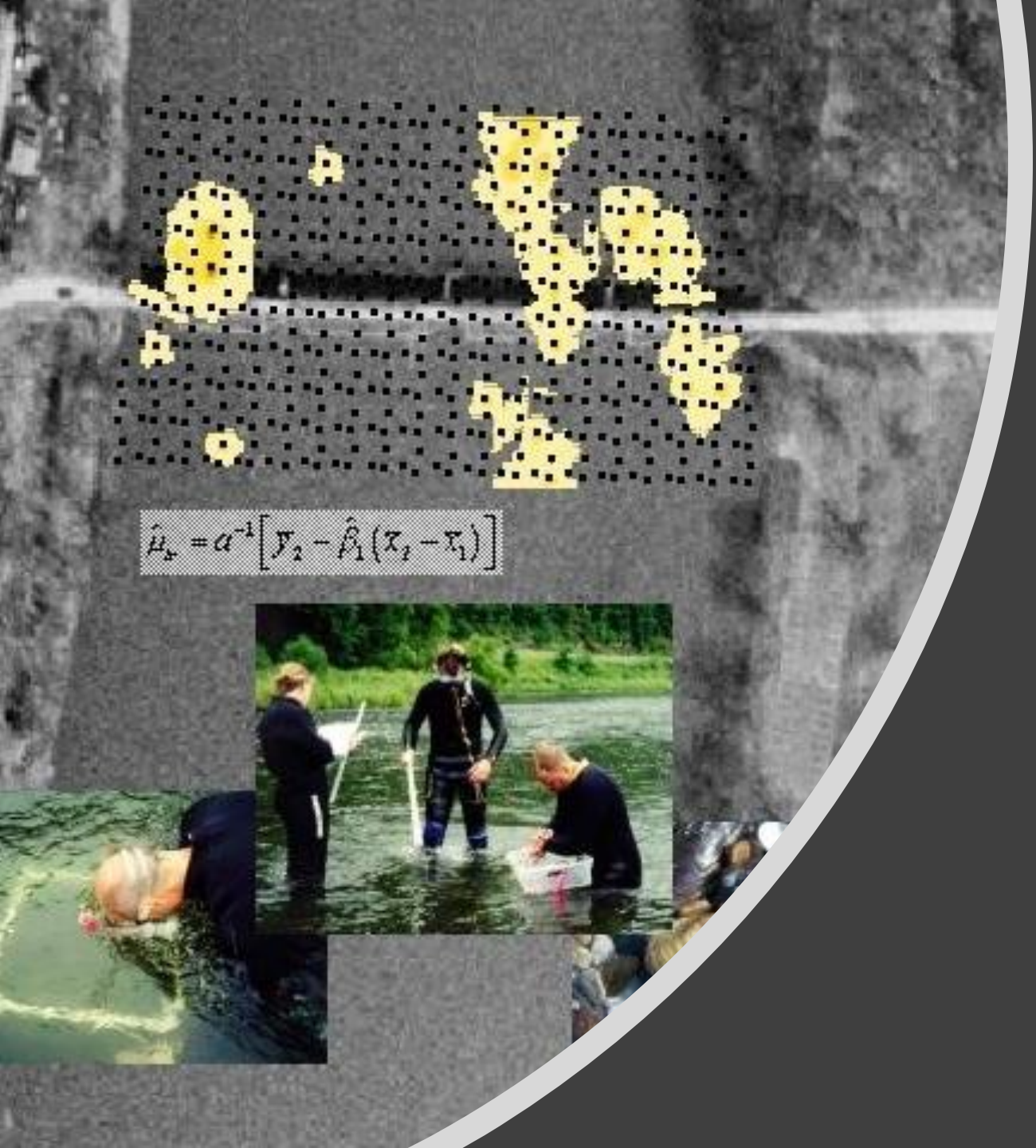

A survey design framework: putting the why before the how

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Outline

Conceptual framework for the why and how

- Broad conservation questions that motivate survey work
- Parameters and endpoints
- Core Techniques
- Survey design principles

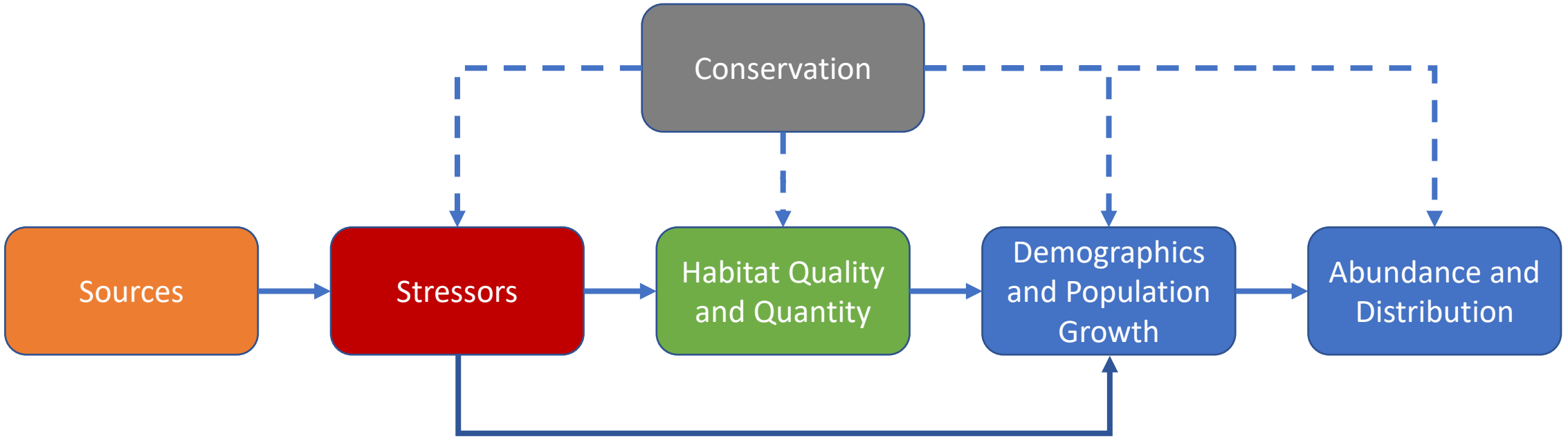
What are folks doing based on a review of pubs, 2000-2022

