

# Estimating changes in forest attributes with 3D remote sensing

Piotr Tompalski



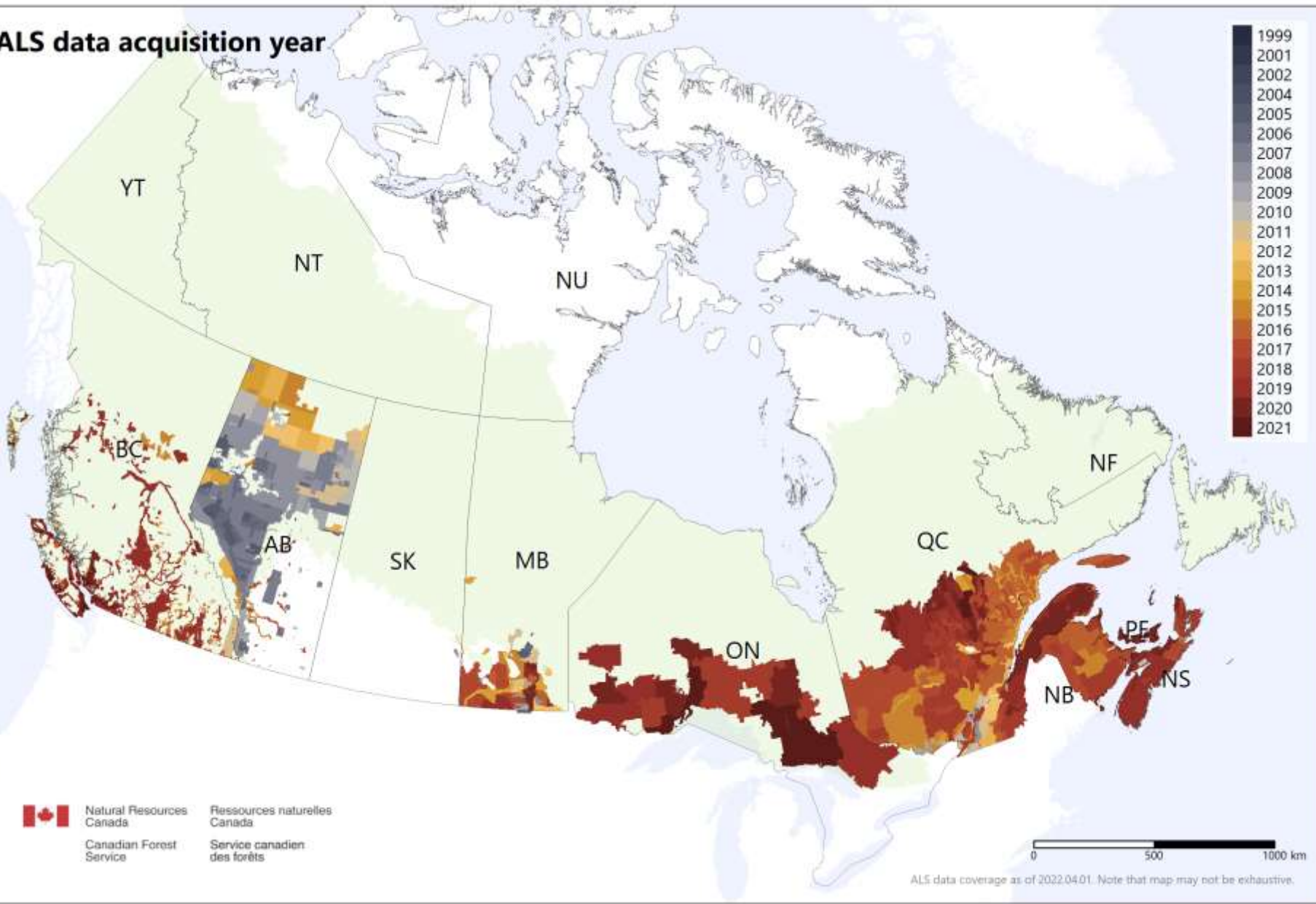
Natural Resources  
Canada

Canadian Forest  
Service

Ressources naturelles  
Canada

Service canadien  
des forêts

# ALS data acquisition year



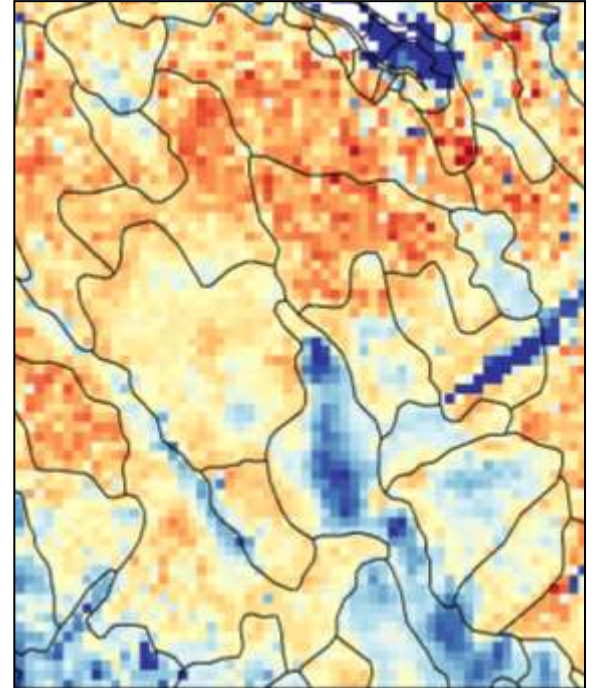
 Natural Resources Canada / Ressources naturelles Canada  
Canadian Forest Service / Service canadien des forêts



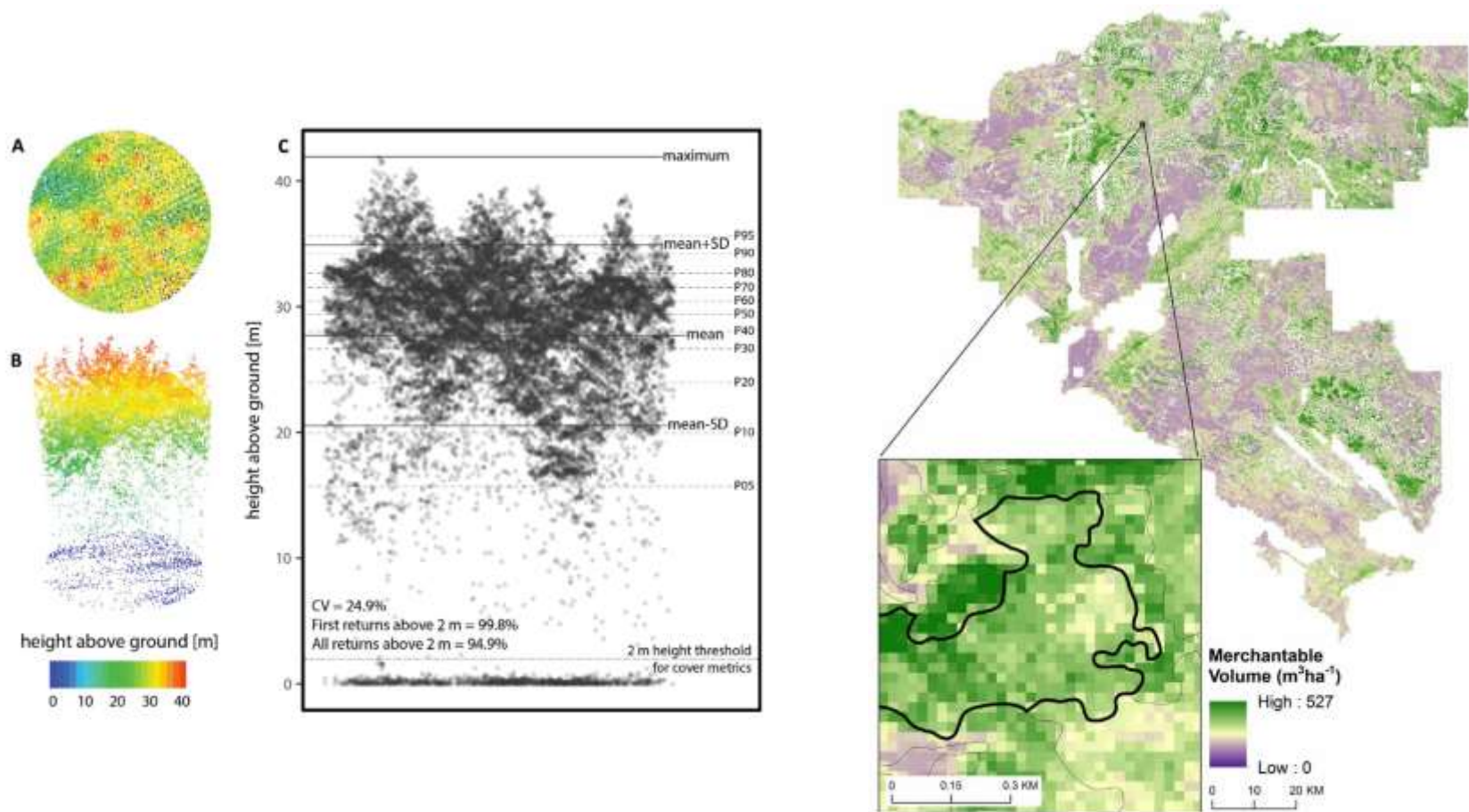
ALS data coverage as of 2022.04.01. Note that map may not be exhaustive.

