Flanders
State of the Art

Development of a semi-automated process to analyse data from the Flemish forest inventory

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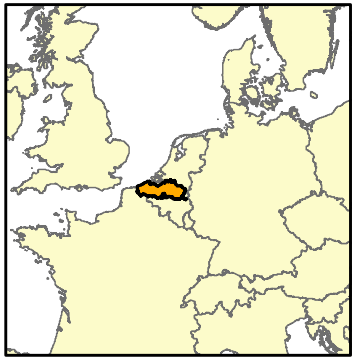
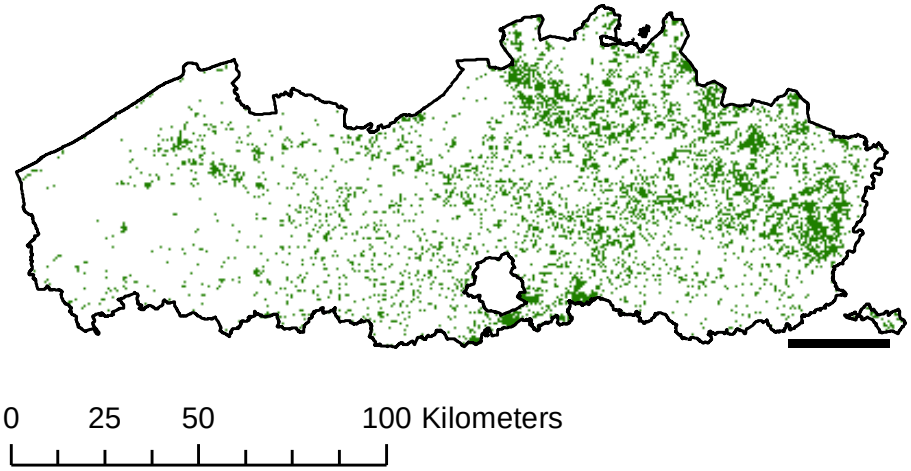
Overview

- Forest inventory in flanders: objectives and design
- Challanges for data analysis
- Semi-automated analysis process
  - Quality control of measured variables
  - Calculation of derived variables
  - Actual data analysis
- Conclusions

Flemish forest inventory



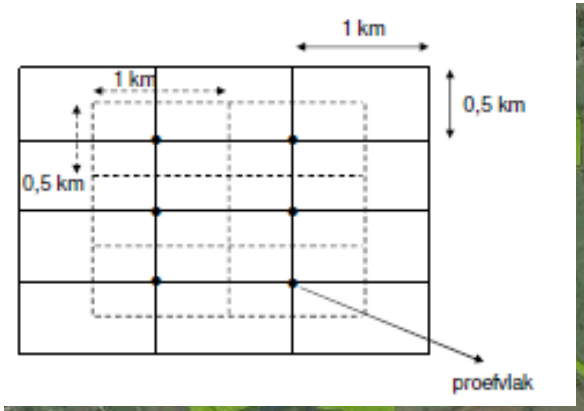
- Forest cover in Flanders
  - 185600 ha
  - 7,3 %



Flemish forest inventory

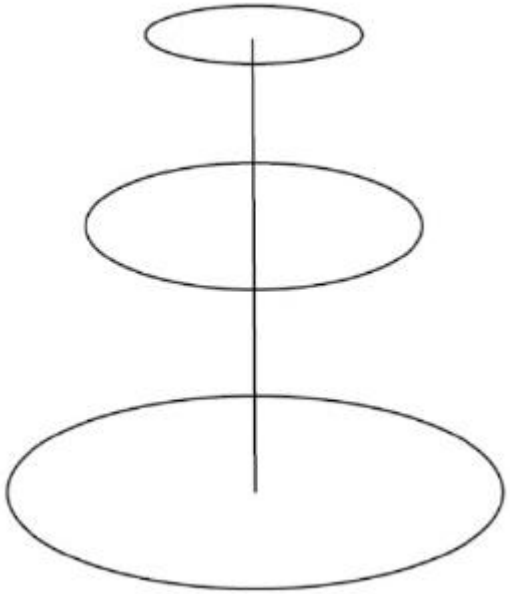
- Flemish forest inventory (VBI)
  - Information on status and trends of forest characteristics in Flanders
  - Managed by Agency of Nature and Forests (ANB)
  - 61 monitoring questions/ targets
  - 6 thematic categories
    - Forest distrubution
    - Tree species composition
    - Forest stand characteristics
    - Biodiversity indicators
    - Vegetation composition
    - Forest management and forest use (wood quantity and quality)

