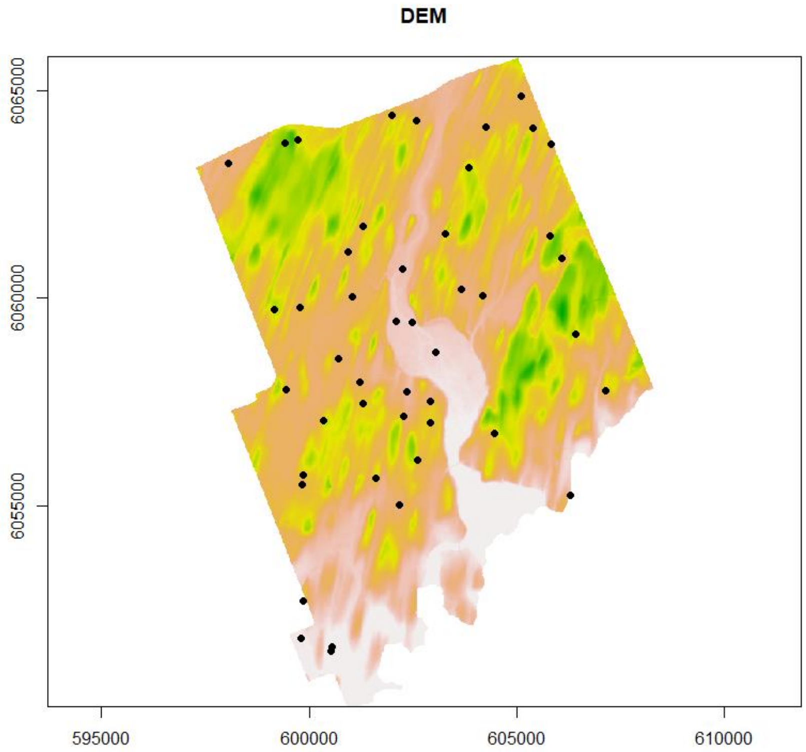

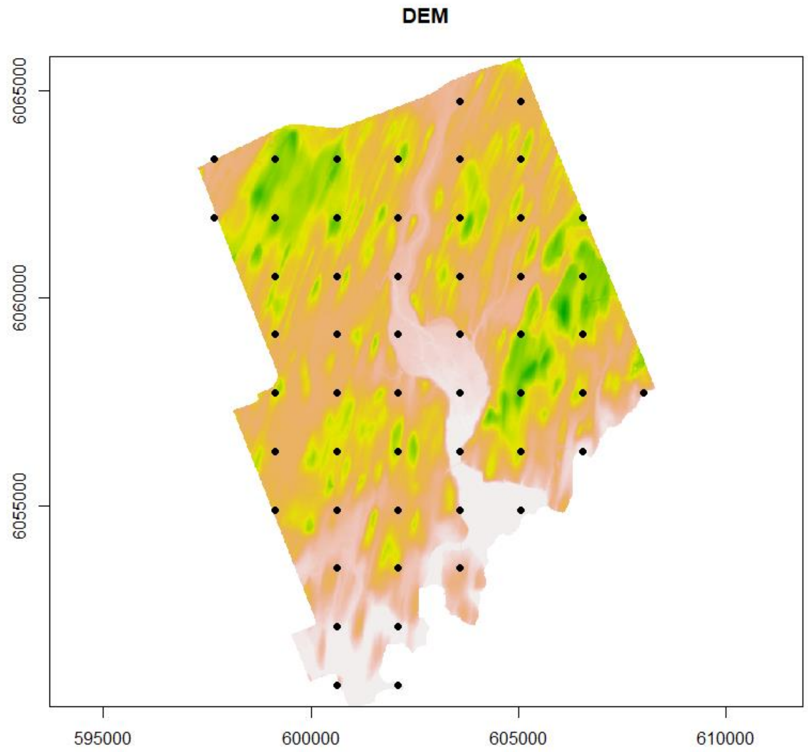

4. Sampling Design for Digital Soil Mapping

Canadian Digital Soil Mapping Workshop, 2020

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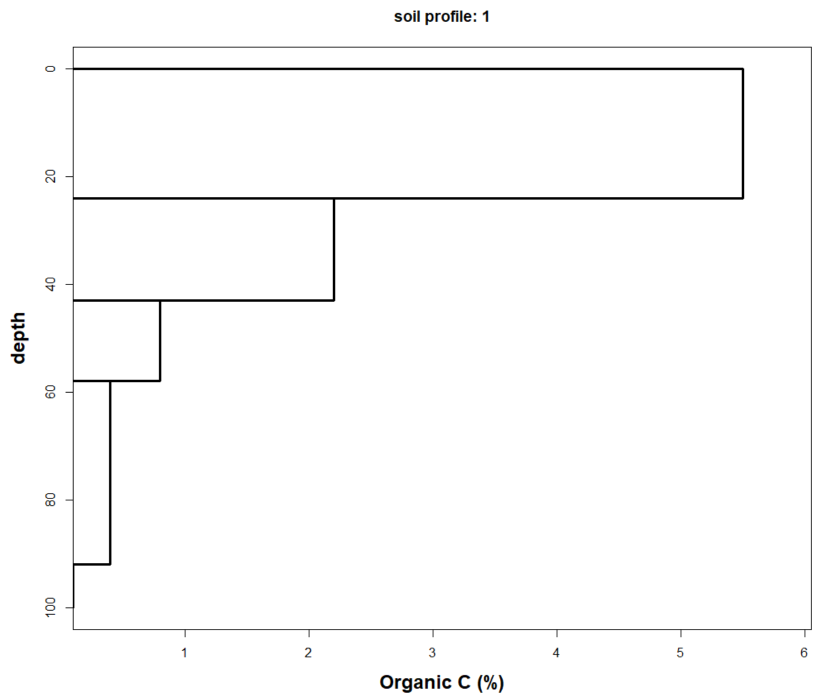
Outline

1. **Harmonizing soil profile data**

2. Sampling Design

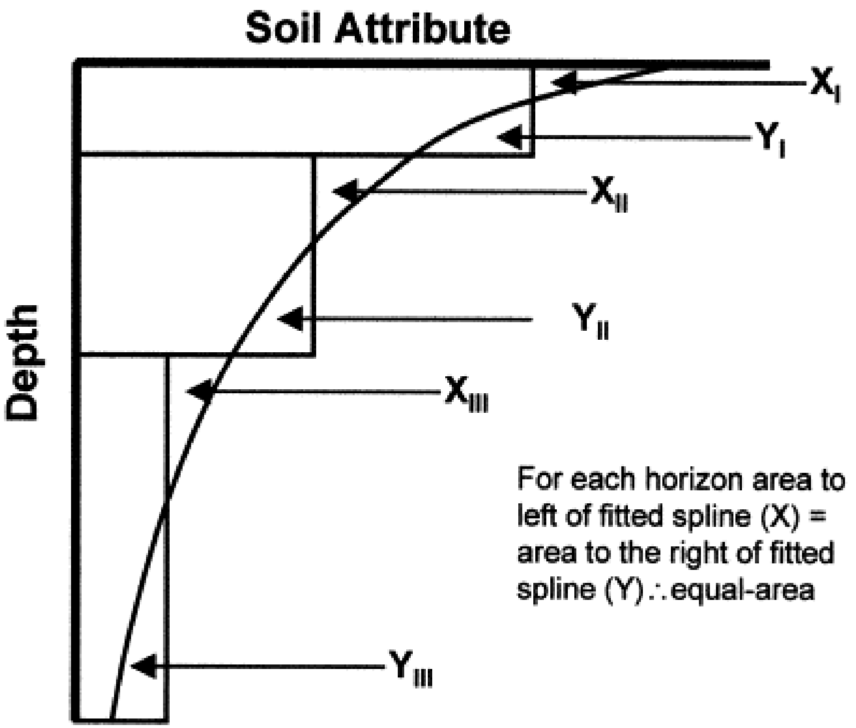
Depth Functions

- Soil sampling traditionally completed by pedogenic horizon (e.g., Ah, Ae, Bt, Ck)
- Bulk sample is collected from each horizon
- Analyses are completed and results represent the mean for that horizon
- In Digital Soil Mapping, we need the ability to predict for any depth interval
- 2 common approaches:
    - 3D predictions
    - stacked 2D predictions
- We will deal with stacked 2D approach



Depth Functions – 2D Stacking Approach

- To allow us to set prediction intervals, we need to convert the horizon data to a continuous function
- Most common approach is to use a mass preserving spline, or equal area quadratic spline function
- 2 parameters:
  - lam – controls smoothness
  - d – depth intervals
- User can specify as many depth intervals as wanted
- GlobalSoilMap.net specifications: 0-5, 5-15, 15-30, 30-60, 60-100 and 100-200 cm



Fun Fact:
One of the early pioneers of this approach, Dr. Ponce-Hernandez, is professor at Trent University!

