Experimental Design and Restoration Monitoring

Bob Hilderbrand
Appalachian Lab
University of MD Center for Environmental Science
Frostburg

Apples & Oranges

$2+2=5$

Gravenstein≠Arkansas Black

$8-3=14$

Restoration Monitoring

- Historically not done
  - NRRSS papers
- Recently, lots of monitoring
  - Application is ahead of the science
- Monitoring for sake of monitoring
  - Definitely expensive
  - Diverts resources
  - May not be useful

Smarter Monitoring – 2 Levels

- Project Level: What is the goal?
  - Clearly stated, measureable restoration goals and objectives
    - E.g., 30% nitrate load reduction
  - Did the restoration achieve the goal?
  - Always some explanation for failures
- Bigger Level
  - What techniques work under situation X
  - Analysis across groups of projects
    - Individual projects idiosyncratic
    - Not applicable for any single restoration

Fundamental question: Project Level

- How does the restored stream compare to what it would be if there was NO restoration (Stewart-Oaten)?
  - Simply measuring is NOT enough to assess if the restoration actually improved anything
  - Must compare against something to account for variation

Fundamental question: Bigger Level

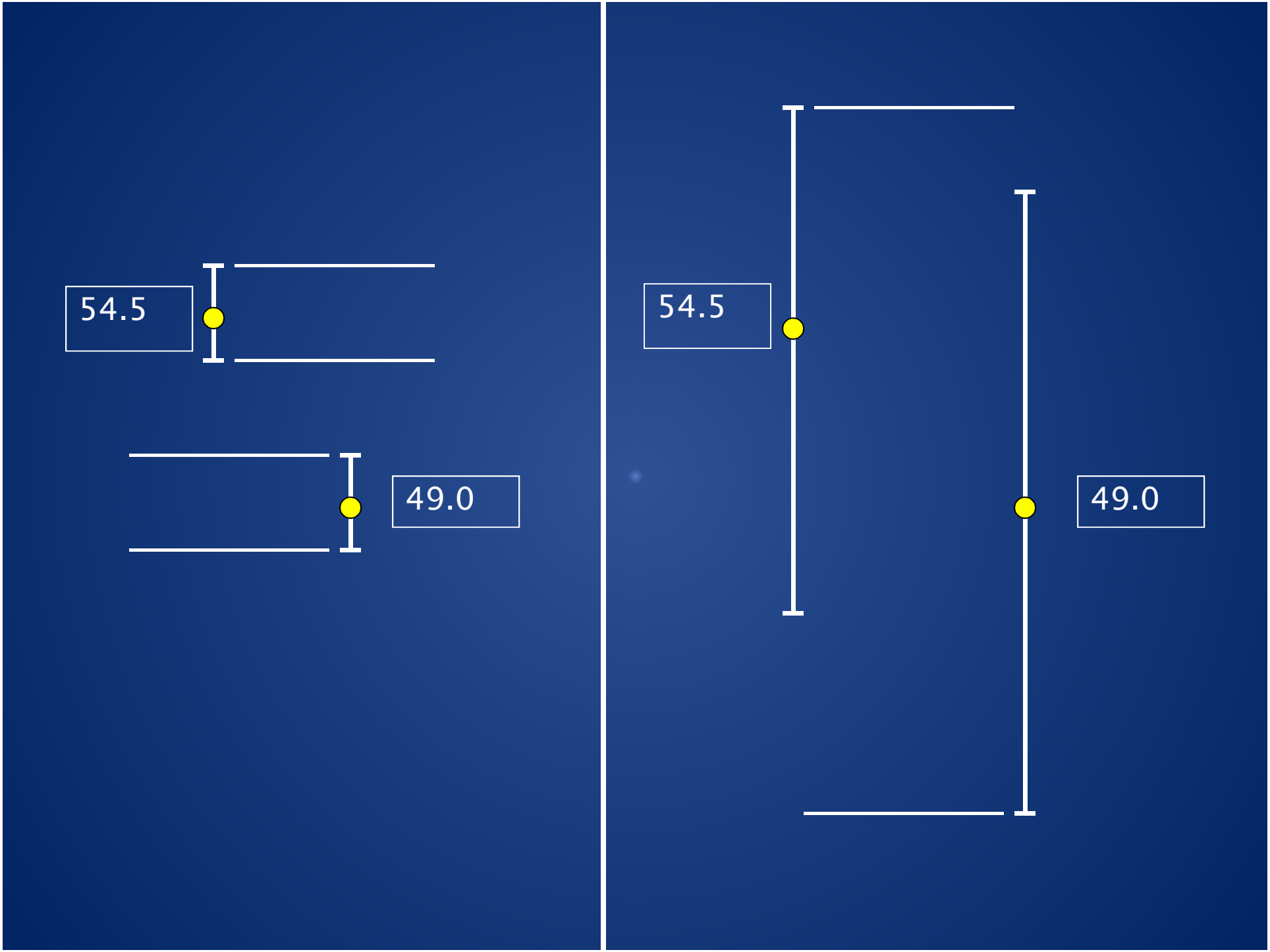
- Does approach Z achieve the restoration goal?
  - Weight of evidence based on many projects using approach Z
  - Each project evaluated in a way that allows for rigorous comparisons
    - Lots of coordination or a single overarching entity