Standardized protocol

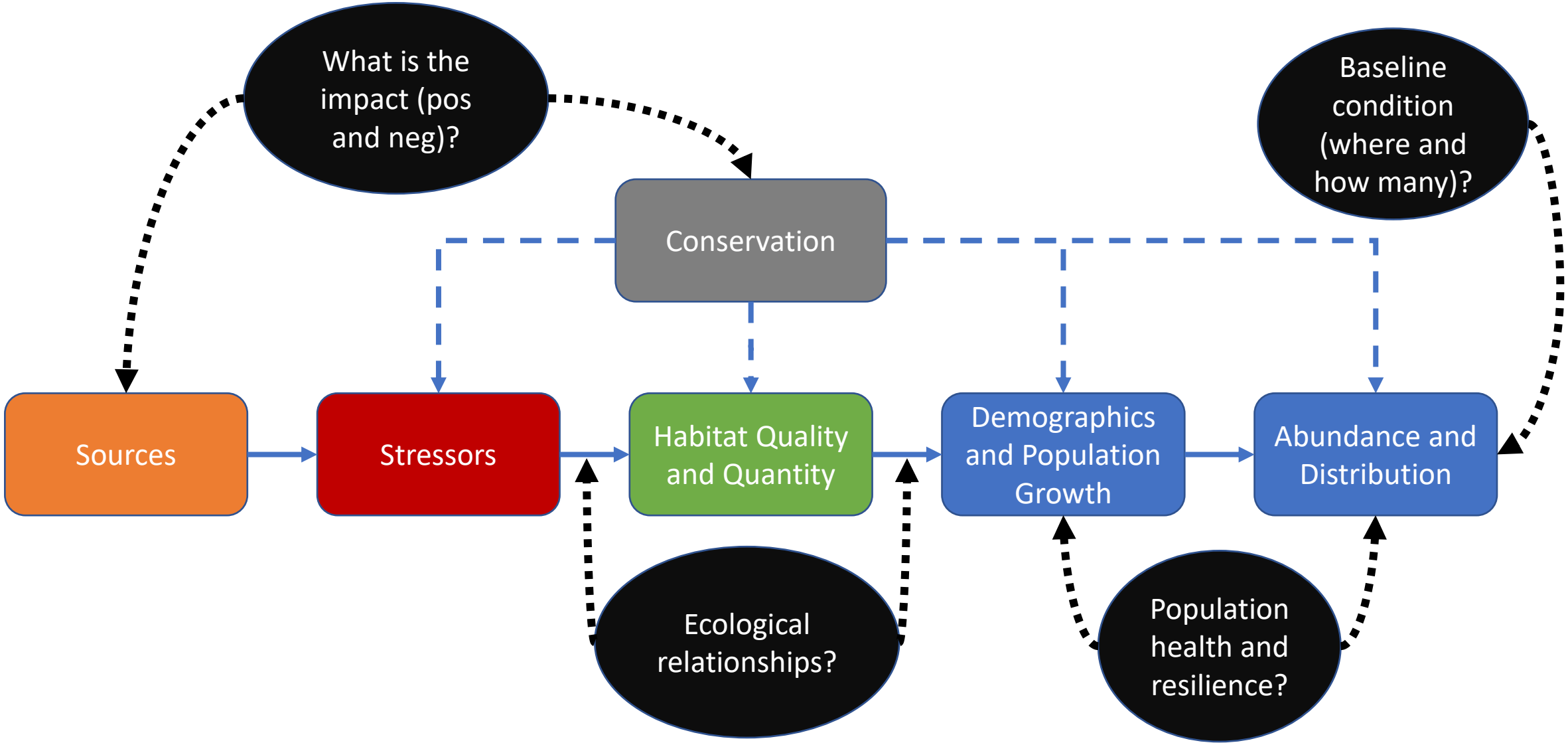
- Can it be done?
- Should it be done?