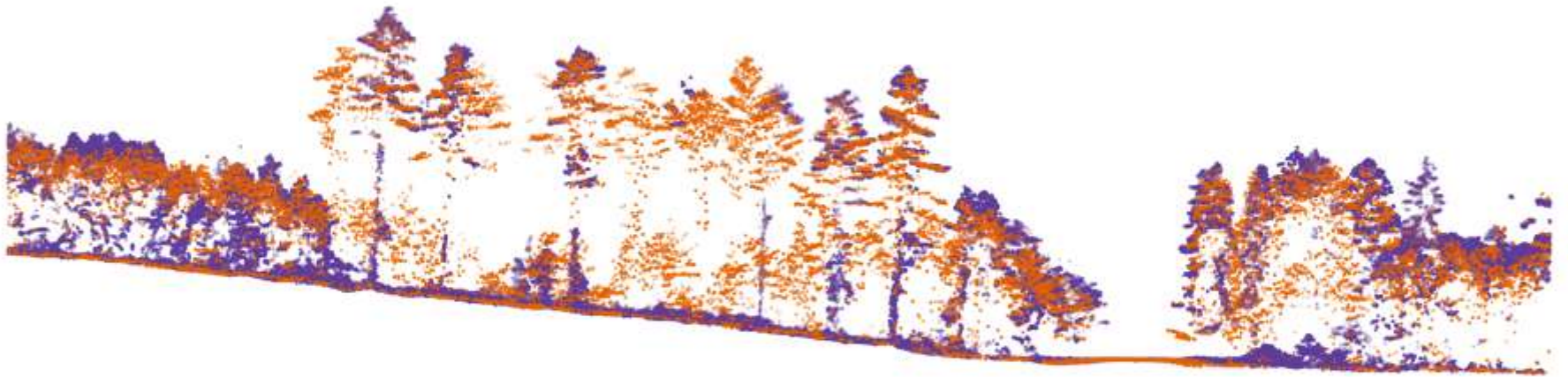
# ALS in forestry

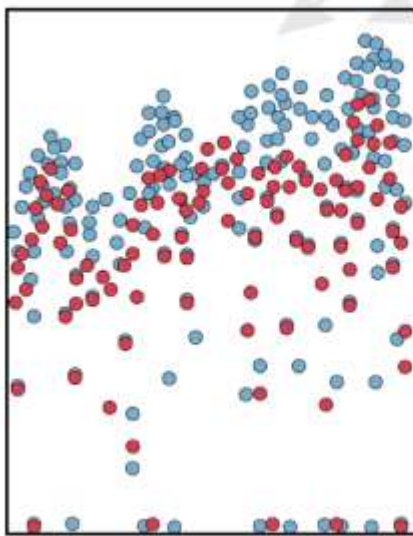
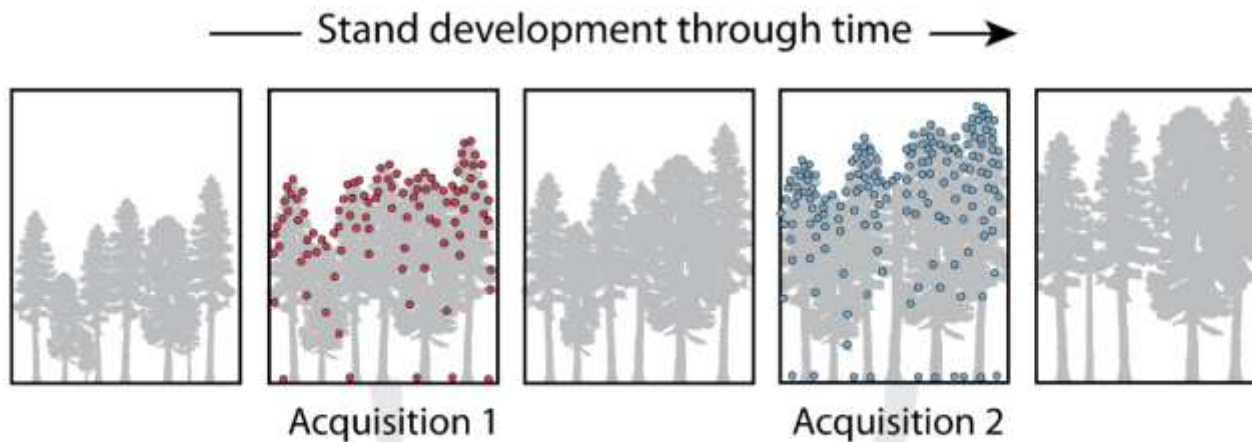
- Stand attributes at pixel- or tree-level
- Height, basal area, volume, biomass + many more
- Accurate, detailed, wall-to-wall
- "Enhanced forest inventory"



