# Response patterns of macroinvertebrate indicators to landscape and hydrologic alteration across multiple spatial scales in the Western U.S.

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# Acknowledgements: Team members and funding

a) Jason May (CA), Anne Brasher (UT), Larry Brown (CA), Chris Konrad (WA), Terry Maret (ID), Bob Black (WA), Ian Waite (OR), Terry Short (CA), Anne-Marie Matherne (NM), Tim Rowe (NV), Donna Knifong (CA), Bob Ourso (AK), Kurt Carpenter (OR).

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# Overview of Presentation

1. Project components
2. Data sources and analysis tools
3. Brief synopsis on landscape alteration and hydrologic modification as it relates to this project
4. Overview of scale related assessments
5. Summary of results by component
6. Conclusions and future work
7. How are these findings relevance to the bioassessment community and managers

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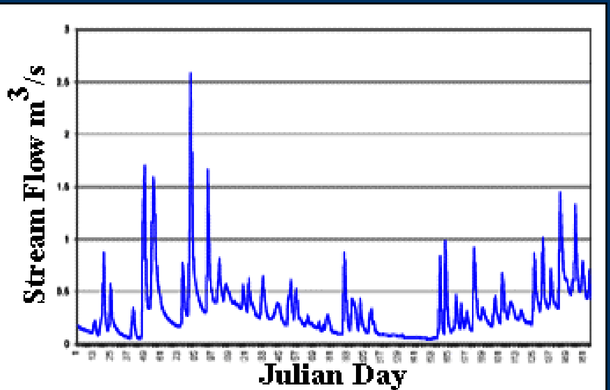
# Project components:

(1) Assess relations between stream flow parameters and MBI metrics across western U.S. (n = 115)

-Flow parameters encompass high, low and central tendency flows

-Characterize magnitude, duration, frequency, timing and variation in flow regime

*Konrad, Brasher, and May -submitting to Freshwater Biology*

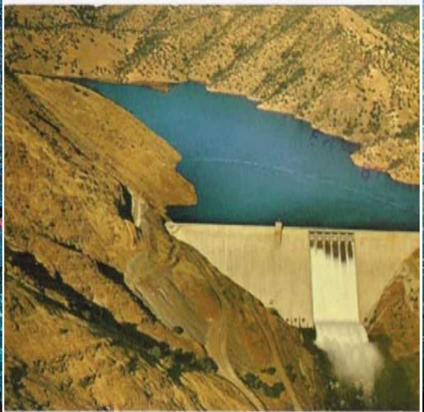




# Project components- continued

## (2) Analysis of MBI relations to catchment-based measures of landscape alteration and hydrologic infrastructure across multiple spatial scales (n =332)

**May, Brown, Short, Konrad, Maret and Brasher sending to Landscape Ecology*


# Component 2 continued..

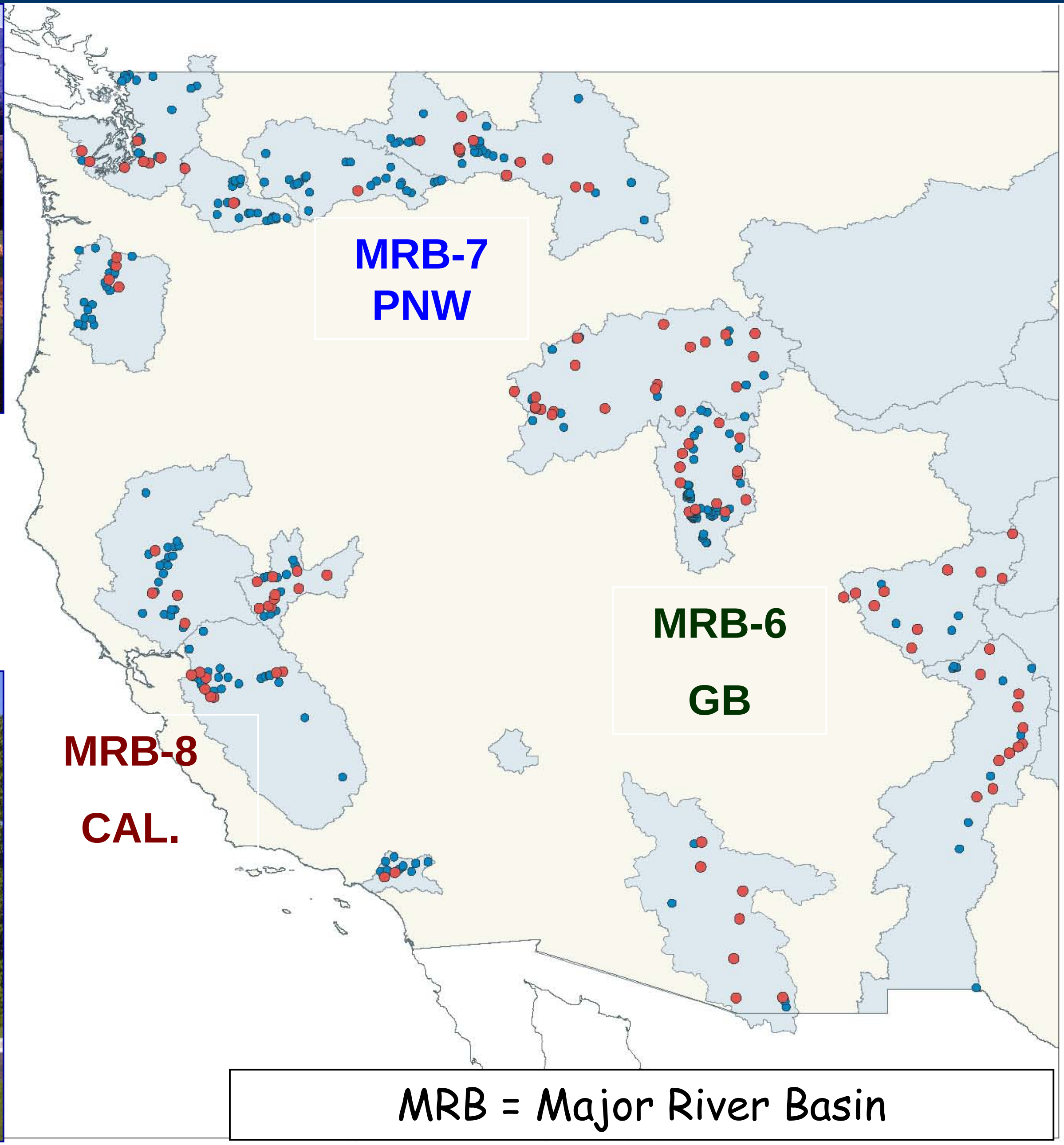
- Analysis consists of 5 MBI metrics vs.
  - Two measures of percent developed land (AG +URB land use) on basin and segment scale
- Two measures of hydrologic infrastructure
  - # dams and km manmade channels in the watershed
- Over three spatial scales
  - West-Wide
  - Biome (MTN =<u>WET</u>/XER =<u>DRY</u>)
  - Biome-regions (MTN1-4 and XER1-4)

# IR 6 Sampling locations

Explanation

- All IR6 sites
- IR6 site with Robust Hydrology*

*(5 or more years of record)

