Vulnerability Assessment of New England Streams: Developing a Monitoring Network to Detect Climate Change Effects

National Water Quality Monitoring Council
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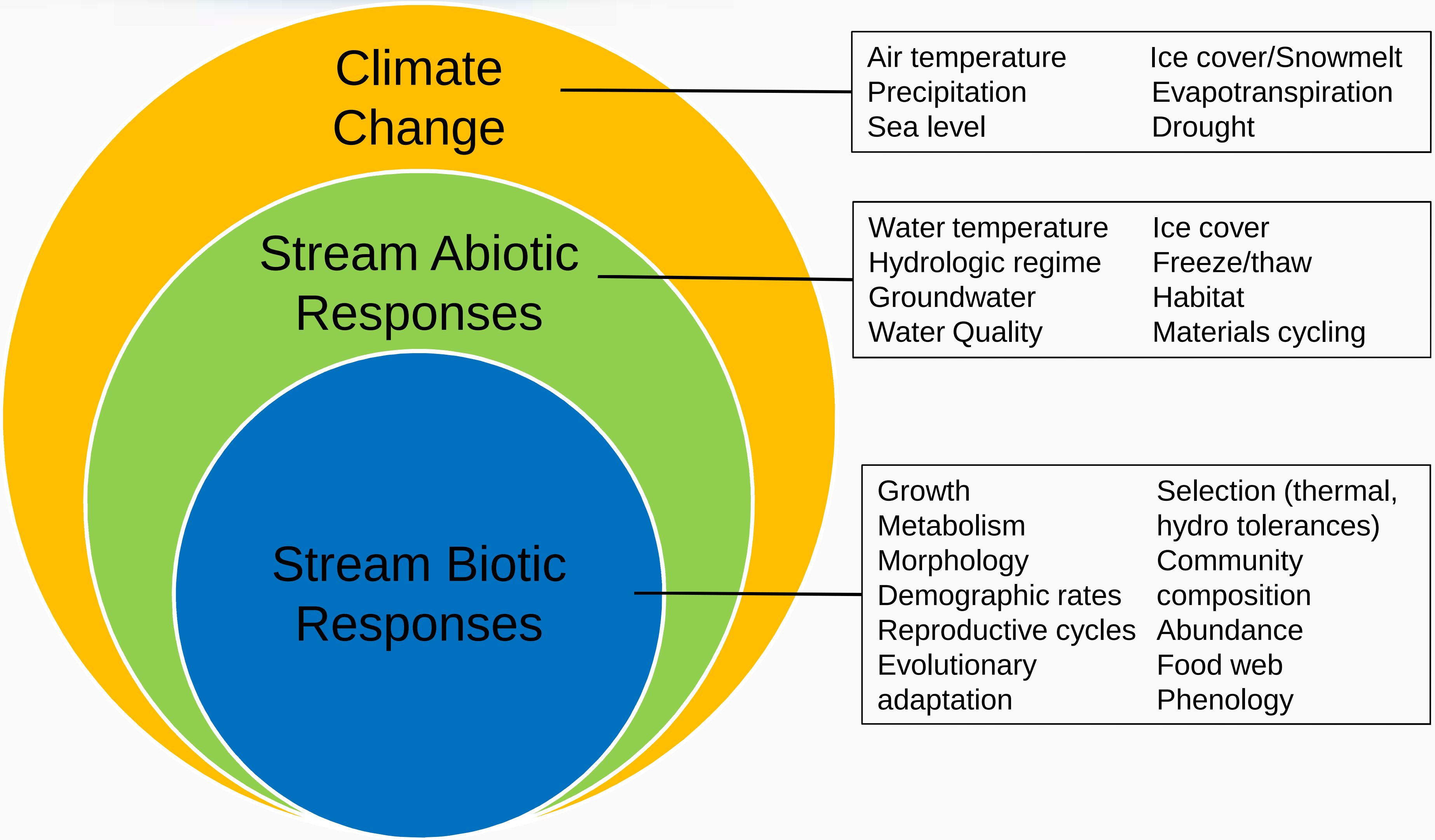

Climate Change
Stream Abiotic Responses
Stream Biotic Responses
Air temperature
Precipitation
Sea level
Ice cover/Snowmelt
Evapotranspiration
Drought
Water temperature
Hydrologic regime
Groundwater
Water Quality
Ice cover
Freeze/thaw
Habitat
Materials cycling
Growth
Metabolism
Morphology
Demographic rates
Reproductive cycles
Evolutionary adaptation
Selection (thermal, hydro tolerances)
Community composition
Abundance
Food web
Phenology

Monitoring designed to…

- Detect impairment relative to reference condition
- Report on ecosystem condition

Monitoring is not yet designed to detect climate change effects in aquatic ecosystems

Northeast Climate Change Monitoring Pilot

New England/New York

Benefits of regional approach

- Pool limited resources
- More data to analyze
- Ecoregions cross state lines
- Climate is larger scale

Challenges of regional approach

- Differences in collection methods, sample processing/subsampling methods, taxonomy, index periods (season of collection)
- Jurisdictional cooperation

Technical Steering Group includes biologists from state biomonitoring programs, EPA Regions & OWOW, & USGS

Objectives & Design

Monitoring Objectives

- Detect climate-related changes early and inform management (e.g., restoration, adaptation) strategies
- Distinguish climate change effects from other sources of environmental variation and stressors

Additional Monitoring Considerations

- **What geographic scale is appropriate?**

  Use classification and variance structure
- **How do climate change effects influence site selection?**
  Conduct vulnerability assessment using climate exposure, site sensitivity
- **What sample size is sufficient?**

