Evaluating the species-specific changes in the tree crown structure based on bi-temporal airborne laser scanning data

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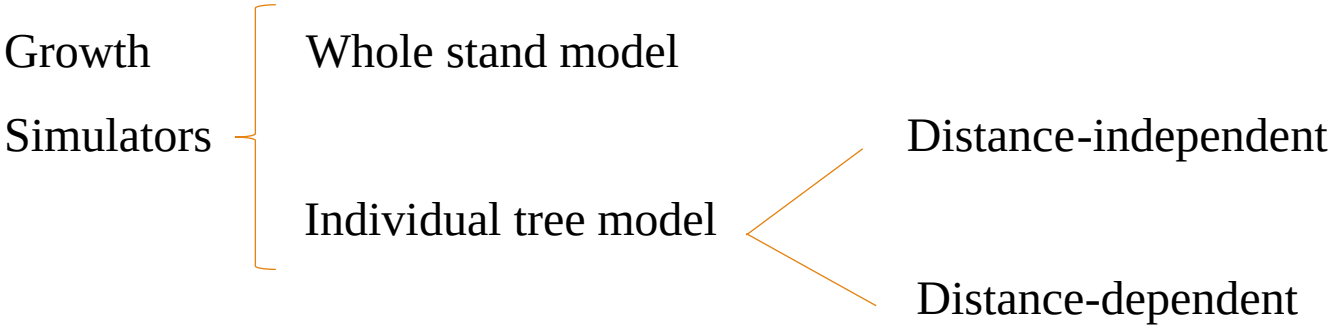
Forest as a long-lived dynamic biological system

Sustainable forest management requires accurate information on both current and projected stand conditions that can be described by growth models.

The importance of forest growth models

- ✓ Predicting future yield
- ✓ Exploring management alternative and silvicultural options
- ✓ Important role on terrestrial carbon cycle
- ✓ Monitoring possible effect of climate change on forests growth rate
- ✓ Ability to update field inventory

Tree crown and its role in forest growth



- ✓ Its main functionality of assimilation, respiration, and transpiration
- ✓ It is one complement of net primary production and its dimension show the tree health
- ✓ Important character of precipitation interception, light transmission, forest litter accumulation, soil moisture loss, and transpiration rates
- ✓ Useful in predicting growth responses in spacing and thining

Main data sources for growth measurements

(1) Repeated measurements on permanent sample plots

(2) Temporary sample plots data from periodic inventories

(3) Stem analysis data

(4) Airborne Laser Scanning (ALS) individual tree-crow based inventory

- Trajectory methods
- Bi-temporal methods
  - Direct (Differencing)
  - Indirect

