EMAP SYMPOSIUM- 2004
Theme 2 – Session 2:
RELATING FINDINGS FROM 305(b) TO 303(d)

Session Chair
Scott Urquhart
Department of Statistics
Colorado State University

DESIGN-BASED APPROACHES FOR RELATING FINDINGS FROM 305(b) TO 303(d)

- What is "Design Based"?
  - ➔ Statistical inferences rest on the probability structure incorporated in the selection of the sample
- Design Based, but Model Assisted
  - ➔ Design based, but incorporate models, like various kinds of regression models
- Model Based
  - ➔ Statistical inference rests on assumed models
    - *Perhaps well defended*

DAN McKENZIE:
ONE OF THE THEME ORGANIZERS
IS NOT HERE

- **I Knew What He planned to Say in His Intro to the Theme Yesterday**
  - ➔ **I had planned to build on what he said!**
  - ➔ **It is hard to build without a foundation!**
  - ➔ **So I'm going present five of his slides.**

EMAP's Guiding Figure

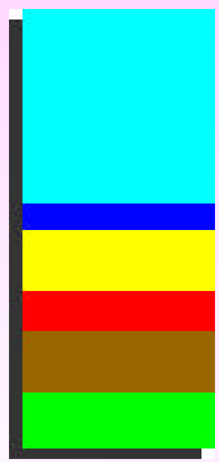
Status & Association Questions

Status

Associations

Extent
of
Resource

(number,
length,
area)



Good
%

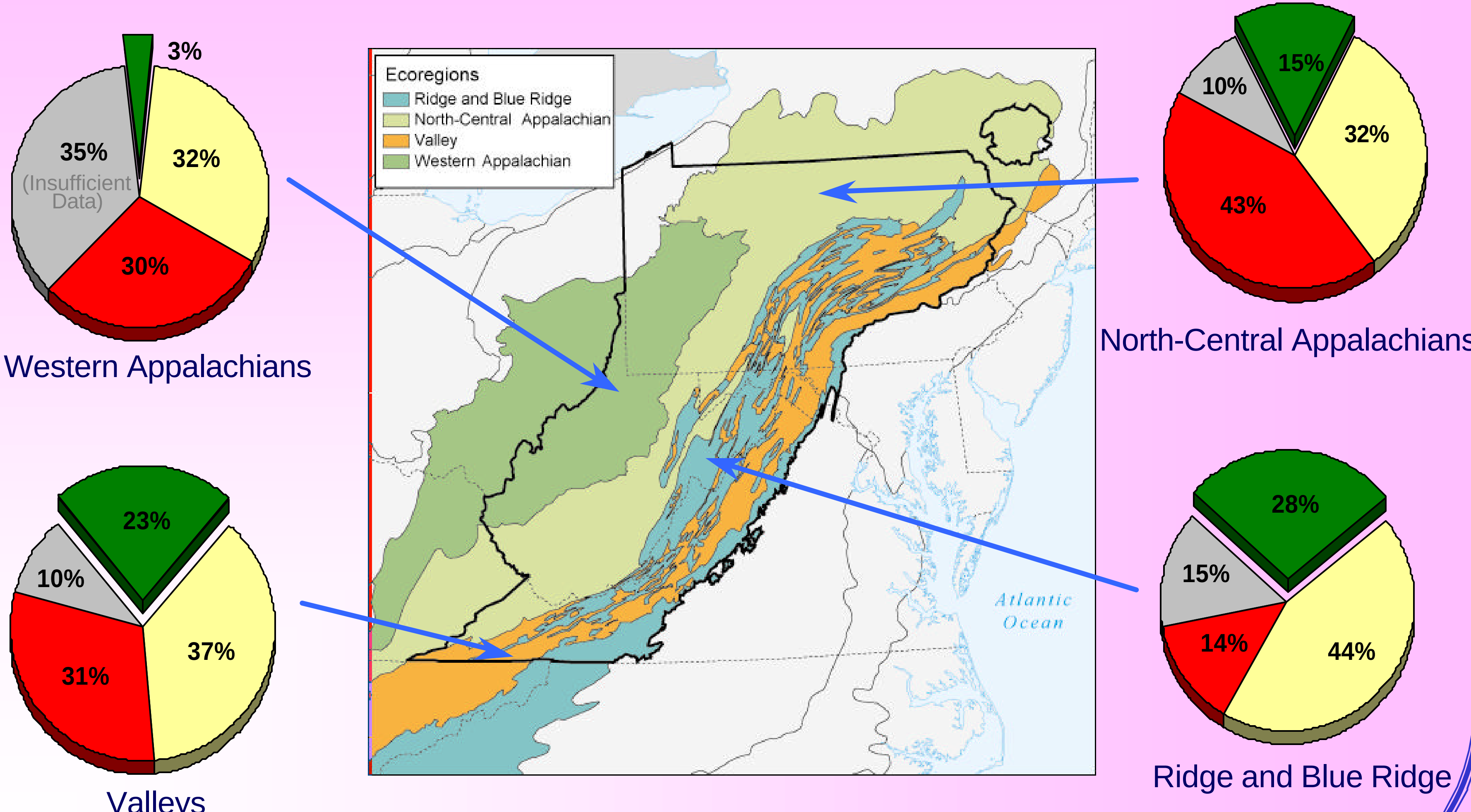
Poor
%

- Nominal
- Unknown
- Acidity
- Toxicity
- Eutrophication
- Habitat

FROM DAN McKENZIE – LABELED "DRAFT – DRAFT"

