Lidar for Forest Monitoring

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5th UN-REDD Regional Lessons Learned Workshop on Forest Monitoring Systems and Reference Levels for REDD+

Hanoi, Viet Nam

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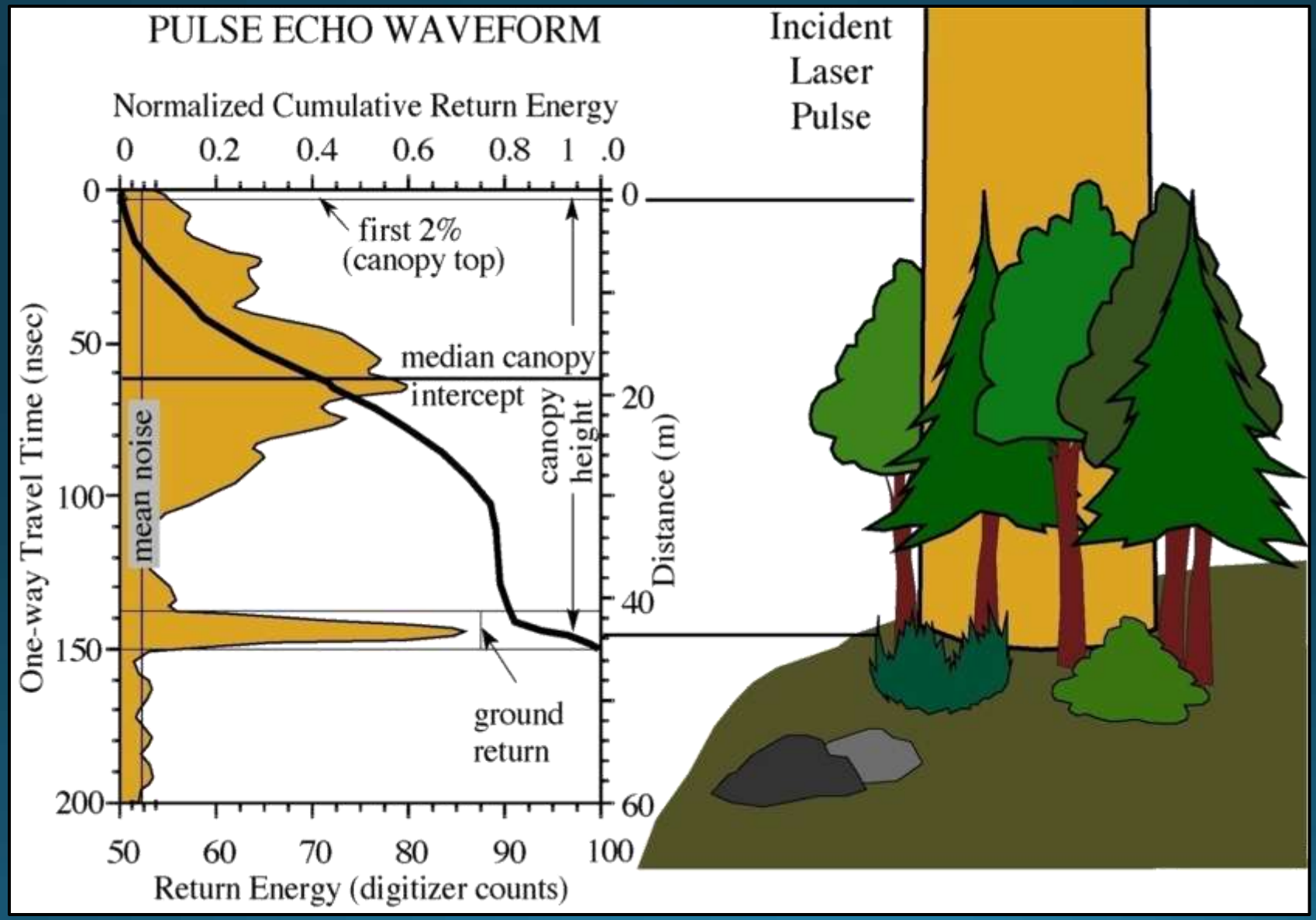
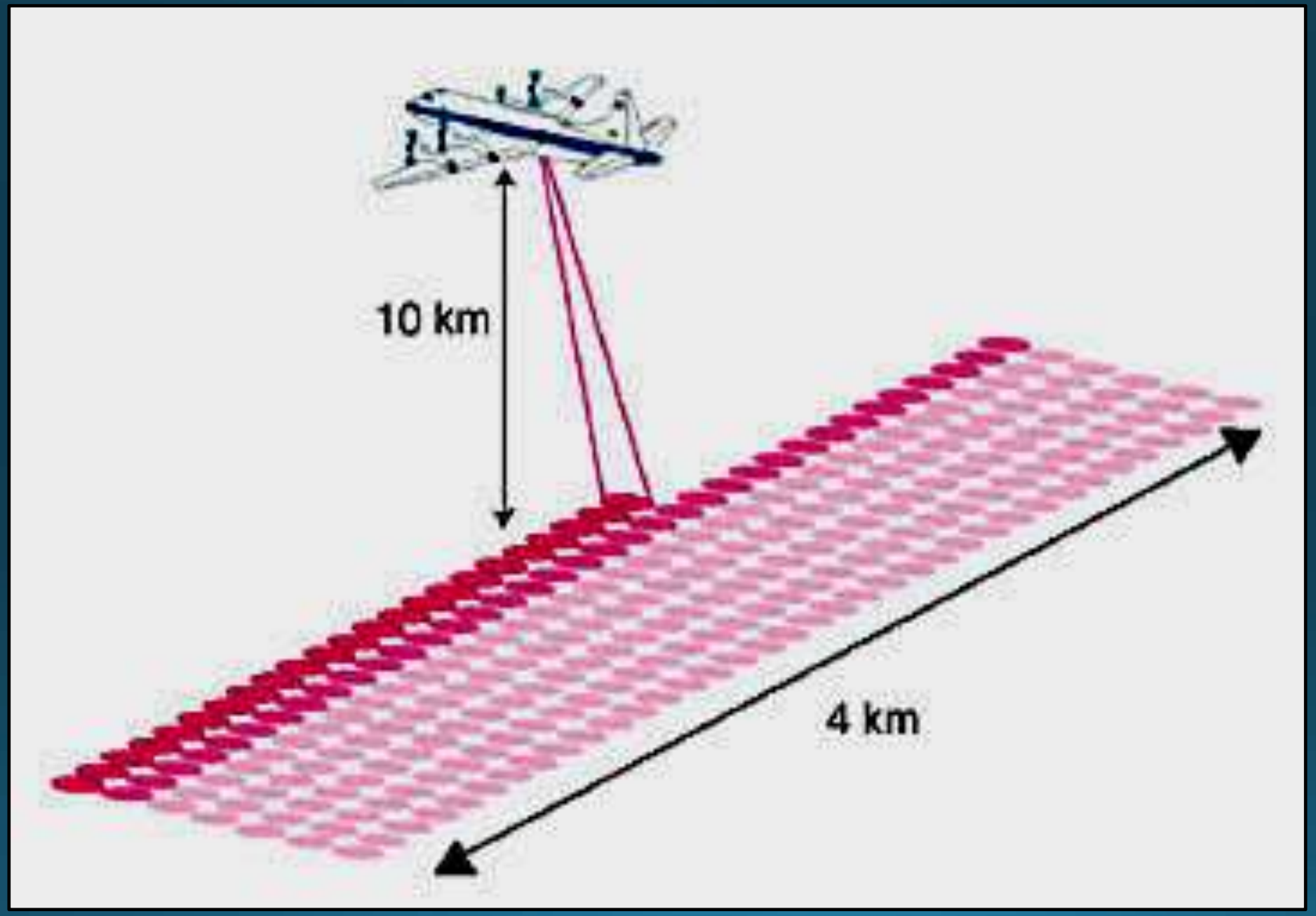
What is Lidar?

