Lidar: Future Directions for Forest Management

Forestry Applications of Lidar and Future Research

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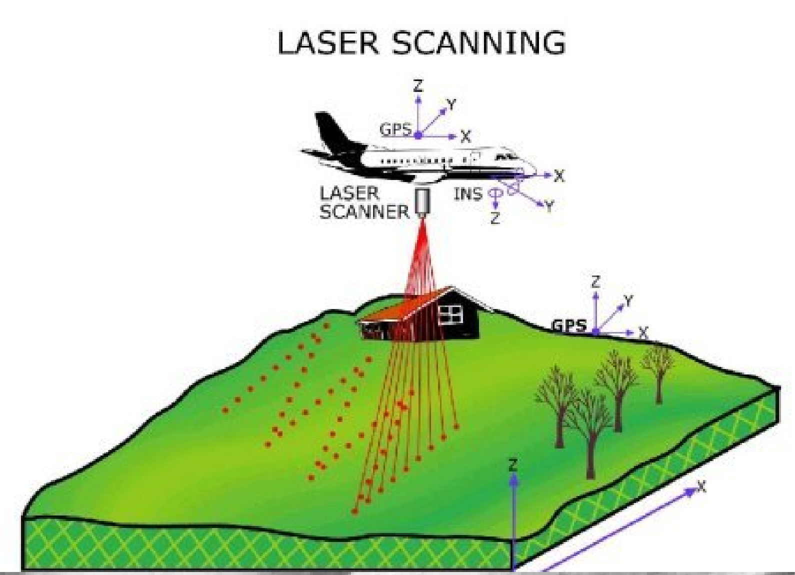
Lidar: What is it?

Light Detection and Ranging

Essentially a laser rangefinder that has been strapped to the belly of an airplane.

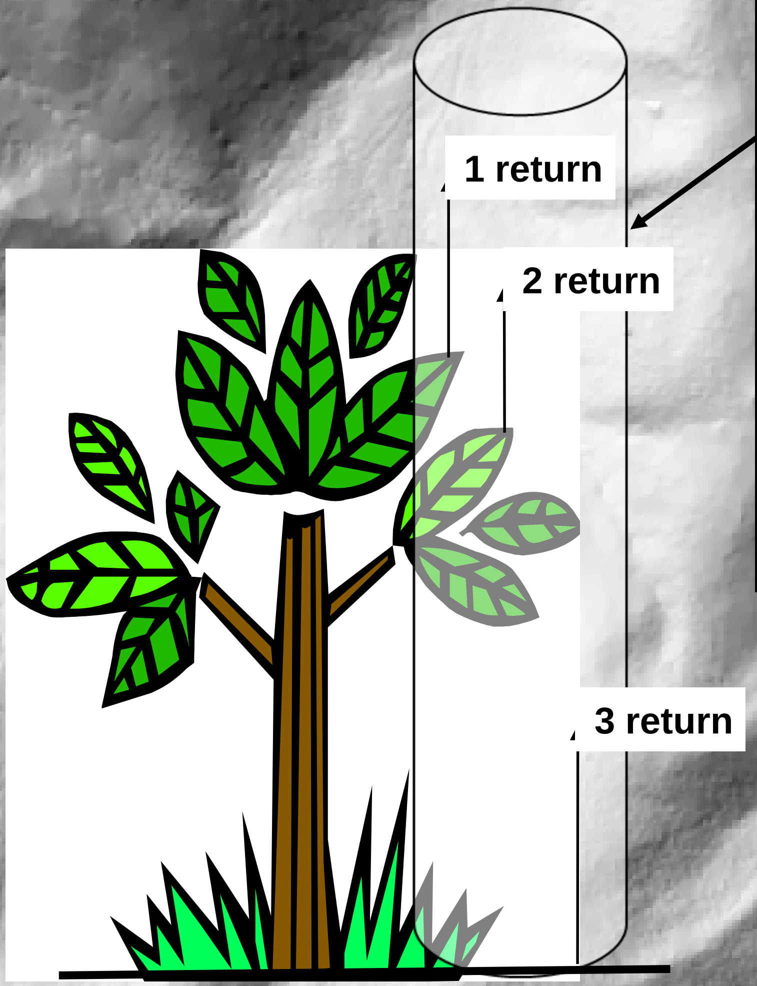


The time for the light to travel to and from the target is used to determine distance:

Distance = Speed x time

This distance and the position of the airplane is used to get elevation and location.

Lidar: What is it?



Each pulse of laser light contains a large number of photons.

A few of these photons return to the sensor

The 1st return might be a tree top, while the last return could be from the ground.

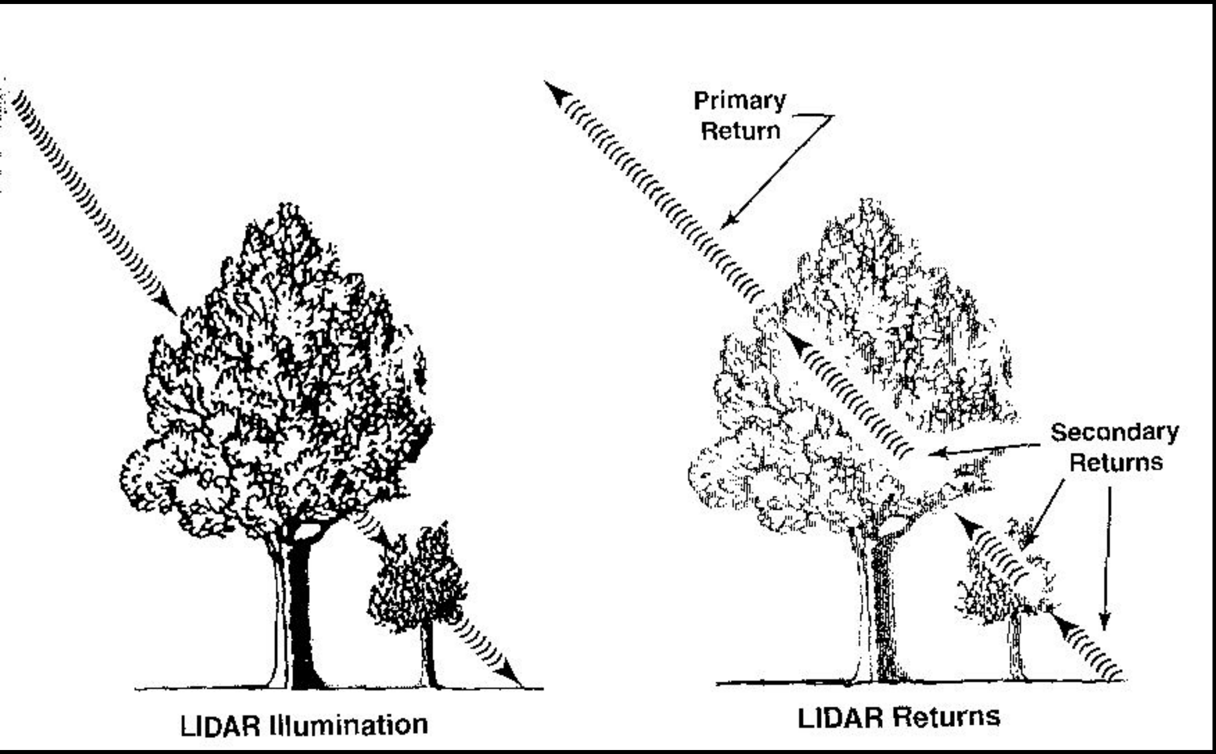
It is important to note that:

The 1st could also be the last return.

The Last return might not be the ground.

Lidar: Understanding the Returns

The laser pulse travel can travel through trees before hitting the ground. Secondary returns might not be from the ground

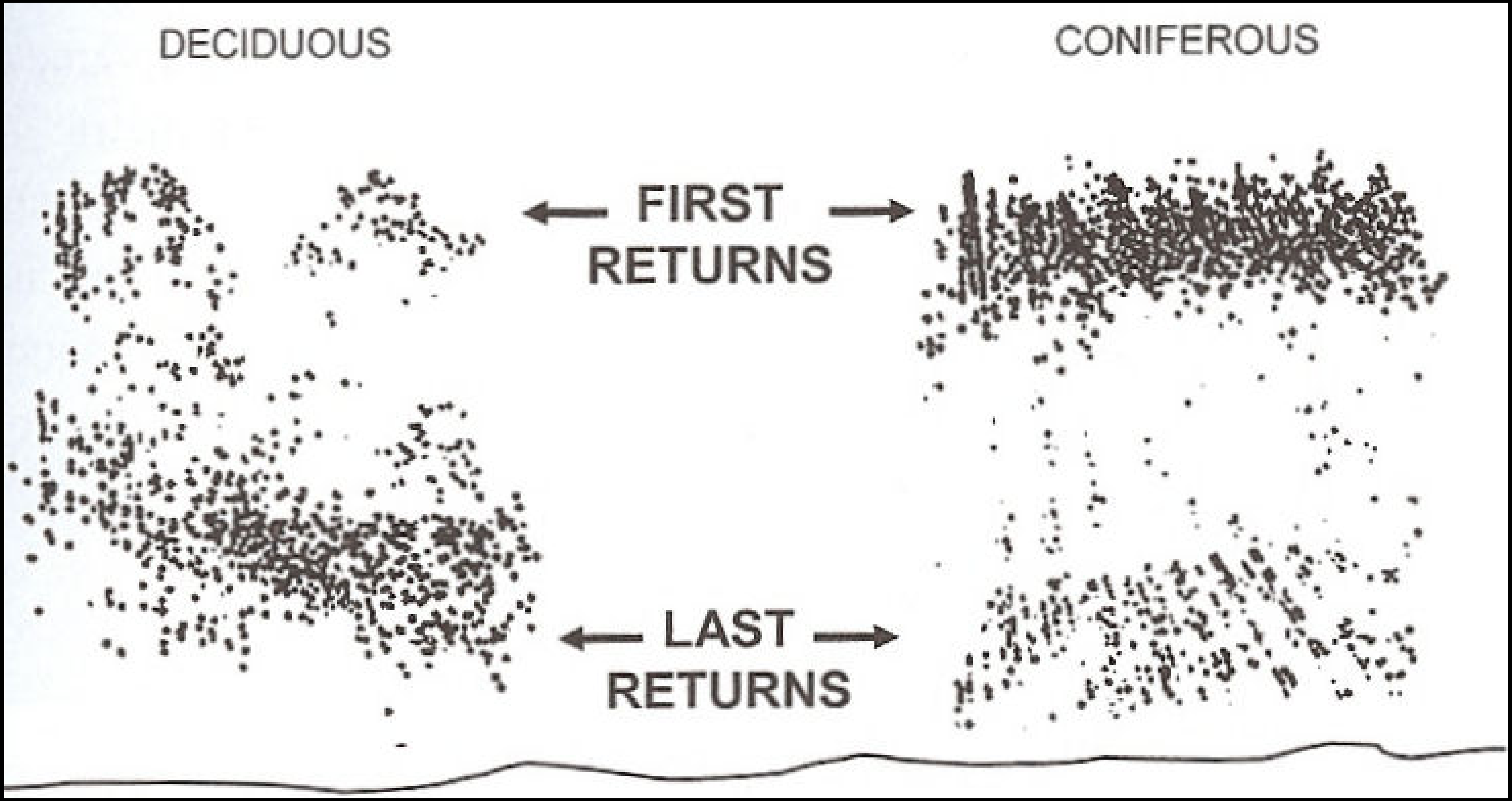


Non ground objects could include:

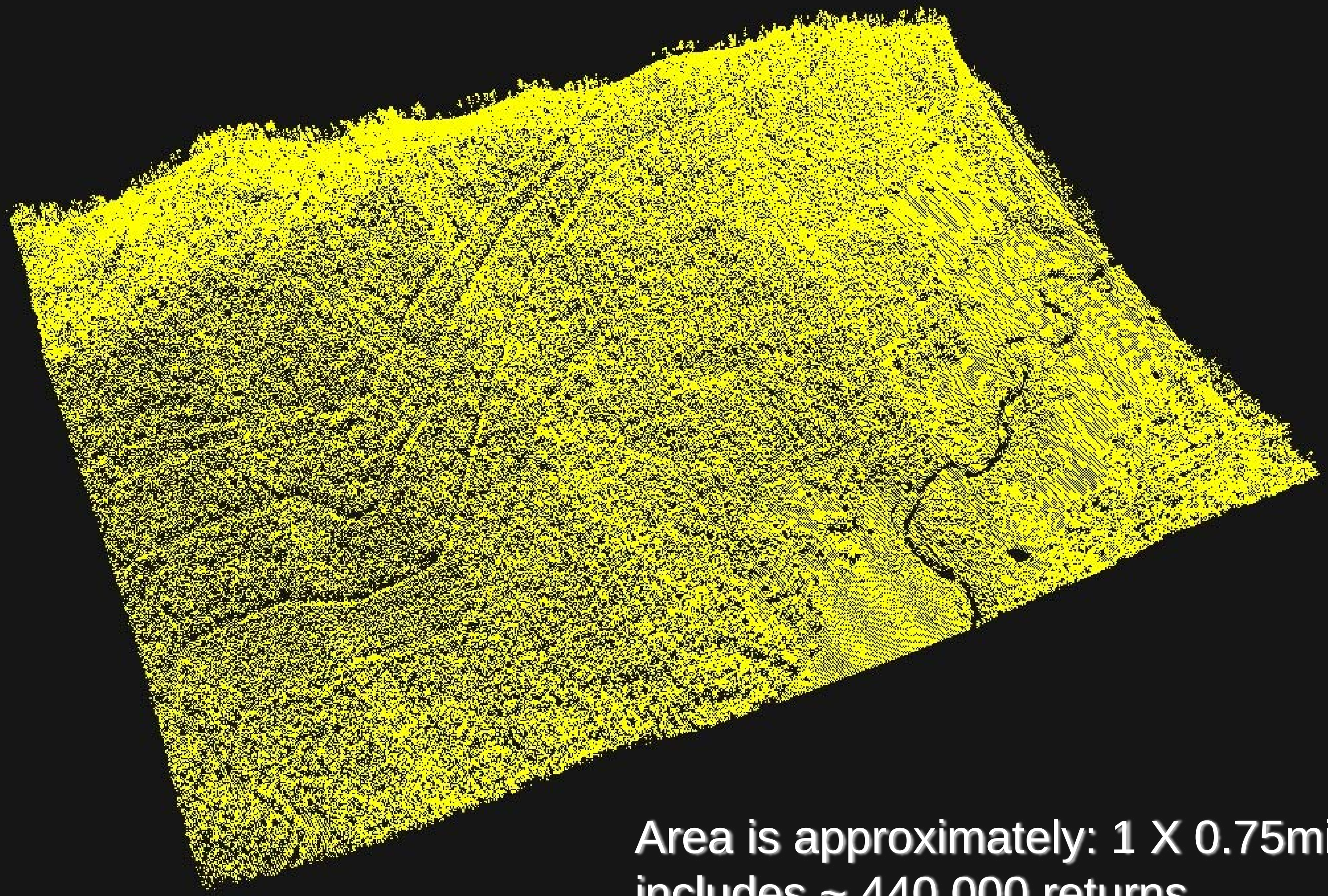
- Shrubs
- Ladder Fuels
- Seedlings
- Buildings
- Wildlife
- TANKS!!!

Lidar: Understanding the Returns

The different vertical structure of deciduous and coniferous forests can be highlighted by the returns