Flemish forest inventory



Flemish forest inventory

- Sample plot: stand characteristics and tree measurements



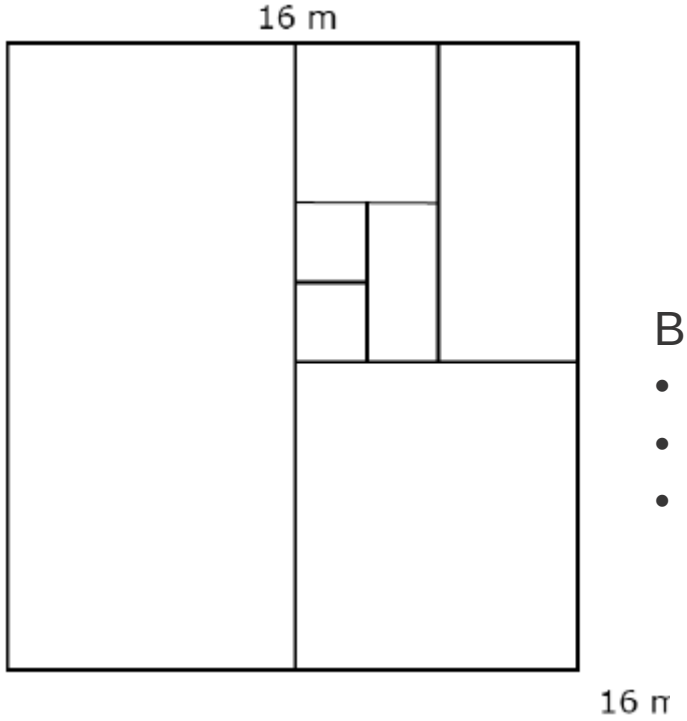
A2
- 4,5 m radius
- Trees with perimeter < 22 cm and height >= 2 m
- Number per species

A3
- 9 m radius
- Trees with 22 cm <= perimeter < 122 cm
- Species, status, perimeter, height, location

A4
- 18 m radius
- Trees with perimeter >= 122 cm
- Species, status, perimeter, height, location
- Stand characteristics

