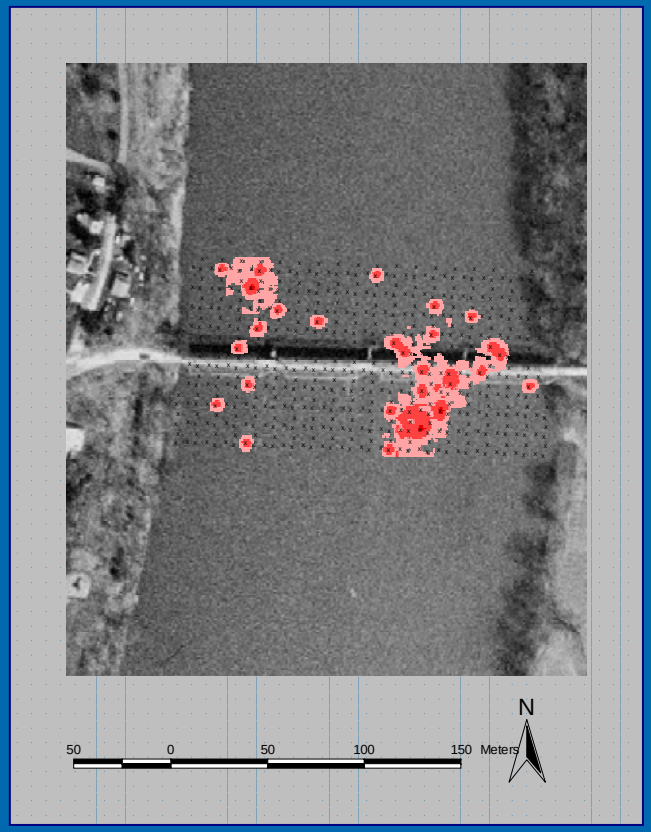
Sampling Freshwater Mussel Populations: A Case Study



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Module Objectives and Outline

- Module Objectives: *I hope you will learn (or I hope to reinforce)* …
  - The importance of evaluating survey design prior to implementation (will it meet survey objectives?)
  - The benefits of good spatial coverage when sampling rare and clustered organisms
  - The use of double sampling for estimating detectability
- Outline:
  - Introduce a Framework for Sampling Freshwater Mussels
  - Part I: Present a Case Study that Incorporates the Framework
  - Part II: Present Sampling Designs for Common Objectives
  - Open it up for discussion

Five Considerations that Guide Survey Design

What are the objectives?

What is the target population?

What resources ($ and time) are available?

What is known about the study site?

What is known about the biological pop'ns?

Survey Design Loop (asking a critical question)

