Monitoring Forest Disturbance and Structure in the Northeast with Sensor Fusion to Support Ecosystem Assessment

Lamprey River Symposium

January 8th, 2018

Lindsay Melendy, Applied Geosolutions

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Overview

1. AGS Missions
2. Project Goals
3. Field Data Collection Sites
4. Example Remote Sensing Observations
5. Lidar Basics & Tools
6. Lidar Products
7. Conclusions & Next Steps

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Applied Geosolutions (AGS)

Leading edge science-based firm, established in 2000

- Monitoring, assessing, developing
  - geospatial decisions support systems
  - environmental change and ecosystem services
  - create/apply tools and web mapping for non-experts
- National and international collaborators
  - academic institutions, government agencies, industries, and private clients
- This project partners with UNH & UMASS

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Forest Disturbances

NH Tornado, 2008

Gypsy Moths, RI

WMNF Fire, 2017

NH land conversion to cattle farm in Epsom, NH

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Project Goals

- Map forest structure metrics
  - Aboveground biomass, forest stand height, crown canopy cover
- Understand relationships between metrics, ecosystem functions and services, and their dynamics
- Detect and evaluate intensity, frequency and magnitude of disturbances

Phase II Instrument Characteristics

L-band satellite (PALSAR-2)
(14-day, 4-pol, 6m+ pixels, 5,625km^2 coverage)

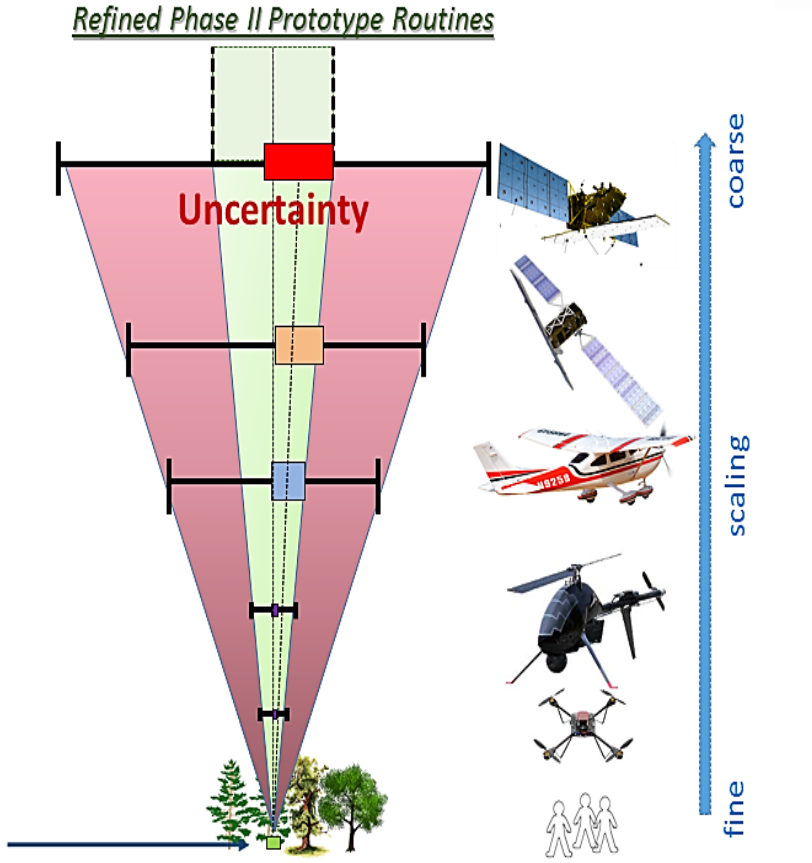
C-band satellite (Sentinel-1 A & B)
(6-day, 2-band, 10m+ pixels, 250km swath)

airborne L- and S- SAR (Cesna)
(seasonal, 200-band, 1m pixels, 7km swath)

UAS Lidar (Pulse Vapor Riegel VUX-1)
(ad hoc, 2-channel return, 15cm pixels)

UAS Quadcopter (DJ)
(ad hoc, 4-band, 1m pixels, 25hectares)

field level plots / terrestrial lidar
(ad hoc, 1m pixels, site)



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Field Work at a Lamprey / Oyster River Watershed Site

