
UNIVERSITETET FOR MILJØ- OG BIOVITENSKAP
MDCCCLIX

Simulator for airborne laser-based sampling

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Intro

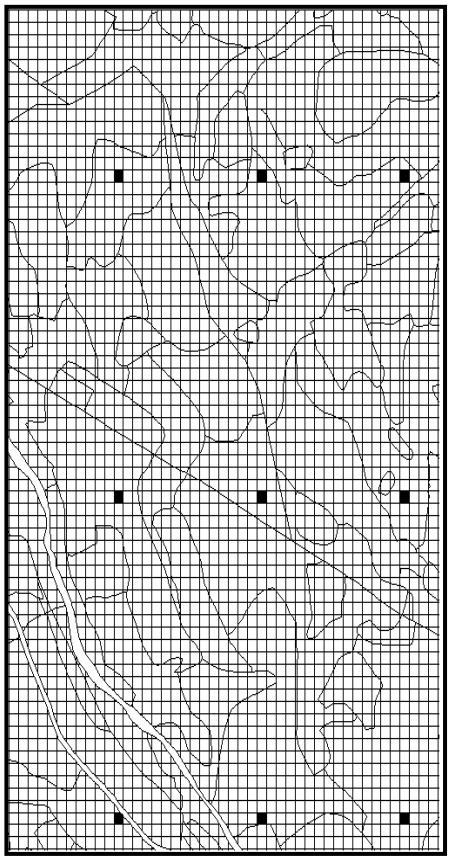
- related to the Hedmark project
- partners:
  - UMB
  - NASA
  - Yale University(USA)
  - SLU(Sweden)
  - Norwegian NFI
- parallell development at UMB and SLU
  - UMB version based on empirical measurements
  - SLU is focusing on intensive modelling work

Intro

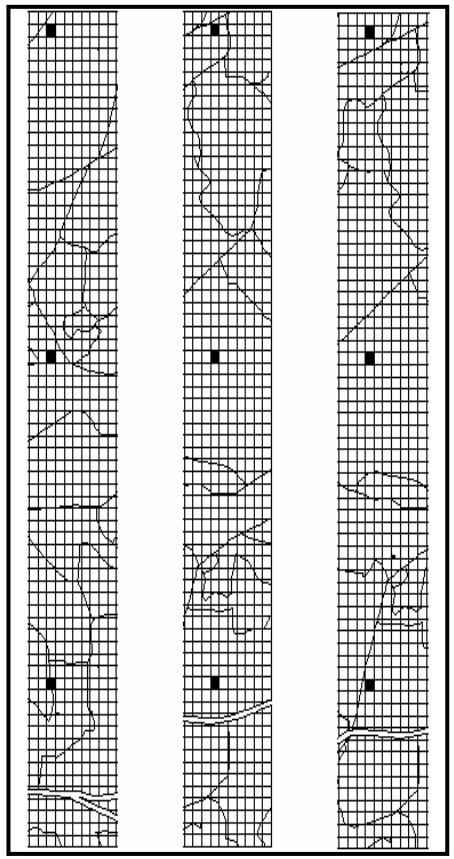
- profiling LIDAR can provide estimates for large areas at low costs
- scanning LIDAR provides accurate refered data for ”wall-to-wall” forest mapping
  - expensive for regional inventories
- increasing demand for sub-regional estimates(e.g. at sub-county level)