  Conduct power analysis using reference site data, climate-sensitive indicators

Analytical Foundation for Network Design

Reference sites selection

- Define criteria
- Examine spatial coverage, access, long-term protection

Regional classification

- Define areas of similar ecological type
- Partition natural variation
- Sample as unit to assess condition and track climate change
- Common reference population

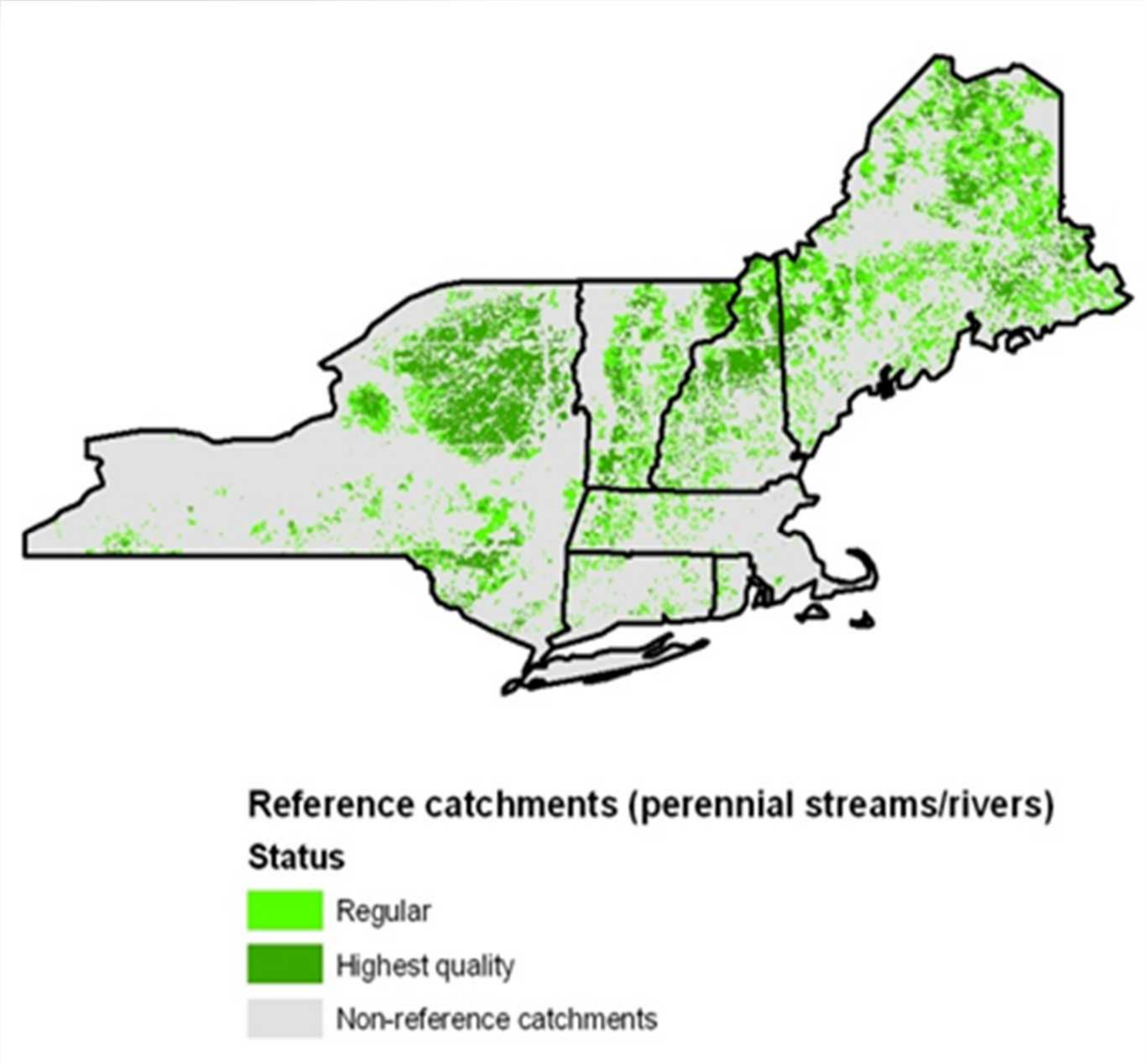
Vulnerability analysis

- An additional ‘axis’ of classification
- Account for exposure and sensitivity to climate change
- Focus sample design for earliest detection, greatest responses

Sampling Methods (common across network)

