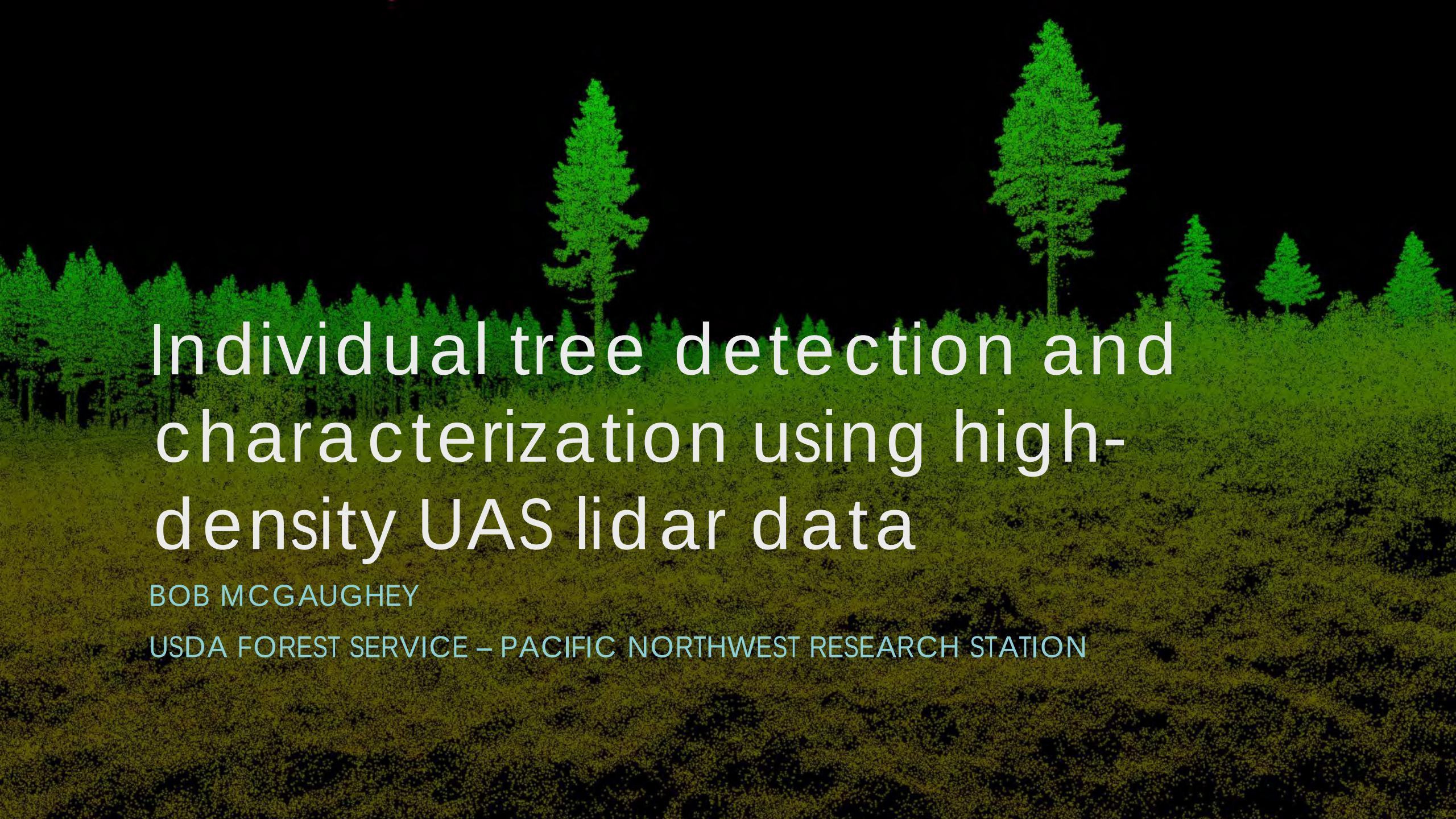


Individual tree detection and characterization using high-density UAS lidar data

BOB MCGAUGHEY

USDA FOREST SERVICE – PACIFIC NORTHWEST RESEARCH STATION

UAS lidar data

- General characteristics
- Is it the same as “traditional” airborne lidar?
  - Can you analyze the data using the same tools and methods?
  - Does increased point density cause problems?
  - How do you take advantage of the increased point density?
- Individual tree detection and characterization
  - Not as far along as I would like
  - Overview of methods with some specifics

Data collected by:

Acknowledgements

- West Fork Environmental—Tumwater
  - UAS lidar data
- University of Washington
  - School of Environmental and Forest Resources
  - Olympic Natural Resource Center

Data collected by:

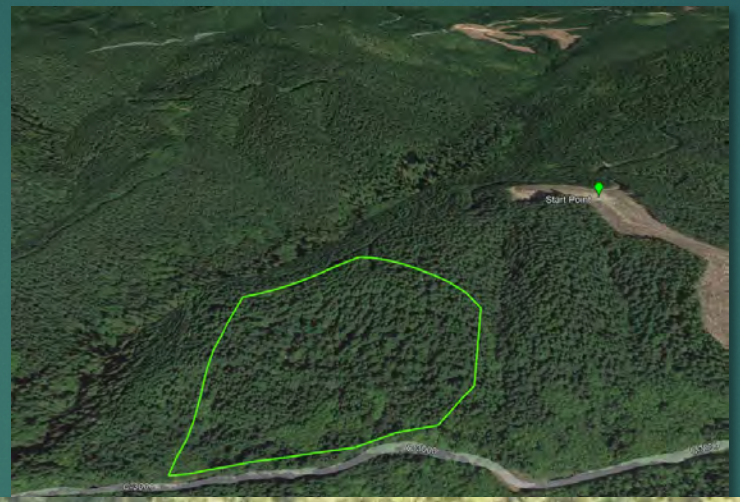
Lidar data

- Study area is on the west side of the Olympic Peninsula, Washington
  - Dense Douglas-fir/western hemlock forests part of Olympic Experimental State Forest managed by Washington DNR
  - Project area is part of a study that focuses on ecological and socio-economic concerns associated with management options
- Lidar sensor: **Quanergy M8**
  - 430K pulses/second
  - 360º FOV across-track but limited to ~120º
  - -17º to +3º FOV along track (sensor looks to the rear of the aircraft)
  - Up to 3 returns/pulse
  - 80-100m range but decreases as target reflectivity decreases
- UAS: **DJI Matrice 600 Pro**

Data collected by:

WEST FORK ENVIRONMENTAL

Data acquisition



Data collected by:

WEST FORK ENVIRONMENTAL

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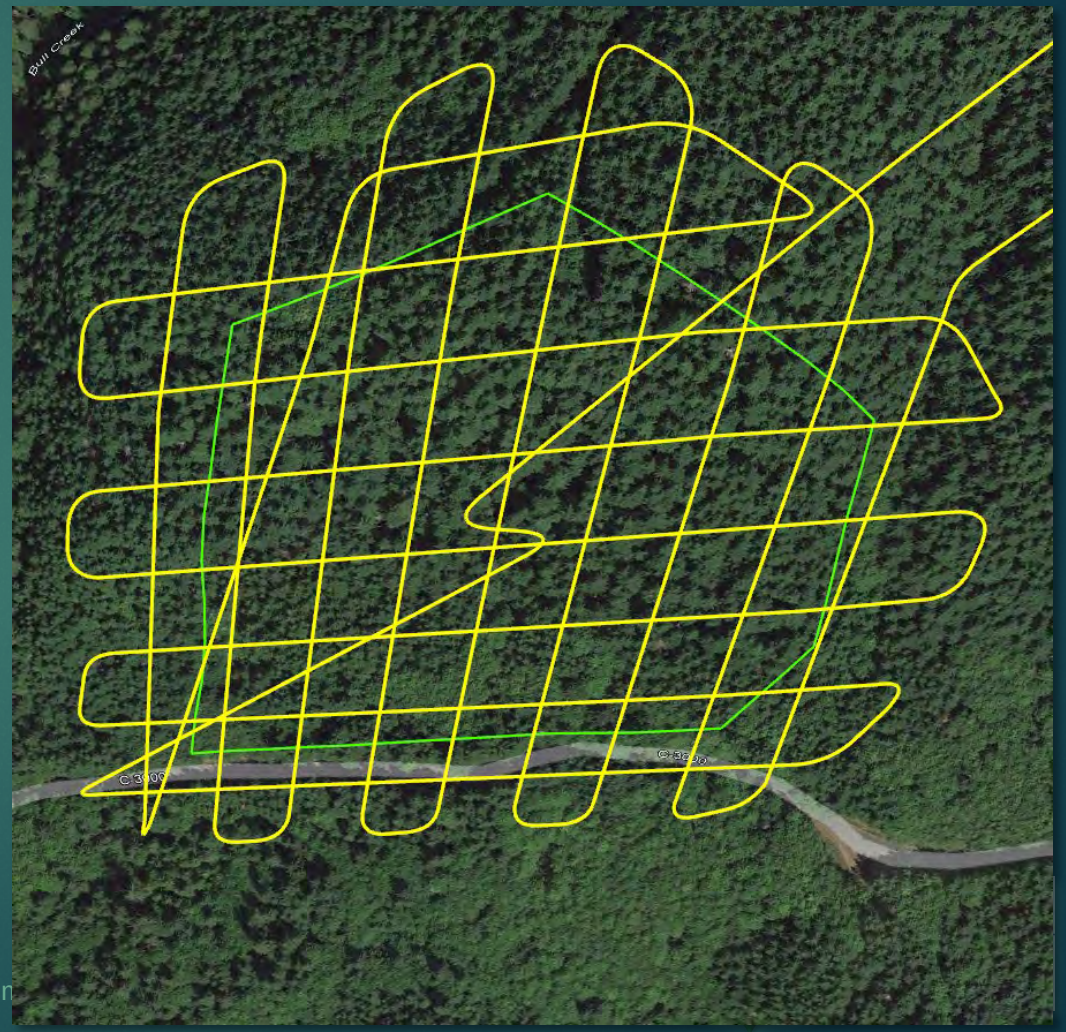
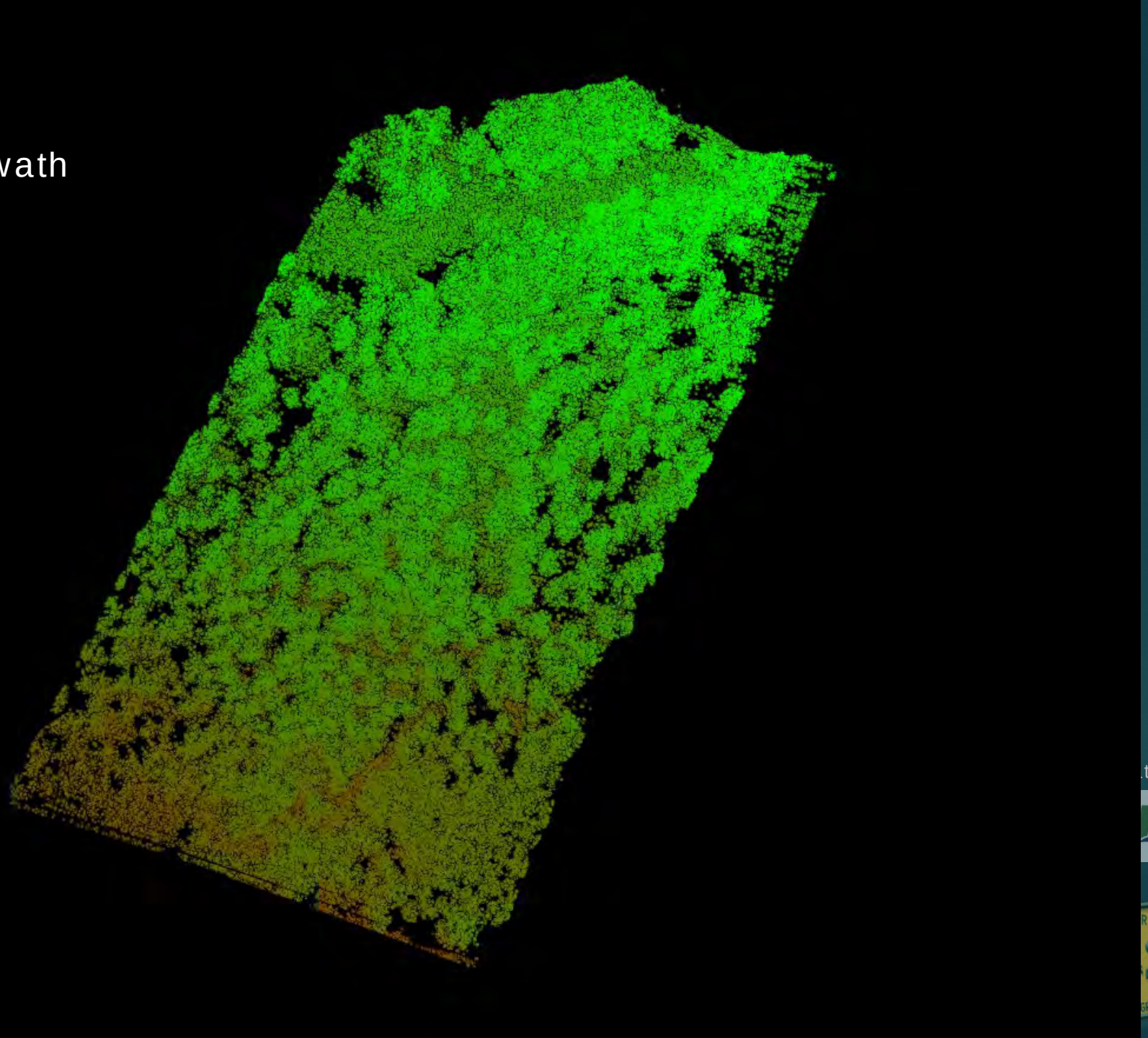
Point data

- Individual strips
  - FOV: ~120°
  - Sidelap: 70-80%
  - Density: ~40-60 pulses/m^2 (~40-160 points/m^2)
- Aggregate data
  - Density: ~400-900 pulses/m^2 (~400-1400 points/m^2)



Individual swath
145m wide
~120° FOV
70-80m AGL



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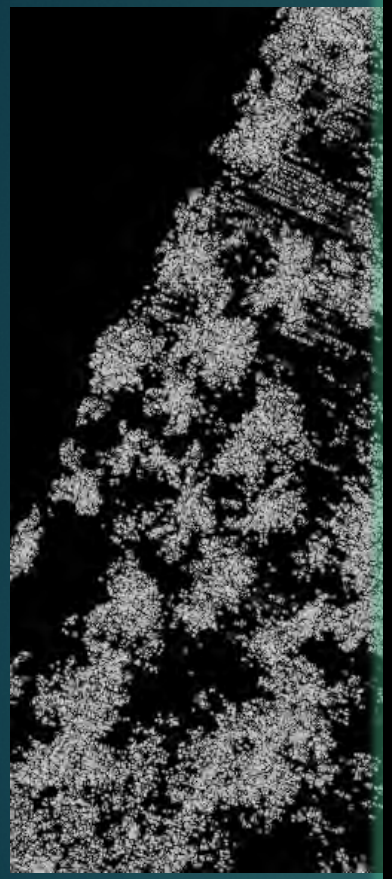
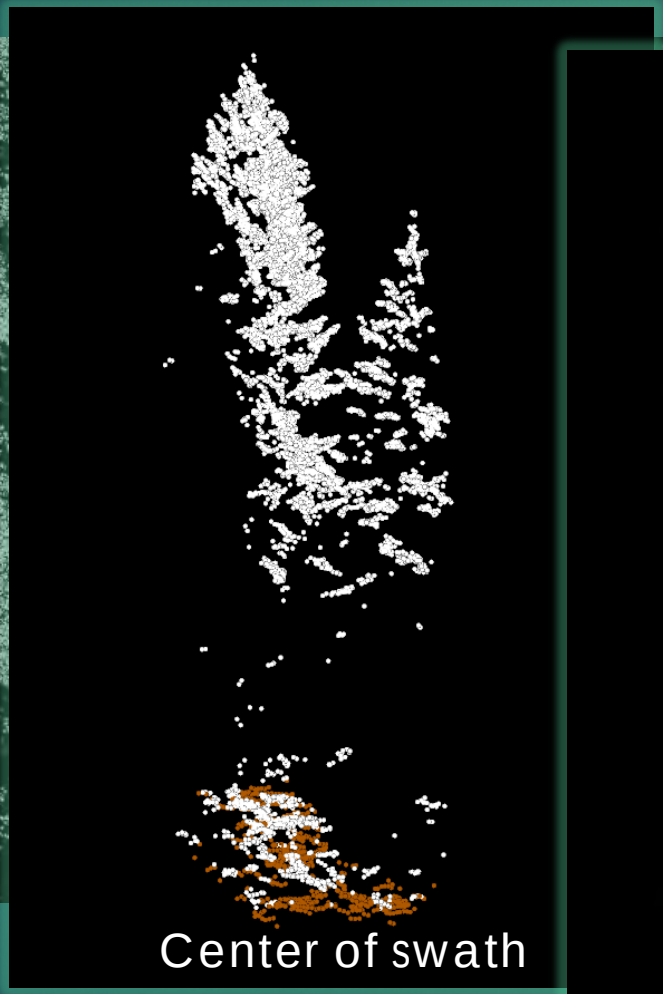
Individual swath