# Enhanced forest inventory (EFI)







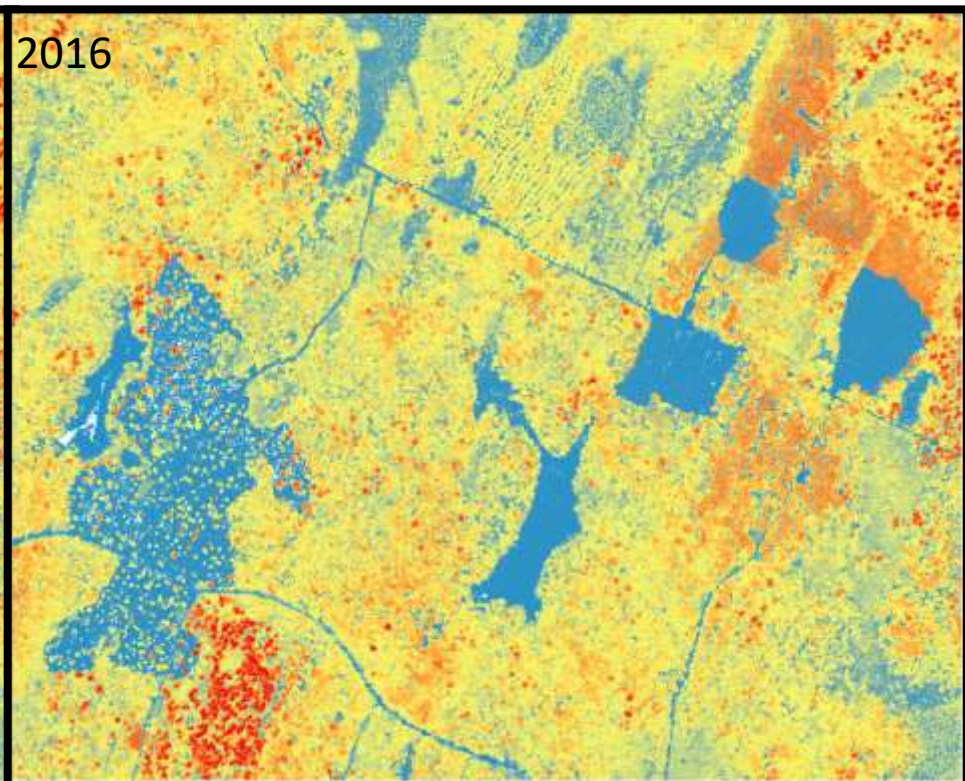
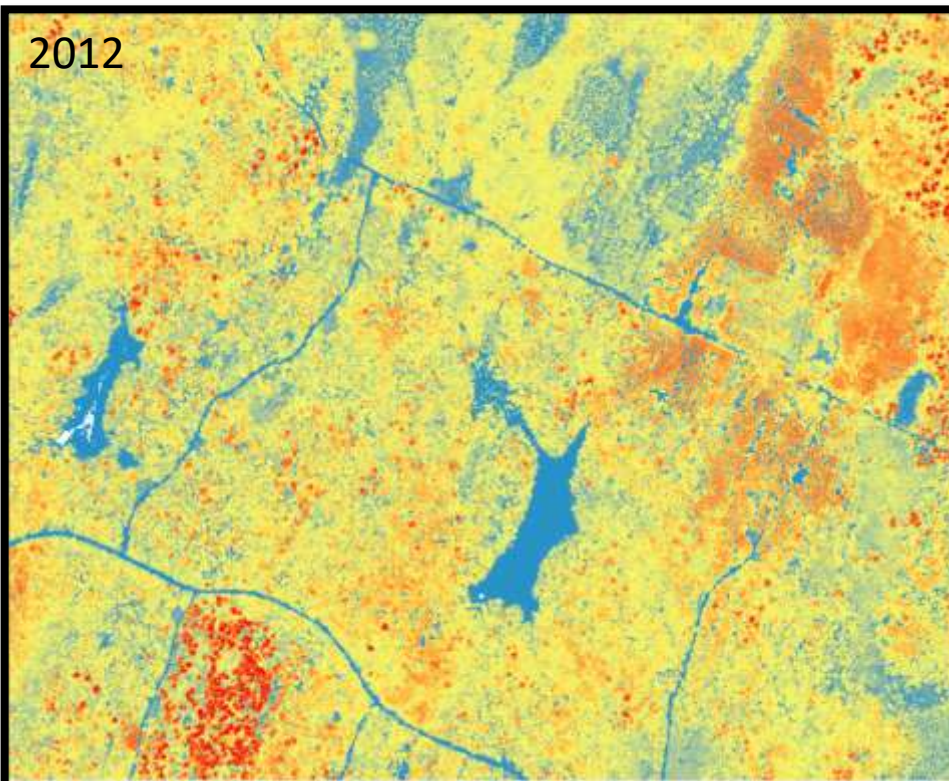
**Retrospectively estimating growth**

- point cloud-based change estimates
- area-based or tree-level detail
- direct / indirect approaches

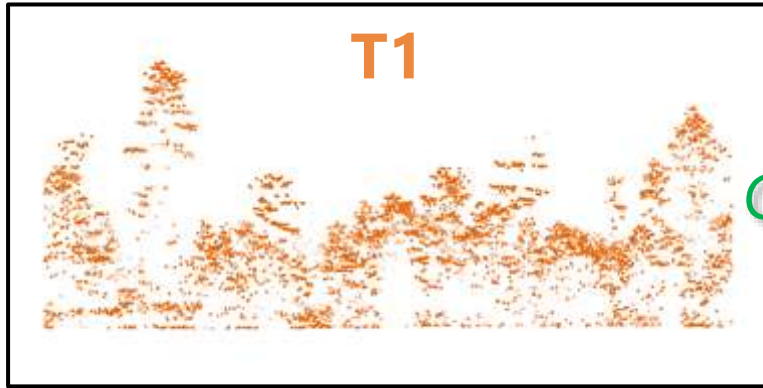
**Forecasting forest attributes into the future**

- growth simulators and productivity models
- plot / curve matching approaches
- developing growth functions

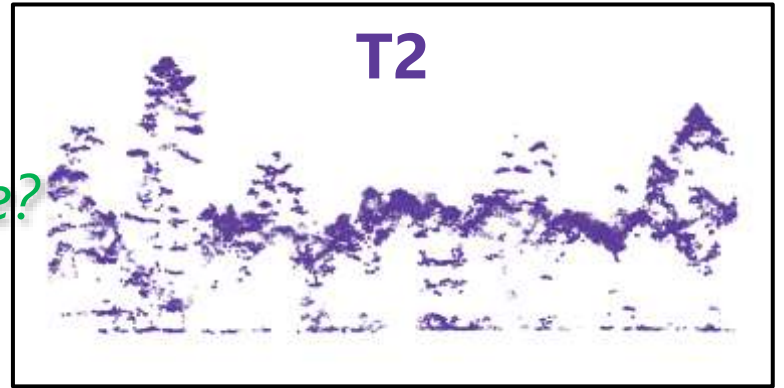
# RETROSPECTIVELY ESTIMATING GROWTH

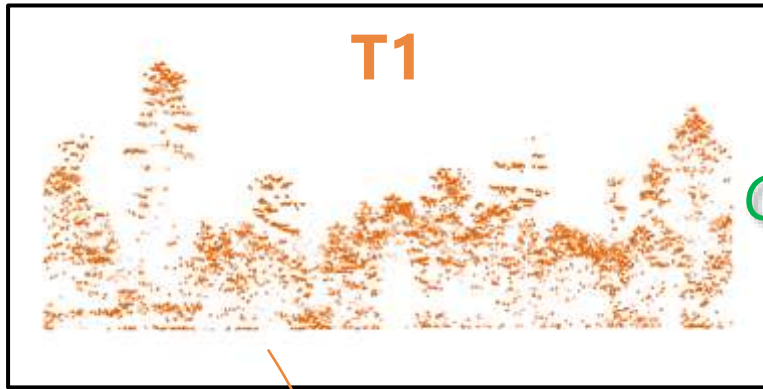




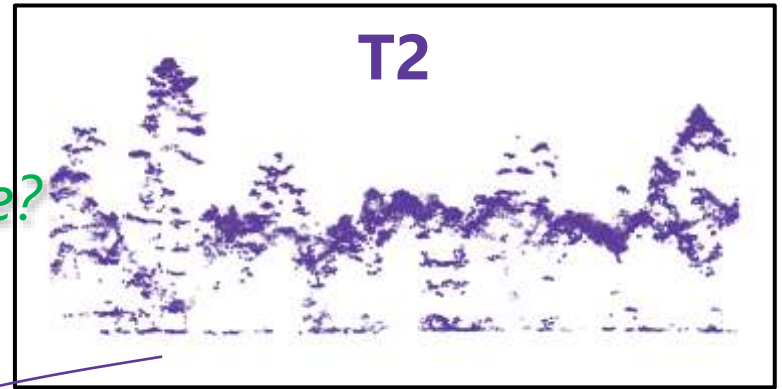


Change?