Indicator selection

Spatial Distribution of Reference Catchments

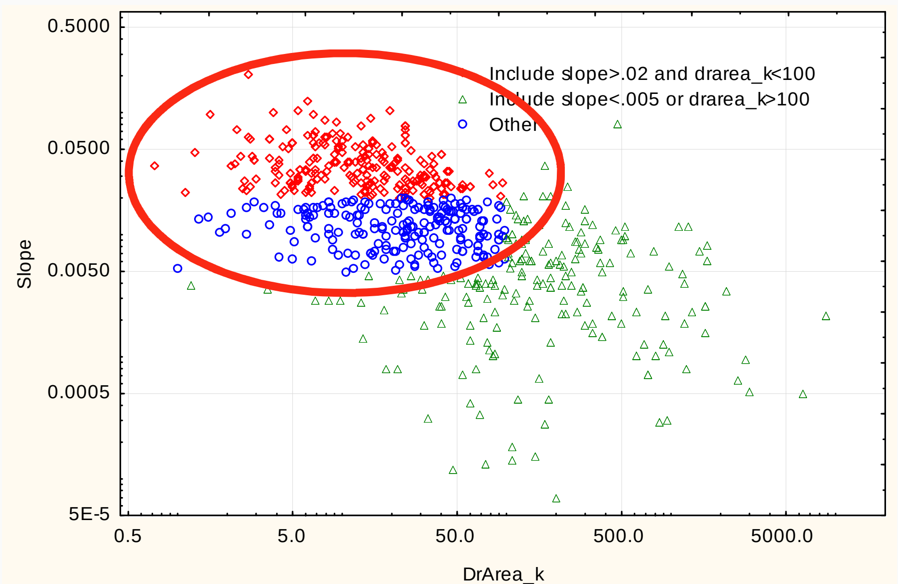


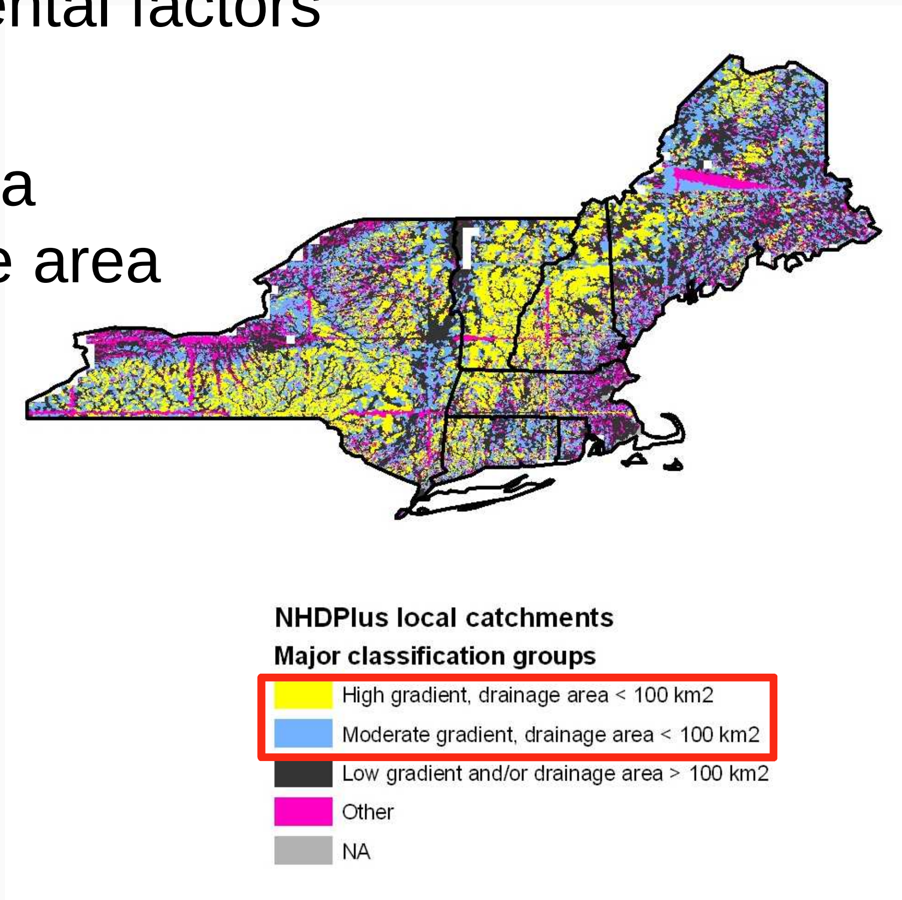
Regional Classification

Multivariate analyses

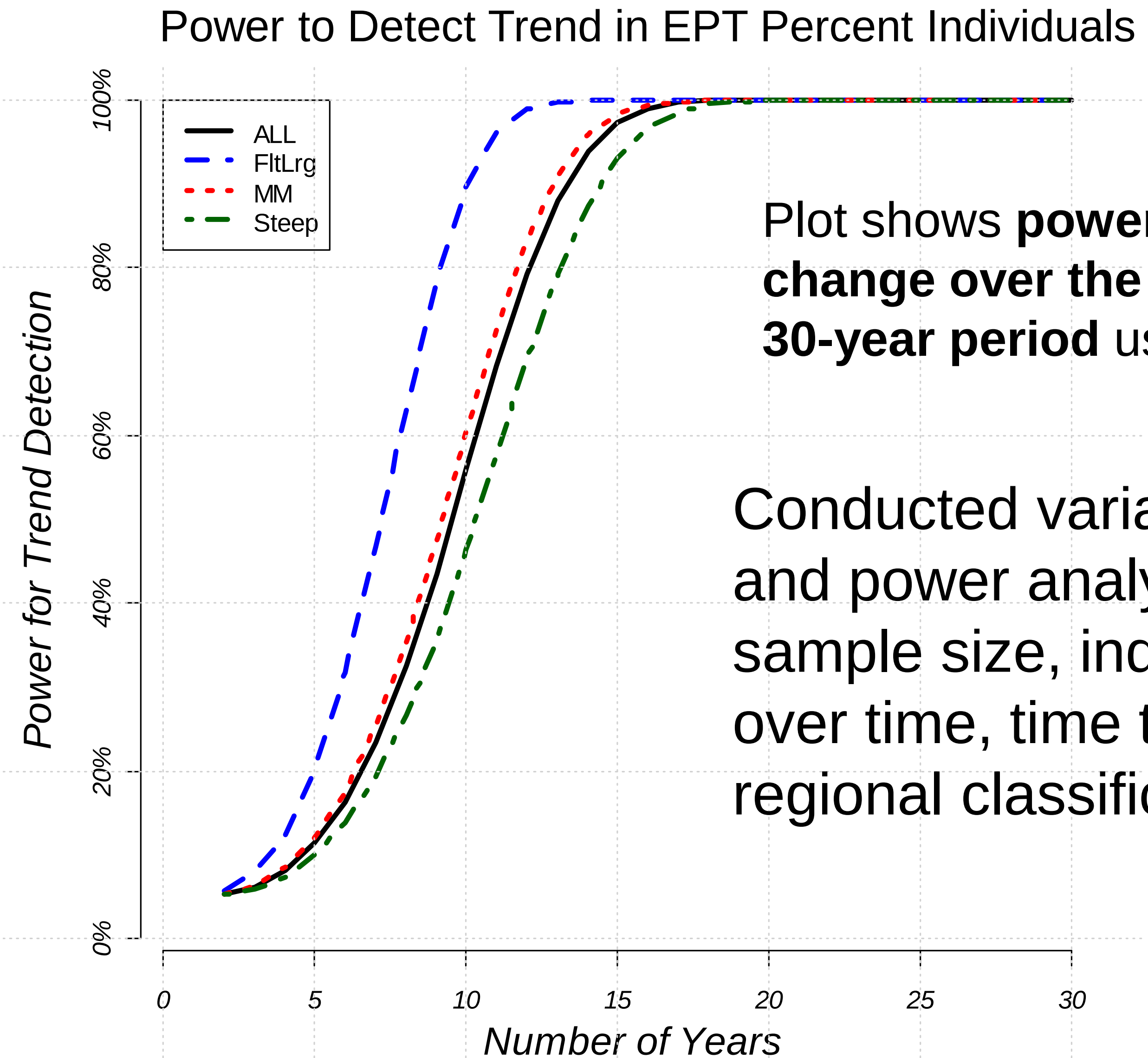
1. Discern dominant environmental factors
2. Minimize variance

