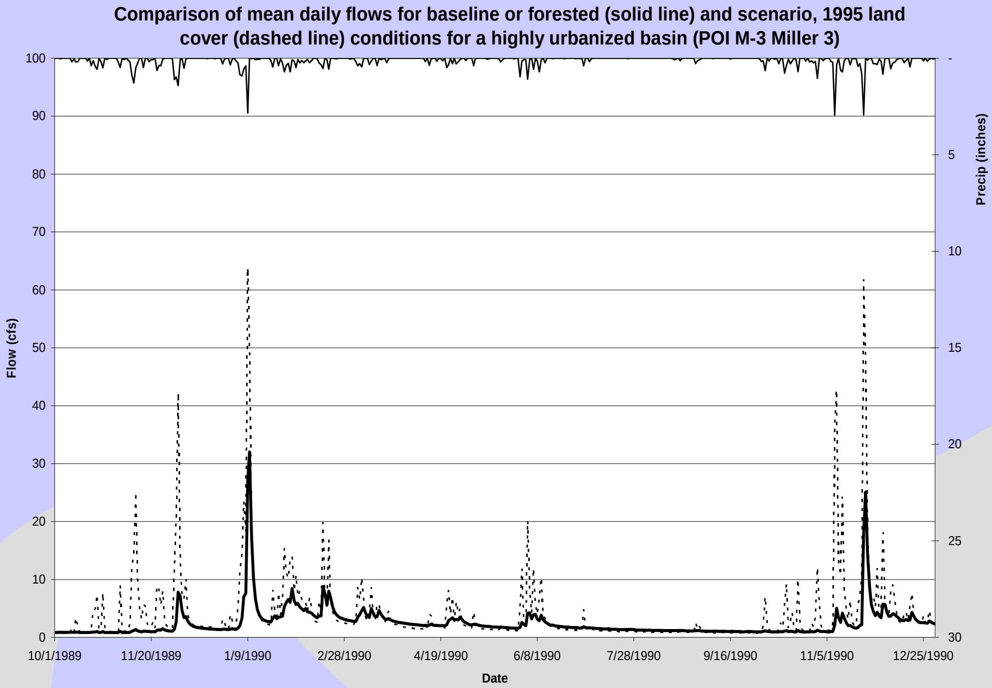
2. taxa with traits suggesting <u>tolerance of</u>, or <u>rapid recovery from</u> flow disturbance ➔ positively correlated with flow alteration;

3. traits suggesting <u>sensitivity to</u>, or <u>slow recovery from</u> flow disturbance ➔ negatively correlated with flow alteration

# Methods

- Define metrics (flow and biology)
- Criteria for selecting metrics to test
- Identification, compilation, QC of data sets
- Exploratory analyses – detecting patterns….

# Hydrologic metrics – capture biologically relevant changes in flow regime




- Magnitude
- Frequency
- Duration
- Timing
- Rates of Change

# Hydrological Metrics Tested

- **High Flows (>200% MAF)**
  - Number high pulses (F)
  - Days between high pulses (D)
  - Days within high pulse period (D)
  - Date onset of fall flows (T)
- **Low Flows (50% MAF)**
  - Number pulse events during low flows (F)
  - Days between pulses during low flows (D)
  - Days within the low pulse period (D)

# Hydrological Metrics cont.

- Other
  - T-Q Mean (flashiness)
  - Stream Power
  - Q2:Q10
  - % time above 2-yr flow rate (baseline – forested) (D)