Workshop sessions and discussion

Conceptual model



Uncertainties and knowledge gaps

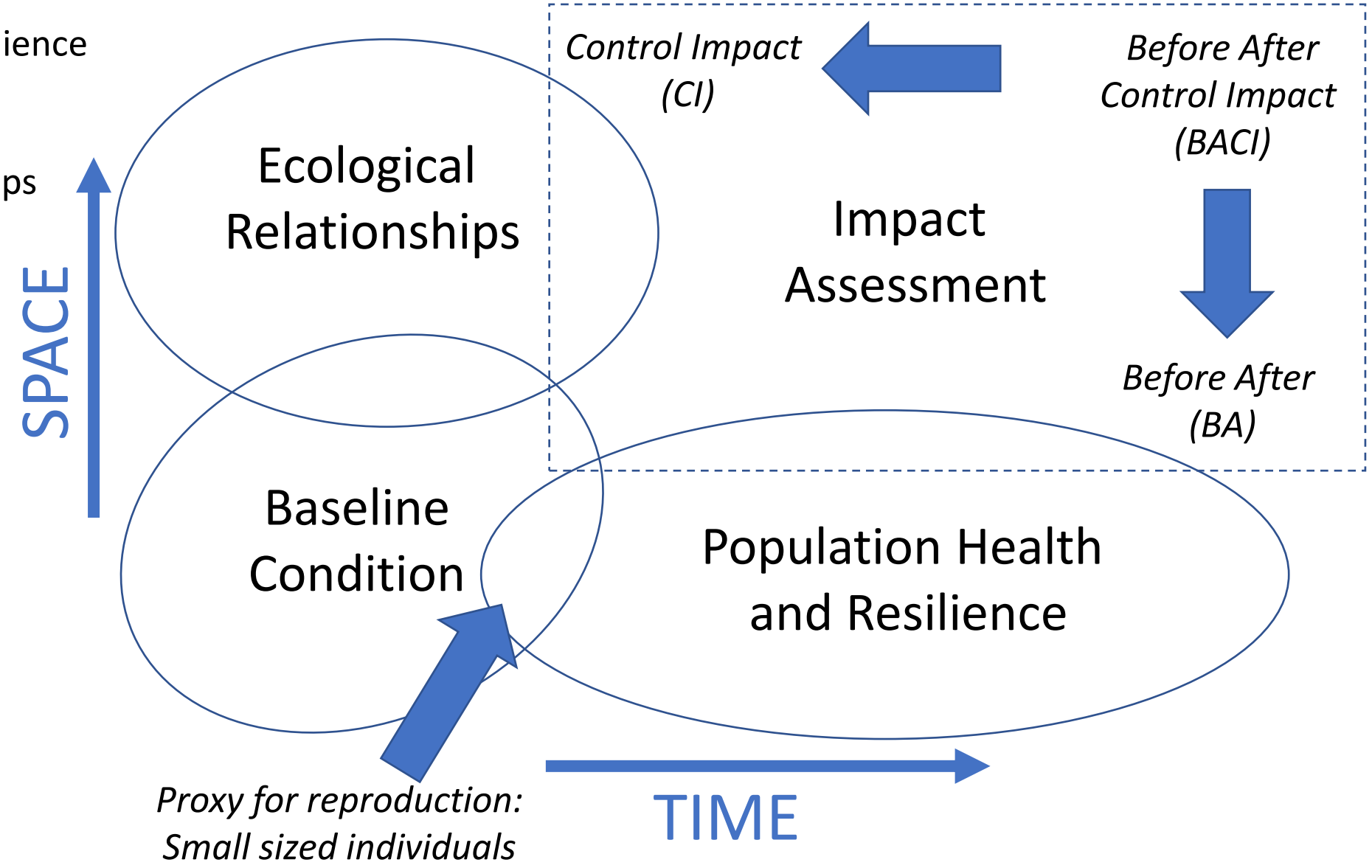


Intrinsic factors*:

- Baseline conditions
- Popn health and resilience

Extrinsic factors*:

- Ecological relationships
- Impact assessment



*From Ferreira-Rodriquez et al. (2019)

Lit review: what methods are being applied for what purpose?

- 103 publications from a google scholar search "freshwater mussels OR Unionid AND monitoring OR sampling“, published between 2000 and 2022
  - Reviewed 68 so far

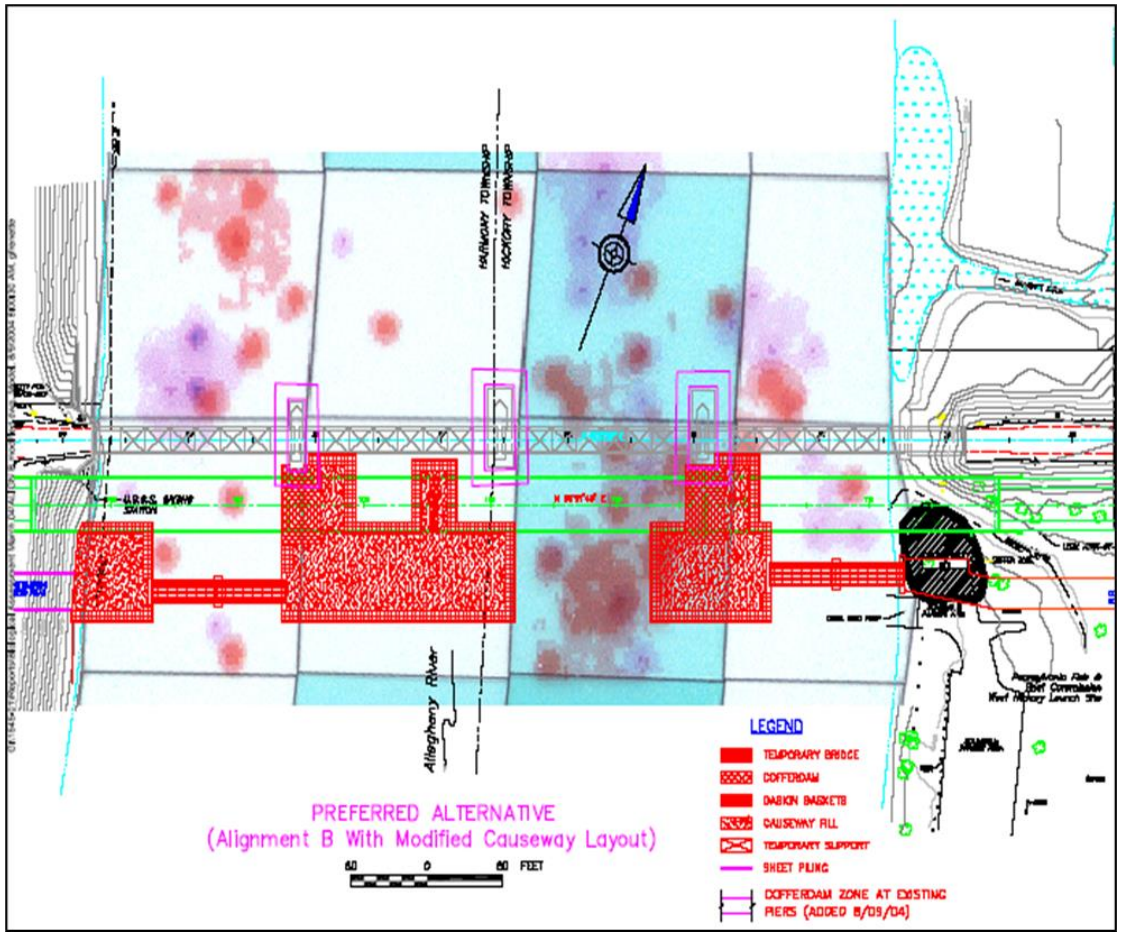
- 13 countries:
  - 62% (42) US, 19% (13) Europe, 9% (6) Canada, 4% (3) Australia, and 1% (1 each) Bangladesh, Brazil, China, Japan
- For each paper, categorized
  - Motivating Question
  - Core Technique
  - Parameter or Endpoint
  - Statistical Inference/Analytical Approach
  - Sampling Effort

Highlight four motivating questions (“why”)

- For each motivating questions, consider:
  - Conservation need/relevance
    - These data or information are needed for…
  - Parameters or endpoints and design considerations
    - Distribution, abundance, vital rates, habitat, etc.
  - Core techniques
    - Qualitative, semi-quantitative, or quantitative sampling
    - eDNA and genetics protocols
    - Tagging and mark-recapture modeling
    - Sampling to support occupancy modeling
    - Habitat sampling

Baseline condition (who, where, how many)?

- Motivating question for 16% (11)
- Conservation need
  - ‘Snapshot’ description
  - Potential take of T&E species
  - Ecosystem services
  - Help address other questions
- Parameters or endpoints
  - Distribution (36%)
  - Species richness and diversity (27%)
  - Density or abundance (18%)
  - Also,
    - Individual growth
    - Recruitment
    - Habitat quality and quantity



Villella and Nelson (2005) West Hickory report to PennDOT

Population health and resilience?