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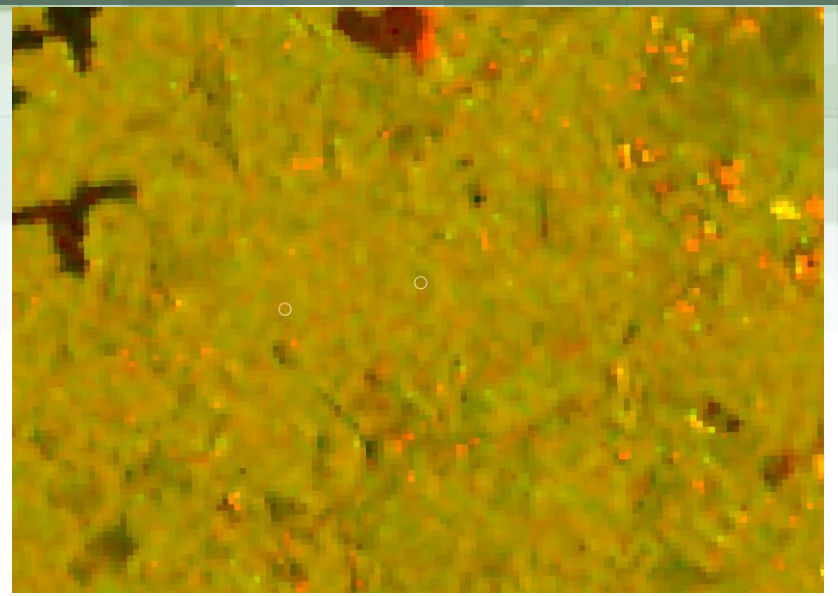
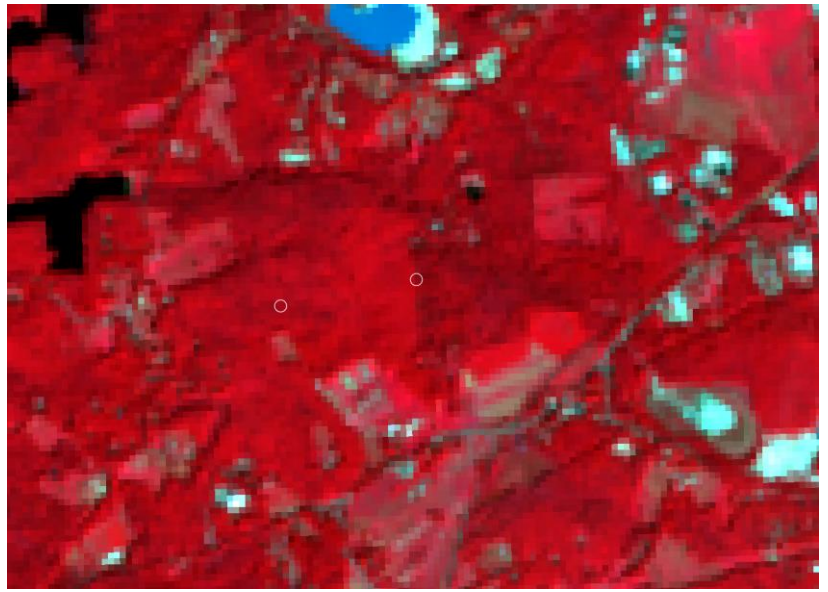
Satellite Sensor Data over Lamprey River Watershed Region

- Radar (L-band PALSAR-2, C-Band Seninel-1A):
  - Active sensor
  - through cloud cover
  - vegetation structure, geometry, and moisture content
  - wavelength frequency, polarization and viewing geometry
    - longer wavelengths (smaller frequency) = greater penetration of canopy
    - cross-pol (HV) or dual-pol (HH or VV)
    - incidence angle (θ)
- Optical (Landsat 8)
  - Passive sensor
  - susceptible to interference from clouds and other climate factors
    - Cloudmask
  - include the visible, near-, middle-, and shortwave-infrared
  - detecting and measuring forest health





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Components of a Lidar System

- Laser device
- inertial navigational measurement unit (IMU)
  - continuously records aircraft's orientation
- High-precision airborne global positioning system (GPS) unit
- computer interface
  - manages communication among devices and stores data
- GPS base station
  - known location on the ground
  - within 50 km of the aircraft

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Lidar Basics

- Laser device emits pulses of light
  - determines the range to a target
- Distance to target = time delay between the emission of the pulse and the detection of the reflected (backscattered) signal
- Pulses in the near-infrared part of the spectrum (1040 - 1065 nm)
  - topographic mapping and forestry applications
- Often cost-prohibitive
  - Very high spatial resolution
  - Expensive equipment
  - not easy to collect (need pilot, someone knowledgeable about sensor systems)

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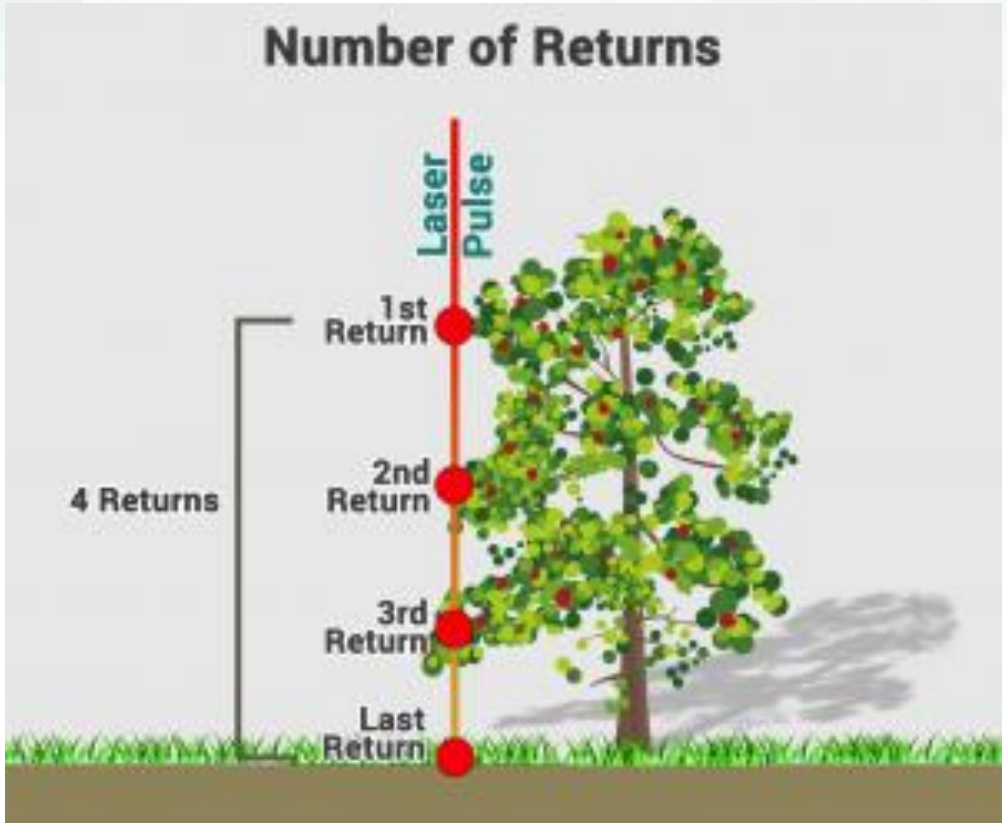
Lidar Basics, cont…



- Pulse density = spatial resolution
- Return density = mean number of returns in the data set in a unit square area
- Return intensity
  - strength of the beam backscattering
  - Depends on target reflectance properties
  - Can be used in classification
- Return number = rank of a return among those generated from a single beam
- Number of returns
- Classification scheme (2=ground,3=low vegetation,

4=medium vegetation, etc...)

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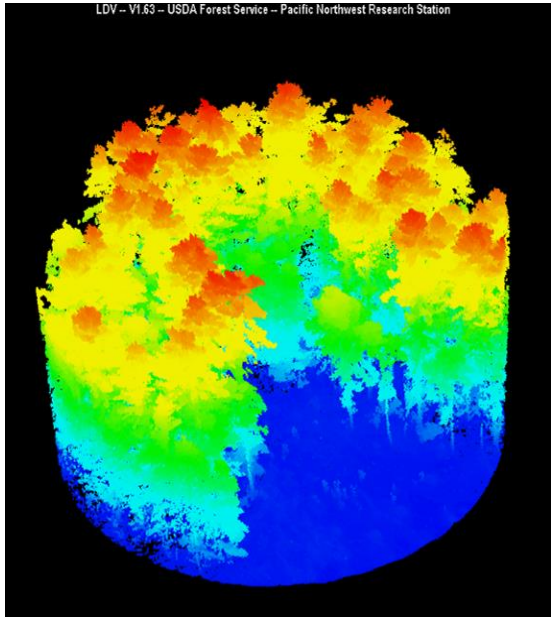
Open-source Lidar Tools

- Lidar2dems
  - Create DEMs from Lidar data, uses PDAL
  - Locally developed tool, AGS/UNH/outside developers
- FUSION
  - Generate point cloud statistics, canopy cover stats, select/display Lidar data
  - developed by the Silviculture and Forest Models Team, Research Branch of the US Forest Service
- PDAL (Point Data Abstraction Library)
  - translates and processes point cloud data
- LAStools
  - classify, tile, convert, filter, raster, triangulate, contour, clip, and polygonize LiDAR data

LAS files- (Lidar Data Exchange File, binary)



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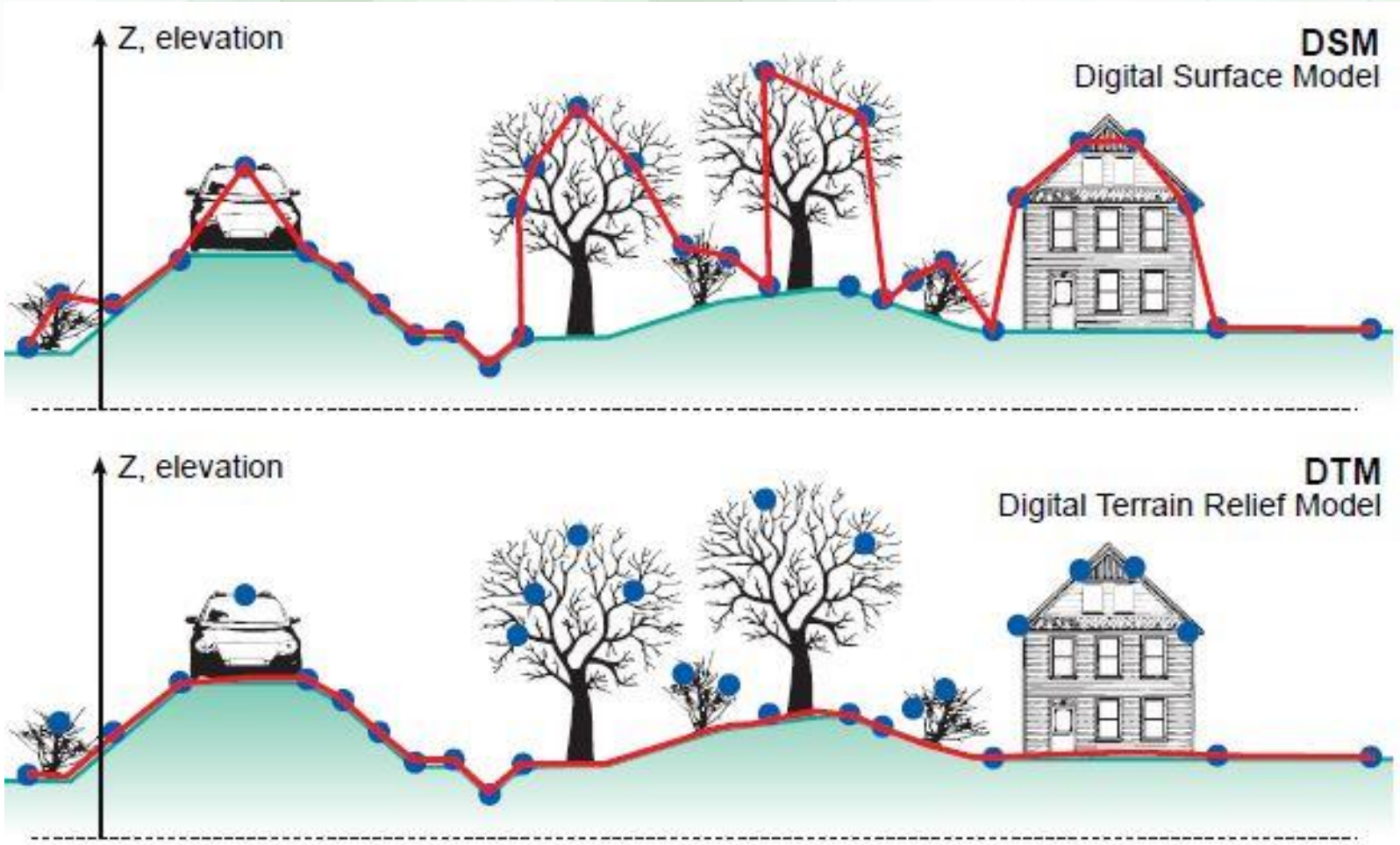
Lidar Products



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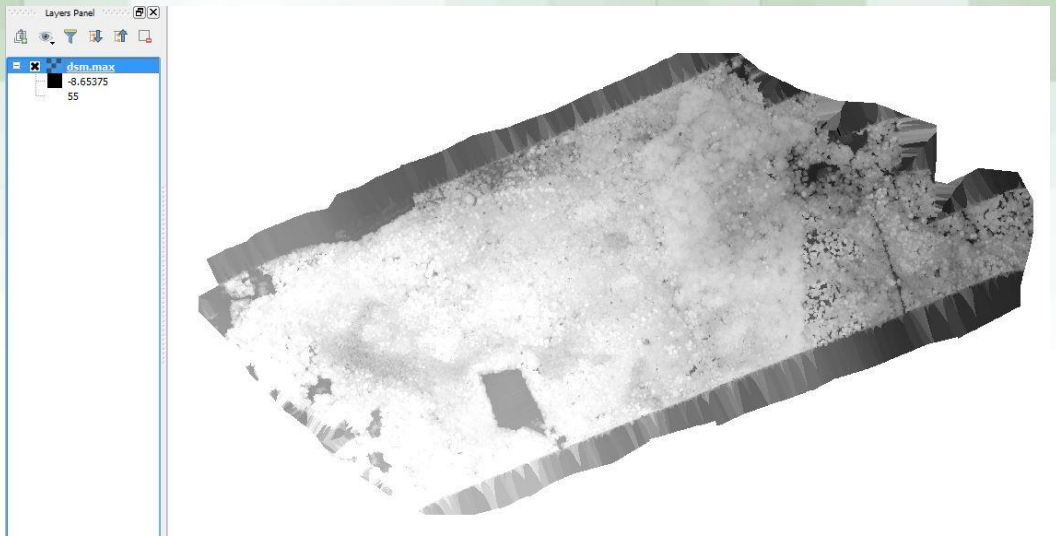
Lidar Products, etc…



DSM

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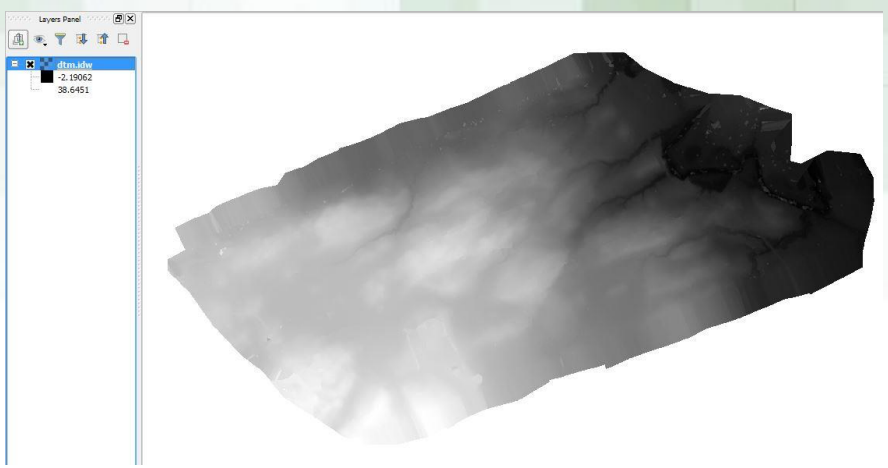