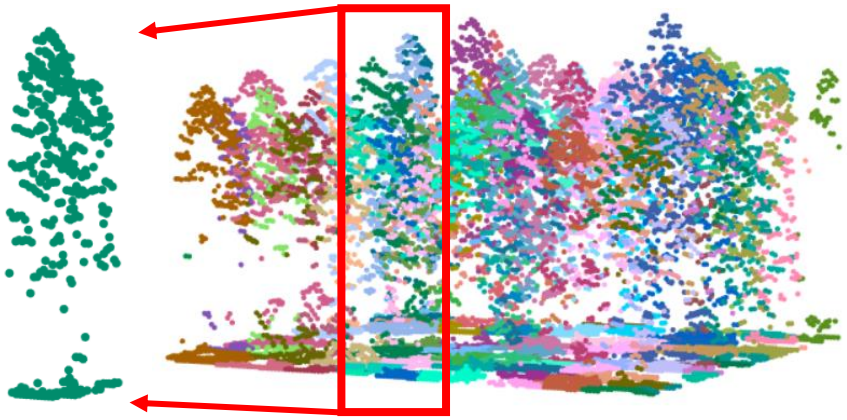


Table 1. Literature review

Reference	Density (pulse/m2)	Response variable	Independent variable	Time span	Forest type	Scale	Accuracy
Næsset and Gobakken, 2005	0.9-1.2	Mean tree height, basal area, and volume	ALS-derived height and density metrics	1999, 2001	Southeast Norway, Dominated with conifers	Grid	P-value <.001 for young forests height growth
Yu et al., 2006	10	Individual height growth	Individual tree top height differencing, DSM differencing, and canopy height distribution differencing.	1998, 2003	Boreal, Finland	Object	R2 of 0.68 and a RMSE of 43 cm
Yu et al., 2008	10	Plot height and volume growth	Individual tree top height differencing, DSM differencing, and canopy height distribution differencing.	1998, 2000, 2003	Boreal, Finland	Object, grid	R2 of 0.86 for height and 0.75 for volume
Zhao et al., 2018	6.1-23.7	Individual height growth and plot biomass dynamic	Individual tree top height differencing	2002, 2006	Mainly plantation by coniferous	Object, grid	R of 0.67 and Bias of 0.02
Ma et al., 2018	10	ALS- derived individual tree height, crown area and crown volume growth	ALS-T1 growth controlling factors including original tree sizes, topographic parameters, competition indices, and forest structure indices	2008, 2013	Mainly Coniferous trees	Object, grid	R2 of 0.1-0.43
Maltamo et al., 2022	-	Periodic annual increment of width of tree rings	ALS derived metrics	10 years	Boreal	Grid	RMSE of 21%

- Largely unexplored lidar detection of individual tree growth over time.
- The lack of established lidar-assisted monitoring framework.
- An increasing demands for high-resolution ecosystem dynamics products.
- A need for better understand of amount of time necessary for sufficient growth to overcome excess noise and other uncertainties within ALS systems.
- Tree growth is prone to high variability within and between tree species.

Aim of study

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- Feasibility analysis of species-specific crown development detection by ALS time series data
- Investigating the possible ALS-derived crown changes between and within groups of different species i.e. *Pinus sylvestris*, *Picea abies*, and *Betula sp.*