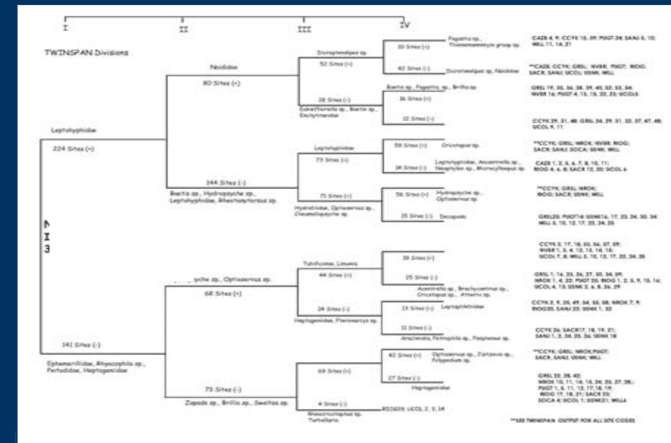


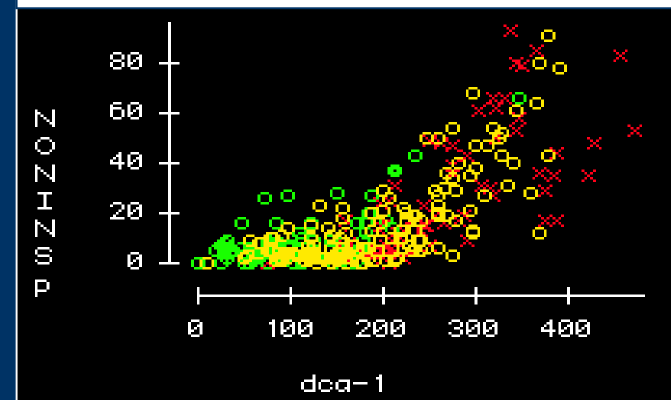
# Data sources and analysis tools

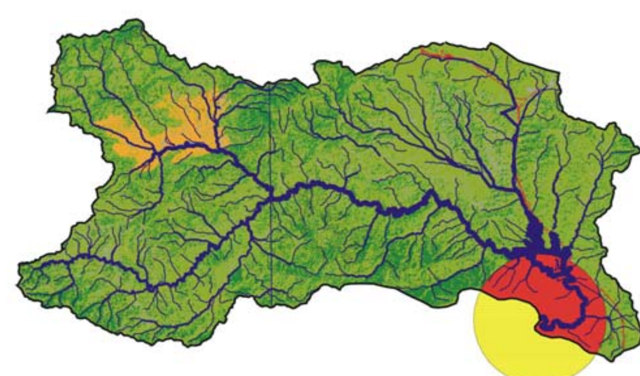
- Invertebrate RTH data collected during 1993-2002 by the NAWQA program only use one year rep.

- Habitat by NAWQA protocols

- Flow information: USGS NWIS
- Landscape variables:
  - Landuse/Land cover-NLCDe
  - Hydrologic Infrastructure: NHD, NID
- Preliminary analyses:
  - Univariate and multivariate statistics
  - BIOTDB/IDAS-Metrics and taxa list files: started with 157 bug metrics formulated on lowest practical level typically genus information



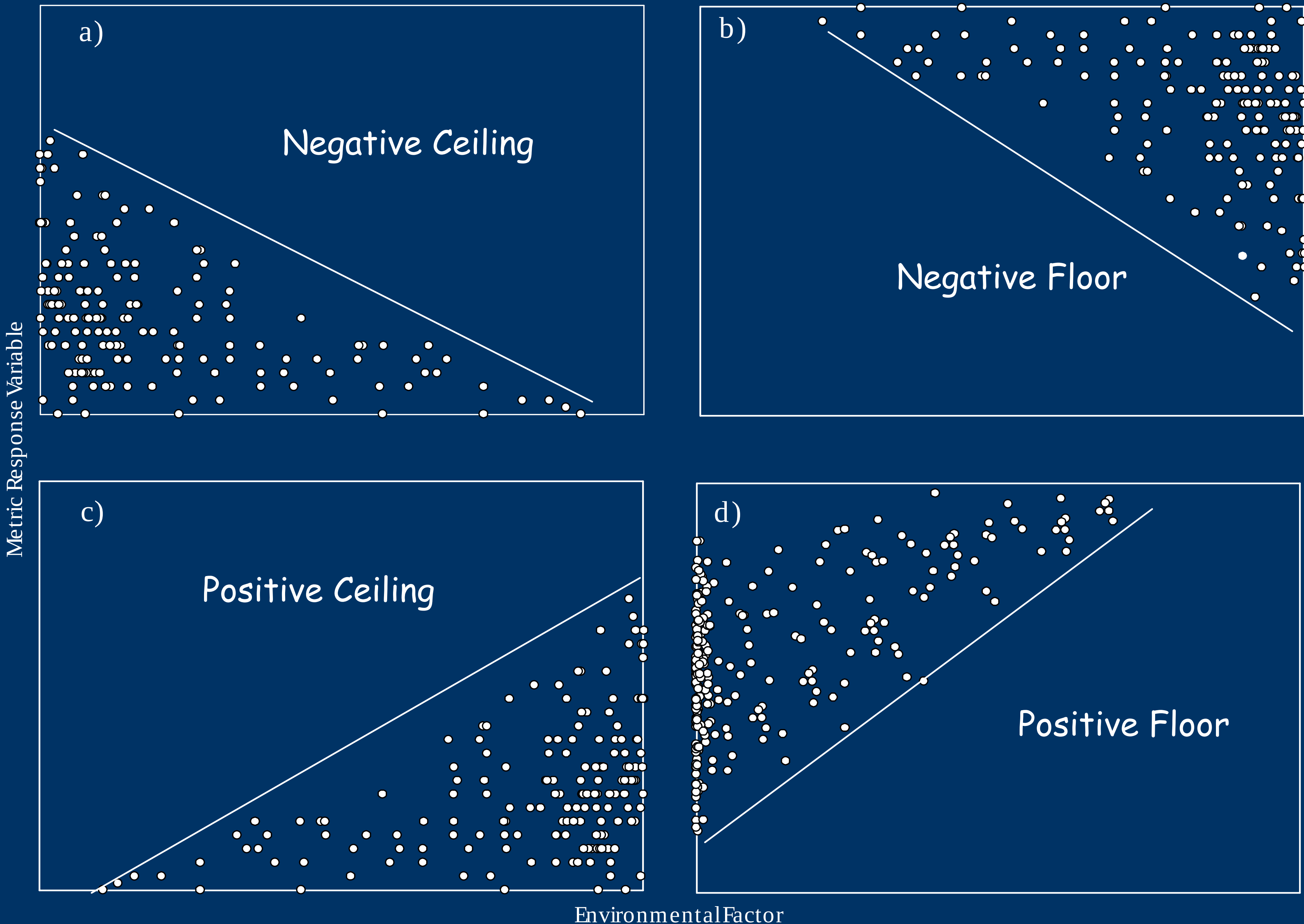



# Data sources and analysis tools

- Nonparametric Screening Procedure-VB based Macro
  - A statistically based bi-variate screening tool that identifies negative and positive ceilings and floors
  - Quantile regression (similar to upper bound or lower bound regression)