- Motivating question for 21% (14)
- Conservation need
  - Assess extirpation risk for protection or recovery
  - “Stock assessment”
  - Health and resilience is a function of abundance and population growth rate
  - Temporal component
- Parameters or endpoints
  - Trend across time or population growth (50%)
  - Density or abundance (21%)
  - Change across stressor or habitat gradient (14%)
  - Also,
    - Distribution
    - Survival, Recruitment
    - Individual growth
    - Habitat quality and quantity

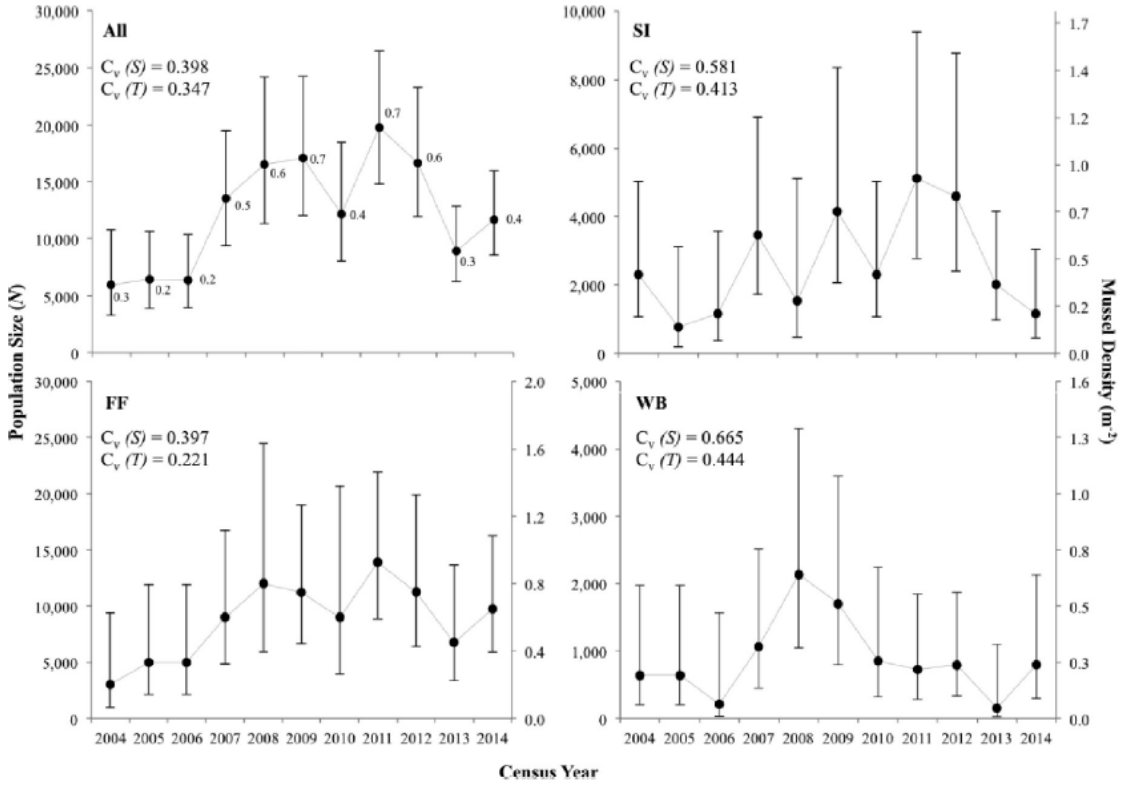


Fig 2. Estimates of population size and mean density (bars represent 95% confidence limits corrected for non-normality) for *Epioblasma brevidens* in the Clinch River, Hancock County, TN, at Frost Ford (FF), Swan Island (SI), Wallen Bend (WB), and population size averaged across all three sites (All) from 2004–2014. Numbers next to point estimates on All plot indicate average density across the 3 sites. The value C_v (S) is the total coefficient of variation measured in the time series, which includes both sampling error variance S^2 ($\hat{N}$) and true temporal process variance. The value C_v (T) is true temporal process variation, after mean S^2 ($\hat{N}$) was removed from C_v (S).

https://doi.org/10.1371/journal.pone.0256279.g002

Lane et al. (2021) PLoS ONE 16(8): e0256279.

What are the ecological relationships?

- Motivating question for 32% (22)
- Conservation need
  - Habitat protection and management
  - Designing conservation strategies
  - Predicting potential distribution and abundance
- Parameters or endpoints
  - Change across stressor or habitat gradients (73%)
  - Target parameters:
    - Richness, density or abundance, distribution
    - Survival, Individual growth
    - Habitat quality and quantity