- Light Detection and Ranging
  - Laser altimeter
- Active remote sensing
  - Spaceborne
  - Airborne
  - Ground-based
- ICESAT, LVIS, SLICER, etc.
  - Coming soon: GEDI

- Many different types
  - Full waveform
    - Large to medium foot print (20 to 150 m resolution)
  - Discrete return
    - Small footprint (1-2 m resolution)
  - Photon counting
    - 15-20 pts/m^2

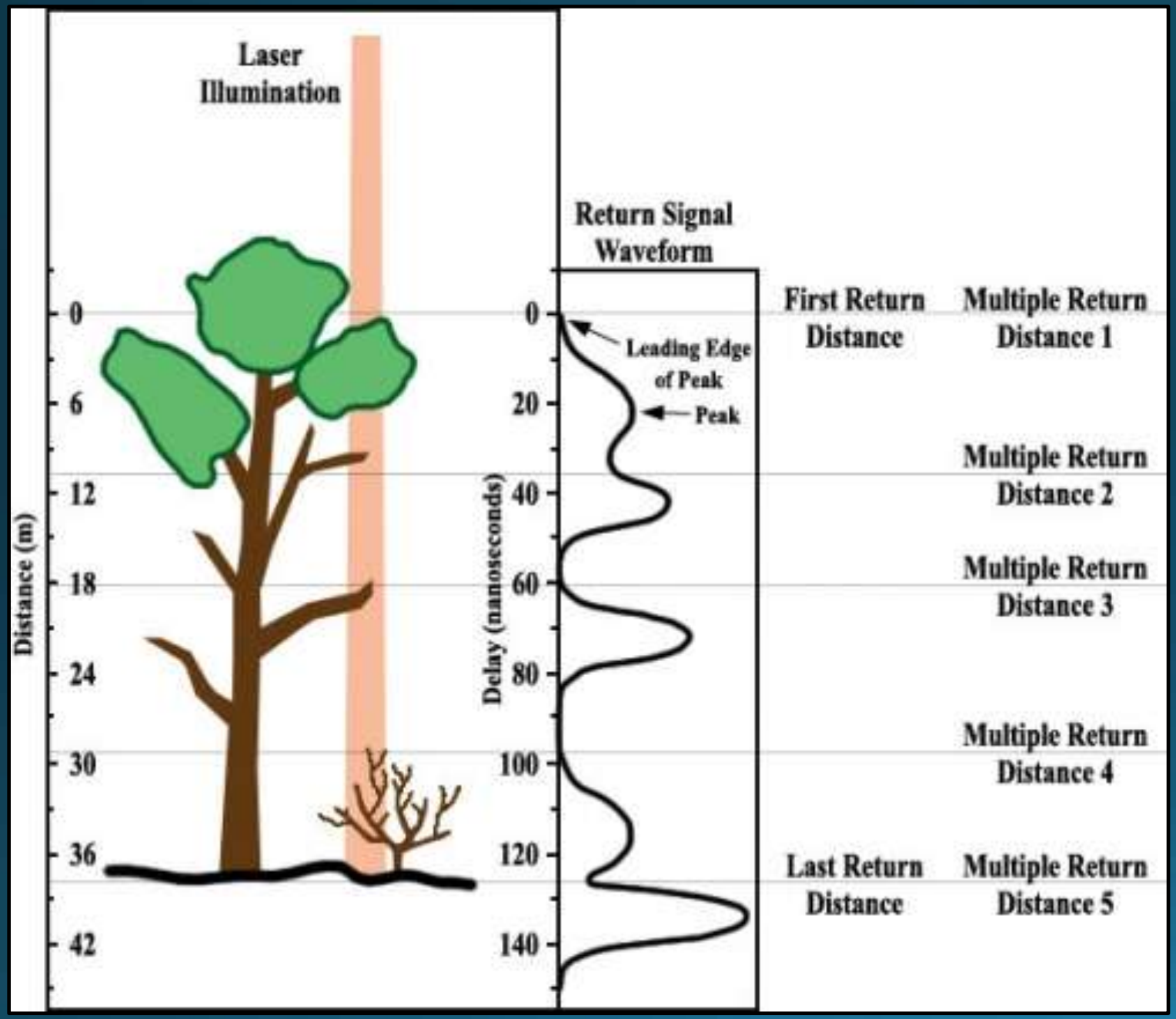
Waveform Lidar



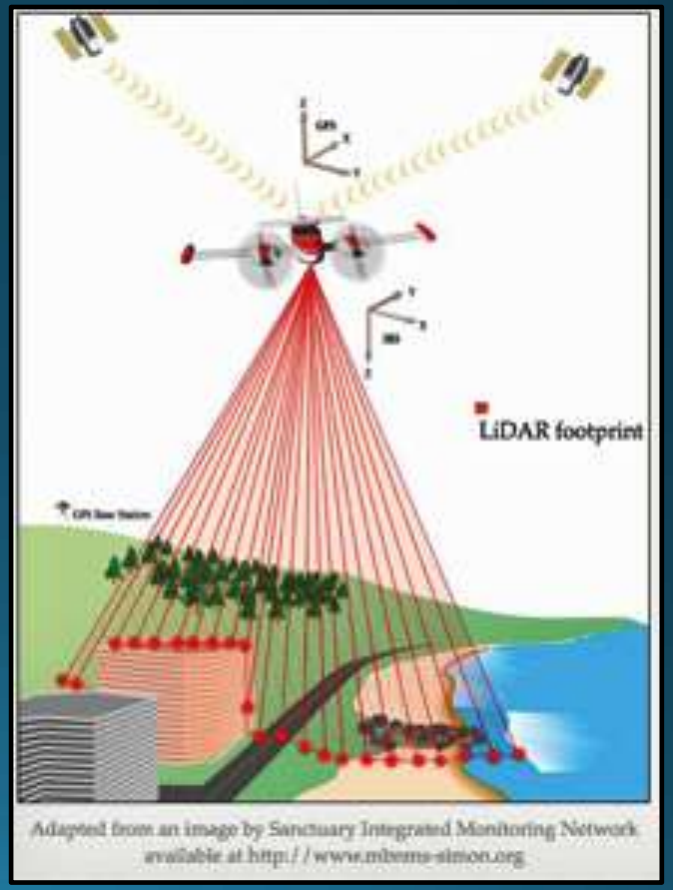


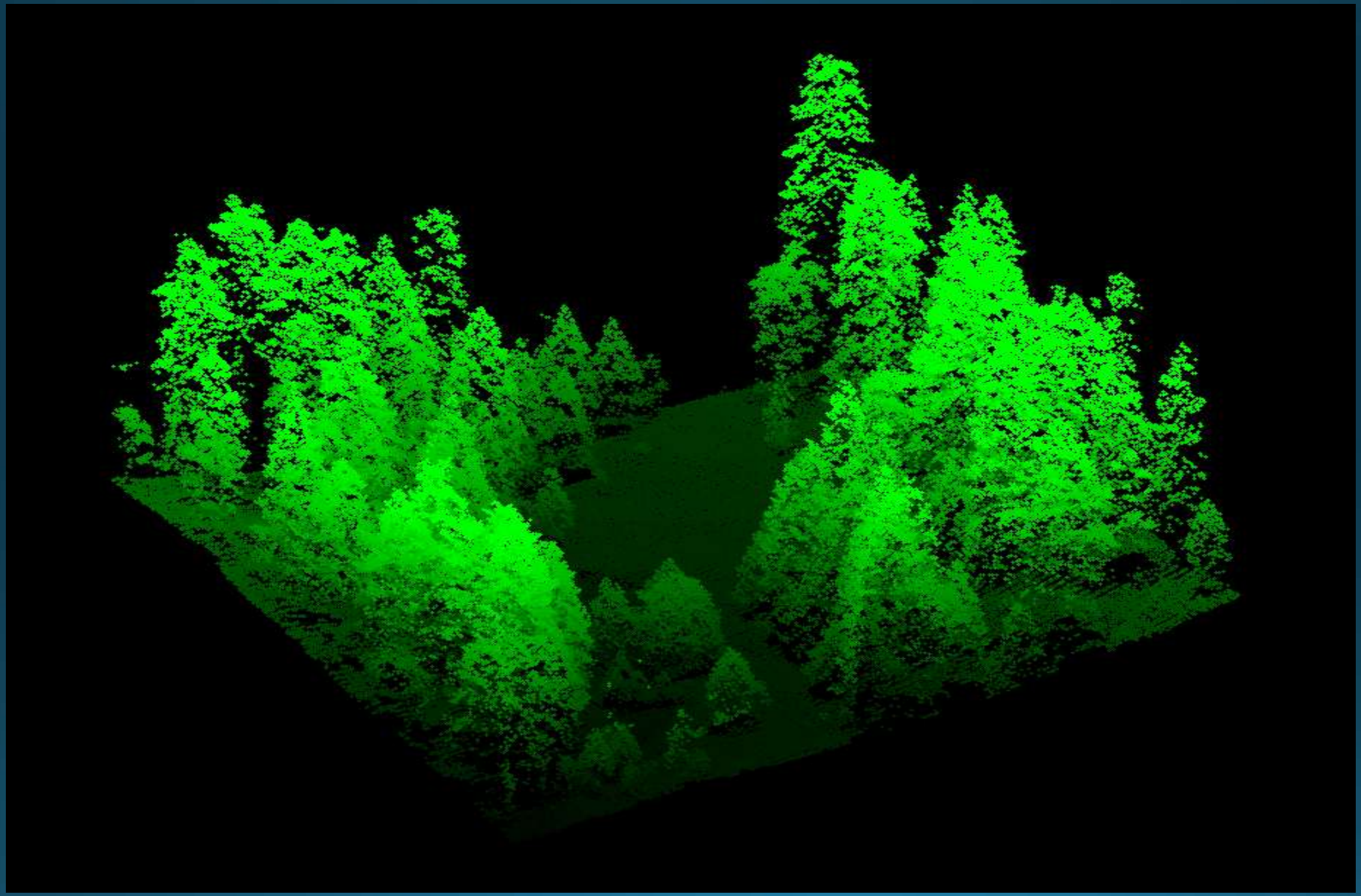
https://lvis.gsfc.nasa.gov/