Module 4.1: Depth Functions

- Hypothetical soil profile was sampled on a horizon basis.
- Particle size fractions, SOC, and pH were measured.
- Equal-area spline function will be used to convert the data into standard depth increments
  - 0-5 cm
  - 5-15 cm
  - 15-30 cm
  - 30-60 cm
  - 60-100 cm

Outline

1. Harmonizing soil profile data

2. Sampling Design

Sampling Design

- Sampling design is a critical first step in DSM, much like any experiment
- Two high-level types of sampling:
  - Probability sampling (design-based)
  - Non-probability sampling (model-based)

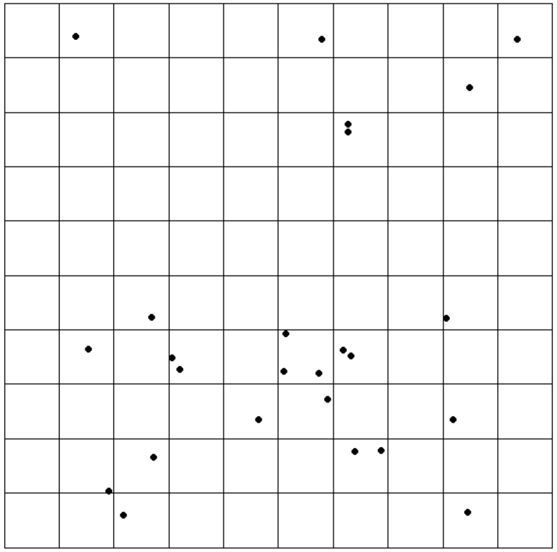
- Design-based Sampling must meet 2 requirements:
  - All units of the population have a probability of being selected
  - Selection probability of each unit is known

- Today we will review design-based sampling approaches:
  - Simple Random Sampling
  - Stratified Random Sampling – Equal
  - Stratified Random Sampling – Proportional
  - Grid Sampling
  - Conditioned Latin Hypercube Sampling

Simple Random Sampling

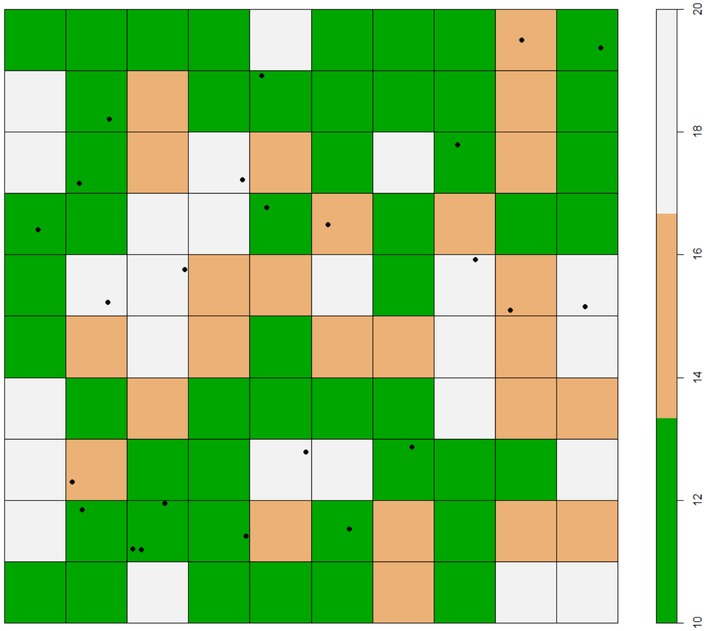
- All samples within the region have equal probability of being selected
- Advantages
  - Simple
  - Prior knowledge of the population not required