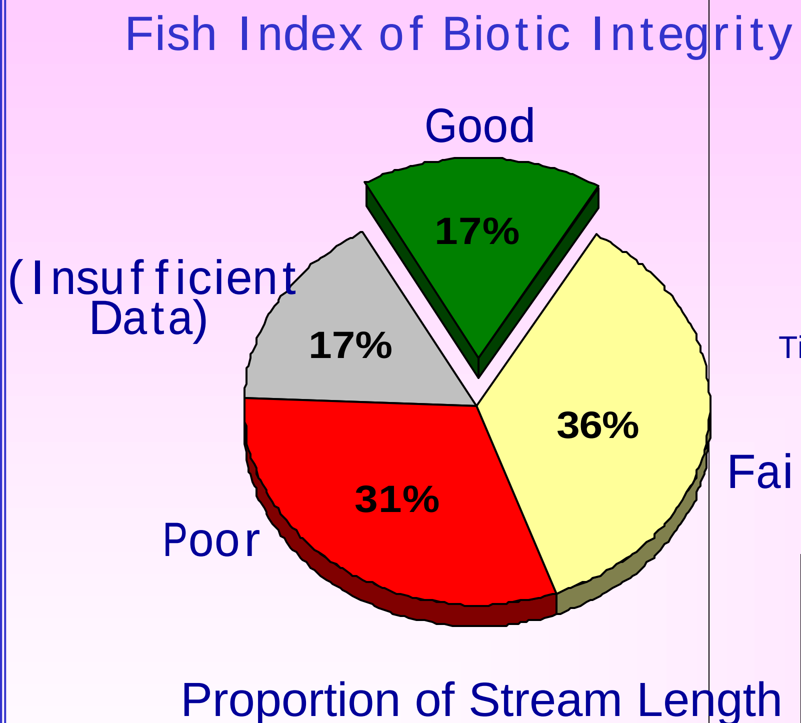
Geographic Targeting

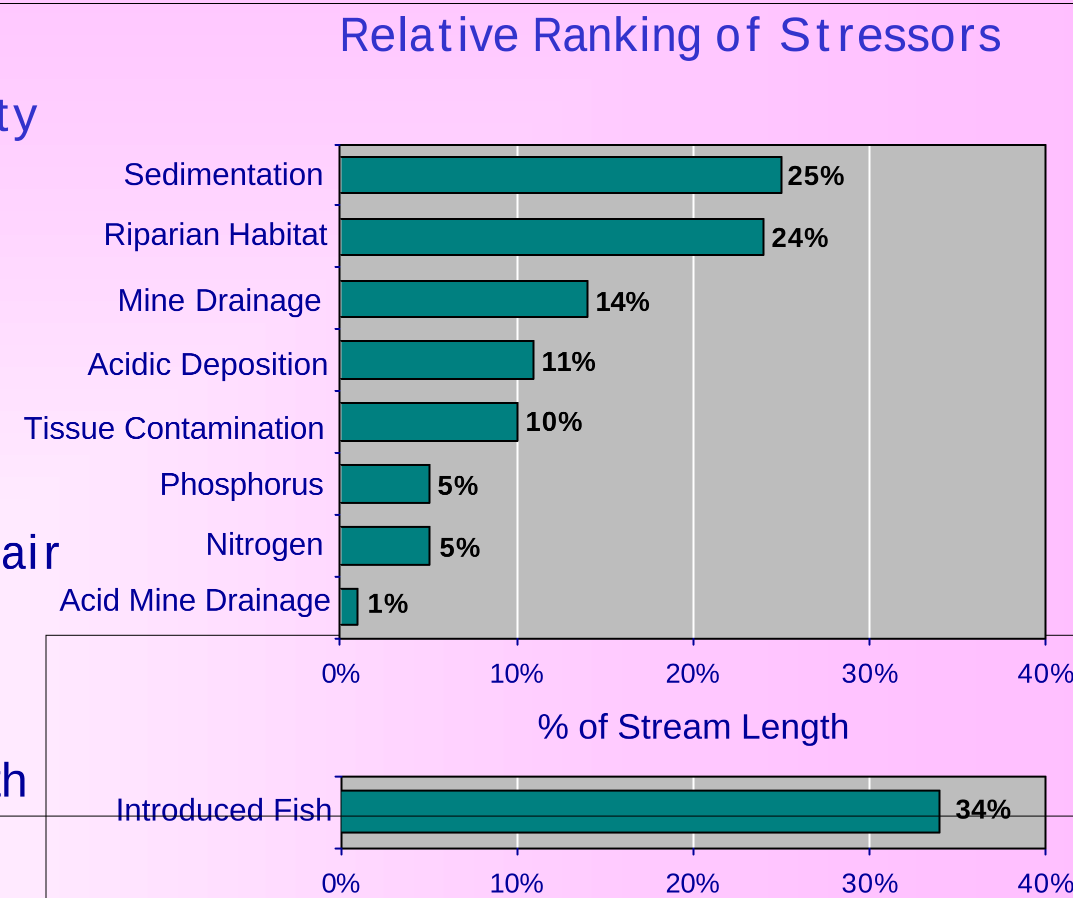
Where does Fish IBI suggest problems?