Jargon

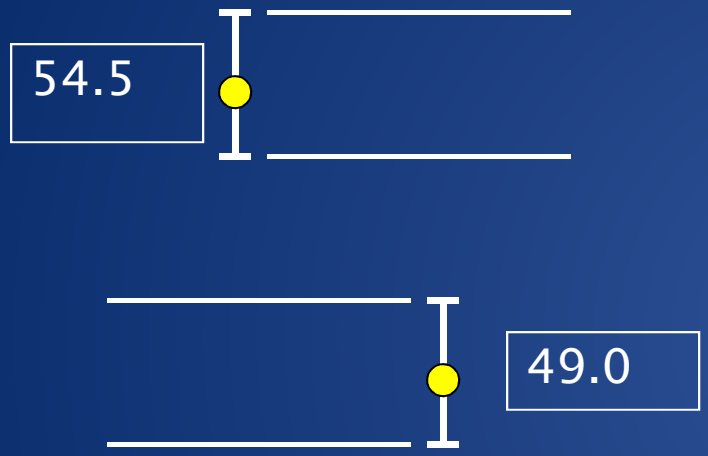
- Control
  - A stream used for comparison
  - Usually an unrestored stream in similar condition to a stream pre-restoration
  - Ideally on the same stream as the restoration
- Reference
  - Usually a minimally disturbed, high quality stream

Contrived, Simple question: Which is Bigger?

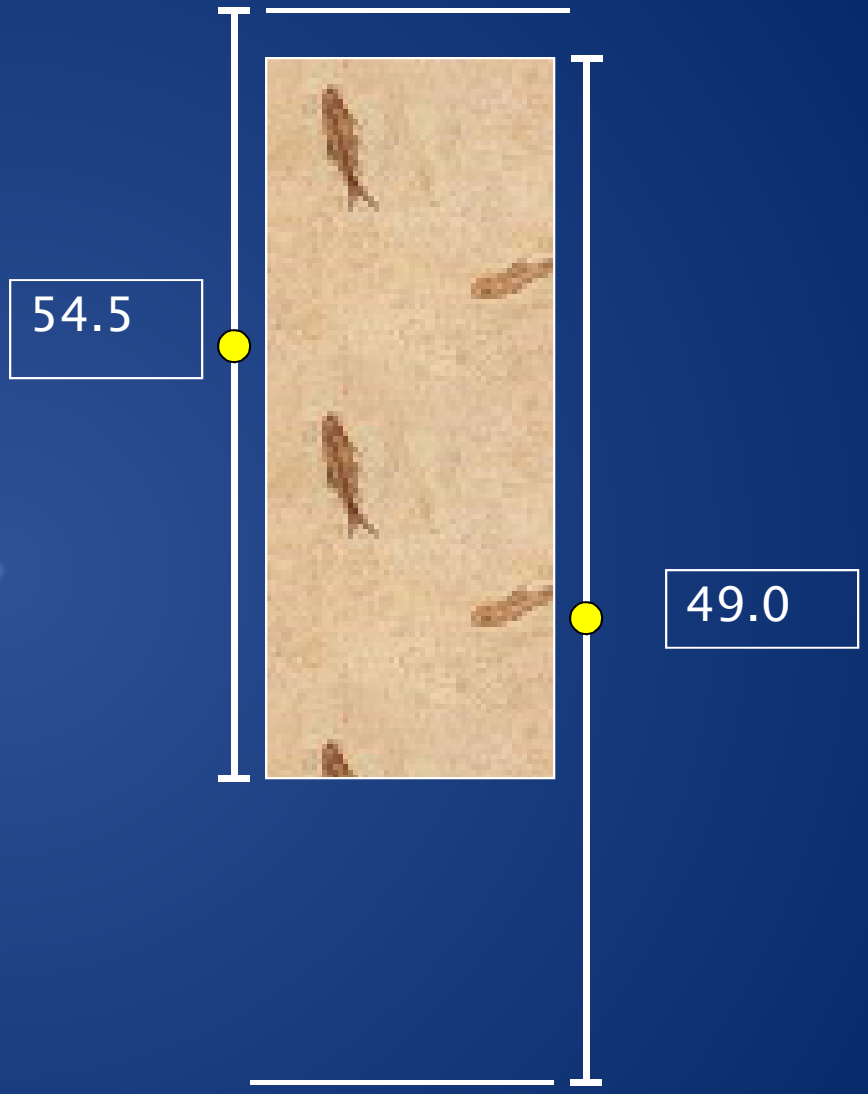
- Annual sediment load
  - Group 1 = 54.5 Tons/year
  - Group 2 = 49 Tons/year
- Taxonomic richness
  - Group 1 = 54.5 species
  - Group 2 = 49 species