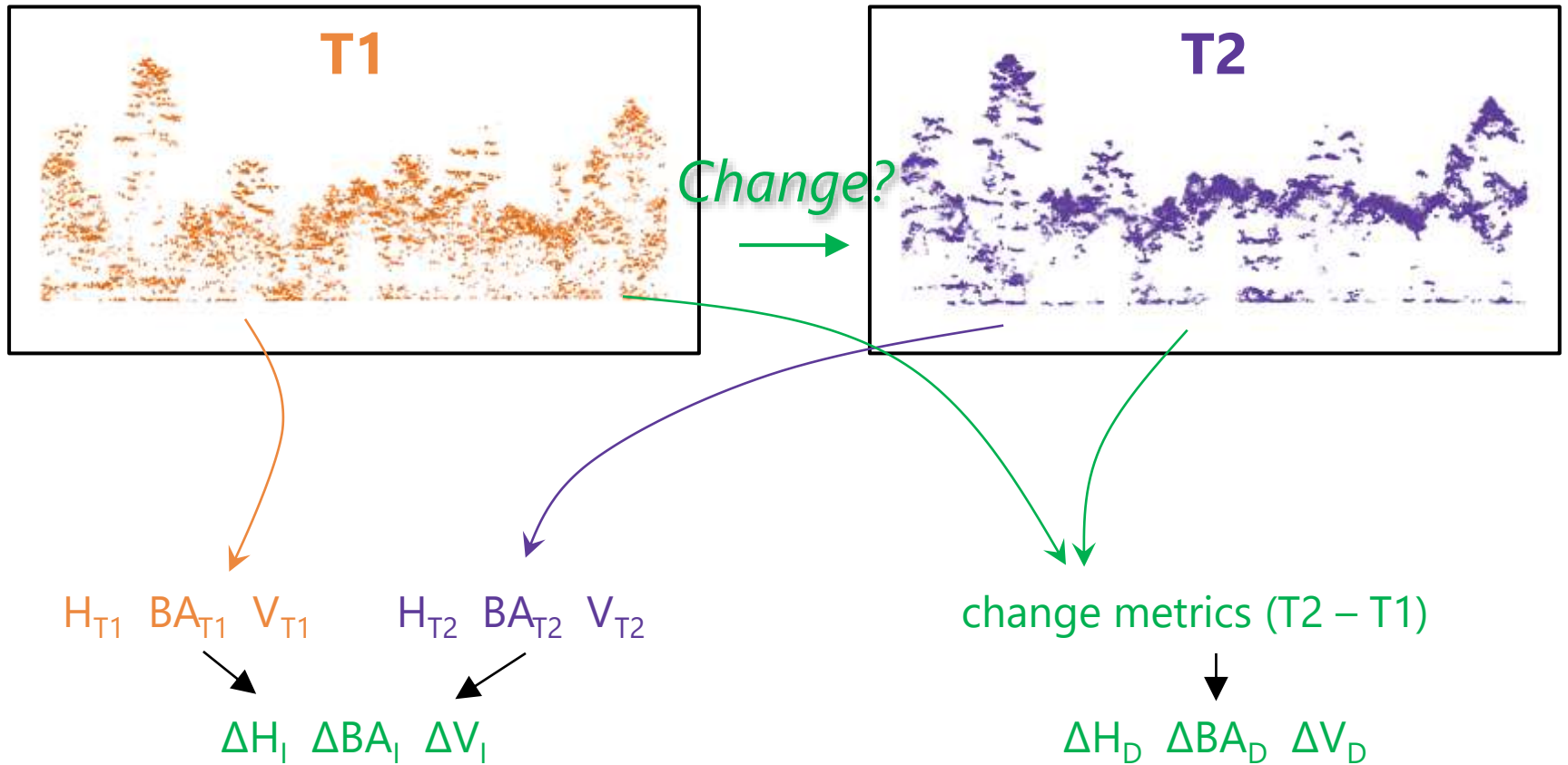
Change?

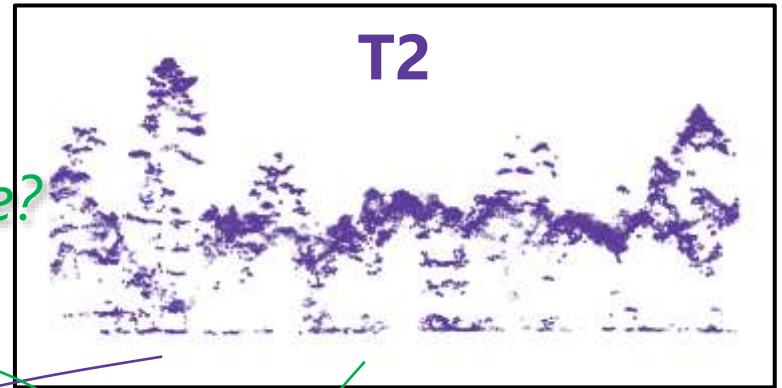
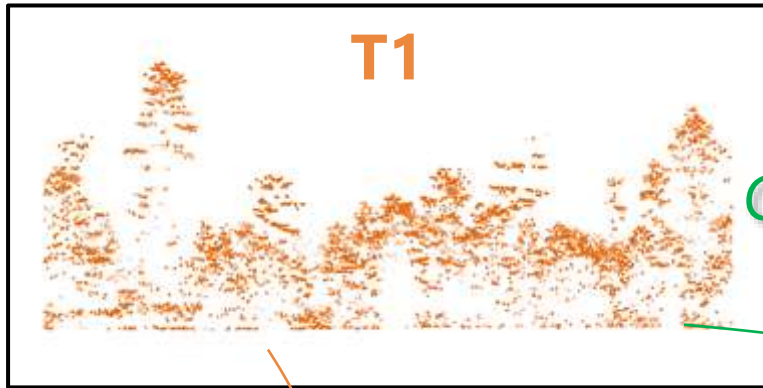


$H_{T1}$   $BA_{T1}$   $V_{T1}$

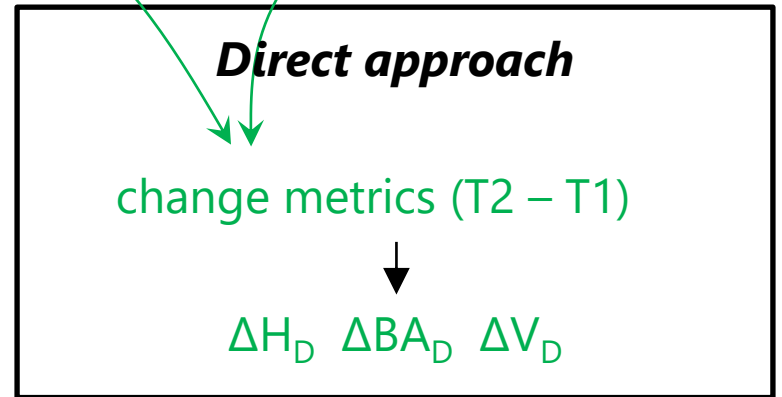
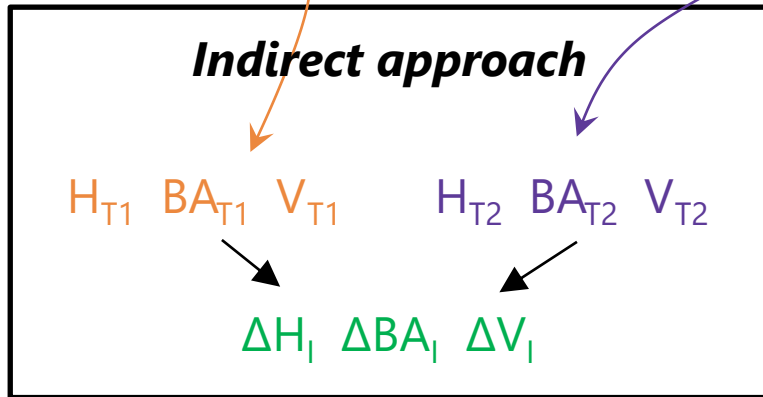
$H_{T2}$   $BA_{T2}$   $V_{T2}$

$\Delta H_1$   $\Delta BA_1$   $\Delta V_1$



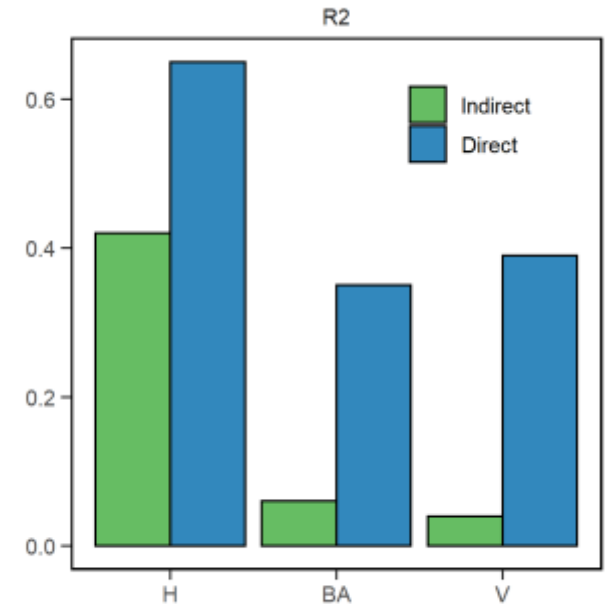


Change?

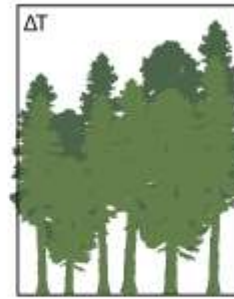
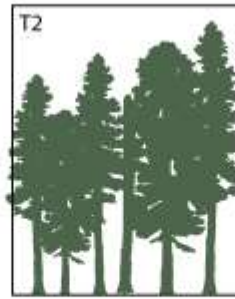


# Direct vs indirect

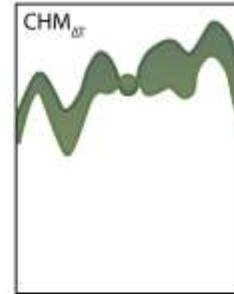
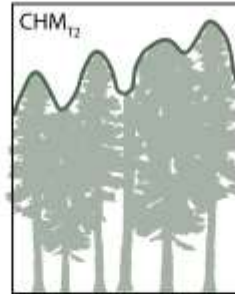
- In our research – direct is better
- No consensus in the literature
- Both sensitive to mortality and disturbance
- $\Delta H$  - the most accurate
- Time interval is important – growth should exceed the uncertainty in attribute predictions



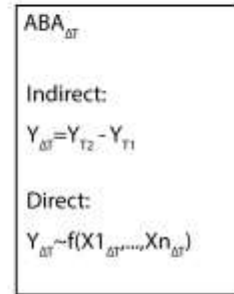
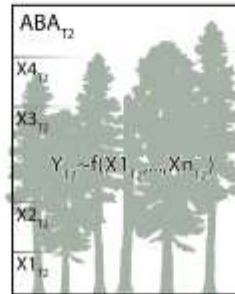
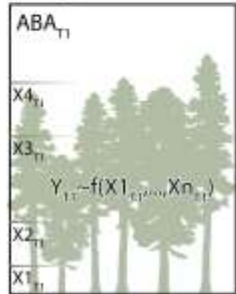
Forest stand at two points in time



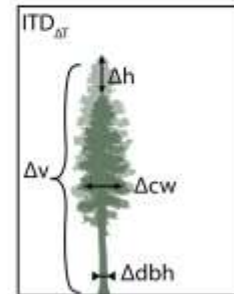
Analysis based on CHM



Analysis at cell level

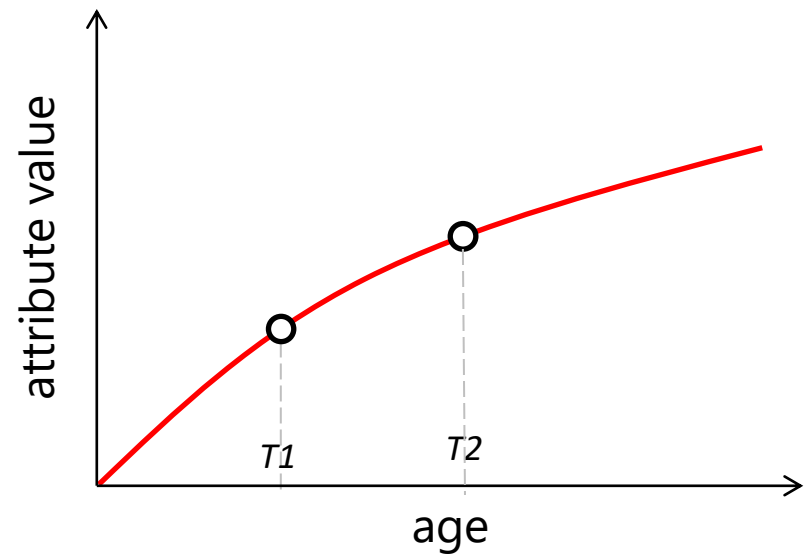


Analysis at individual tree level



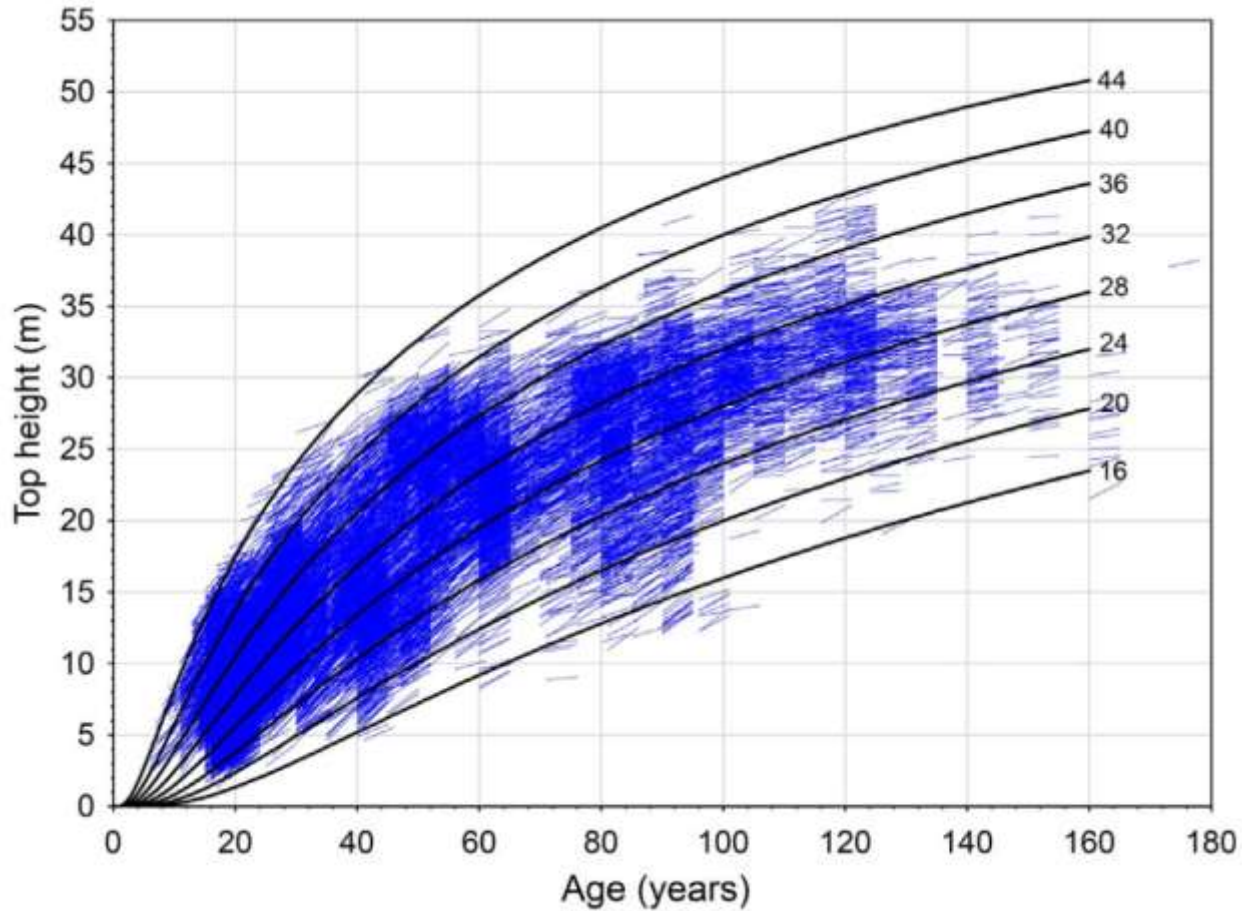
FORECASTING FOREST  
ATTRIBUTES INTO THE FUTURE

- Modeling Forest Productivity with Multi-temporal Point Cloud Data
- Integrating Point Cloud Data with Growth Simulators
- Data Assimilation

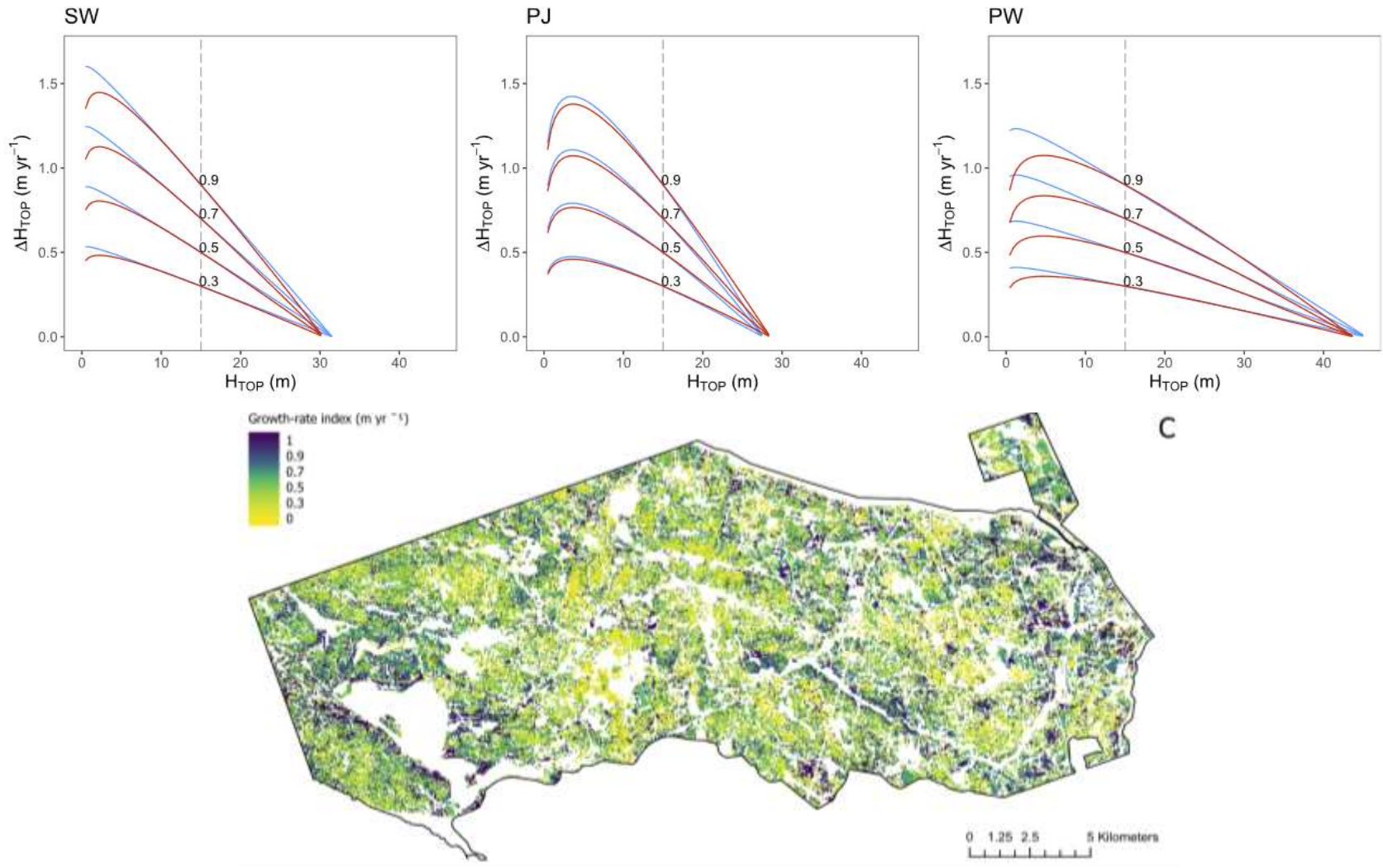




# Site index

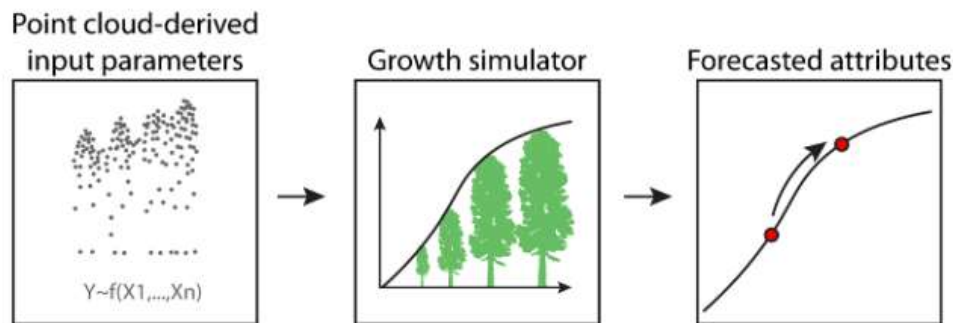


# Age-independent 'site index'



# Approaches to integrate growth simulators with point cloud data

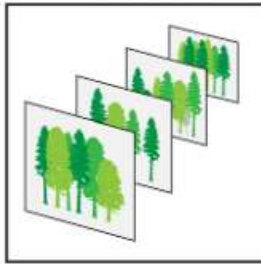
## a Parametrizing a growth simulator



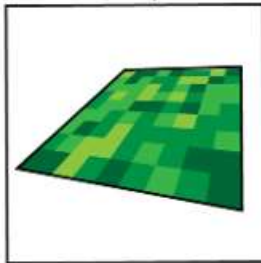
# Approaches to integrate growth simulators with point cloud data

