Designing a Survey

Garrett Stillings (Stillings.Garrett@epa.gov)

Monitoring and Analysis Branch-NARS

NARS National Workshop: April 5 & 6, 2022

Section 1

Design Planning

Probability Sampling VS a Census

- **Census:** Examination of every unit in a population of interest.
- **Probability Sampling:** Allows for the extrapolation of information from a subset of the population (sample).

Probability Sampling Benefits

1. Less time consuming
2. Less costly
3. Estimates can exhibit higher accuracy because staff can perform field operations more thoroughly, reducing measurement error.

Define Survey Objectives

- Objectives should be linked to management decisions and reporting requirements.
- Ensure the level of effort will sufficiently answer the questions.
- Define the target population of interest.

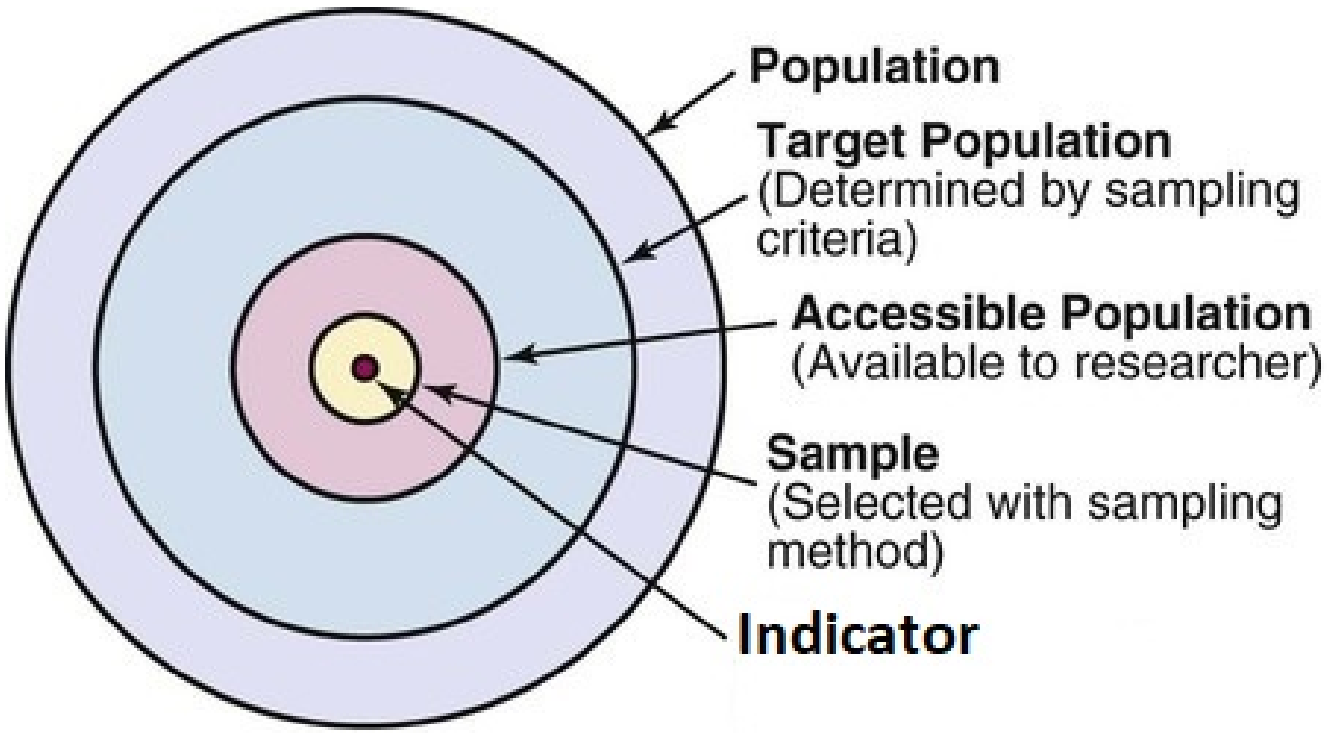

Figure 1: Survey Plan

Target Population

- The target population defines the extent of units that will be monitored.
- Must define what elements make up the target population (i.e. Subpopulations).
- The target population should align with your organizations monitoring strategy and objectives.

