Case Study: Consequences of climate change for biocriteria

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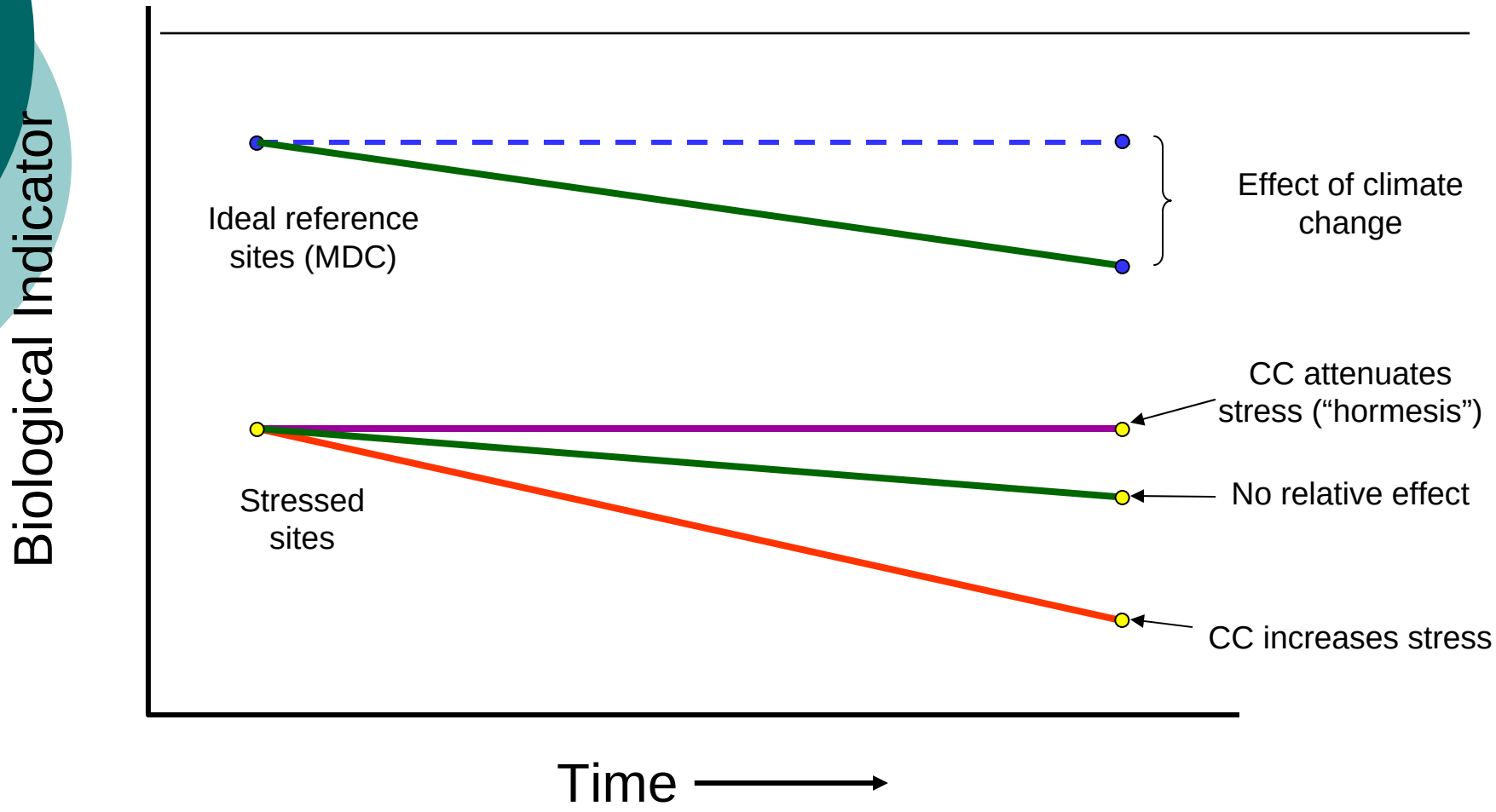
Approach

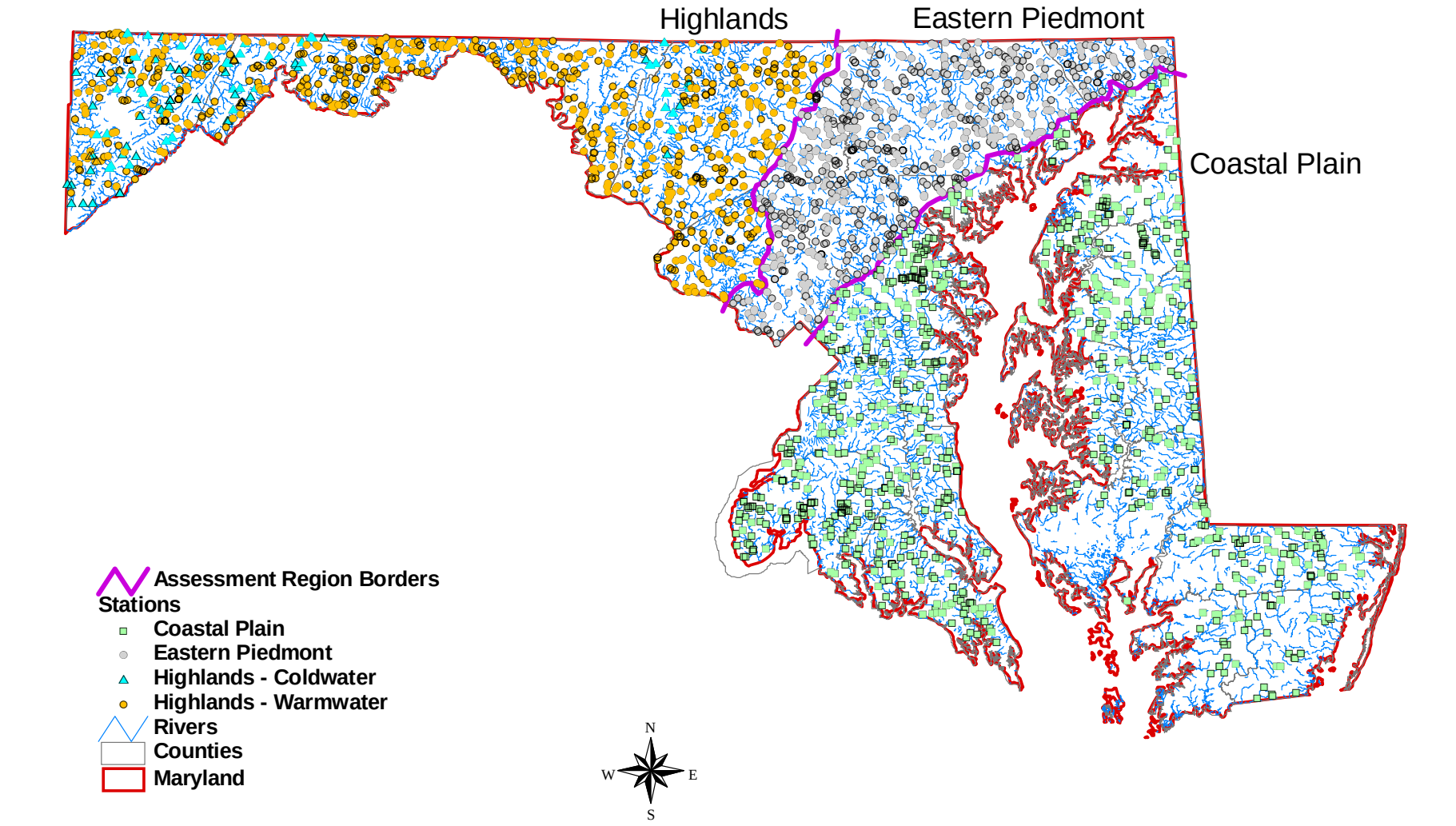
- Examine effects of temperature, hydrologic parameters, and climate *within* single data set
- Data requirements:
  - Fish and benthic macroinvertebrates
  - Long time period to cover climate variations (dry and wet periods)
  - Cover range of at least some stressors (least to most)
  - Data QA complete