- Benthic macroinvertebrate data
- Slope and watershed drainage area





Power Analysis Results

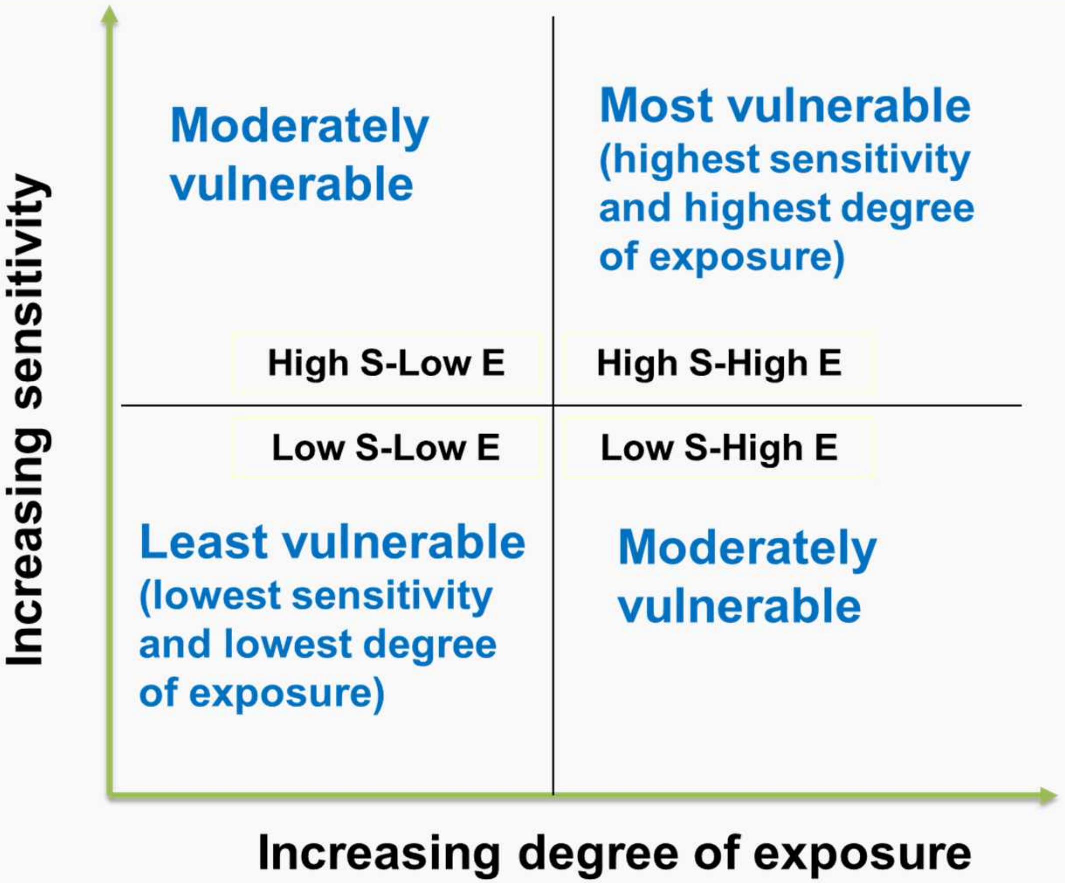


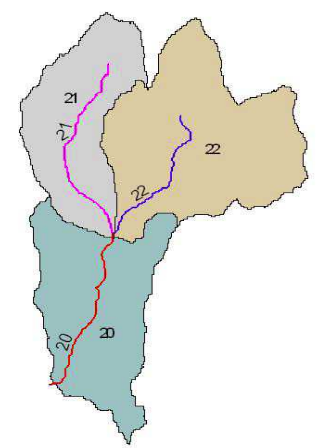
Plot shows **power of detecting a 2% change over the class mean** for a **30-year period** using **25 sites**