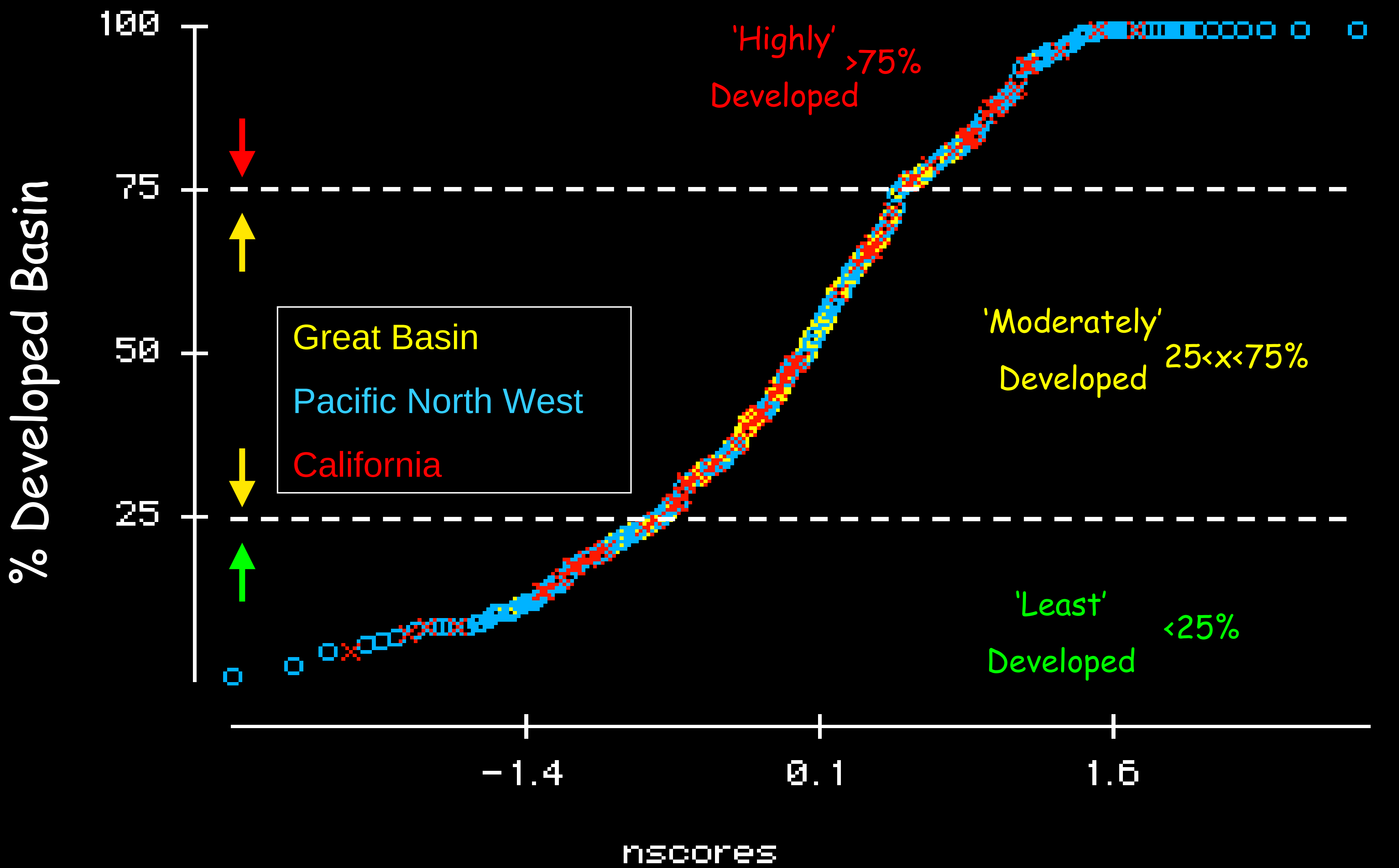
Habitat crew for hire

Figure 2. Conceptual Diagram of Potential Metric Response Patterns
a) Negative Ceiling; b) Negative Floor; c) Positive Ceiling; d) Positive Floor



# Background on landscape alteration and hydrologic infrastructure

# Distribution of NAWQA sites West-Wide by Percent Development Basin (%AG + %URB-LU/LC)



# PDB is moderately to strongly correlated with a number landscape and local features

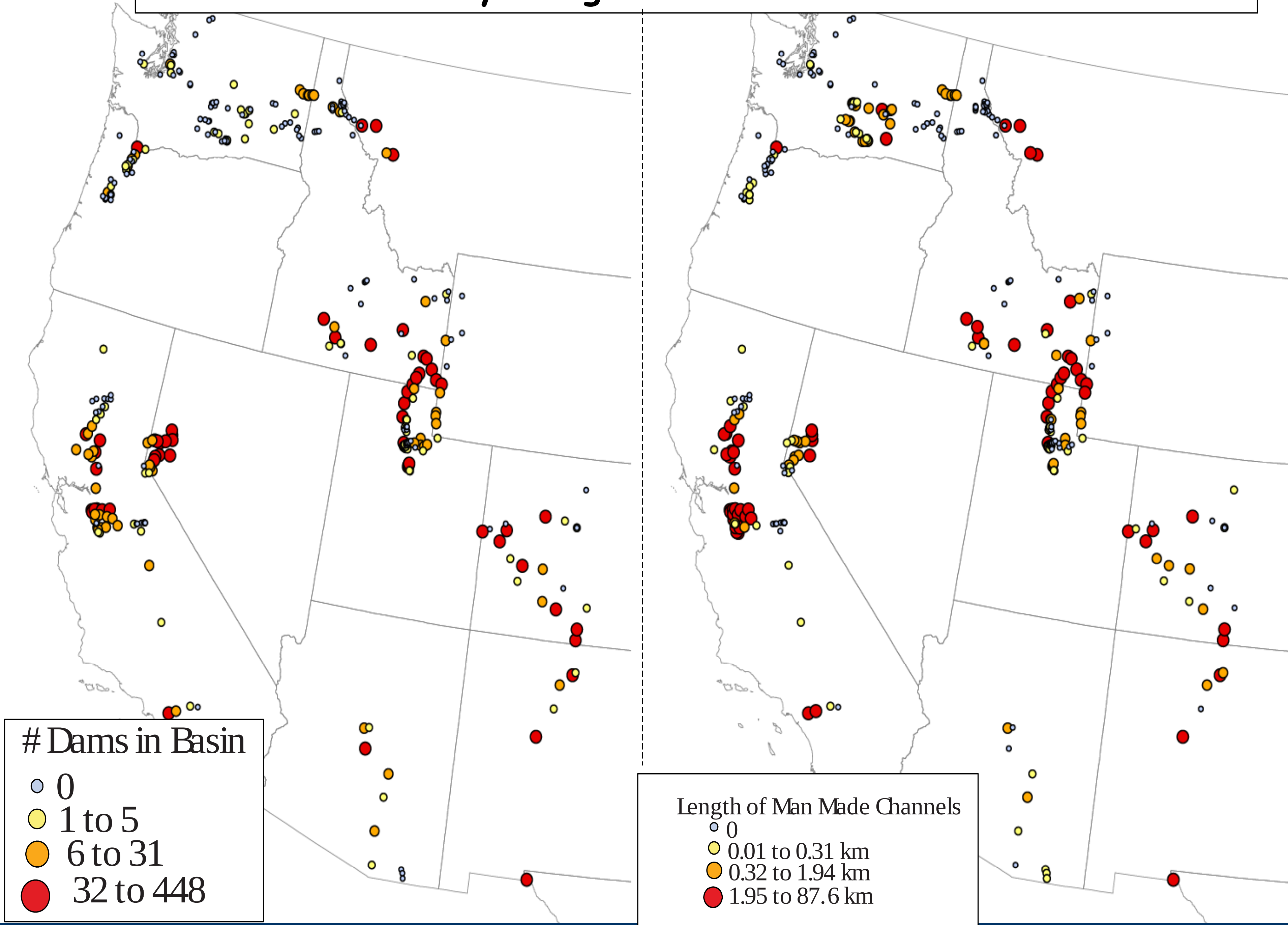
| Watershed Characteristics | PDB | Habitat (Channel) | PDB |
|---|---|---|---|
| Latitude | 0.116 | %Pool | -0.241 |
| Longitude | -0.329 | **%Riffle** | **-0.499** |
| Drainage area | 0.124 | **%Run** | **0.504** |
| **Mean Basin Elevation** | **-0.538** | Mean Open Canopy | 0.124 |
| **Mean slope** | **-0.685** | | |

| Landscape//hydrologic characteristics | PDB | Habitat (particle size) | PDB |
|---|---|---|---|
| **Road Density** | **0.547** | %BR | 0.025 |
| **1990 Pop dens** | **0.635** | **%SILT** | **0.426** |
| **SUM_FOR-b** | **-0.632** | **%COBBLE** | **-0.52** |
| **#ManMade Channels** | **0.454** | **%BOULDER** | **-0.464** |
| #Dams | 0.282 | | |