Flemish forest inventory

- Sample plot: vegetation

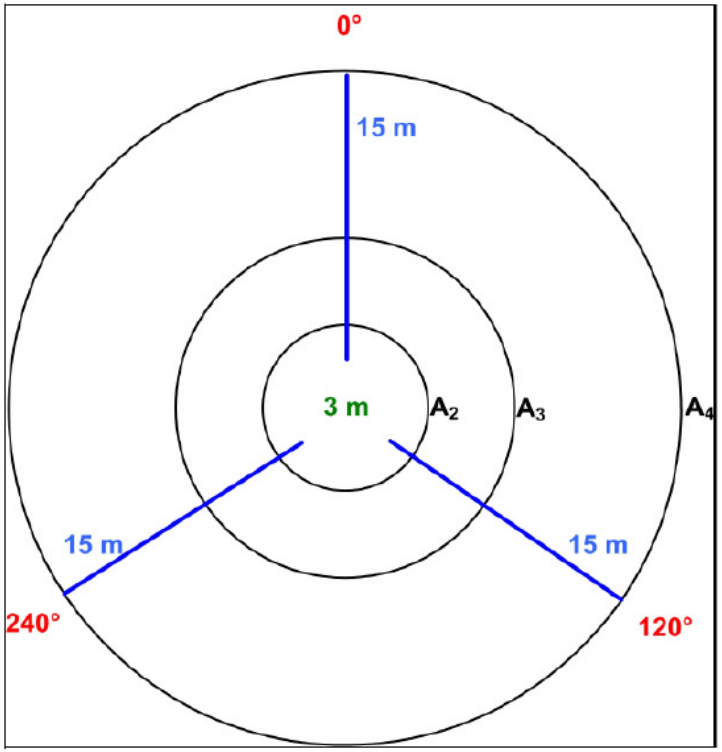


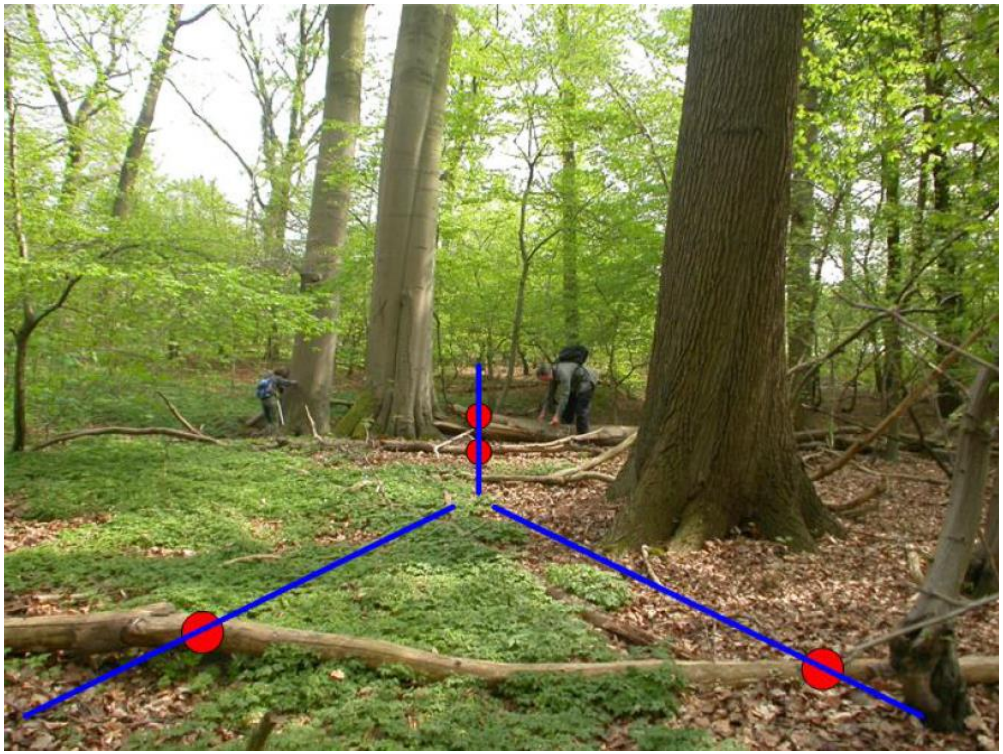
Braun-Blanquet cover/abundance

- Herb layer
- Shrub layer
- Tree layer

Flemish forest inventory

- Sample plot: line intersect sampling for laying dead wood





Flemish forest inventory

- 1st inventory: 1997 – 1999
- 2nd inventory: 2009 – ongoing
  - 12 year cycle
  - Approximately 50 % of marked sample plots could be retrieved → mixture of permanent and tempory sample plots
  - Various differences in measurement protocol
    - 1st inventory: plots on forest edge or containing different stand types removed to get homogeneous forest plot
    - 2nd inventory: plots are put on original position