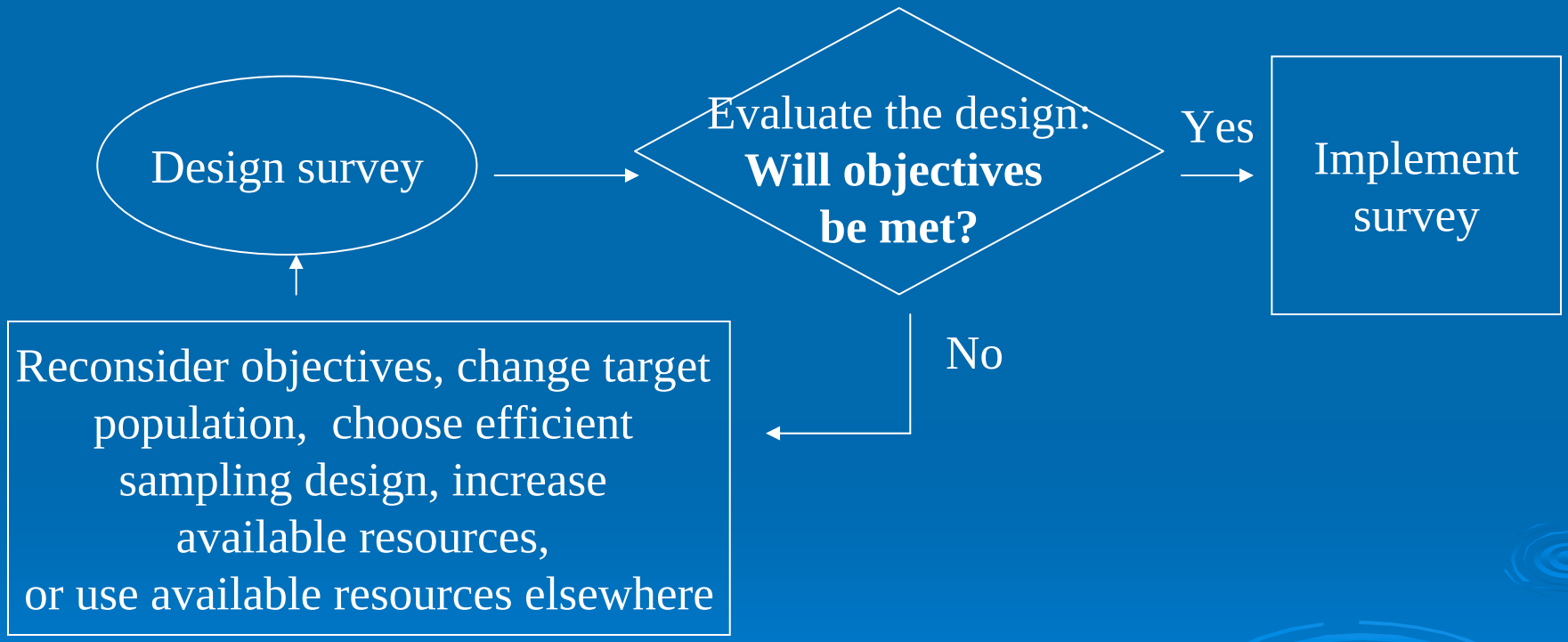


Table 1 from Strayer and Smith

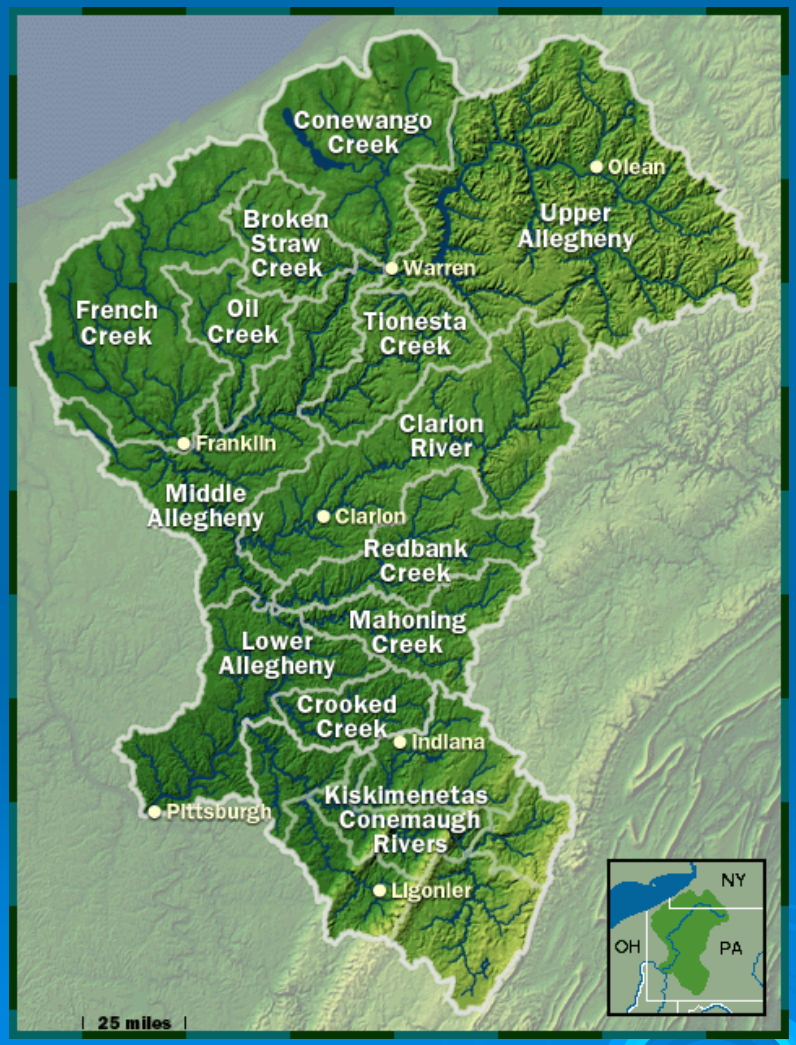
Sequence of Steps to Implement a Mussel Survey

Choose a sampling design	Complete coverage Haphazard sampling Probability-based sampling
Collect mussels within sampled sediment	Visual/tactile search of surface Sediment excavation
Observe, measure, or count mussels	ID species Measure lengths Count individuals
Analyze observations to estimate population parameters	Formulae depend on sampling design

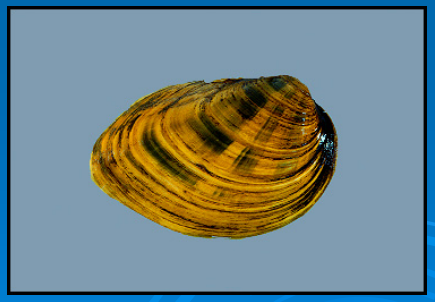
Acrobat Document

Table 1. Cross-tab of survey designs (click on icon to open)

Case Study: Endangered Species in the Allegheny River

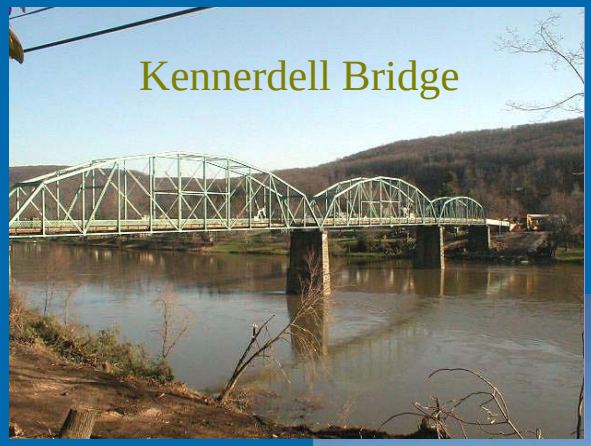


Epioblasma t. rangiana
Northern riffleshell



Pleurobema clava
Clubshell

Motivation: Biological Assessment under the ESA



- Federal funds used to replace bridges in the Allegheny watershed
- Biological assessment required to determine whether formal consultation is necessary
- Biological assessment determines species present and potential impacts
- Based on reliable, credible information; best data available

Kennerdell Bridge Demolition

Survey Design

- Five guiding considerations and an important question
  - Objectives
  - Target population
  - Resources to conduct survey
  - Site characteristics
  - Biological considerations
  - Will the design meet the objectives?

Objectives and Target Population

- Objectives
  - Determine species present
  - Estimate species-specific density
- Target population
  - Depends on effects of construction
    - Mortality, displacement, reduced growth and reproduction
  - Area of direct effect
    - Effect certain due to burial, crushing, or severe erosion
  - Area of indirect effect
    - Effect uncertain due to temporary changes in flow causing sediment erosion and deposition