- Disadvantages
  - May not consider feature attributes (covariates)
  - Potential for clustered sampling
  - Efficiency may be reduced



Stratified Random Sampling

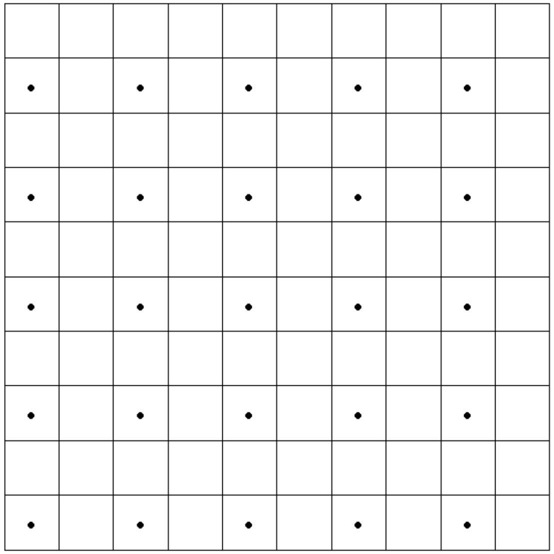
- Divide the population into strata (e.g. elevation)
- Sampling is random within the strata
- Equal sampling or proportional sampling by strata
- Advantages
  - Higher accuracy (if strata are meaningful)
- Disadvantages
  - May not consider feature attributes (covariates)
  - Strata knowledge may be flawed



Grid Sampling

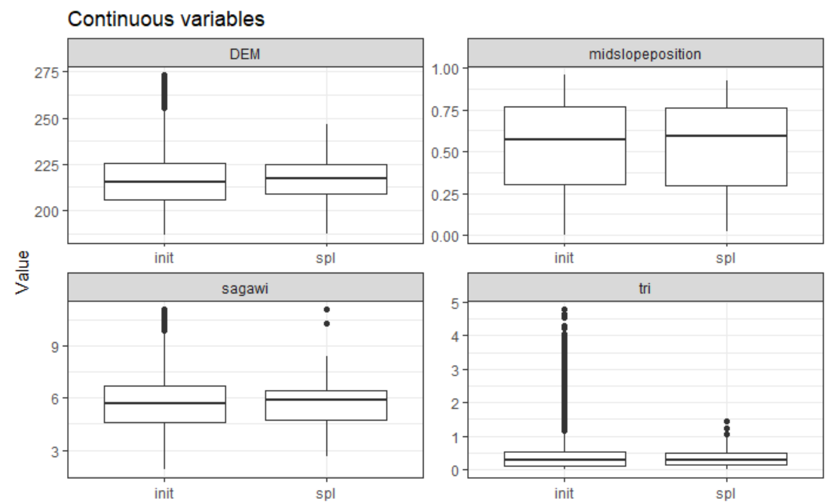
- Systematic sampling approach
- Must determine adequate grid spacing
- Advantages
    - Simple
    - Efficient
    - Low Cost

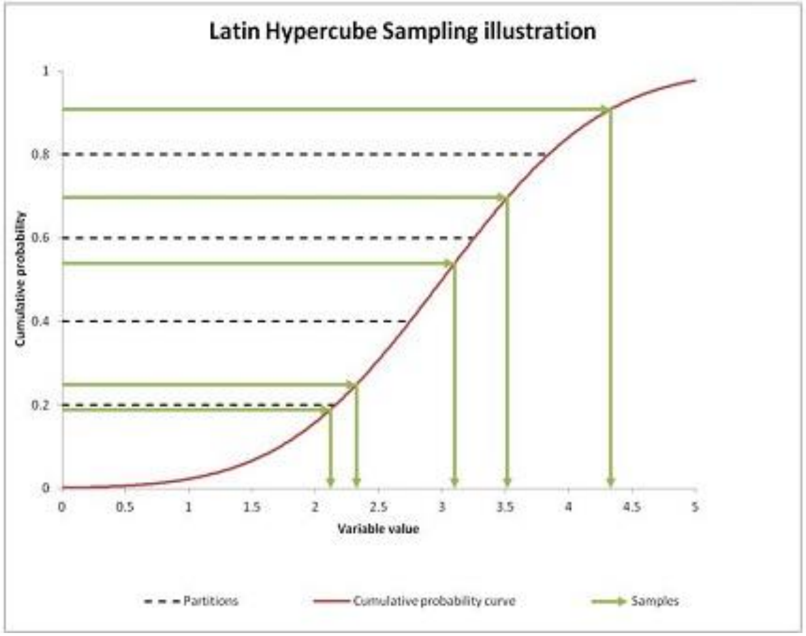
- Disadvantages
    - May not consider feature attributes (covariates)
    - Hard to determine appropriate grid size
    - Coarse grid could miss small-scale variability