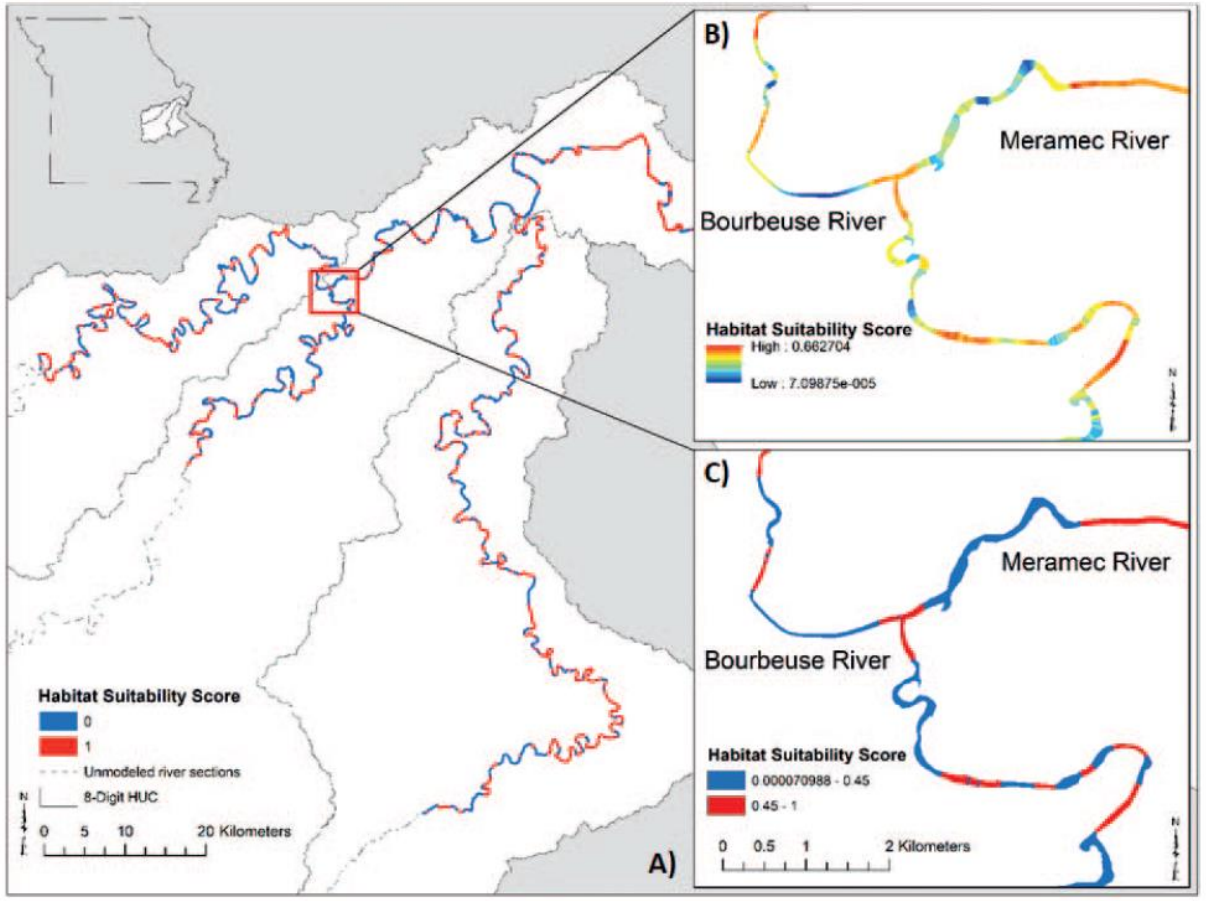
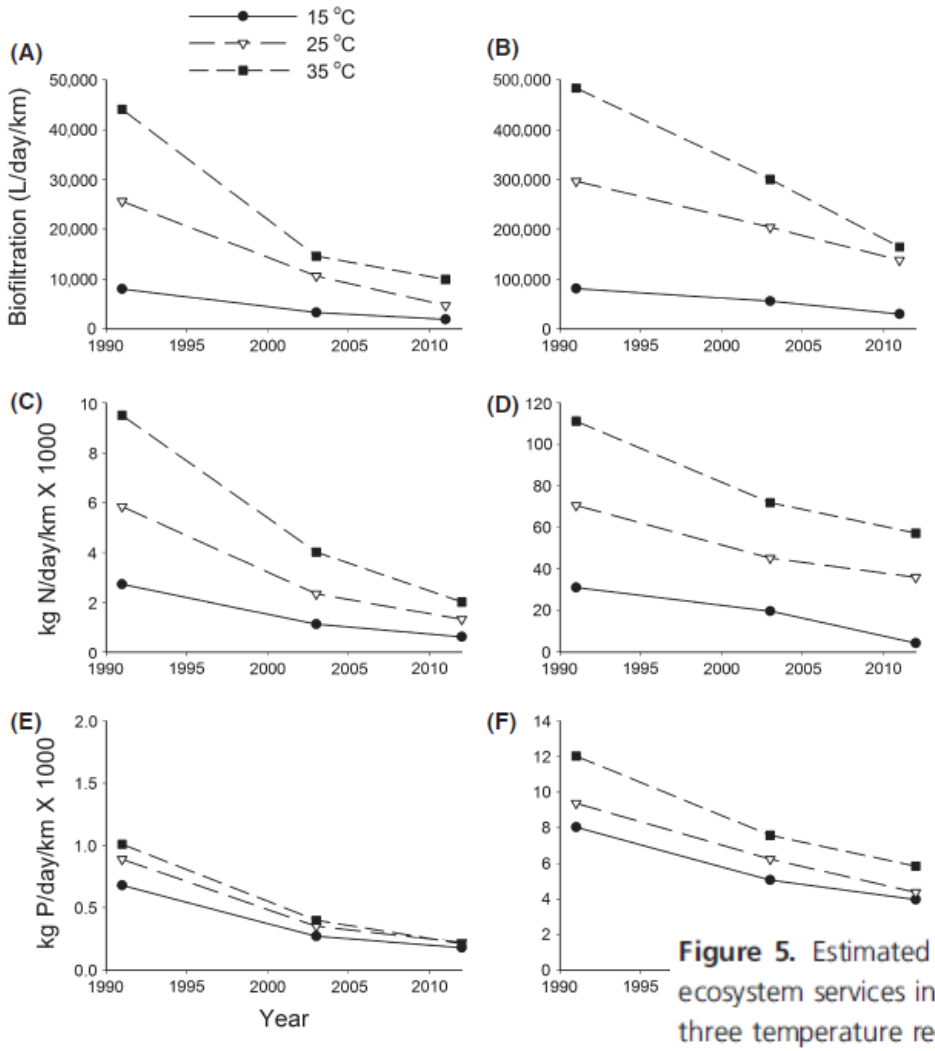


Figure 3. Model results for classifying stream reaches in the Meramec River basin with regard to their suitability for mussel beds. (A) Map of the entire study area showing a binary classification (suitable or unsuitable). (B) Detailed map of an example section of the watershed showing continuous suitability scores. (C) Detailed map of an example section of the watershed showing binary scores.

Key et al. (2021) FMCS 24: 43-58

What's the impact?

- Motivating question for 31% (21)
- Conservation need
  - Determining actual take
  - Designing mitigation measures
  - Determining conservation effectiveness
  - Impact of drought, barrier management, translocation.
- Parameters or endpoints and design considerations
  - Change across stressor or habitat gradients (67%)
  - BACI, BA, or CI designs
  - Target parameters:
    - Richness, density or abundance, distribution
    - Survival, Individual growth
    - Habitat quality and quantity