Study area and datasets

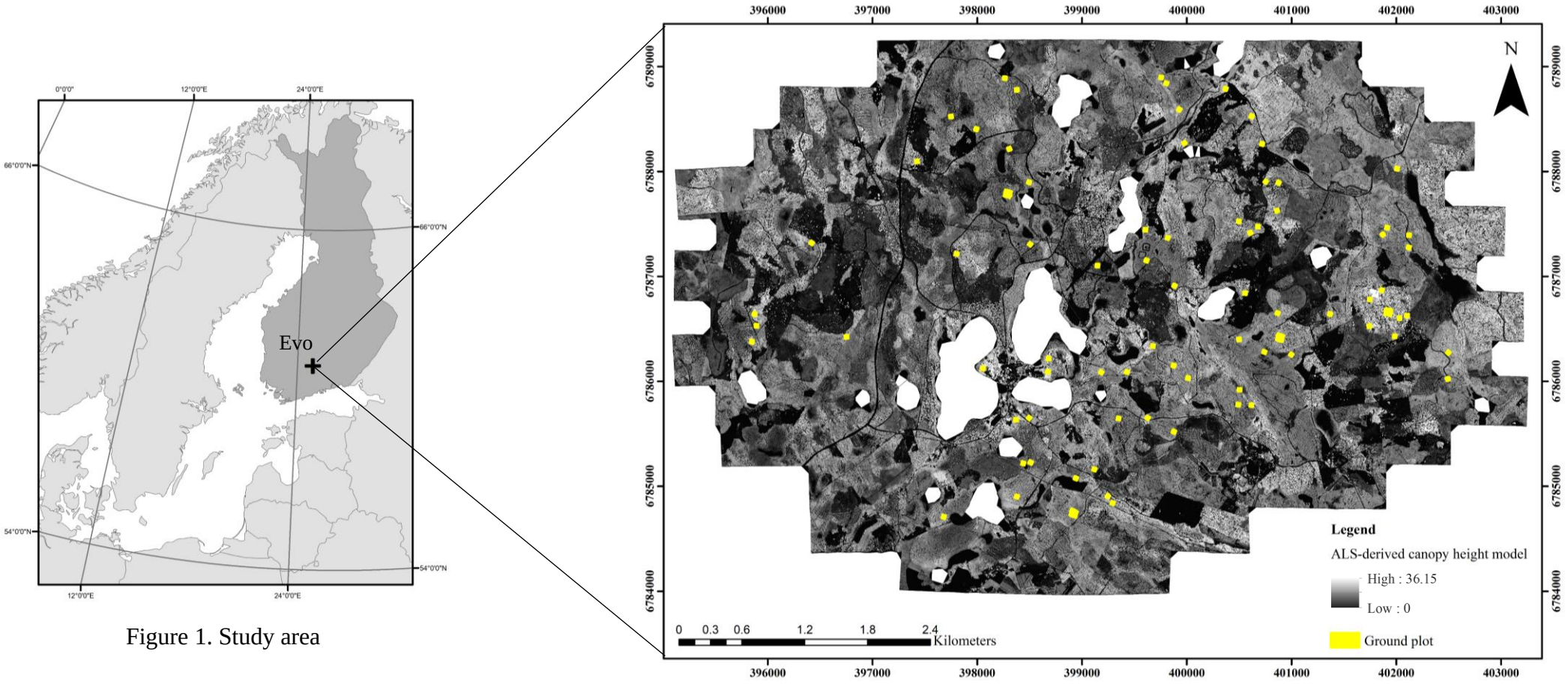


Figure 1. Study area

Date	Scanner	Average pulse density (pulses/m2)	Flying altitude	Corresponding ground data
July 2009	Leica ALS50-II SN058	10	400	-
September 2014	Leica ALS70-HA	6	900	91plots (32×32 m)