Conceptual model



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
N
W
E
S
80
0
80
160
Miles

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)

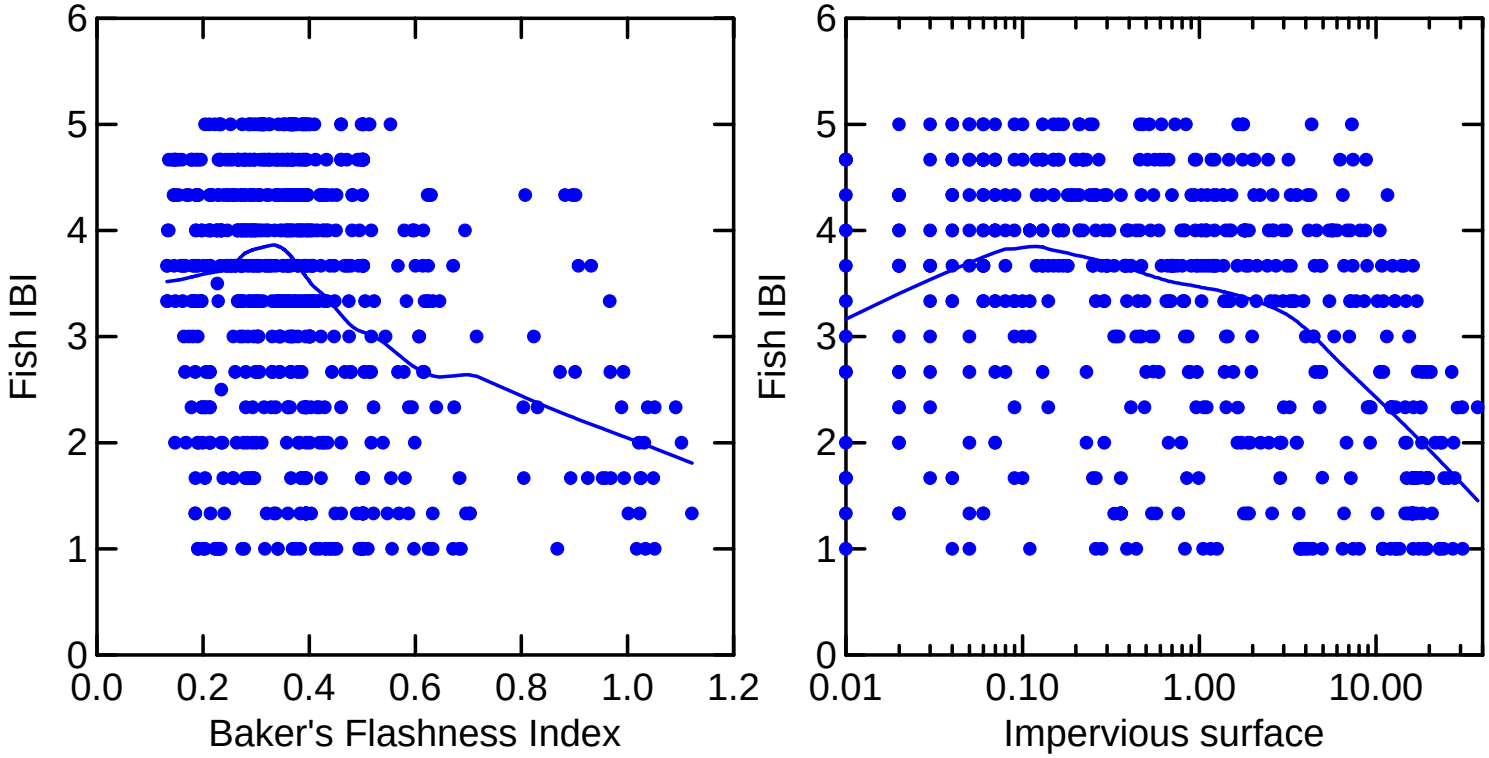
Response variables

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

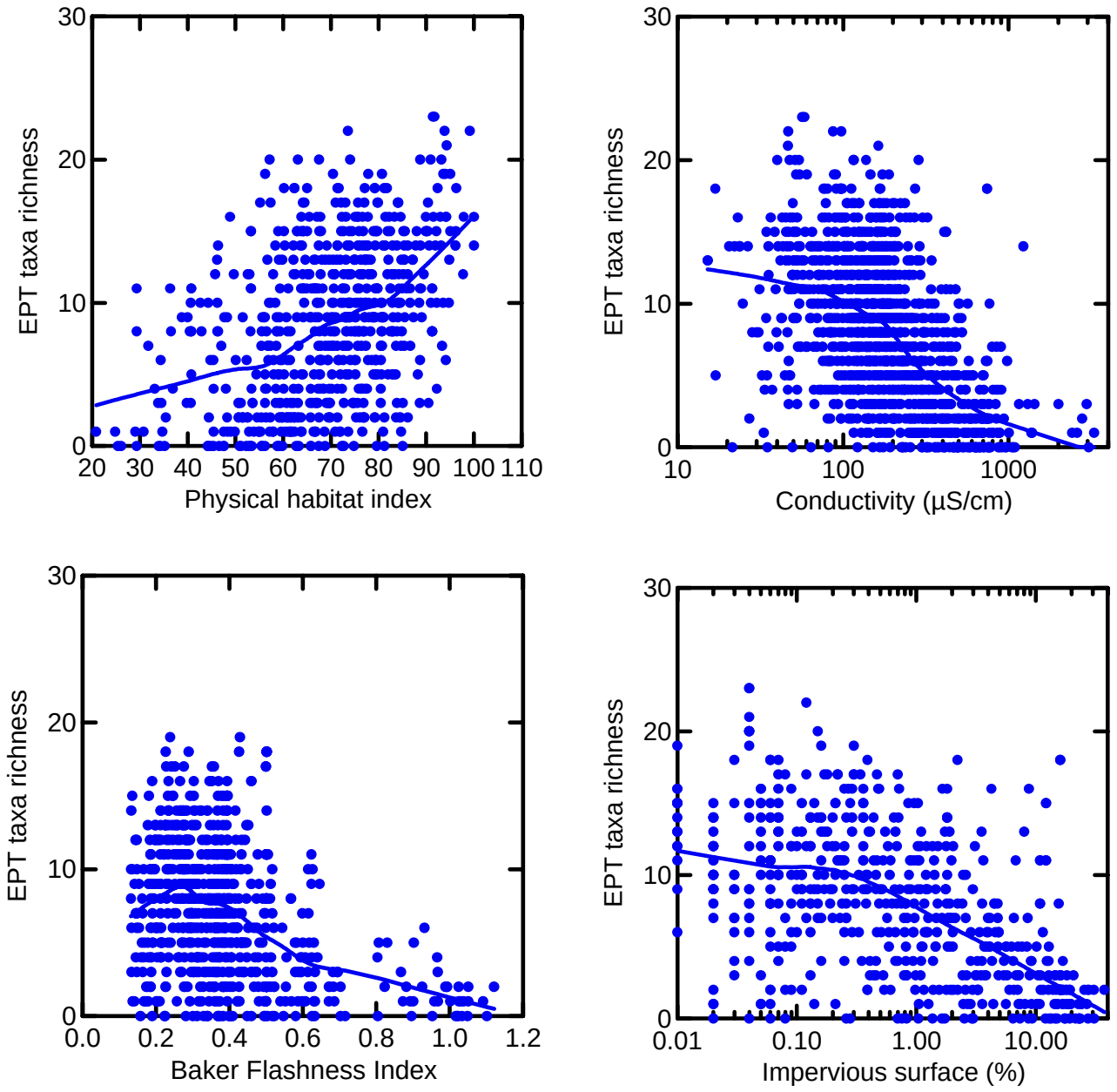