LiDAR- based sampling methods

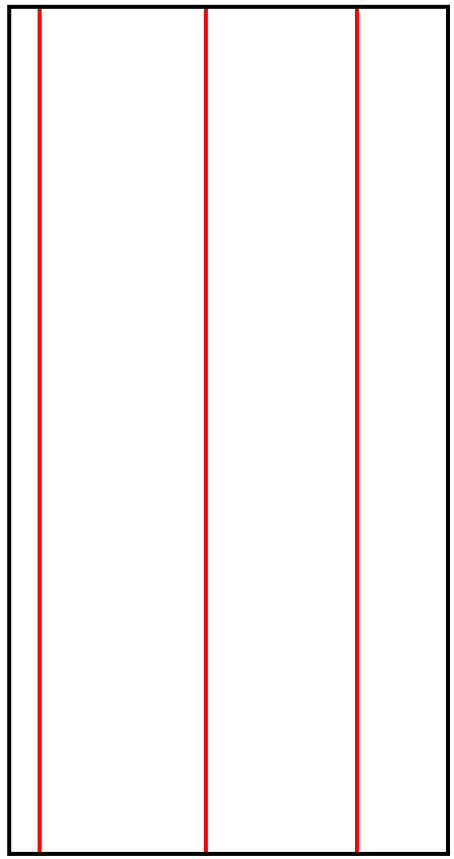
”Wall-to-wall”



Sampling by scanning



Sampling by profiling



Intro

- using airborne scanning LiDAR as a strip sampling tool for regional and sub-regional forest inventories
  - previous studies using double sampling framework
    - do not make full use of the LiDAR data
- assessement against profiling LiDAR
- need a simulator!

Material

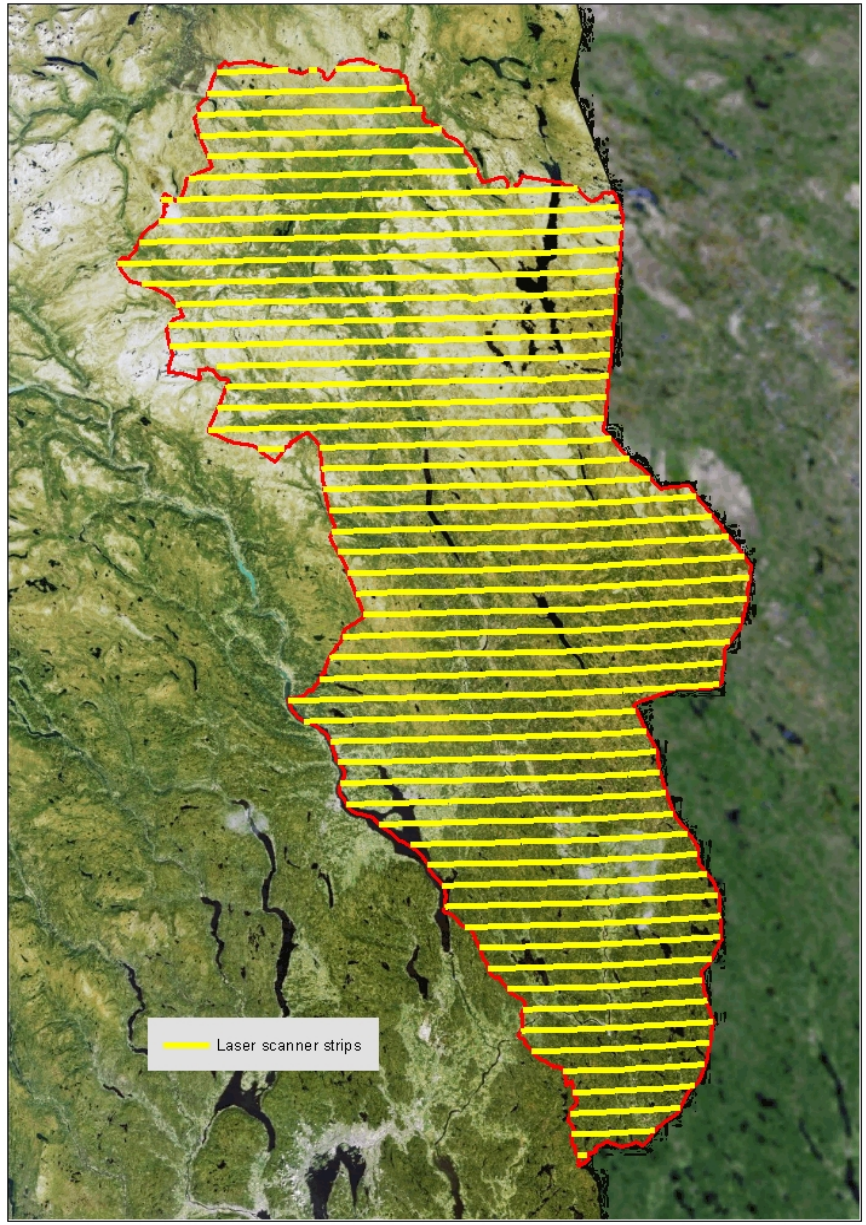
- the target region is Hedmark county, Norway
  - total area of ca. 27,000 km2
  - 13,420 km2 productive forests dominated by:
    - Scotch pine(48 %)
    - Norway spruce(42 %)
    - birch(8 %) - as dominant deciduous tree species