54.5
49.0
54.5
49.0

Bigger



No Difference



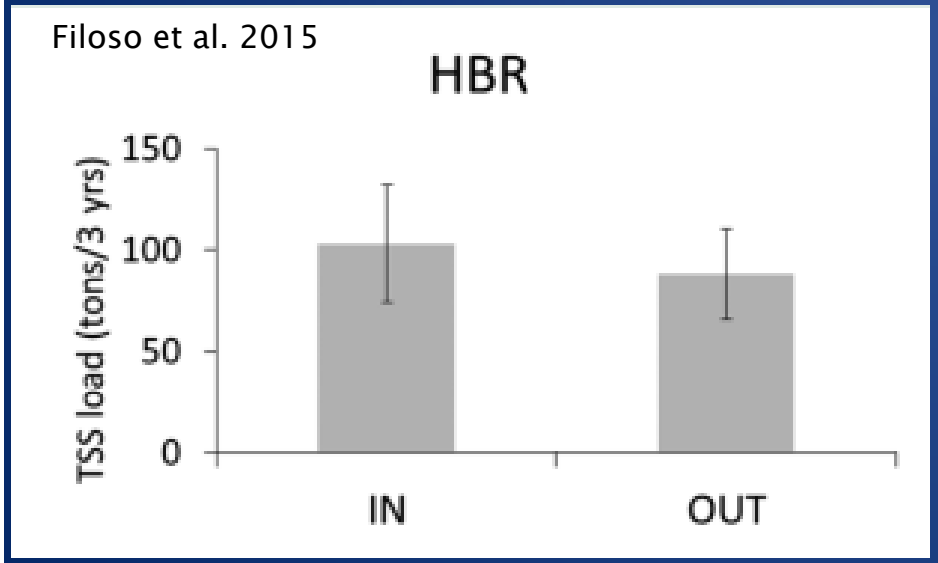
High variation is normal and everywhere

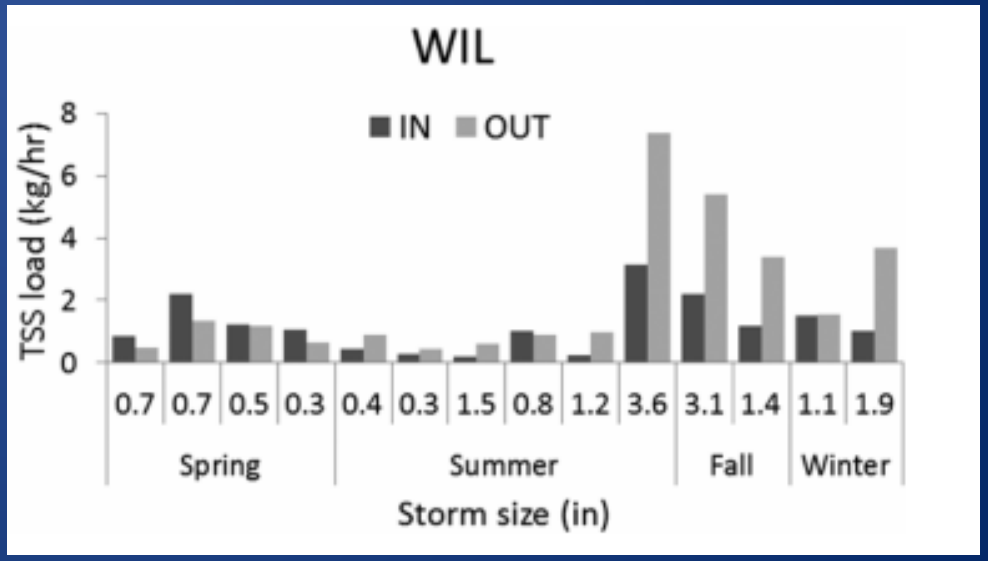
http://theguamguide.com

Variation

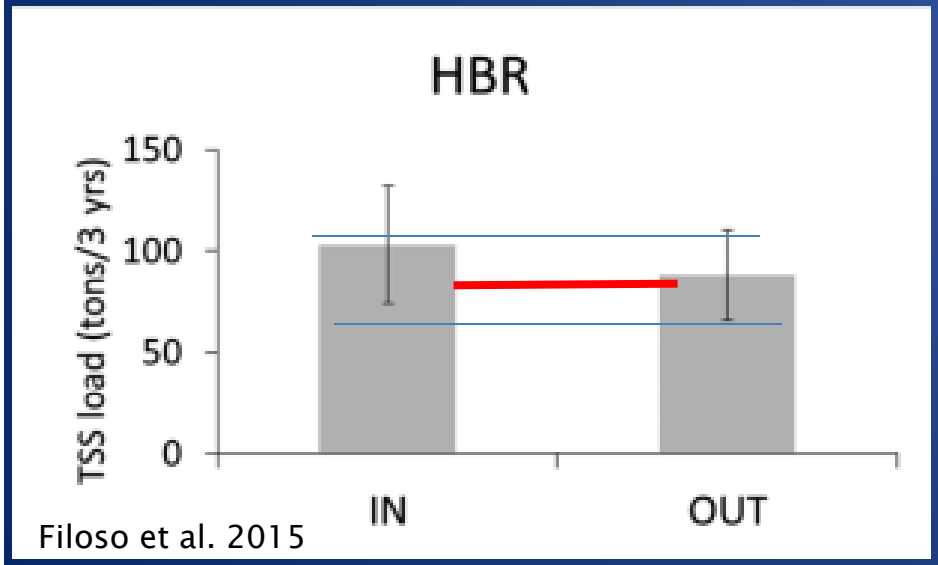
- Variation is normal
- Must consider variation

Filoso et al. 2015





Variation is real and complicates interpretations



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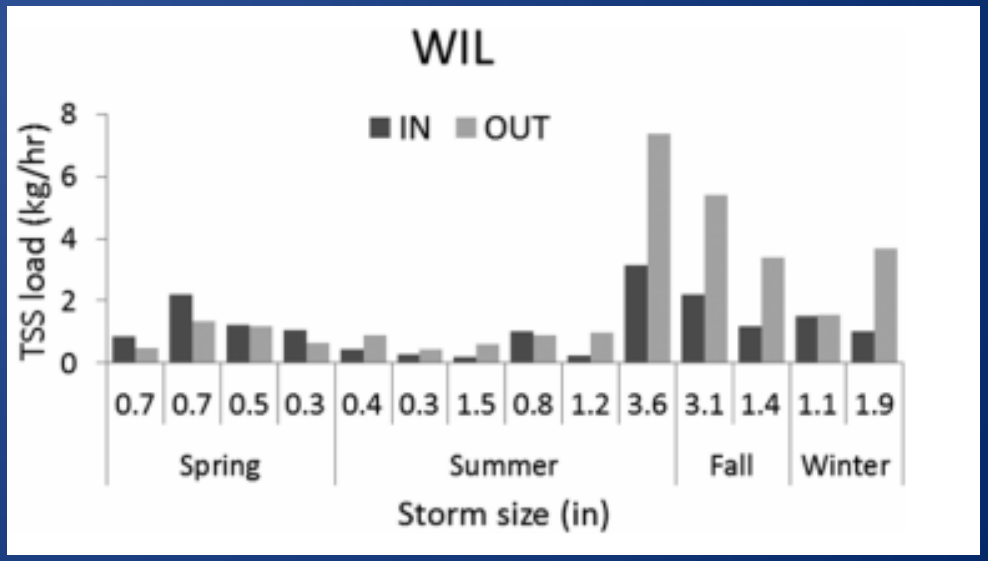