FROM DAN McKENZIE – LABELED "DRAFT – DRAFT"

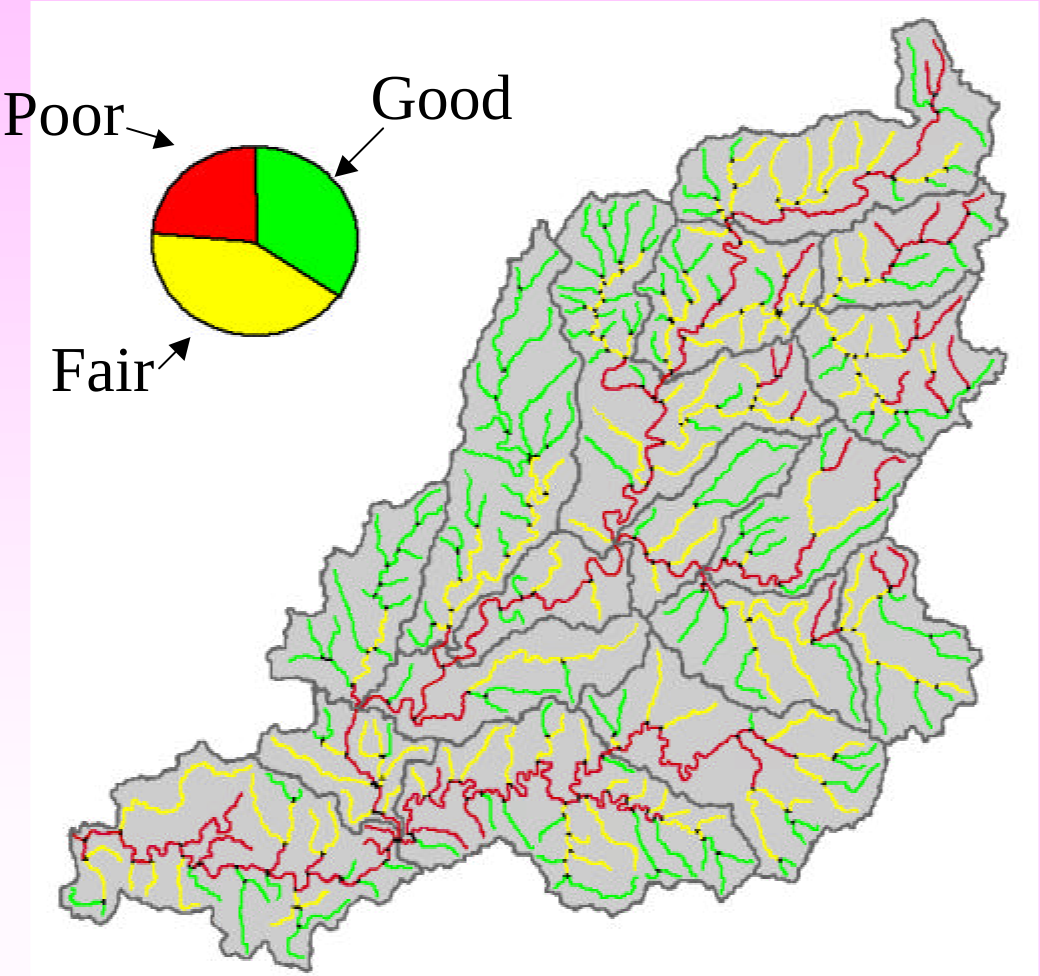
EMAP Probability Survey Example Results (complex)





FROM DAN McKENZIE – LABELED "DRAFT – DRAFT"

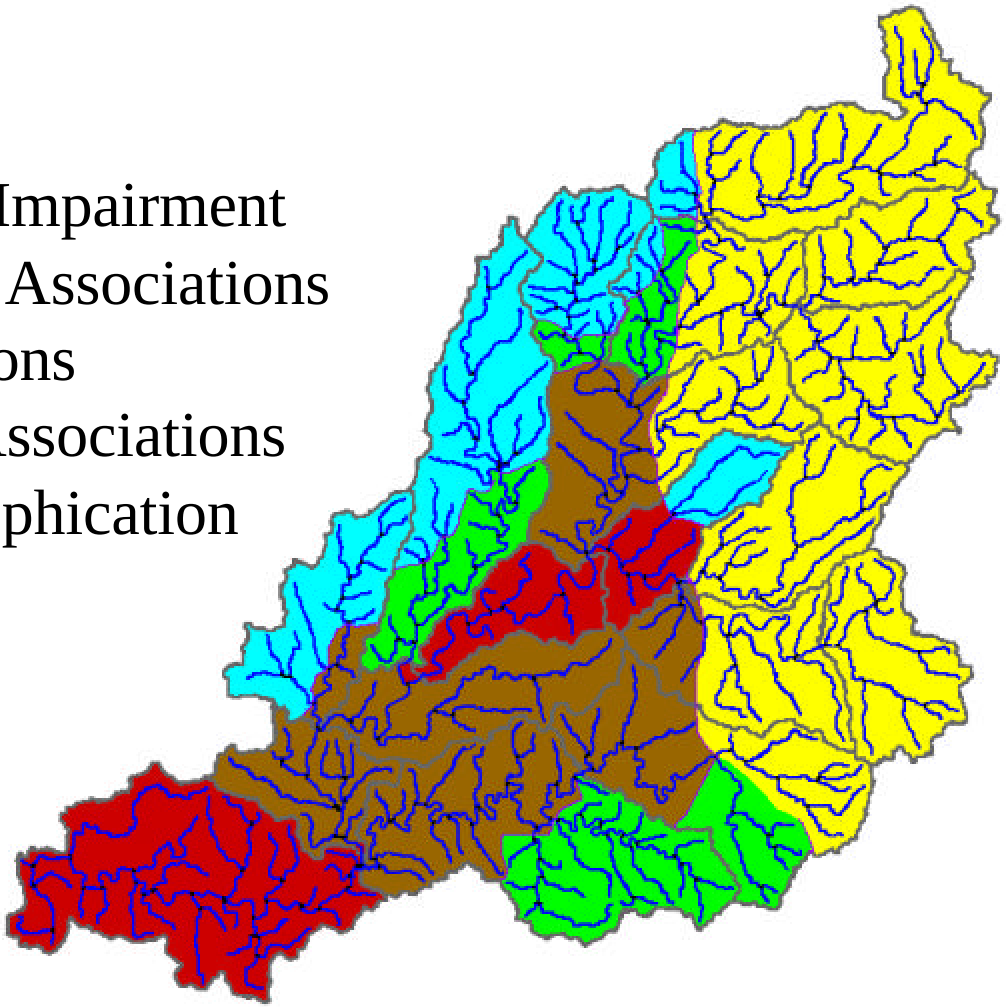
Example: Extending EMAP Status
Estimated IBI Condition at Reach Scale



