A Simulation Model to Evaluate the Efficiency of Adaptive Cluster Sampling

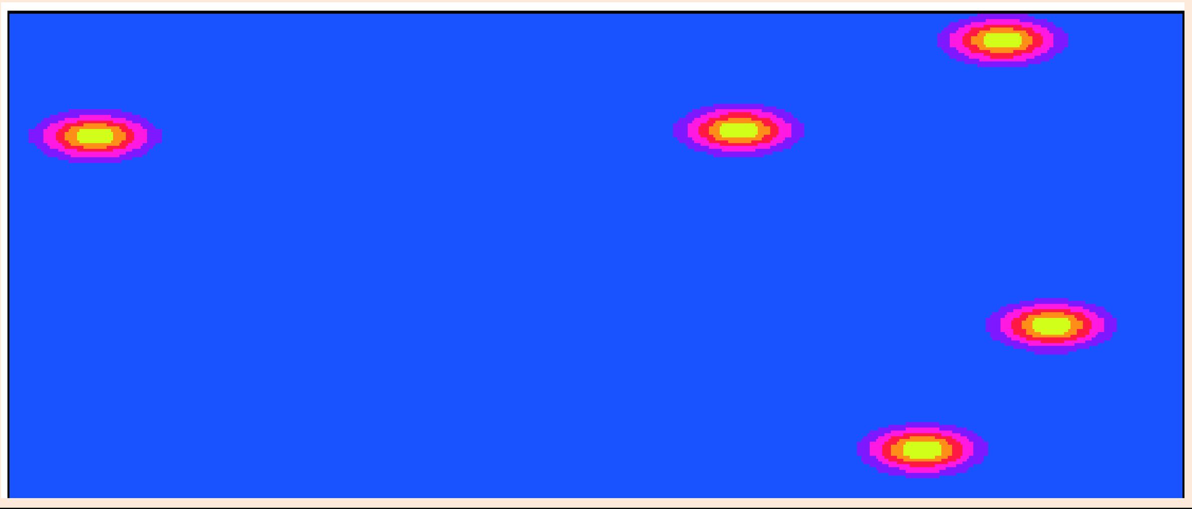
Jesse A. Marks, jmarks@centralmethodist.edu

Robert T. Leaf, robert.t.leaf@usm.edu

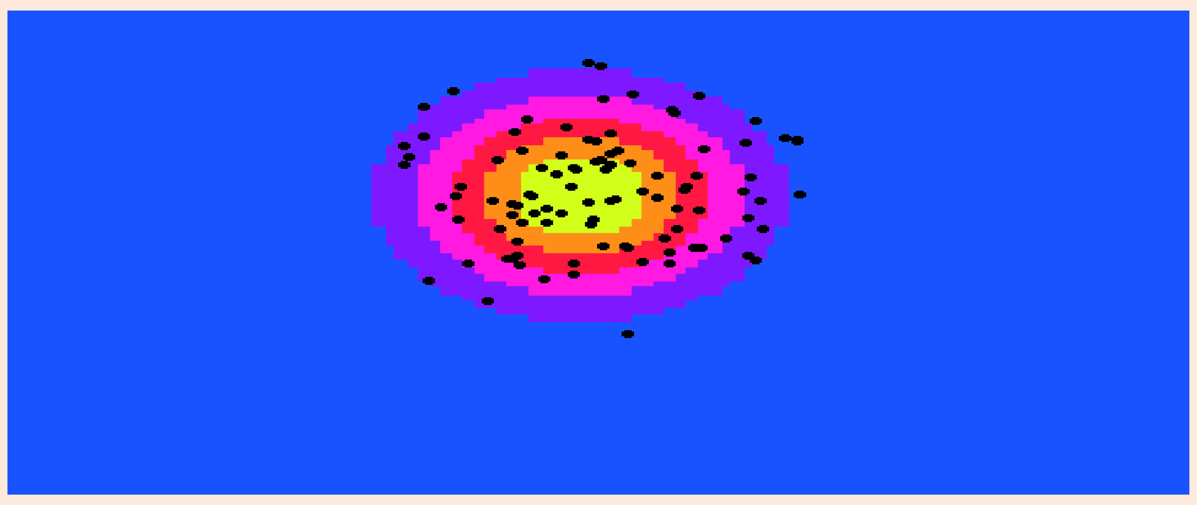
- The **objective** of this simulation analysis is to examine how sample allocation strategy influences the precision of total population estimates in a simulation approach and to use the properties of the estimator to refine the survey design of eastern oyster populations in the Chesapeake Bay.