Conducted variance components and power analyses to inform on sample size, indicators to track over time, time to detect trend and regional classification scheme

Climate Change Vulnerability Assessment

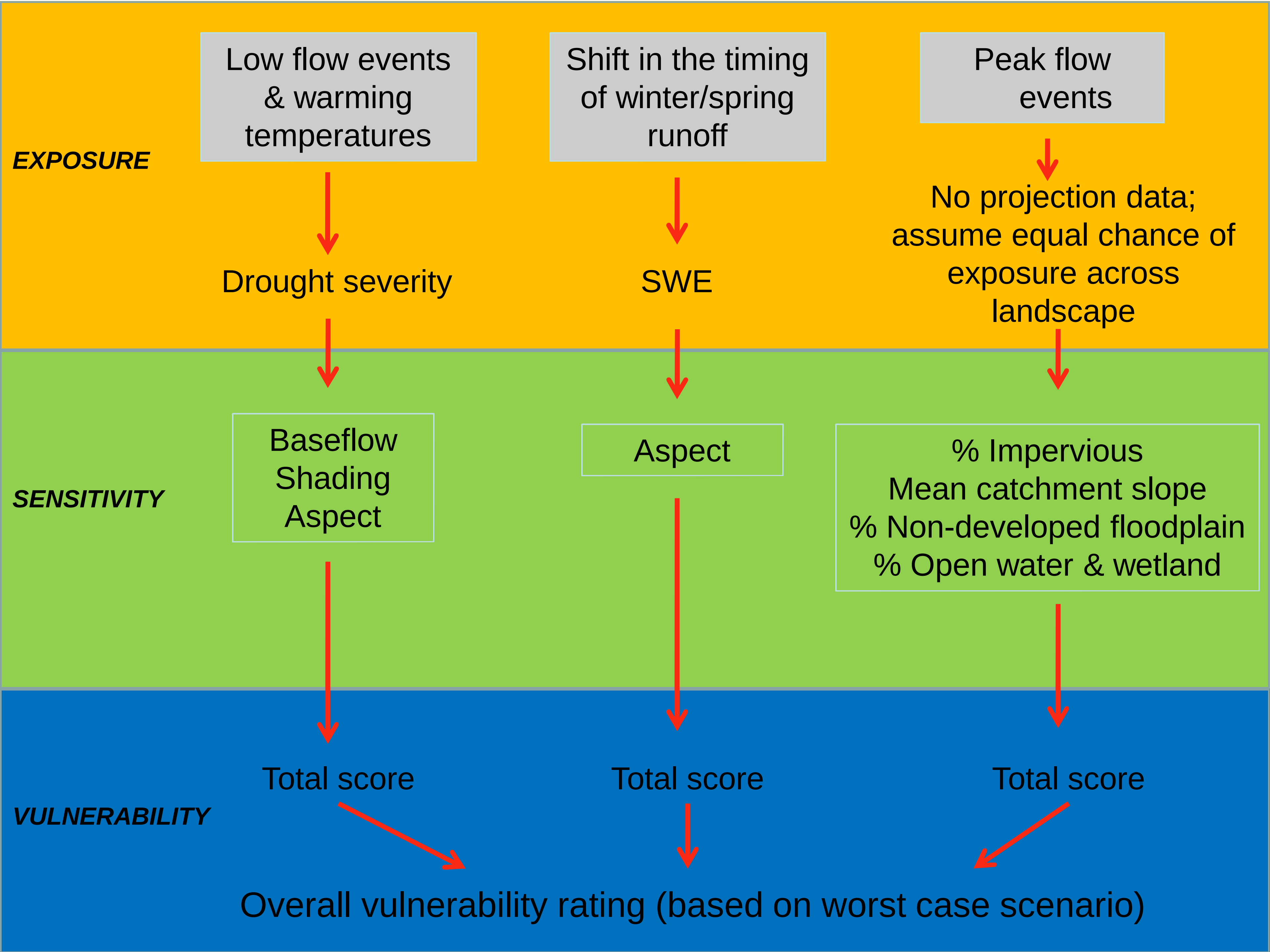
Local catchments sorted by degree of exposure to climatic change (E) X sensitivity (S)