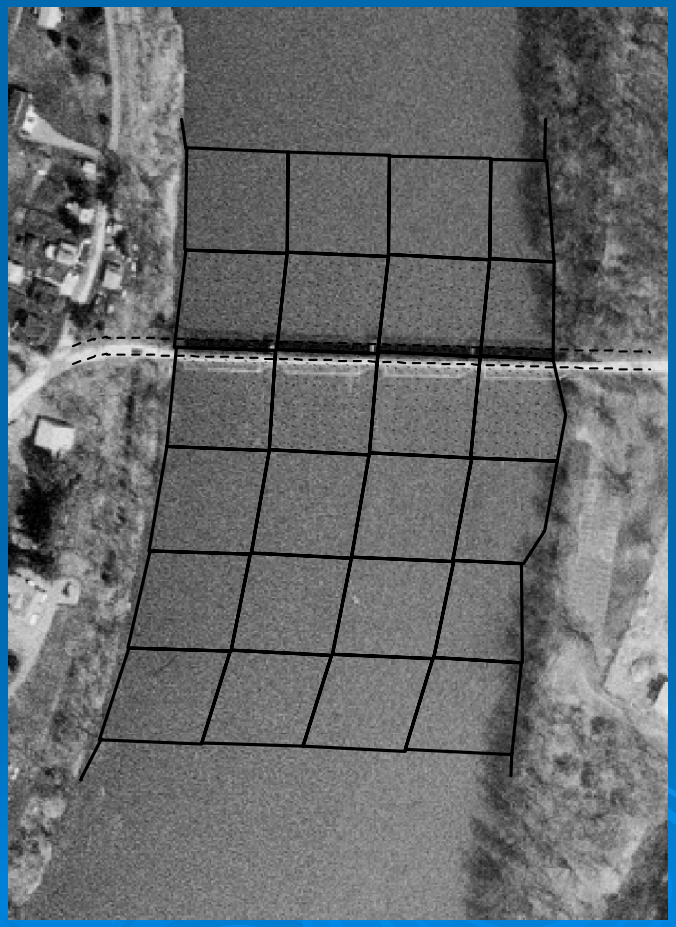
Site Characteristics

- Main stem Allegheny
  - 150 to 250 m wide
  - Up to 10 m deep (SCUBA)
  - Low turbidity at low flow
  - Regulated flow
- Tributaries, e.g., French Creek
  - 20 to 30 m wide
  - Up to 3 m deep (SCUBA)
  - Low turbidity
  - Flashy flow regime

50 0 50 100 150 200 Meters

Resources to Conduct Survey

- Status quo sampling effort not sufficient
- Mussel sampling is labor intensive and costly
- Area of direct effect
  - Objective: Determine species present and estimate species-specific density
- Area of indirect effect
  - Objective: Determine species present



50 0 50 100 150 Meters

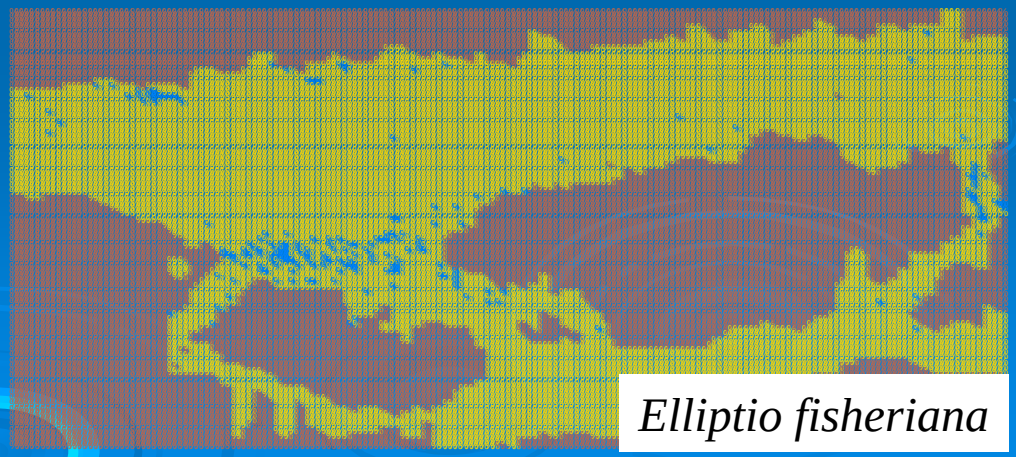
Resources to Conduct a Quantitative Survey

- Approximate guidelines for labor required to quantitatively sample a river
- Time required: 1 to 4 days

River width	Crew size
<20 m	2-4
20 to 60 m	4-6
60 to 300 m	6-12

Biological Considerations

- Spatially rare and clustered
- Relatively immobile and benthic
- Detectability affected by behavioral, demographic, and environmental factors



