



Case Study: Consequences of climate change for biocriteria

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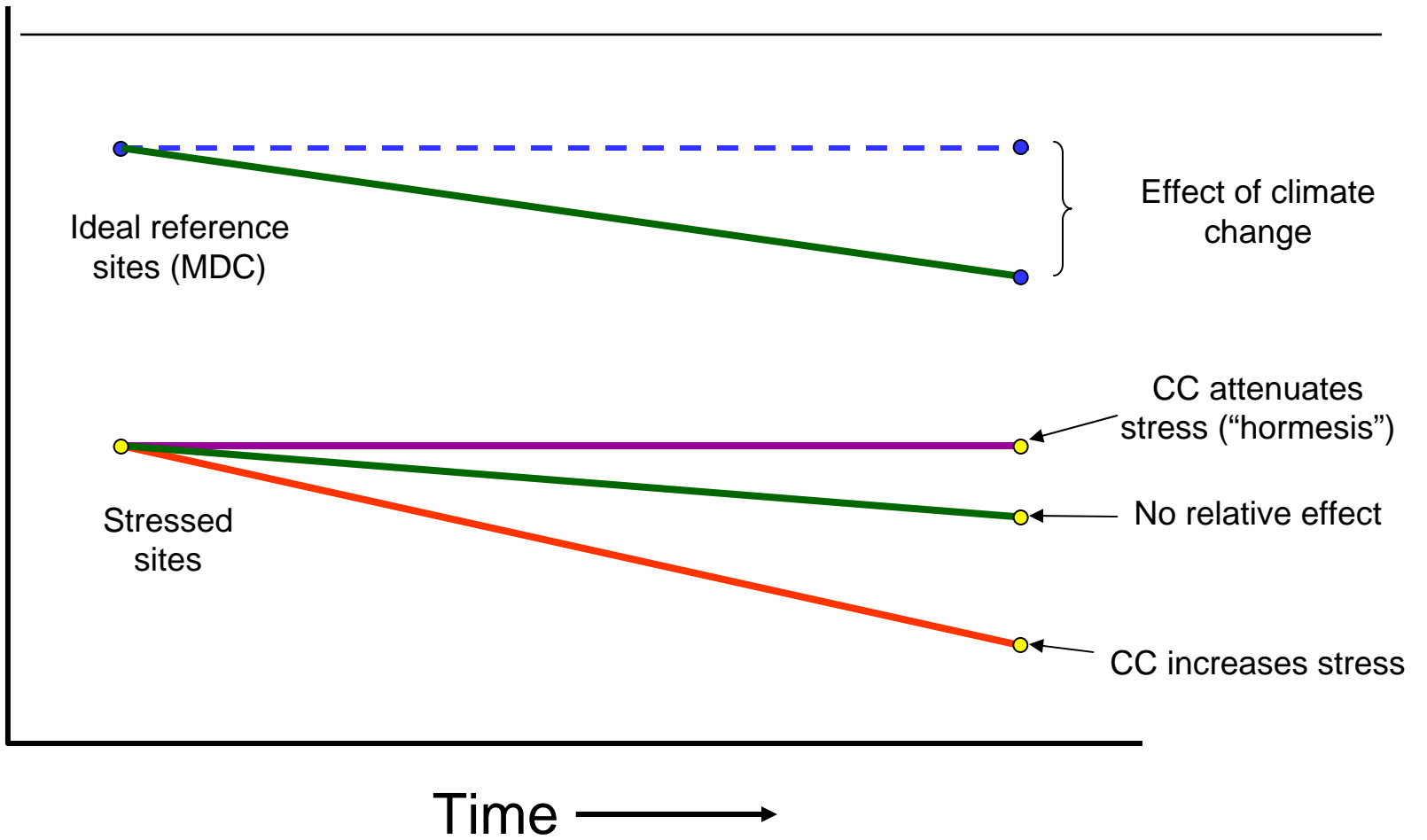


Approach

- Examine effects of temperature, hydrologic parameters, and climate *within* single data set
- Data requirements:
 - Fish and benthic macroinvertebrates
 - Long time period to cover climate variations (dry and wet periods)
 - Cover range of at least some stressors (least to most)
 - Data QA complete

Conceptual model

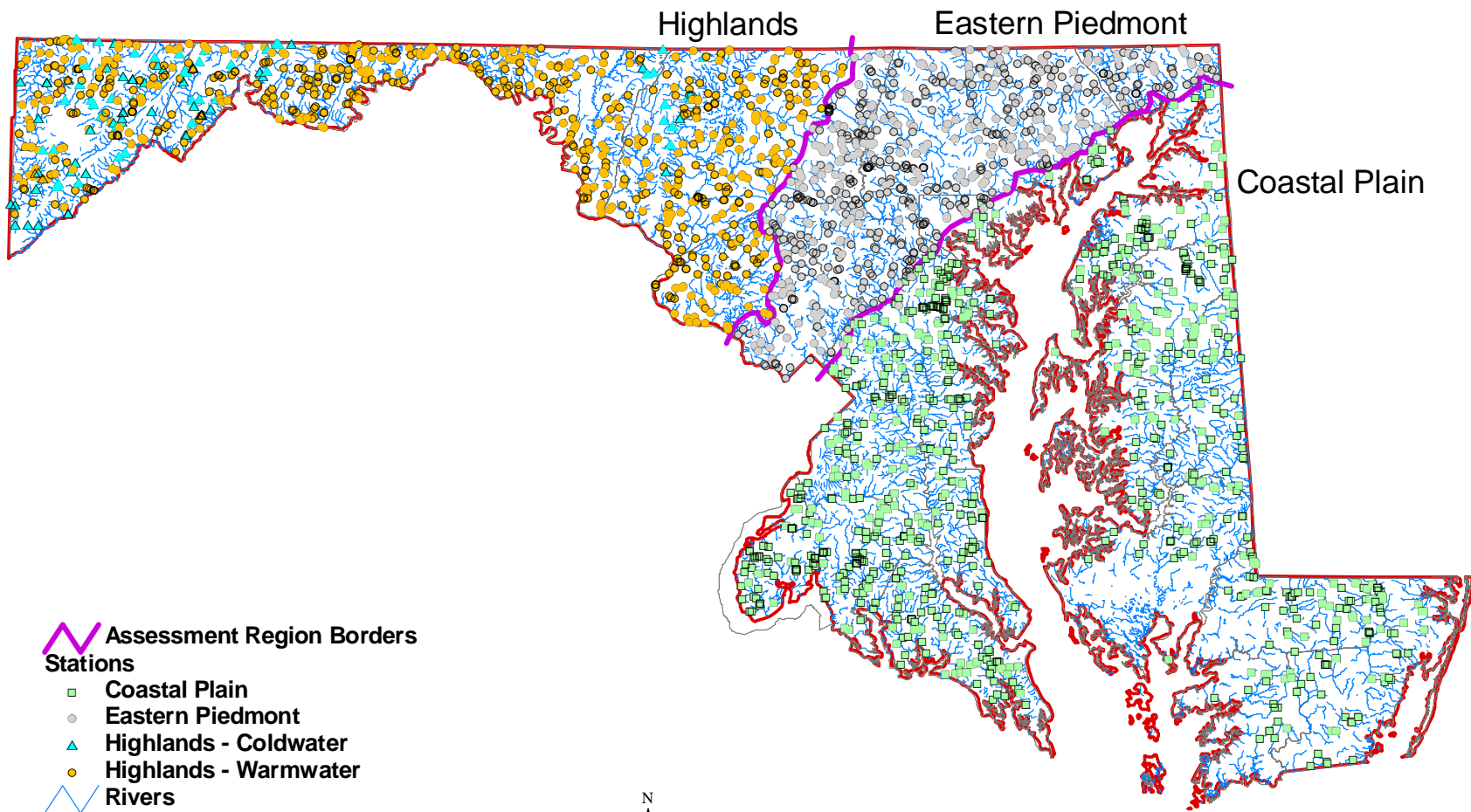
Biological Indicator





Data – Maryland Biological Stream Survey (MBSS)