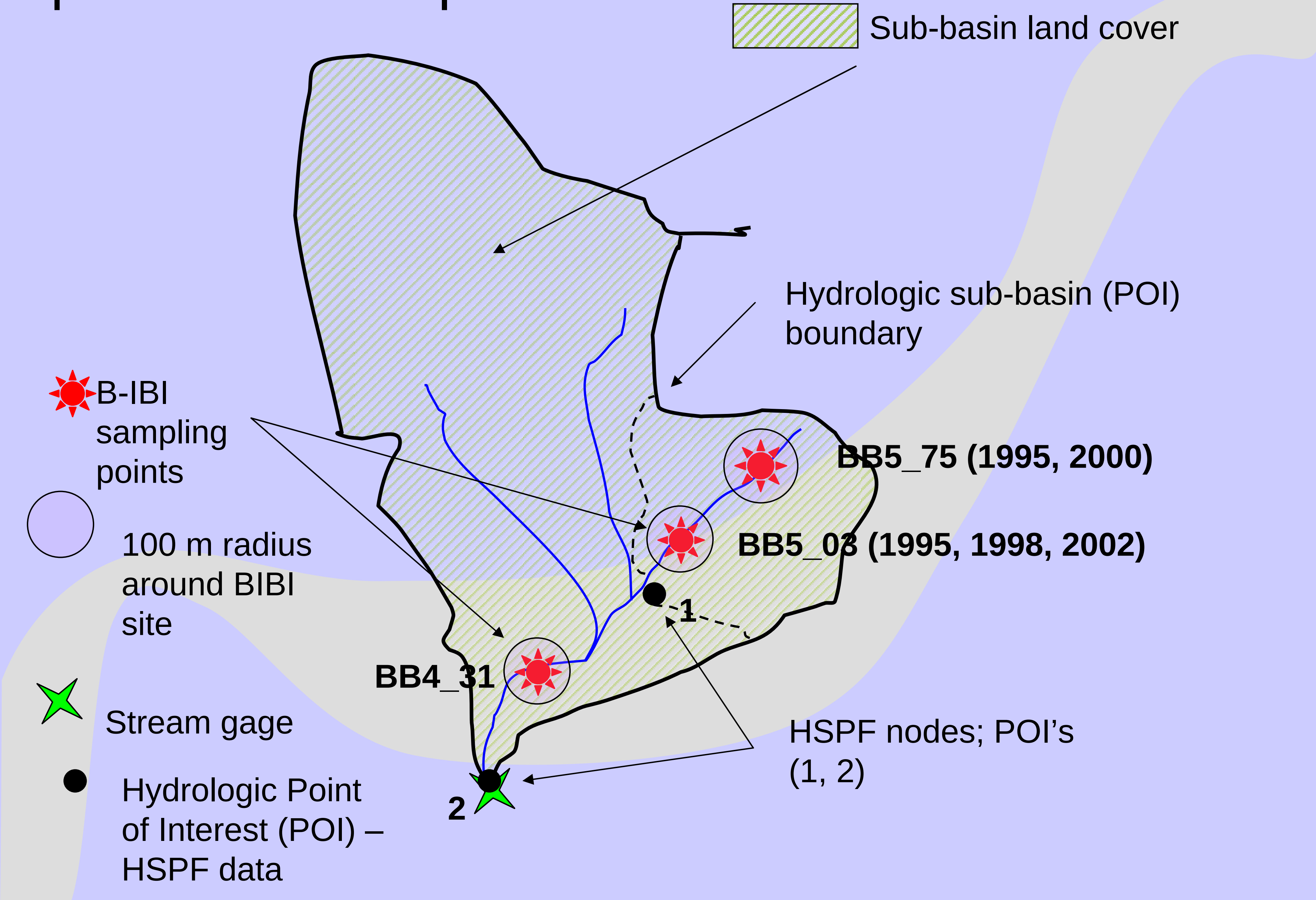
# Benthic Macroinvertebrate Metrics

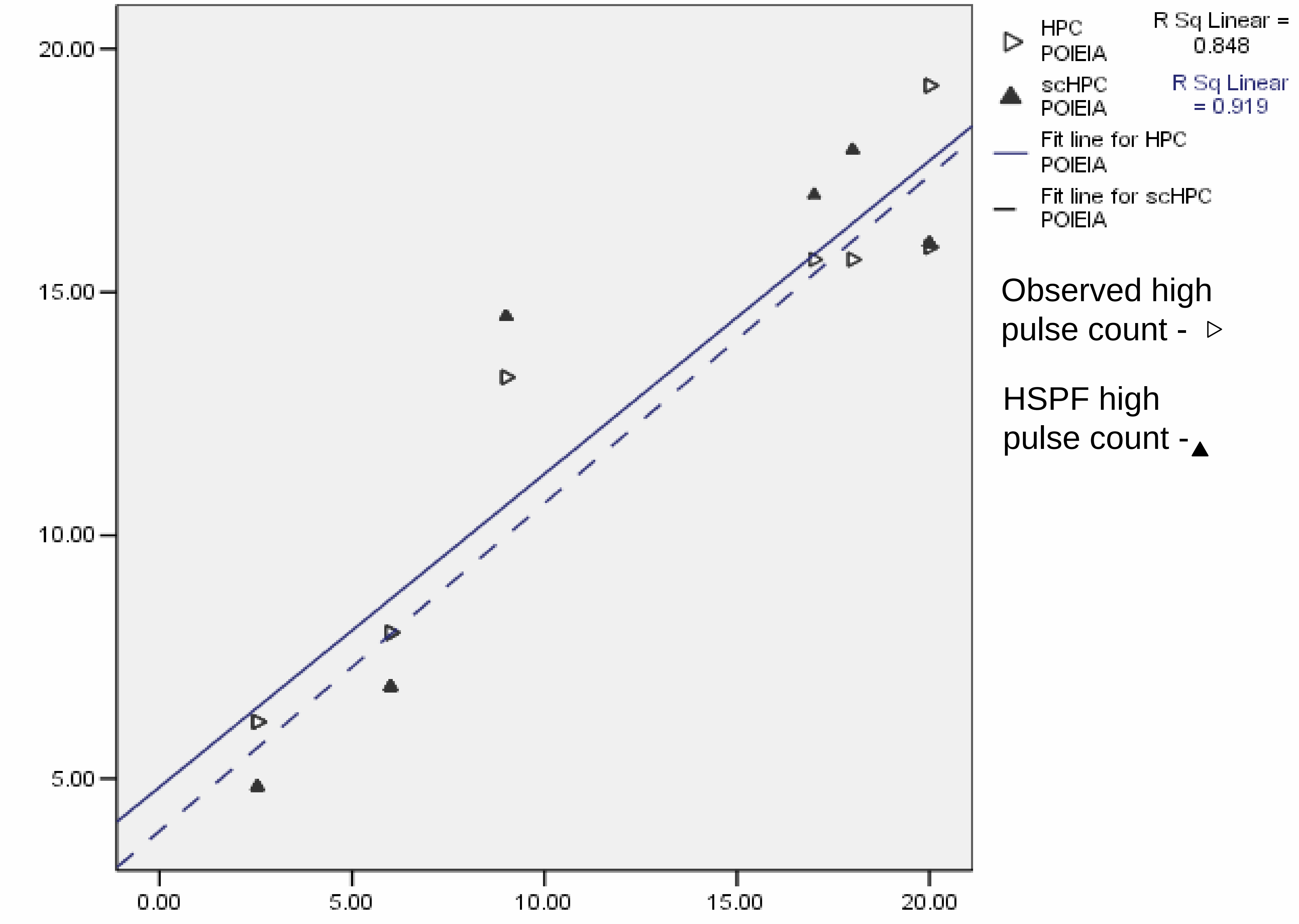
- % Chironomids
- **% Baetidae**
- Plecoptera Taxa
- Trichoptera Taxa
- Ephemeroptera Taxa
- Clinger Taxa
- Total Taxa
- % Predators
- Tolerant Taxa
- % Intolerant
- % Dominant Three
- **BIBI Score**

# Data Sets –

- HSPF and observed stream flow data
  - Gages – 1989-2002 period of record
  - Models – 1950 – 2002 period of record
- Sub-basin land cover & local (B-IBI site) land cover
  - Sub-basin – 1995 land cover values
  - Local – 1995, 1998, 2000, 2001
- Benthic macroinvertebrate data
  - Individual sites and years (1994-2002; 110 HSPF sites/yr; 43 gage sites/yr)