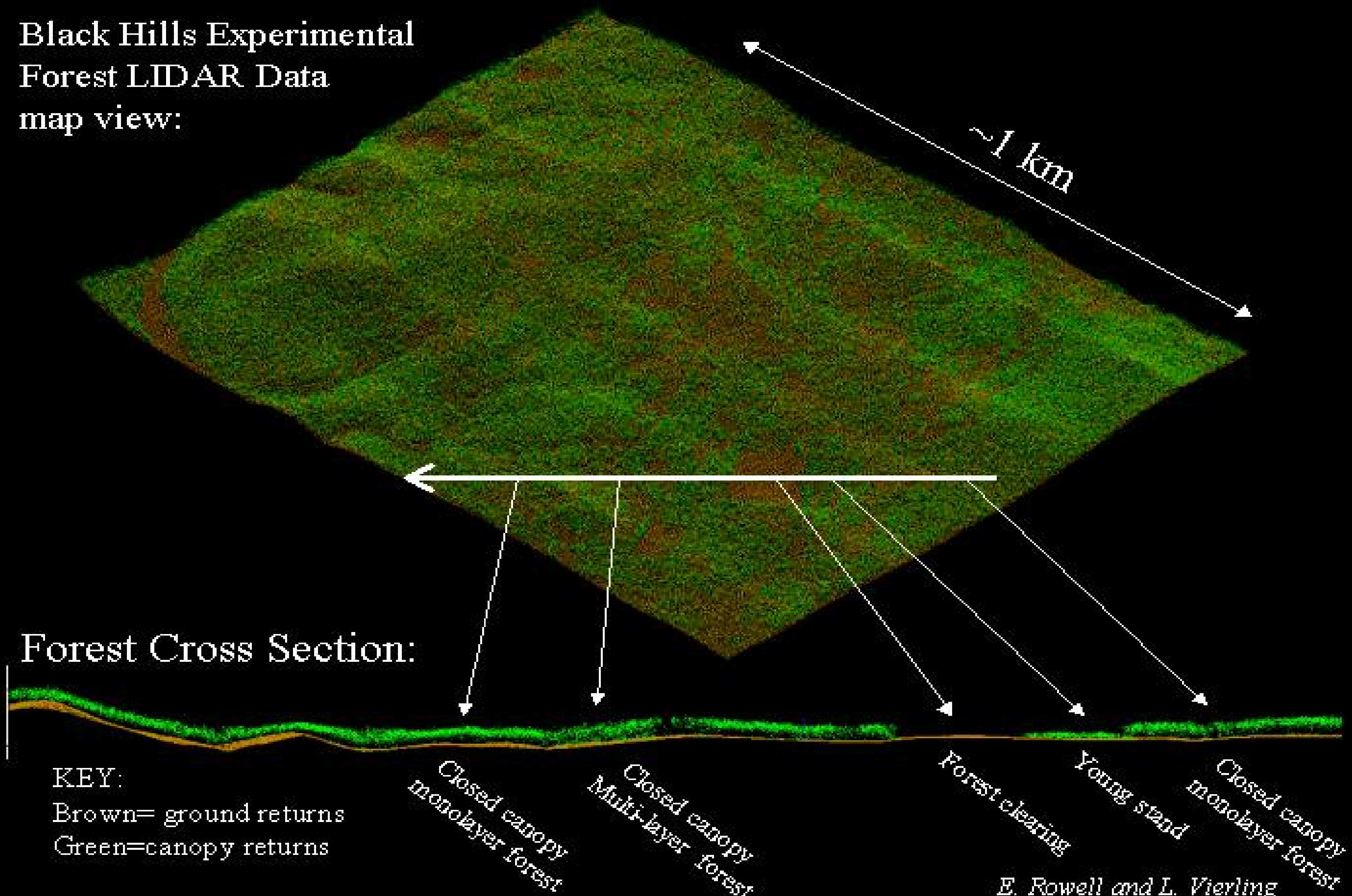


Lidar: What the Data Looks Like



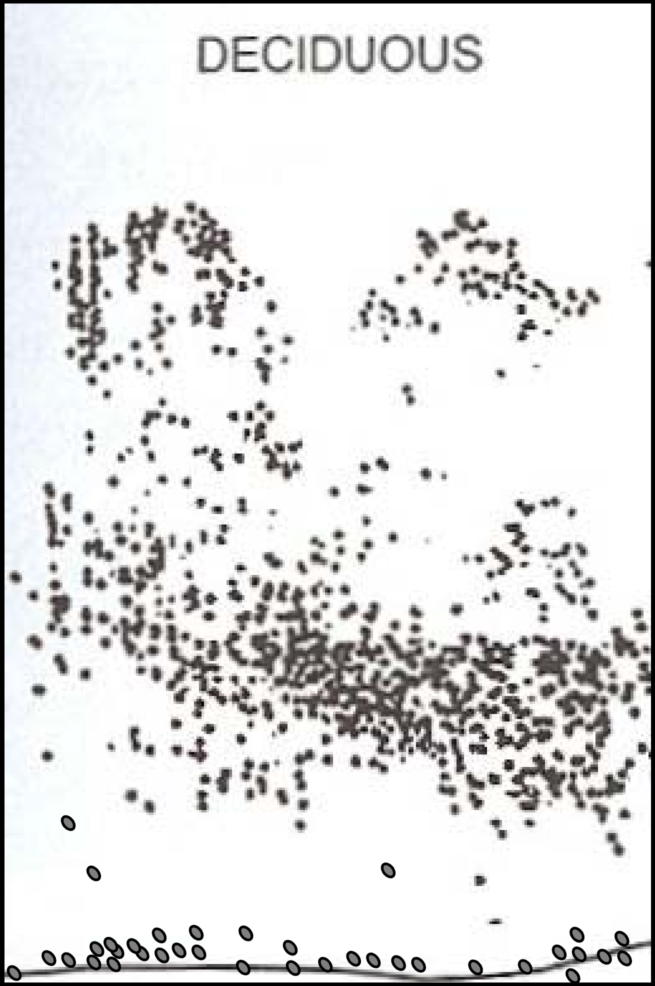
Area is approximately: 1 X 0.75mi.
includes ~ 440,000 returns

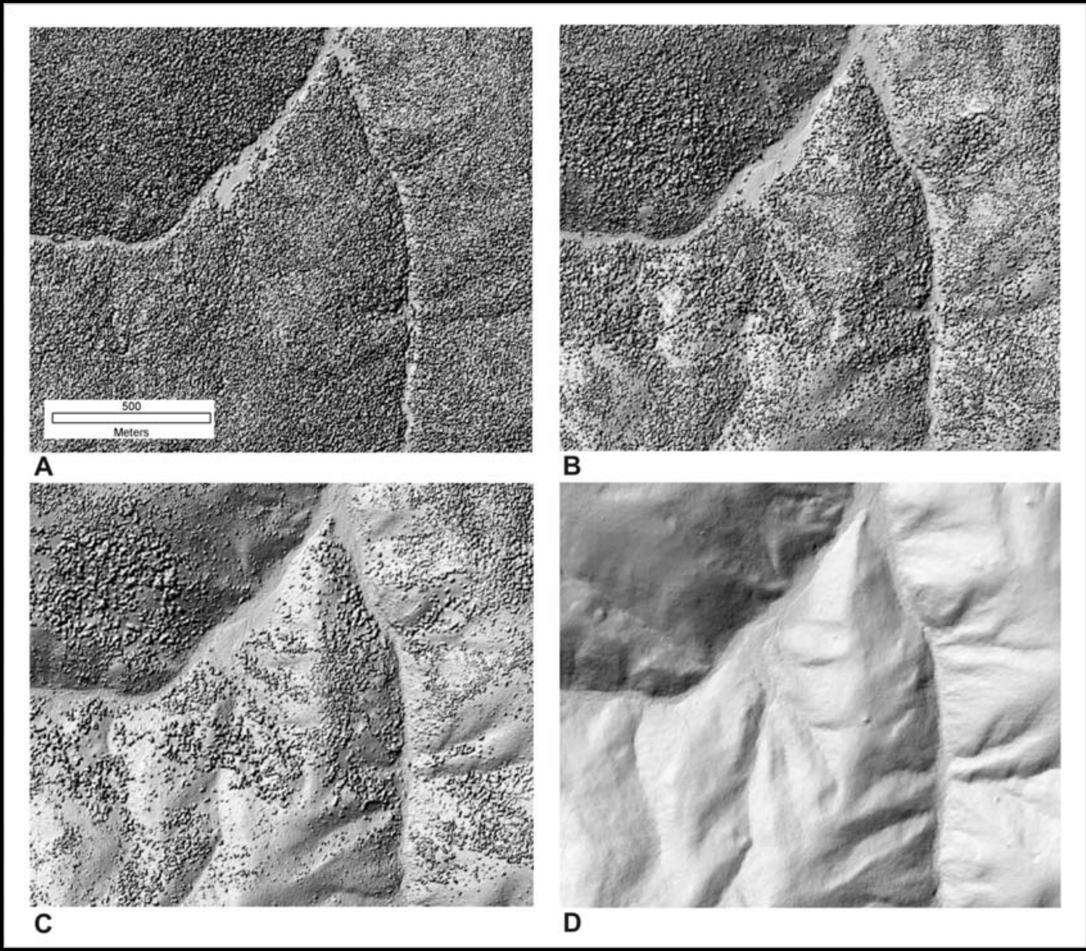
Lidar: The Raw Data



Lidar DEMs: The General Principal

To generate a DEM from Lidar we identify what returns are associated with the ground reflections and delete all the rest.

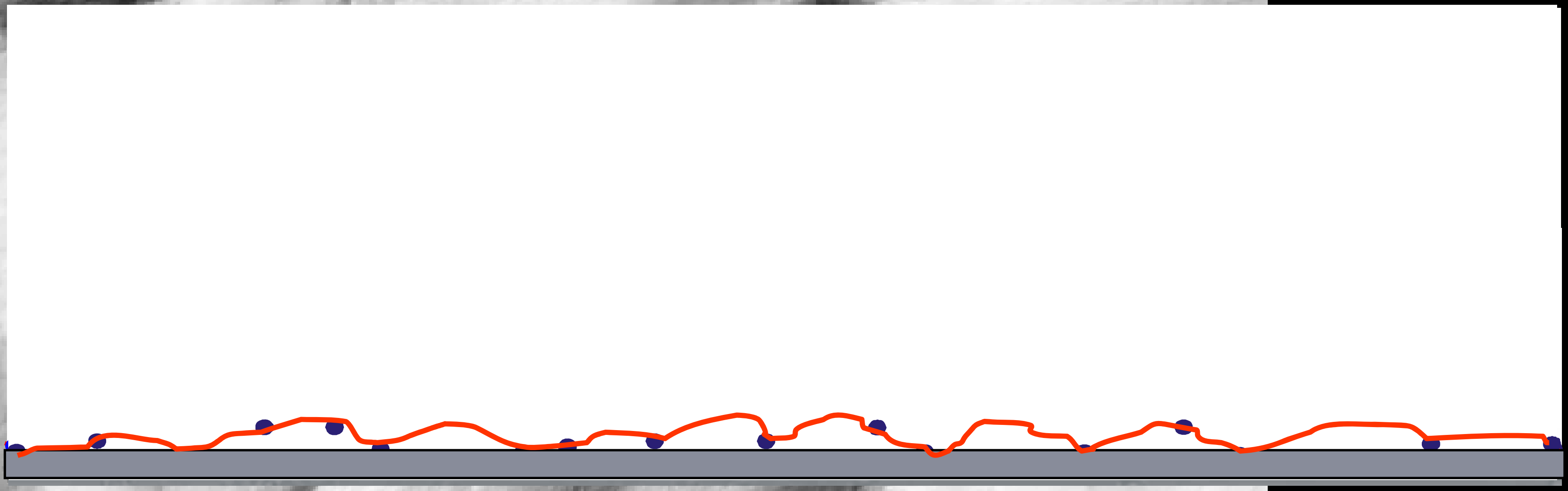




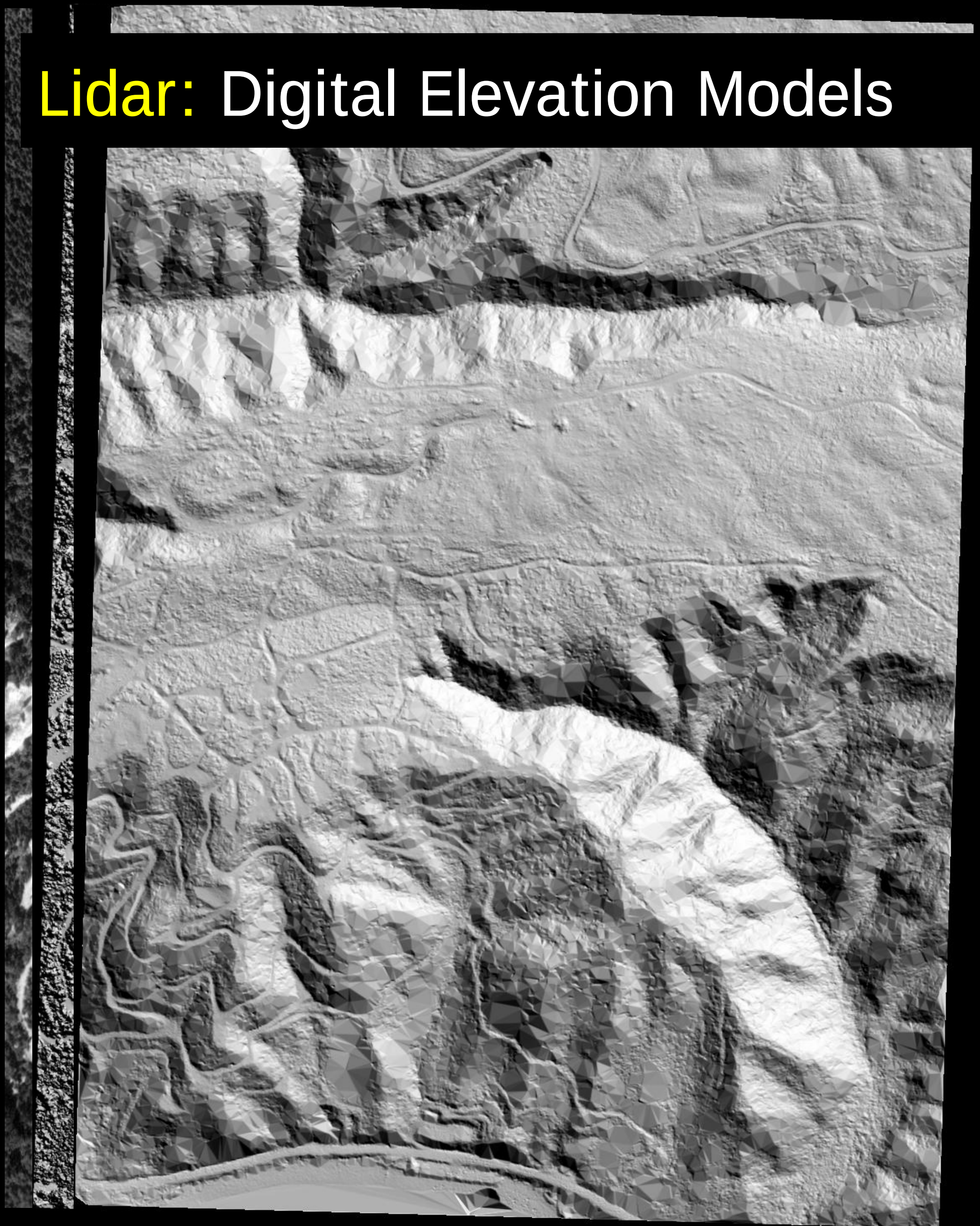
Source: Jeffrey Evans USFS RMRS-Moscow

Lidar: Digital Elevation Models

This process is repeated until the surface stops changing:



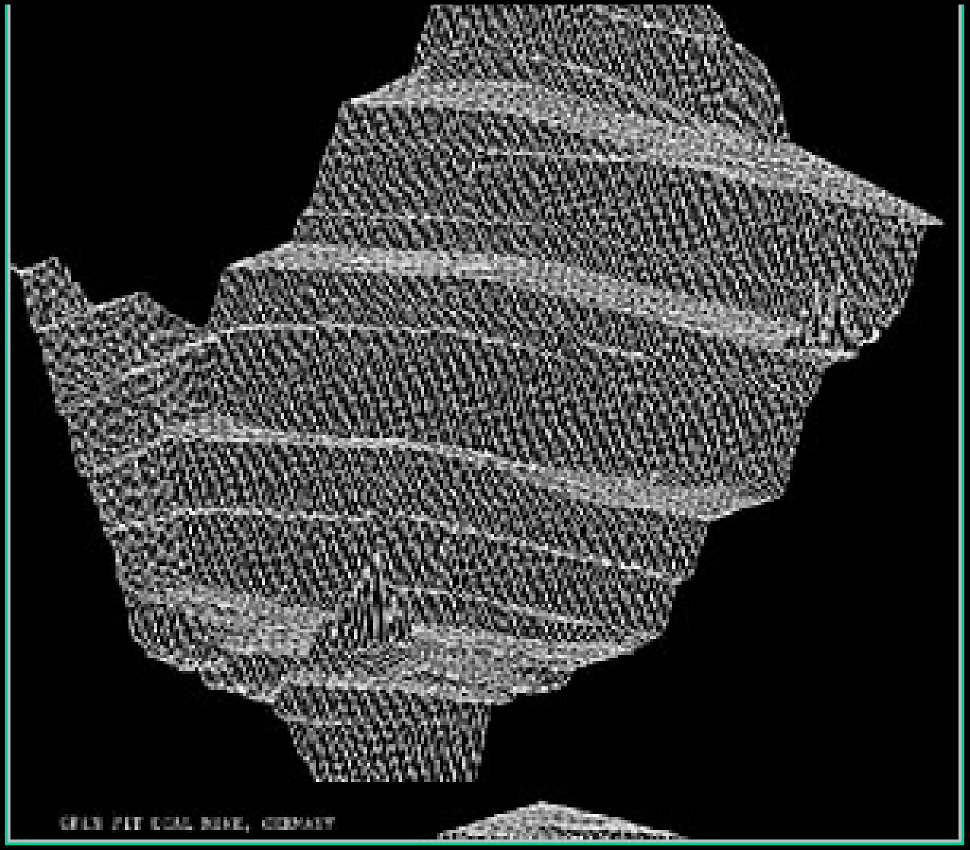
Lidar: Digital Elevation Models



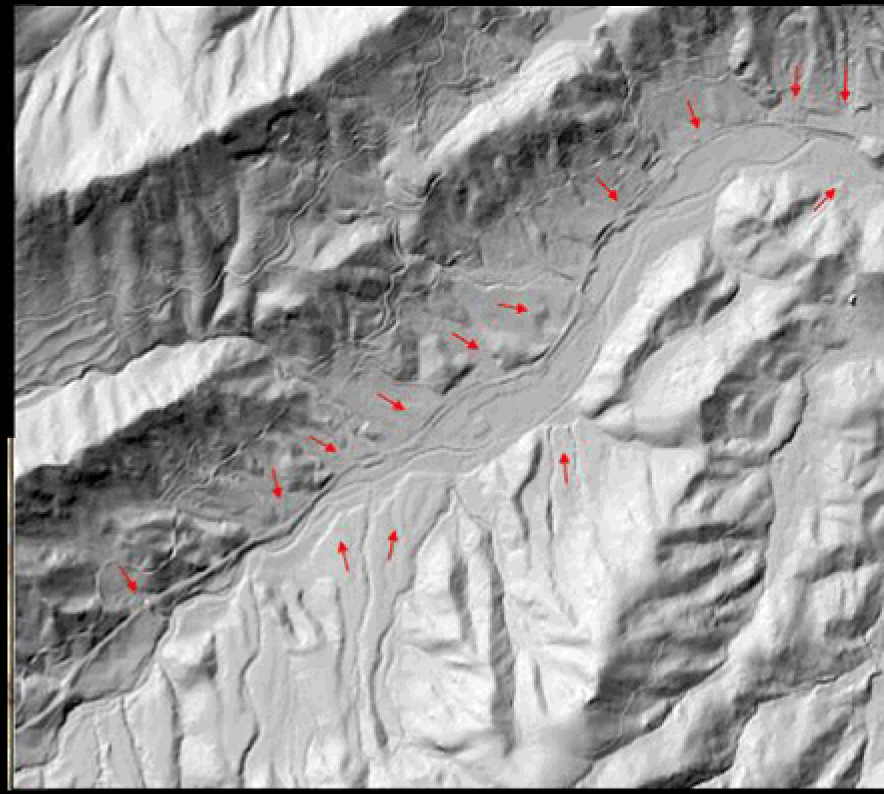
Lidar: Digital Elevation Models

Lidar: Geomorphologic Applications

Volume change in open pit mines



Landslide Detection



Utilities map power lines for signs of damage:

Lidar: Mapping Fault Lines

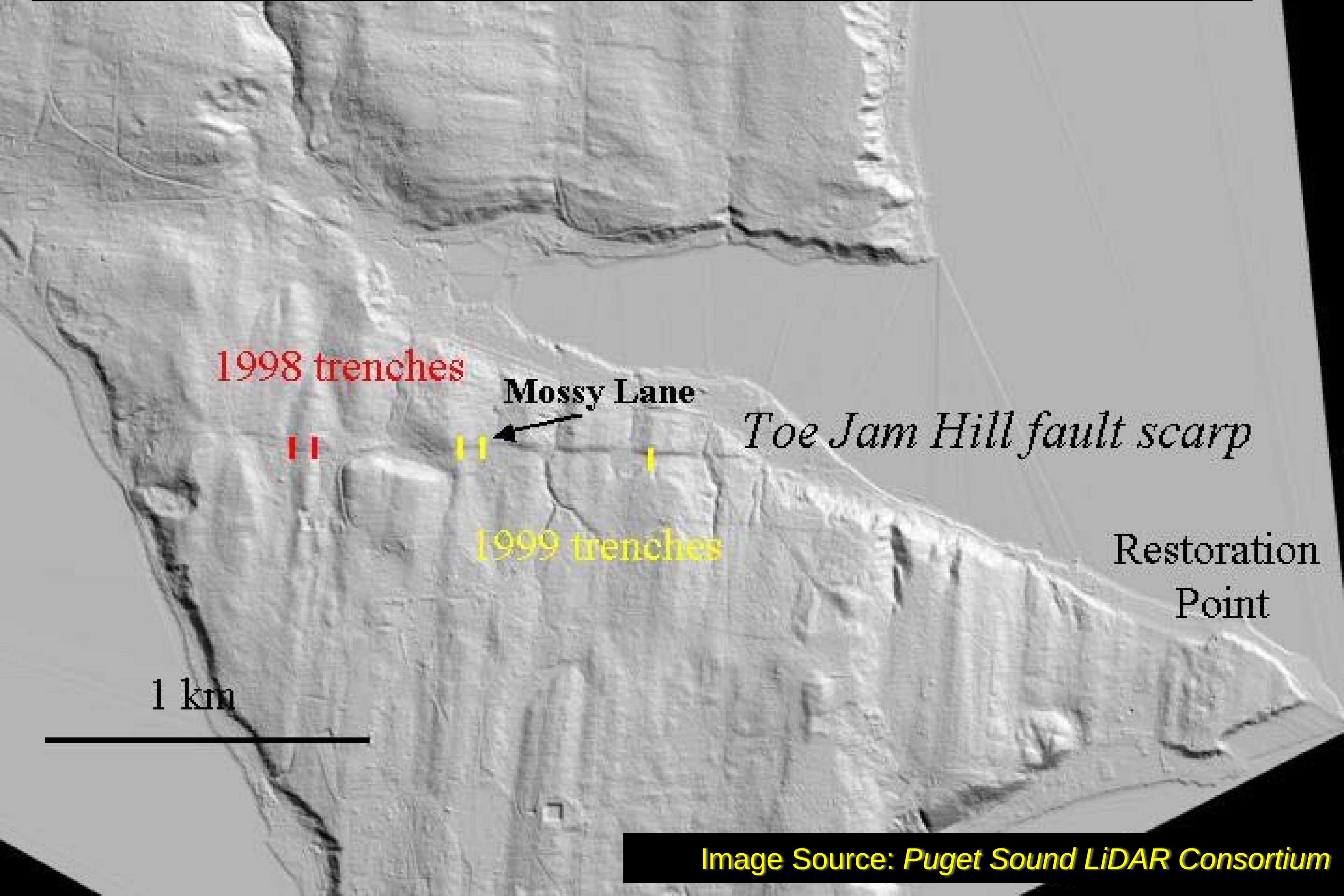
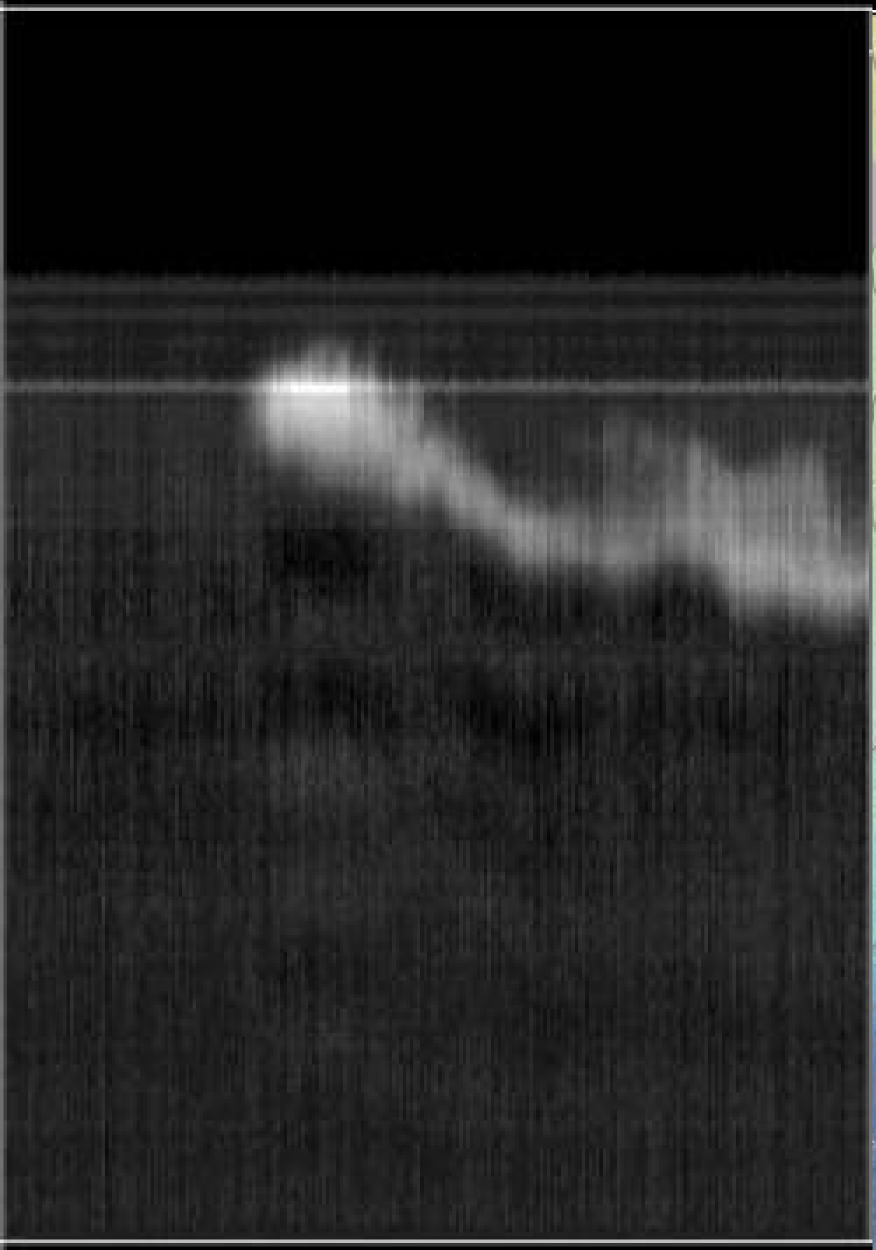
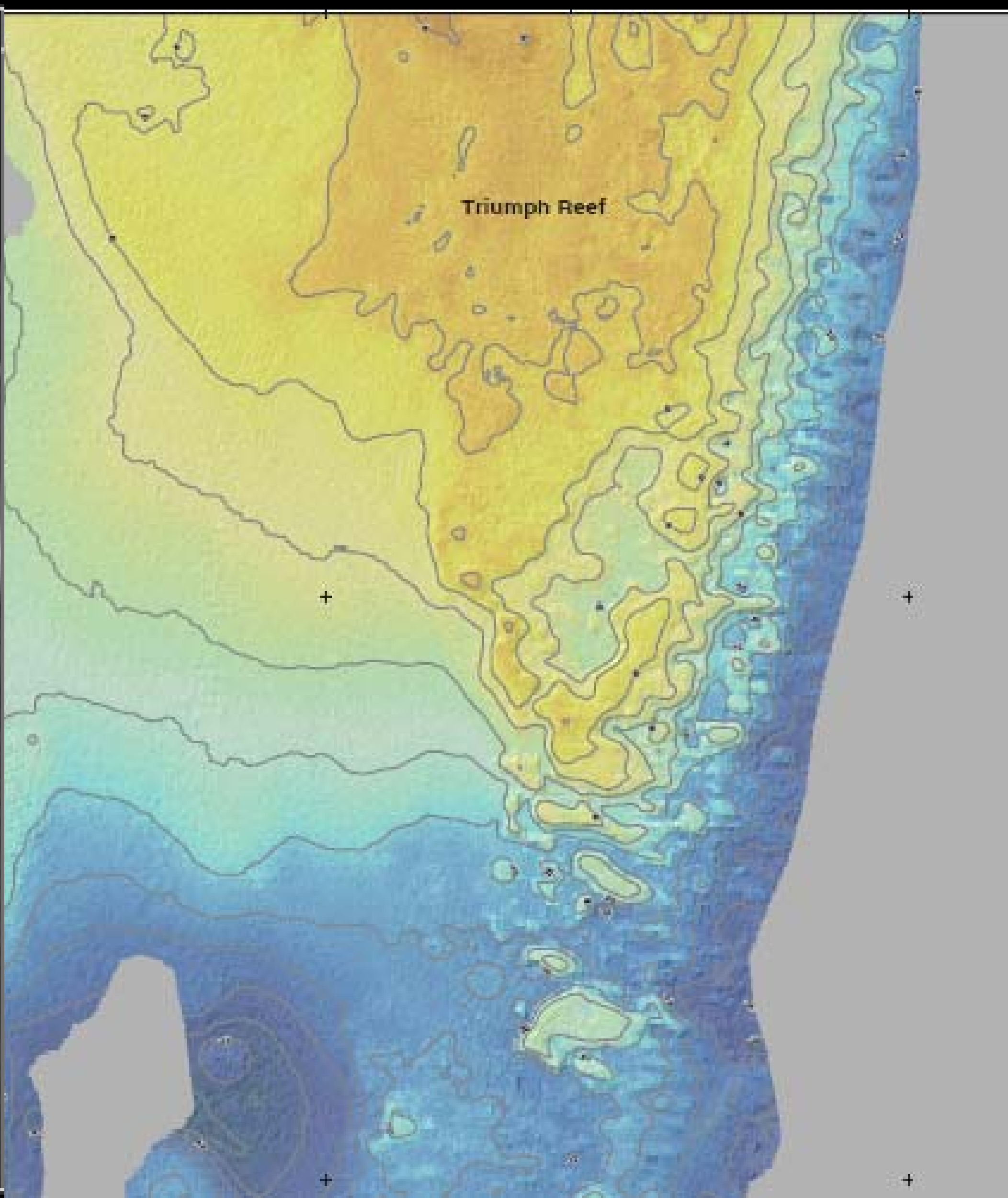


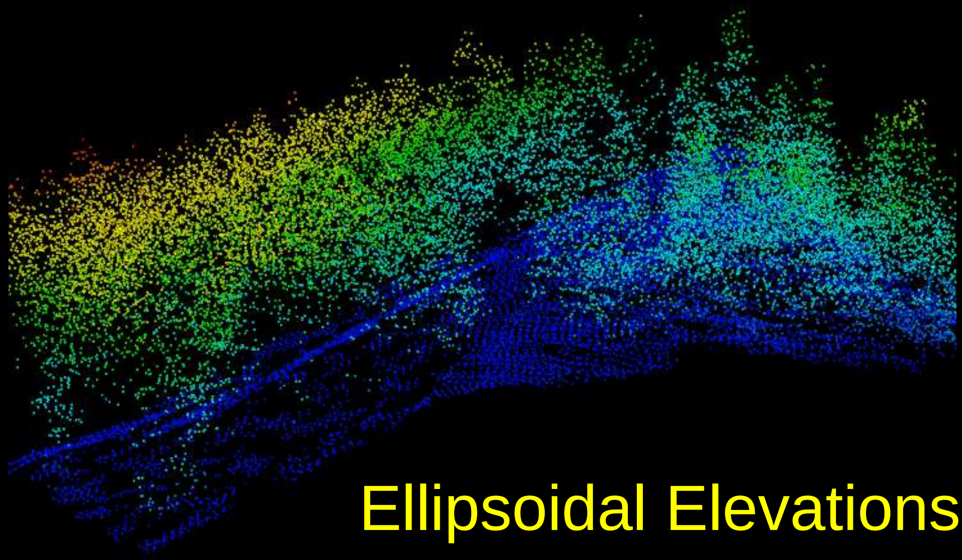
Image Source: *Puget Sound LiDAR Consortium*