- 1995-2005
- Fish (summer) and bugs (spring)
- Land cover, water chemistry
- 5-year rotating basin design
- Stream segments stratified by order; sites selected from list frame of segment-miles
- Used Piedmont and highlands regions: 0-100% urban, some agriculture



Highlands

Eastern Piedmont

Coastal Plain

Assessment Region Borders

Stations

- Coastal Plain
- Eastern Piedmont
- ▲ Highlands - Coldwater
- Highlands - Warmwater

- Rivers
- Counties
- ▭ Maryland





Stressors

- Habitat alteration
- Impervious surface
- Baker's flashiness index (from model)
- Nutrients (summer)
- Temperature (summer)
- Climate
 - Palmer Hydrological Drought Index (NCDC; monthly estimate by region)



Response variables

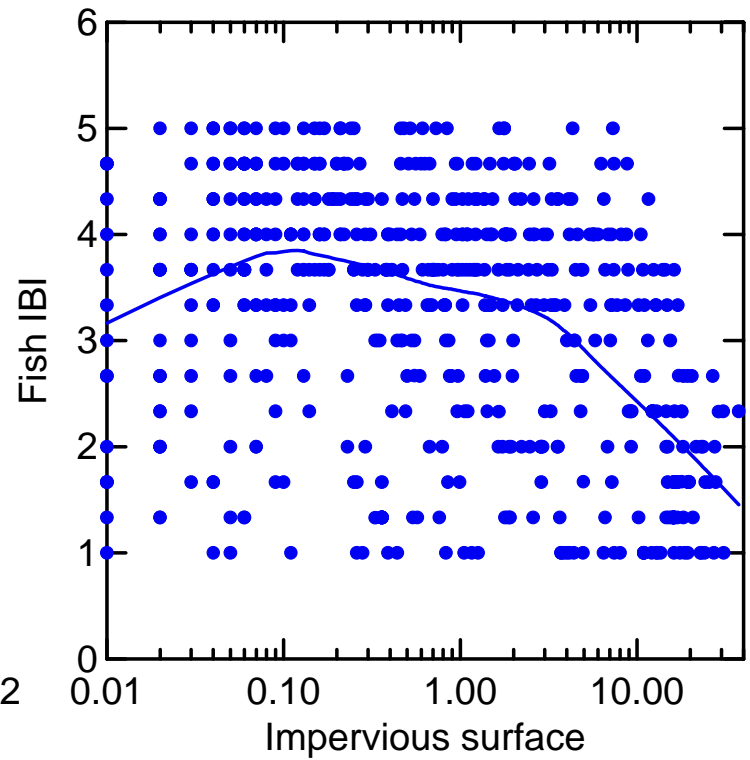
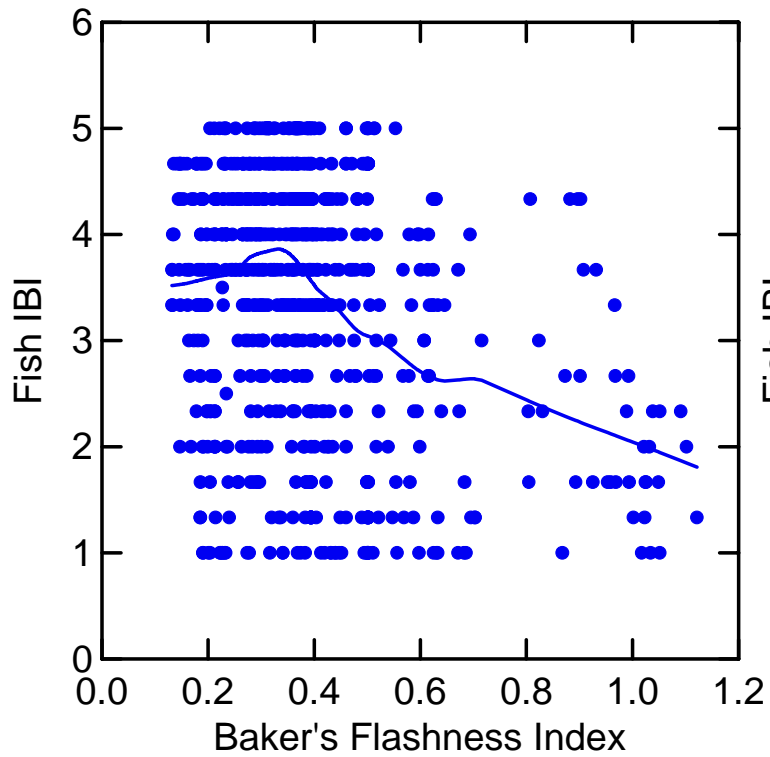
- Maryland benthic IBI (B-IBI)
- EPT taxa
- Maryland fish IBI
- Fish taxa



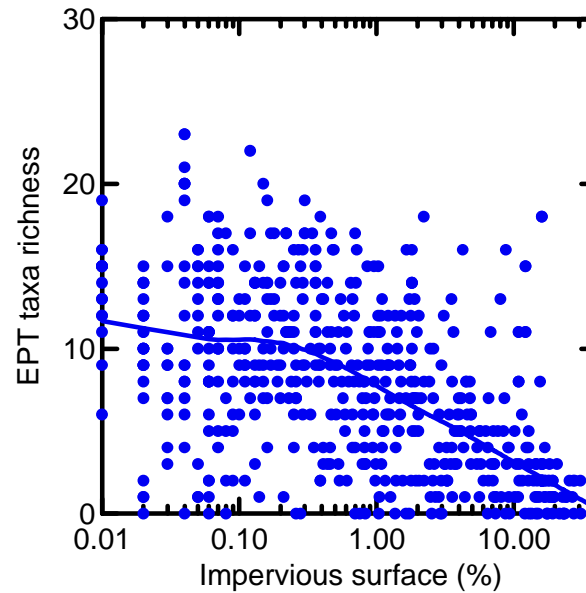
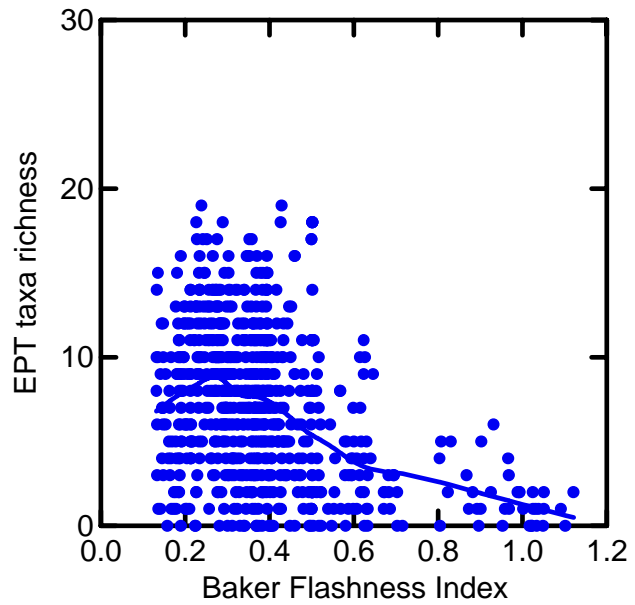
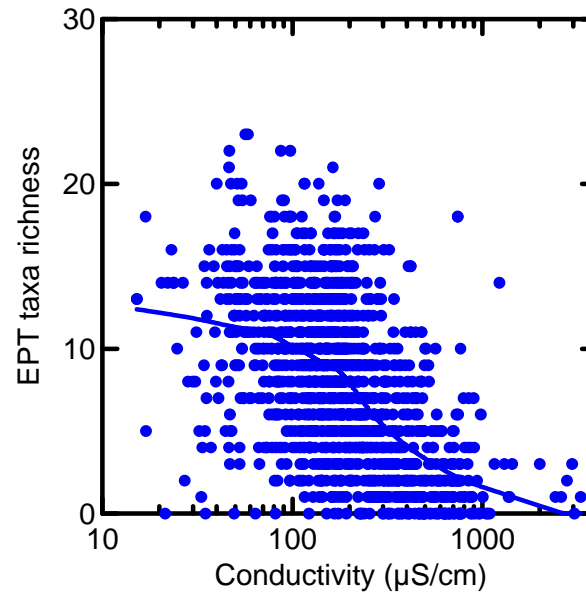
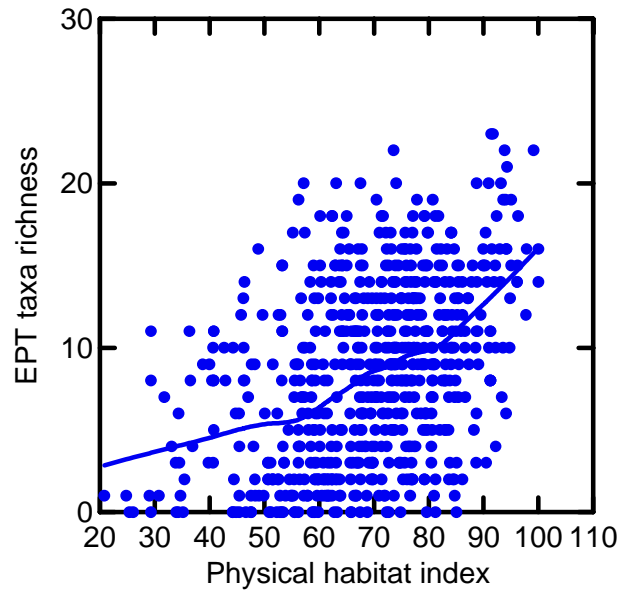
Biological Responses