Discrete Return Lidar



https://www.e-education.psu.edu/lidar/files/lidar/Figure_1_10.jpg





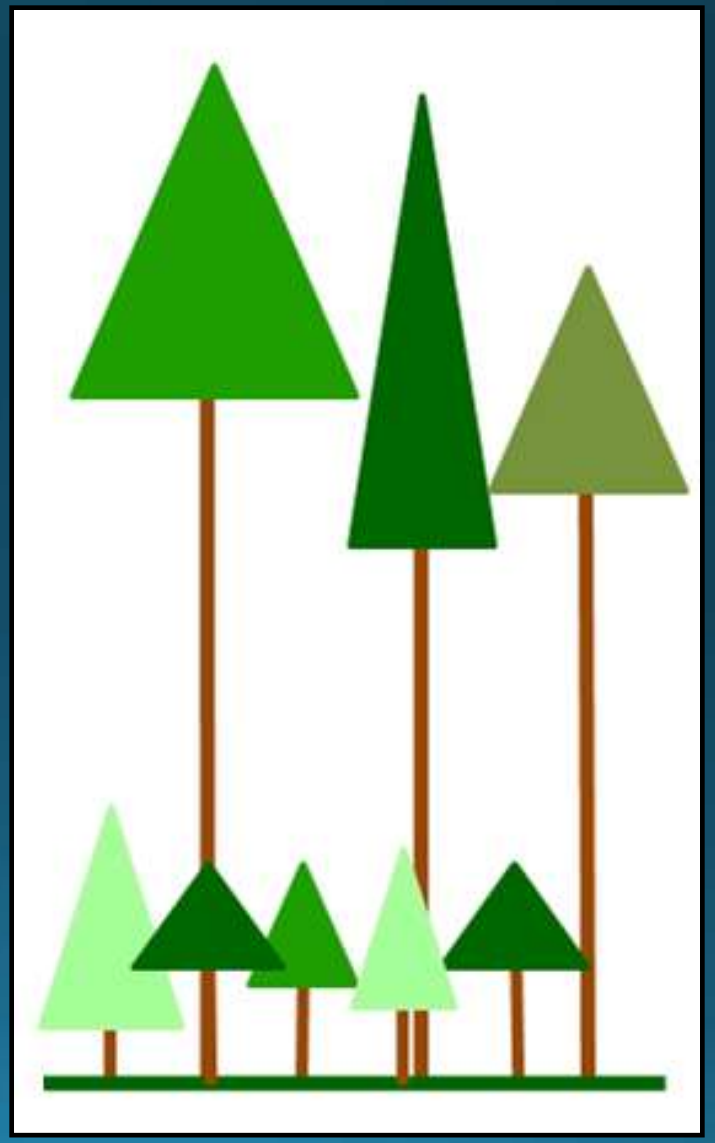
http://ucanr.edu/blogs/Green/blogfiles/11605_original.png

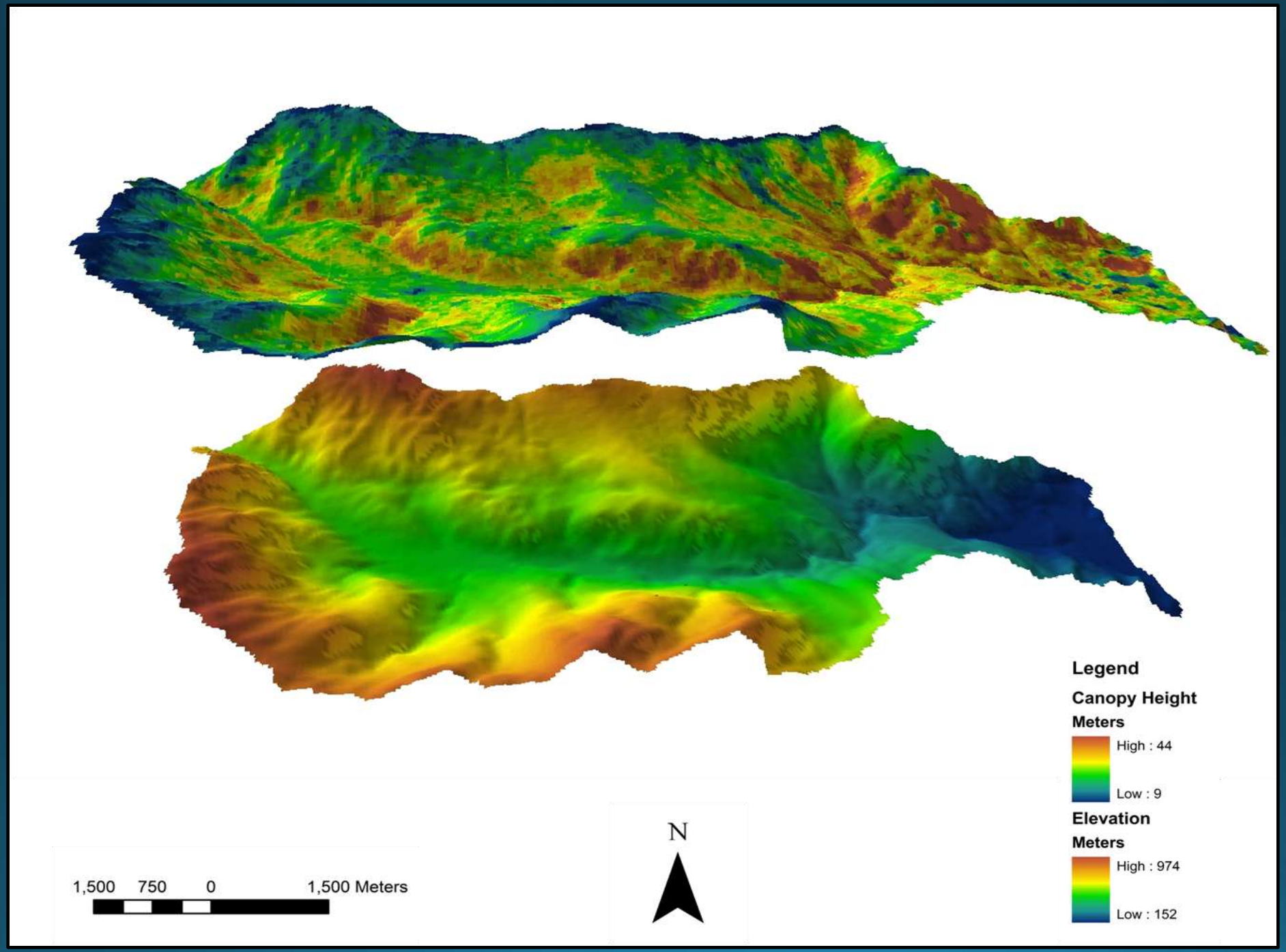
How do we use the data?