Target Population Example

If the designer only has an interest in assessing the condition of perennial waters in a state, the target population is defined as perennial waters and intermittent and ephemeral waters are defined as **Non-Target populations** and should be omitted from the selection process.

Section 2

Sample Frame Creation

Sample Frame

- A **Sample Frame** is a GIS representation (e.g. shapefile) of **ONLY** the resource target population which is used to select the sample sites.
- The corresponding attribute file should contain covariates representing design features such as Strata and Categories.

Types of Sample Frames

1. **Discrete Objects:** Represented by point resources which serve as sampling units for selection (i.e. Lakes).
2. **Linear Features:** Represented by a linear resource in which a sampling unit is selected along the networks length (i.e. Streams and Rivers).
3. **Areas:** Represented by polygon resources where regions within which points are selected in the sample (i.e. Wetlands and Coastlines).

Geometry Types

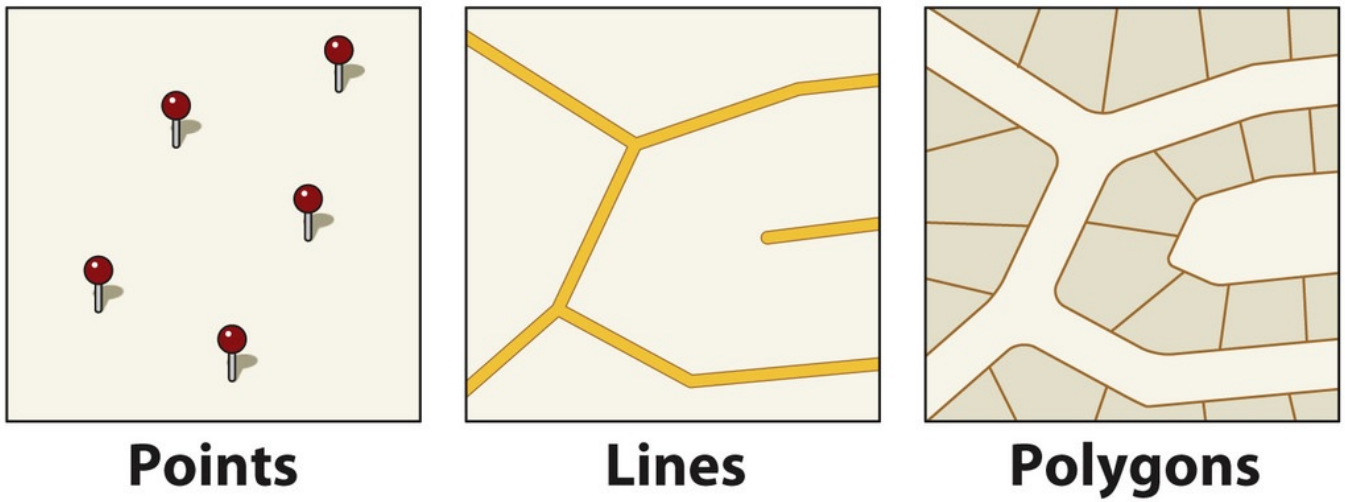

Figure 2: Sample Frame types

Section 3

Survey Design

Design Preperation

Generalized Random Tessellation Stratified (GRTS) Design

- Spatial balance disperses sampling effort across the extent of the resource so that samples achieve a similar spatial distribution as the population (Olsen et al. 2012).
  - More representative of the population.
  - Give more precise estimates.