Material

- field data:
  - ca 2200 NFI plots
    - 3x3 km grid
    - circular plots of 250m2
    - 120-900m a.s.l
  - all trees with dbh>4cm callipered
  - 10 tree heights per plot measured, on average
  - plot centers geolocated within 1m accuracy
  - georeferenced tree locations

Material

- LiDAR data:
  - Optech ALTM 3100C
  - 6km spacing between flight lines, ca 4500 km flight lines
  - ca 2.8 pulses/m2
  - footprint ca 24cm
  - (x,y) accuracy ca 40cm
  - flown over ca 50% of the NFI plots (8.4 % of the area)
  - up to four returns per pulse



Framework

- design based, model-assisted approach
- generate a synthetic population using empirical data
- consider the syntethic population as fixed
- assess the population parameters independently by simulations

Framework

- two-stage sampling procedure:
  - LiDAR-based samples along flight lines from the target area
  - sample ground truth references
  - fit models for parameters of interest (e.g. volume, estimates of biomass)
  - prediction

- on-going colaboration at work-group level(Yale & SLU) regarding development of apropriate estimators

Objectives

- to assess
  - sampling designs
  - regression models
  - statistical properties of estimators
  - sampling methods
    - e.g. relative efficiency of conventional vs. LiDAR based inventories
    - profiling vs. scanning LiDAR
  - the effect of non-sampling errors
- can be integrated with a growth simulator
- teaching tool, etc