Biological Responses

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

Fish responses



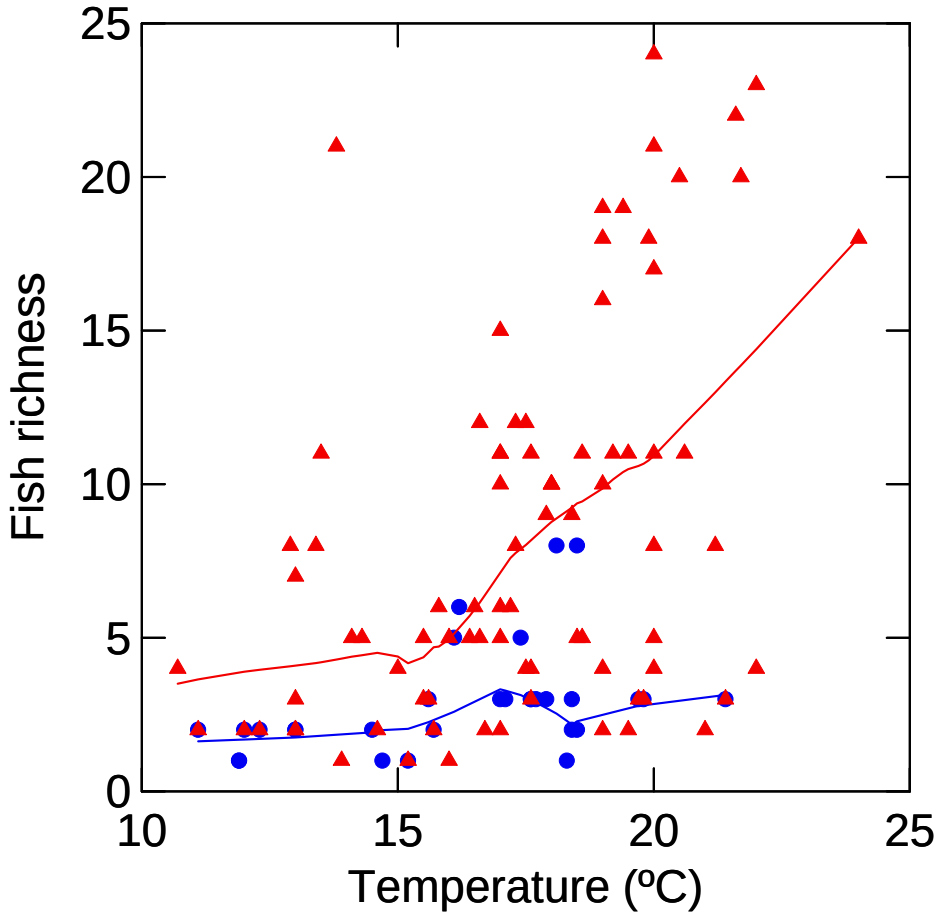
EPT responses



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

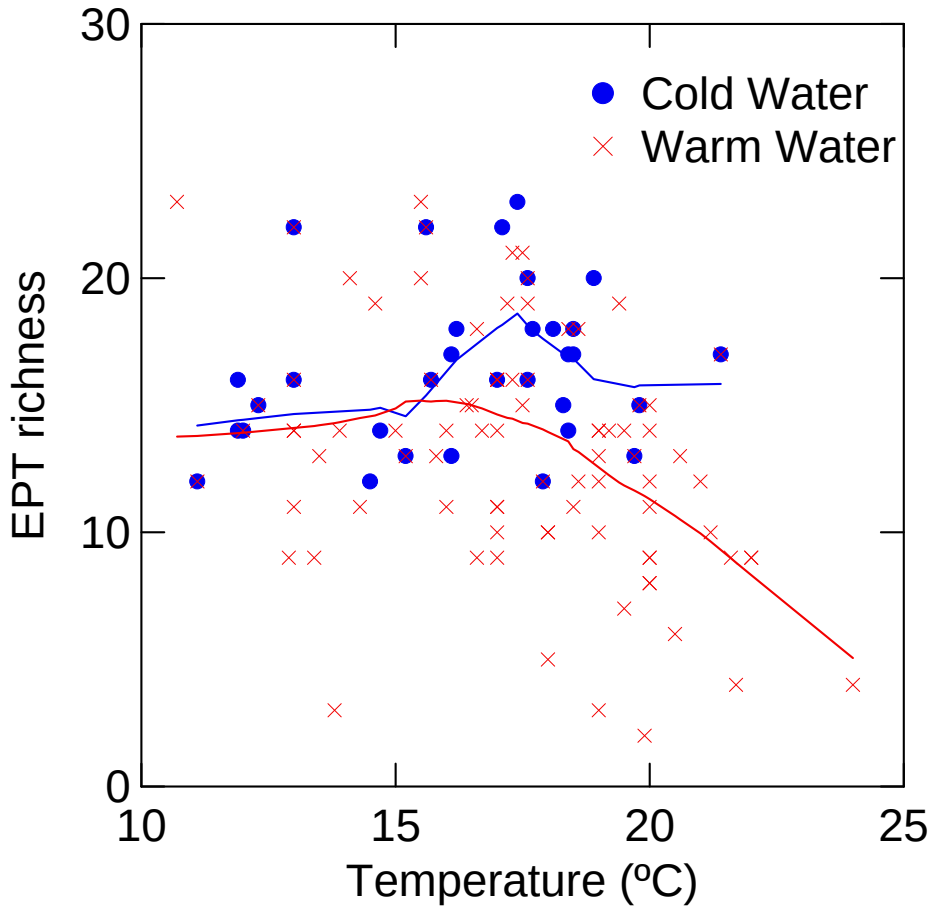
Fish and Temperature



Warm Water
(Red)