- Fish
 - Habitat
 - Flow (stream size)
 - Flashiness
- Macroinvertebrates
 - Physical habitat, embeddedness
 - Flashiness, impervious surface
 - Total P
 - Conductivity

Fish responses



EPT responses

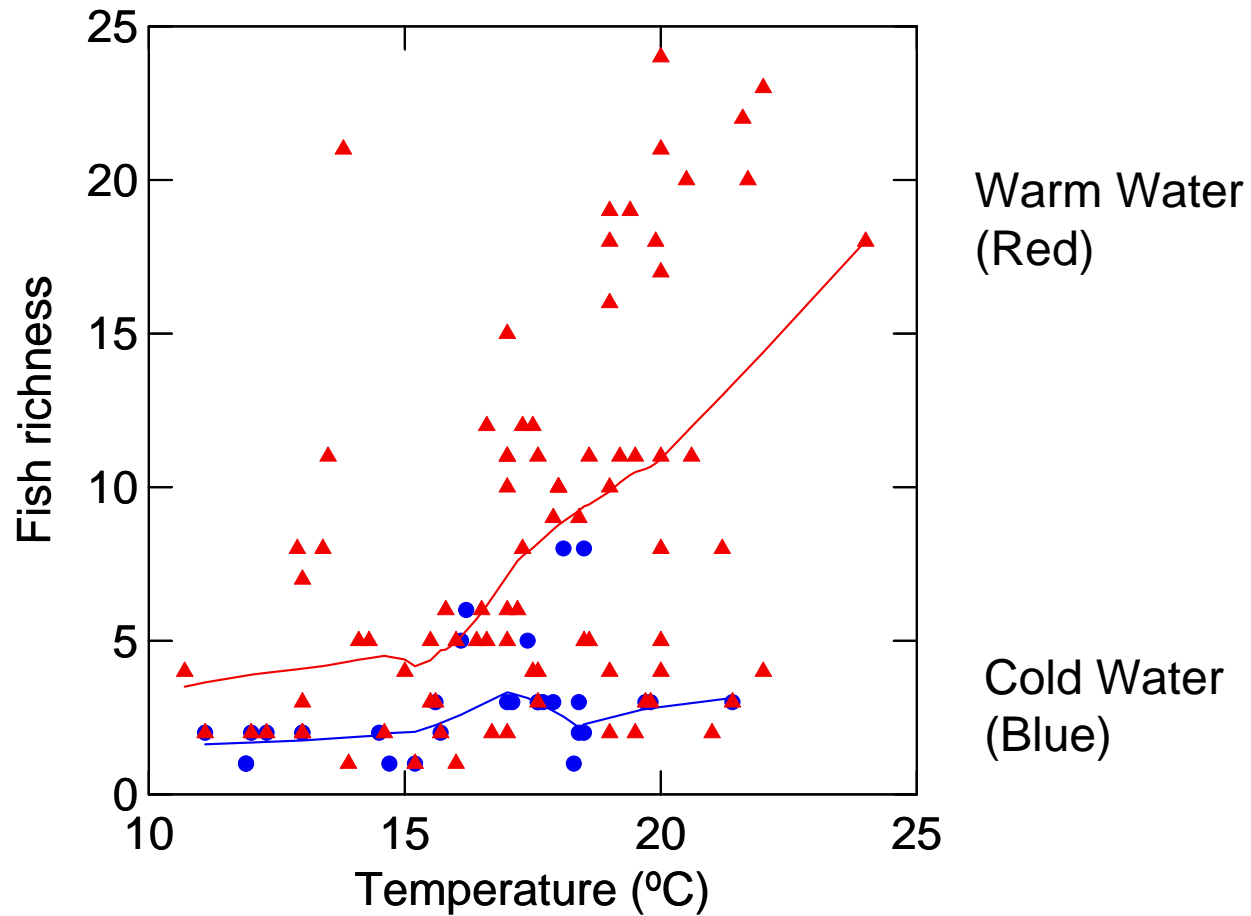




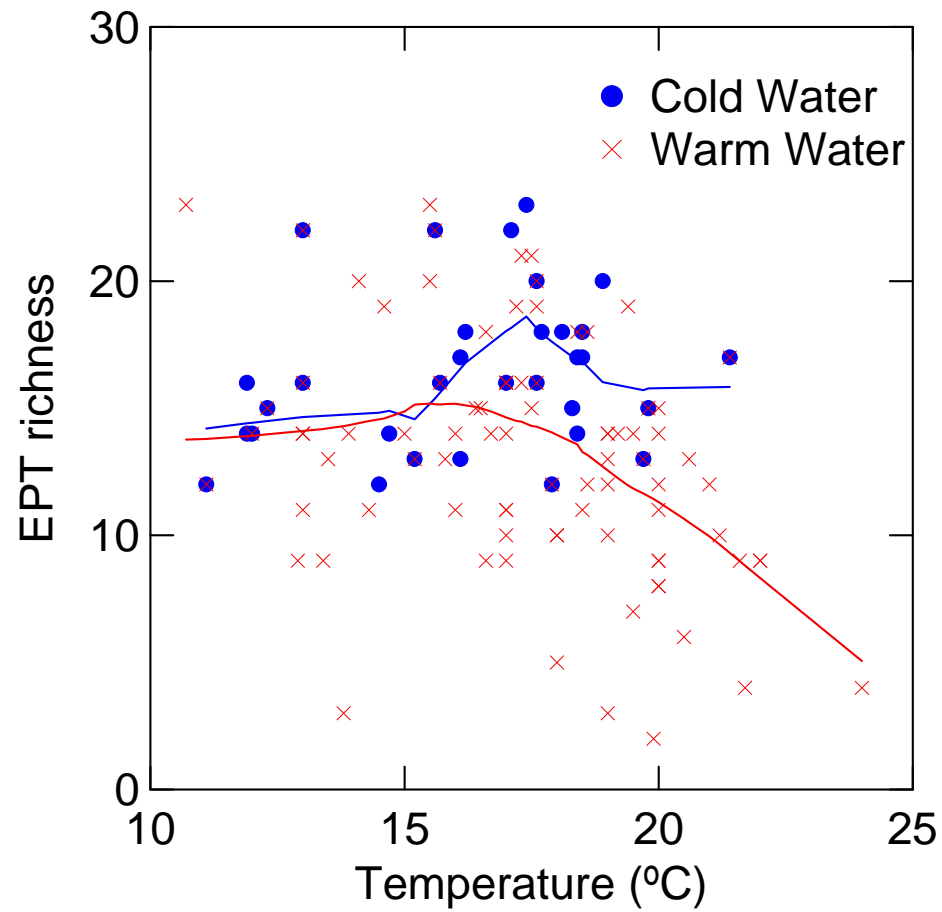
Temperature

- Fish taxa richness higher in warm water habitats
- Invertebrate taxa richness declines with increased temperature in highland streams
- No effect on invertebrates in Piedmont streams