A. Local Catchments for Reaches 20, 21, and 22

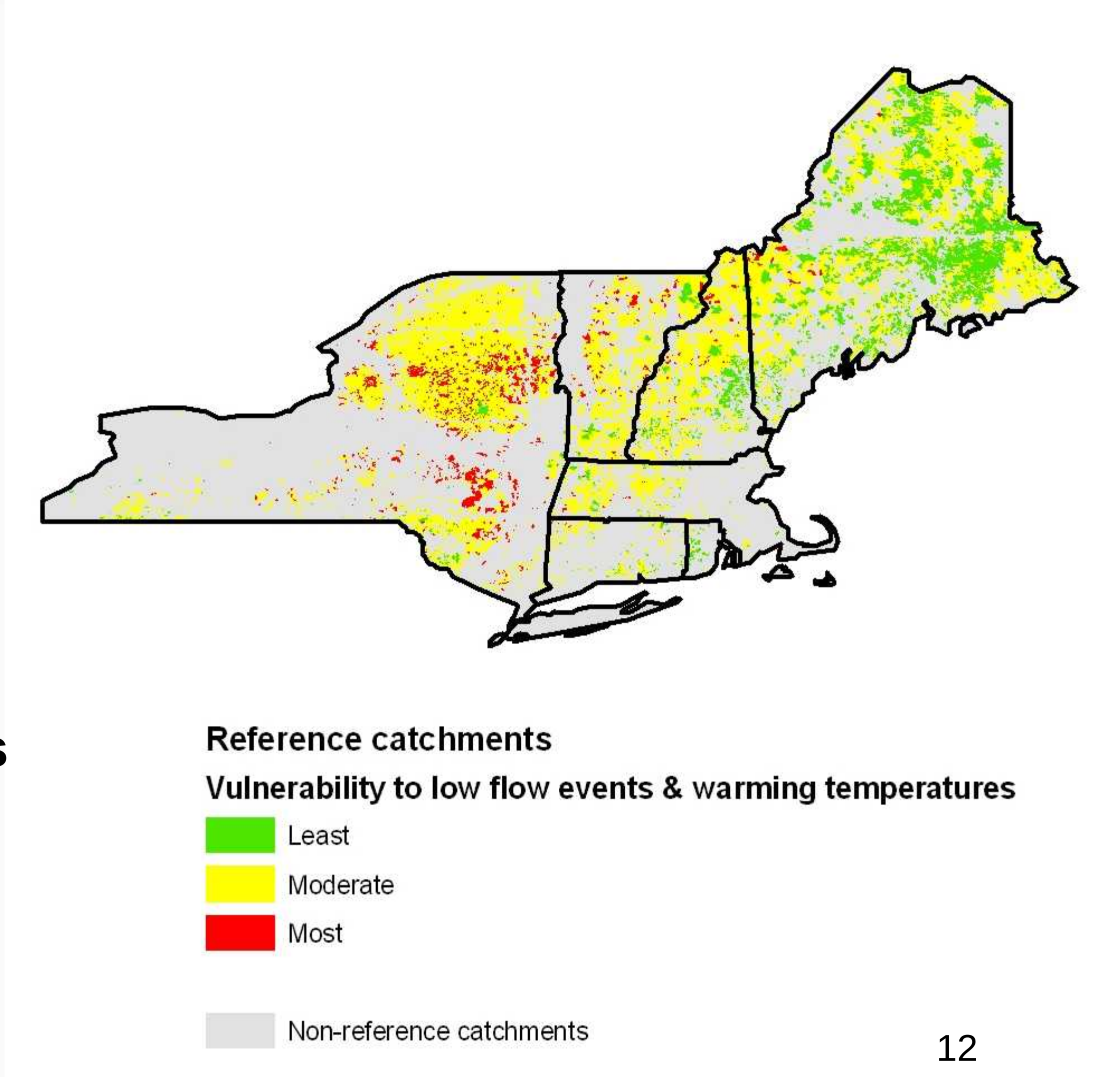
NHD-plus local catchments


EXPOSURE
Low flow events & warming temperatures
Shift in the timing of winter/spring runoff
Peak flow events
Drought severity
SWE
No projection data; assume equal chance of exposure across landscape
SENSITIVITY
Baseflow
Shading
Aspect
Aspect
% Impervious
Mean catchment slope
% Non-developed floodplain
% Open water & wetland
VULNERABILITY
Total score
Total score
Total score
Overall vulnerability rating (based on worst case scenario)

EXPOSURE 1: low flow events & warming temperatures

Hypotheses to test:

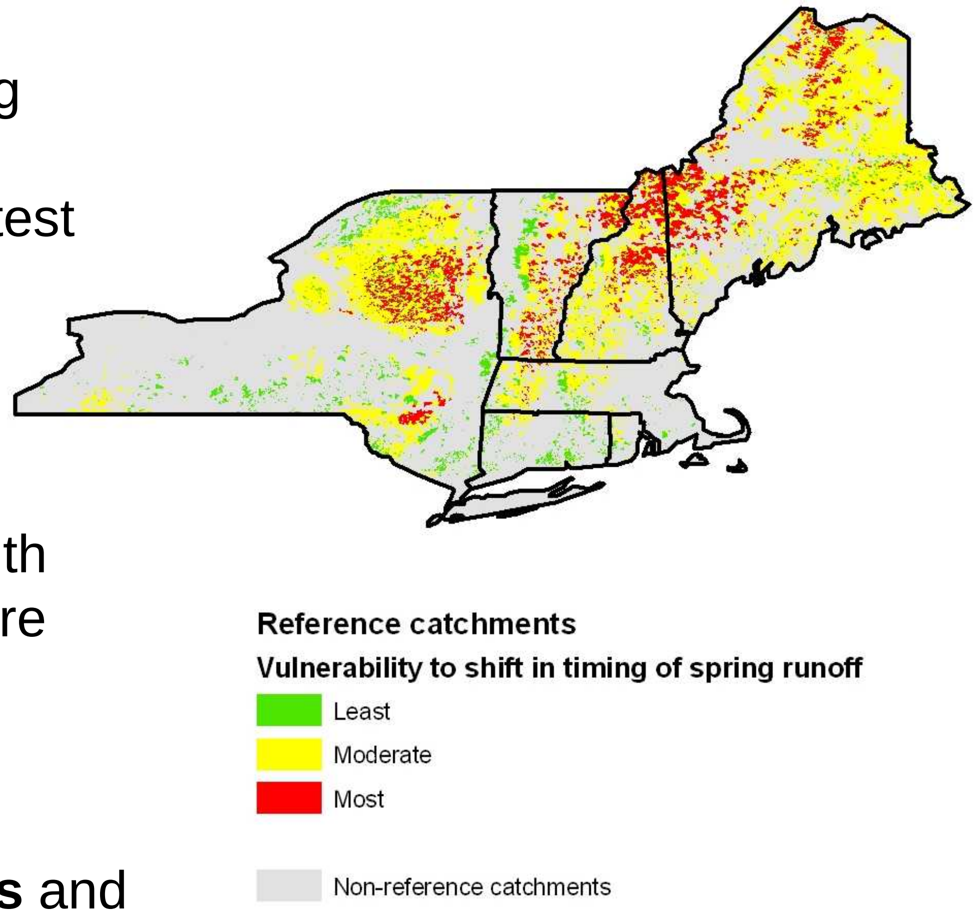
- Are future projections for **drought severity** holding true?
- Are there shifts in **temperature-sensitive species**?
- Are catchments with strong **baseflow**, good **shading** and/or **north-facing slopes** least sensitive to low flow events and warming temperatures?