- **Topography**
  - Flood events: predictions and analysis
  - Erosion
  - Volcano lava flows and explosions
- **Forest Structure**
  - Vertical structure
    - Stand structure and canopy cover
  - Habitat analysis and characterization
  - Biomass estimates/carbon stocks
  - Forest monitoring
- **Fusion**
  - Radar
  - Hyperspectral
  - Optical
    - Landsat/Modis

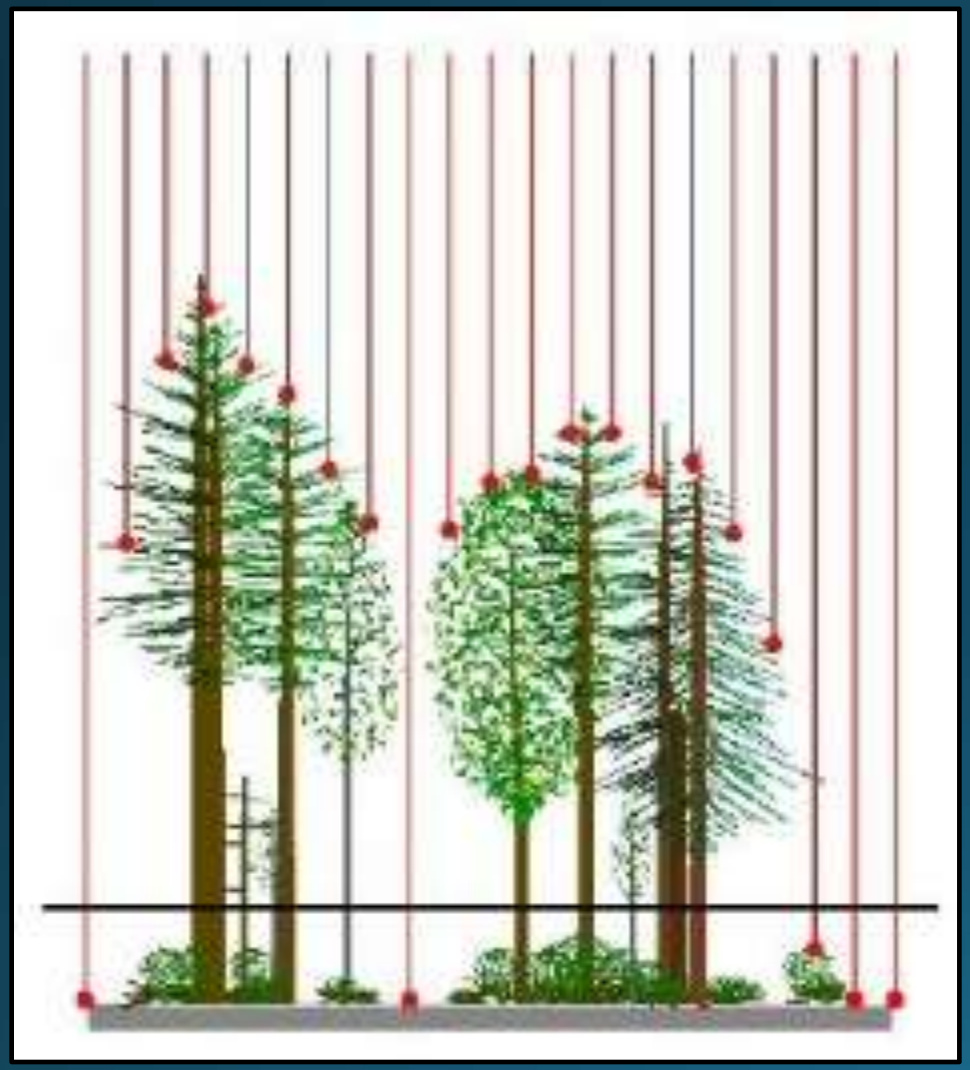
Forest Structure and Biomass

- Essential part of forest ecosystem dynamics
  - Plant species diversity
  - Plant growth
  - Animal species diversity and habitat
  - Biomass estimation
- Elements of vertical structure
  - Canopy height
  - Canopy cover
  - Layering




Legend
Canopy Height
Meters
High : 44
Low : 9
Elevation
Meters
High : 974
Low : 152
N
1,500 750 0 1,500 Meters

Canopy Cover



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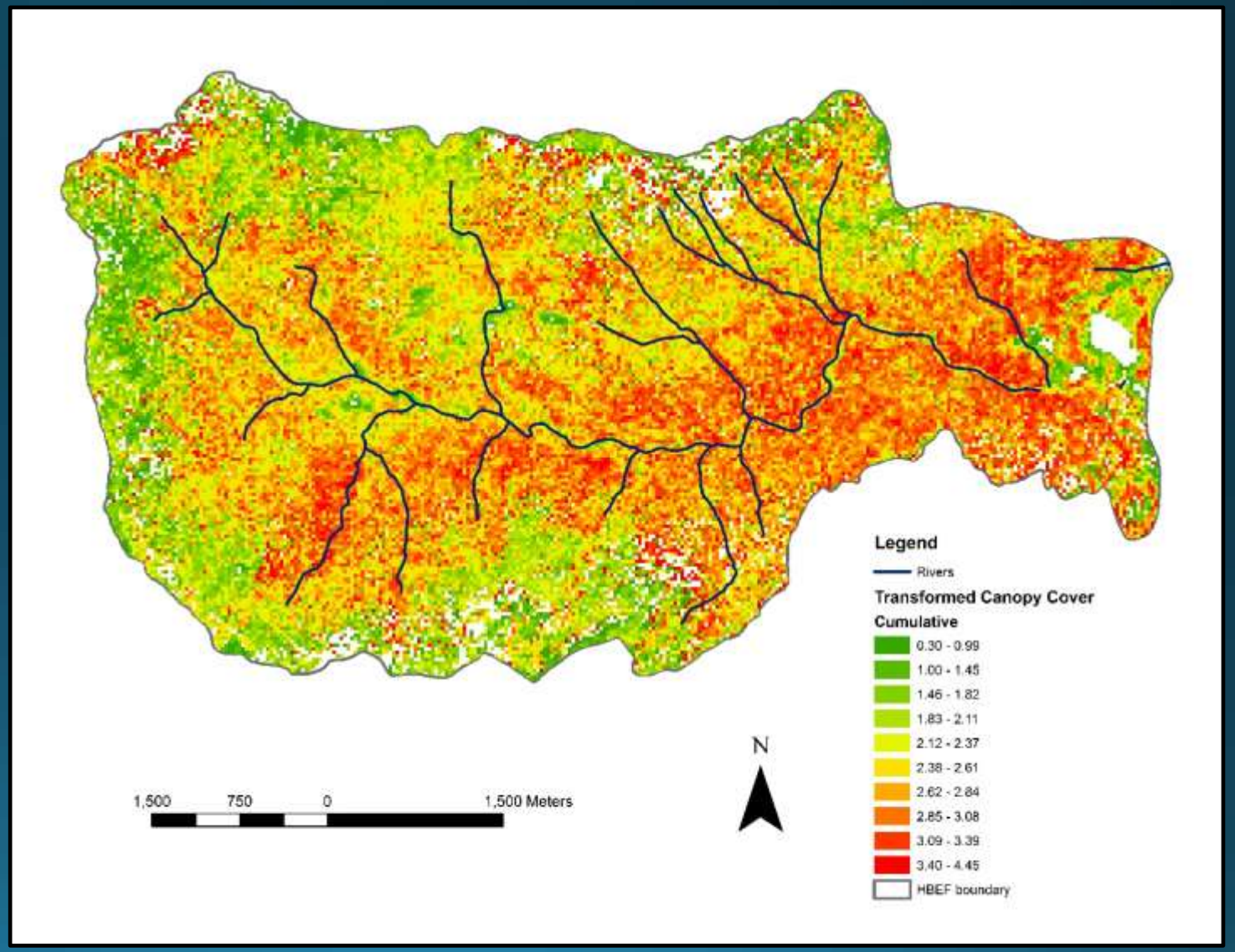