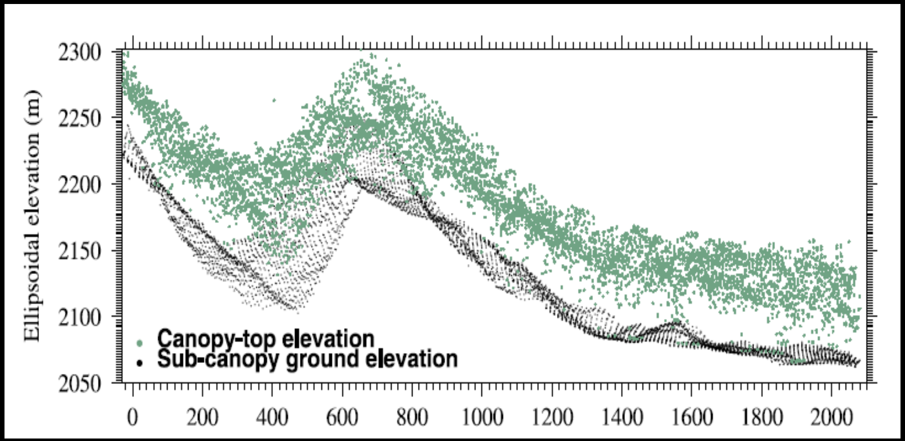
Lidar: Riparian and Coastal Ecology





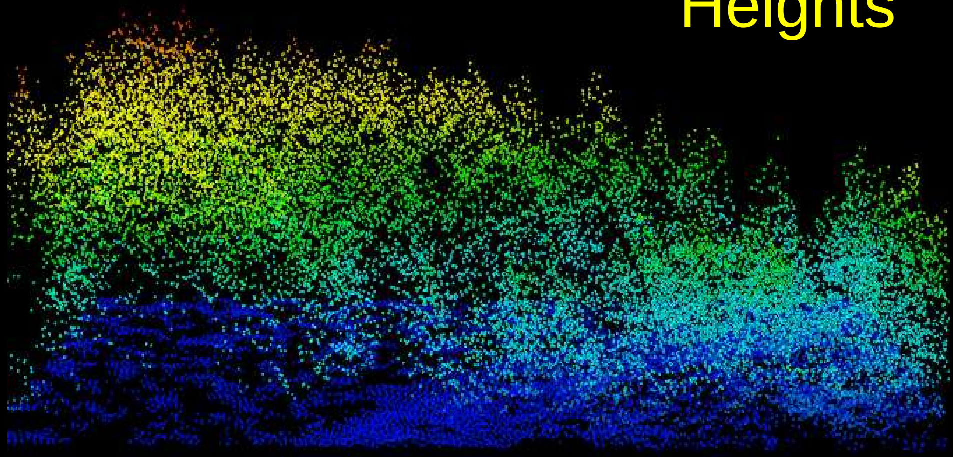
Lidar for Forestry: Getting at Canopy Heights





Ellipsoidal Elevations

Heights



Subtract DEM surface elevations from LiDAR point elevations


Image source: H-E Anderson

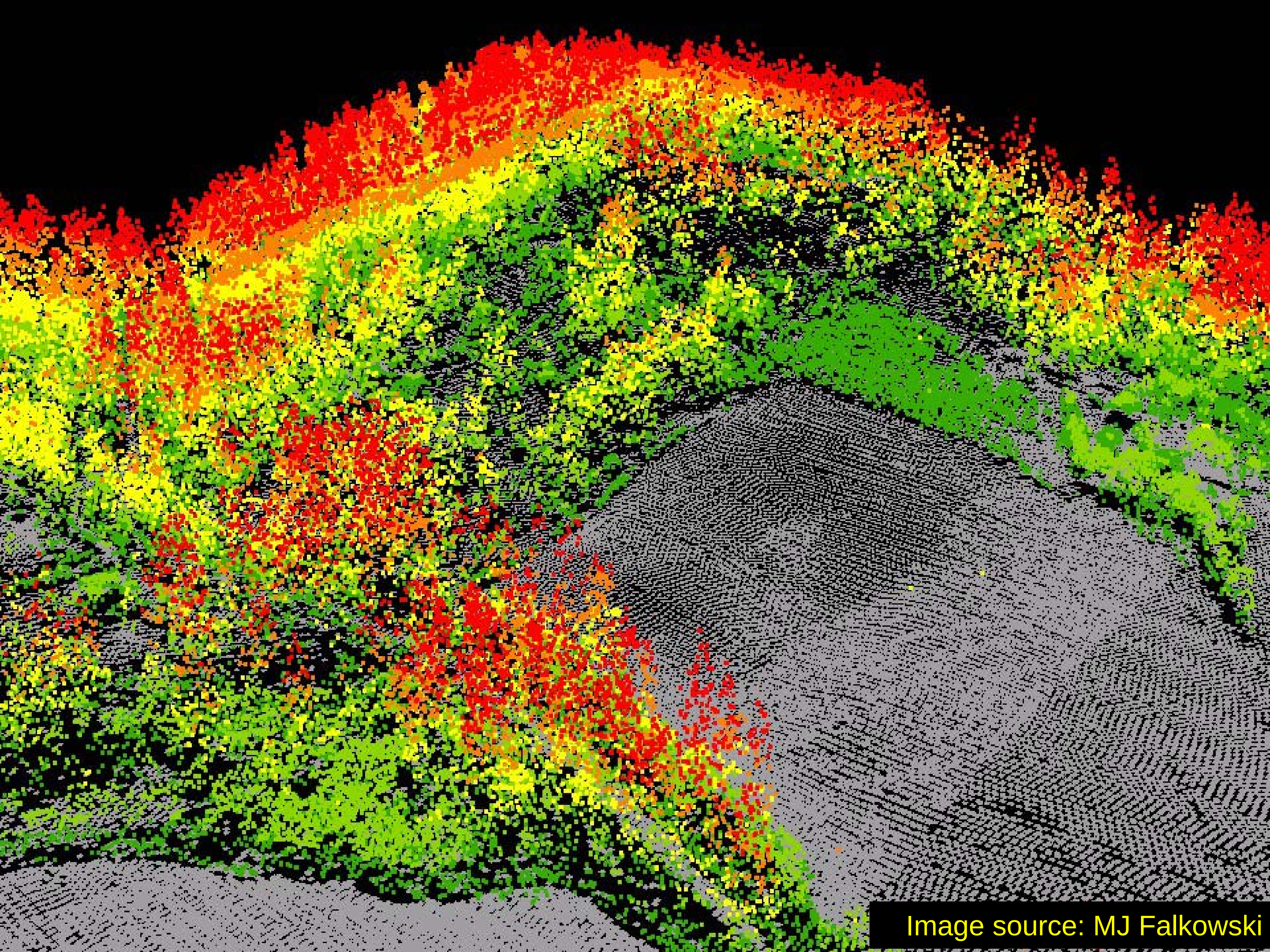
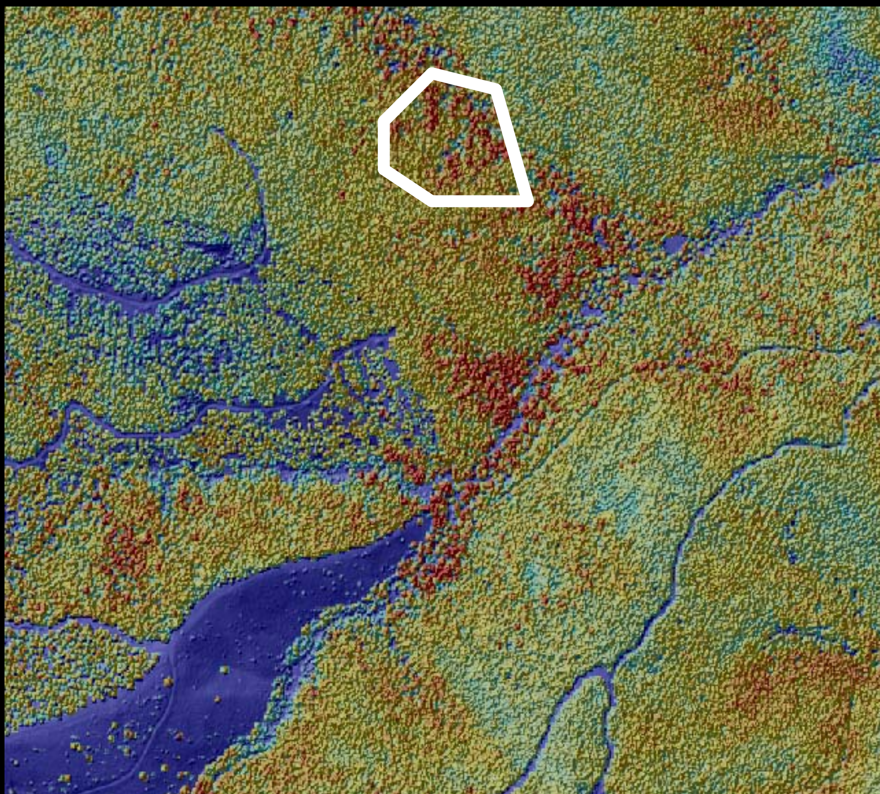


Image source: MJ Falkowski

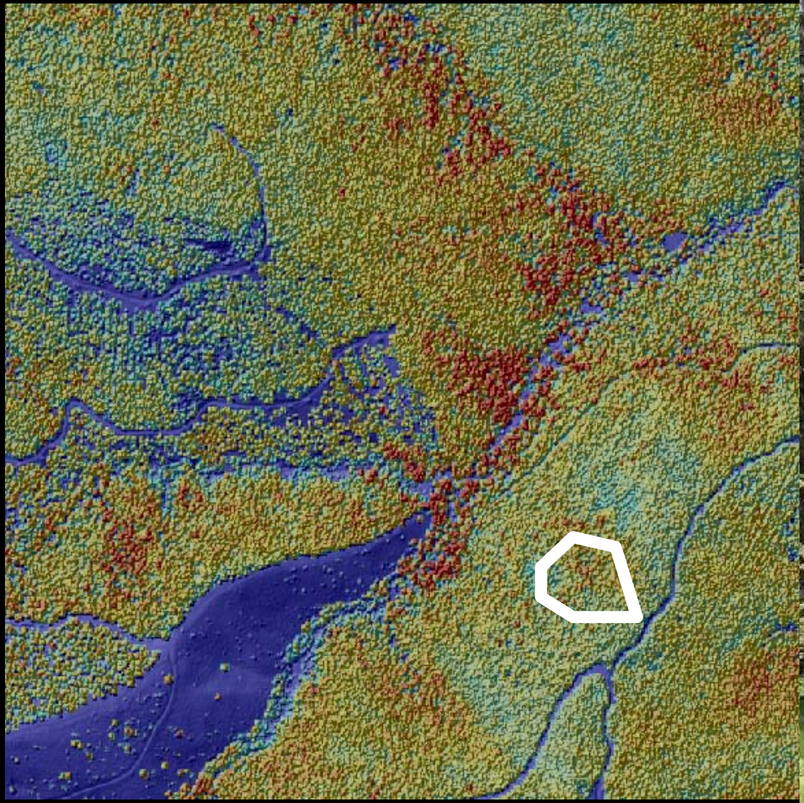
Lidar: Stand Canopy Heigh

Canopy Height Map :