FROM DAN McKENZIE – LABELED "DRAFT – DRAFT"

Potential Areas for Target Surveys

- High Prob. Non-Impairment
- Riparian Habitat Associations
- Acidic Associations
- Eutrophication Associations
- Toxicity & Eutrophication Associations



FROM DAN McKENZIE – LABELED “DRAFT – DRAFT”

EMAP SYMPOSIUM- 2004
Theme 2 – Session 2:
RELATING FINDINGS FROM 305(b) TO 303(d)

- Linking CWA Sections 305(b) and 303(d) – statistical Perspective.
  - → Overview - Scott Urquhart, Colorado State University
  - → A Role for Small Area Estimation -F. Jay Breidt, Colorado State University
  - → Estimating Power to Detect Trends – Brian R. Gray, USGS

A STATISTICAL PERSPECTIVE
ON
LINKING SECTIONS 305(b) AND 303(d)
OF
THE CLEAN WATER ACT

N. Scott Urquhart

SENIOR RESEARCH SCIENTIST
DEPARTMENT OF STATISTICS
COLORADO STATE UNIVERSITY

EMAP Affiliate

SPACE-TIME AQUATIC RESOURCE MODELING and ANALYSIS PROGRAM (STARMAP)

STARMAP FUNDING

Space-Time Aquatic Resources Modeling and Analysis Program

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PATH for TODAY
GETTING FROM
305(b) SURVEYS TO 303(d) TMDLs

- Spatial-Temporal Modeling for Aquatic Systems
- A Conceptual Model for Linking Two Sorts of Data: Probability Survey & Other Sites Where STARMAP fits in
  - ➔Spatial-temporal modeling for aquatic systems
  - ➔Relevant current STARMAP research
  - ➔Learning materials for aquatic monitoring
    - *Poster: 6 – 8pm, Wednesday, Bellview Ballroom*
- How YOU Can Help STARMAP Develop Tools to Help YOU
- Discussion/Questions

SPATIAL-TEMPORAL MODELING
for
AQUATIC SYSTEMS

- Spatial-temporal Modeling = ???
  - ➔ Most statistical techniques taught in graduate statistical methods courses assume observations are uncorrelated.
  - ➔ REALITY = Nearby things often are more alike than things far apart – regardless of context
    - *This is spatial correlation*
  - ➔ So what should we do?
    - *Design studies to minimize the impact of spatial correlation – EMAP is set up this way*
      - Good use of resources for summaries & estimating relationships
    - *Capitalize on the spatial correlation to get reliable forecasts of nearby response values*
  - ➔ Add time to the mix for spatial-temporal modeling
- How to Pull All of This Together FOR 305(b)/303(d)?

AVAILABLE INFORMATION

("ASSUMPTIONS")

- A Response of Interest
- A Probability Sample In A Region {305(b)}
- Some Purposefully Chosen Points in the Region
- Spatially Intensified Points Near Some of the Points
- Predictors at Whatever Density Desired, Like Landscape (GIS)

STRATEGY TO CONSIDER

- 1. Estimate Response/Predictor Relationship
- 2. Estimate the Spatial Relationship
  - ➔ Semivariogram
- 3. Estimate the Response/Predictor Values for a Dense Set of Points
- 4. Use Spatial Interpolation to Combine Forecasted Response Values With Observed Values
- 5. Get Confidence Bounds on the Combined Estimates

1. ESTIMATE RESPONSE/PREDICTOR RELATION

- **Estimate the Relation Between the Response and the Predictors Using:**
  - **(a) The probability selected points, and separately**
  - **(b) The purposefully selected points**
  - **Combine the two estimates?**
    - ***If (a) & (b) don't differ very much, combine them***
    - ***If they differ substantially, use (a)***
      - **Reason – by differing, the biases in the purposefully selected points affect the estimated relation, while the probability selected points represent the whole region.**
  - **Denote the resulting estimate as $f_1(s)$, where s represents a point in (two-dimensional) space**

LIMITATIONS OF APPROACHES

- **Many Investigators Have Unreasonable Expectations for**
  - **Remotely sensed variables (GIS generated data)**
    - ***Good for extent – like land use classes, but …***
    - ***Aerially sensed features see the surface***
      - **Even only the canopy top**
    - ***Much flowing water has been underground at some point in its transit from precipitation to its eventual resting place***
    - ***Variables like land classes may predict from 50% or even 70% down to 10% of the variation in some interesting chemical indicators.***
  - **Spatial Statistics (to be discussed next)**
    - ***We'll return to this***