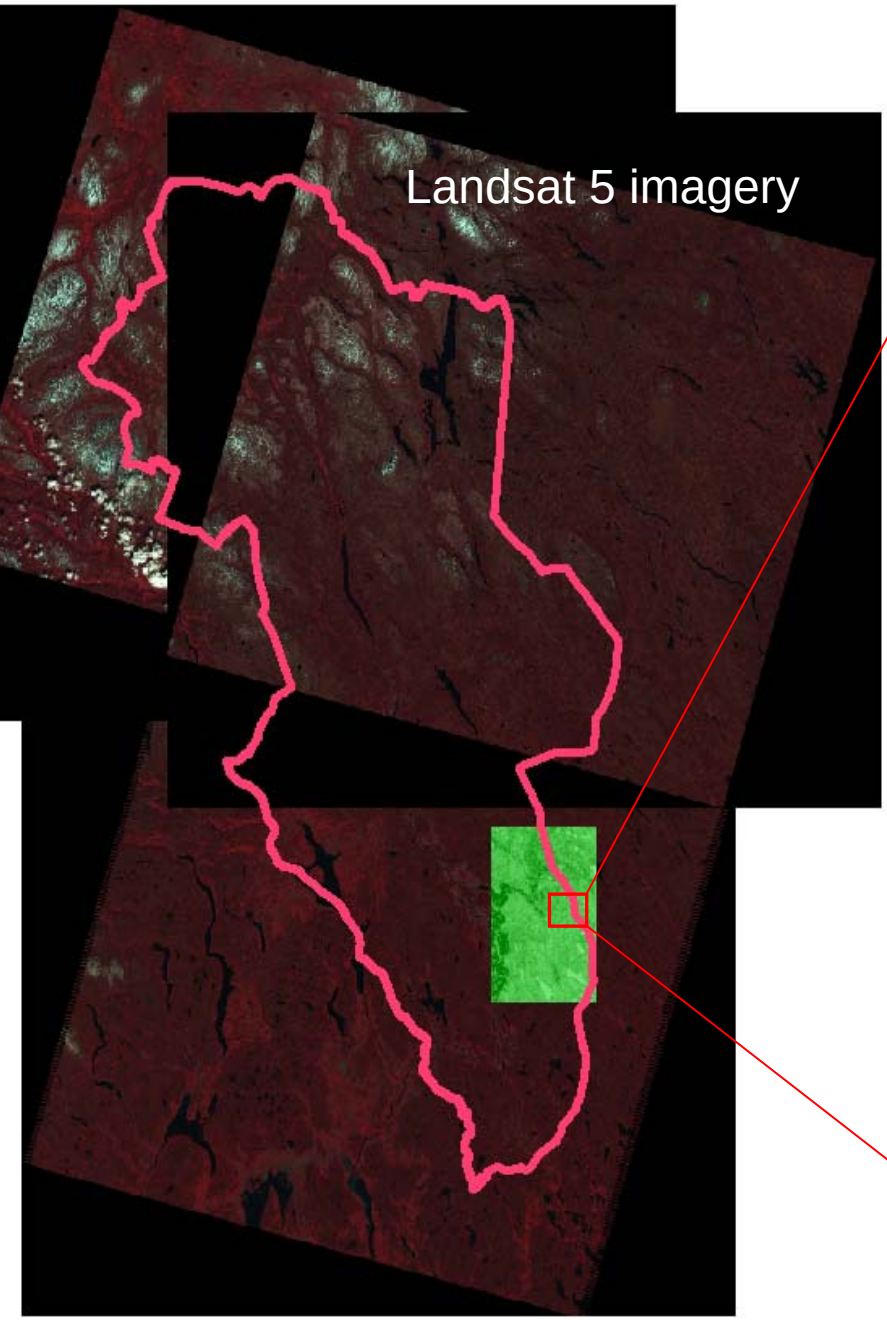
Synthetic population

- input data:
  - three thematic maps based on nearest neighbor estimation
    - volume of productive forest
    - 2200 NFI plots
    - three Landsat 5 Thematic Mapper scenes from June, 2007
  - land-use and site index maps
  - DTMs
- most similar neighbor