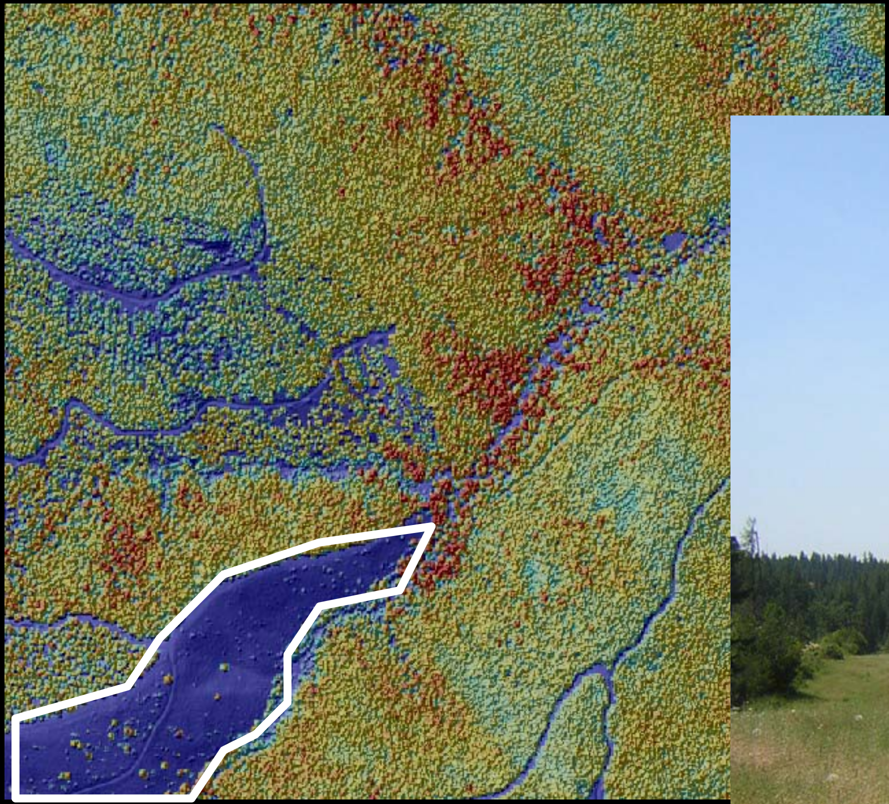
Lidar: Canopy Height P

Canopy Height Map :



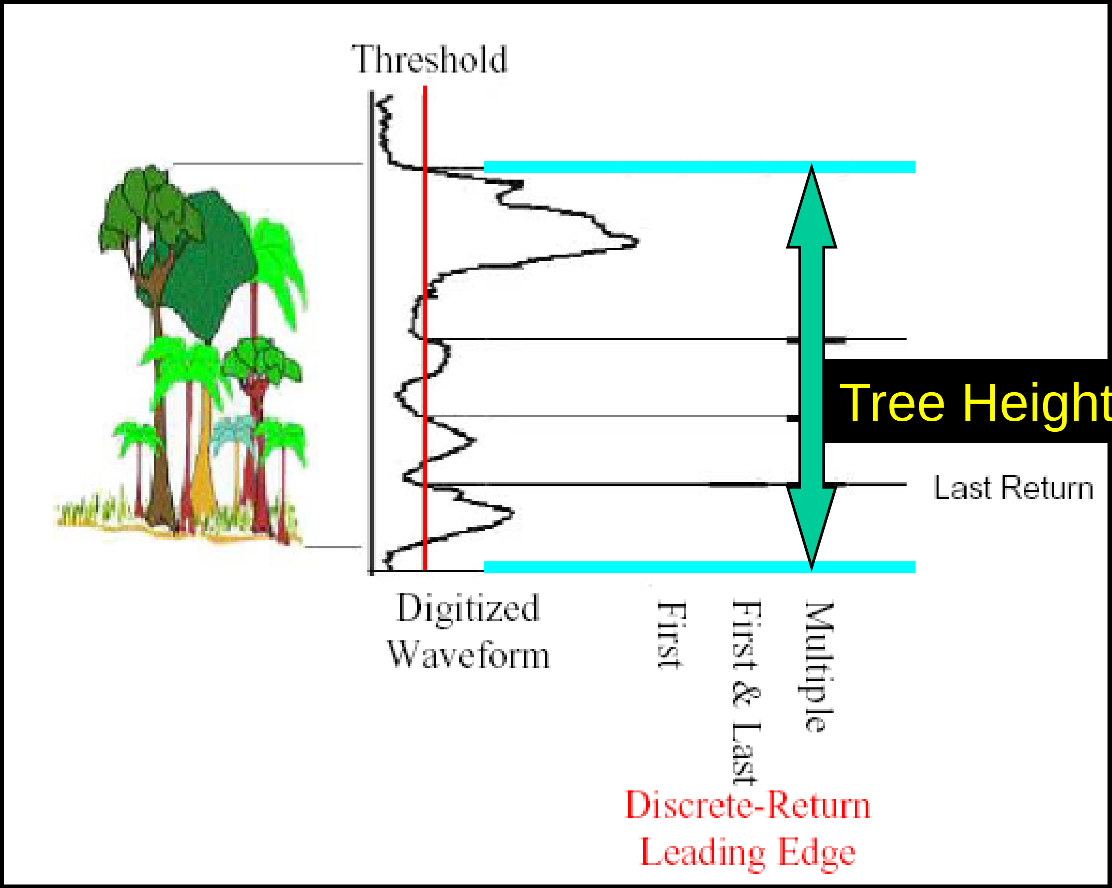
Lidar: Canopy Height Profiles

Canopy Height Map :



Plot Level Metrics: Getting Maximum Tree Height

Assume each local maximum in the canopy surface is a tree-top



Popescu, S.C., Wynne, R.H. and Nelson, R.F. (2003.

Plot Level Metrics: Tree Crown Widths and Locations

Valley Following

1. Assume each local maximum in the canopy surface is a tree-top

2. Apply contours to the canopy surface map

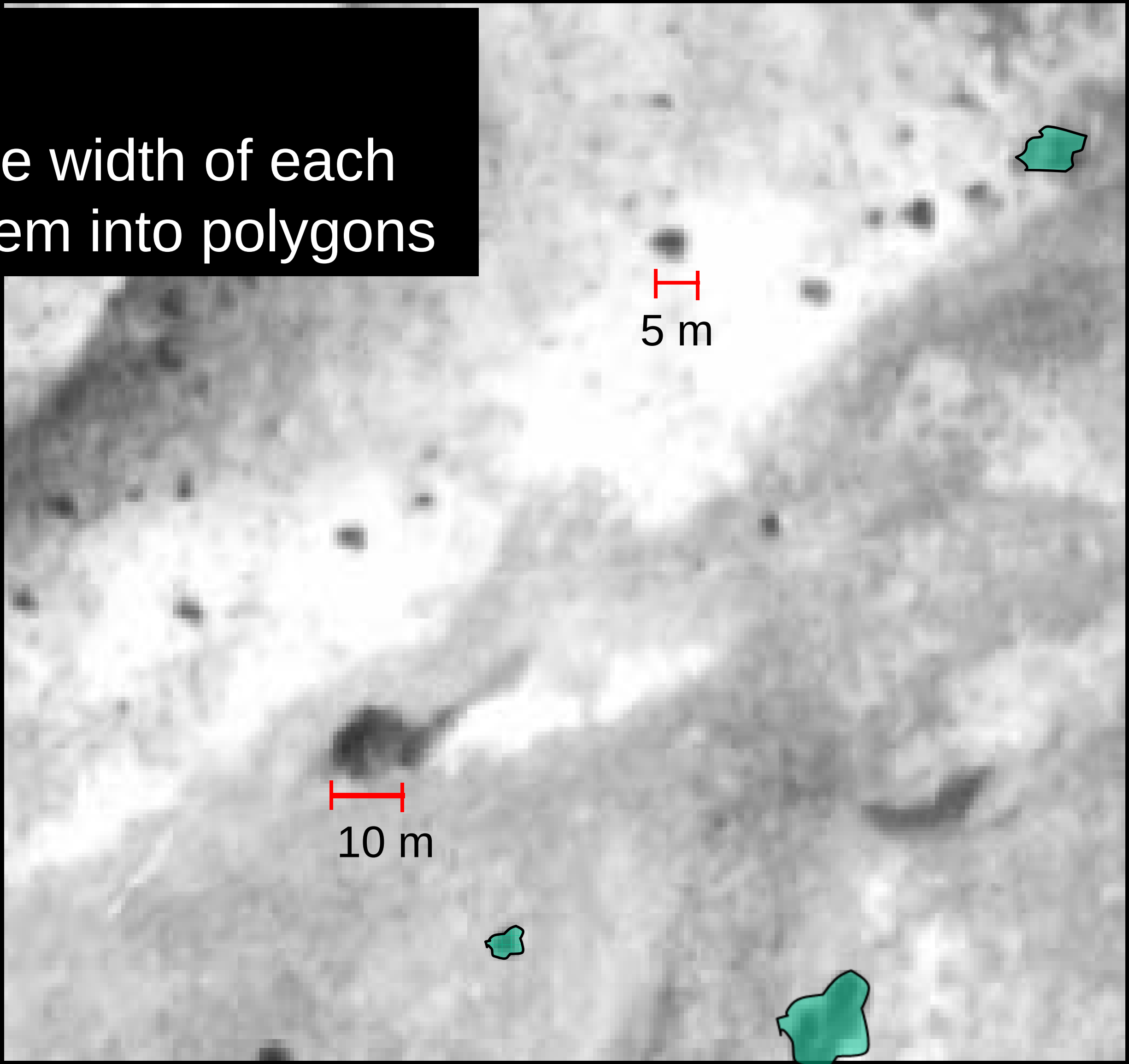
4. Find the local minimums surrounding each local maximum