Biomass Estimation

- Allometric equations
  - Equations that relate above ground tree biomass to specific tree measurements
    - Height/height to live crown
    - Diameter at breast height (dbh)
    - Crown diameter
    - Tree species identification

- Biomass determined from field work is used to determine equations for above ground biomass using lidar metrics

- Typical lidar metrics used
  - Canopy height
  - Height of median return
  - Canopy cover

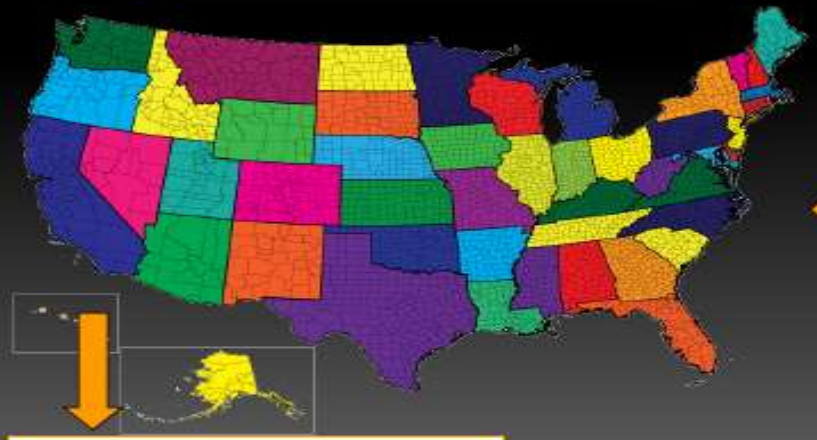
NASA Carbon Monitoring System

- US national initiative to monitor carbon stocks and fluxes
  - Lead to a better understanding and quantifying of carbon sources and sinks