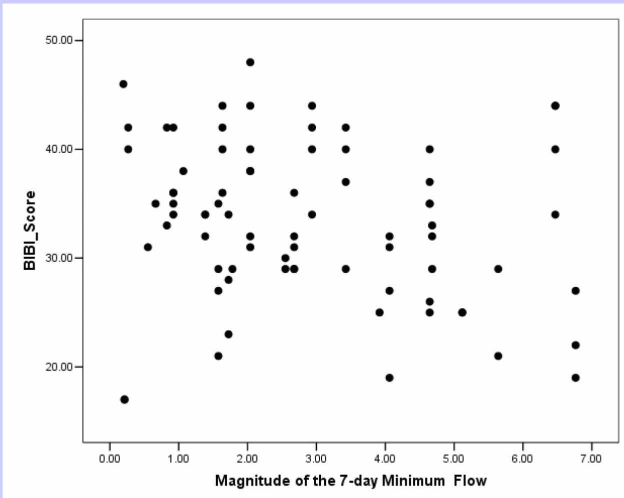
# Spatial and Temporal Scales



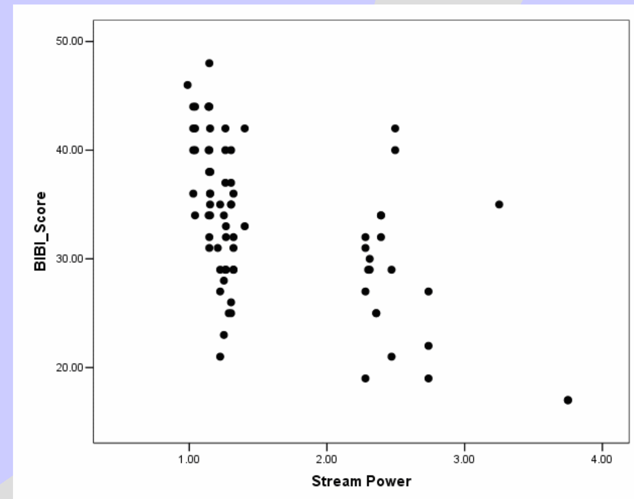

20.00
15.00
10.00
5.00
0.00
5.00
10.00
15.00
20.00
HPC POIEIA
scHPC POIEIA
Fit line for HPC POIEIA
Fit line for scHPC POIEIA
R Sq Linear = 0.848
R Sq Linear = 0.919
Observed high pulse count -
HSPF high pulse count -

# B-IBI Score vs. hydrologic metrics – using **HSPF** flow data…..

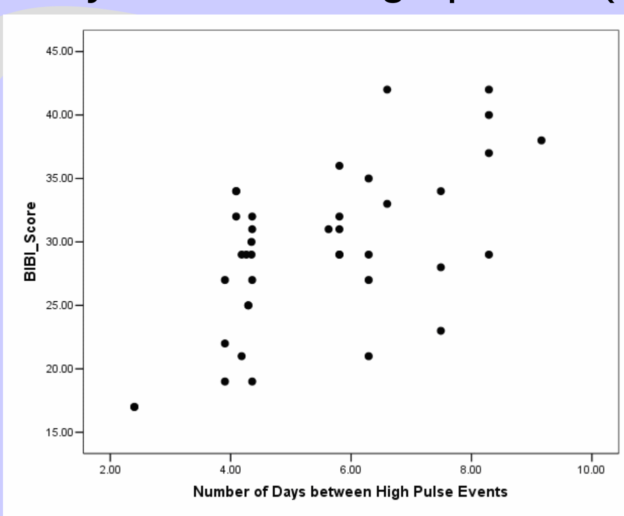
7-day minimum flow (r =-.017)



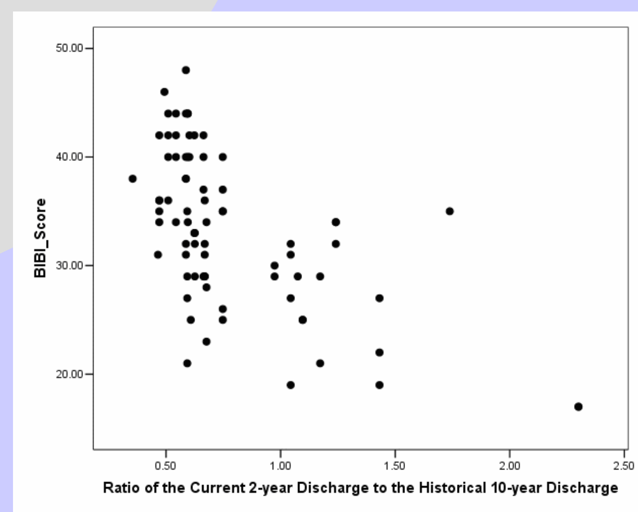

Stream power (r = -.560)




Days between high pulses (r = .483)




Q2:Q10 (r = -.609)