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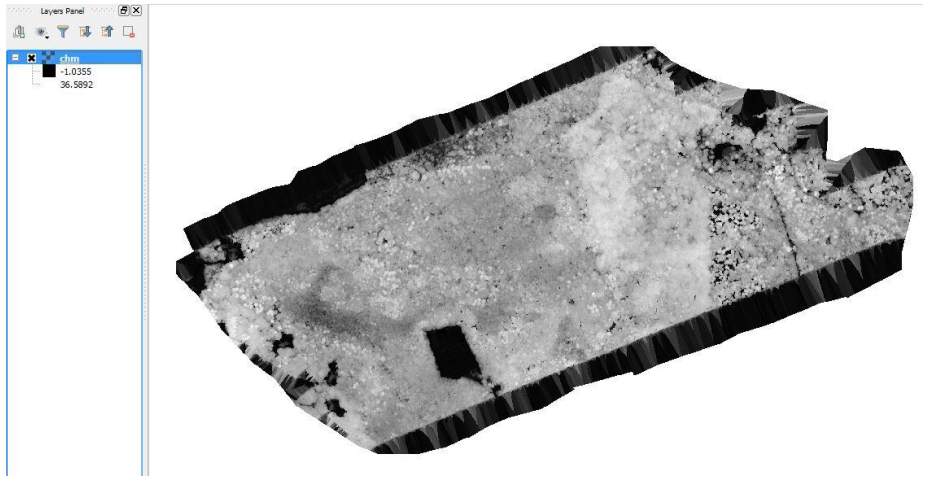

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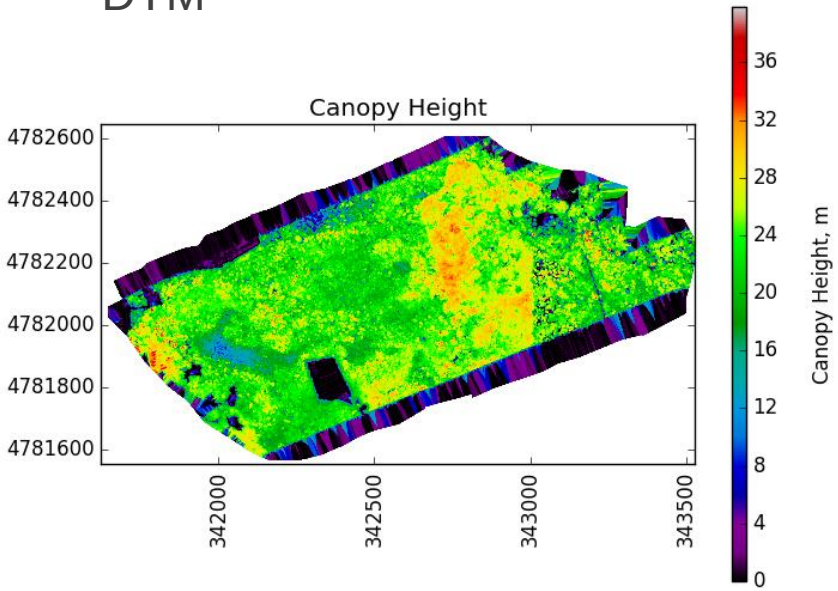