- Biomass pilot project
  - Quantify vegetative carbon stocks

Nested Scales of Observations

National Mapping

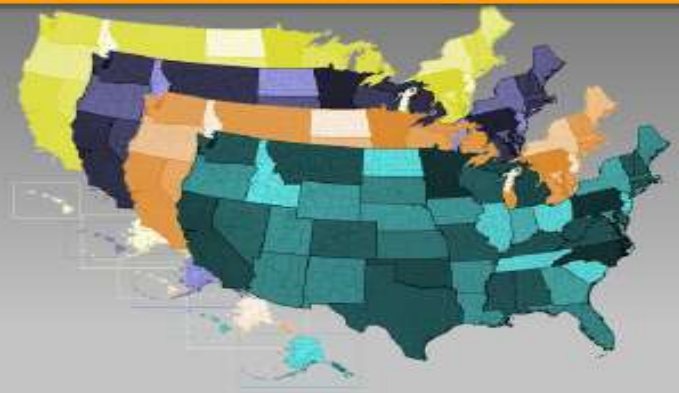


Validation

Local Mapping

National/State Reporting

Comprehensive Carbon Monitoring System

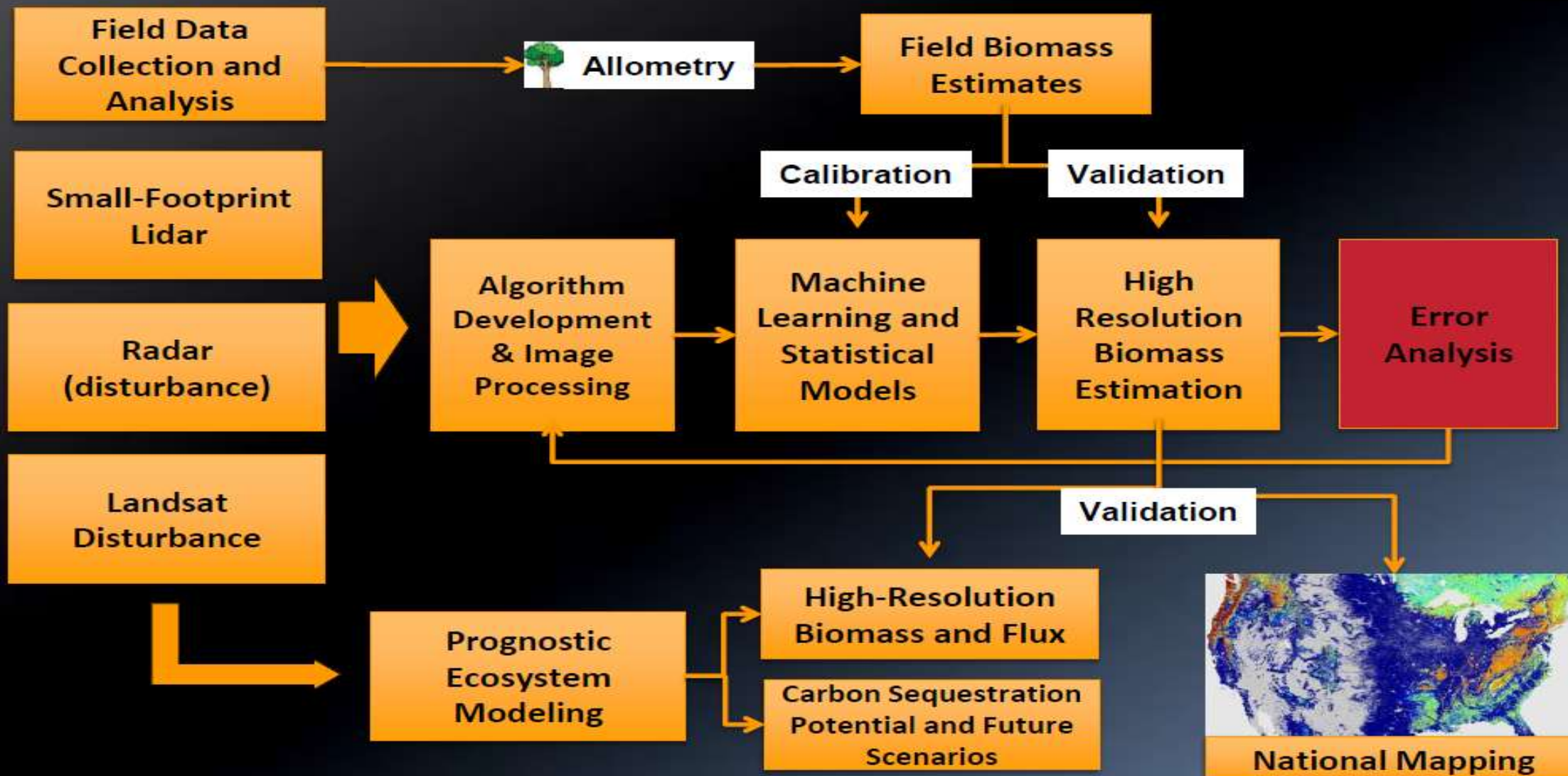


Project Valuation
Policy/Management

OBSERVATIONAL DRIVERS
Space-based

OBSERVATIONAL DRIVERS
Aircraft, Ground & Space-based

Methodological Approach



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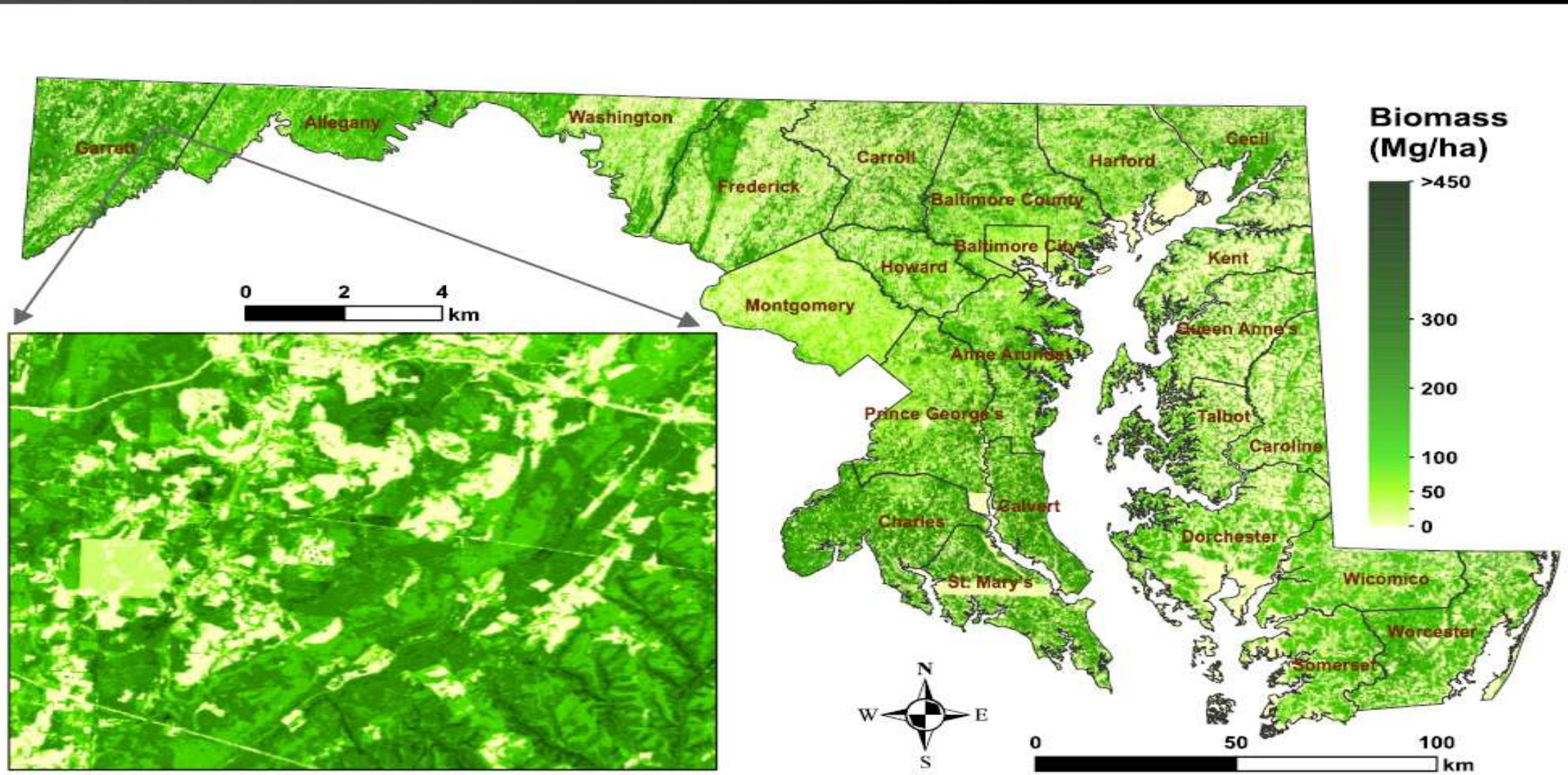
UNIVERSITY OF MARYLAND

Empirical Biomass [30 m]