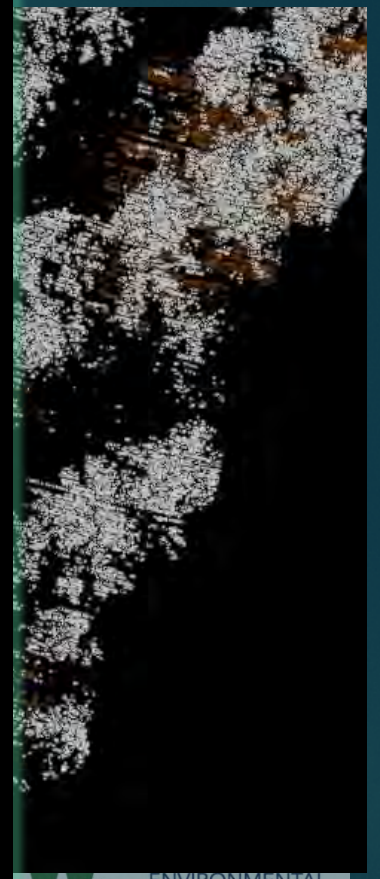




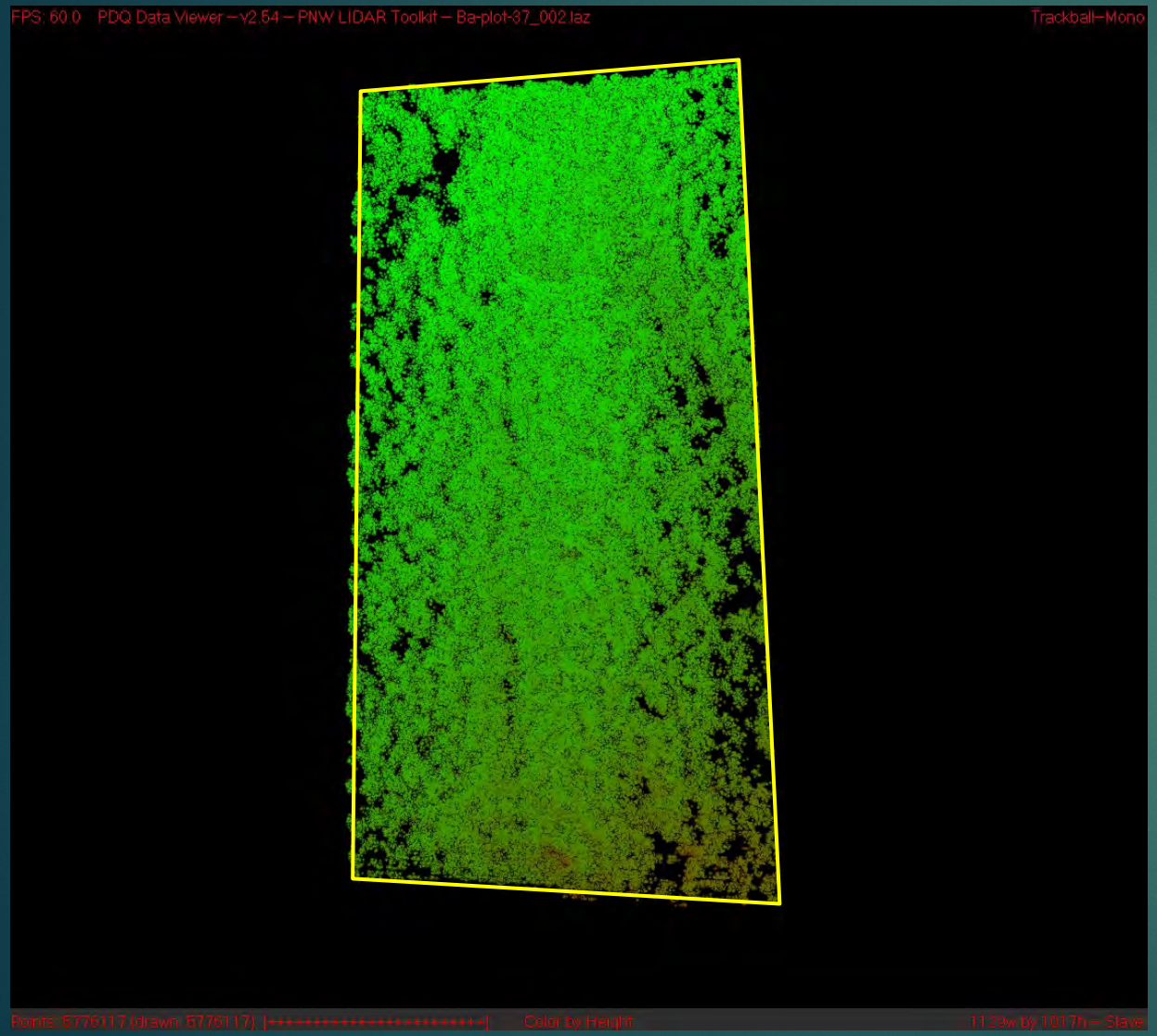
Center of swath

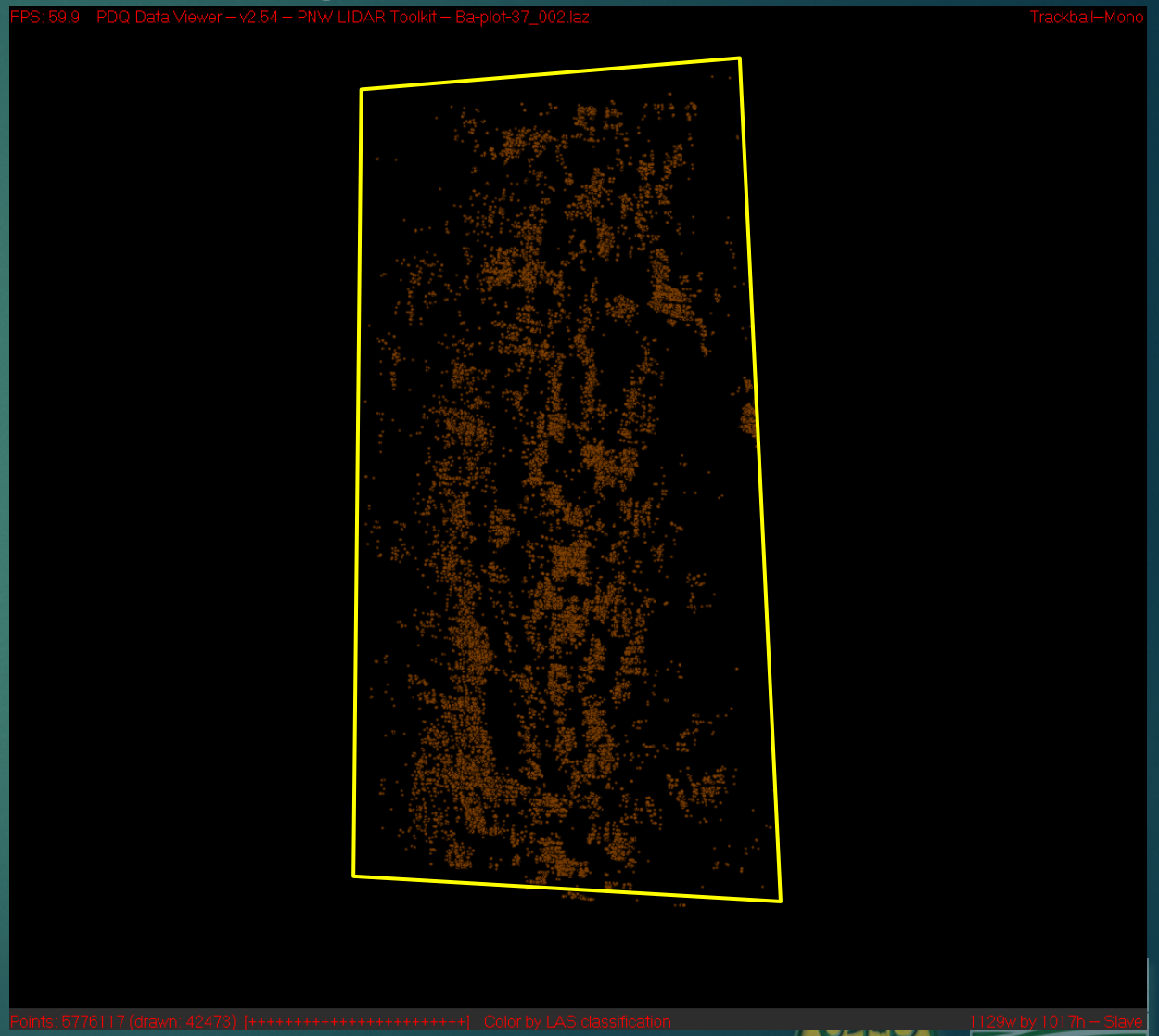
All swaths

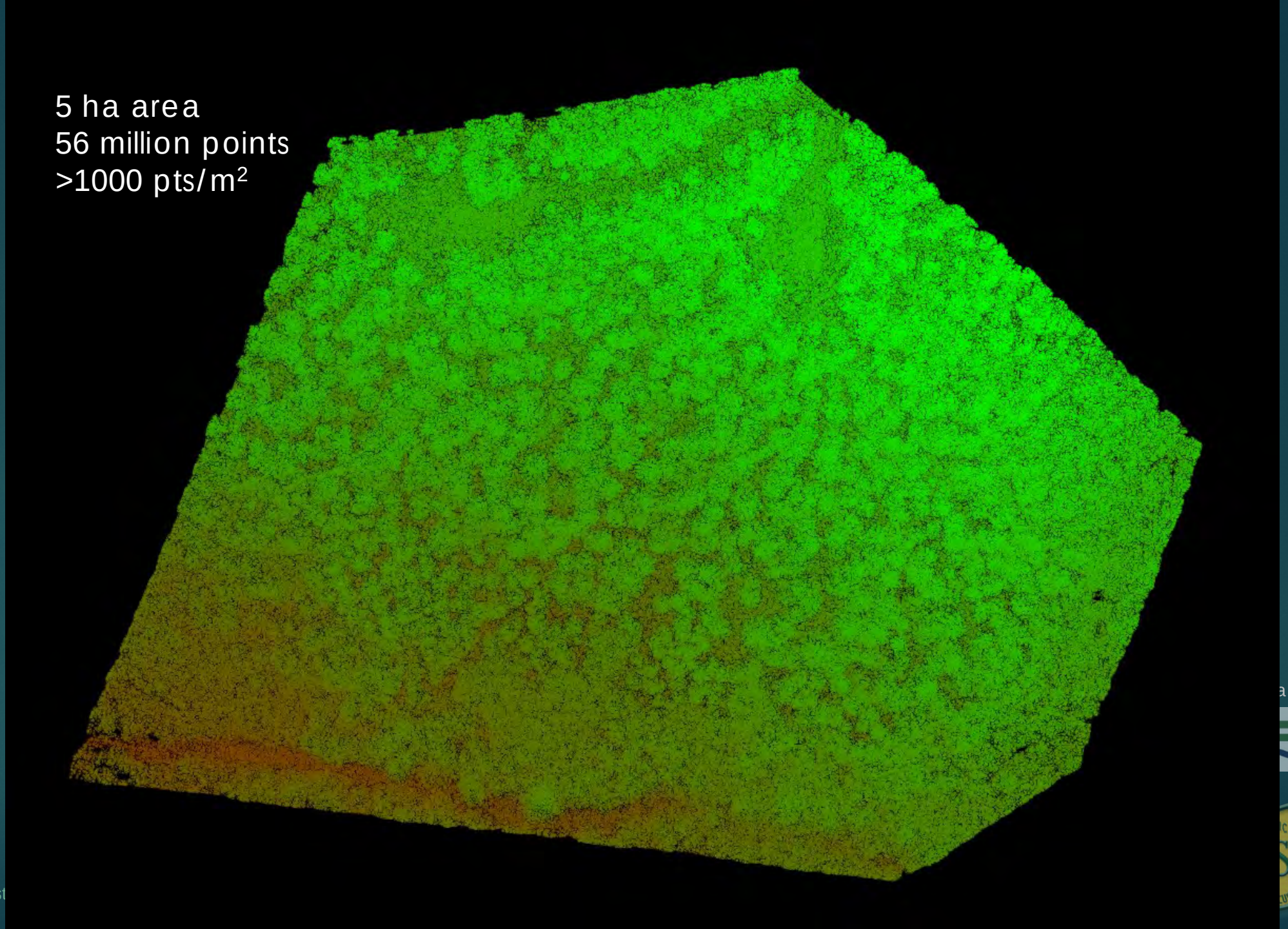
Edge of swath



Individual swath—brown is ground







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USDA Forest

Basic questions

- Can you characterize stand structure?