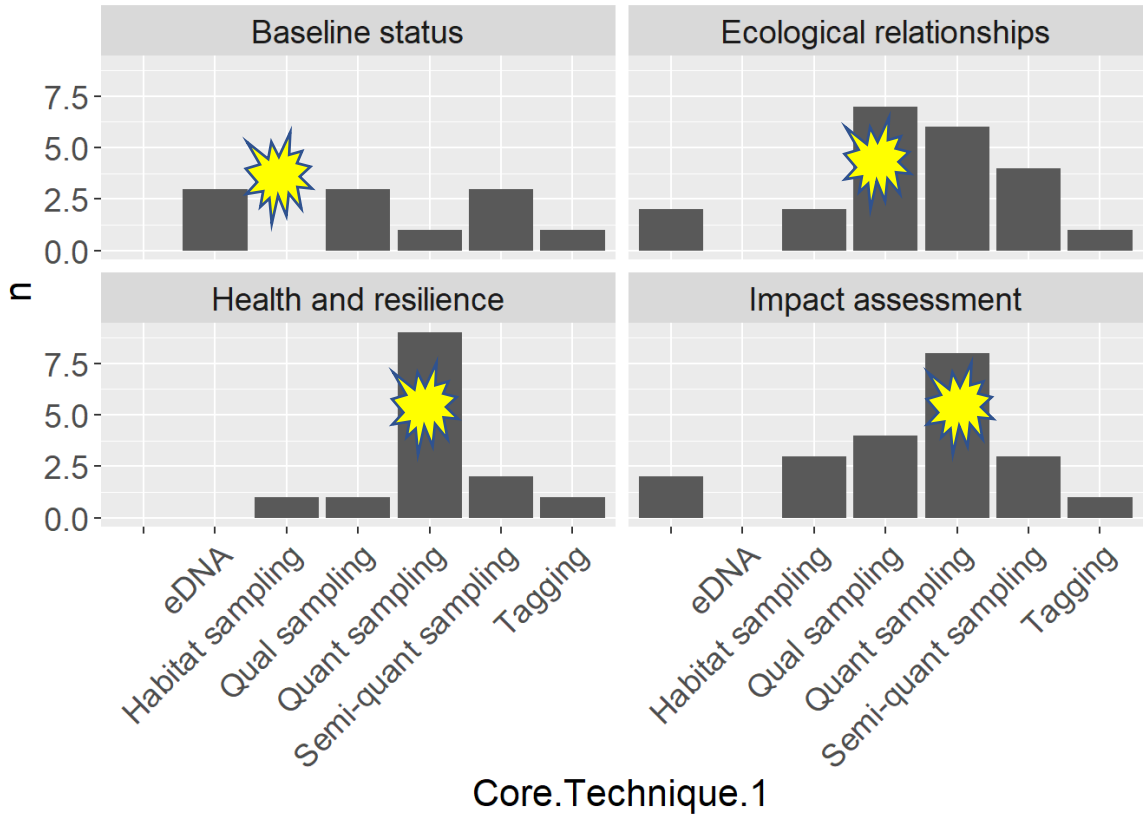


Vaughn et al. (2015) Ecol and Evol 5(6): 1291-1305

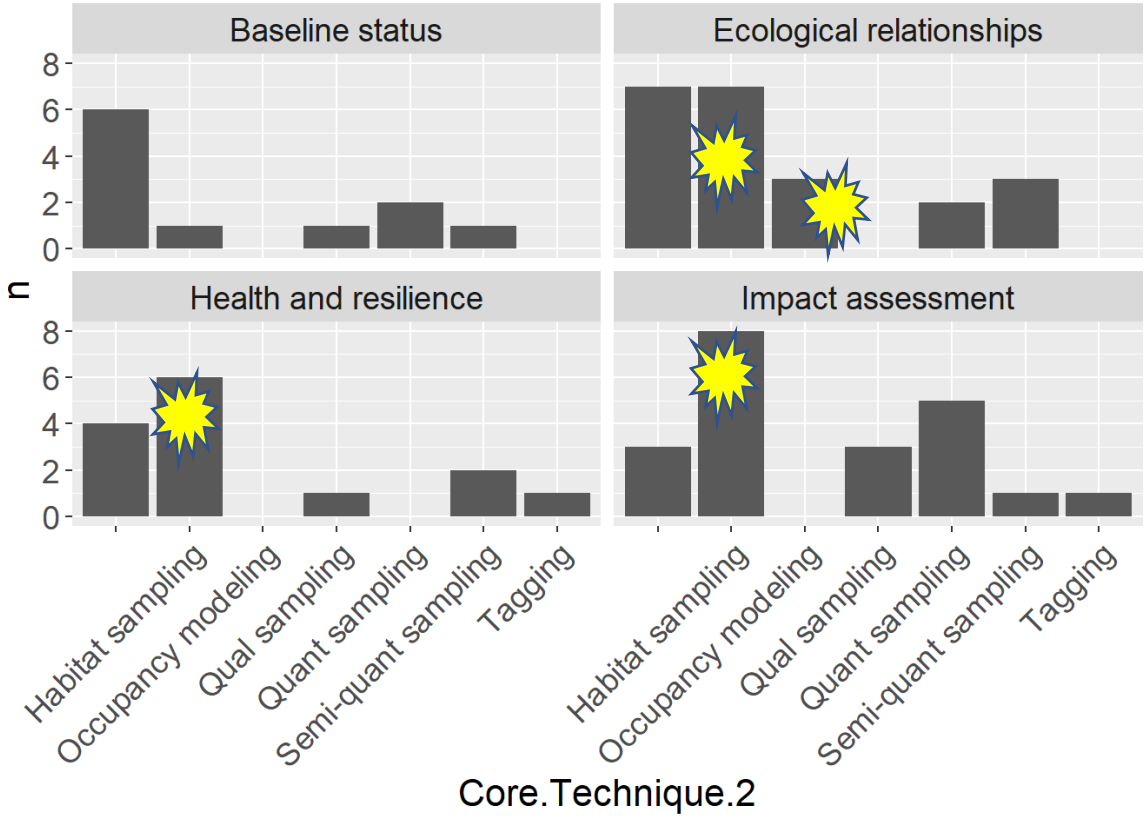
Figure 5. Estimated mussel-provided ecosystem services in the Kiamichi River for three temperature regimes over the three time periods. (A) Upstream biofiltration. (B) Downstream biofiltration. (C) Upstream nitrogen recycling. (D) Downstream nitrogen recycling. (E) Upstream phosphorus recycling. (F) Downstream phosphorus recycling. Filled circles 15°C, open triangles 25°C, and filled squares 35°C.