Villosa iris, rainbow-shell

M. C. Barnhart

Lampsilis reeveiana, broken-rays mussel

M. C. Barnhart

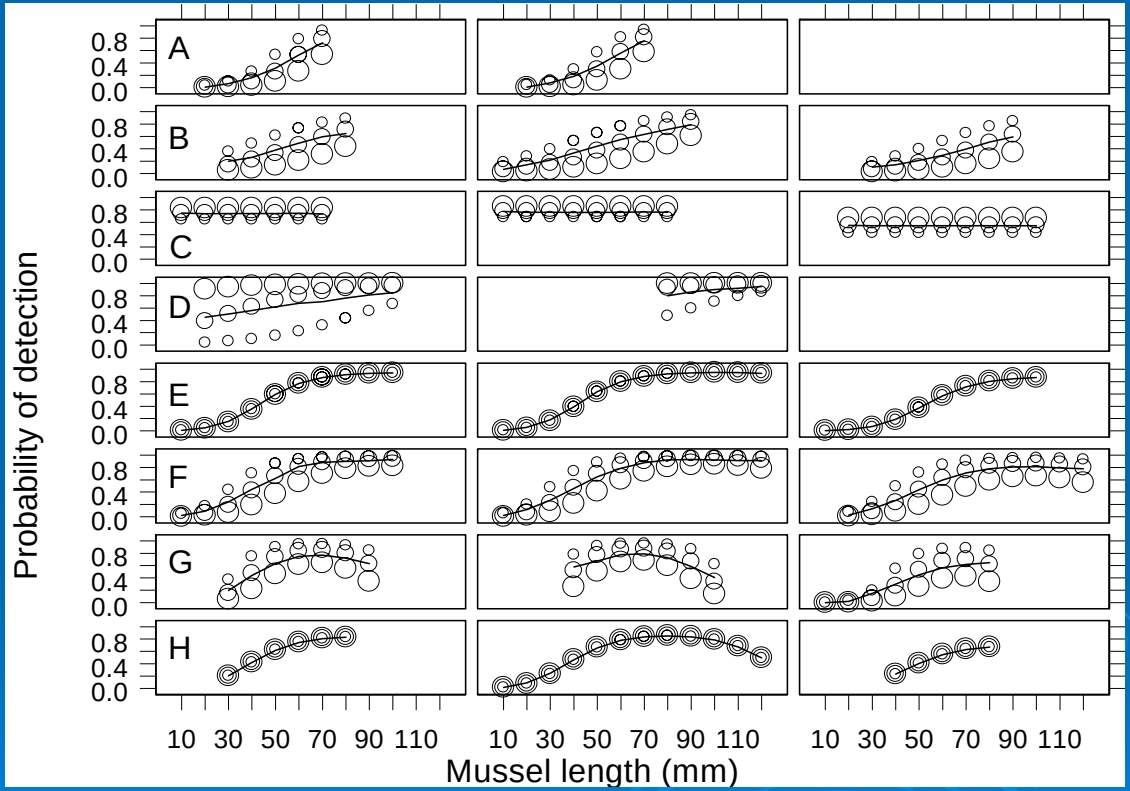
M. C. Barnhart

Ptychobranchus occidentalis, kidneyshell

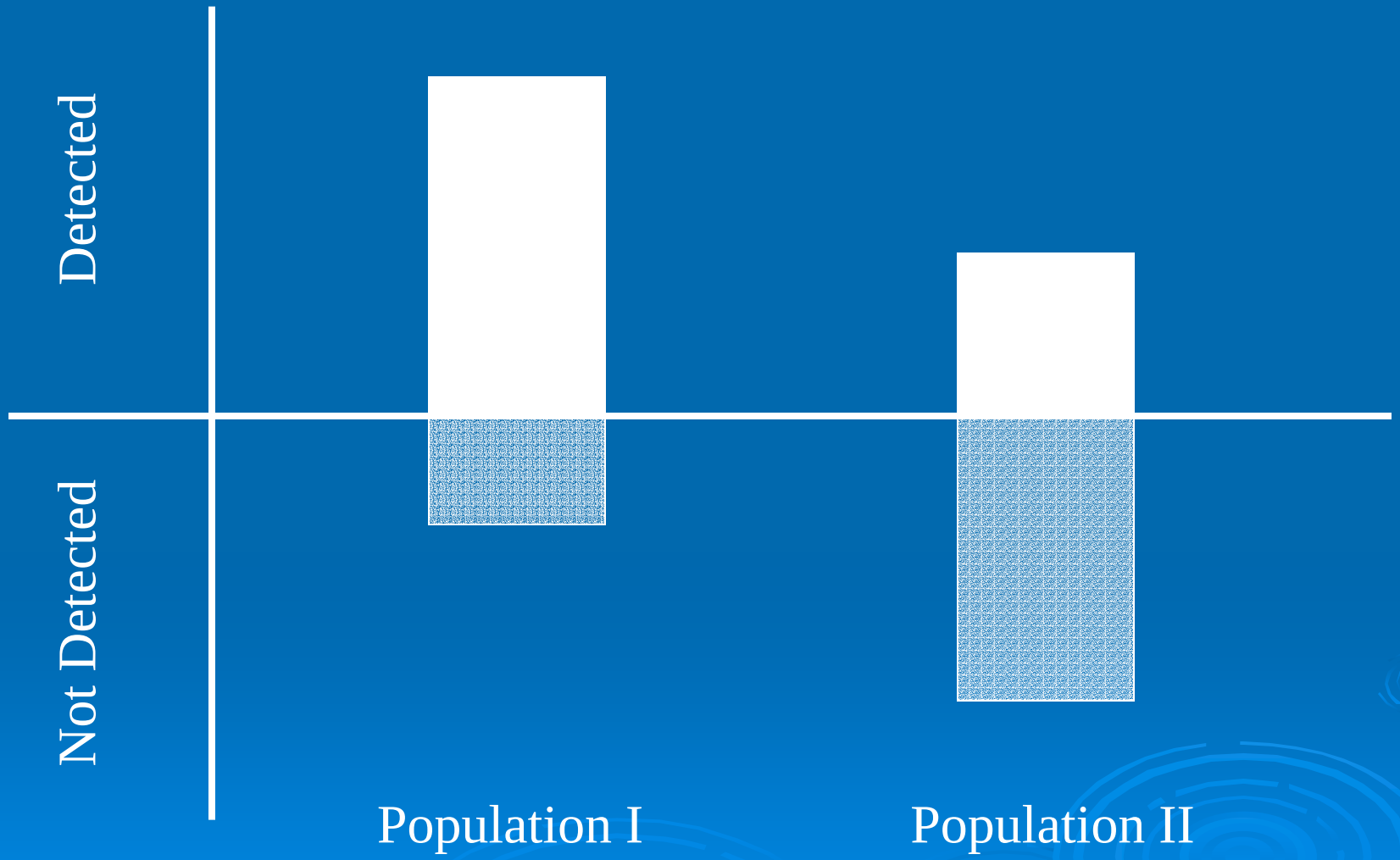
Chris Barnhart

Detectability

- Mussel species, sex, age or length
- Water temperature and depth
- Substrate type
- Vegetation
- Flow
- Turbidity
- Observer skill and fatigue



Based on *Elliptio complanata* at 14 streams (10 Atlantic Slope, three Interior Basin, and one St. Lawrence River Drainage)

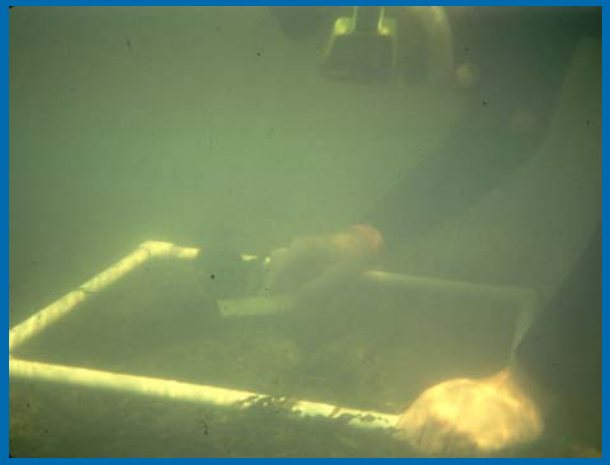

Detected
Not Detected
Population I
Population II

Detectability of endangered dwarf-wedge mussel

Site	Surface density (no. m^{-2})	Total density (no. m^{-2})	Percent detected at the surface
Ashuelot River	0.25	1.11	22
Neversink River	0.45	0.71	64
Connecticut River	1.31	2.45	55

Excavation of sediment

- Method to collect endobenthic mussels
- Time consuming
- Disturbs organisms and habitat
- Some is necessary, but can it be minimized?