Types of variation

- Time
  - Daily, weekly (rain events)
  - Seasonal
  - Annual
- Space
  - Within stream
  - Across streams
  - Across watersheds
  - Across regions

Many reasons for variation

- Land use
- Configuration of land use
- Weather (magnitude & intensity)
- Season
- Topography (watershed & stream)
- Soils
- …….∞

Because of variation

- Should replicate (avoids rare events)
  - Multiple restorations
  - Multiple control or reference sites
  - Replication reduces risk of random errors or events
  - Replication among restoration projects allows us to draw conclusions about the effectiveness of an approach

Why replicate? Unique cases

'Whisky and 15 cigarettes a day is the secret of my good health' says Dorothy as she celebrates her 100th birthday (with a glass of her favourite tipple, of course)

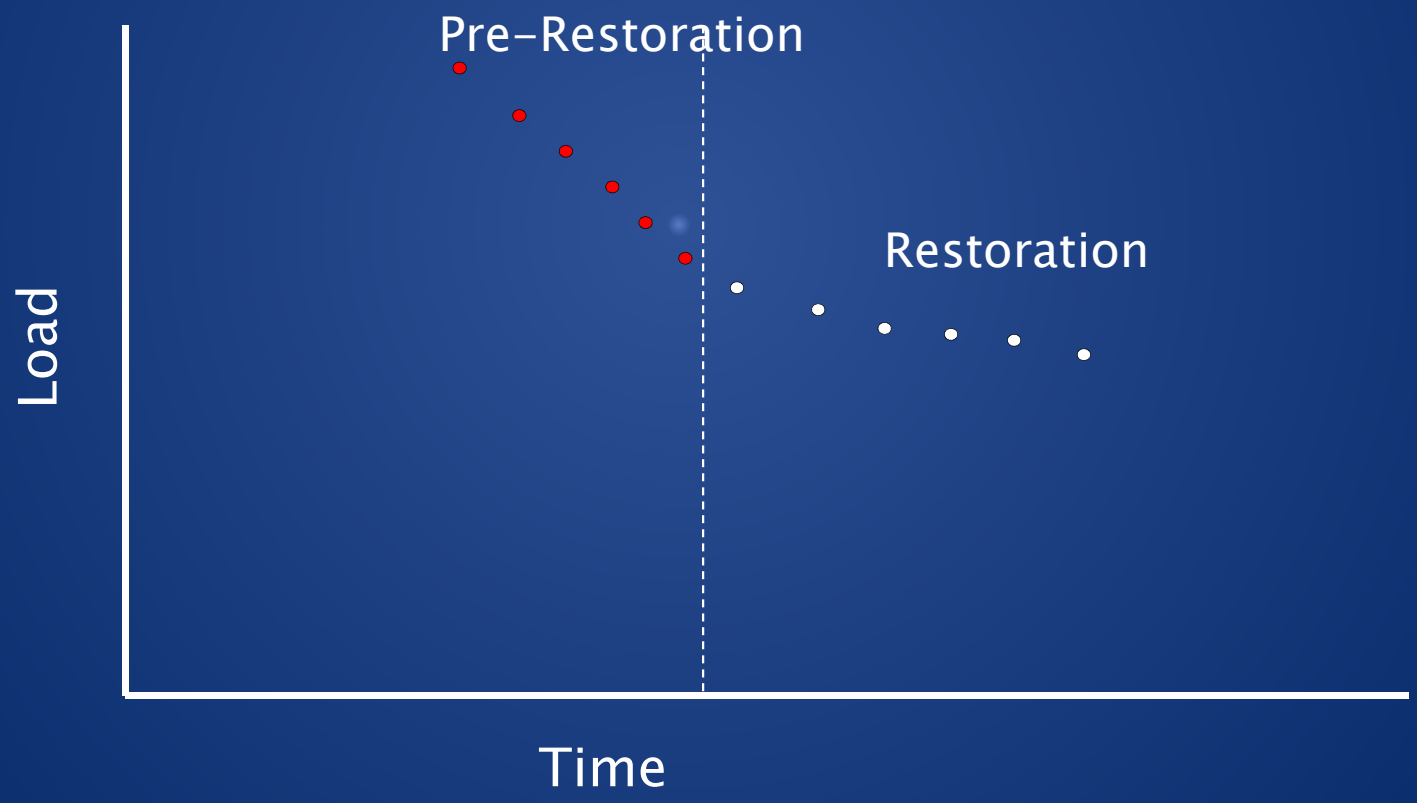
The Daily Mail, 2013

Because of variation

- Must have something to compare against
- Different experimental designs for different situations