Fish and Temperature



Invertebrates and temperature - Highland streams

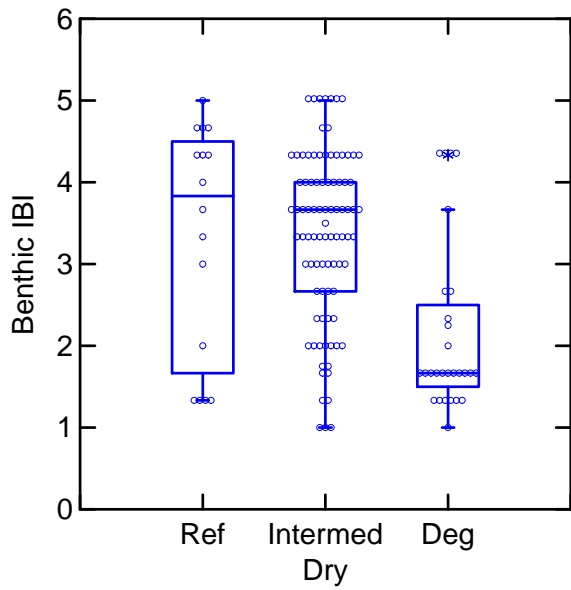




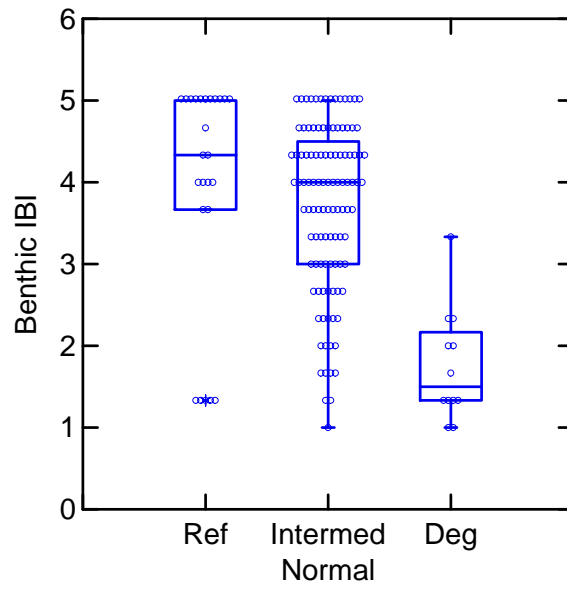
Detection of impairment

- Climate condition:
 - “Dry”: PHDI < -2.5
 - “Normal”: -1.1 < PHDI < 1.0
 - “Wet”: PHDI > 3.5
- Ability to detect impairment, reference and stressed sites