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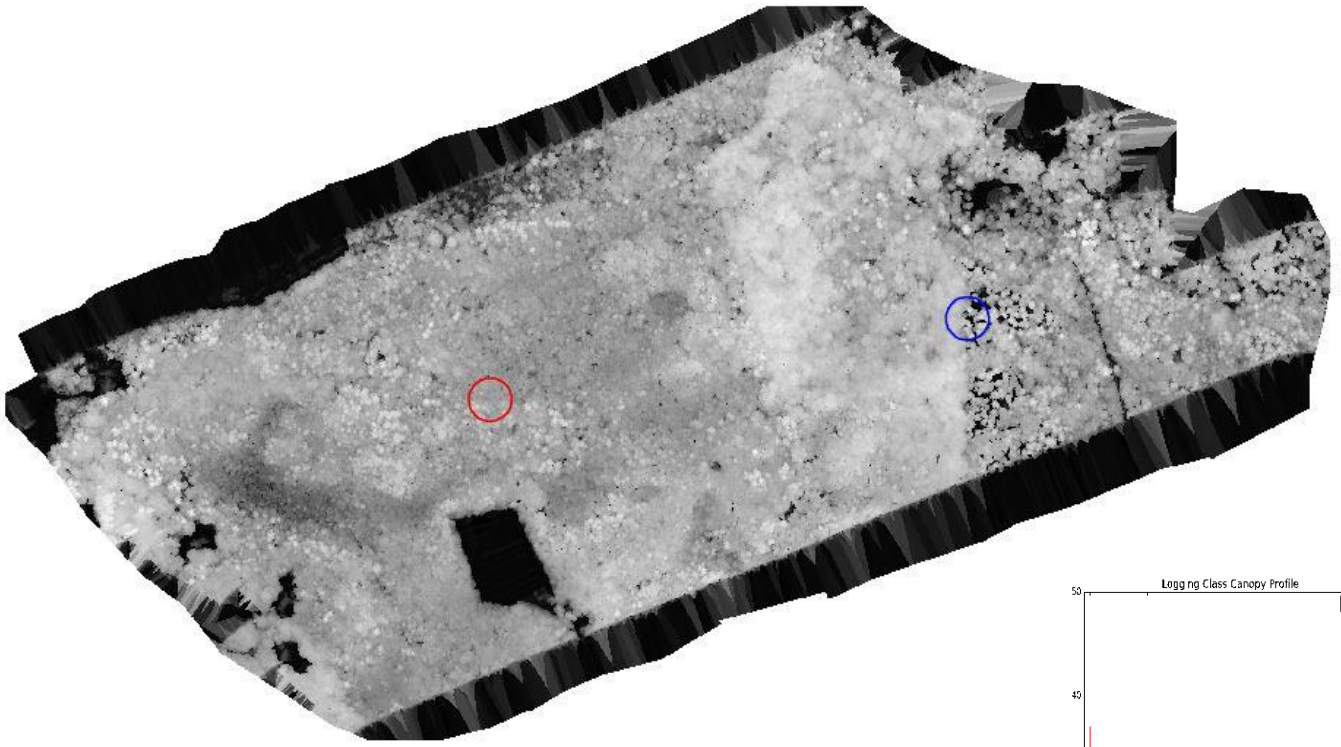
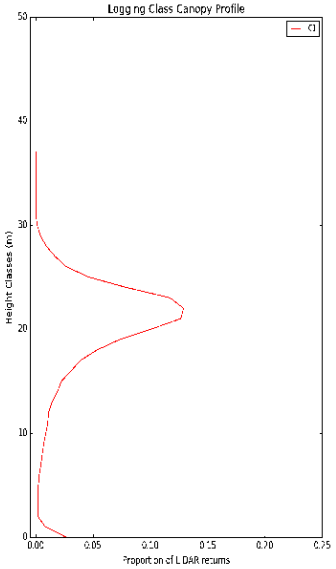
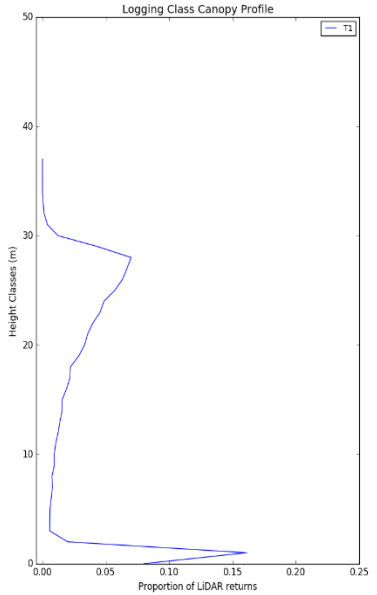
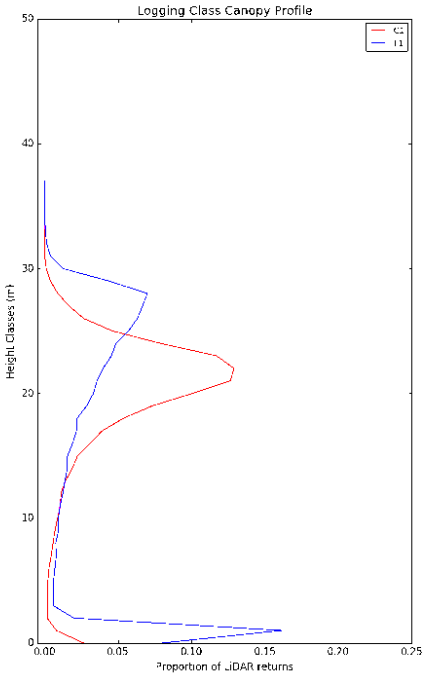
Field Data Collection Sites- Kingman Farm









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Conclusions

- Multi-sensor fusion / combination provides more thorough assessment
- Lidar very accurate tree height maps @ 1m resolution
- Repeat-pass InSAR fairly accurate height maps @ ~1-3 hectare scale

Next Steps

- Measuring tornado regrowth and shifts in forest structure (stand height, AGB, crown size)
- Gypsy Moth monitoring and forecasting this upcoming season (defoliation extent, intensity, timing)
- Other application partnerships in Lamprey watershed?

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Questions?

Thank you!

Happy to share products, code, and field data!

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