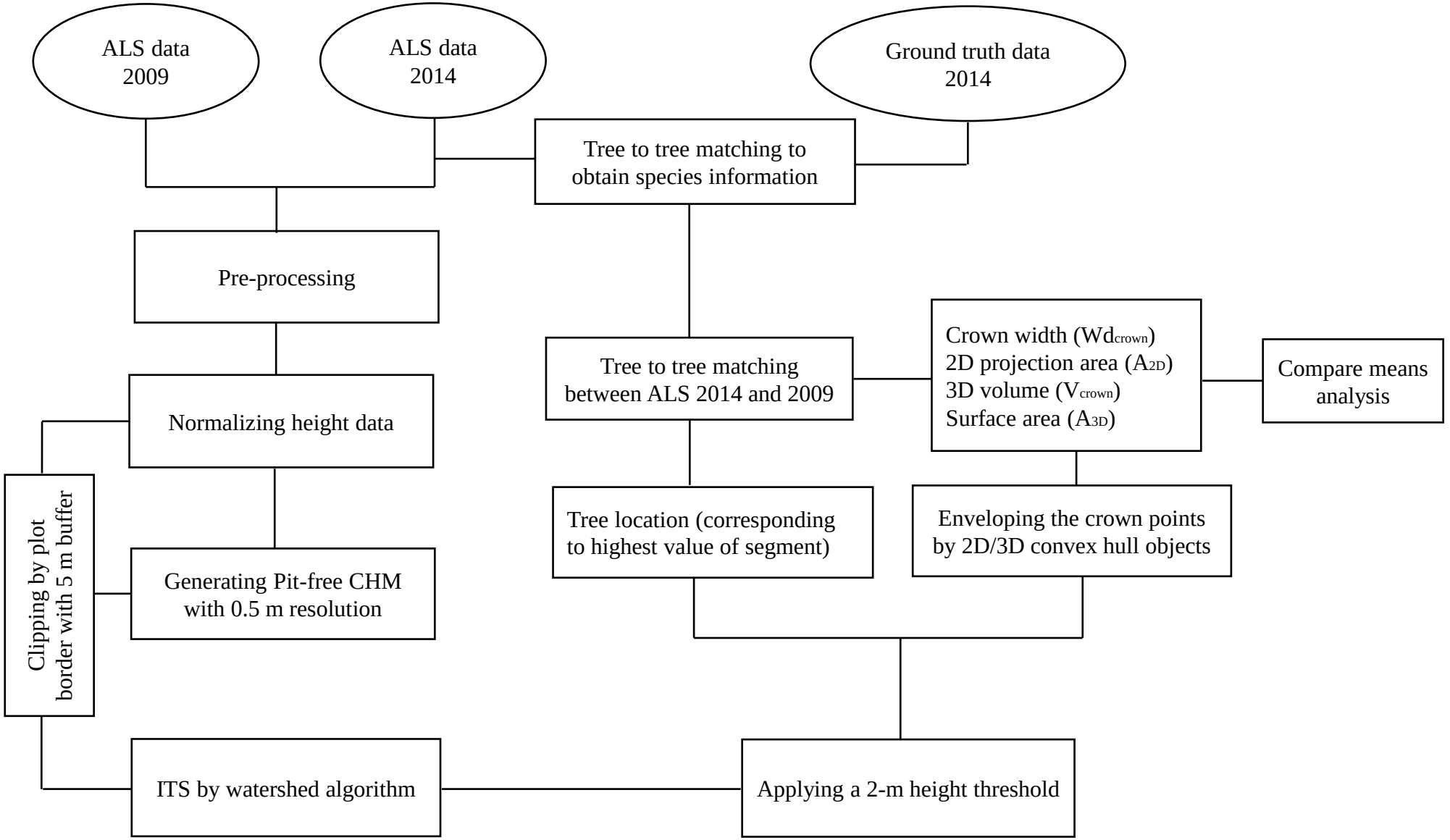


Figure 2. Flowchart of the methodology

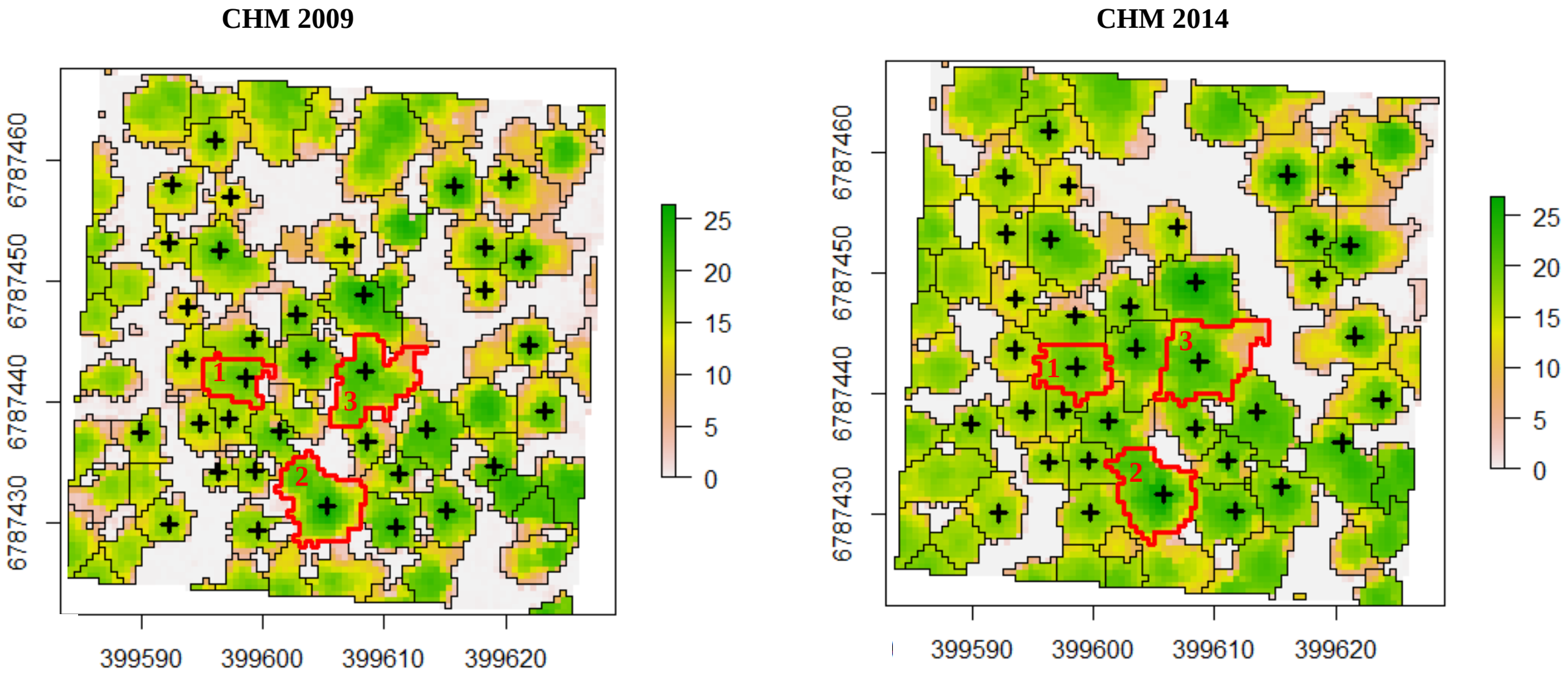
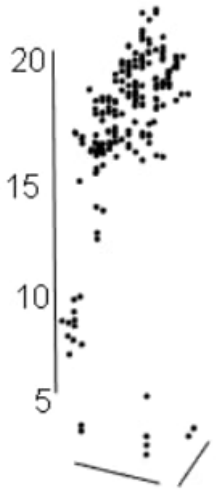
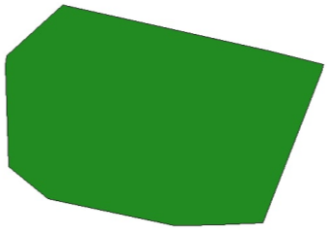