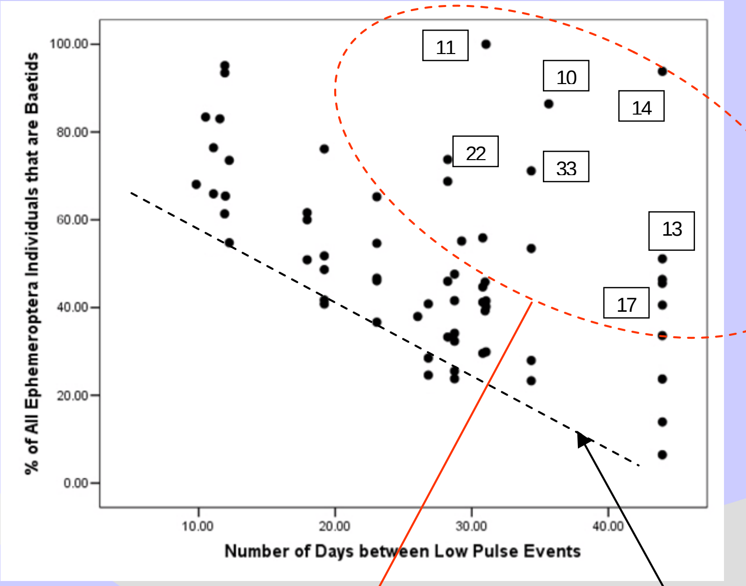


## Measures of general biological condition vs. flow metrics….

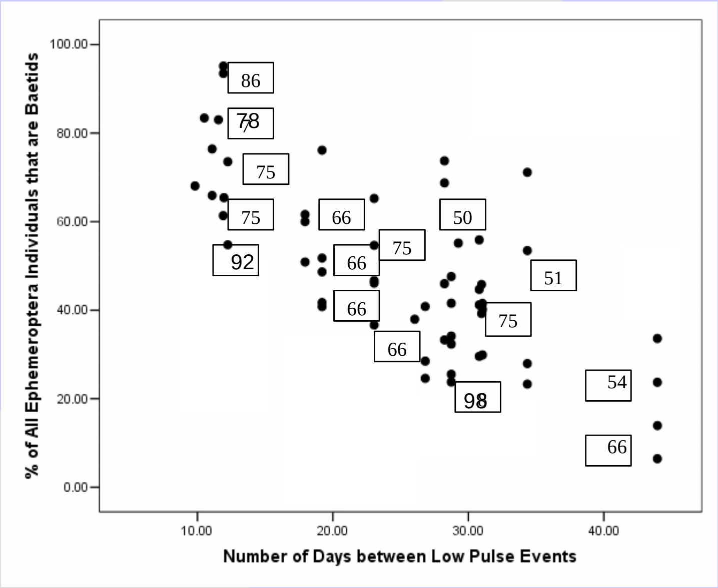
- B-IBI score correlated with several hydrologic metrics
- Observed and simulated flow data result in similar patterns with B-IBI score
- Strongest correlations with B-IBI score:
  - **Stream power**
  - **Q2:Q10**
  - **% time above 2-yr forested baseline**
  - **TQ Mean**
  - **Onset of fall flows**
  - **High and low pulse metrics**
  - **Rise count**

# Do local land cover <u>and</u> flow metrics explain patterns?

% Baetids vs. days between low pulses – all sites




% Baetids vs. days between low pulses – sites with >50% local forest cover are labeled with % forest cover; sites with <25% forest cover excluded




Longer period between low pulses & high proportion of Baetids

Lower limit to cloud of points set by hydrology? Proportion of non-Baetids limited by time between low pulses?