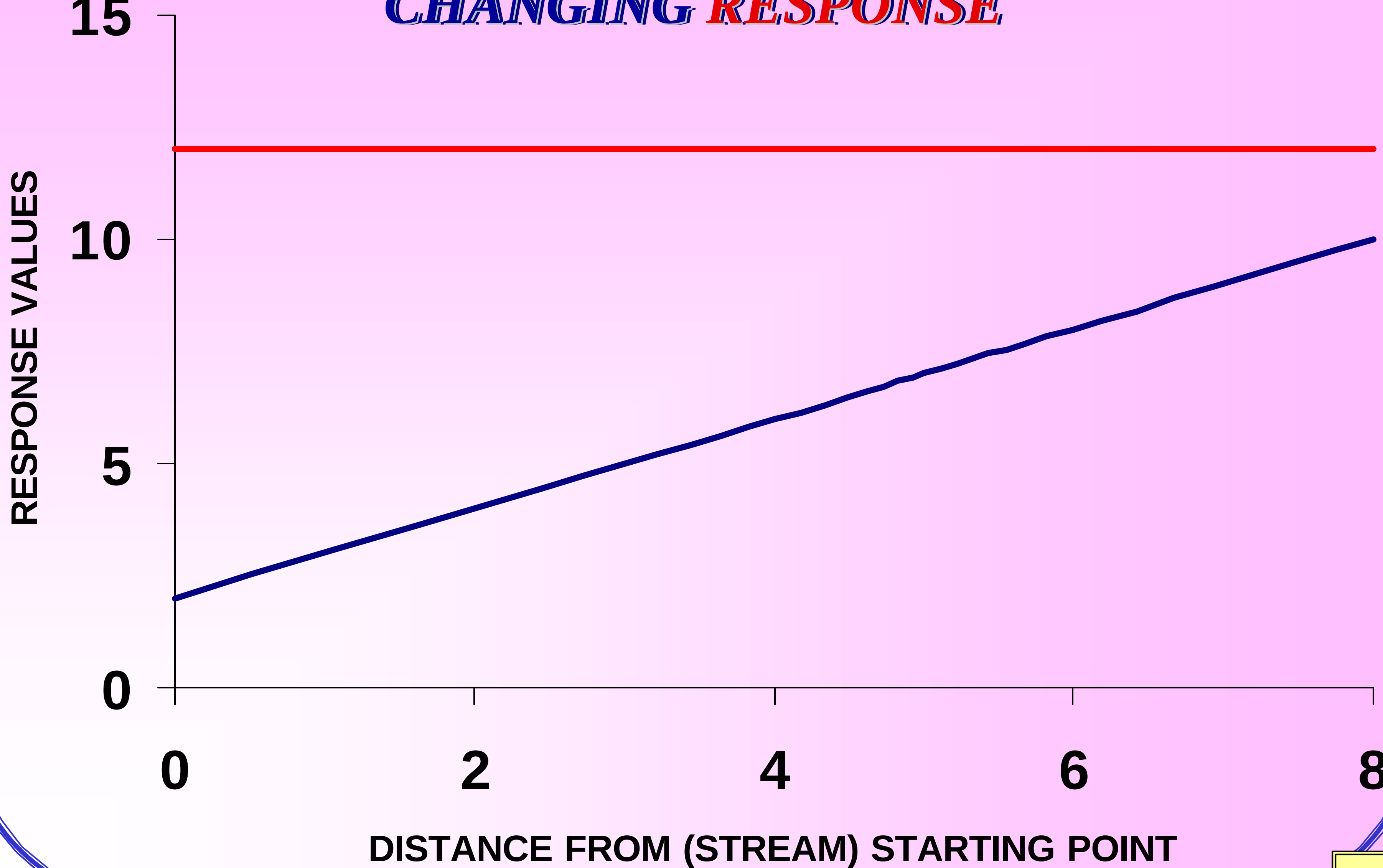
2. ESTIMATE THE SPATIAL RELATIONSHIP

- Use All Of The Available Relevant Data to Estimate the Semivariogram, $g(h)$,
- But Especially Rely on the Intensified Set of Points.
  - ➔ Spatial statistics usually mesures distance “as the bird flies”, but
  - ➔ Consider measuring distance along the stream/river network
    - *STARMAP has active work in this area*