Figure 3. Tree to tree matching results where segments marked by + are matched trees. Segments with red borders of 1, 2, and 3 are *Pinus sylvestris*, *Picea abies*, and *Betula sp* respectively.

Pinus sylvestris

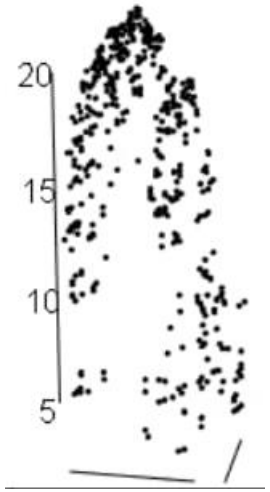


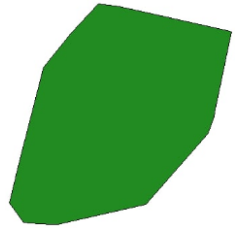


2009: Wd_{crown} =5.41, A_{2D} =16.43, V_{crown}=192.382, A_{3D}=238.68

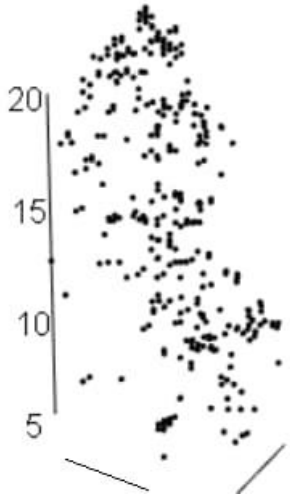
2014: Wd_{crown} =6.58, A_{2D} =25.54, V_{crown}=367.54, A_{3D}=334.429

Picea abies



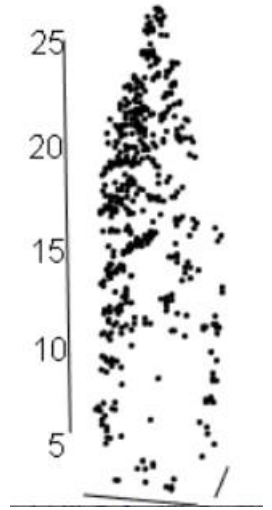


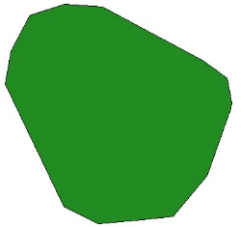
2009: Wd_{crown} =7.43, A_{2D} =34.32, V_{crown}=539.21, A_{3D}=437.36



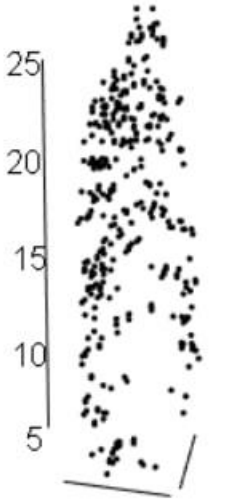
2014: Wd_{crown} =8.26, A_{2D} =39.22, V_{crown}=620.60, A_{3D}=477.20

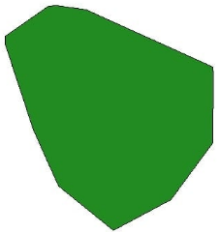
Betula sp.





2009: Wd_{crown} =7.04, A_{2D} =37.53, V_{crown}=484.15, A_{3D}=399.64





2014: Wd_{crown} =7.87, A_{2D} =45.95, V_{crown}=630.19, A_{3D}=445.40

Future expected results

- ALS derived species-specific crown characteristics are changing in time significantly.
- There are similarities between the crown development of Pine and Birch.
- Relative growth of crown volume is larger for Spruce than for Pine and Birch.
- Relative growth of crown width is larger for Pine than for Spruce and Birch.

Thank you!

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