# Baetids:

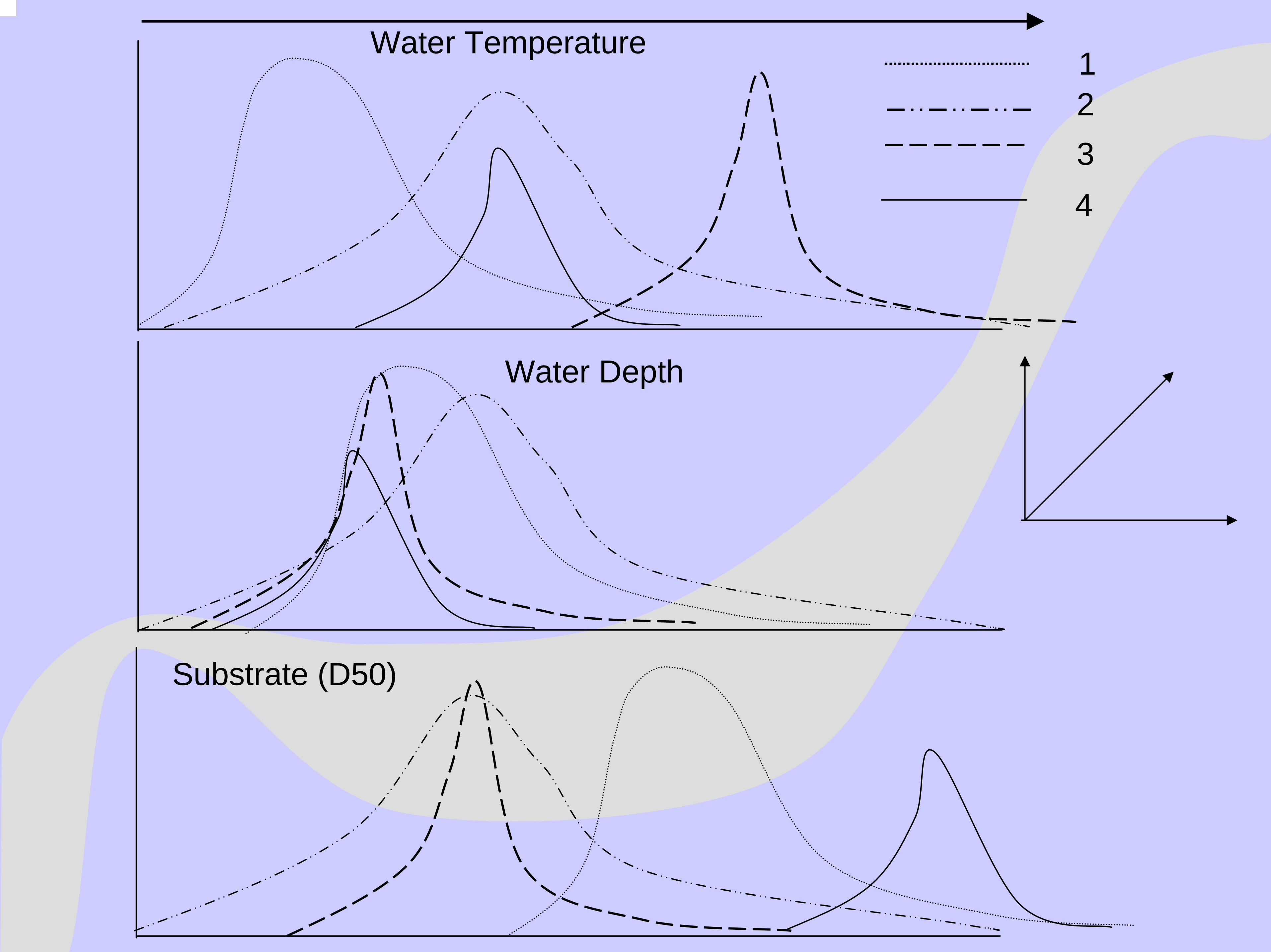
- **% Baetids – positive correlation with:**
  - Stream power
- **% Baetids – negative correlation with:**
  - Days between low pulses

If <u>increased</u> stream power & more frequent low pulses constitute <u>disturbance</u>, then

