A survey design framework: putting the why before the how

Dave Smith
U.S. Geological Survey
Eastern Ecological Science Center
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

- Sources
- Stressors
- Habitat Quality and Quantity
- Demographics and Population Growth
- Abundance and Distribution
- Conservation
Uncertainties and knowledge gaps

Sources → Stressors → Habitat Quality and Quantity → Demographics and Population Growth → Abundance and Distribution

- What is the impact (pos and neg)?
- Baseline condition (where and how many)?
- Ecological relationships?
- Population health and resilience?
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
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

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

Core Techniques

**Primary**

- Baseline status
- Ecological relationships
- Health and resilience
- Impact assessment

**Secondary**

- Baseline status
- Ecological relationships
- Health and resilience
- Impact assessment

Core Technique 1

Core Technique 2
Sampling effort

Number of sites

Quadrats within sites
How HAVE our collective time and resources been allocated to answering the four questions that we considered?

- **Lit Review**
  - 16% Baseline status?
  - 31% Impact assessment?
  - 21% Population health and resilience?
  - 32% Causal relationships?
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)

- 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 ($\geq 250$) 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
• 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