Methods to Estimate Detectability

- Mark-recapture
  - Tried removal method, didn't solve problem
  - Biased and imprecise
- Distance sampling
  - Tried it, didn't solve problem
  - Precise, but biased
- Double sampling
  - Solved problem
  - Some amount of excavation required
  - Evaluated effect of excavation on survival

Double Sampling

Steps in a Double Sampling Design:

1) Initial sample: Take a large random sample of *n´* units
2) Implement a *frugal* and *inaccurate* method on the initial sample (e.g., surface count)
3) Calibration sample: Take a random subset of *n* units from the initial sample
4) Implement a *costly* and *accurate* method on the calibration sample (e.g., total count)
5) Relationship between frugal measurement and costly measurement is used to adjust the remainder of the initial sample

Double Sampling

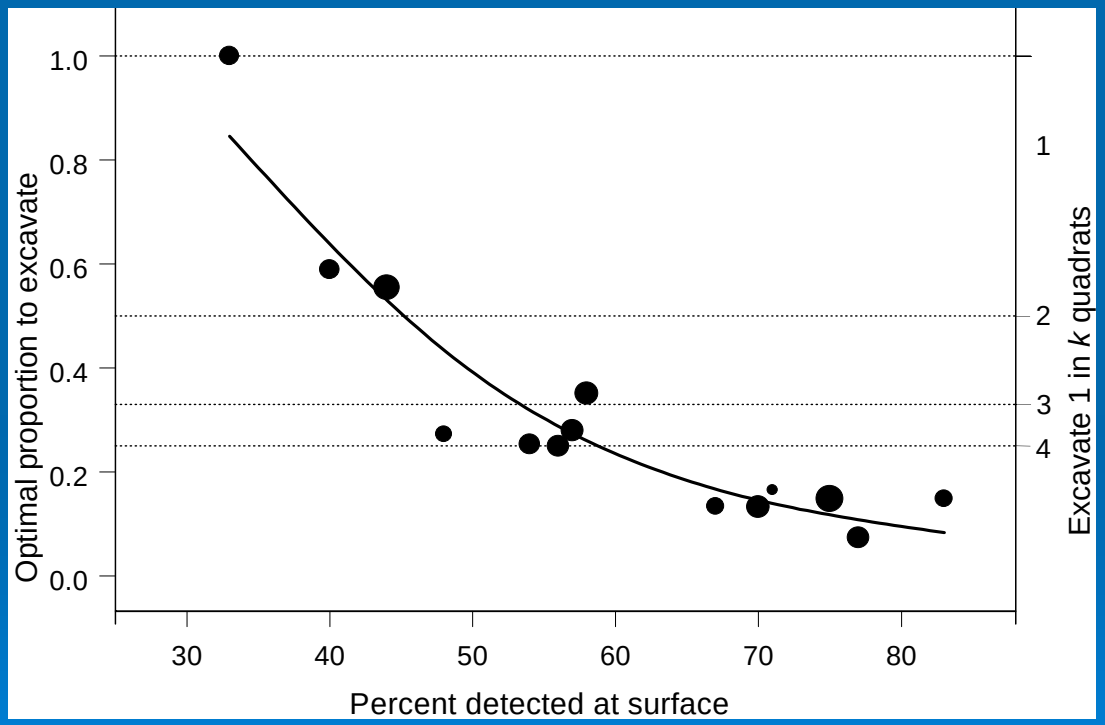
In the mussel case:

1) Take initial sample of quadrats
2) Count mussels at substrate surface
3) Select a subset of the initial sample
4) Excavate sediment and count mussels that were not counted on the surface
5) Surface count/Total count = Detectability

- Use regression formulae to estimate density
- Optimal allocation is an important issue

(i.e., how large should the calibration sample be?)

Allocation of Sampling Effort



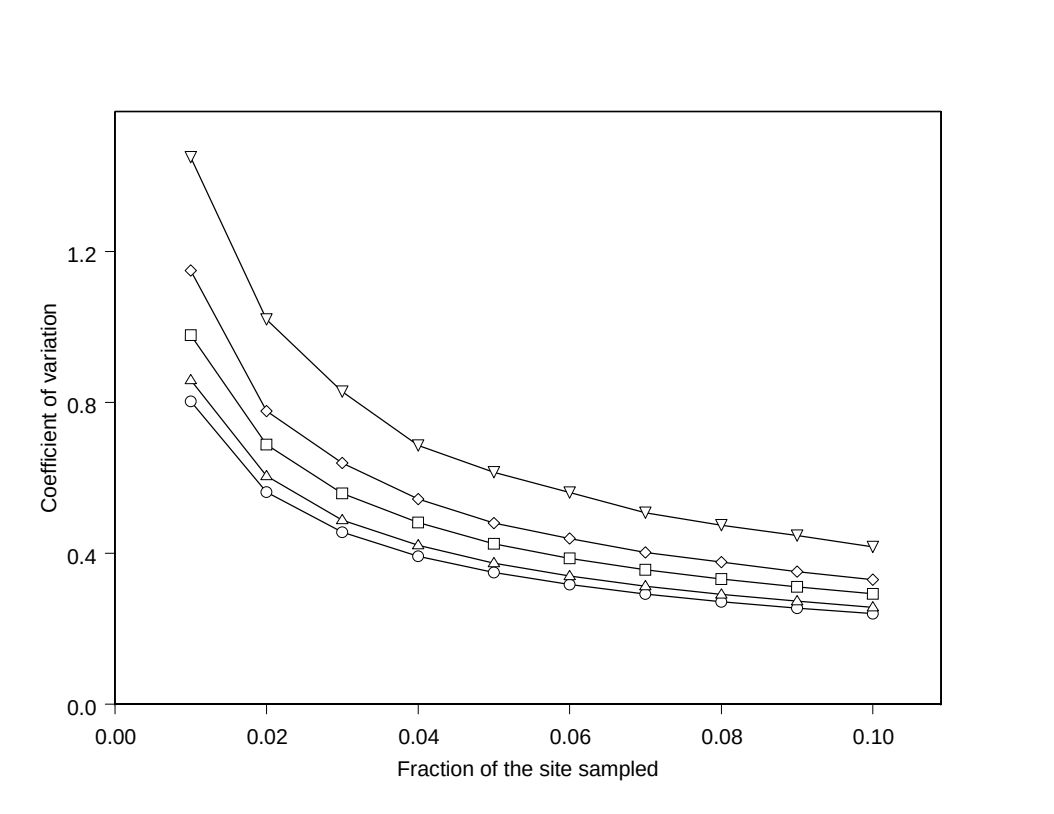
Detection	Excavate "1-out-of"
> 60%	4
50 to 60%	3
40 to 50%	2
< 40%	1