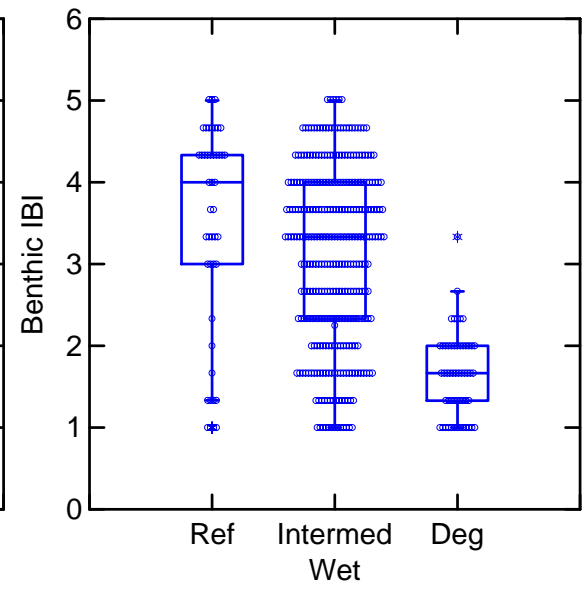
Benthic IBI



Dry

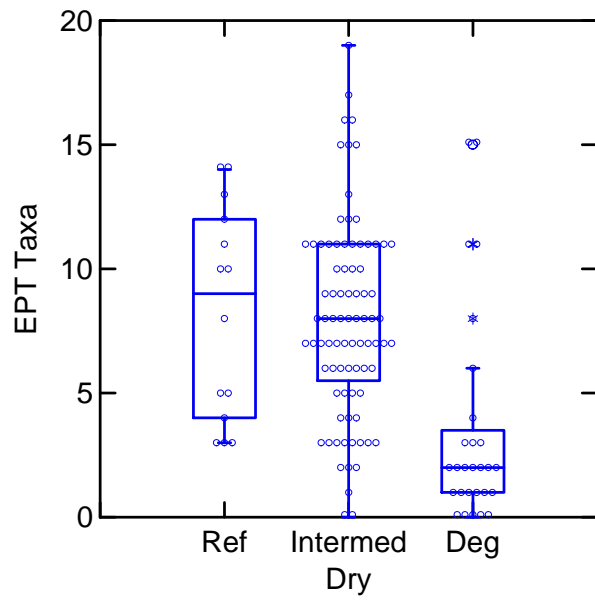


Normal

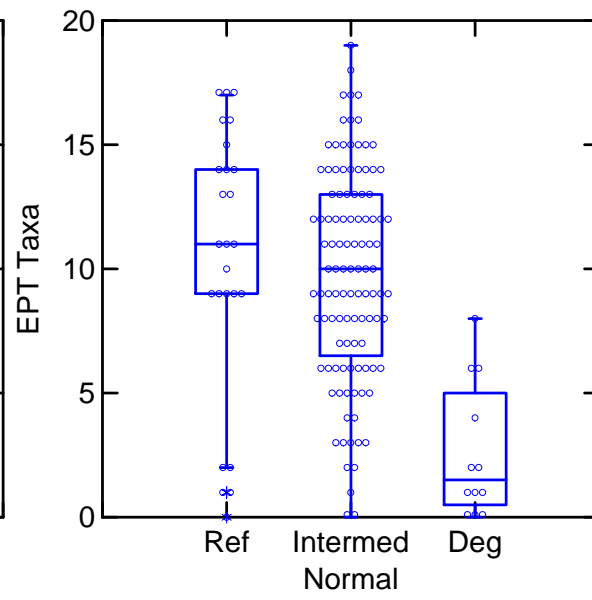


Wet

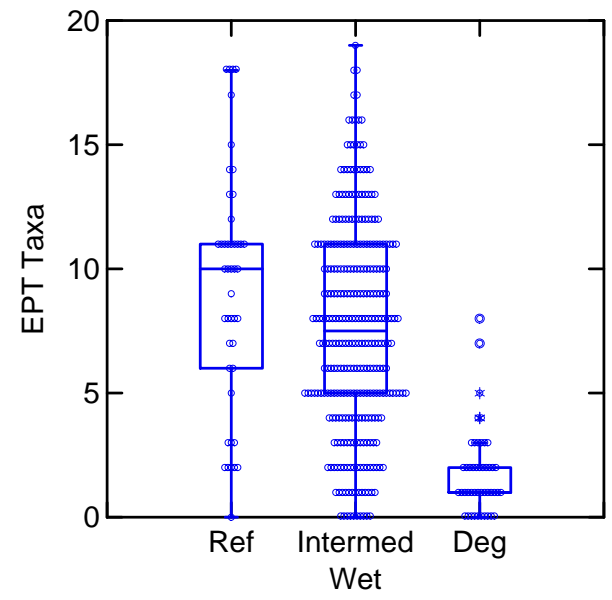
EPT



Dry

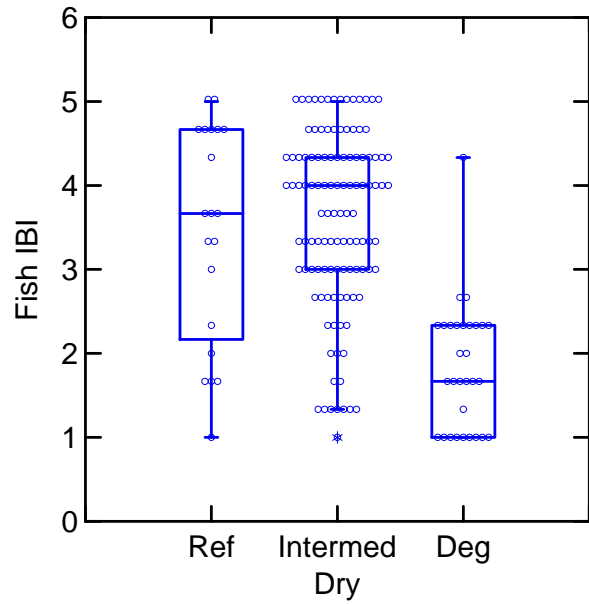


Normal

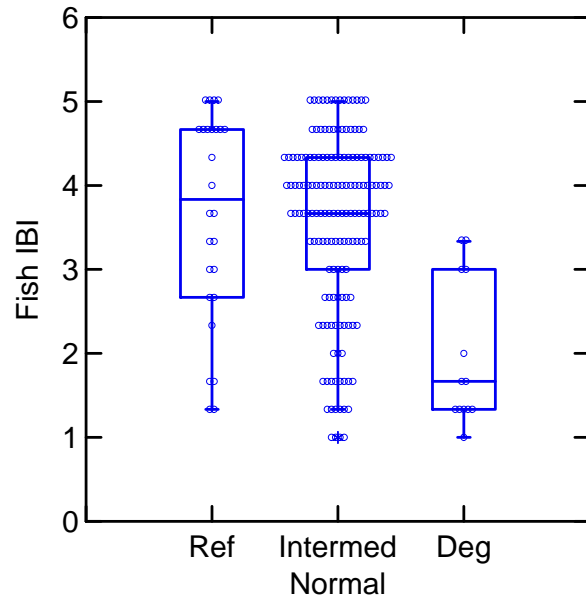


Wet

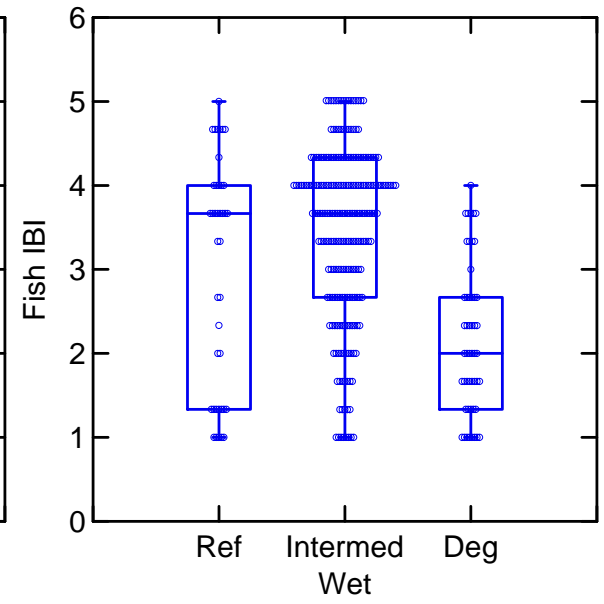
Fish IBI



Dry



Normal



Wet



Detection of Impairment

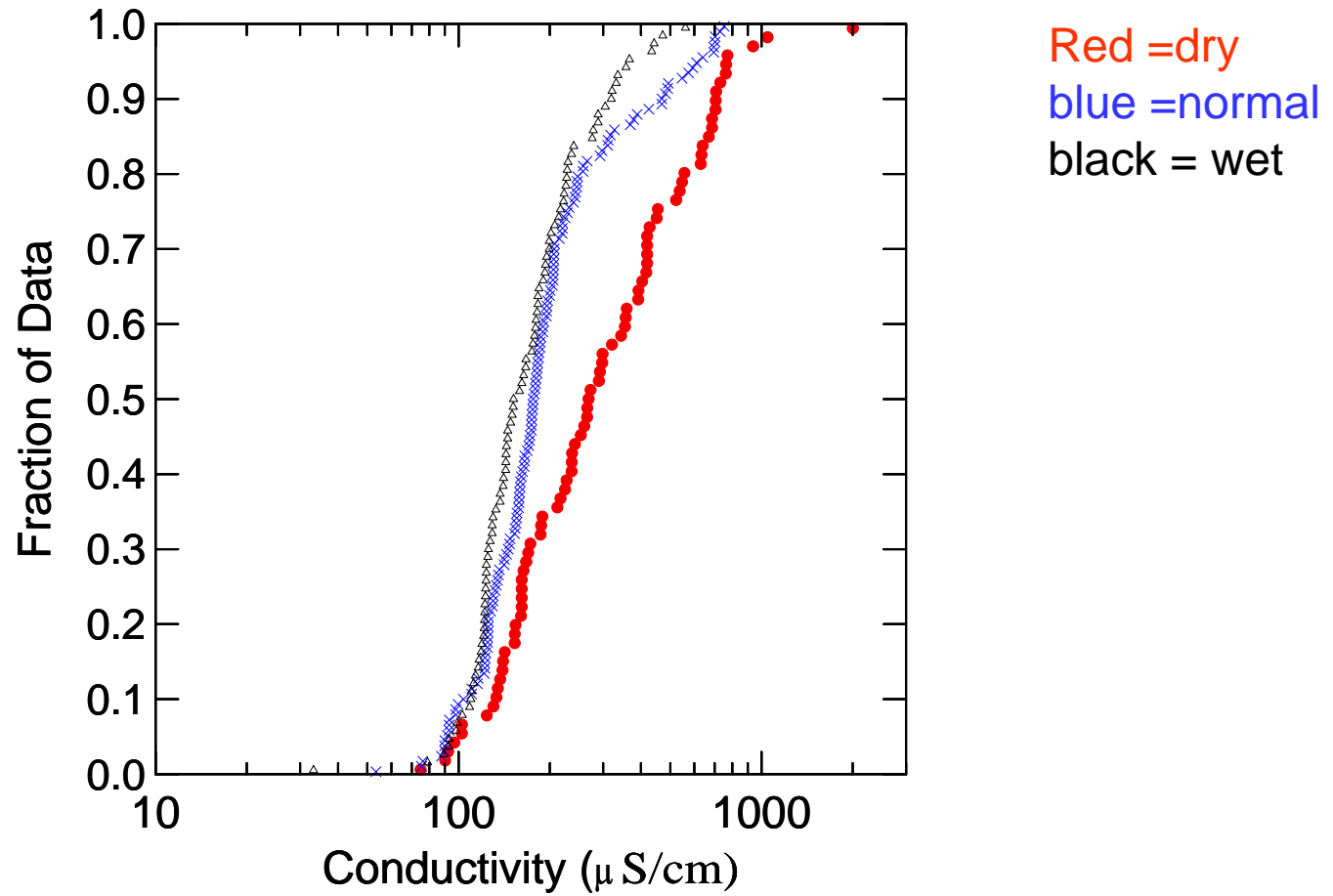
- Greater variability in “non-normal” conditions, especially in reference
- Slight decline of reference value
- Reduces ability to detect impairment



Stressor Identification

- Example stress-response relationships
- Re-examine under wet and dry conditions
- Conductivity, impervious surface

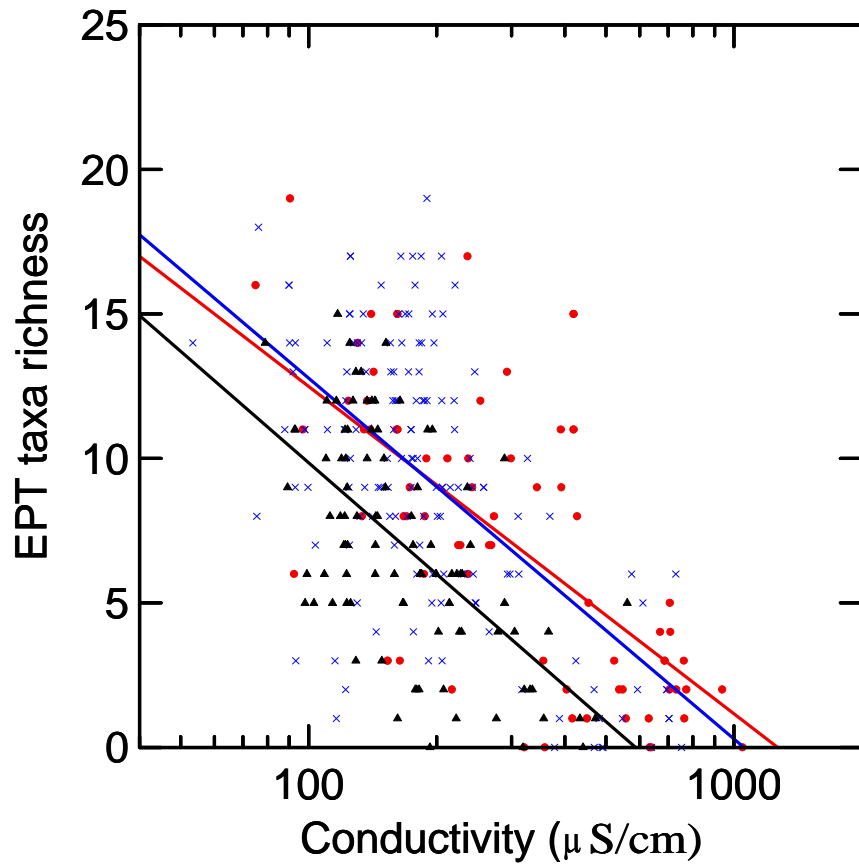
Conductivity CDFs Piedmont



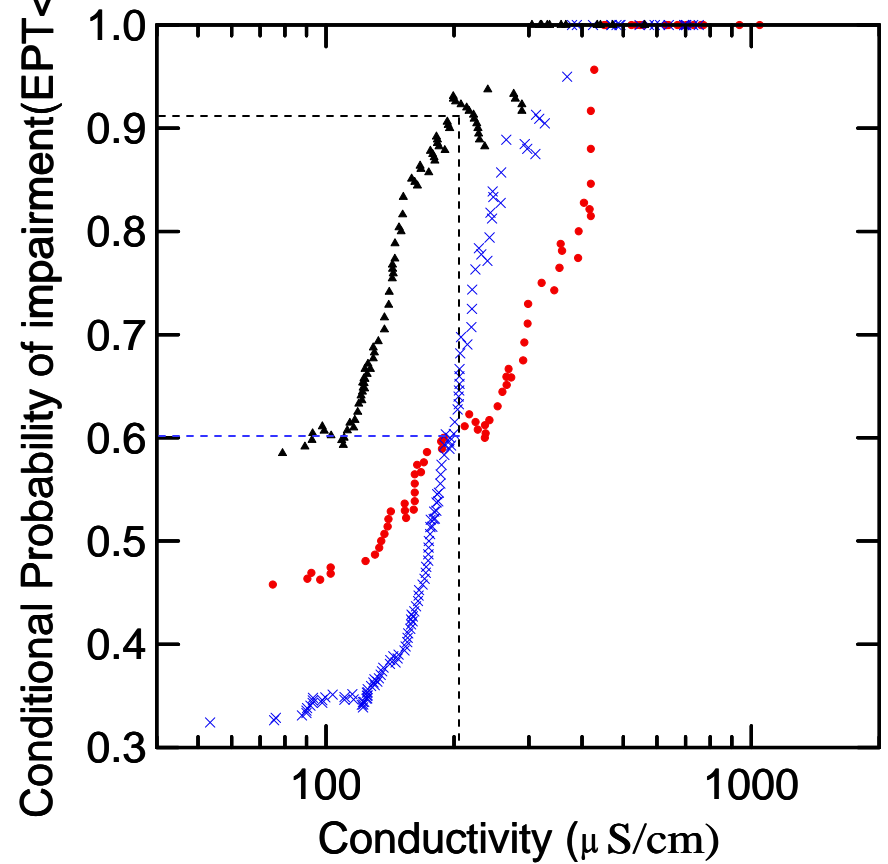
Conductivity Stress-Response Piedmont

Red = dry
blue = normal
black = wet

Data and regressions



Conditional probability model



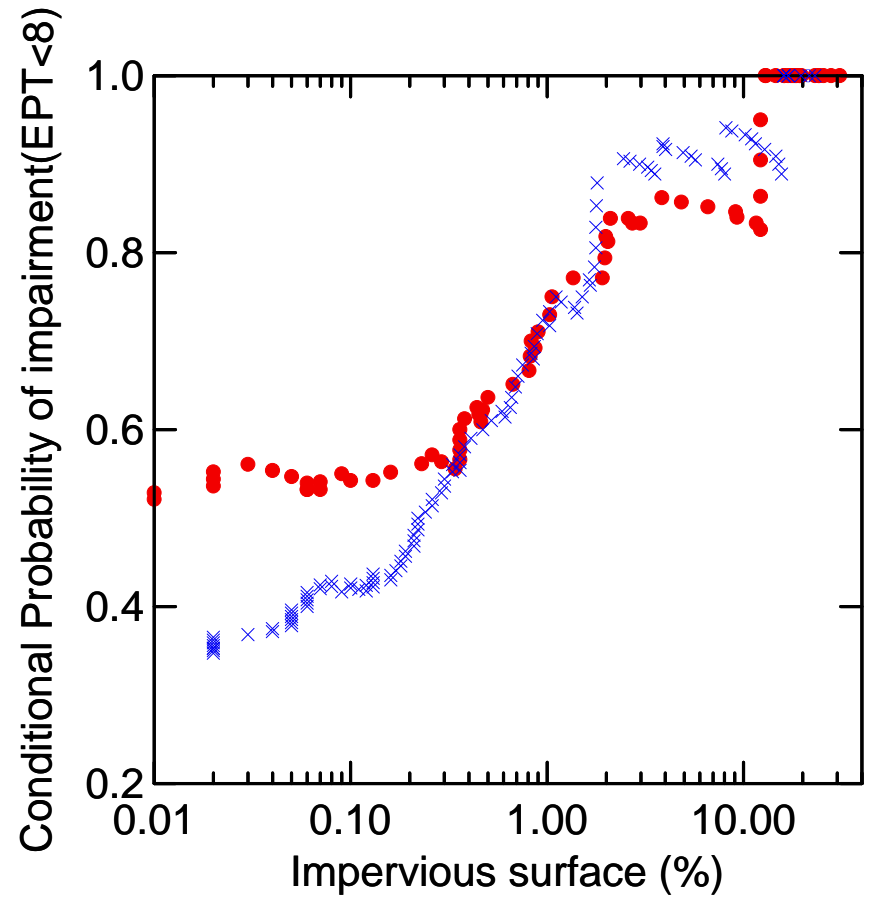
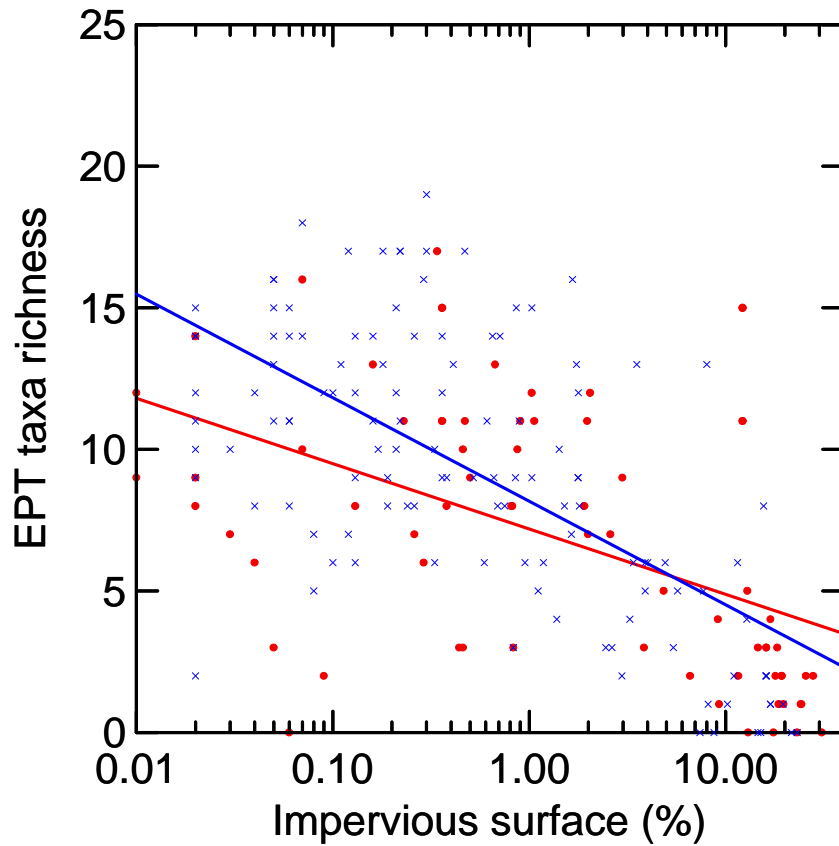