## b Tree list matching

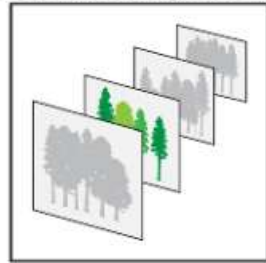
Database of tree lists



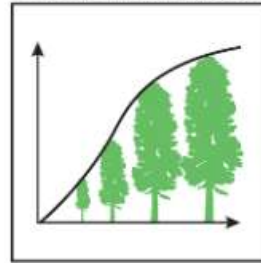
ABA layers



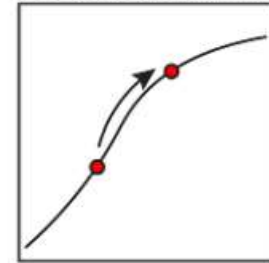
Best matching tree list



Growth simulator

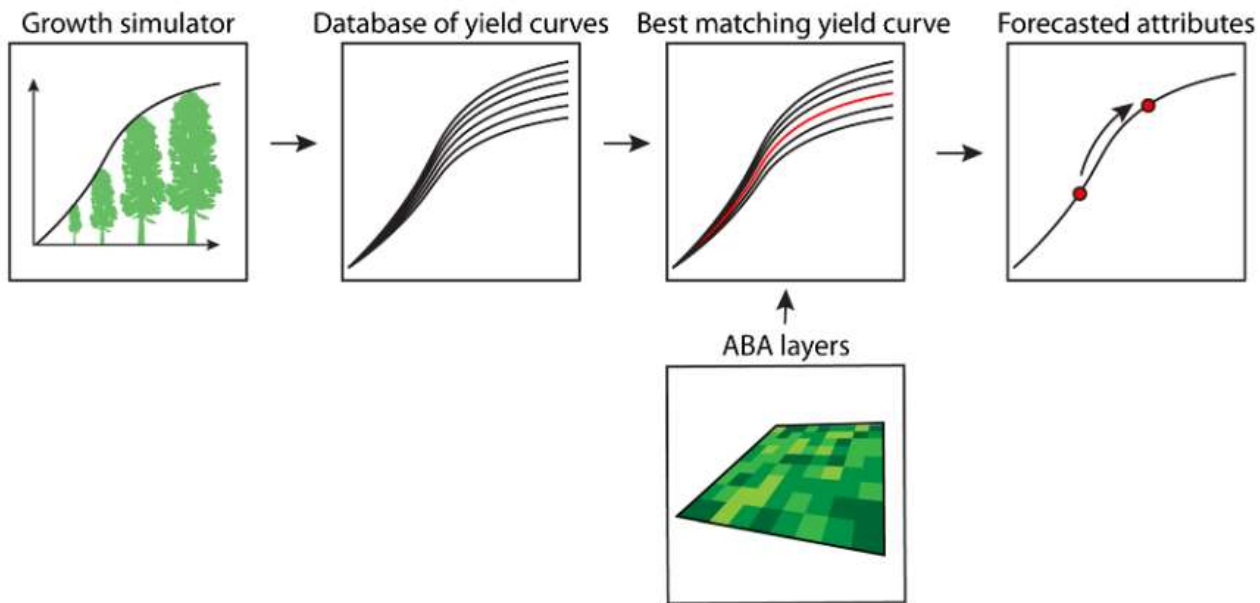


Forecasted attributes

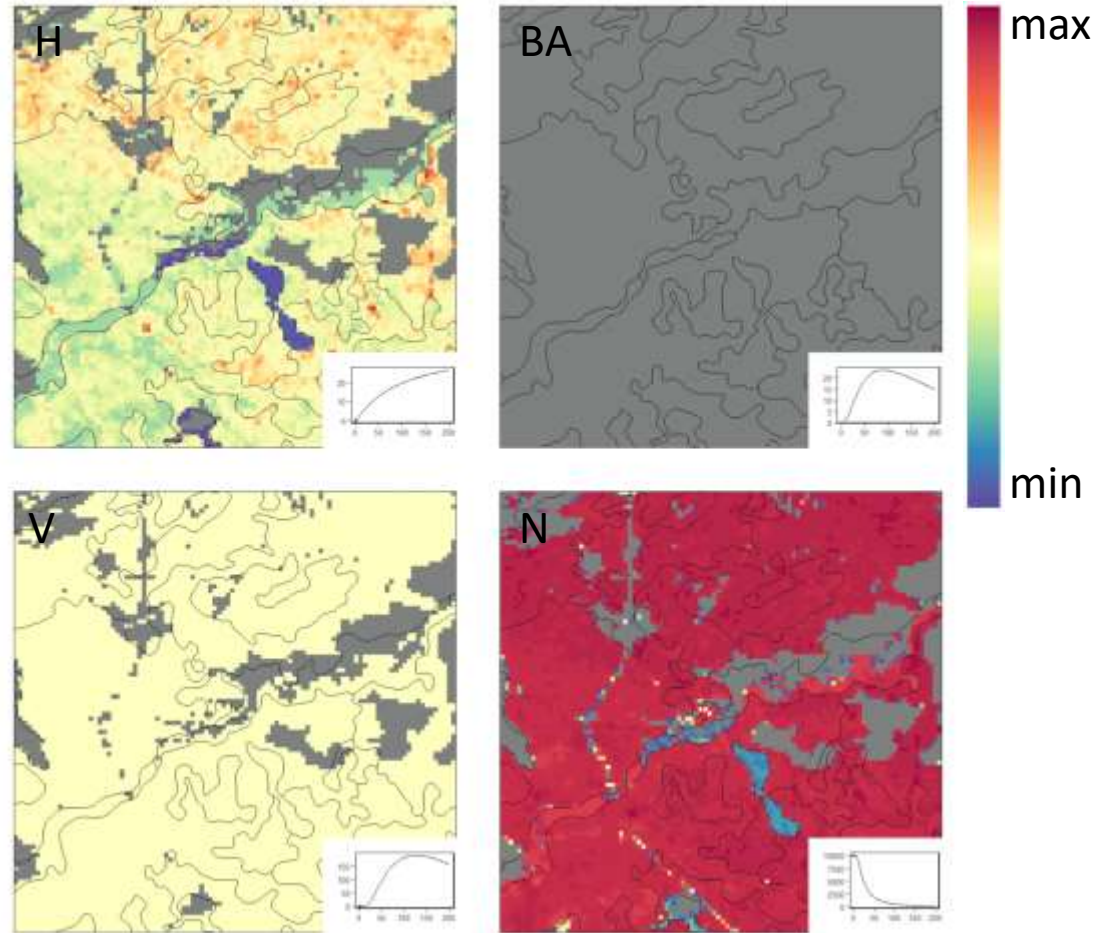


# Approaches to integrate growth simulators with point cloud data

## c Curve matching

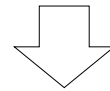
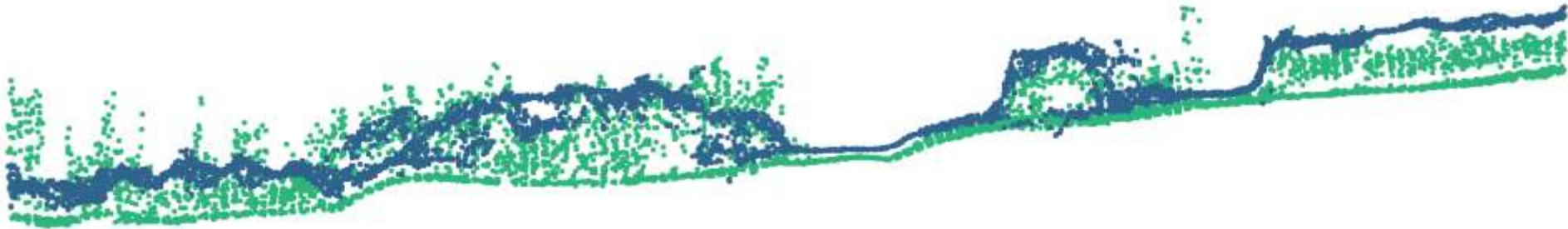


# Yield curves matched at pixel-level

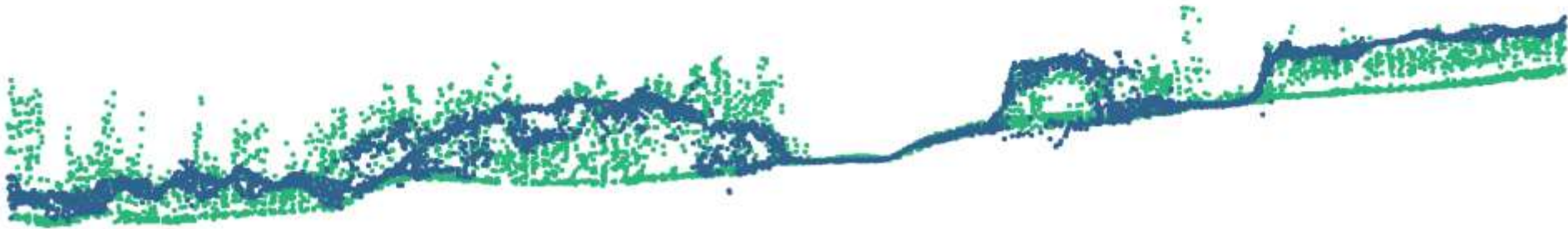


CHALLENGES

# Data harmonization

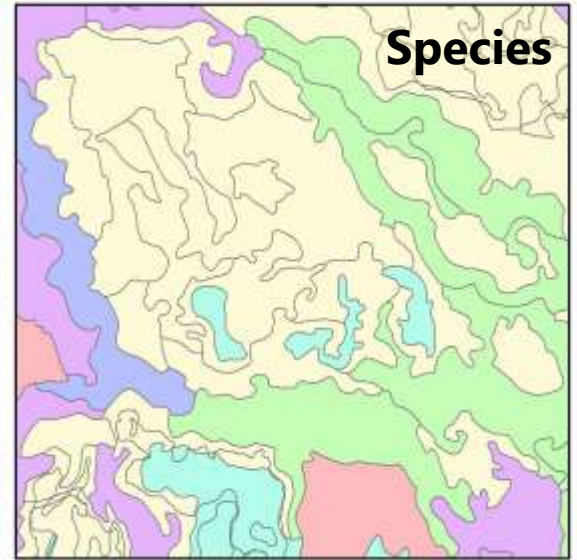
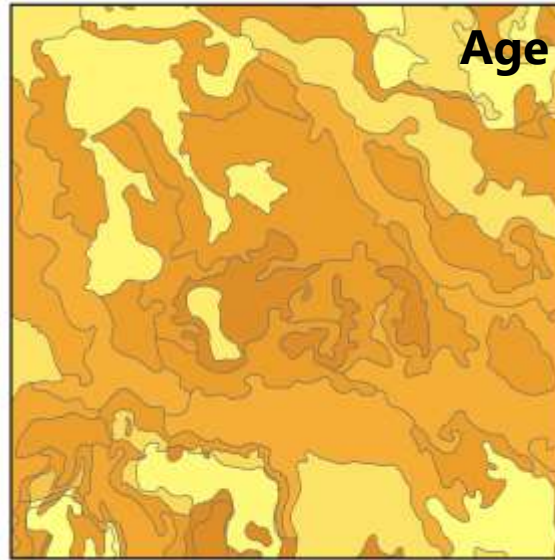
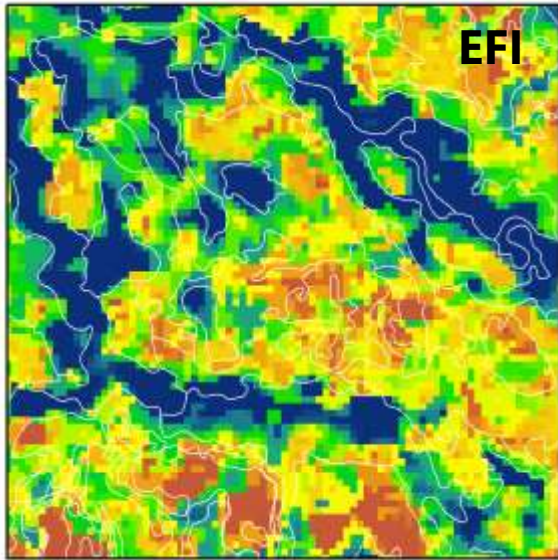