Sampling Rare and Clustered Populations

- Adaptive cluster sampling
  - Increased yield, but did not increase precision
  - Final sample size is a random variable
- Systematic sampling with multiple random start
  - Good spatial coverage
  - Efficient (Christman. 2000. JABES 5:168-201)
  - Valid estimates of sampling variance

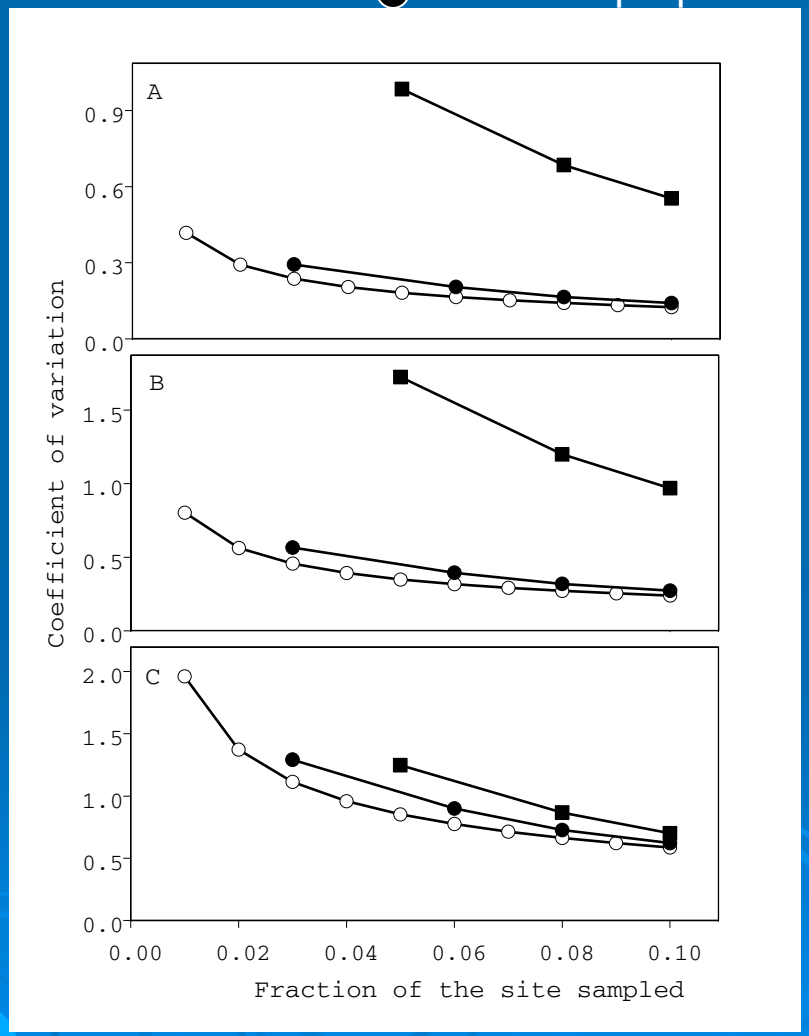
Choice of Sampling Unit

- For spatially clustered populations, the smaller the unit the better (reduced sampling variance)
- Logical tradeoff, at some point boundary errors exceed reduction in variance



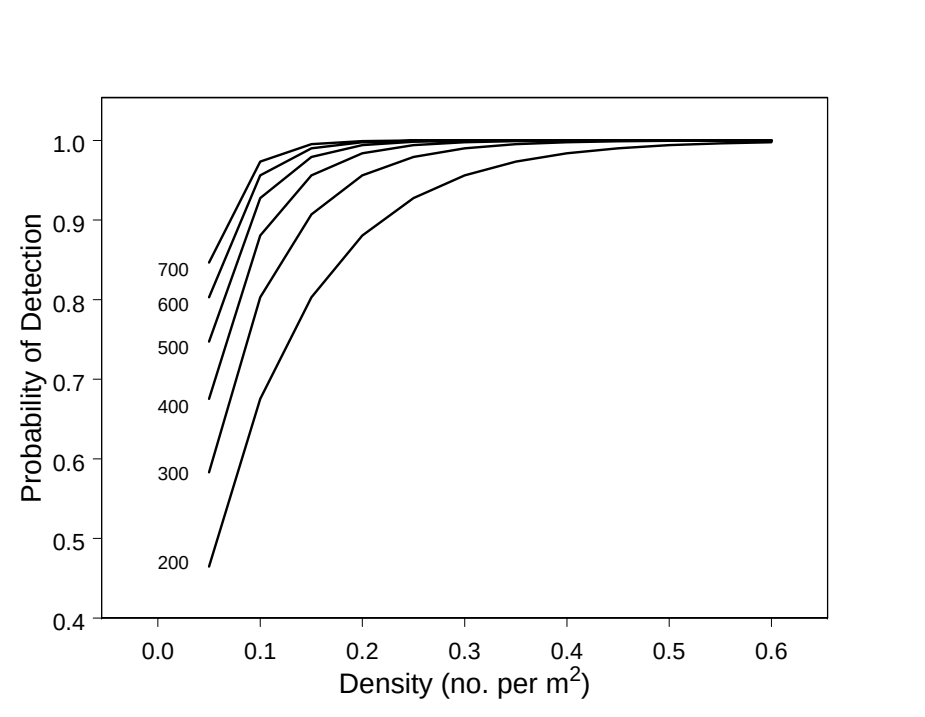
Choice of Sampling Unit

- For estimating abundance
  - 0.25 m^2 quadrat is typically the best choice
- For estimating <u>minimum</u> abundance,
  - 1 m^2 transect *oriented perpendicular to shore* is a good alternative to 0.25 m^2 quadrat
  - Difficult (impossible) to excavate 1 m^2 transects