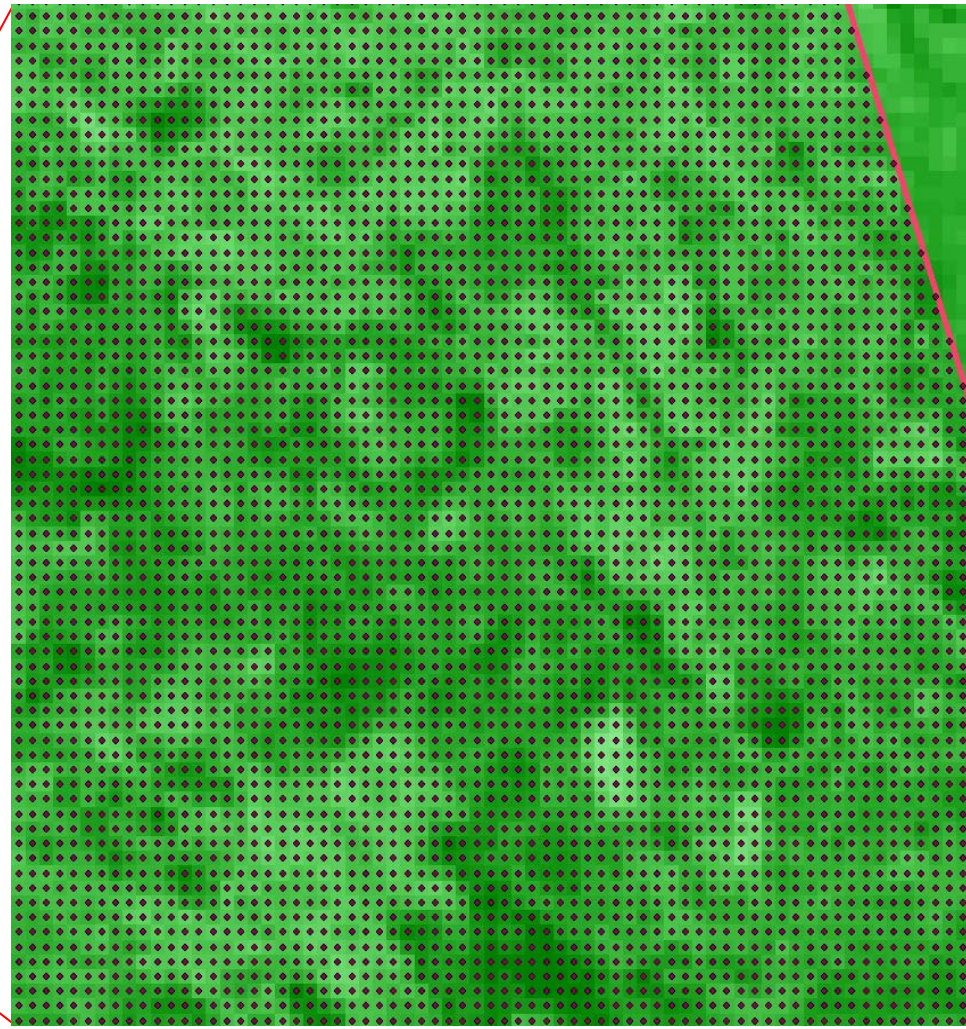
Synthetic population

- aiming to preserve the spatial structure existing in the NFI plots a.m.a.p.

- grid of rectangular cells co-registered with the thematic maps
  - 25m and 30m spatial resolution
  - cell boundaries the same as pixel boundaries



pixel centers



Synthetic population

- to populate the cells
  - define AOIs as squares within the NFI plots used for nearest neigbor estimation
  - crop the trees within AOIs
  - crop the LiDAR measurements within the AOIs
  - positioning cropped areas at the cell centers and reflect them across their boundaries until the whole cell is covered
    - list of geolocated trees and corresponding LiDAR data
    - volume and biomass calculations for each tree

Synthetic population

- spatial distribution and correlation
  - inherent in the thematic maps
    - geographical trends S-N and E-V

- the spatial distribution of the trees at cell level should not influence the relative efficiency of the estimators
  - test against a population of random located trees at cell level

Simulator functionalities

- sampling design
  - user defined
  - stratified/non-startified
  - cluster sampling
  - systematic
    - random start first line
    - random start first line, stratified
  - plot shapes:
    - circular
    - square
    - rectangular

Simulator functionalities

- scanning LiDAR
  - strip width
    - input by design
    - should be held constant along flight lines
  - complete cover of square patches
  - square and hexagonal raster for prediction

- stratification
  - user defined
  - based on Hedmark data

Simulator functionalities

- independent variables(area based, first echo)
  - percentiles corresponding to various quantiles of laser canopy height
  - canopy densities associated to height percentiles
  - IQR, CV, ...

- response variables (area based)
  - biomass
  - volume
  - no. of stems
  - basal area
  - basal area weighted mean height, ...

Simulator functionalities

- prediction models:
  - parametric regression
    - heteroscedasticity
      - multiplicative models(linear regression with log-transformed variables)
      - square root transformation of response
  - non-parametric methods

- possibility for varying the point density

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