Conductivity response

- Stress-response of EPT: more likely to have reduced EPT under wet conditions (but slope unchanged)

Impervious Surface stress-response Piedmont

Red =dry
blue =normal



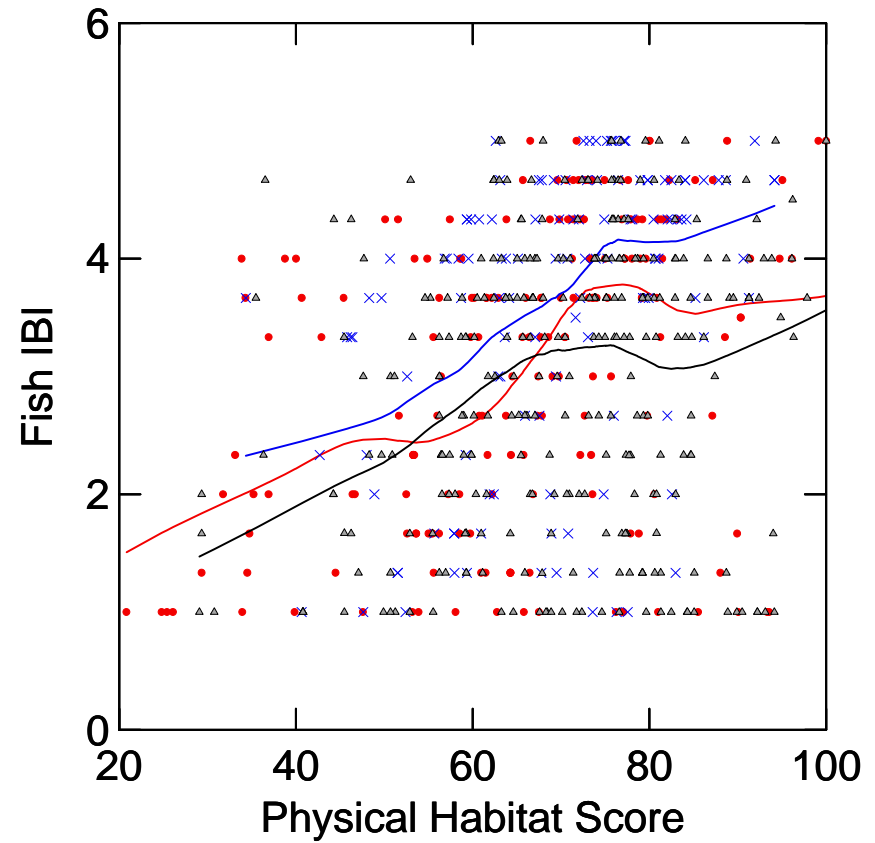
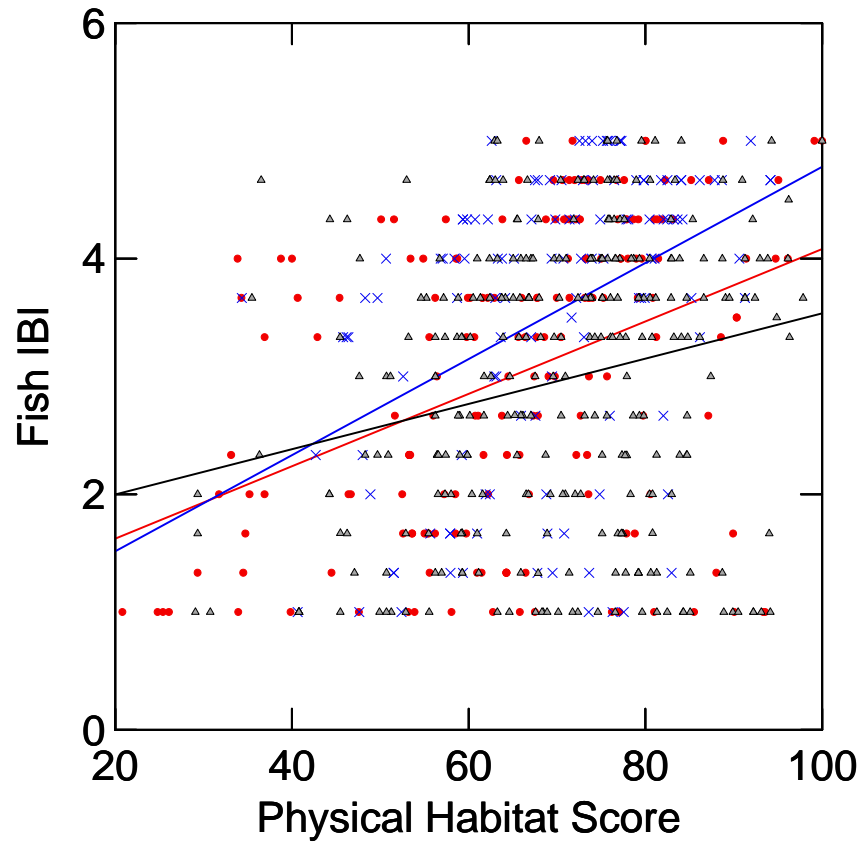


Impervious surface

- In dry years, EPT reduced in less-stressed sites, but EPT in highly stressed sites are less affected by the dry conditions

Fish IBI Stress-response to habitat.