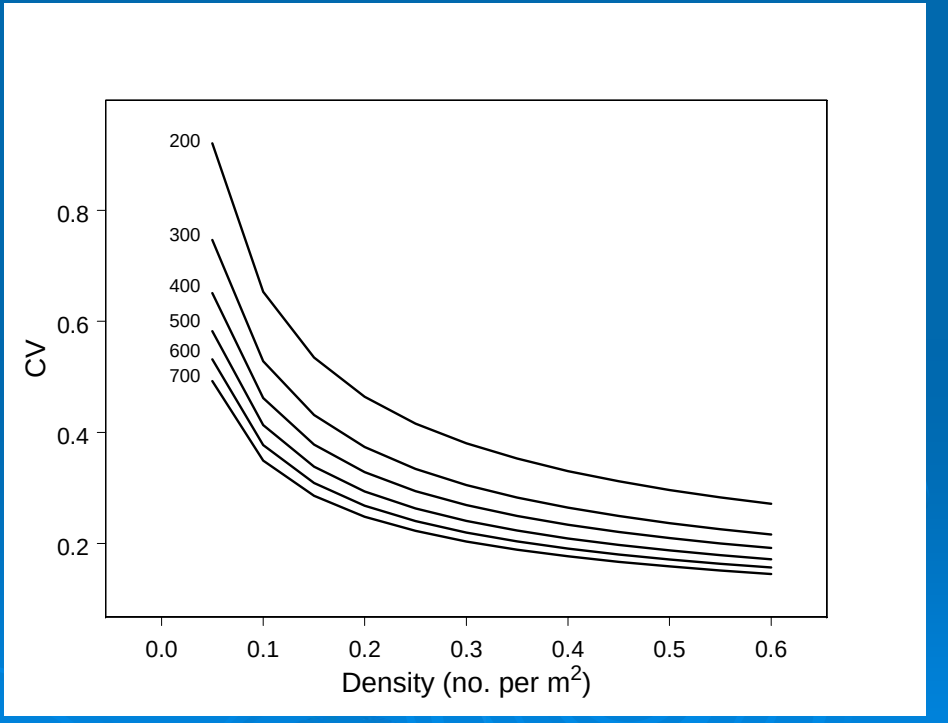


Will the survey satisfy the objectives?