EXPOSURE 2: shift in timing of winter-spring runoff

Hypotheses to test:

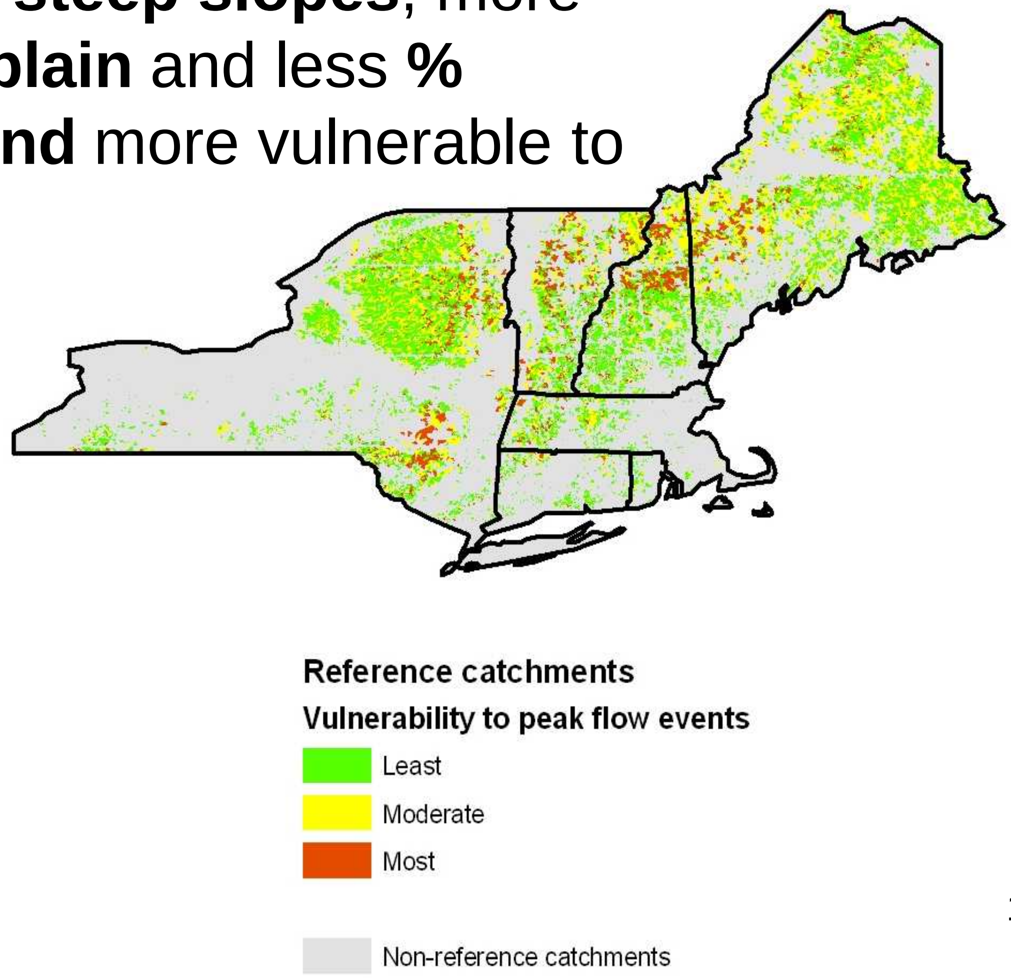
- Are future projections for changing **snow water equivalent (SWE)** holding true? Are areas with greatest change in SWE also areas with greatest shifts in timing of spring runoff?
- Are **transitional cool-water assemblages** present in areas with greatest change in SWE? If so, are these assemblages experiencing greater changes in taxonomic composition than others?
- Are catchments with **steep slopes** and **southern exposure** more sensitive to shifts in timing of spring runoff?



EXPOSURE 3: peak flow events

Hypothesis to test:

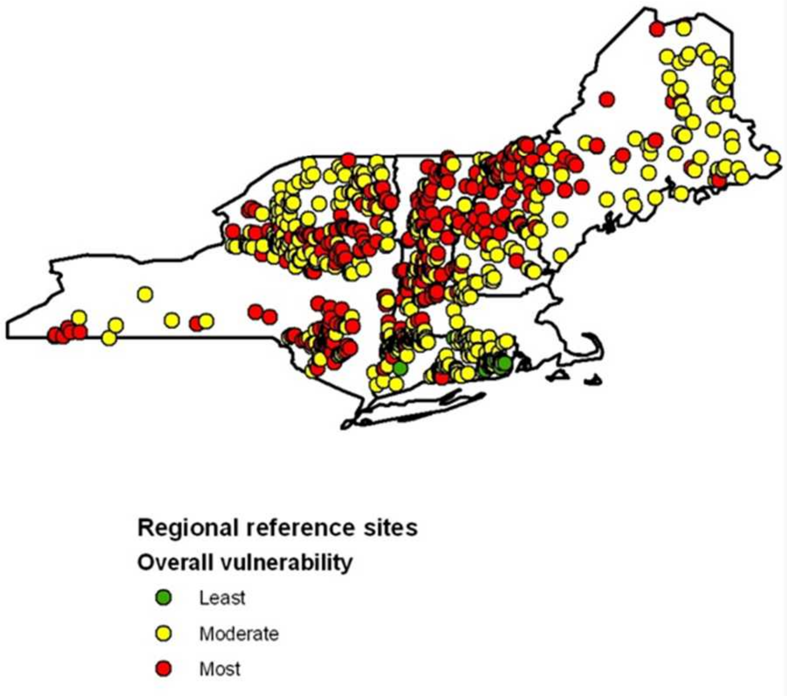
- Are catchments with **steep slopes**, more **% developed floodplain** and less **% open water & wetland** more vulnerable to peak flow events?

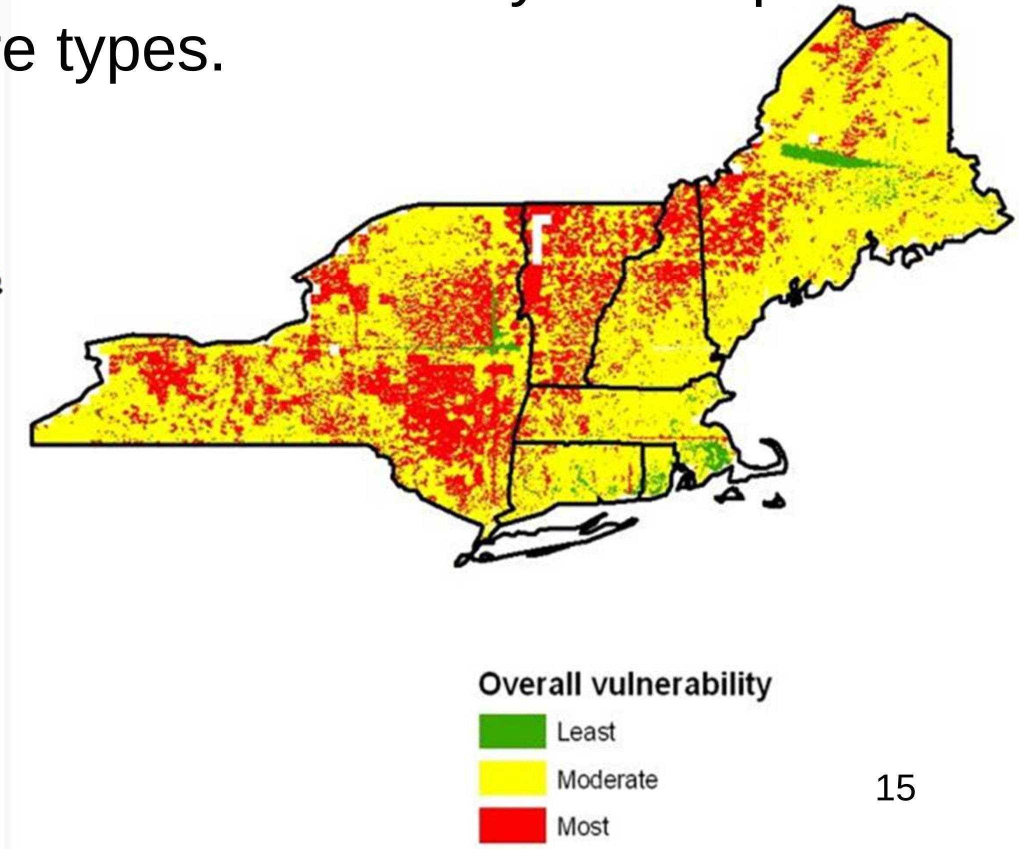


Overall vulnerability rating

If we assign an overall vulnerability category based on the 'worst case' rating, most catchments fall in 'most' and 'moderate' vulnerability categories.

Some catchments are most vulnerable to only one exposure type; others to > 1 exposure types.





Continued Partner Input

- Focus on all 3 vulnerability scenarios (sampling strata)
- Priority on warming temperatures and increased frequency of summer low flows
- Interest in concentrating sites in highest and lowest vulnerability catchments
  - Several other suggestions
- Funding big issue
  - Standardized method
  - Analyses
  - Temperature, flow measurements and equipment

Standardized Collection Methods

If we don't use standardized collection methods across states, the monitoring network can still have value…

But will pose problems with data comparability and analyses
(as demonstrated in our regional classification analysis, as well as in other studies)

Scientific, Practical and Technical Considerations

Network monitoring sites - mix of **scientific** -

- Reference status
- Classification
- Regional coverage
- Results from climate vulnerability assessment
- Temperature and flow measurements

And **practical considerations**

- Tie into existing monitoring programs - sustainability
- Use of existing sites (reference, long-term) or select new sites
  - Proximity to active USGS gages
  - Risk of future development
  - Accessibility

Technical Standardization

- Standard physicochemical parameters
- Standard collection methods (biological) to limit sampling variability

Summary

- Input from technical steering group is guiding goals, selection of stream type, vulnerability type, and overall network design
- Vulnerability assessment can identify and prioritize potential monitoring sites to detect climate change effects in rivers and streams
- Site selection/prioritization differs geographically among vulnerability types
    - Not clear whether overall vulnerability vs. individual vulnerability types is better choice


Thanks!
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