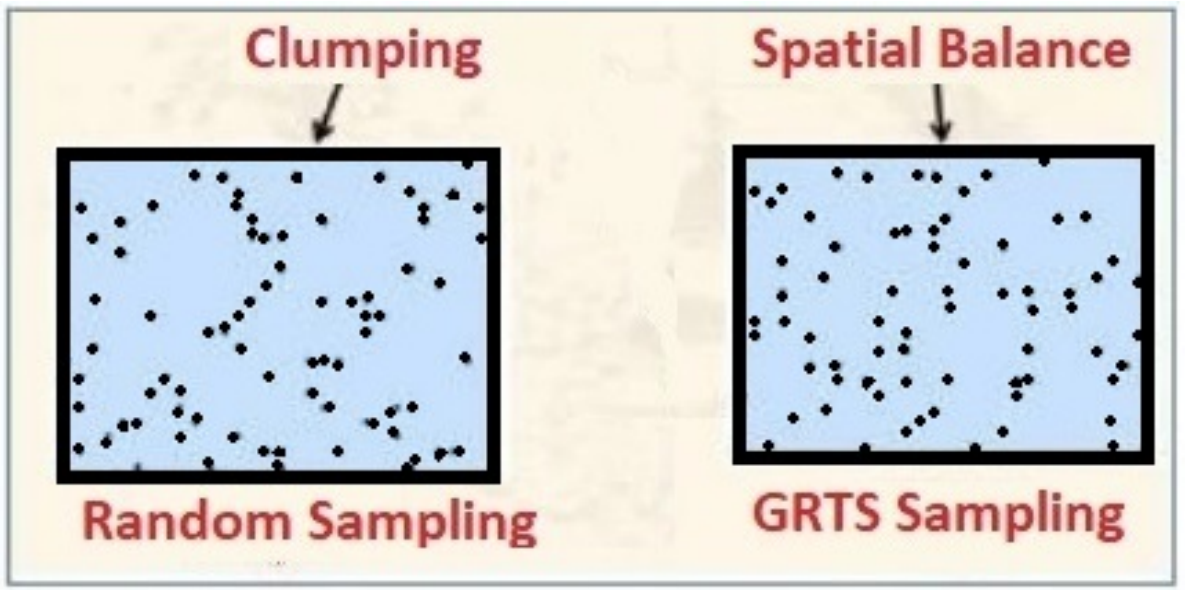

Figure 3: Spatial Balance

Sample Selection

Sampling Methods

a. **Unstratified Sampling:** Random samples are drawn from the sample frame as a whole.

b. **Stratified Sampling:** The sample frame is divided into non-overlapping strata from which independent random samples are drawn.

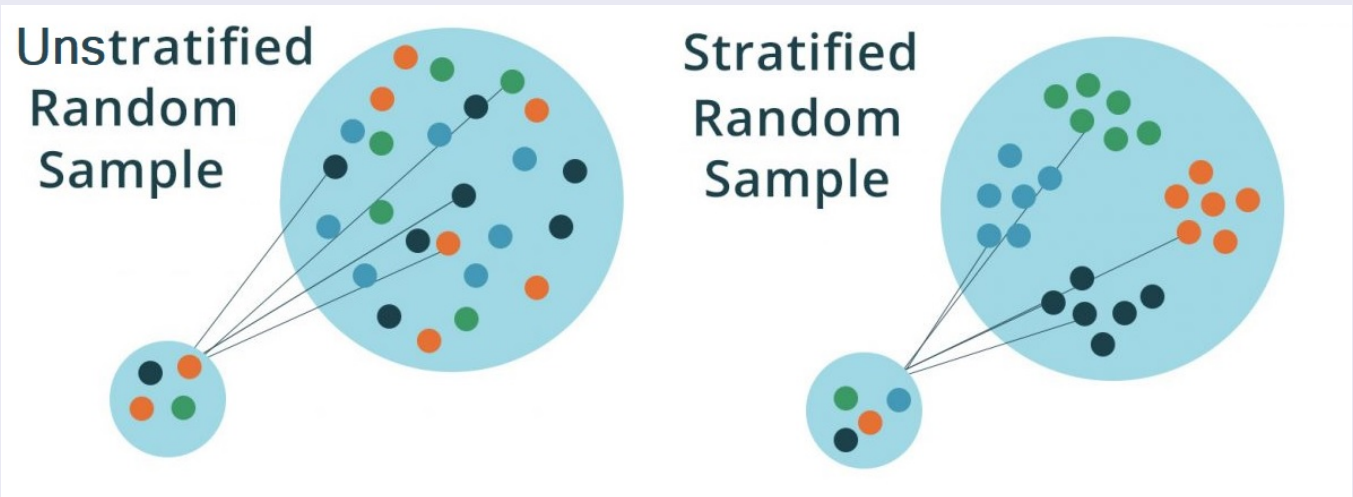

Figure 4: Stratified Sampling

Sample Selection (cont.)