Conditioned Latin Hypercube Sampling (cLHS)

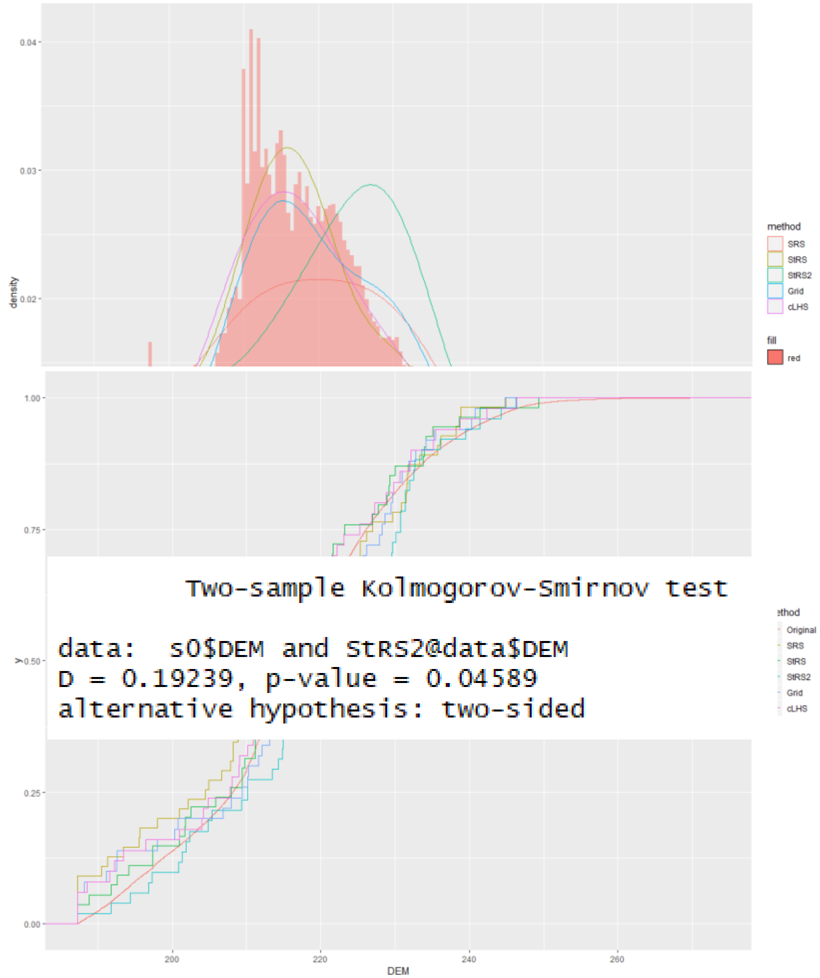
- Type of stratified sampling
- Full factorial experiment is not feasible with many covariates
- Covariates are each split into intervals based on their CDFs
- Selects one observation per partition of the CDF for each covariate
- Advantages
    - Closely resembles the distribution of the population of the covariates
    - Sample plan always optimized for feature space
- Disadvantages
    - Determining sample size
    - Access to sites can be difficult
    - No spatial component (e.g., potential for clustering and dispersion)