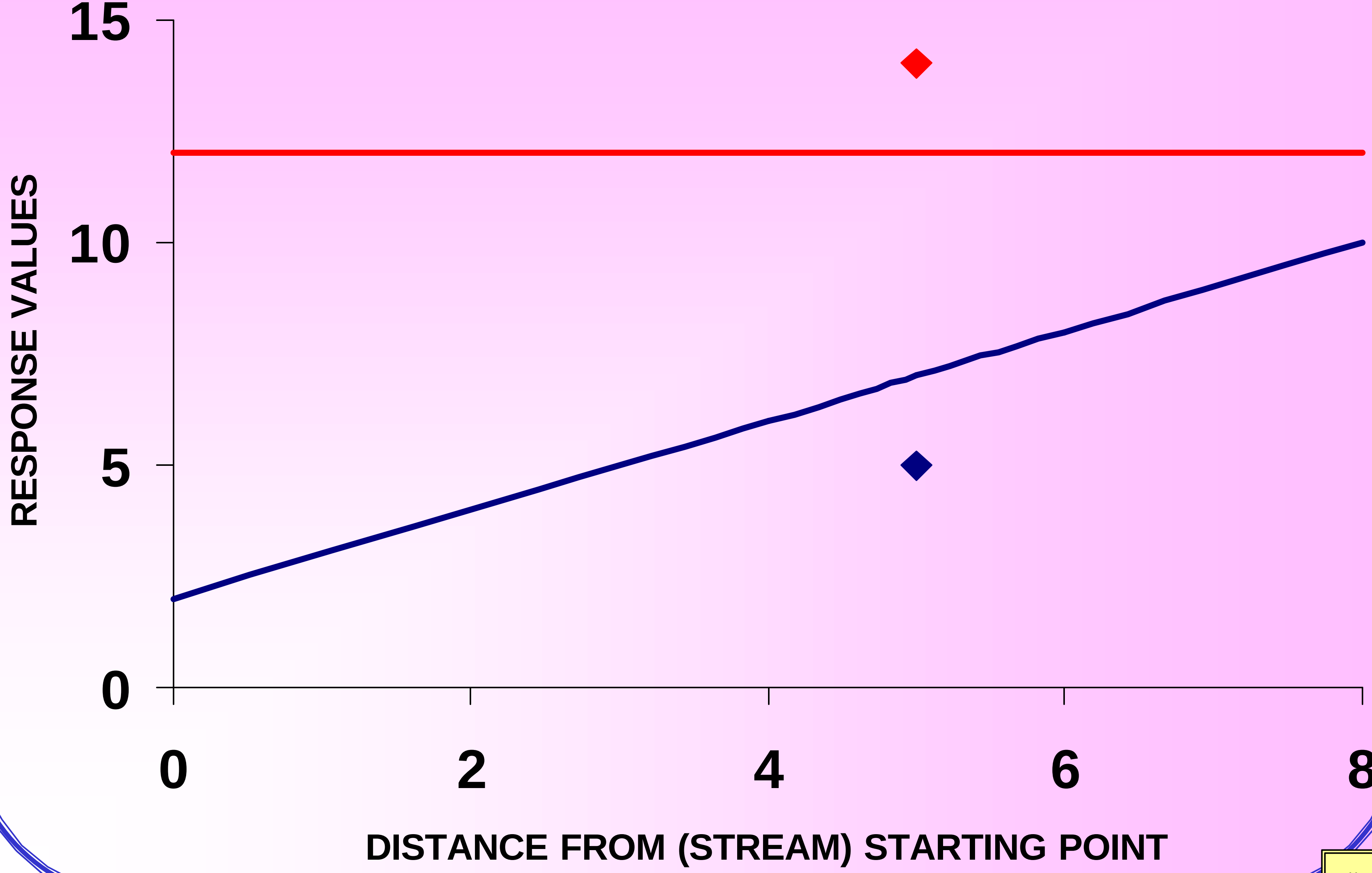
3. ESTIMATE THE RESPONSE/PREDICTOR RELATION FOR A DENSE SET OF POINTS

- A Dense Set of Points Might Be Every Kilometer Along the Stream/River Network
  - ➔Along a particular part of the stream network the result might look like what is shown on the next slide
    - *This shows only a small local part of the functions*
    - *This sort of representation should extend across the entire stream/river network*

CONSTANT RESPONSE
or a
CHANGING RESPONSE



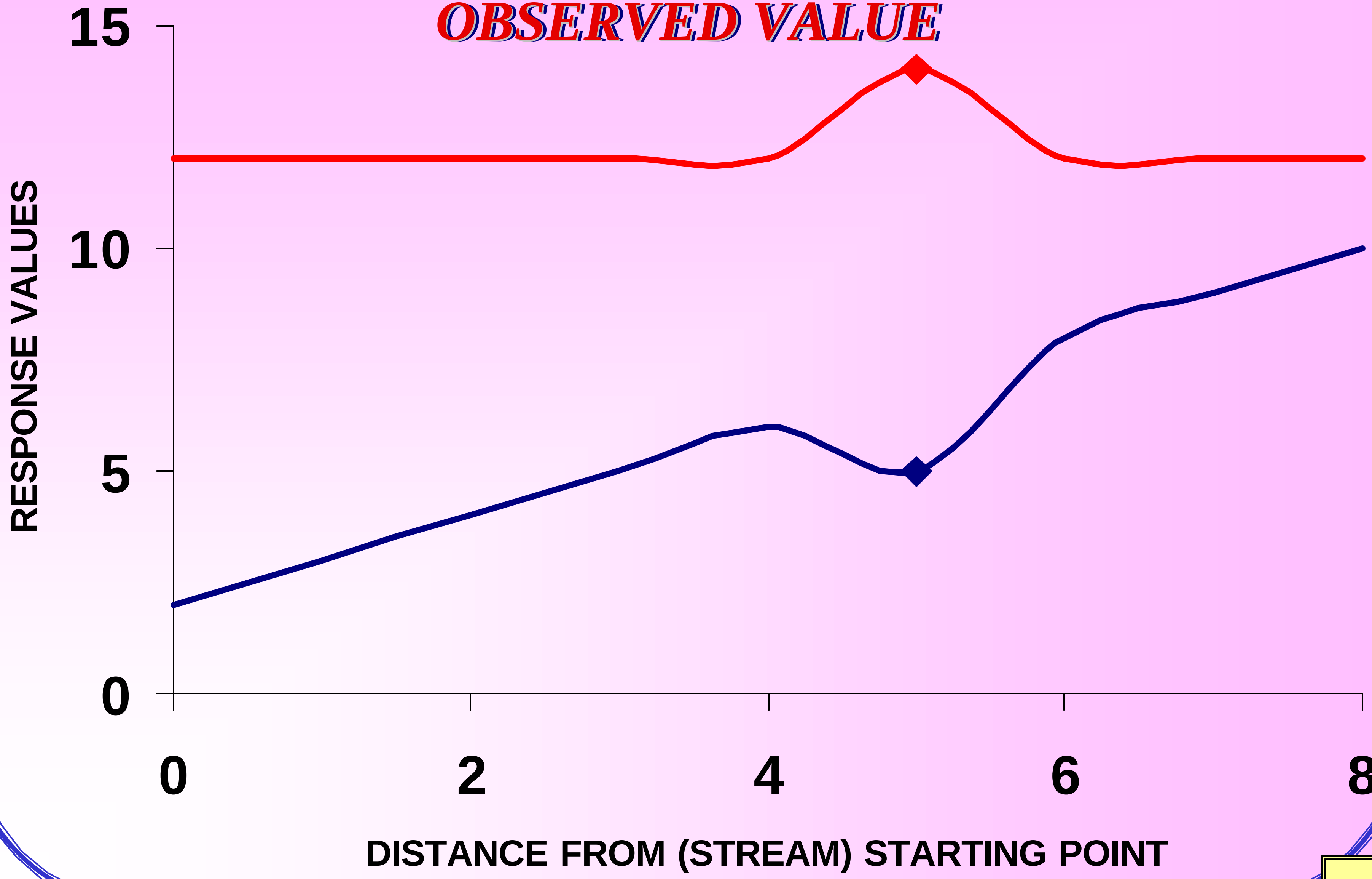
DO WHAT IF THE OBSERVED DATA DOESN'T MATCH THE PREDICTIVE RELATION?