- The simulation includes the following components:
  - Initialization of the two-dimensional heterogeneous **spatial landscape** at two scales: a landscape scale and a smaller patch scale.
  - Create particles that are the **target entities** of the sampling.
  - Construct **sampling units** used to estimate the oyster density.
  - Compare the results of the simulated sampling regime using cluster and random sampling algorithms

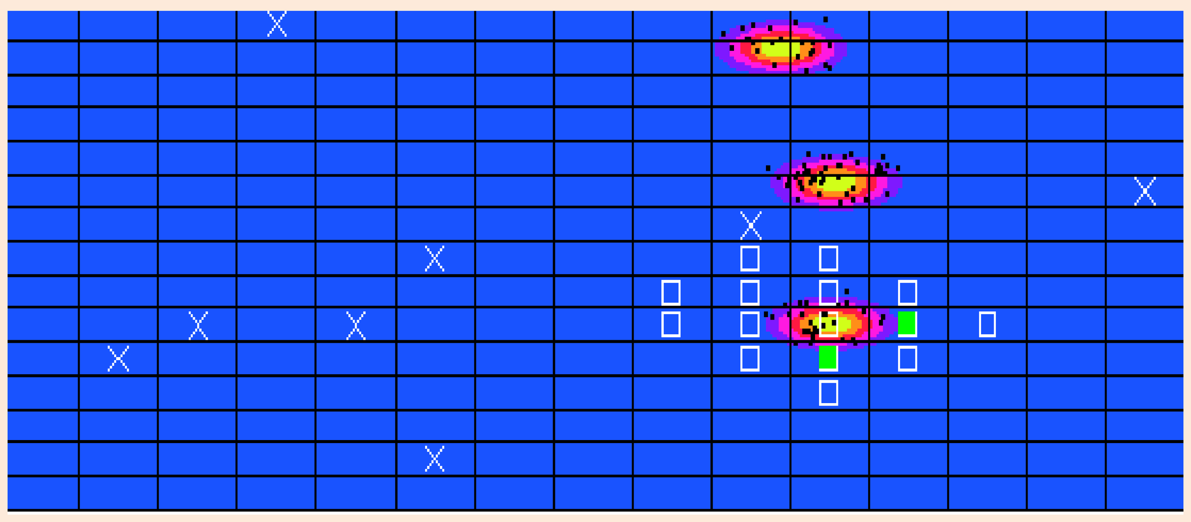
- The dimensions of the landscape were established using vertical and horizontal dimensions of 500 by 500 cells with cell-specific of arbitrary resolution (0.02 by 0.02).
- Random parameter, bivariate skewed-normal distribution within patches were used to determine the probability of occurrence of a particle at that location.
- The parameters that define the variance of the distribution control patchiness.



- A grid function, was used to allocate the landscape into evenly sized quadrilateral cells (N x N).
- The area of one cell represents the area that cam be searched with one sample.
- The cell-specific resolution can be altered by the user.
- Particles are assigned to the landscape based on probability set within a patch.
- The number of particles assigned to the landscape, n_p, is a variable determined by the user.



- Initial cells to sample from the landscape are selected using a random number generator.
- When a cell contains at or above a critical value *C* number of particles, the cells in that neighborhood, or adjacent cells, are searched as well.
- This iterative process continues until no new cells are adaptively searched.
- The initial number of cells to search, the critical value *C*, and also the definition of a neighborhood are all variables that can be altered by the user.



Variables, Parameters and Equations of ACS and SRS

Variables

N = total number of cells in the landscape.

n = number of initial samples taken.

n^* = number of samples taken during SRS (the total amount searched during ACS)

y_i = The number of particles in cell i.

Ψ_i = The indices of the cells that belong to the network that the initial cell i belongs to.

m_i = The number of plots in network Ψ_i.

$\tau_i = \sum_{j \in \Psi_i} y_j$ = The total number of objects per plot in network Ψ_i.

$w_i = \frac{\tau_i}{m_i}$ = The mean number of objects per plot in network Ψ_i.

ACS Mean and Variance Estimators

Hansen-Hurwitz mean per plot estimate- $\hat{\mu}_{acs} = \frac{1}{n}\sum_{i=1}^{n} w_i$

Hansen-Hurwitz variance estimate- $\widehat{Var}(\hat{\mu}_{HH}) = \left(\frac{N-n}{N}\right)\left(\frac{1}{n(n-1)}\right)\sum_{i=1}^{n}(w_i - \hat{\mu}_{acs})^2$

SRS Mean and Variance Estimators

Simple random sample mean per plot estimate- $\hat{\mu}_{srs} = \frac{1}{n^*}\sum_{i=1}^{n^*} y_i$

Simple random sample variance estimate- $\widehat{Var}(\hat{\mu}_{srs}) = \left(\frac{N-n^*}{N}\right)\left(\frac{1}{n^*(n^*-1)}\right)\sum_{i=1}^{n^*}(y_i - \hat{\mu}_{srs})^2$

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Confronting the model with data…

- The observed distribution and abundance of an organism is a conditional probability that is determined by its abundance, scale of aggregation, and availability to the sampling gear.
- To evaluate the adequacy of alternative sampling designs we will:
  1.) Compare the observed distribution to that in the model base run.
  2.) Alter the parameters in the base model that control the distribution and abundance of particles to match that observed in the field survey. These parameters include:
    - Number of clusters of organism density in the study
    - Number of trawls (samples)
    - Parameters to control the kurtosity and skew of the frequency of occurrence distributions
    - Number of particles
    - Trawl dimension as a fraction of the current grid extent what is the trawl length as a fraction of grid size
  3.) Derive a set of alternative sampling strategies that can be employed in future surveys.
  4.) Evaluate the ability of each of the alternative sampling strategies provide precision estimates of organismal density.