Core Techniques

Primary

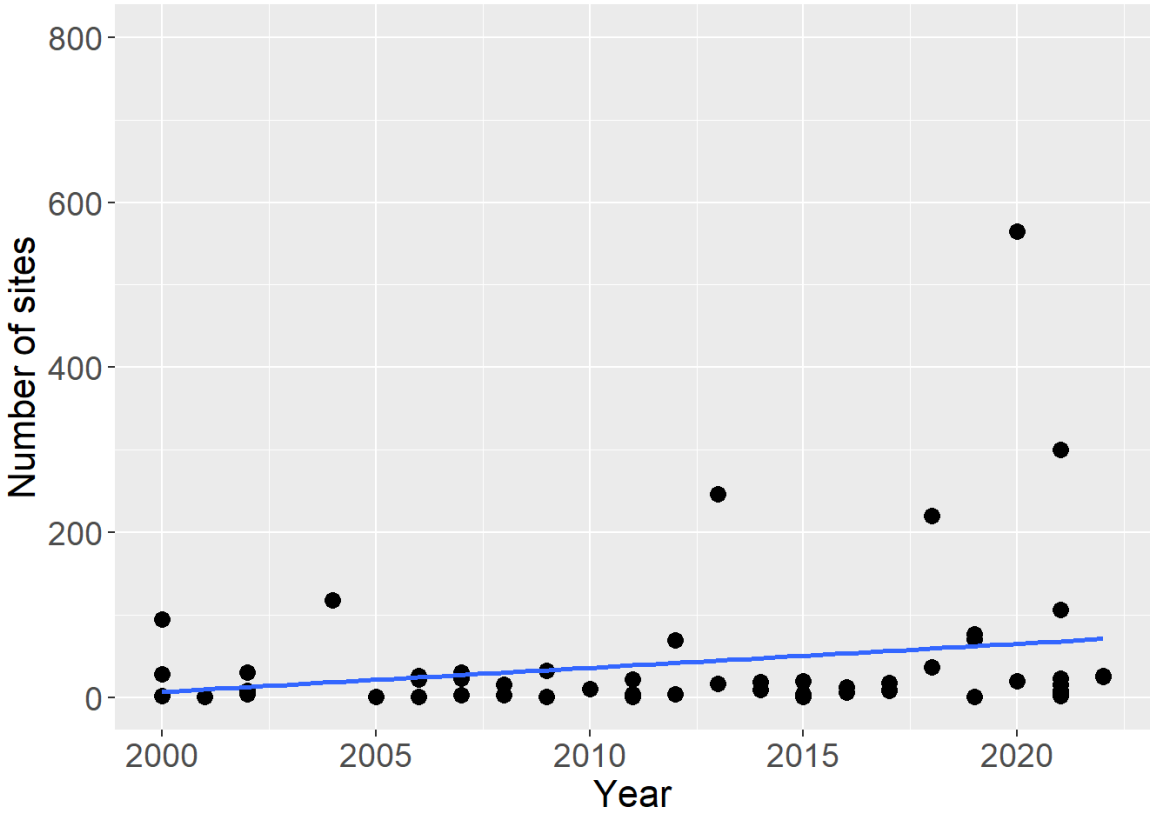


Secondary

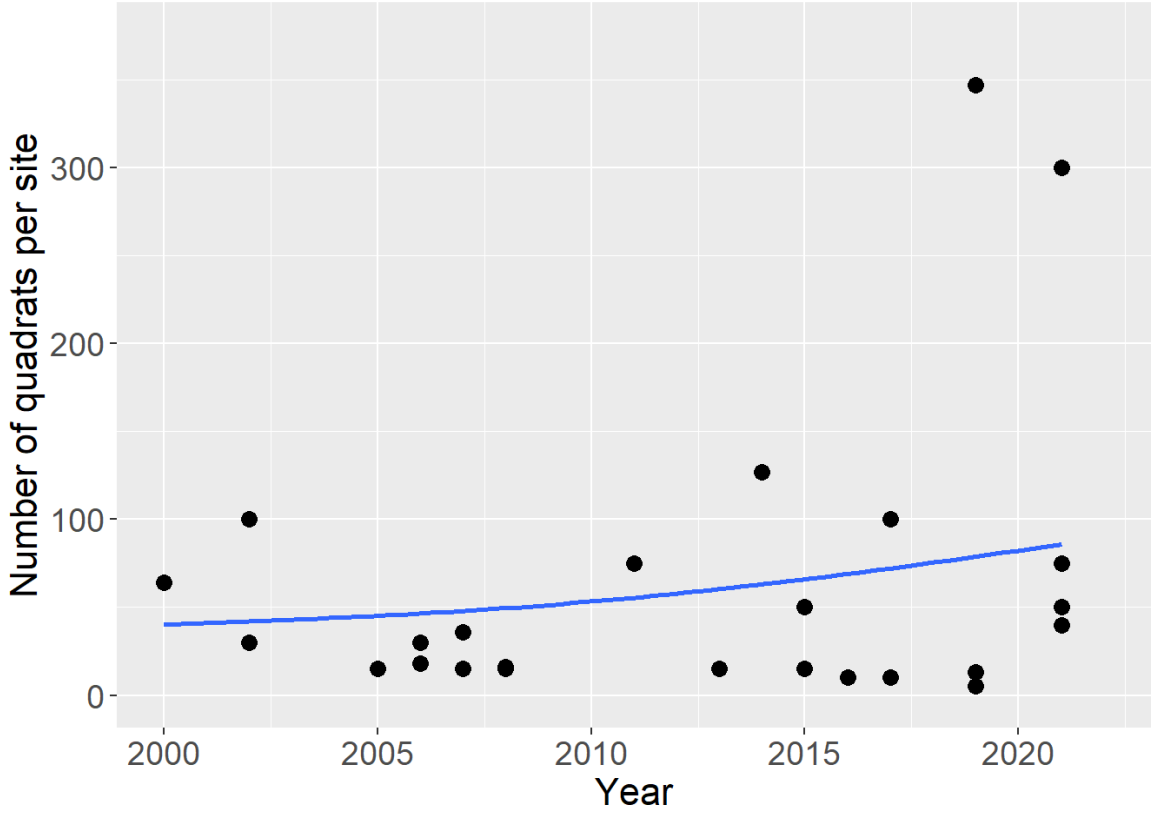


Sampling effort

Number of sites



Quadrats within sites



NCTC Webinar July 2020

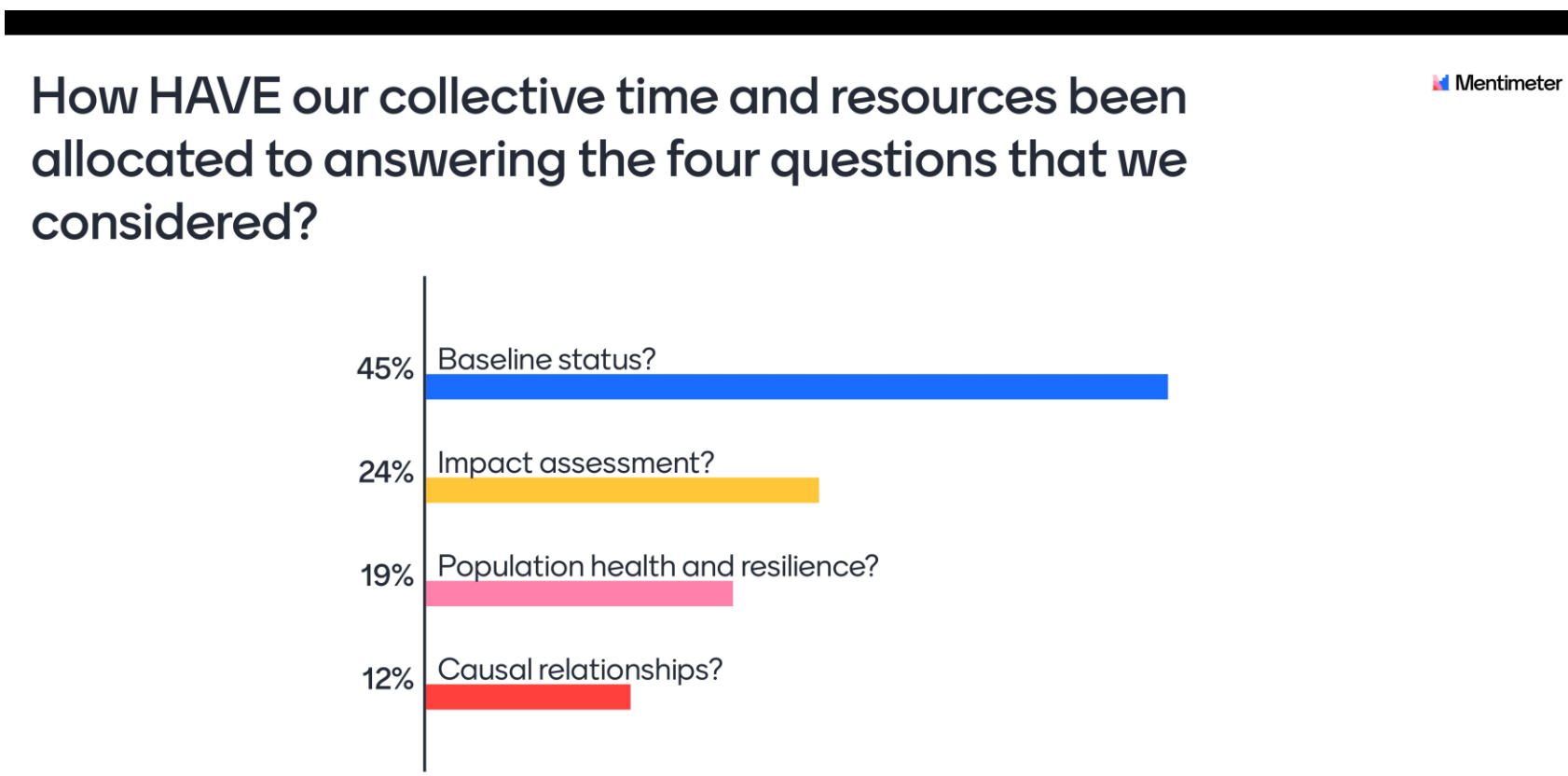
Lit Review

16%

31%

21%

32%



Why standardize?

- Comparability facilitates inference over larger spaces and times
- If baseline surveys are comparable, then results can be combined for broader assessment and inference
- Examples
  - Boon et al (2018) Developing a standard approach for monitoring freshwater pearl mussel (*Margaritifera margaritifera*) populations in European rivers. Aquatic Conserv: Mar Freshw Ecosyst. 2019;29:1365–1379.
  - Dunn (1999) Development of strategies for sampling freshwater mussels (Bivalvia: Unionidae). Proceedings of the First Freshwater Mollusk Conservation Society Symposium page 161-167.

Boon et al. (2018)

- Prescriptive for one species, *Margaritifera margaritifera*
- Published under auspices of the European Committee for Standardization
- Primary objective is to aid conservation at multiple scales
  - site level assessment of population condition (aligned with baseline condition and population health and resilience)
  - catchment level developments and impacts (aligned with ecological relationships and impact assessment)
- Parameters:
  - Population: abundance and viability
  - Habitat: fish host, WQ, physical habitat
- Techniques
  - Collection of shells
  - Semi-quantitative (search within fixed areas)
  - Individual length measurements (≥250) to examine size distribution (proxy for recruitment) collected within quadrats
  - Electrofishing for fish host
  - Habitat: WQ, hydromorphology

Dunn (1999)

- Informative, Not prescriptive
- Objective focused
  - Baseline inventory (baseline condition)
  - Management (population health and resilience, ecological relationships, impact assessment)
  - Long-term monitoring (population health and resilience)
  - Impact assessment
- Parameters
  - Presence
  - Richness and diversity