Cold Water
(Blue)

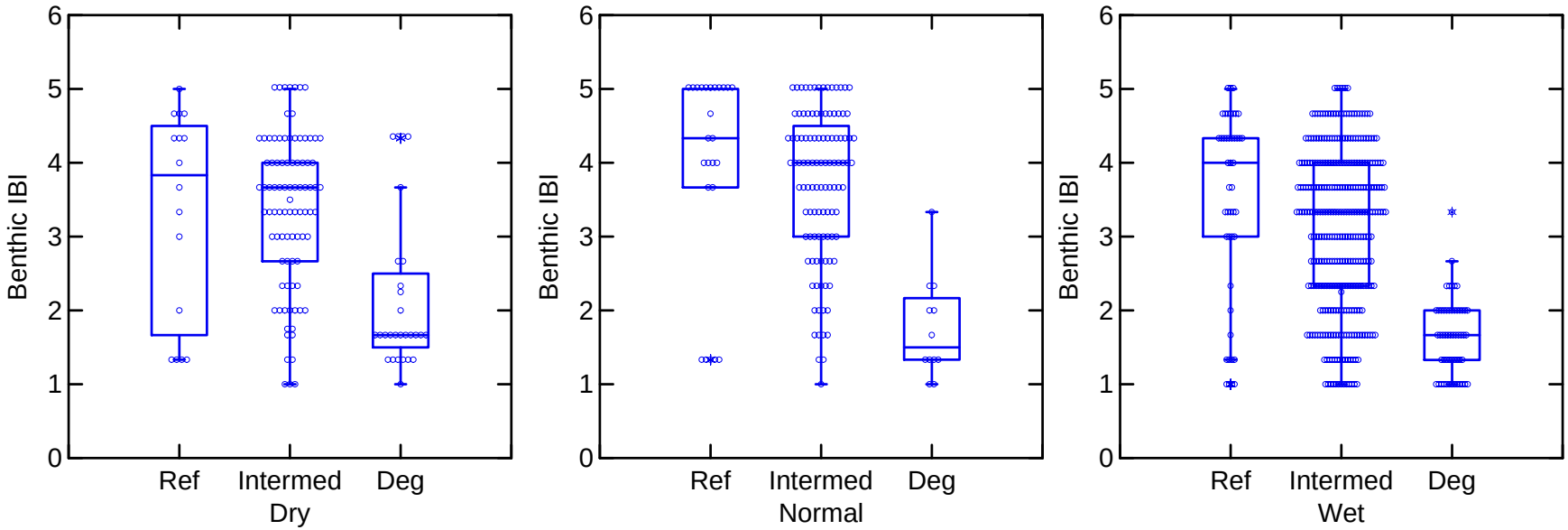
Invertebrates and temperature - Highland streams



Detection of impairment

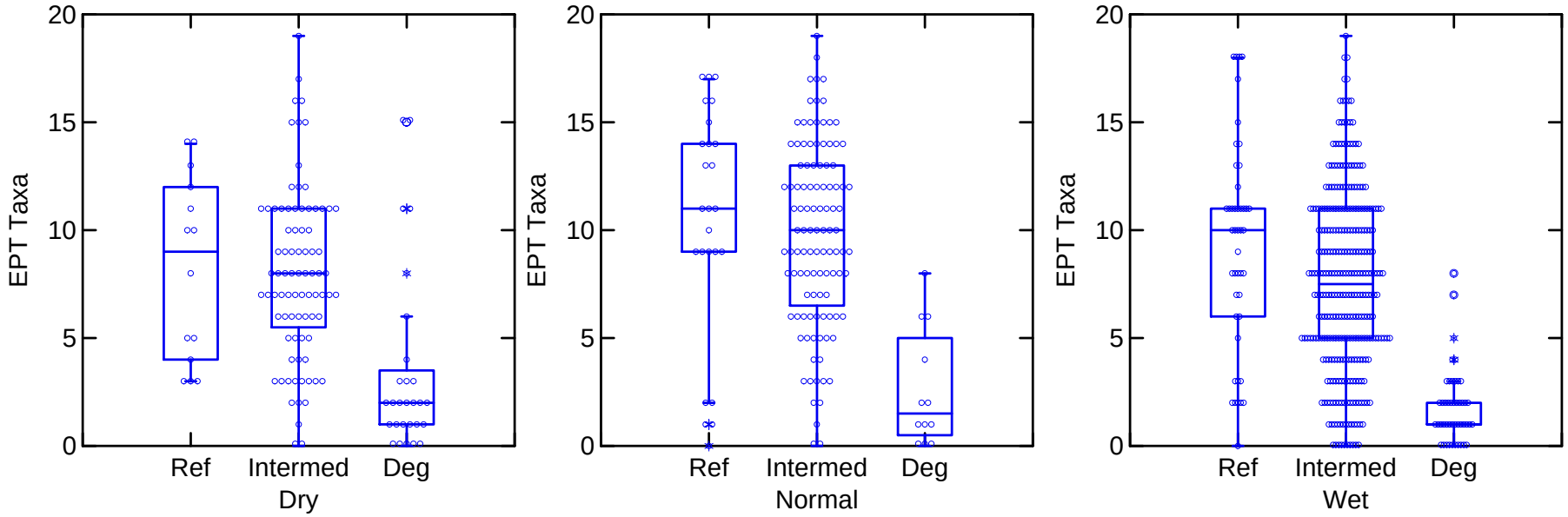
- Climate condition:
  - “Dry”: PHDI < -2.5
  - “Normal”: -1.1 < PHDI < 1.0
  - “Wet”: PHDI > 3.5
- Ability to detect impairment, reference and stressed sites