Assessing the Feature Space Coverage of a Sampling Plan

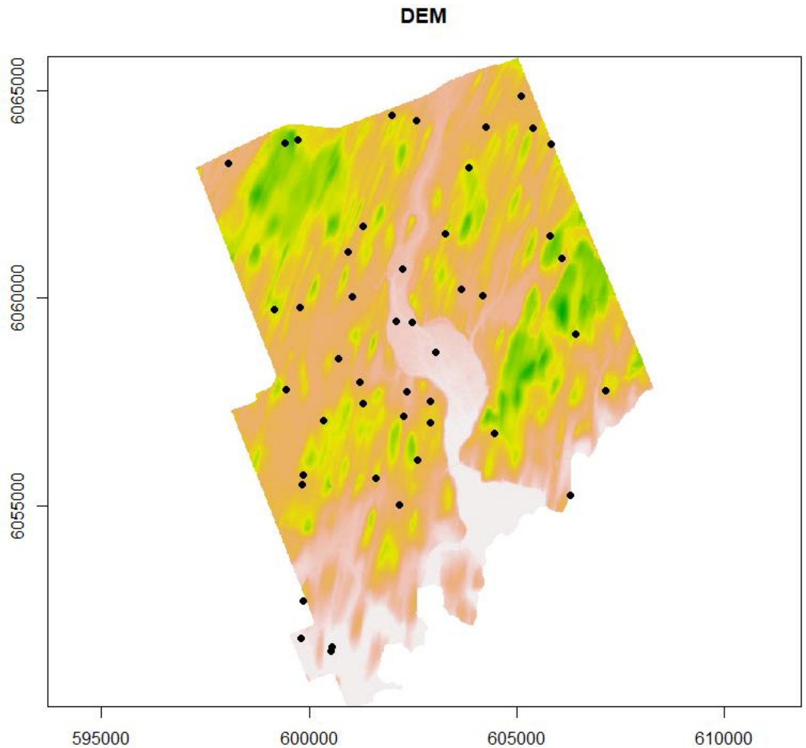
- Visual assessment comparing histograms
- Visual assessment comparing cumulative distribution functions
- Kolmogorov-Smirnov test
    - Non-parametric test of the equality of continuous distributions
    - Compares the CDFs
    - Null hypothesis is that both samples come from the same distribution
    - Reject at $p < 0.05$

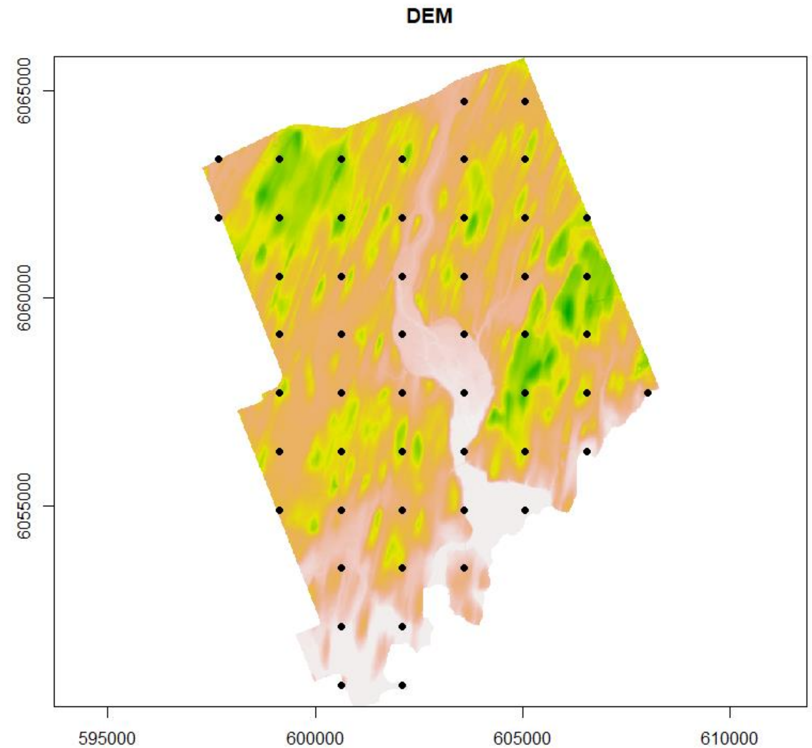


Module 4.2: Sampling Designs

- Generate sampling designs in R for Keene, ON:
    - Simple Random Sampling
    - Stratified Random Sample: Equal Sampling within Strata
    - Stratified Random Sampling: Proportional Sampling within Strata
    - Grid sampling
    - Conditioned Latin Hypercube Sampling

- Evaluating sampling designs





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