4. A ROLE FOR SPATIAL INTERPOLATION

- If a Legitimate Observation is Below the Predictive Relation, It is Likely Nearby Points are Also. Make Use of This Expected Relation.
- Use Spatial Interpolation, of Which Kriging is An Example, to Smooth the Relation Through the Observed Point and Back to the Less Informed General Relation
  - ➔ Perhaps take a weighted average between the predicted value and the observed or spatially interpolated value
    - = *“shrinkage” estimate*

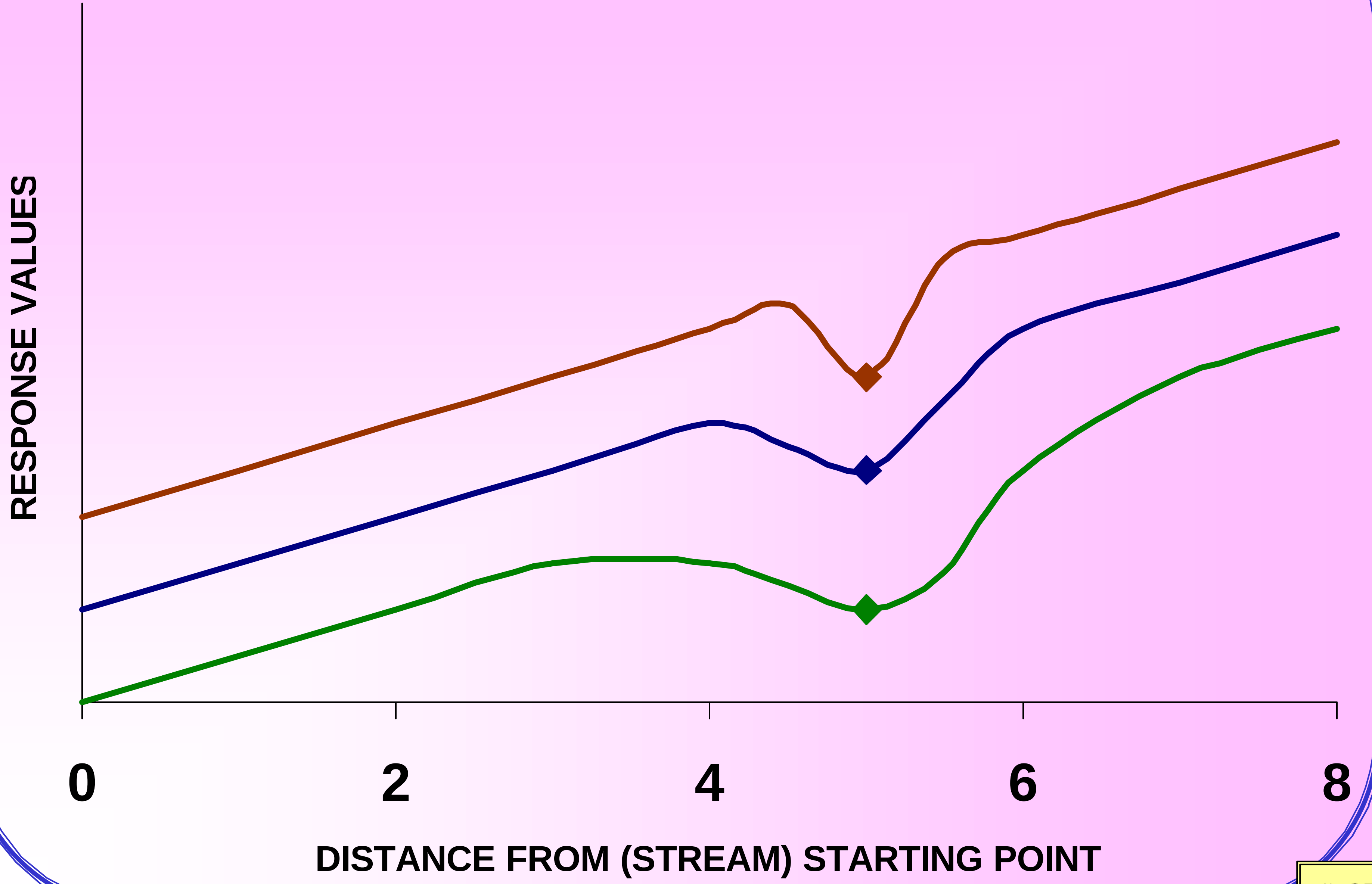
CHANGING RESPONSE WITH SPATIAL INTERPOLATION THROUGH OBSERVED VALUE



OPEN QUESTION

- How Far Should the Spatial Interpolation Extend?
  - ➔ What difference would that make?
  - ➔ See the next figure
- This is an Open Question for Now.