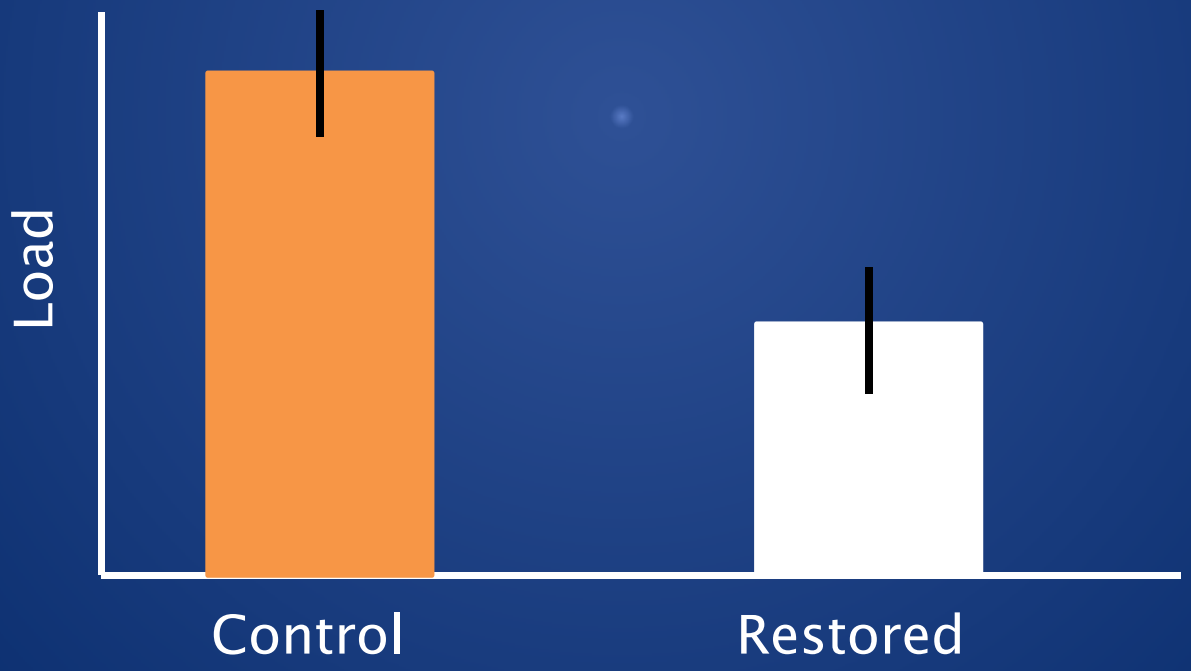
Monitoring design approaches

- Time: before vs after



Monitoring design approaches

- Space: restored vs control (or reference)
  - No pre-restoration data
    - Weakness, but not a fatal flaw with good controls