- Can you cleanly detect individual trees?
- What attributes can be produced for each tree?
- Do algorithms developed for “traditional lidar” work for high-density UAS-lidar data?
  - UAS-lidar is noisier
  - UAS-lidar captures a high level of detail but:
    - Fine resolution CHM may provide too much detail
    - Tree movement due to wind is captured

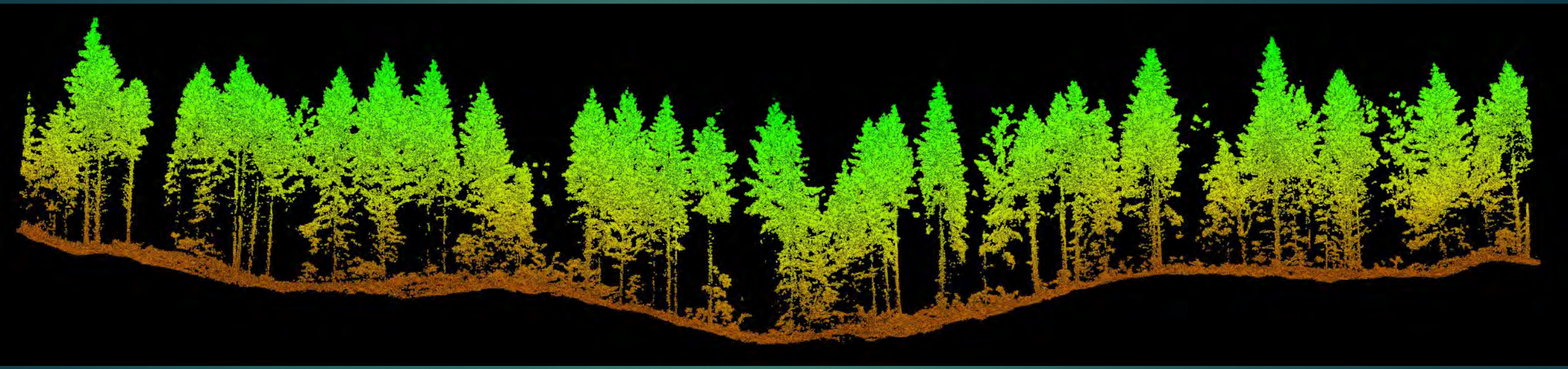
Data collected by:

WEST FORK ENVIRONMENTAL

USDA

Stand structure

10m wide strip



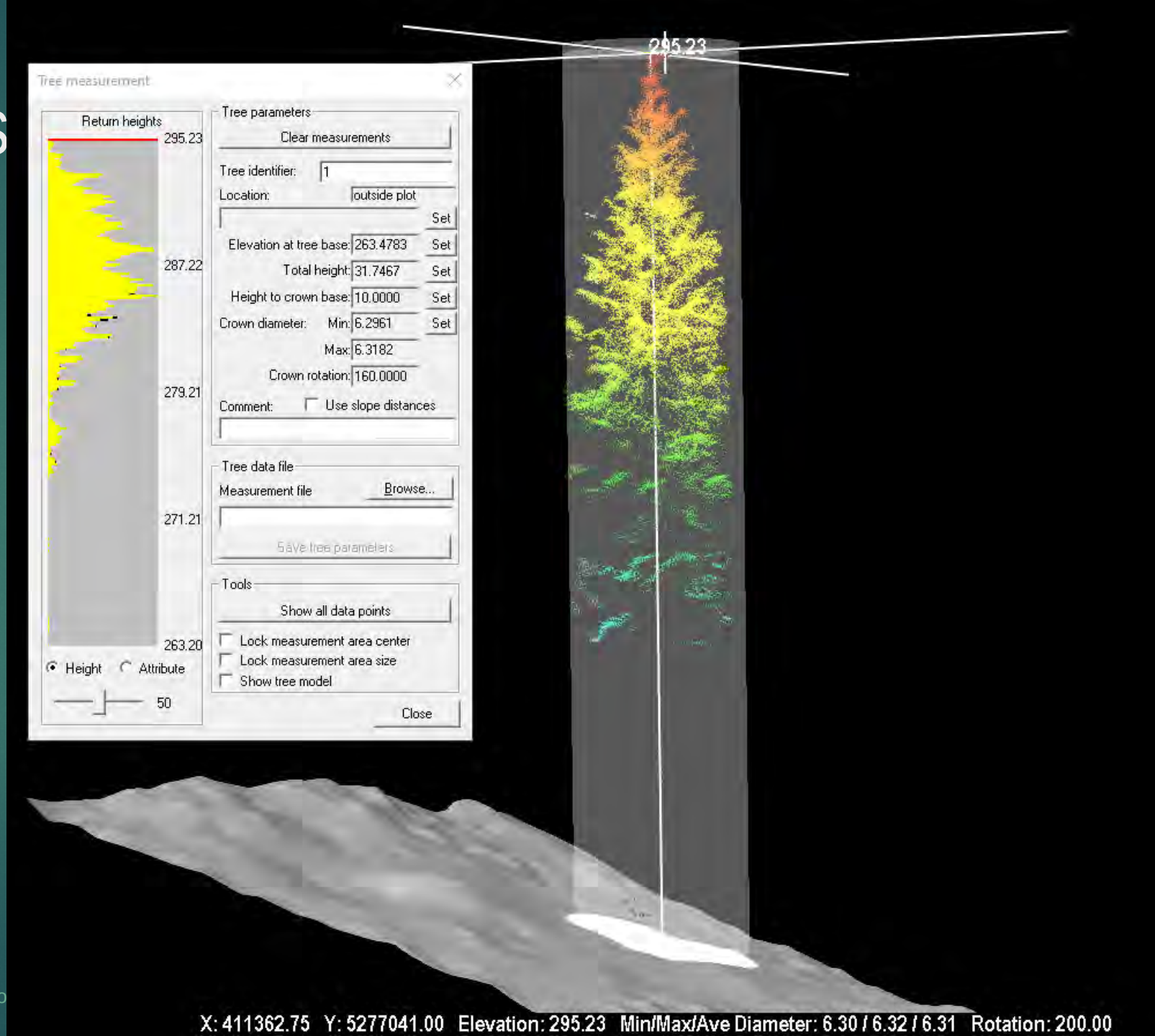
Data collected by:

WEST FORK ENVIRONMENTAL

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

USDA

Individual trees



Individual tree detection (ITD)

- FUSION's TreeSeg and CanopyMaxima tools
- lidR package for R and other R packages
- Use canopy height model (CHM) or point cloud or **both**
- My initial thoughts were that ITD for overstory trees would be easy with these data
  - ITD is sensitive to parameters used to create CHM (resolution and smoothing)
  - Highly detailed CHM does not produce good ITD results

Data collected by:

WEST FORK ENVIRONMENTAL

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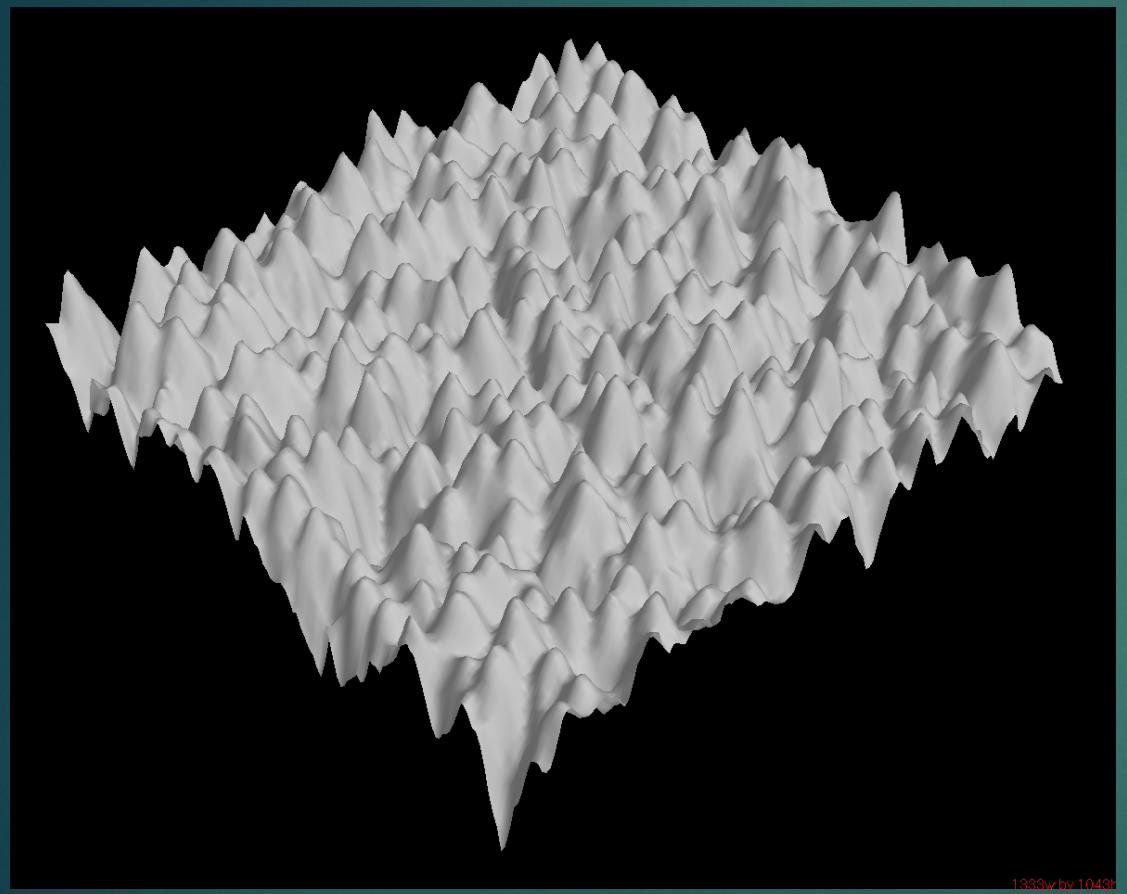
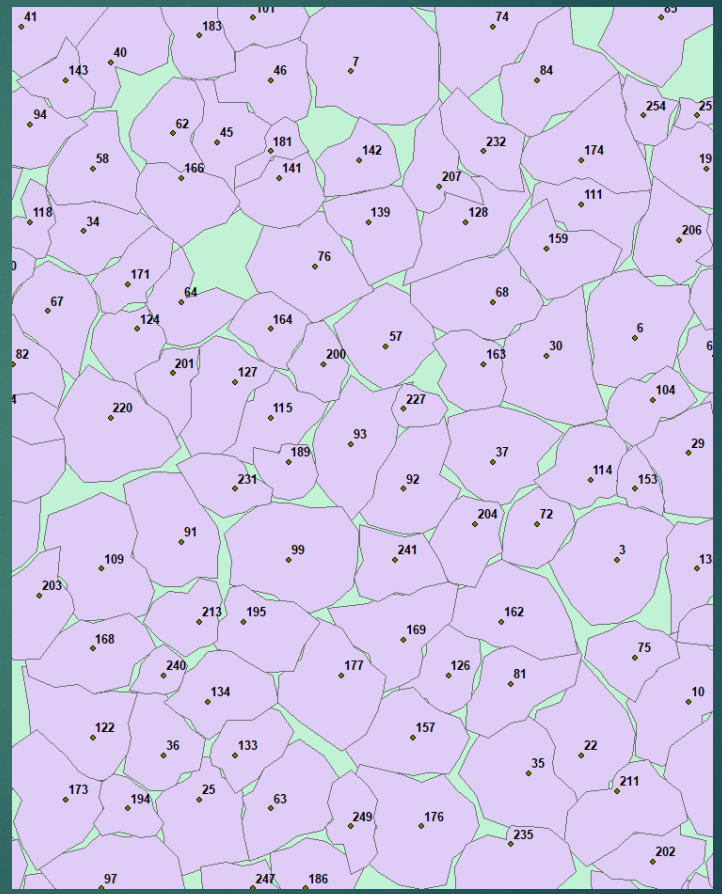
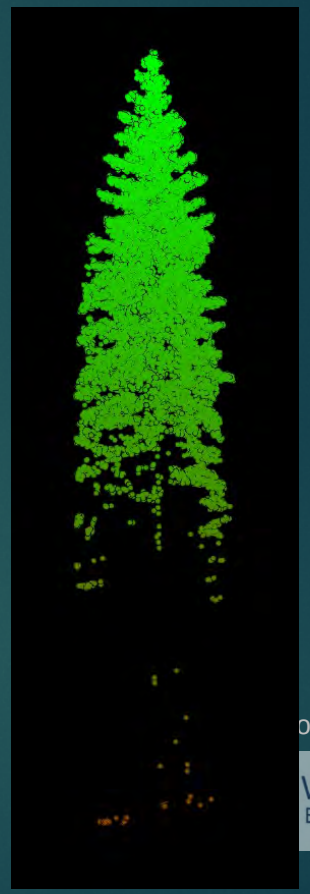
FUSION's TreeSeg program







ollected by:

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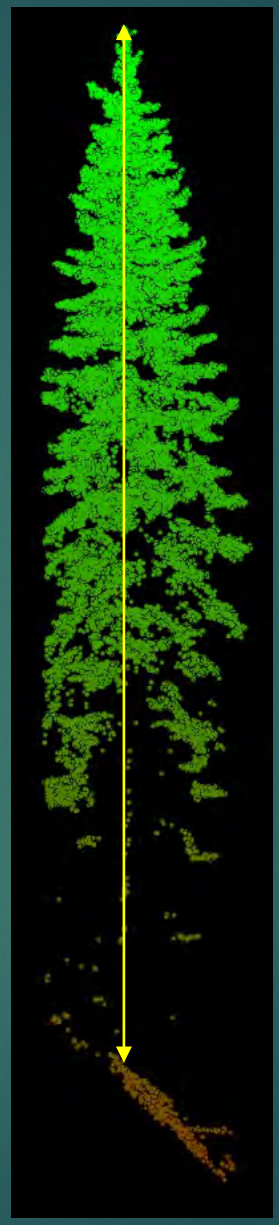
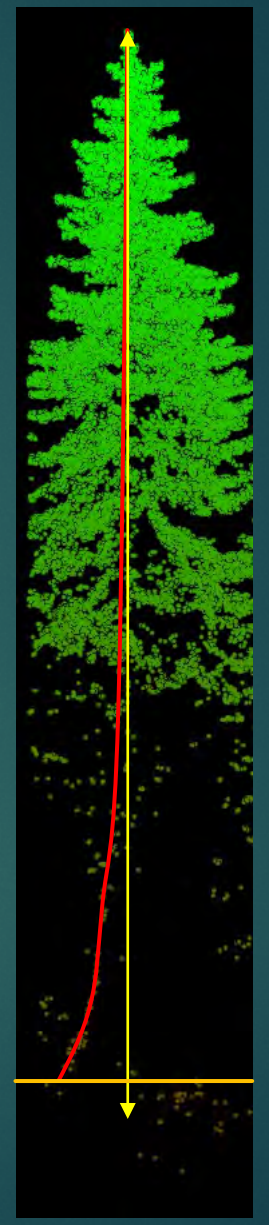
USDA

Tree height

- Trees don’t always grow straight (sweep)
- Trees lean
- Simple method subtracts ground elevation for same XY as treetop
- Better to detect stems and subtract elevation at the base of the stem

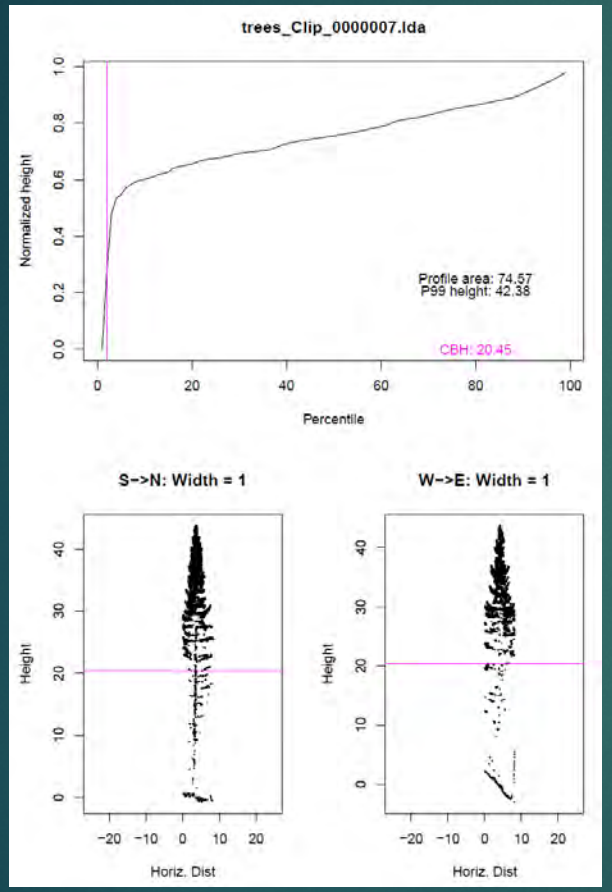




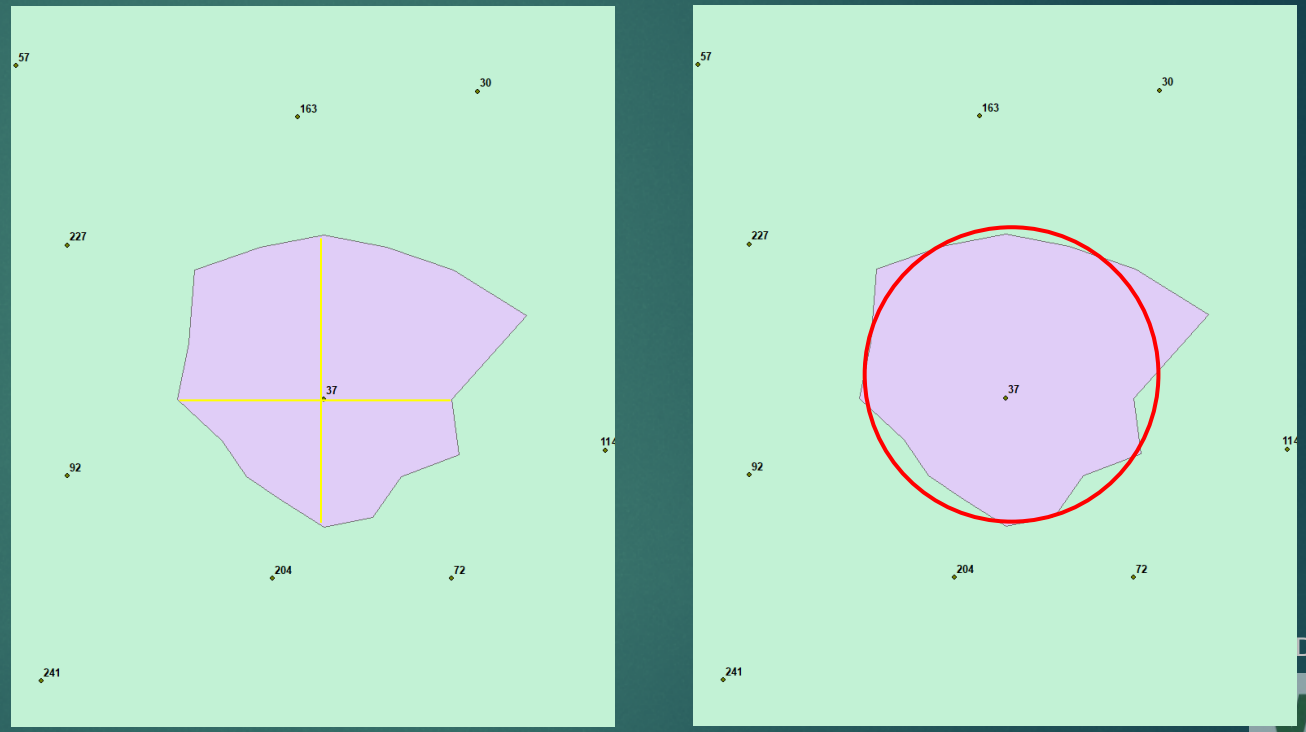
Data collected by:

WEST FORK ENVIRONMENTAL

Other tree attributes



Height to live crown



Crown size (area, diameter, radius)

Data collected by:

WEST FORK ENVIRONMENTAL

DBH

- Predict DBH = f(height)
- Not the best but can be improved by knowing species...