Red = dry
blue = normal
black = wet





Fish IBI response to habitat

- Slope of response unchanged, but wet or dry conditions equivalent to 10-20% reduction of habitat index

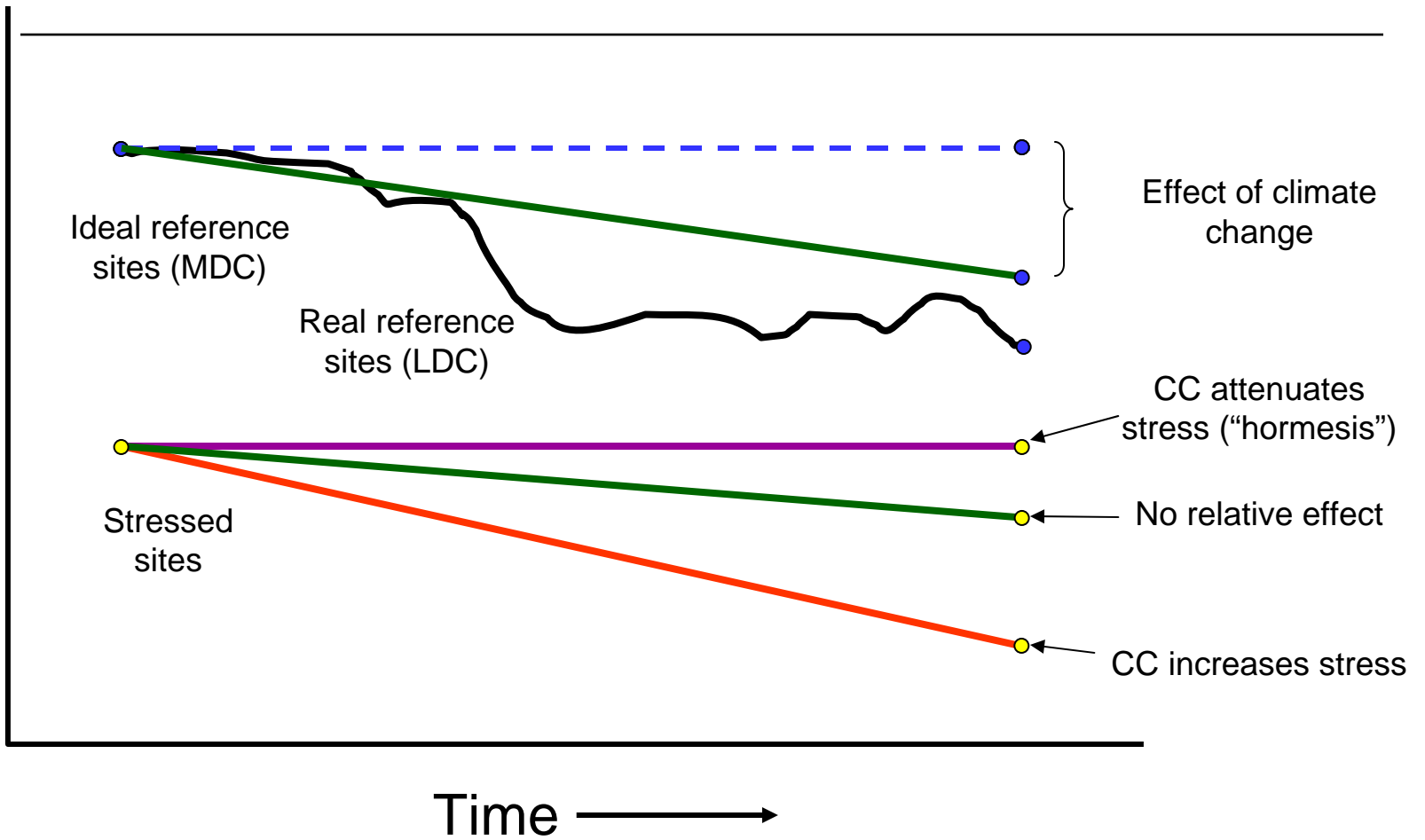


Consequences

- Loss of cold and cool-water habitats
- Decreased ability to detect impairment
- General increase in variability
- Decreased precision of some stress-response relationship
- Projected changes from this analysis NOT devastating or overwhelming
- Adaptation?

Conceptual model

Biological Indicator





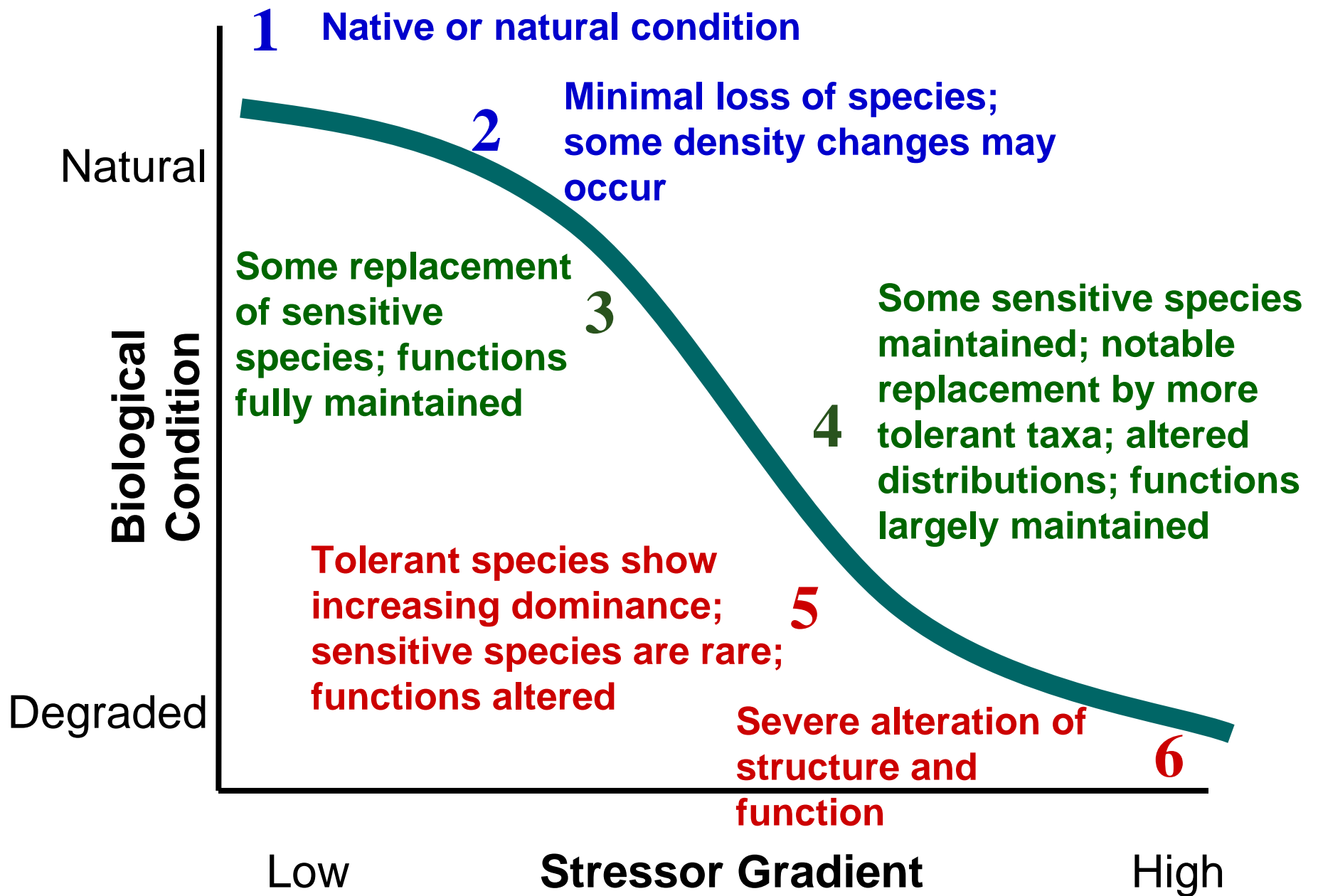
Recommendations

- Adopt universal measurement scale: calibrate biological condition gradient



The Biological Condition Gradient

- Conceptual model - describe changes with increasing stress
- Biologically identifiable levels (tiers) of condition
- Ecological theory and empirical knowledge
- Universal yardstick for degree of change from natural
- Regional calibration
 - Conceptual model
 - Quantitative decision model





BCG (cont.)

- Levels of biological condition can be used directly as regulatory criteria and management goals
- Direct bridge between technical observation and management for ecological endpoints



Recommendations (cont.)

- Nationwide calibration of BCG: establishes 2 baselines
 - Level 1 pristine condition (relies on historical descriptions)
 - Present-day minimally or least stressed condition
- Protect reference sites, least stressed or better
- Monitor sentinel sites (reference and non-ref)
- Research on analytical methods, indicators, for stressor identification