Assessment of understory vegetation in a plantation forest of the southeastern United States using Terrestrial Laser Scanning

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Background

Southeastern United States Forest

- 12 % of the world's industrial roundwood
- 19 % pulp and paper productions

However, the **growth rate of the existing pine plantations is substantially lower** than the pine plantation in other temperate and subtropical regions.

Low soil fertility and **interspecies competition between herbaceous and woody plants** for resources are documented as one of the major limiting factors for pine growth in the South (*Lee Allen et al., 2005*).

Studies have shown **a two to four-times increase in stand productivity** and significant improvement in survival **after controlling the competing vegetation** (*Miller et al., 2003; Michael, 1980*).

Objectives:

- To quantify and map understory vegetation biomass and its spatial distribution using terrestrial laser scanning (TLS) derived metrics.
- To compare volume estimation methods for TLS point cloud, including voxelization, alpha-hull fitting, and Mean Height Understory cover based method.

Methods

Study Area

- Intensively managed loblolly and slash pine plantation forest in Nassau county, northern Florida
- Soil : **Poorly to moderately well-drained** loamy to sandy soils **and low in fertility**.
- Dominating evergreen understory species Gallberry, saw palmetto, ti-ti, fetterbush etc.
- **Precipitation:** Average 133 cm (65% in summer)
- **Data Collection:** July-August, 2022
- **Sample :** 60 plots and 2 subplots inside

Study area map

Data Collection

1) Understory Biomass

The process for collecting understory dry biomass. First, a 1m^2 PVC frame was used to establish an understory subplot (a). Then, after conducting destructive sampling, the samples were placed in bags and labeled (b). Next, the collected samples were dried in an oven (c) for 48 hours at 105°C before dry biomass weight measurement (d).

Methods cont.

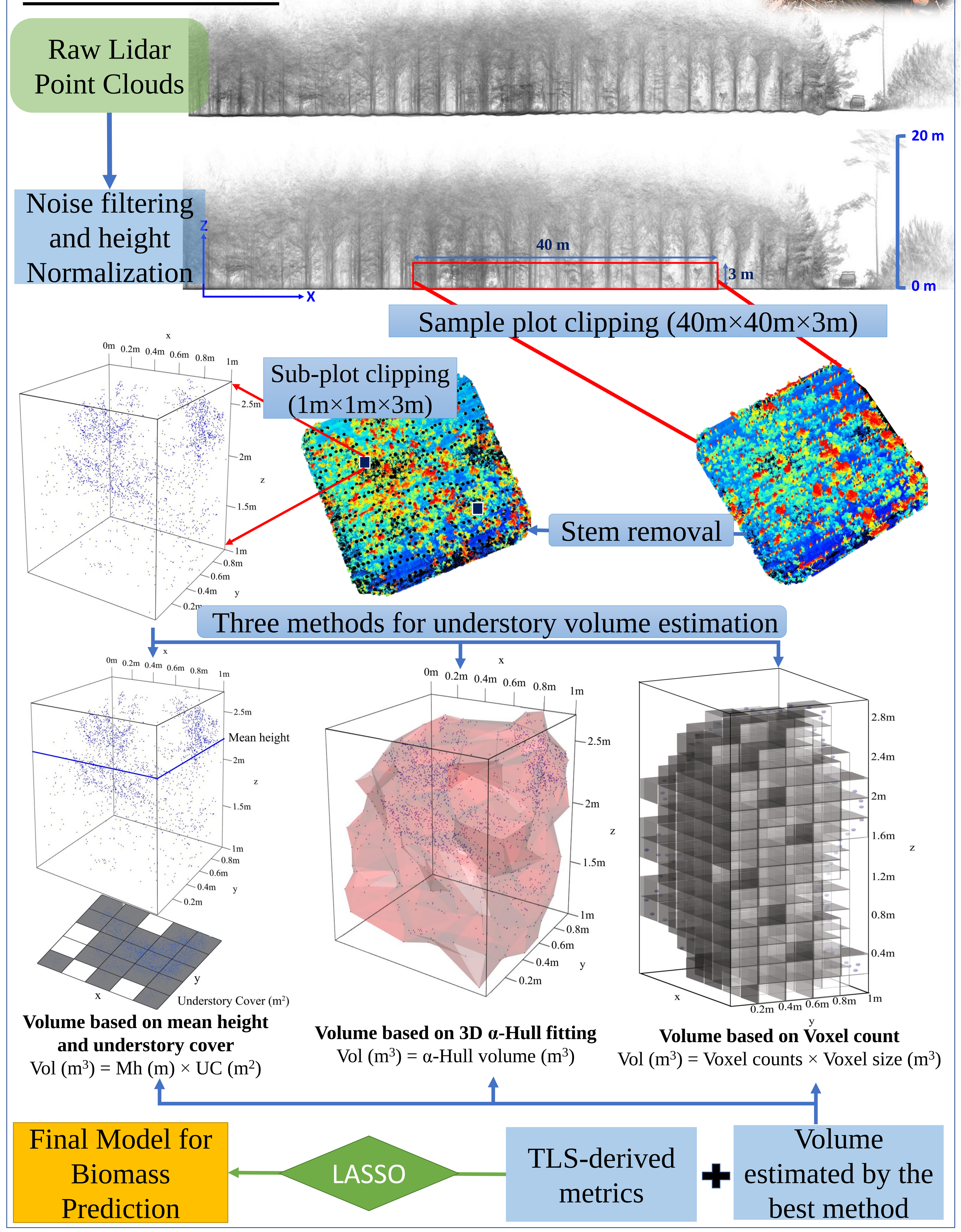
2) Terrestrial Laser Scanning (TLS) data