harmonization



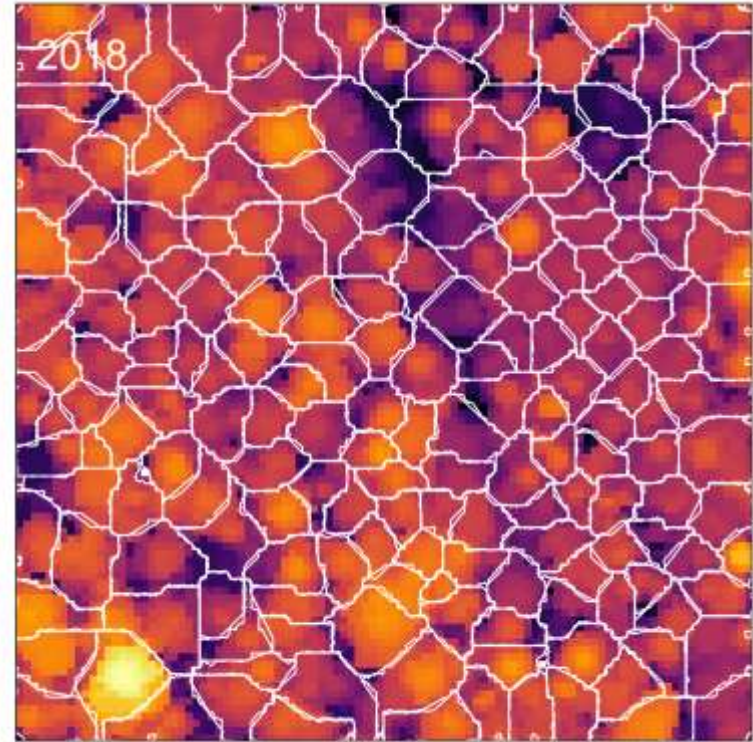
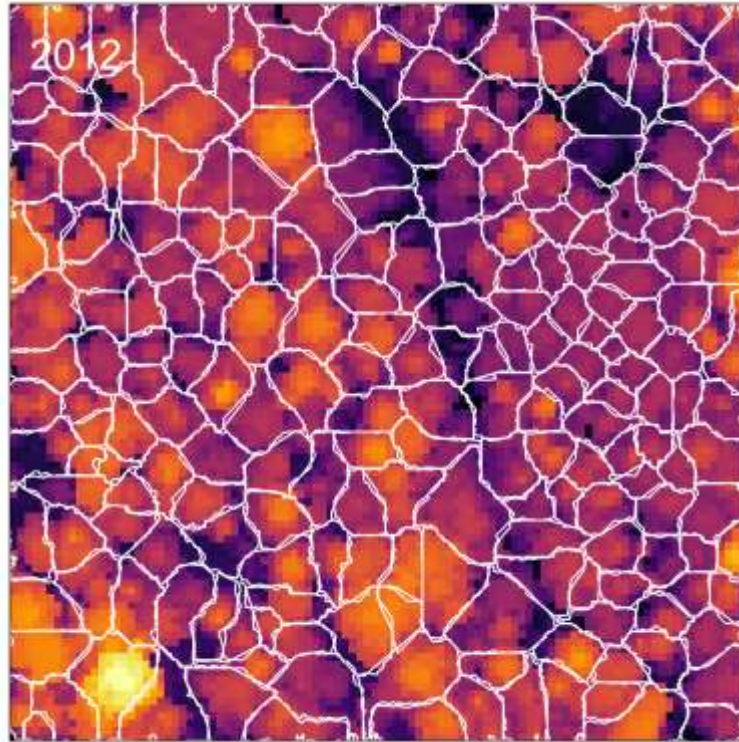


# Species? Age?

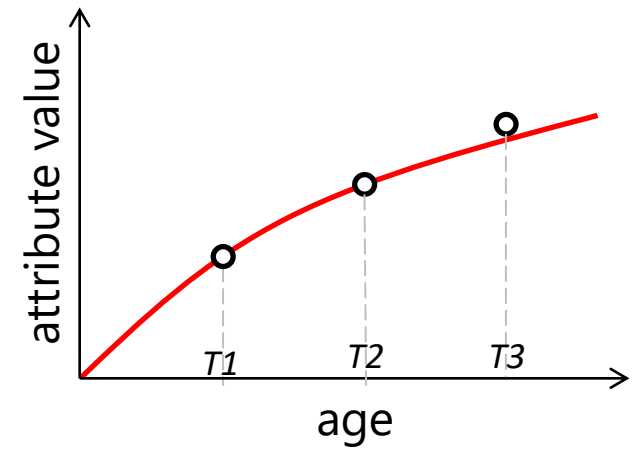
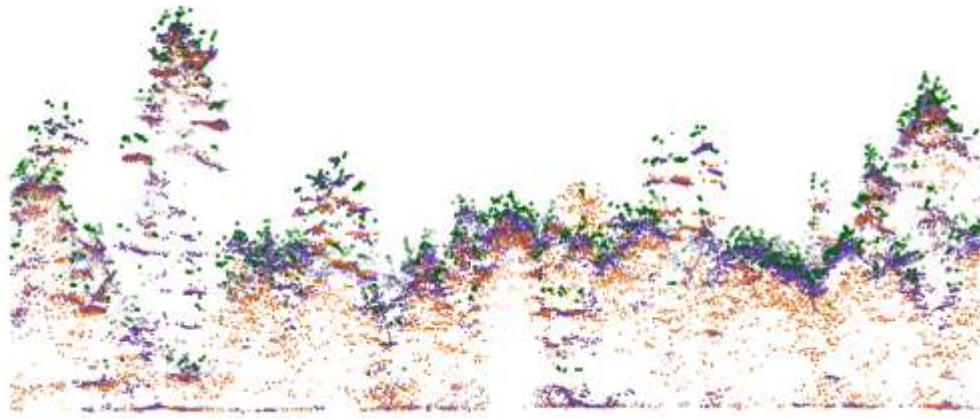


# Estimating change at tree-level

- Tree detection / segmentation independent for each dataset
- Tree-to-tree matching



# Multi-temporal datasets ( $n > 2$ )



# Growth

- Integration with existing growth models
  - Existing methods in early stages of development
  - Designed to work with specific growth simulator
- Growth models driven entirely with remote sensing data
  - Do not necessarily need to mimic existing growth simulators, rather utilize the advantages provided by point clouds and other remote sensing data

# Thank you!

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Current Forestry Reports

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REMOTE SENSING (J SUAREZ, SECTION EDITOR)



## **Estimating Changes in Forest Attributes and Enhancing Growth Projections: a Review of Existing Approaches and Future Directions Using Airborne 3D Point Cloud Data**

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