  - Density and abundance
  - Age distribution, recruitment, mortality (survival)
- Techniques
  - Reconnaissance and timed-search (qualitative)
  - Searching within a defined area without excavation (semi-quantitative)
  - Searching and excavating a quadrat (quantitative)
  - Choice dependent on objective, stream/river size, depth, velocity, substrate
  - Sample effort dependent on desired precision and available resources

Standardization Discussion

- What is the minimum sampling required to address standard information needs for freshwater mussel conservation?
- What are the standard information needs/goals/objectives?
  - Baseline condition (where and how many within a site)
  - Population health and resilience (abundance and population growth or proxy measures)
  - Ecological relationships (habitat needs)
  - Impact assessment (stressor effect -drought, conservation effect – barrier removal)
- What is the structure and basics of the protocol
  - Parameters or endpoints or metrics (presence, richness, density or abundance, vital rates, trends, relationships
  - Core techniques, qual, semi-quant, quant, tagging, habitat, eDNA
  - Survey design principles: spatial coverage, reference sites, sampling over time to capture signal from the noise
  - Minimal effort to ensure comparability
  - Analytical approach recommendations: account for detectability in occupancy, survival, individual growth

Let’s get to it!

Fundamental survey techniques

- Qual, semi-quant, quant and habitat sampling
- Collection, identification, field processing
- Marking and tagging
- Statistical estimation of fundamental parameters and endpoints

Advanced topics

- Developed protocols, Guidelines and recommendations, Case studies, Overview/Tutorial
  - Population/Community health
  - Use of genetics
  - Species risk assessment
  - Long-term monitoring
  - Impact assessment
  - Occupancy modeling, niche modeling, multi-species models
  - Ecosystem services
  - Hydrodynamic application
- Discussion
  - Open topics
  - Standardization

Discussion and Q&A