Data collected by:

Specie

- For som
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- Point-cl
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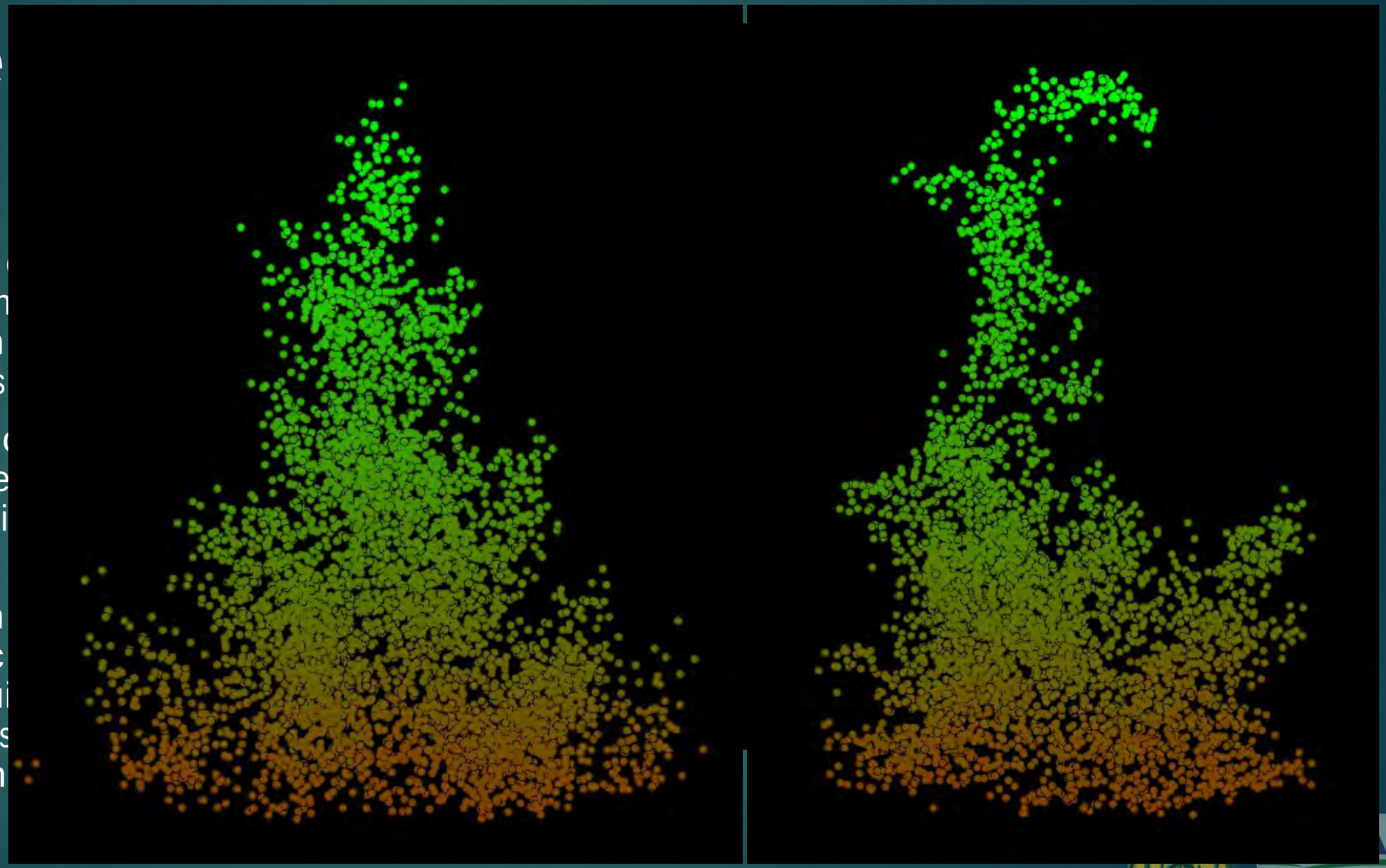

Species

- Machine learning methods using point-cloud metrics or the raw point cloud
- Likelihood for success is best for dominant and co-dominant trees
- Imagery
  - No concurrent imagery collected with the lidar but this is an option
  - 30-50cm, 4-band imagery is available but hasn't been incorporated for species identification

Data collected by:

UAS lidar data are different

- Sensor range limits the areas that can be flown
  - May limit the number of ground returns
  - 50-60m stand height with 70-85m flying height
- Sensor is a little noisy
  - May be no worse that “big” scanner but the noise is more problematic with a small beam footprint and high-density data

Data collected by:

WEST FORK ENVIRONMENTAL

Noisy sensor

Center of single swath

All swaths

Data collected by:

WEST FORK ENVIRONMENTAL

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- Ground point density can be low

Data collected by:

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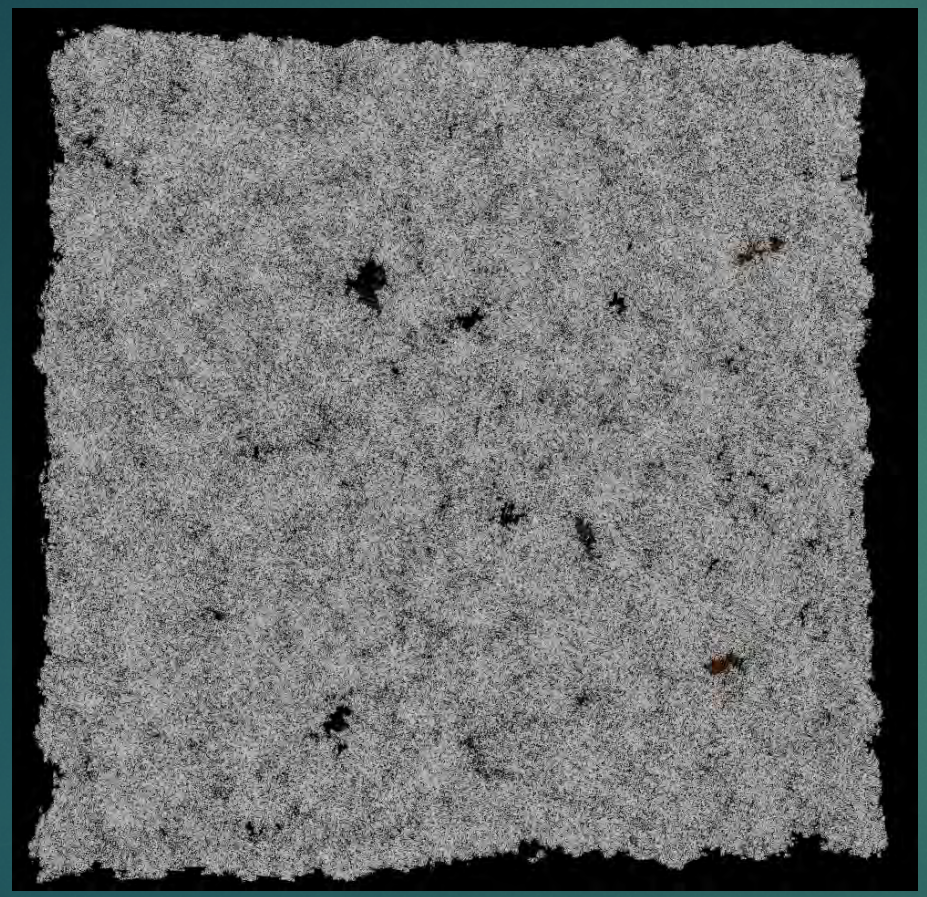
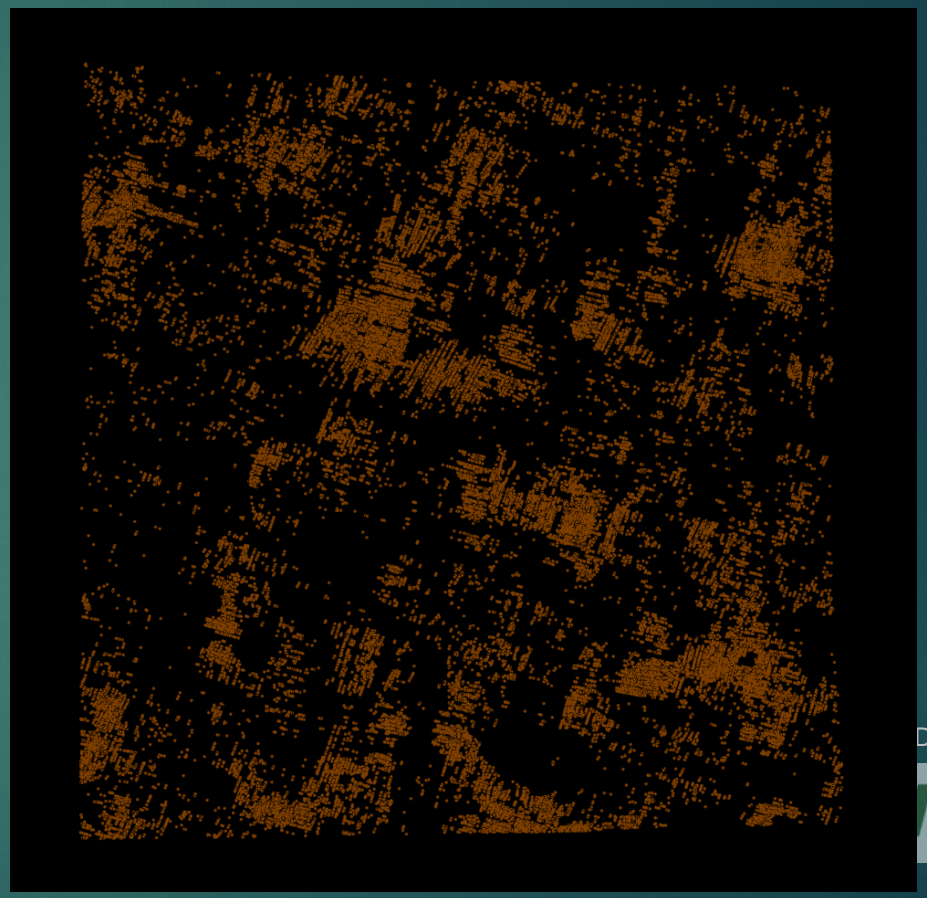
Ground point density