Monitoring design approaches

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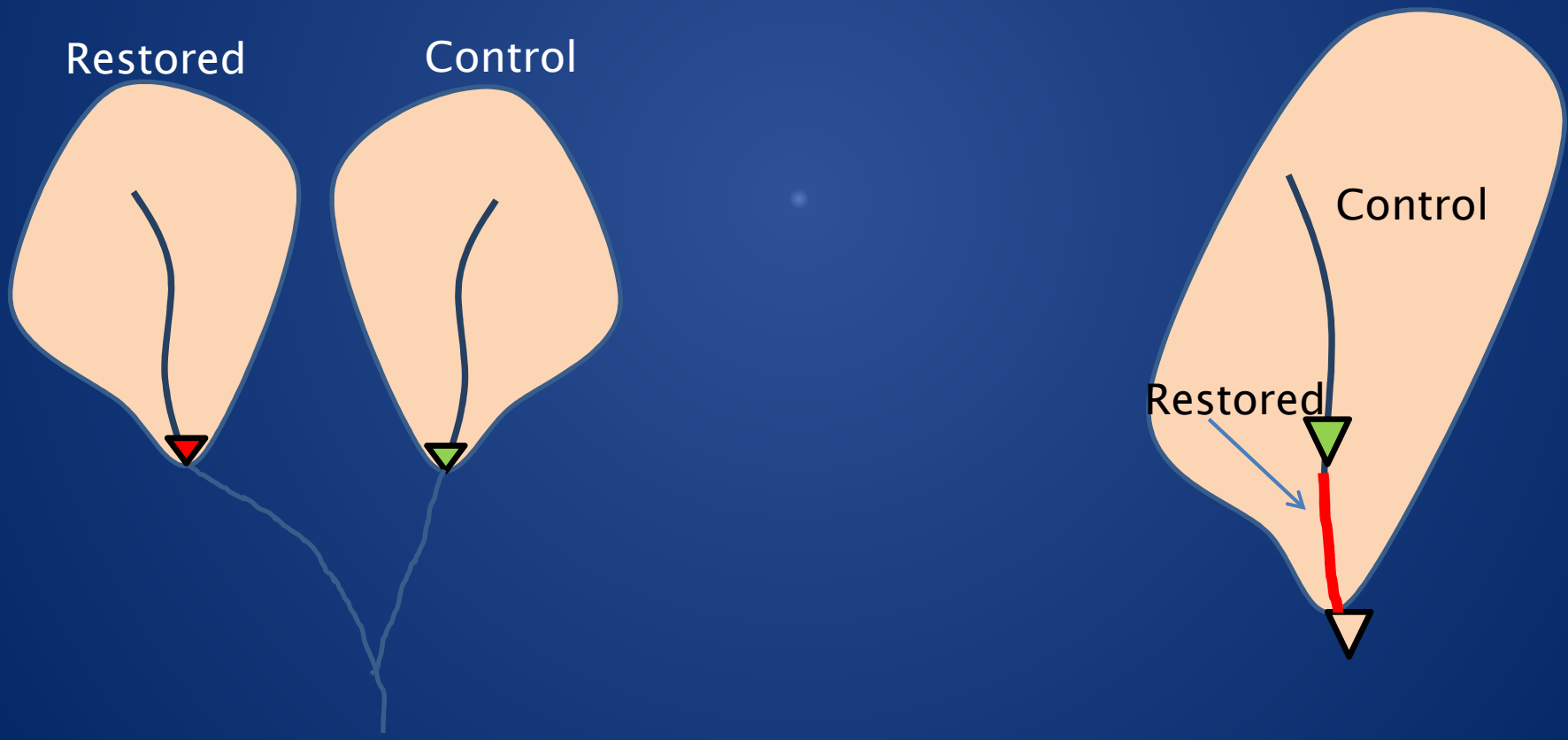