Spearman's correlation coefficients

PDB = % developed basin (AG+URB land use)

# Pervasiveness of Hydrologic Infrastructure Across the West



# Background on spatial scale in aquatic assessments

# So What do we mean by Scale??

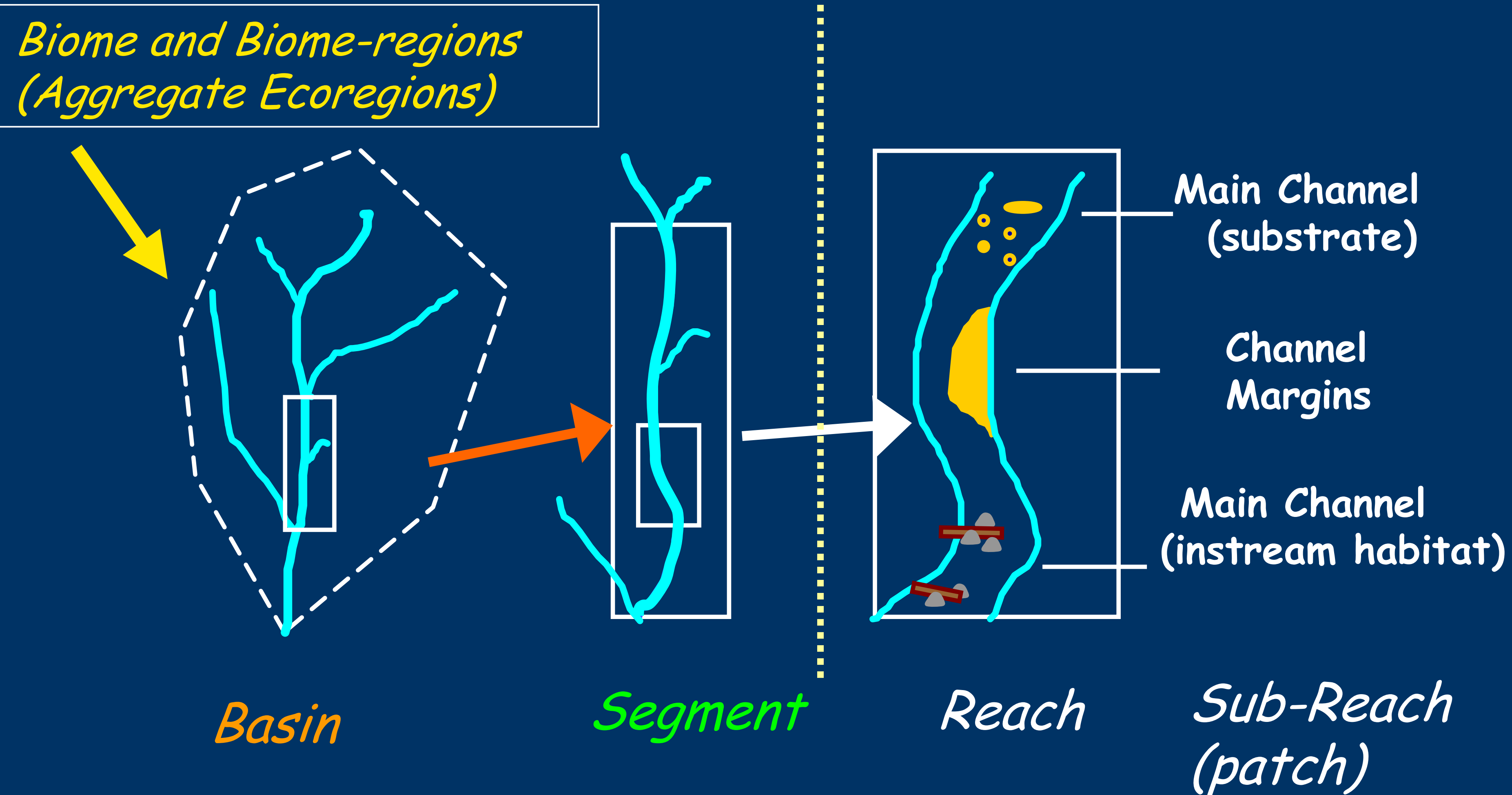
## Something like this 'Presidential-babushka' scale??

Scaling of Presidential '___________'

Nested in hierarchical organization

Scales are linked via evolution and history of impacts

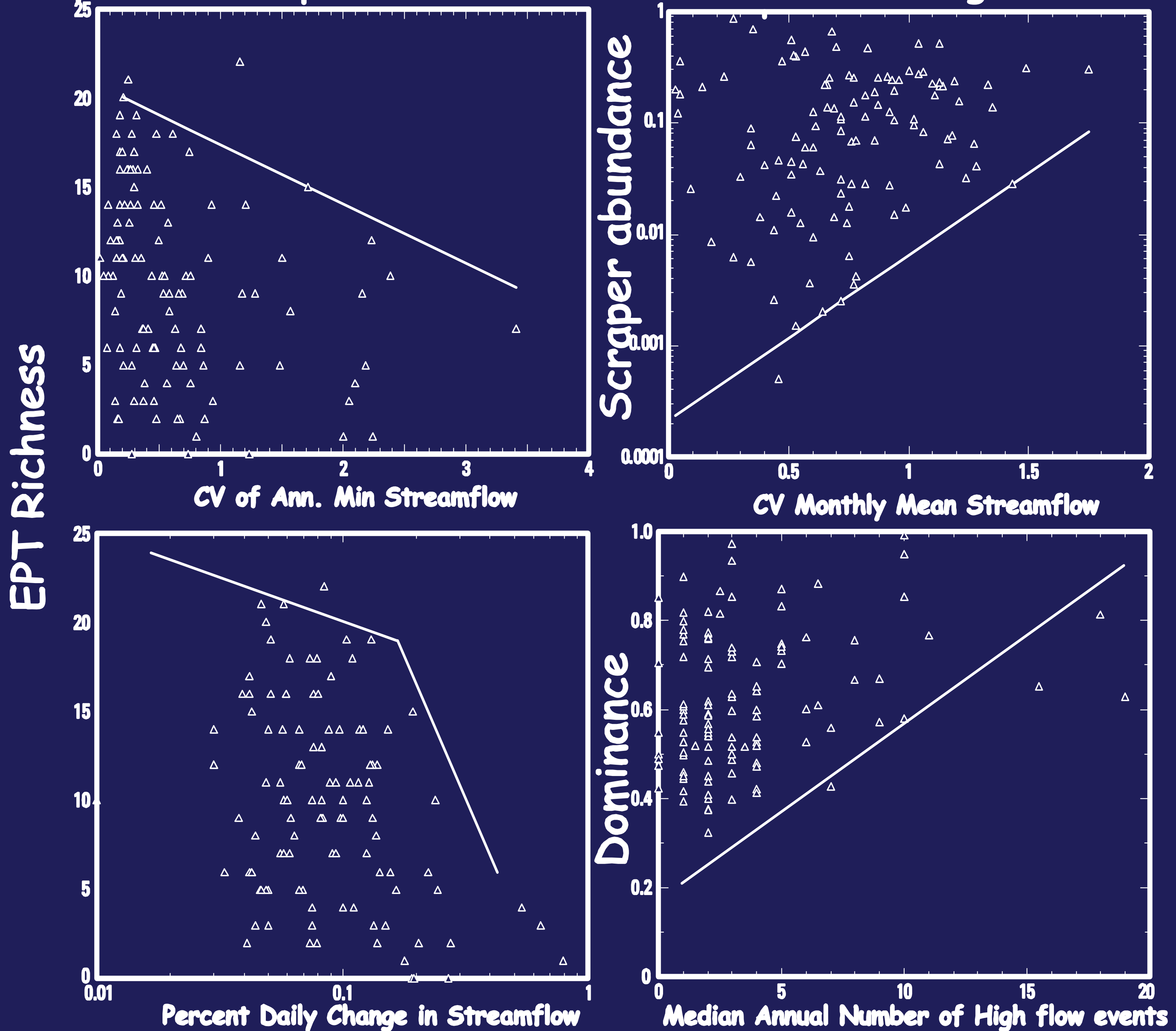
# Biotic/Abiotic characterization based on a geographic and spatial hierarchy…..