Sampling Methods

a. **Equal Probability Sampling:** All members of the sampling frame have equal probabilities of being selected.

b. **Unequal Probability Sampling:** Selection where the chance of being included is calculated relative to the distribution of a categorical variable across the population. Can give smaller populations a greater chance of being selected.

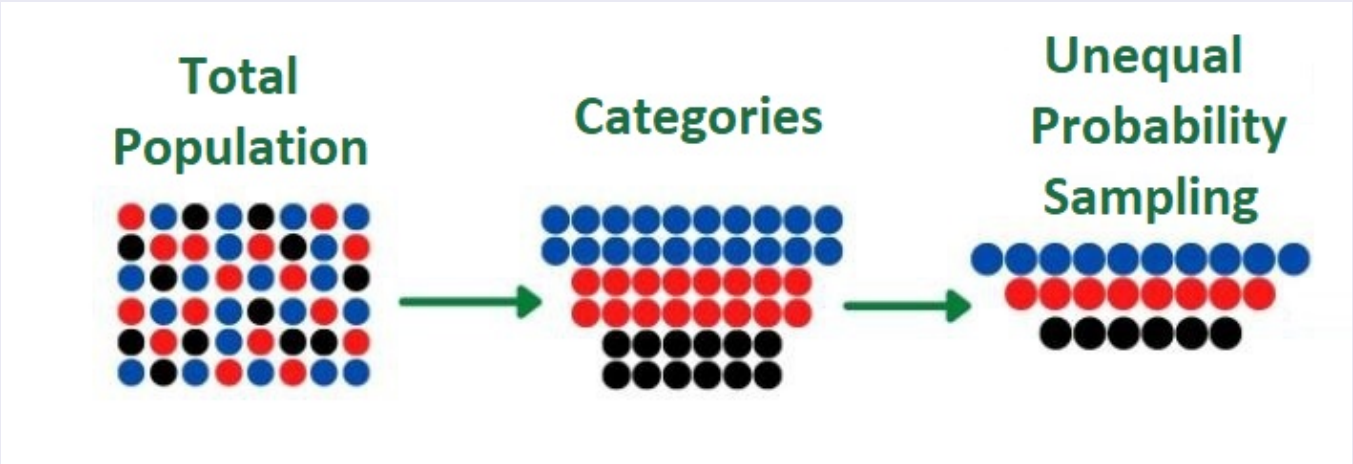

Figure 5: Unequal Sampling

Sample Selection (cont.)

Sampling Methods

c. **Proportional Probability Sampling:** Selection where the chance of being included is proportional to the values of a positive **Auxiliary Variable**.