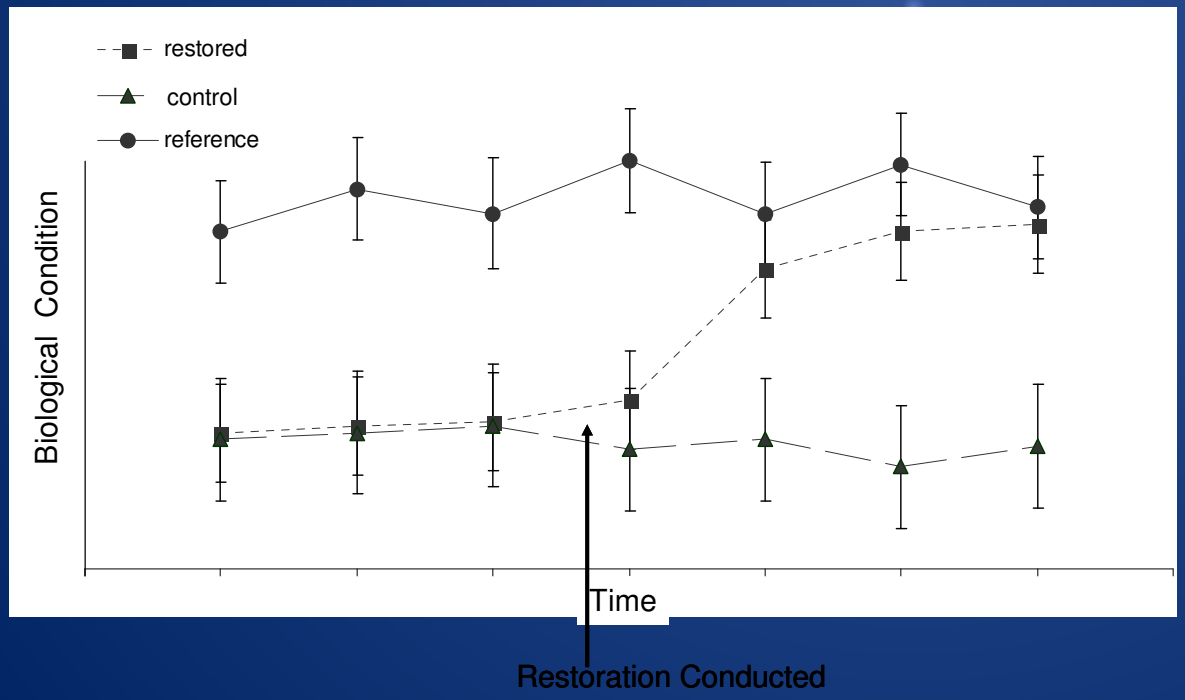
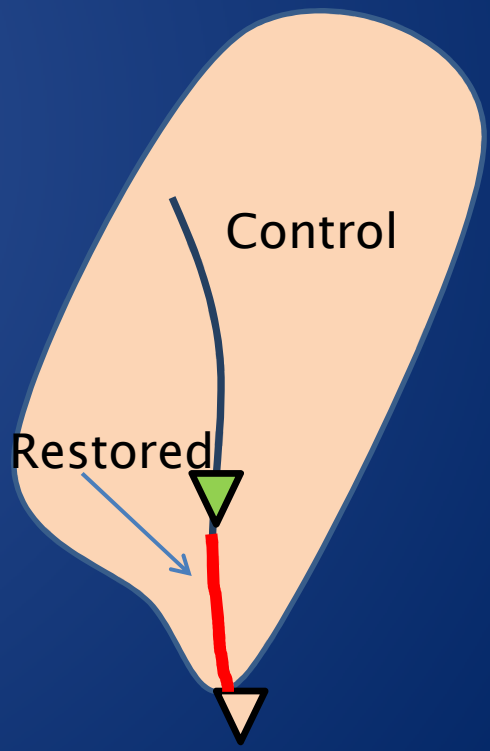