Analysing data from the Flemish forest inventory

- Goal: periodical reporting of results based on standardized data analysis

- Challanges

  - Many types of data collected in the field
  - Many variables derived from raw data (for example: wood volume, biodiversity indices, Ellenberg values,…)
  - Many monitoring questions to be answered

→ Good organization and documentation of dataset

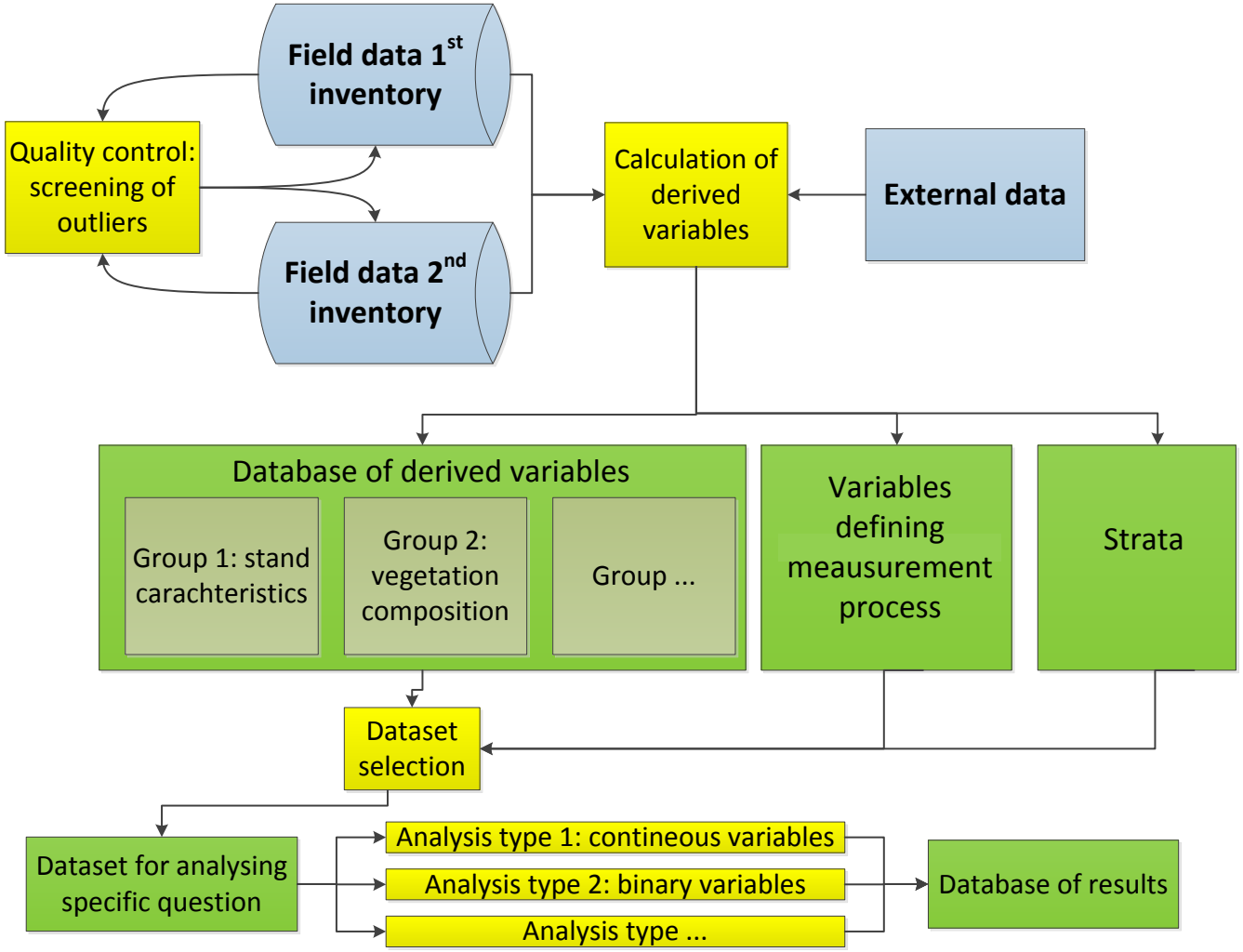
  - Mixture of permanent and temporary plots
  - Some plots are only partially covered by forest