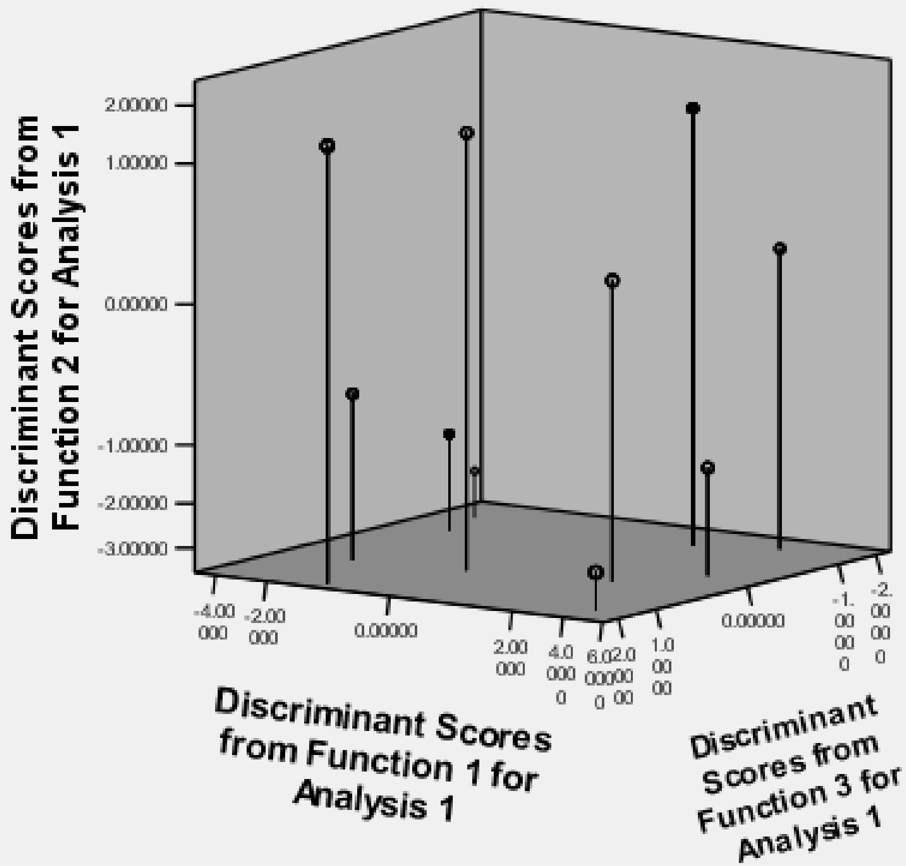
Baetids are more dominant with increased <u>flow</u> disturbance

# Discriminant Function Analysis

- Analogous to multiple regression with categorical dependent variable
- Categorize sites into four groups by B-IBI score (4 = ‘best’; 1 = ‘very poor’)
- Do combinations of flow metrics discriminate among B-IBI ‘groups’?



Water Temperature
1
2
3
4
Water Depth
Substrate (D50)