DIFFERENT INTERPOLATION RANGES



LIMITATIONS OF APPROACHES

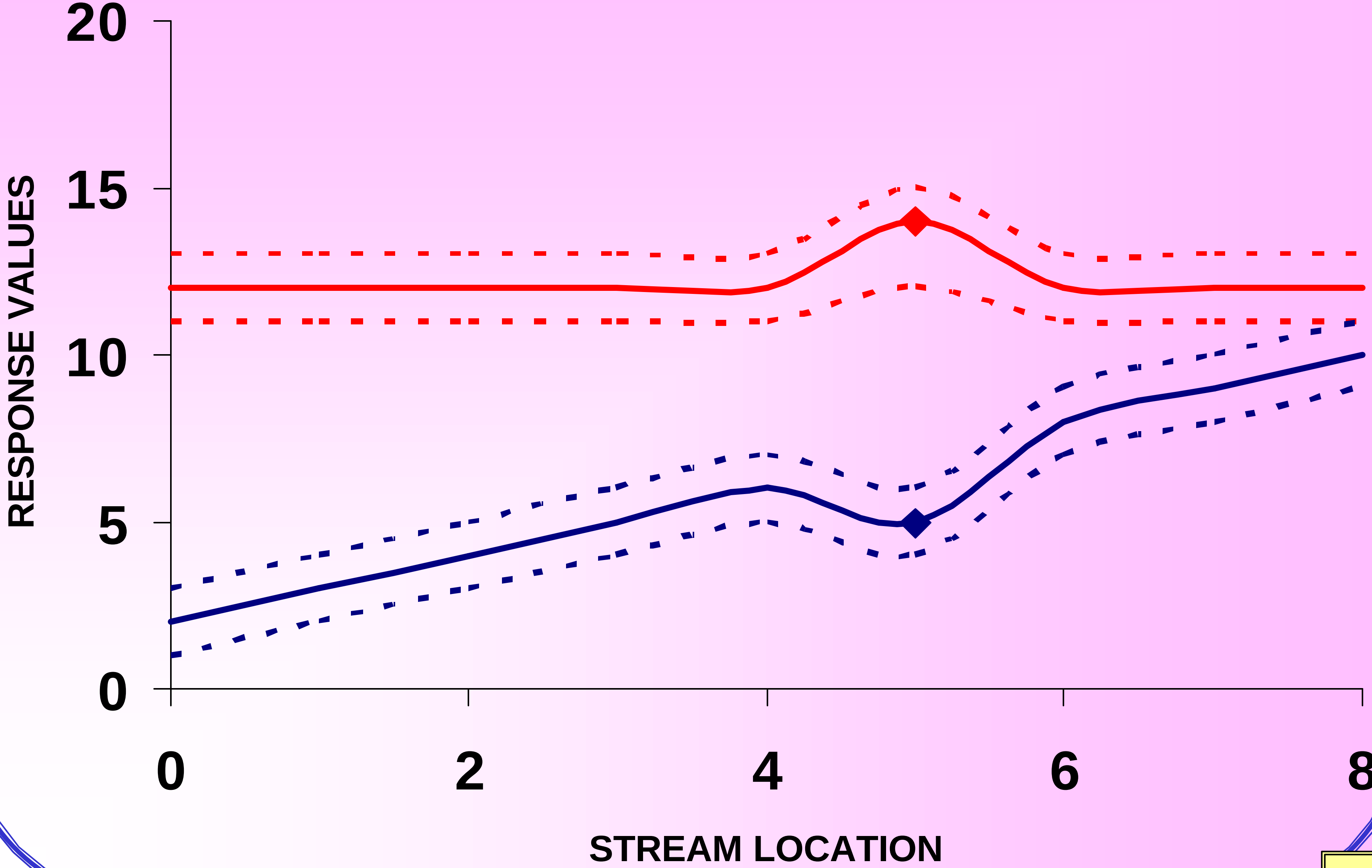
(second look)

- **Many Investigators Have Unreasonable Expectations for**
  - **Remotely sensed variables (GIS generated data)**
    - ***Discussed earlier***
  - **Spatial Statistics**
    - ***After accounting for habitat-type variables, aquatic responses may not exhibit much spatial correlation***
    - ***Certainly true in some forest situations***

RELATION TO CWA 303(d) IS?

- Wherever the Forecasted Response Exceeds the Standard, Go Check for Possible Violation
  - ➔ "Exceed" could be either high or low, depending on the response

5. FORECASTED RESPONSE VALUES WITH CONFIDENCE BOUNDS



RELATION TO CWA 303(d) IS?

- **Wherever the Forecasted Response Exceeds the Standard, Go Check for Possible Violation**
  - **"Exceed" could be either high or low, depending on the response**
- **Better Yet, Get a Confidence Bound on the Forecasted Response**
  - **Examine locations which exceed the confidence bound, rather than the forecasted response only.**
    - ***Way to allocate scarce resources***
  - **Width of confidence bounds will vary depending on how good the information is for the various points**

RELEVANT CURRENT STARMAP RESEARCH

- **Overall Objective: Develop and Disseminate Statistical Methods**
  - ➔ **Spatial/temporal/survey-related modeling**
  - ➔ **Relevant to aquatic monitoring**
  - ➔ **Next talk illustrates some of this perspective**
- **Current Research: How Should EMAP-type Sampling Be Intensified to Estimate Spatial Correlation:**
  - ➔ **Current context – City of San Diego and Southern California Coastal Water Research Project (SCCWRP)**
    - ***Accurate maps of environmental measures around SD's oceanic sewage outfall***

RELEVANT CURRENT STARMAP RESEARCH

(continued)

- Learning Materials for Aquatic Monitoring
  - → See poster

WHAT CAN YOU DO FOR STARMAP?

- ❖ **That Will Benefit Your Interests?**
  - ➔ **Do you have, or know of, aquatic environmental data sets which**
    - *Are dense along a stream or river network?*
    - *Like every 100m to 2 km*
    - *n = 100^{+} - hopefully without major habitat changes*
    - *If so, talk to me about them before we leave here*
  - ➔ **Look at the learning materials**
    - *Feedback on the interface*
    - *Poster: 6 – 8pm, Wednesday, Bellview Ballroom*
    - *Statistical topics you would like to be included – forms at poster display*
    - *Have access to studies which might be turned into case studies?*

QUESTIONS ARE WELCOME