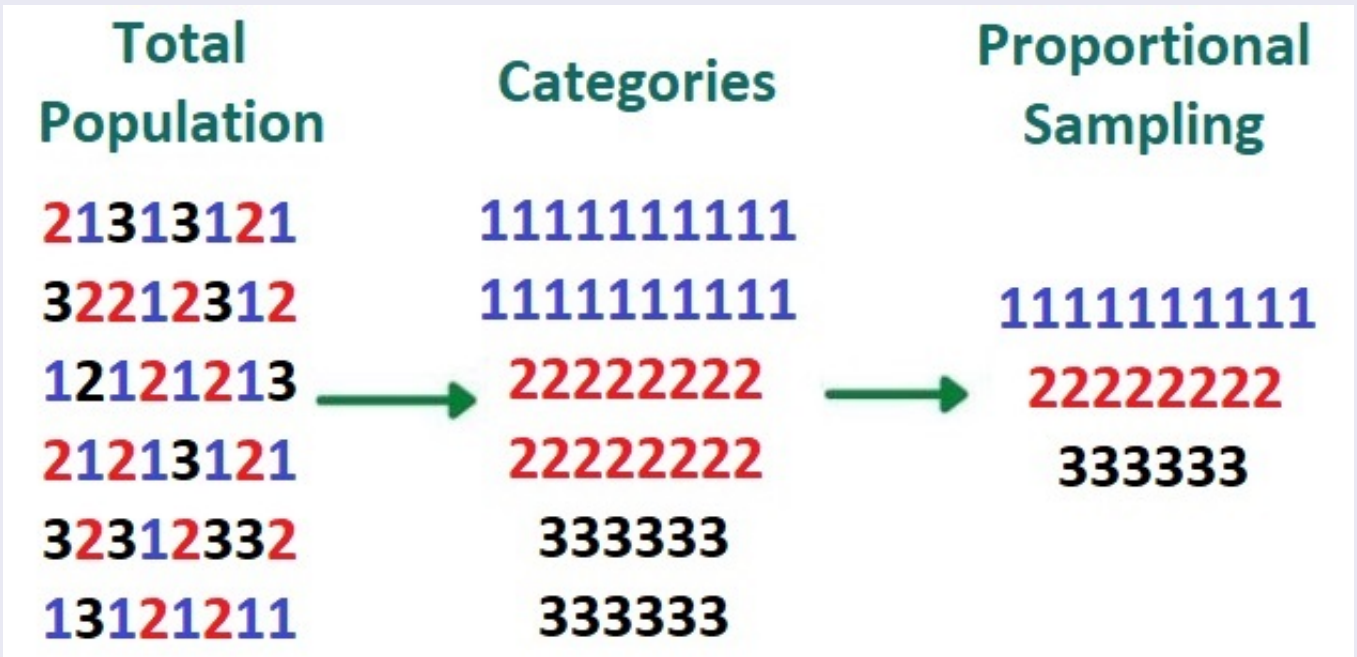

Figure 6: Proportional Sampling

Sample Selection (cont.)

Additional Sampling Methods Available

1. **Legacy Sampling:** Sites that were selected in a previous sampling design and should be included in the current sample.
2. **Minimum Distance Sampling:** Enforces a minimum distance between sites.
3. **Replacement Sampling:** Provides sites available to replace sites in the base sample for which data cannot be collected.
   - **Reverse Hierarchical Ordering (Default):** Sites are first selected using the GRTS algorithm then determined as base sites or replacement sites in a way that preserves as much spatial balance as possible.
   - **Nearest Neighbor:** Closest site measured by Euclidean distance to the base site without preserving spatial balance.

Section 4

Survey Sample Size

Determining the Sample Size

- Setting an appropriate sample size and considering how they should be allocated across a sample frame is a fundamental step in designing a successful survey.
- Many surveys are limited by budgetary and logistical constraints. The designer must determine a sample size which can overcome these constraints while ensuring the survey estimates the parameter(s) of interest with a low margin of error.
- Sample sizes must be large enough to adequately cover the region of interest.

Determining the Sample Size

Things To Consider

- Compare the **Spatial Balance** of surveys. Typically, estimates from spatially balanced surveys are more precise (vary less) than estimates from non-spatially balanced surveys.
- Consider if the parameter(s) of interest will result in low variation across the survey. A smaller sample size can yield an estimate with a low margin of error in this case. Use the tools **Population Estimate Simulation** to test this.
- Allocate additional sampling time to survey extra sites if needed. When designing the survey, be sure to generate **Replacement Sites** to use for oversampling.

Section 5

Survey Weights

Weights

- Allows for a dataset to be re-balanced so that results more accurately represent the population.
- Sample sites must be proportioned according to the target population.