Collected using GeoSLAM ZEB HORIZON mobile laser scanner

TLS based twenty-seven metrics extraction from sub plots

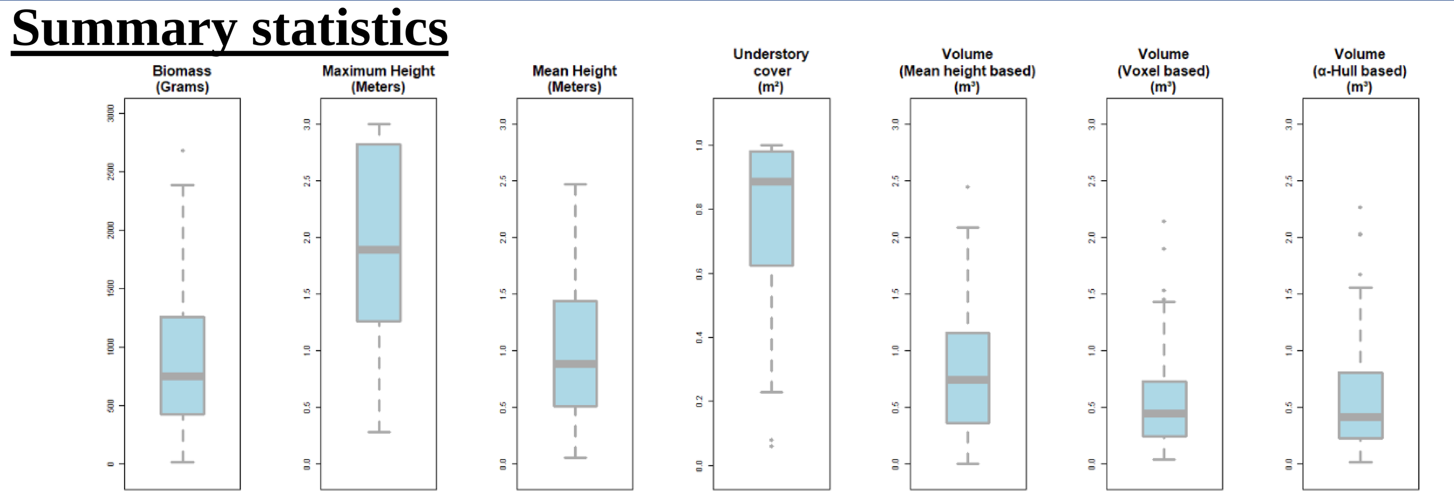
- Volume based on voxel count
- Volume based on mean height and understory cover
- Volume based on 3D α-Hull fitting
- Echo height percentiles and descriptive statistical variables (mean, median, SD, etc.) of echo height