Theory ( Minshall 1983, 1988, Frissell et al 1986) Examples-( Carter et al 1996, Roth et al 1996, Li et al. 2001, Wright and Li 2002, Sponseller et al. 2001, Black et al. 2004, Potter et al. 2004, 2005, Ode et al 2005) demonstrated the relationships of catchment-based stress measures with macroinvertebrate assemblages

# Results of Flow regime-invertebrate metric assessments

# Graphical examples of MBI metric-streamflow regime relations



# MBIs were responsive to a variety of stream flow parameters

| | ABUN | NONINp | RICH | EPTr | NONINr | TOLrp | DOM3 | DIVR |
|---|---|---|---|---|---|---|---|---|
| **High Flow Parameters** | | | | | | | | |
| Q10 | | N F | | **P F** | | NCF | | |
| High flow duration | | N F | | P | **N F** | | N C | |
| 100-day high flow duration | | N C | | P C | **NCF** | **NCF** | | |
| 30-day HFF | | | | P C | N F | **N F** | | |
| Months with high flows | | | | N F | | | P C | N F |
| **Low Flow Parameters** | | | | | | | | |
| 100-day min | | N F | | | | **N F** | | |
| Low flow duration | | | | | N C | **N C** | | |
| 30-day low flow duration | | | | | P F | | | |
| Months with low flows | | | | | | | | |
| **Central Tendency Flow Parameters** | | | | | | | | |
| 100-day mean | | **N F** | | P F | N F | **N F** | | |
| % Daily Change | | | N C | **N C** | | **P F** | **P F** | **N C** |
| 30-day % Daily Change | **N F** | | | | | | | |
| CV month | | **N F** | | P C | **N F** | | | |

Associations of selected streamflow and invertebrate metrics ($p < 0.05$ that bivariate ranks were independent; **bold**, $p < 0.01$; blank, $p > 0.05$). Ceilings indicated with "C", floors indicated with "F", and direction of association indicated by "P" for positive and "N" for negative.

# General Summary of Findings
# Obj. 1 Flow regime perspective

- Daily streamflow variability was associated with the most invertebrate metrics such as richness, evenness, and diversity, and relative abundance of feeding groups and specific taxa.

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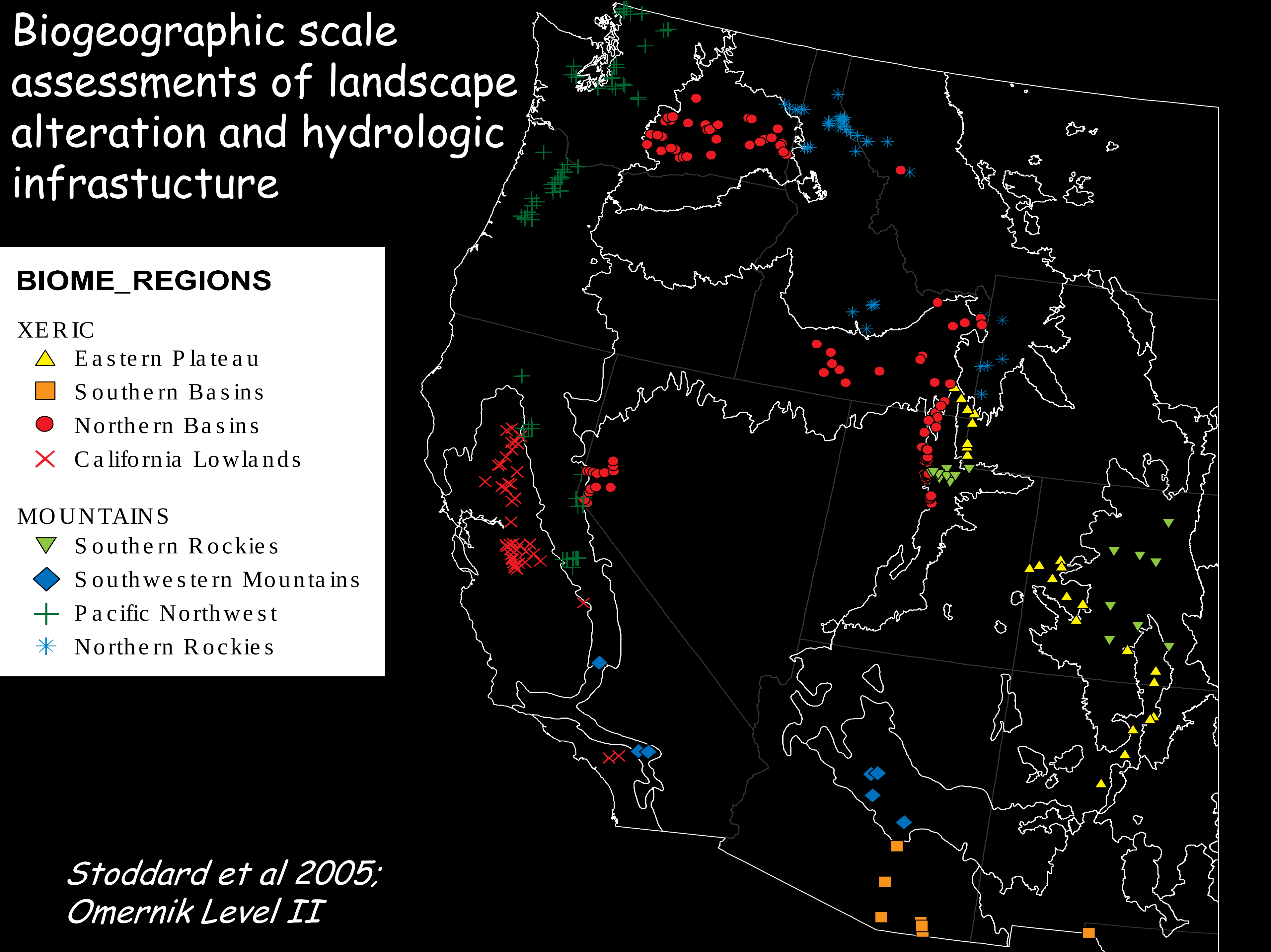
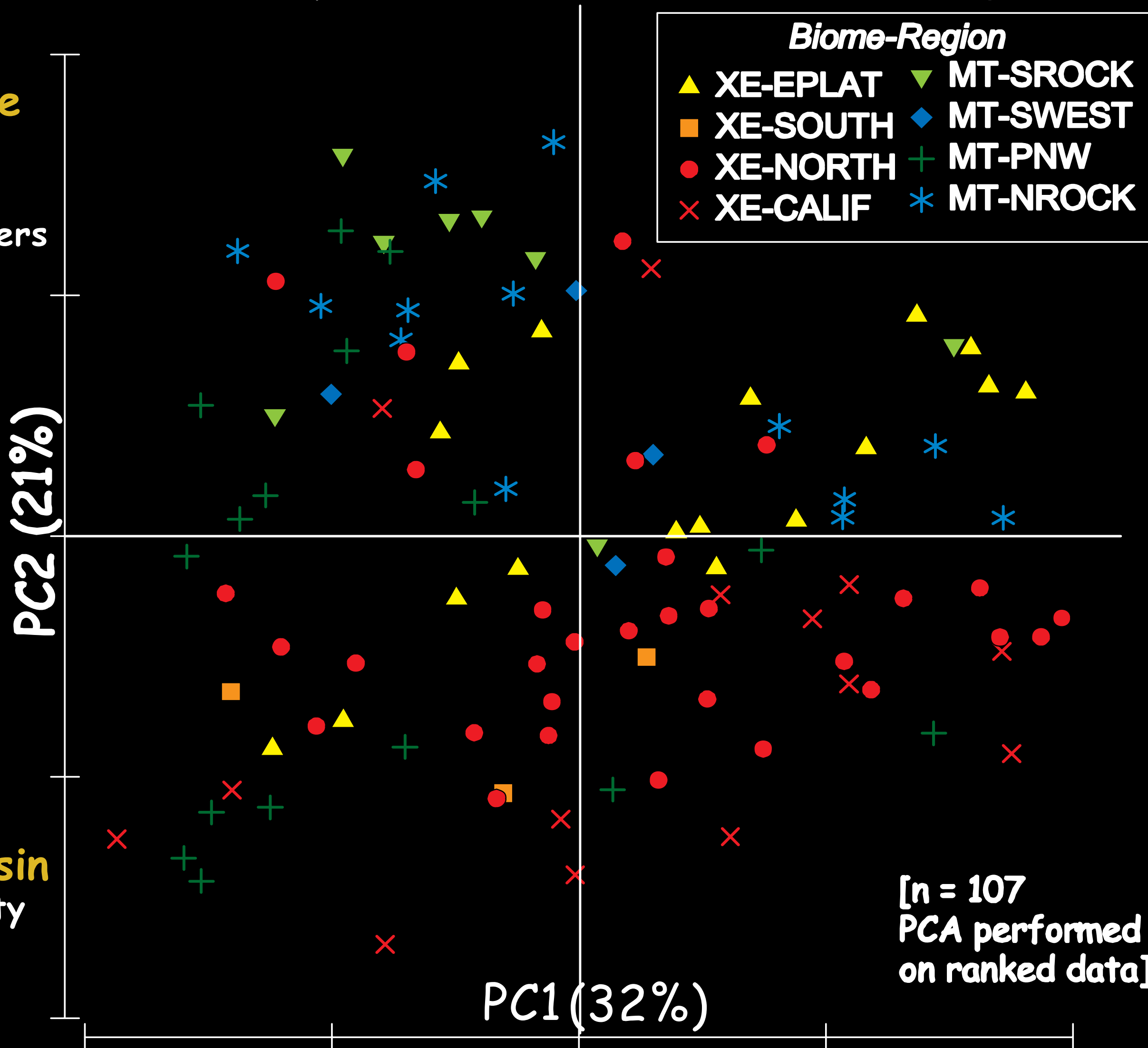
# Biogeographic scale assessments of landscape alteration and hydrologic infrastucture




*Stoddard et al 2005; Omernik Level II*

PCA: Flow regime parameters and landscape features were widely distributed across all biome-regions

**Elevation and Slope**
**Forested basin**
2 landscape factors
3 stream flow parameters

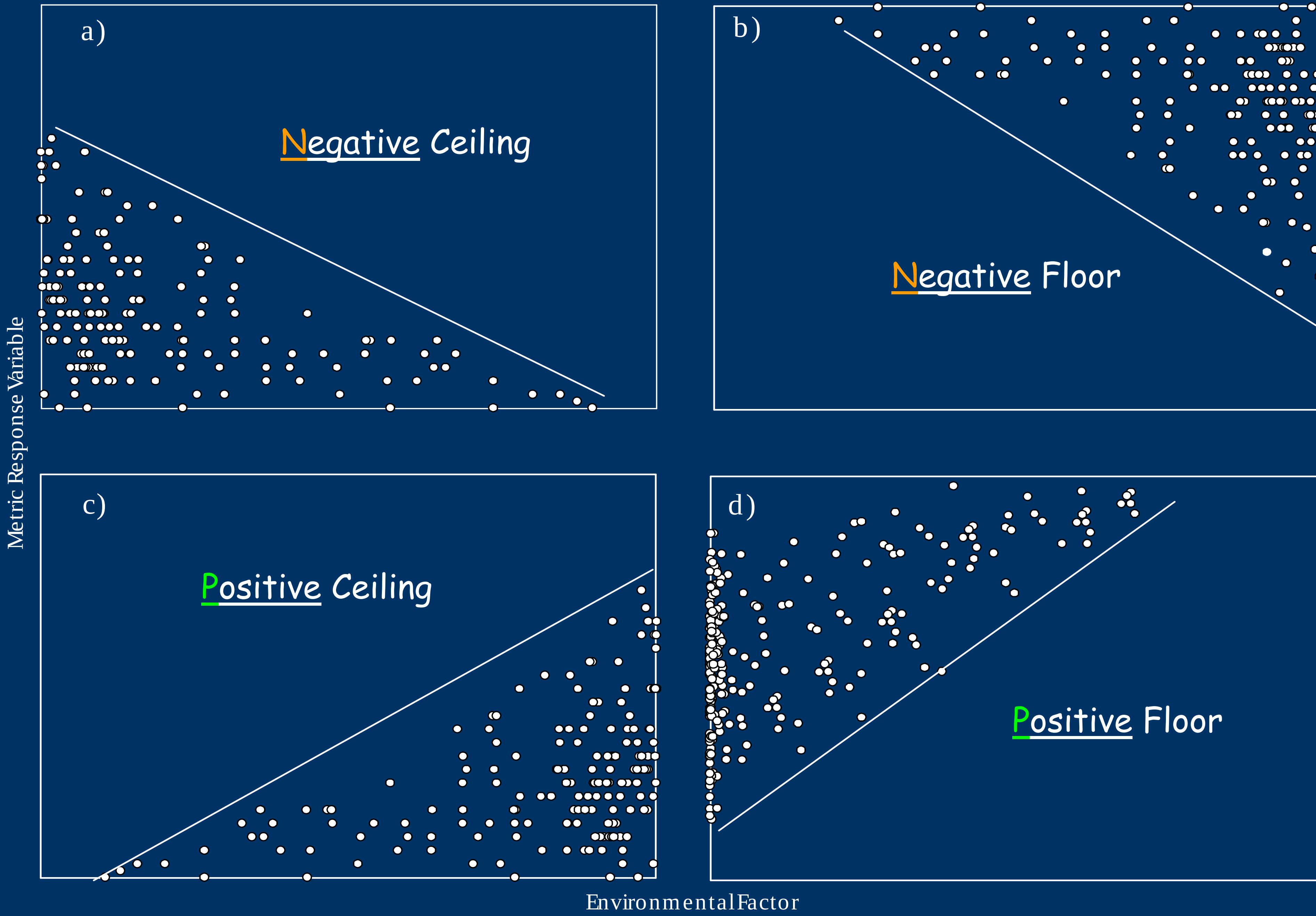



**Percent Developed Basin**
2 measures of human denisty
1 stream flow parameter

**% Daily Change Flow**
2 stream flow parameters

**Basin Size**
**Hydro-Infrastructure**
3 reservoir parameters
5 stream flow parameters

Figure 2. Conceptual Diagram of Potential Metric Response Patterns
a) Negative Ceiling; b) Negative Floor; c) Positive Ceiling; d) Positive Floor



# Biotic response patterns across scale: West-Wide

| West-Wide (n =332) | EPTR | ShanDiv | RichTOL | Dom5 | DivFFG |
|---|---|---|---|---|---|
| [Landscape Alteration Parameters] | | | | | |
| Developed Basin (%) | N | N | P | P | N |
| Developed Segment (%) | N | N | P | P | N |
| [Hydrological Infrastructure Parameters] | | | | | |
| Length of manmade channels (km) | N | N | P | P | N |
| Number of dams in basin | N | -- | P | -- | -- |

Relations listed as N = Negative or P = Positive significant patterns at p = 0.05. (--) Indicates a non-significant relation.

# Response Patterns across scale: Mountain biome scale

## All Mountain sites (n = 142)

| | EPTR | ShanDiv | RichTOL | Dom5 | DivFFG |
|---|---|---|---|---|---|
| [Landscape Alteration Parameters] | | | | | |
| Developed Basin (%) | N | N | P | P | N |
| Developed Segment (%) | N | N | P | -- | N |
| [Hydrological Infrastructure Parameters] | | | | | |
| Length of manmade channels (km) | -- | -- | P | -- | N |
| Number of dams in basin | N | -- | P | -- | -- |

## Biome region scale

## Mountain Pacific Northwest (n = 73)

| | EPTR | ShanDiv | RichTOL | Dom5 | DivFFG |
|---|---|---|---|---|---|
| [Landscape Alteration Parameters] | | | | | |
| Developed Basin (%) | N | -- | P | -- | -- |
| Developed Segment (%) | N | -- | P | -- | N |
| [Hydrological Infrastructure Parameters] | | | | | |
| Length of manmade channels (km) | N | -- | P | -- | N |
| Number of dams in basin | N | -- | P | -- | -- |

# Response Patterns across scale: Xeric biome scale

| All Xeric sites (n = 190) | EPTR | ShanDiv | RichTOL | Dom5 | DivFFG |
|---|---|---|---|---|---|
| [Landscape Alteration Parameters] | | | | | |
| Developed Basin (%) | N | -- | P | P | -- |
| Developed Segment (%) | N | -- | P | P | -- |
| [Hydrological Infrastructure Parameters] | | | | | |
| Length of manmade channels (km) | -- | N | P | P | -- |
| Number of dams in basin | -- | -- | -- | -- | -- |

## Biome Region Scale

| Xeric California (n = 42) | EPTR | ShanDiv | RichTOL | Dom5 | DivFFG |
|---|---|---|---|---|---|
| [Landscape Alteration Parameters] | | | | | |
| Developed Basin (%) | N | N | P | P | -- |
| Developed Segment (%) | N | N | P | P | -- |
| [Hydrological Infrastructure Parameters] | | | | | |
| Length of manmade channels (km) | N | -- | P | -- | -- |
| Number of dams in basin | -- | -- | -- | -- | -- |

# General Summary of Findings
# Obj. 2 landscape perspective

- EPT richness, Shannon diversity, and functional feeding group diversity all showed significant declining patterns with increasing measures of human influence across multiple spatial scales.

- Dominance of the 5 most abundant taxa and richness of tolerant invertebrates were positively correlated with increasing patterns of human influence and were consistent across spatial scales.

- EPT richness and RichTol were the most responsive to our measures of landscape alteration and hydrologic infrastructure

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# Conclusions

- Invertebrates responded to a broad range of streamflow parameters.
- Daily streamflow variability was associated with the most invertebrate metrics
- Landscape alteration and hydrologic infrastructure surrogate variables presented here  work reasonably well as a variables for linking biotic response to human influence across multiple spatial scales

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# Next steps…

- Finalize scale based analyses via quantile regression
- Analysis of multi-year data to gain understanding of the effects on water year on our assessments
- Ecological models for prediction and prioritization of restoration activities.
- Future analysis may incorporate species traits for a less variable signal and better understanding of community processes

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# Relevance to the public and managers

- Potential for altering flow management strategies for maximizing biotic integrity
- Prioritization of watersheds for further investigation or restoration activities
- Factors/associations identified in these analyses can potentially serve a base line for regional planning and assessment efforts

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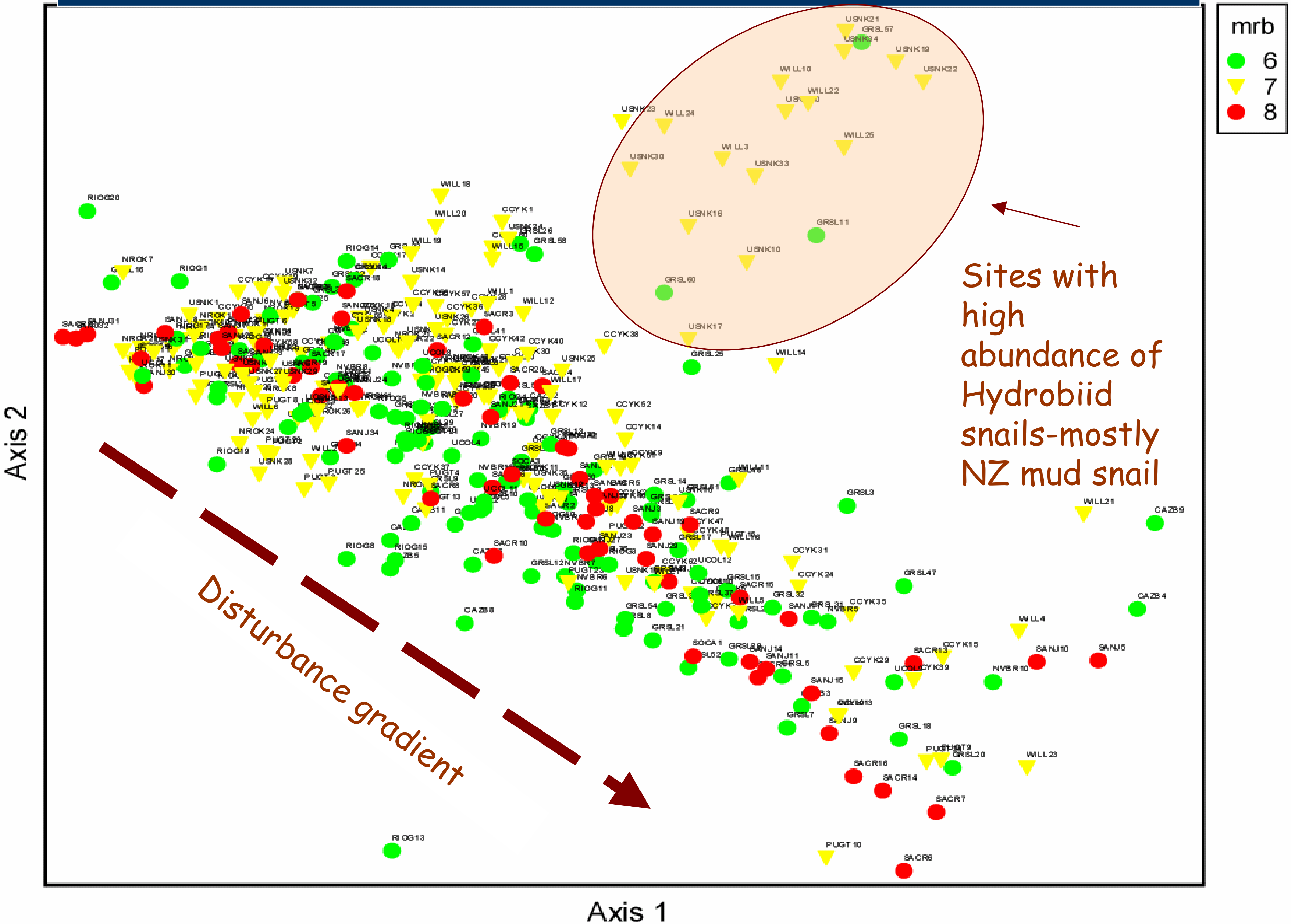
Thank you