Design approaches

- Both Time and Space: BACI design
  - Before-After, Control-Impact
  - Best design in my opinion





There are differences everywhere

- Some differences are noise that we want to weed out
  - Weather: restoration and control sampled under similar conditions
  - Caveat: loads should be sampled across multiple discharges

There are differences everywhere

- Some differences are noise that we want to control
  - Weather
- Some differences are meaningful
  - Intrinsic to the system
  - E.g., stream size, land use
    - Still need to control for their effects, but in a meaningful way
    - Compare within small streams or across size gradient, but don't lump them all into one group

Monitoring design advice

- Good design minimizes differences in:
  - Space – sampling locations
    - Match restorations with similar control sites
      - Basin size, land use, channel type
    - Remove as much noise variation as possible in site selection
    - Ideally control is on the same stream

Monitoring design advice

- Good design minimizes differences in:
  - Space – sampling locations
    - Match restorations with similar control sites
      - Basin size, land use, channel type
  - Time – sample collections
    - Time sampling to be under similar conditions for comparison sites
      - Discharge, time of year, degree days

Monitoring design advice

- Good design identifies differences in:
  - Important attributes
    - Basin size, land use, channel type
      - Have replication with important groups
        - » E.g., 10 small streams (+ controls) & 10 large streams (+controls)

Monitoring design advice

- Density of sampling matched to the objective
  - Loads will require lots of samples at each site due to discharge
  - Biology requires less sampling

Group Example

- Decide on a restoration goal and technique to achieve this goal
- Discuss aspects of a good design to assess the effectiveness of the restoration technique

Hilderbrand Translation Slides

What does this mean for me?

- Monitoring is expensive
- We have to make sure that what we're monitoring is getting us at the right question
- There is the question of whether THIS restoration project worked, then there is the question of whether this TYPE of restoration WORKS in general; i.e., should we do it again elsewhere
- For the latter question, we need to measure at +1 site to capture trends (replication →spatial variability) and we need to compare to static places given that other things change (control sites →temporal variability)
- Variability is a big issue – it's what makes us say when we only measure something at one site "well, it only happened here this way because x, y, z"

What does this mean for me?

- What might I take from this if I am a practitioner:

Let's make sure we frame our questions and get them over to the scientists to answer

- What might I take from this if I am a regulator:

Let's make sure we are asking folks to monitor where it makes sense for an individual project to be monitoring (did the structure stay in place, does it need to be fixed), and let's get our major questions that we need replication and control sites over to the scientists to answer.