5. Calculate Average N-S and E-W Diameter

Plot Level Metrics: Tree Crown Widths and Locations

Using a GIS:

Manually measure the width of each tree and delineate them into polygons



Plot Level Metrics: Tree Crown Widths and Locations

Using Allometric Equations:

1. Assume each local maximum in the canopy surface is a tree-top

2. Derive crown diameter from height relations:

$$cd = 2.56 * 0.14h$$

From:

Falkowski, M.J., Smith, A.M.S., et al., (2006). Automated estimation of individual conifer tree height and crown diameter via Two-dimensional spatial wavelet analysis of lidar data, *Canadian Journal of Remote Sensing,* Vol. 32, No. 2, 153-161.

http://www.treesearch.fs.fed.us/pubs/24611

Plot Level Metrics: Tree Crown Widths and Locations

Using Automatic Methods

1. Convert each lidar canopy height model into a raster grid (via a GIS)

2. Use automated methods to ‘detect’ the location and crown width of each lidar tree

For more information see:

Falkowski, M.J., Smith, A.M.S., et al., (2006). Automated estimation of individual conifer tree height and crown diameter via Two-dimensional spatial wavelet analysis of lidar data, *Canadian Journal of Remote Sensing,* Vol. 32, No. 2, 153-161.

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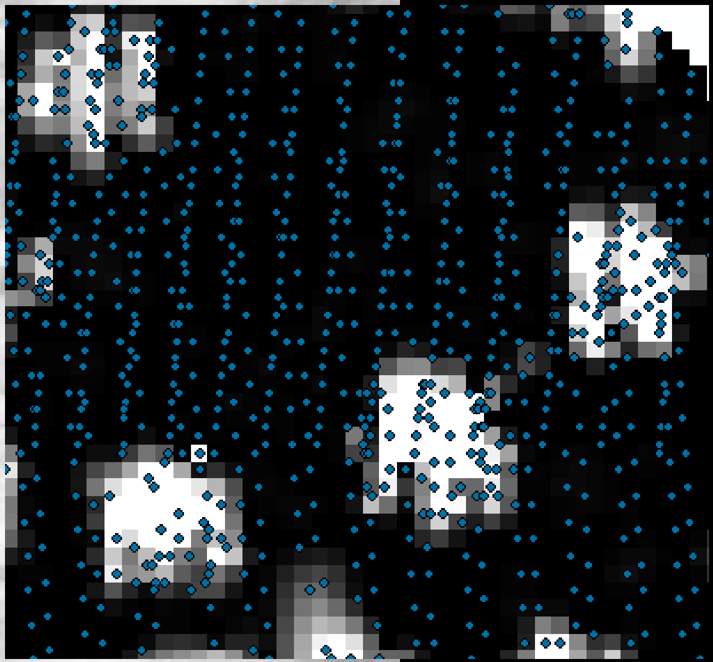
Lidar Height Data



Plot Level Metrics: Tree Crown Widths and Locations

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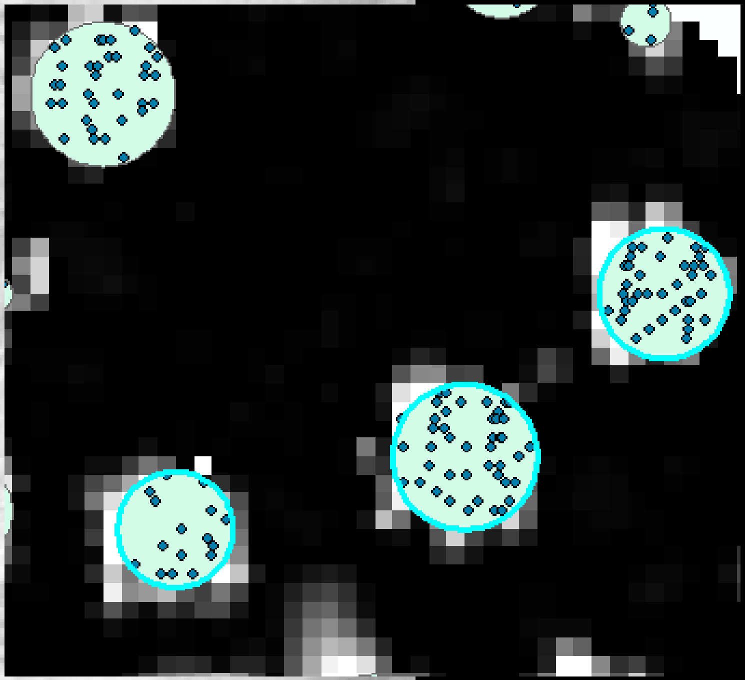
Crown Diameter



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http://www.treesearch.fs.fed.us/pubs/24611

Plot Level Metrics: Crown Base Height

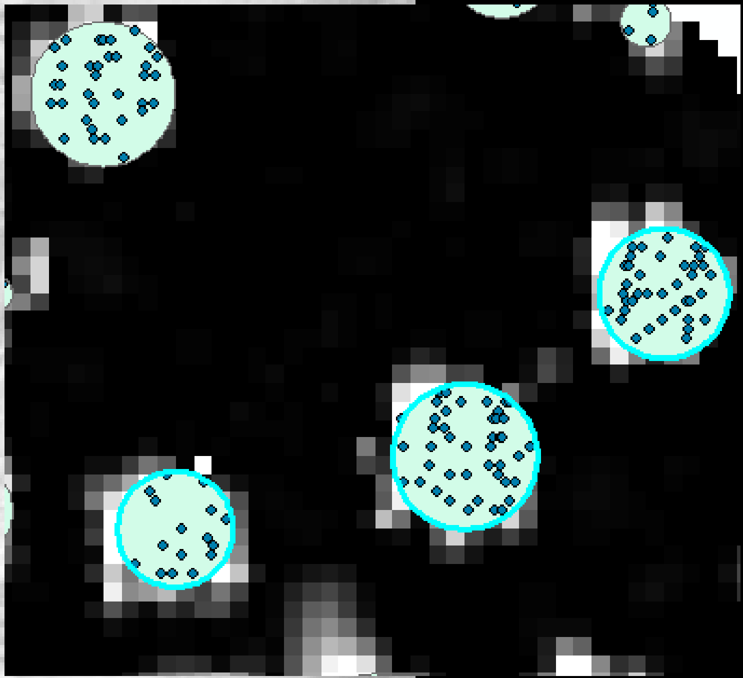
Crown Base Height:

1. Convert each lidar canopy height model into a raster grid (via a GIS)

2. Use automated methods to ‘detect’ the location and crown width of each lidar tree

3. Within the crown diameter find the lowest height > than a set value (e.g. assume heights < 1m from trees: shrubs, rocks, etc)

Crown Diameter



Plot Level Metrics: Crown Bulk Density

Crown Bulk Density

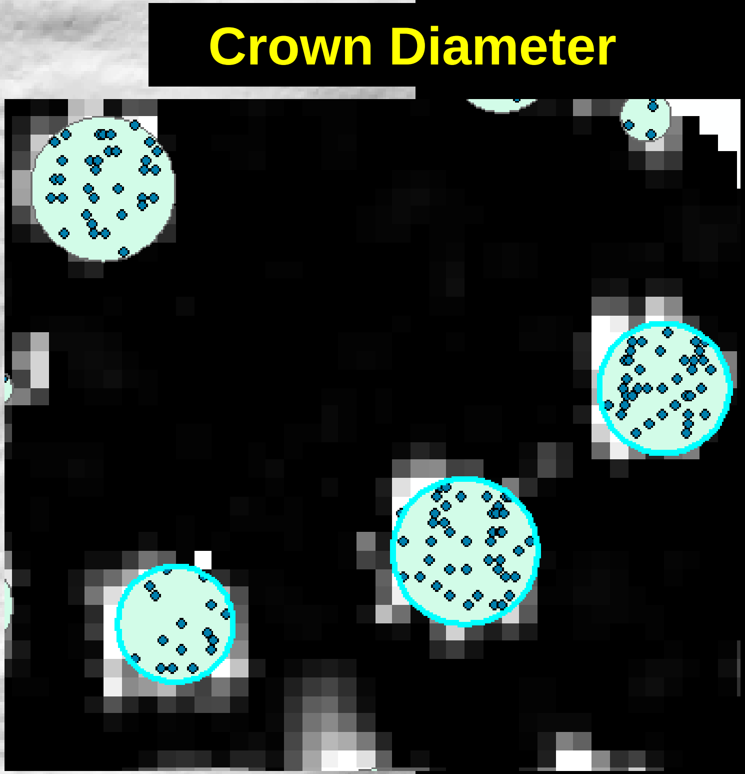
1. Convert each lidar canopy height model into a raster grid (via a GIS)

2. Use automated methods to ‘detect’ the location and crown width of each lidar tree

3. Assume trees have a specific shape – cone, cylinder →Volume

4. Use allometric equations via field measures to get foliar biomass

CBD = Foliar Biomass / Volume



Plot Level Metrics: Crown Class

Analysis of the Lidar data will be able to highlight trees above the canopy and importantly how tall the neighboring trees are.

What do you think the main limitation is?

Plot Level Metrics: Diameter at Breast Height

Lidar can't yet measure DBH directly:

Must model DBH from tree heights and crown widths OR use other allometric methods to directly get Biomass.

This creates a challenge as most Growth & Yield and Productivity models rely on a measure of DBH.

Therefore we need to develop "Lidar aware" allometric relationships!

New Generation of Allometrics: THPL

The Plan:

Inventory THPL (traditional measurements + LiDAR suite of measurements)

Moscow Mountain Lidar Acquisition July 2009

Harvest THPL to get biomass + other measurements (height and diameter of stems)

Any Questions?