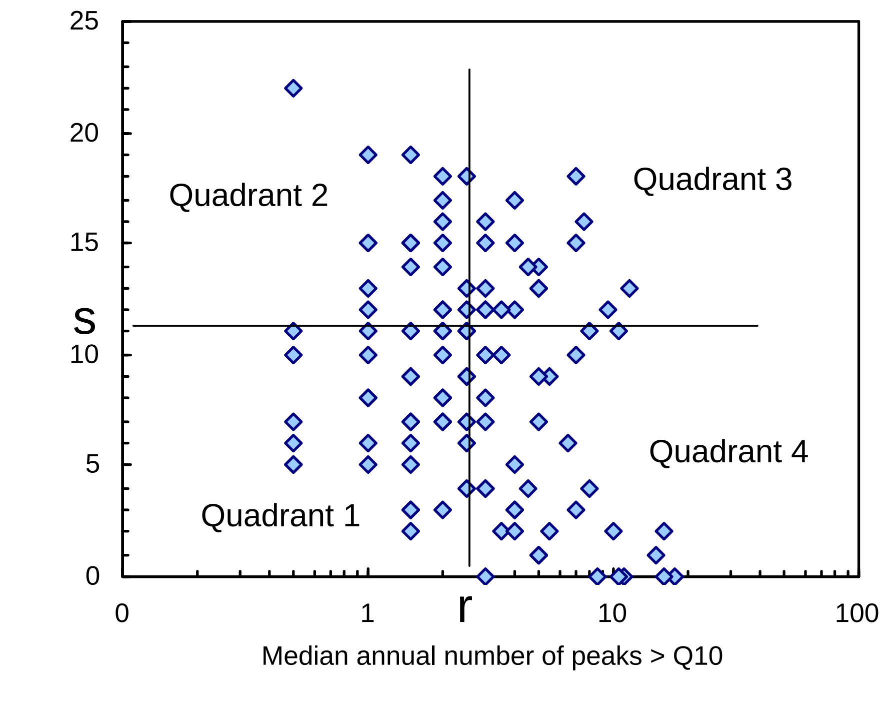
# Effect of NZ Mud Snail in our data set



# Streamflow metrics

| | HIGH FLOW | LOW FLOW | AMBIENT FLOW | RECENT FLOW |
|---|---|---|---|---|
| Magnitude | Geometric mean annual max daily flow,<br>Maximum monthly flow,<br>Maximum Monthly Q as fraction of mean streamflow | Median annual minimum streamflow,<br>Minimum monthly flow | Mean,<br>Mean for month of sample,<br>Mean daily runoff (mm) | 100-day mean,<br>100-day mean/Q50, 100-day max,<br>100-day max/Q10,<br>100-day min,<br>100-day min/Q10 |
| Duration | Q10 (flow exceeded 10 percent of the time) | Q90,<br>Median annual number of continous low flow days | Median<br>TQMean | 100-day high flow duration,<br>100-day low flow duration |
| Frequency | Median annual number of peaks over Q10,<br>Number of months with peak | Months with low flows | -- | 100-day peaks |
| Variability | Inner quartile of annual max daily flow,<br>Standard deviation of annual number of peaks | CV of annual minimum streamflow | Daily CV,<br>Percent daily change in streamflow,<br>Max Monthly Q/Min Monthly Q | 100-day % daily change |
| Timing | Month of maximum monthly streamflow | Month of minimum monthly streamflow | | |

# Screening for Flow-Invertebrate Relations




Divide plots into quadrants around an origin (r,s) where r is the rank of the streamflow metric and s is the rank of the invertebrate metric.

Probability of finding a point in:
Quadrant 1 (lower left) is (r/n)(s/n)
Quadrant 2 (upper left) is (r/n)(n-s)/n
Quadrant 3 (upper right) is (n-r)/n (n-s)/n
Quadrant 4 (lower right) is (n-r)/n s/n

Identify quadrants and associated origins with statistically significant fewer points than expected using the binomial distribution.

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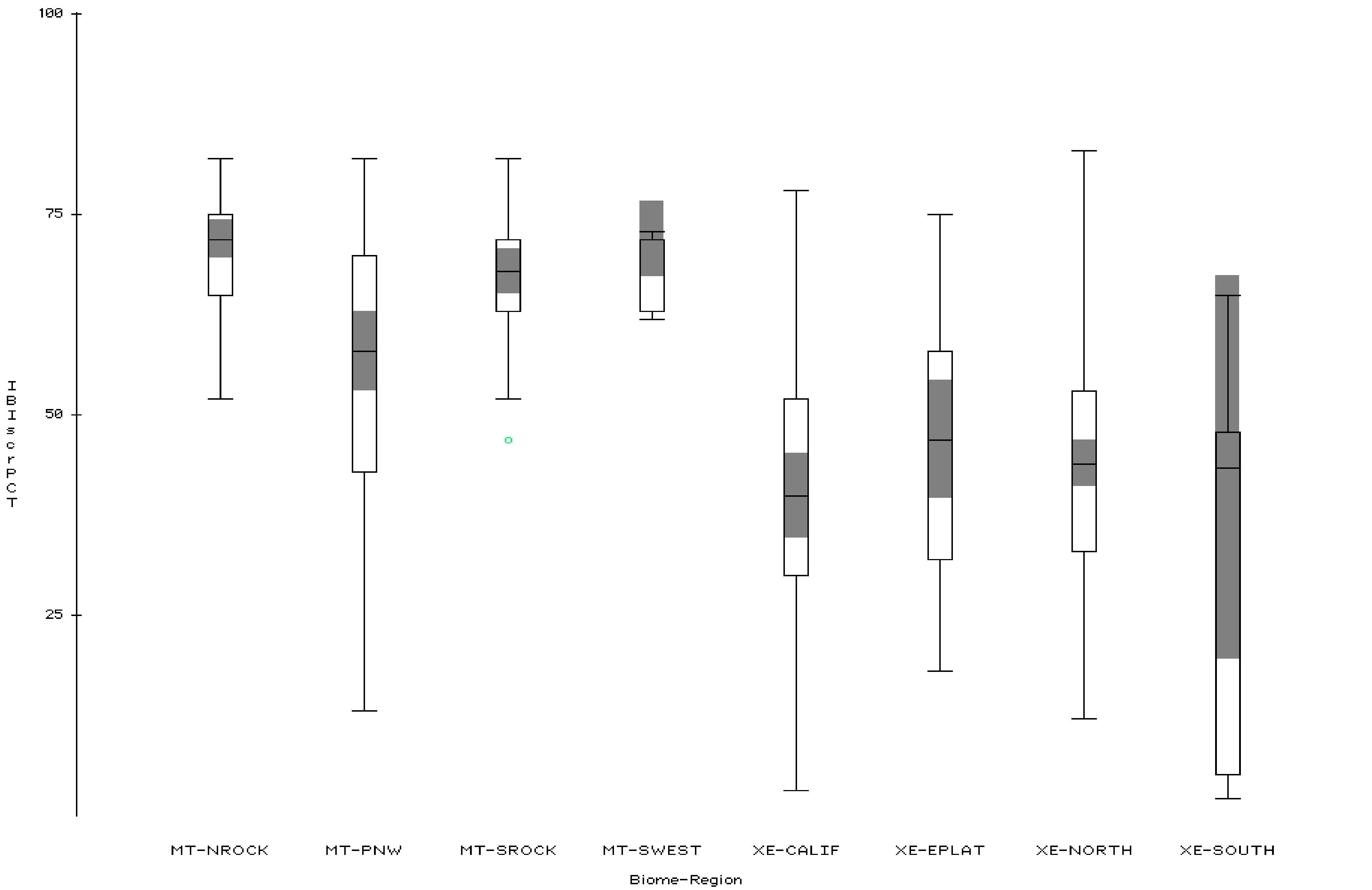
# Distribution of IR6 sites scored according to EMAP-West IBIs (rescaled to 100%)



# WEMAP-IBI in relationship select measures

## Xeric-Tan; Mountain-Green [1-yr REP]

*Without two Snake R sites highly influenced by NZ MUD SNAIL*