Method Flowchart



Results

Summary statistics



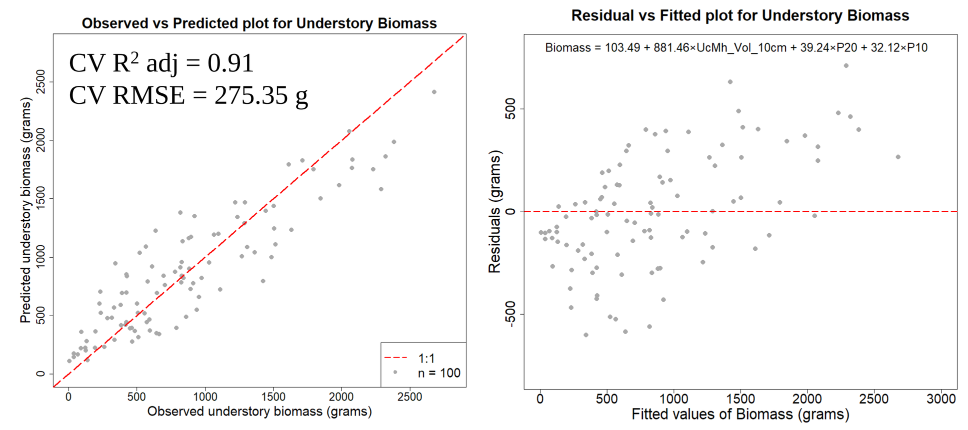
Volume estimation method comparison

Y	Volume estimation methods	Adj. R^2		RMSE (g)		Bias	AIC
		Cal.	CV	Cal.	CV		
Understory	Mnht_UC-based vol_{10cm}	0.80	0.79	276.5	288.0	0.00	1414.2
Biomass	Mnht_UC -based vol_{20cm}	0.74	0.73	318.7	315.6	0.00	1440.6
	Voxel-based vol_{10cm}	0.34	0.33	507.1	508.4	0.00	1533.5
	Voxel-based vol_{20cm}	0.48	0.47	447.9	448.6	0.00	1508.7
	α-Hull-based vol_{10cm}	0.24	0.23	539.3	538.7	0.00	1545.9
	α-Hull-based vol_{20cm}	0.42	0.38	479.8	482.7	0.00	1525.3
	α-Hull-based vol_{30cm}	0.47	0.45	453.2	456.2	0.00	1513.1
	α-Hull-based vol_{50cm}	0.57	0.55	418	413.1	0.00	1494.9

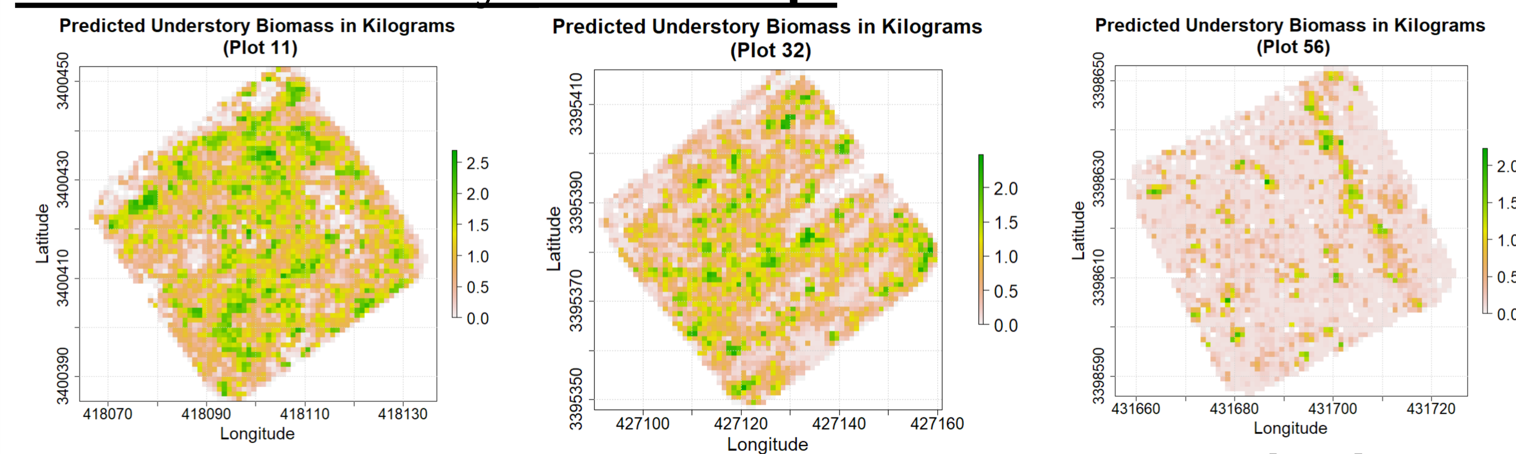
Model for biomass prediction using TLS derived metrics

$$y = 103.49 + 881.5\, x_1 + 39.24\, x_2 + 32.12\, x_2$$

Where, y is the understory biomass, x_1 is volume based on mean height and understory cover, x_2 is 20th percentile of echo heigh, x_3 is 10th percentile of echo height.



Predicted understory biomass maps



High abundance — Medium abundance — Low abundance

Discussion

- This non-destructive method for understory vegetation quantification can be very helpful for the timely detection and quantification of competing vegetation in plantation forests in the southeastern US.
- The mean height and understory-based volume estimation method showed to be more accurate than the voxel and alpha hall-based volume estimation methods, yielding adj. R^2 of 0.79, 0.47, and 0.57, respectively, when used as a single variable in the model.
- It is important to highlight that a major drawback in using TLS lidar data is the inconsistent density and limited detection range, especially when dealing with dense and wet understory vegetation.

References: Michael, J. (1980). "Long-term impact of aerial application of 2, 4, 5-T to longleaf pine (Pinus palustris)." Weed Science **28**(3): 255-257. **Miller, J. H., et al. (2003).** "Growth and yield relative to competition for loblolly pine plantations to midrotation—a southeastern United States regional study." Southern Journal of Applied Forestry **27**(4): 237-252. **Lee Allen, H., et al. (2005).** "What is ahead for intensive pine plantation silviculture in the South?" Southern Journal of Applied Forestry **29**(2)

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