Individual tree segmentation and parameter extraction from leaf-off LiDAR in deciduous forests
Eastern Deciduous Forest

[Map showing the New forest regions: Mesophytic, Appalachian oak section, Oak-hickory, Southern mixed, Oak-pine section, Mississippi alluvial plain, Subtropical evergreen, Beech-maple-basswood, Northern hardwoods-red pine, Northern hardwoods-hemlock]

https://www.nps.gov/im/ncm/eastern-deciduous-forest.htm
Economic context

Sewer line replacement near Leavenworth Kansas

- 254 trees located, measured & identified
- 170 trees > 10” in diameter in ~ 5.3 acres (2.16 ha)
- Average survey cost per tree ~$10 (est.)
- Estimated compensation for a single 12” tree by species:
  - Black Walnut $2,266
  - Osage Orange $1096
  - Dogwood $869
  - Hickory $902
  - Oak $753
  - Maple $615
  - Hackberry $573
  - Locust $494
Project Objectives

1. **Enable rapid site survey of trees for CE project planning**
   a. Tree location
   b. Tree size (DBH & height)
   c. Tree species

2. **Improve estimates of total wood / carbon / fuel per tree**
   a. Measure “whole tree” attributes directly
      i. Typical allometric equations not sensitive enough for carbon
   b. Rapidly generate site-specific allometric equations
      i. Allometric equations are typically biased low
      ii. It's easier to cut & weigh smaller individual trees
      iii. Climate change is altering existing empirical relationships
      iv. “Within species” variation can exceed “between species” variation
Key tree measurements

1. Diameter at Breast Height (DBH) [1.4m]
2. Species
3. Location
4. Height
5. Crown Ratio
6. Crown Volume
7. Age
8. Canopy Base Height (fuel)
9. Crown Bulk Density (fuel)
10. Quality classification (timber)
Structural shapes are diagnostic
Calders et al 2022

field TLS scans
Dec 2015
publication
Dec 2022
Field data collection
LiDAR scan to tree inventory workflow

1. Raw scan files → reconcile flight lines → .las tiles
2. Classify ground → classified .las stage 1 → Individual tree segmentation → classified .las stage 2
3. Classify wood/leaf → classified .las stage 3
4. Extract QSM
   - QSM file
5. Extract biometrics
   - Tree attribute table
6. Convert to graph object
7. Classify species
   - Classified .las stage 4
8. Aggregate to site level
   - Tree inventory
Crux #1 Tree segmentation
Crux #2: occlusion
Trees are directed graphs
Quantitative Structure Models (QSMs)
Thank you

Aaron Smith
asmith@alynix.com