→ Need for appropriate statistical techniques

Analysing data from the Flemish forest inventory

- Quality assurance of data analysis is essential
- INBO developped a semi-automated process to support data analysis and reporting of results
- Analysis process is implemented by a series of R-scripts
- The actual analysis will be performed by ANB

Overview of analysis process



Analysis process: quality control

- Comparison of tree measurements in the 1st and 2nd inventory
- Only for trees that have been remeasured in 2nd inventory (35% of the trees)

- Detection of anomalies and group them into different types
  - Zombies: status changes from dead to alive
  - Shifters: tree changes to another species
  - Movers: tree changes position
  - Outliers in perimeter growth
  - Outliers in height growth

- Validation
  - Change value of measured variable
  - Consider the trees in the 1st and 2nd inventory as different trees → this impacts the further analysis
  - Confirm measurements

Analysis process: database of derived variables

- Most questions can not directly be answered based on the original measured variables → derived variables have to be calculated

- For example
  - What ‘s the volume of dead standing trees per ha?
  - Status, height and perimeter per tree → volume per dead tree → volume dead trees per plot type → volume dead trees per ha

- In total 90 derived variables for 61 monitoring questions/targets

- Variables describing the measurement process are needed to perform a proper statistical analysis
  - Measurement date
  - Plot weight
  - Permanent plot of temporary plot
  - …

Analysis process: database of derived variables

- Derived variables, measurements characteristics and strata information are organised in a database

- Documentation
  - Which derived variables are needed to answer a certain monitoring questions, which external data is used
  - Clear description of how derived variables are calculated

Analysis process: actual data analysis

- Example scripts for detailed analysis of monitoring questions
  - Different types of derived variables: continuous, binary, count data, categorical data
  - Thematically different types of questions
- Data analysis consists of different parts
  - Data exploration
  - Design-based parameter estimation
  - Model-based parameter estimation
- Results can be stored in a database
  - Parameter estimate and confidence intervals
  - Date of analysis
  - Characteristics of analysing technique
  - Characteristics of the dataset on which analysis was performed
- Documentation
  - How to interpret data exploration plots
  - How to interpret models
  - How to validate results

Analysis process: model – based parameter estimation

- Estimating differences between both inventories is not straightforward
  - In only part of the locations plots were remeasured, in the other part new plots were established
  - Measurements in permanent plots are more similar

- Our approach → Generalized linear mixed effects models (GLMM)
  - Plot ID is used as random effect
  - GLMM can handle different data distributions
  - GLMM can handle plot weights
  - Strata can be incorporated
  - Nlme package (Pinheiro et al., 2015)

Analysis process: model – based parameter estimation

- Example analysis (preliminary results)
  - VolumeSnags ~ InventoryID + (1 | PlotID)
  - Model output
    - Fixed effects:

```
             Estimate Std. Error t value
(Intercept)  4.0238    0.3122    12.889
InventoryID2 5.1140    0.5310     9.631
```

  - Estimated standing dead wood volume
    - 1st inventory: 4,0 m^3/ha
    - 2nd inventory: 4,0 + 5,1 = 9,1 m^3/ha
    - Difference: 5,1 m^3/ha
    - 95% confidence interval of difference: 4,1 – 6,2 m^3/ha

Conclusions

- Quality assurance of data analysis process is an essential part of long term monitoring programs

→ Standardized, statistically sound, repeatable analysis of data and reporting of results

- Approach for Flemish forest inventory
  - Conceptual scheme of analysis process
  - Well documented R-scripts
  - Parameter estimation based on GLMM
  - Documentation + manual

Thank you