Determine species present



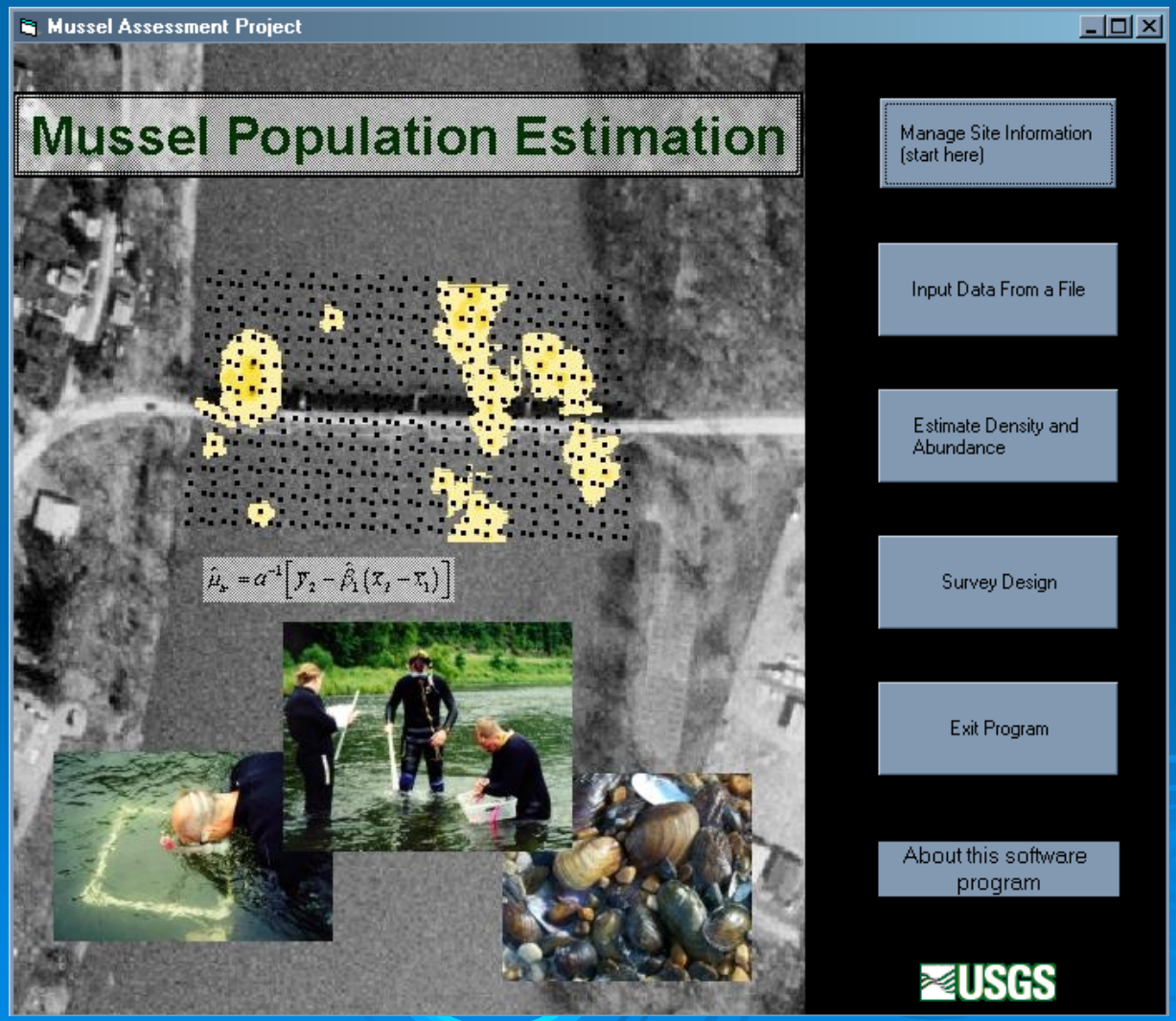
Estimate density



Survey Design

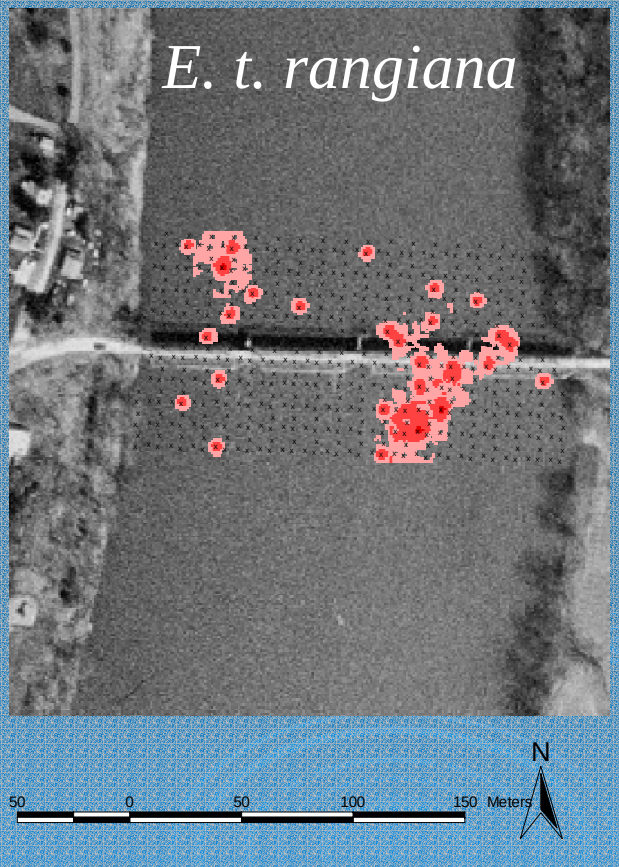
1) Delineate target population: area of direct effects
2) Take a large sample of 0.25 m^2 quadrats
   - Systematic sampling with multiple random starts
   - Base sample size on anticipated density
3) Observe mussels on surface
4) At a subset of quadrats, excavate sediment and observe mussels below surface
   - Use systematic sampling (1-in-*k* sampling)
   - Base sample size on anticipated detection at surface
5) Use regression estimator to estimate density and abundance

Mussel Estimation Program download at www.lsc.usgs.gov/aeb/2068/



Application: West Hickory, PA

Species	Relative Abundance (17 spp.)	Density (no. m^{-2})	Potential 'take'
E. t. rangiana	3rd	0.49 (0.34 to 0.72)	9173 (6,309 to 13,336)
P. clava	4th	0.38 (0.24 to 0.60)	7010 (4,462 to 11,013)

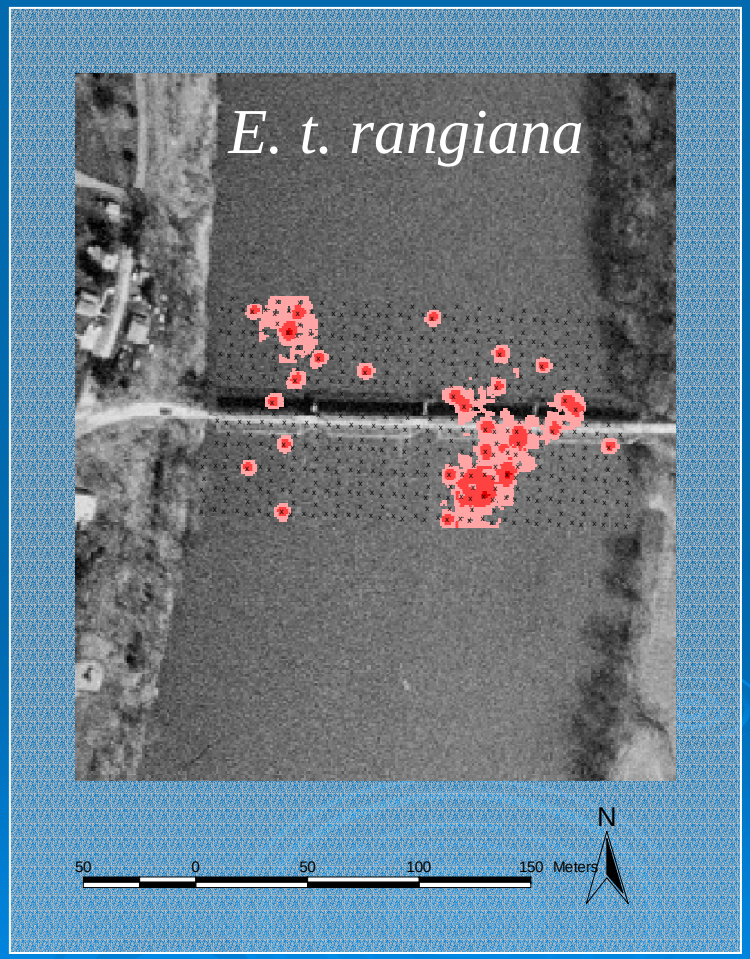


Application: West Hickory, PA

- Observed densities highest ever recorded for these species

- Neither species thought to be more than a minor component of a mussel community

- There remains the problem of interpreting site-specific effects in the context of river-wide (or range-wide) population viability



Take home messages

- Use statistical sampling approaches and avoid informal approaches (e.g., judgment sampling)
- Survey design often involve elements of research: simulation studies, field testing, pilot surveys
- With animal surveys, detectability is nearly always an issue
- Rarity and clustering is often an issue
- Statistical sampling principles and methods offer practical and effective solutions