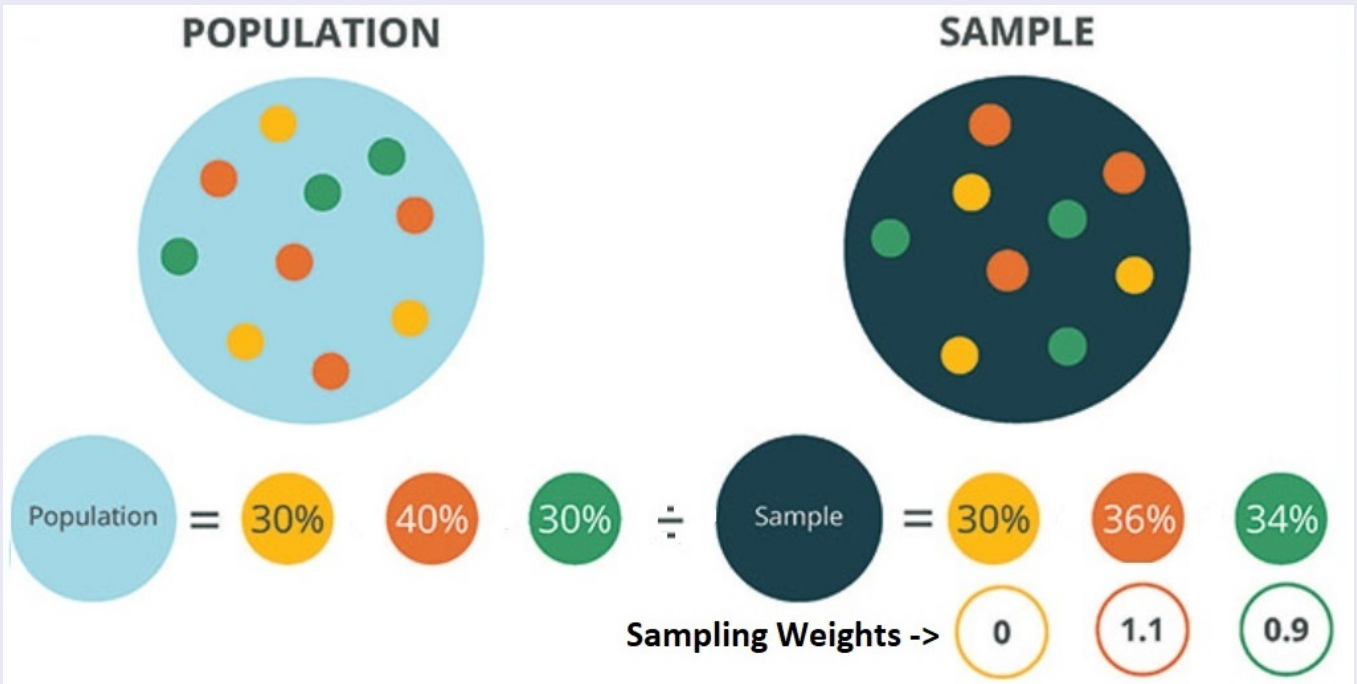

Figure 7: Sampling Weights

Adjusting Design Weights

- Unfortunately, most sample frames are imperfect and will include non-target samples in the frame (**over coverage**) and include parts of the target population that cannot be sampled (e.g. access denials, barriers) (**under coverage**).
- To correct for this bias, the designer must adjust sampling weights prior to data analysis.

When to Adjust Weights

- When **Non-Target** sites are found (remove from target population).
- Samples that are smaller or larger than planned (sites should be weighted more or less).

Section 6

References

References

- *Stevens and Olsen (2004) Spatially Balanced Sampling of Natural Resources*
- *Spatially Balanced Sampling Vignette*
- *A GRTS User's Manual for the SDrawNPS Package*
- *NARS Website*
- Olsen, A., Kincaid, T., & Payton, Q. (2012). Spatially balanced survey designs for natural resources. In R. Gitzen, J. Millspaugh, A. Cooper, & D. Licht (Eds.), Design and Analysis of Long-term Ecological Monitoring Studies (pp. 126-150). Cambridge: Cambridge University Press.