Benthic IBI



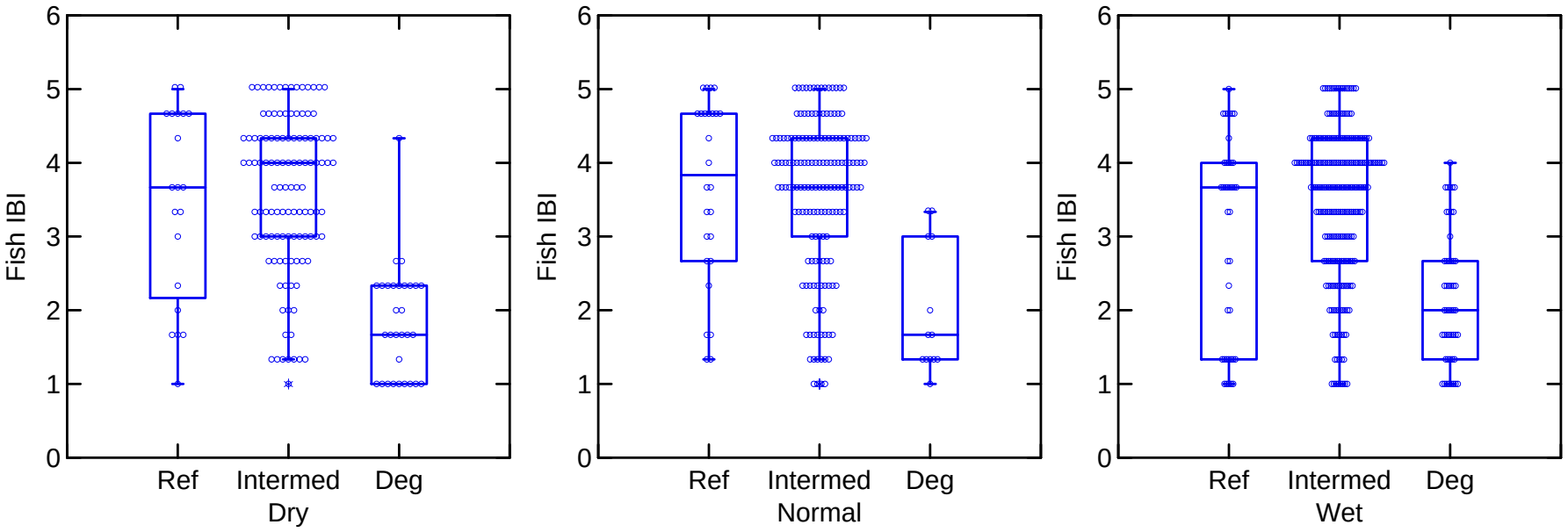
Dry Normal Wet

EPT



Dry Normal Wet

Fish IBI



Dry Normal Wet

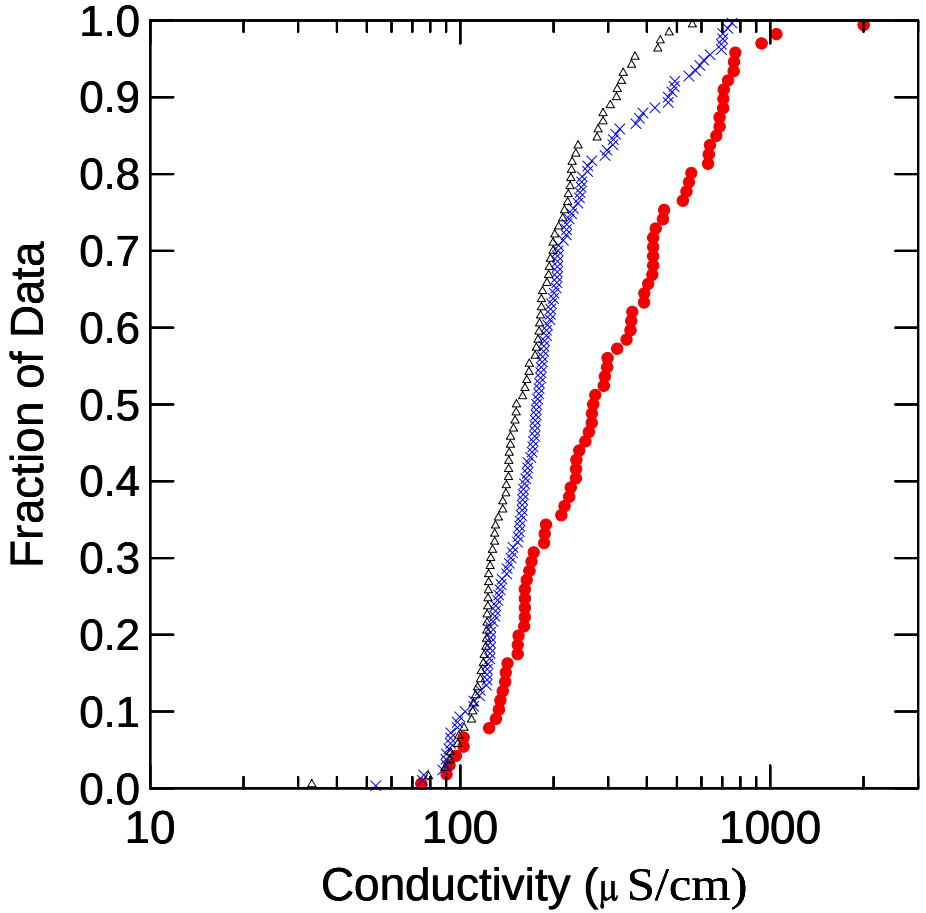
Detection of Impairment

- 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

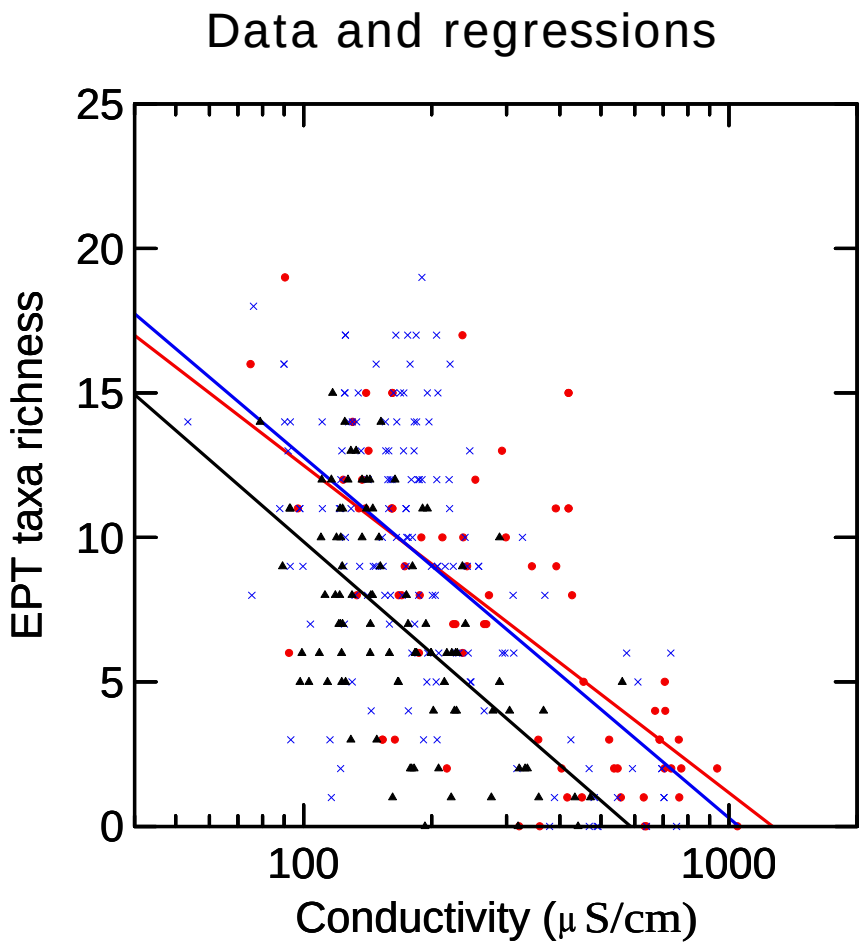
Conductivity CDFs
Piedmont

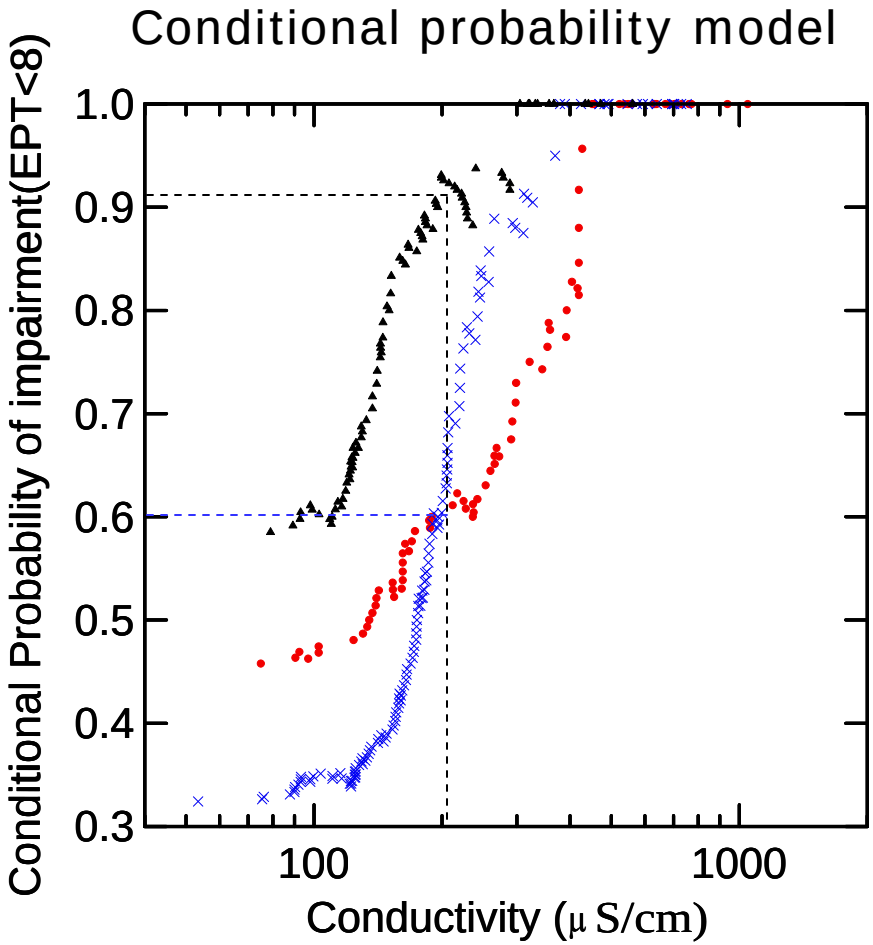


Red =dry
blue =normal
black = wet