1269 pts/m^2



6.7 pts/m^2

Data collected by:

WEST FORK ENVIRONMENTAL

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- Ground point density can be low
- Normalization (subtracting ground elevation to get point heights) may introduce distortion that is problematic for individual tree work

Data collected by:

WEST FORK ENVIRONMENTAL

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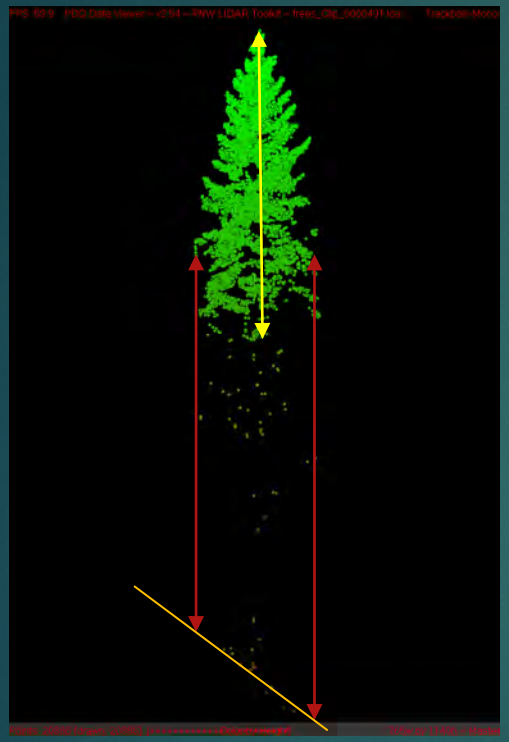
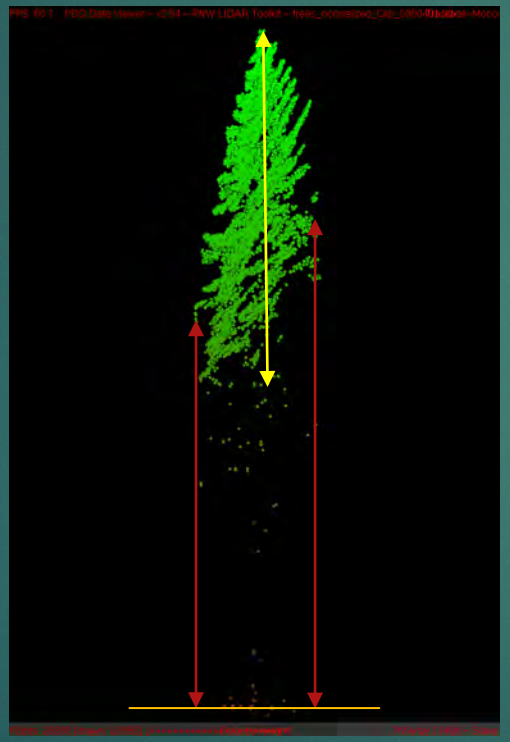
Normalizing point data



"Raw" data



Normalized using ground elevation

- Normalization affects:
  - Overall crown morphology
    - Crown shape
    - Branch angles
    - Live crown length
- CHM also shows differences depending on resolution
- Individual tree algorithms need different tuning

Data collected by:

WEST FORK ENVIRONMENTAL

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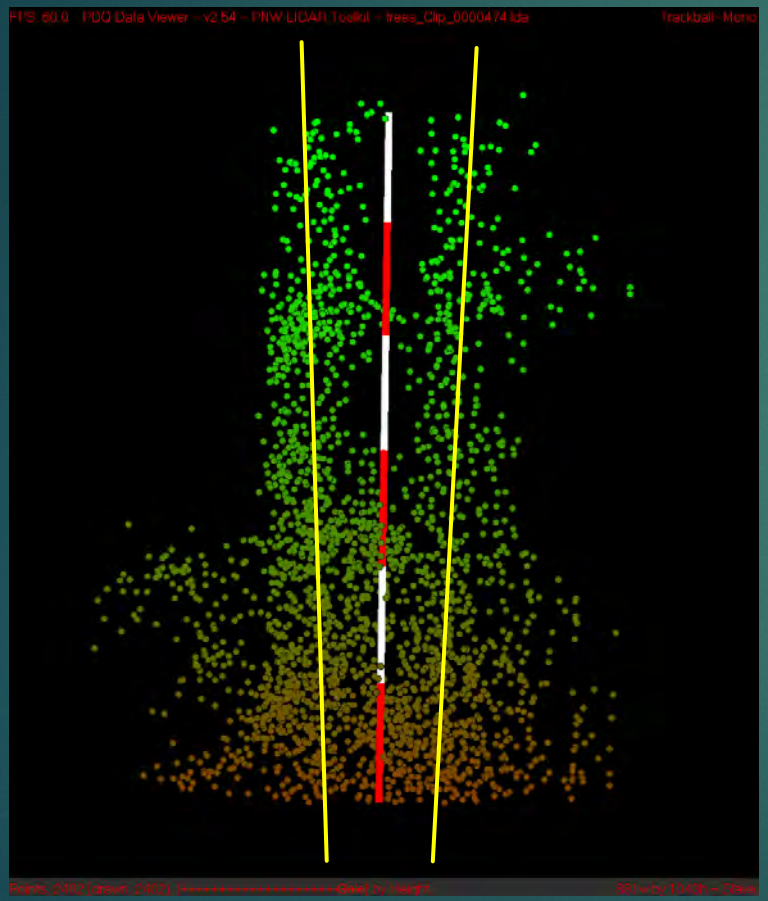
- Ground point density can be low
- Normalization (subtracting ground elevation to get point heights) may introduce distortion that is problematic for individual tree work
- Tree movement may be a problem (different from noise)

Data collected by:

WEST FORK ENVIRONMENTAL

Tree movement due to wind



stripes are 50cm

- Point cloud for upper 3m of crown
- Each treetop is scanned multiple times (multiple passes)
- Apparent offset of 50-75cm
- Some trees in the same area show more/less offset

Data collected by:

WEST FORK ENVIRONMENTAL

The future…

- UAS lidar is awesome!!
- Data are like “traditional lidar” but different
- Existing analysis methods and software tools work well but there is room for improvement and new development
- Great potential as a monitoring tool
  - Rapid deployment
  - Ideally suited for project-specific analyses
  - Detailed information regarding structure and spatial patterns is easily generated
  - General change detection and treatment effectiveness

Data collected by: