

Dvorlai Wulfsohn, Associate Professor, Agrotechnology ([dw@kvl.dk](mailto:dw@kvl.dk))  
 Gabriella Maletti, Assistant Professor, Agrotechnology ([gmm@kvl.dk](mailto:gmm@kvl.dk))  
 Torben Toldam-Andersen, Associate Professor, Horticulture ([tta@kvl.dk](mailto:tta@kvl.dk))

Our goal is to develop practical stereological sampling methodologies for estimating the total number of blossoms (or berries, fruit, ...) on a tree or in an orchard.

We developed a manual sampling strategy based on the unbiased ‘fractionator’ principle of stereology (Gundersen, 1986). We used three sampling stages with systematic uniform random sampling at each stage. Data are collected only at the last stage.



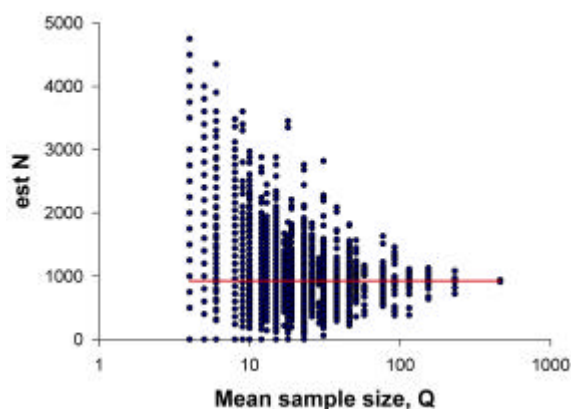
- Sampling fractions:
1. Primary branches 1/4
  2. Branch segments 1/7
  3. Flower clusters 1/15

Final sample size:  $Q = 26$

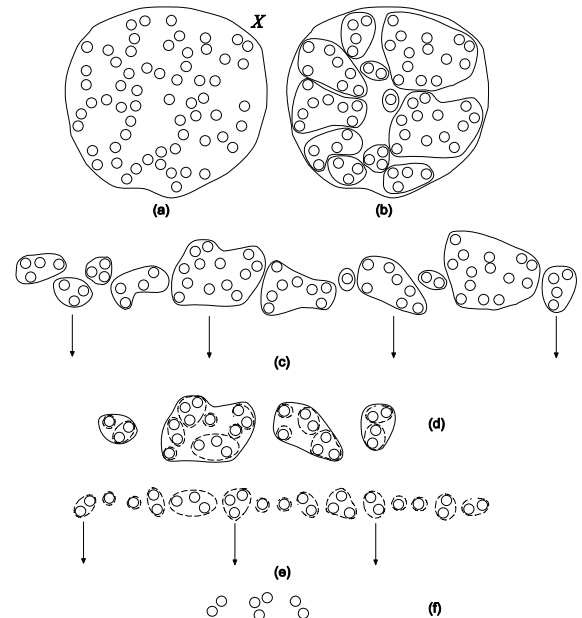
$$\text{est } N = (4)(7)(15)(26) = 10,900$$

$$\text{est } CE = 0.18 \text{ (SD} = 1960\text{)}$$

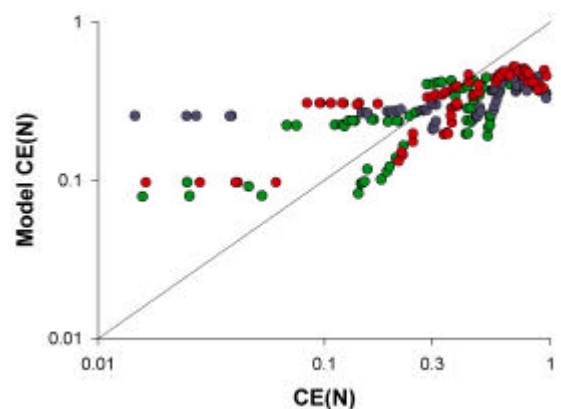
Three-stage design applied to a sour cherry tree. Fractionator units are defined according to the tree flower-containing structure



Performance of 3-stage fractionator for a young apple tree (var. Rød Ananas) determined by resampling



Fractionator principle. (a) A population of 63 objects is (b) divided arbitrarily into ‘units’ from which (c) a systematic uniform random subsample (SURS) of  $1/3^{rd}$  of is taken. (d) The sample is divided arbitrarily into smaller parts and (e) a SURS of  $1/5^{th}$  of the subsample taken. (f) The final sample of 7 objects represents a sampling fraction of  $1/15^{th}$  of the total population. An unbiased estimate of population size is  $15 \times 7 = 95$ .



Performance of Cruz-Orive (1990) semi-empirical model for prediction of CE from a single sample, by resampling three apple trees (var. Rød Ananas)

## Summary:

- We developed a three-stage fractionator design suited for manual sampling of tree structures
  - estN converged to the exact N as sample size Q increased (unbiased)
  - CE decreased exponentially at a rate on the order of  $Q^{-1}$  (precision)
- Cruz-Orive’s (1990) model satisfactorily predicts average CE for ranges of practical interest
- Biological variability between a SURS of 16 apple trees (var. Elstar) in a commercial orchard (Kildebrønne Frugtplantage) was  $CV_{bio} = 0.58$ . Average sampling error  $\text{estCE} = 0.15$  ( $Q_{ave} \sim 60$ ) was only 3% of the total variance.