Conductivity Stress-Response
Piedmont

Red =dry
blue =normal
black = wet



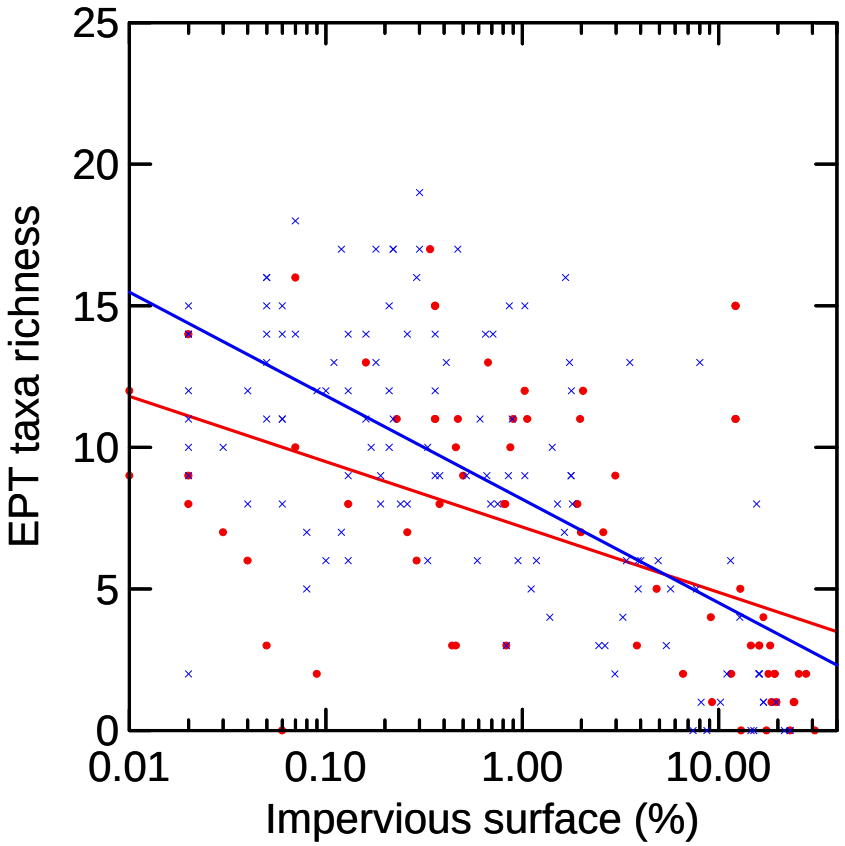


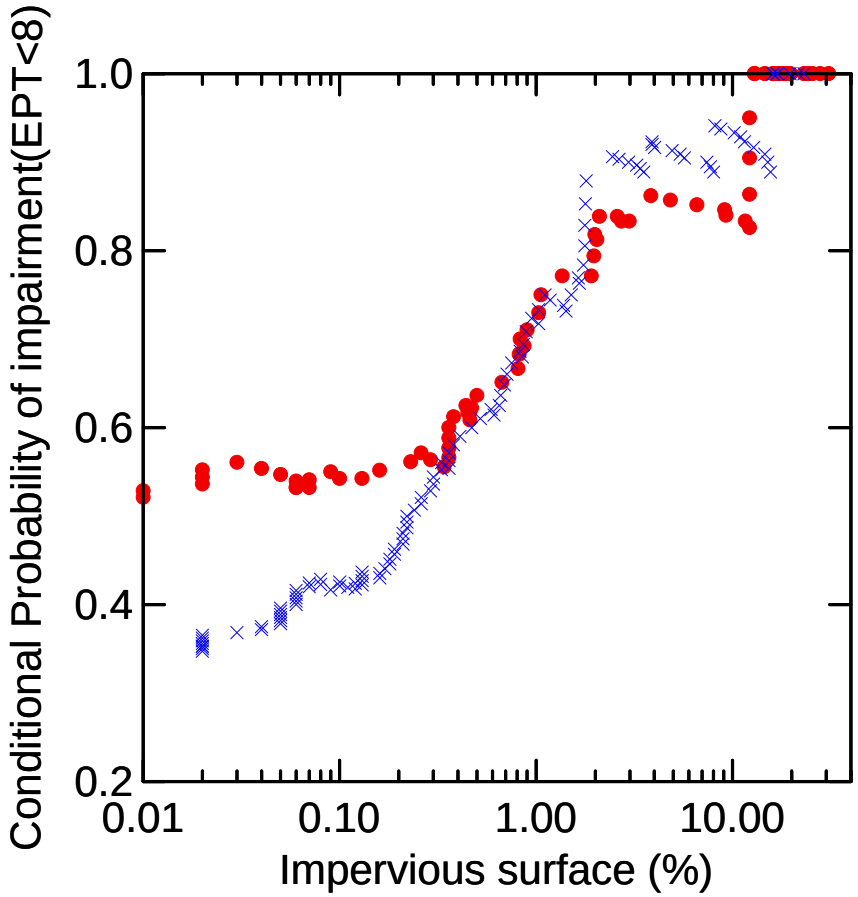
Conductivity response

- 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



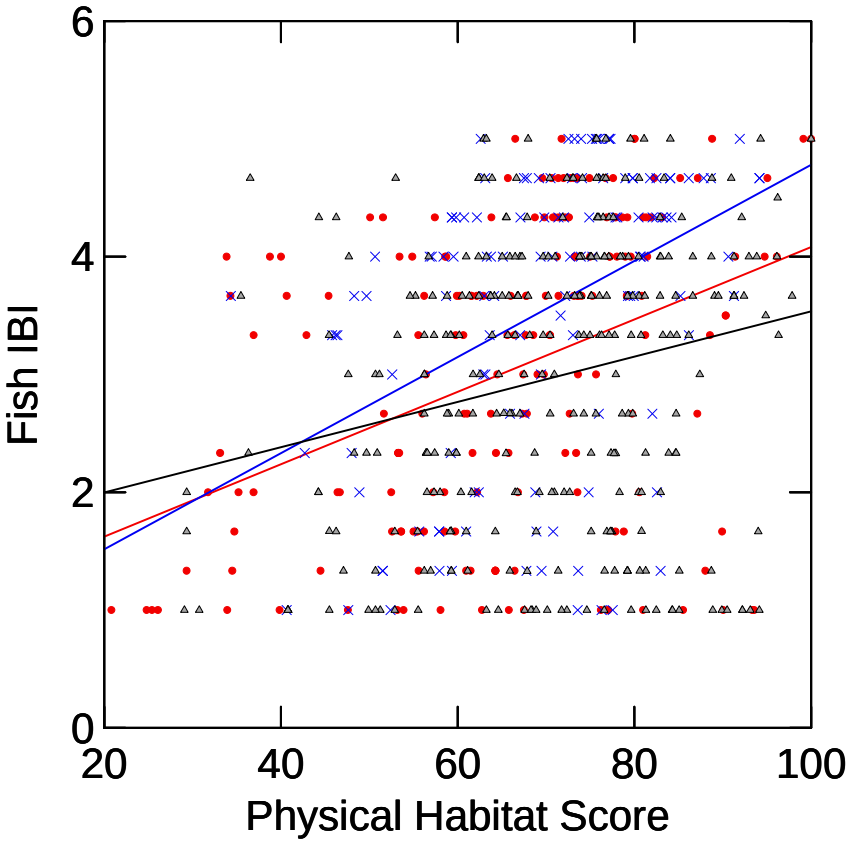


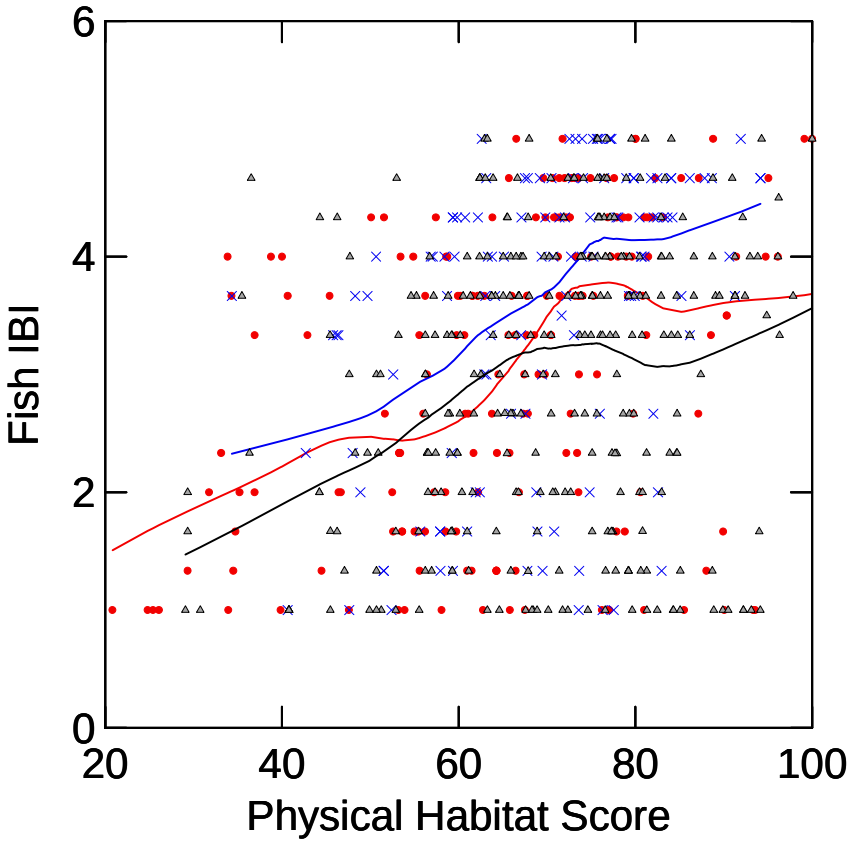
Impervious surface

- 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