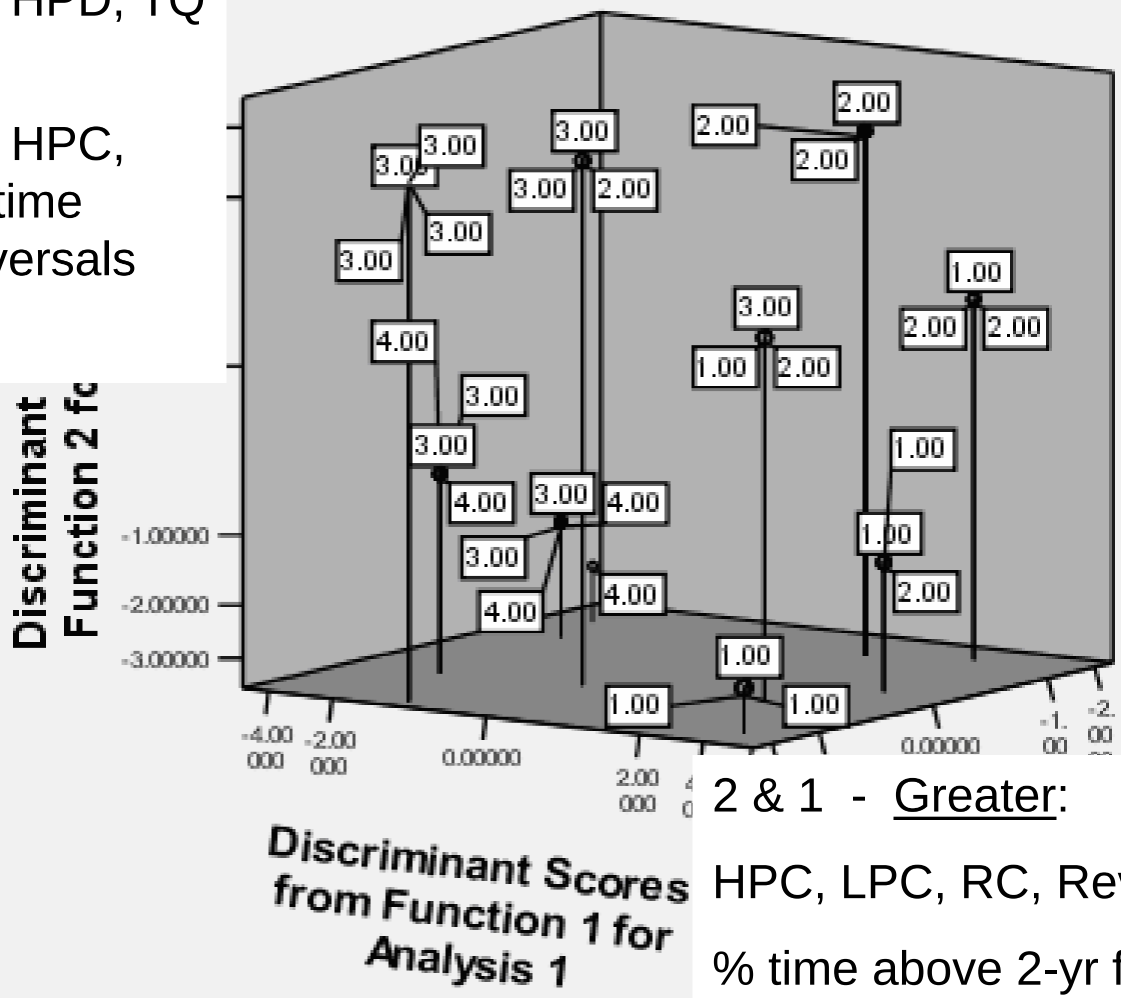


Discriminant Scores from Function 2 for Analysis 1
2.00000
1.00000
0.00000
-1.00000
-2.00000
-3.00000
Discriminant Scores from Function 1 for Analysis 1
-4.00000
-2.00000
0.00000
2.00000
4.00000
6.00000
Discriminant Scores from Function 3 for Analysis 1
2.0000
1.0000
0.00000
-1.0000
-2.0000

3 & 4 –

Greater: LPD, HPD, TQ Mean

Smaller: LPC, HPC, HPR, LPR, % time above 2-yr, reversals




2 & 1 - Greater:

HPC, LPC, RC, Reversals,

% time above 2-yr forested baseline, HPR, LPR

Smaller: HPD, LPD, TQ Mean, % local forest cover

# Three Predictions

- BIBI score **negatively** correlated with measures of flow alteration
- Clingers/Baetids **positively** correlated with some measures of flow ‘disturbance’
- Taxa sensitive to or slow to recover (?) from disturbance **negatively** correlated with flow alteration

# Conclusions

1. Both observed and simulated flow data are useful
2. General condition (B-IBI score) and individual metrics are correlated with hydrology
3. Individual metrics are potential ‘flow-diagnostic’ metrics
4. ‘Best’ and ‘worst’ sites biologically are characterized by differences in flow metric values
5. Combinations of hydrologic metrics separate sites grouped by biological similarity (B-IBI score groups)
6. Combinations of hydrologic metrics, with local forest cover, explain much of the variation among these biological groups
7. Local forest cover explains small amount of variation relative to flow metrics
8. Correlations are strongest for metrics of flow ‘disturbance regime’

# Next Steps

- Develop management guidance
- Identify steps in development of streams flow assessment method based on indicators
- Validate these results with separate data set?
- Explore trends over time in matched bio-hydro data sets (possible post 2005?; 1994-2005 period)?

# Science Review Team Feedback on Streams Analysis

- Patterns clear enough to warrant further exploration & development
- Useful lessons learned about pitfalls and potential for elucidating flow-biology relationships
- Further evaluation/documentation of when use of HSPF data are appropriate
- Work should be widely disseminated – KC experience can benefit and inform others

# Schedule to complete streams report

- Final SRT review comments – end of May
- Selected additional analyses to respond to SRT comments – first week June
- Revise text to incorporate/respond to SRT comments – mid June
- Internal KC review draft (final review) – mid to late June
- Revisions/production – early to mid-July