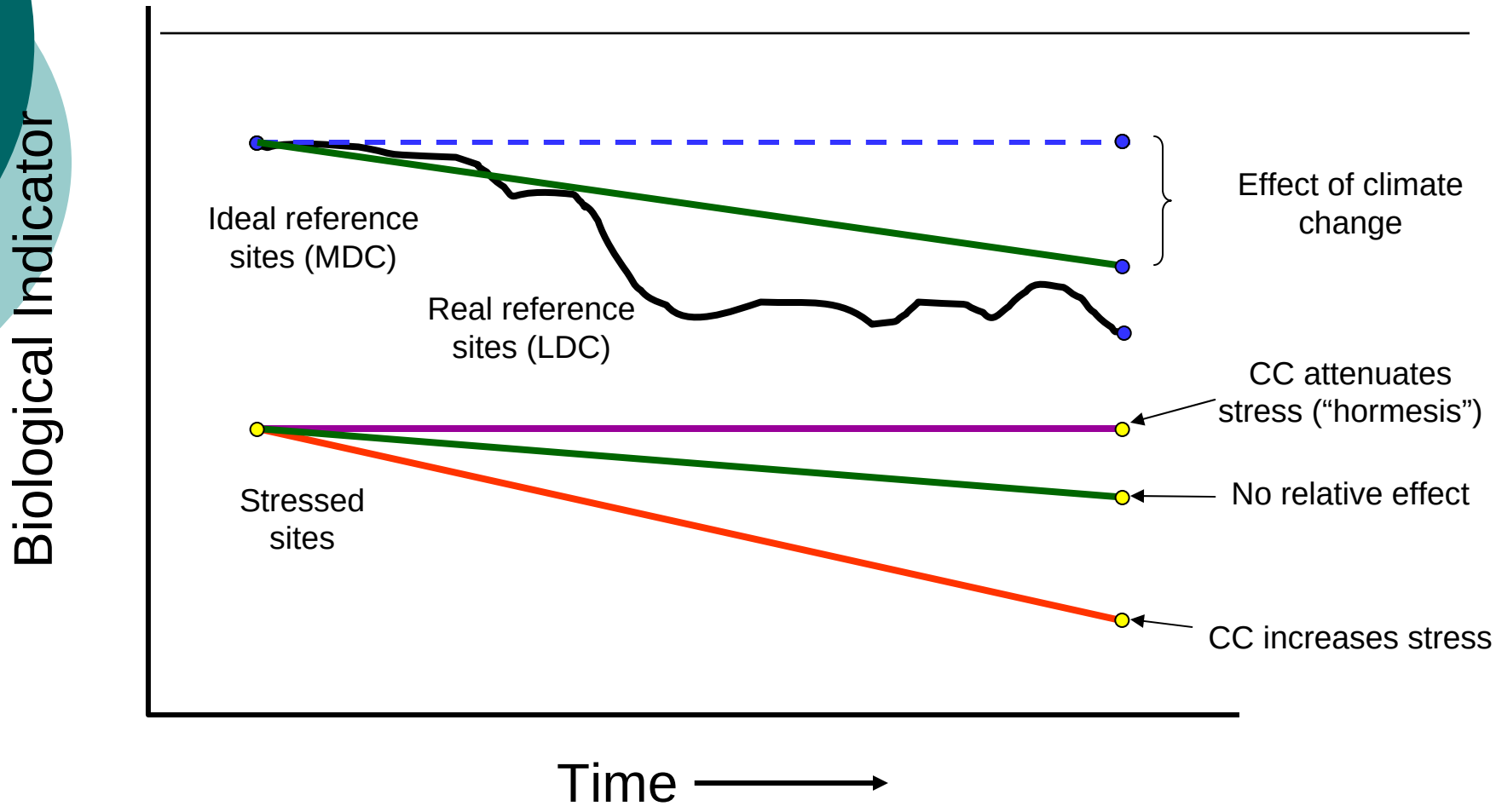
Fish IBI response to habitat

- 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

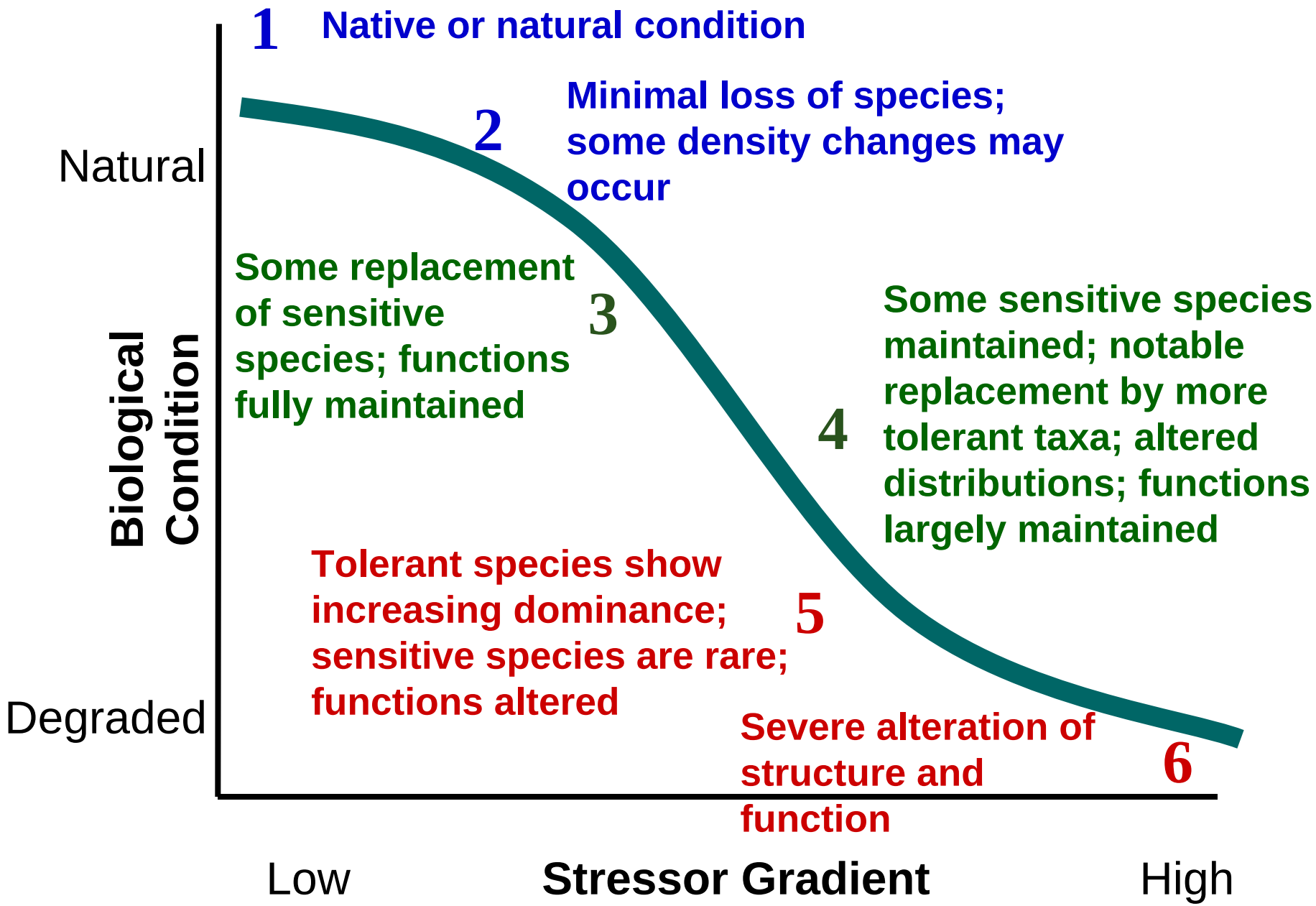


Recommendations

- 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


1
Native or natural condition
2
Minimal loss of species; some density changes may occur
3
Some replacement of sensitive species; functions fully maintained
4
Some sensitive species maintained; notable replacement by more tolerant taxa; altered distributions; functions largely maintained
5
Tolerant species show increasing dominance; sensitive species are rare; functions altered
6
Severe alteration of structure and function
Natural
Degraded
Biological Condition
Low
Stressor Gradient
High

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