Field Work and Validation

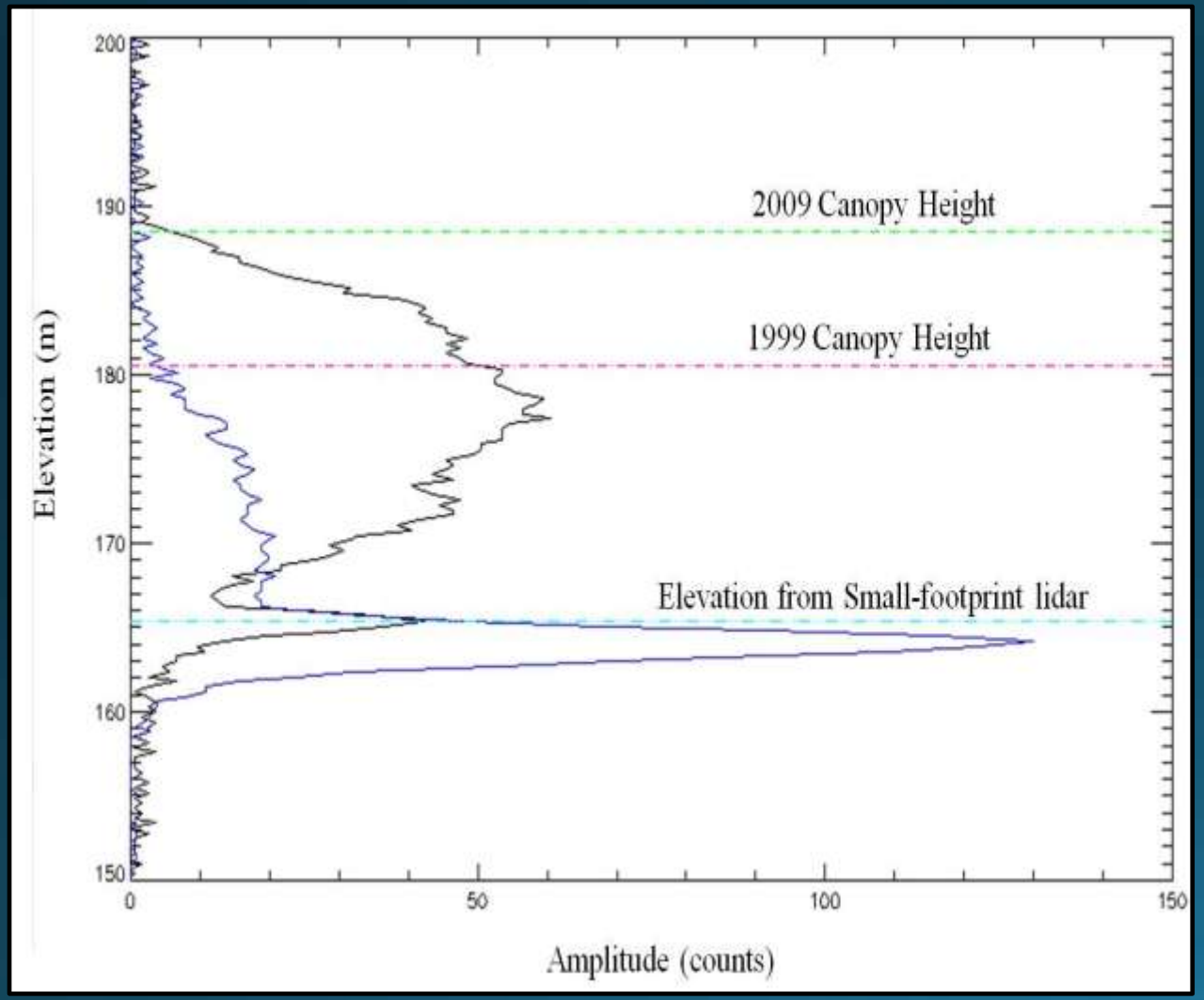
What do we need to validate?

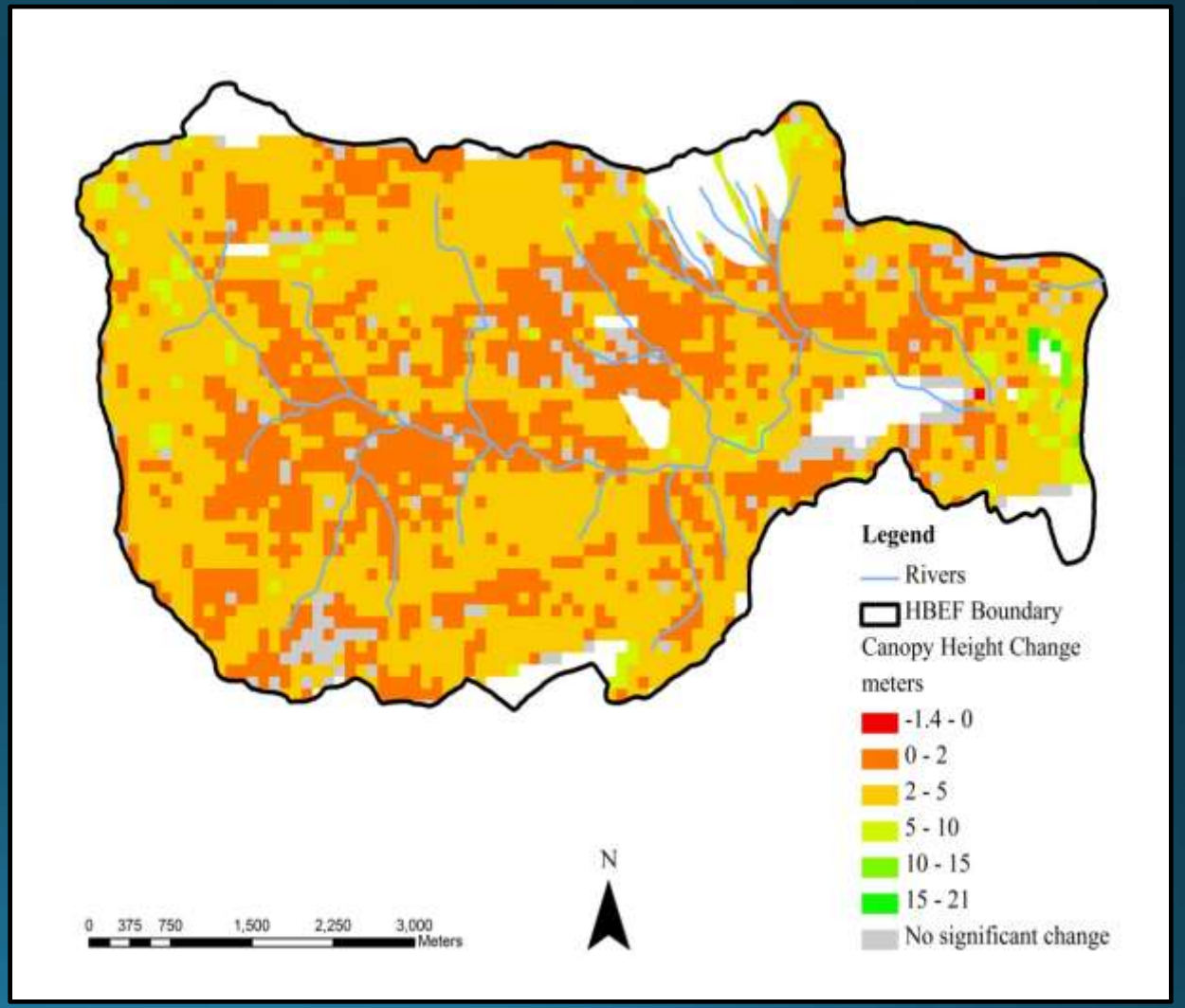
- Height
- Biomass
  - Species
  - Dbh
  - Crown measurements
- Location

Forest Monitoring using Lidar

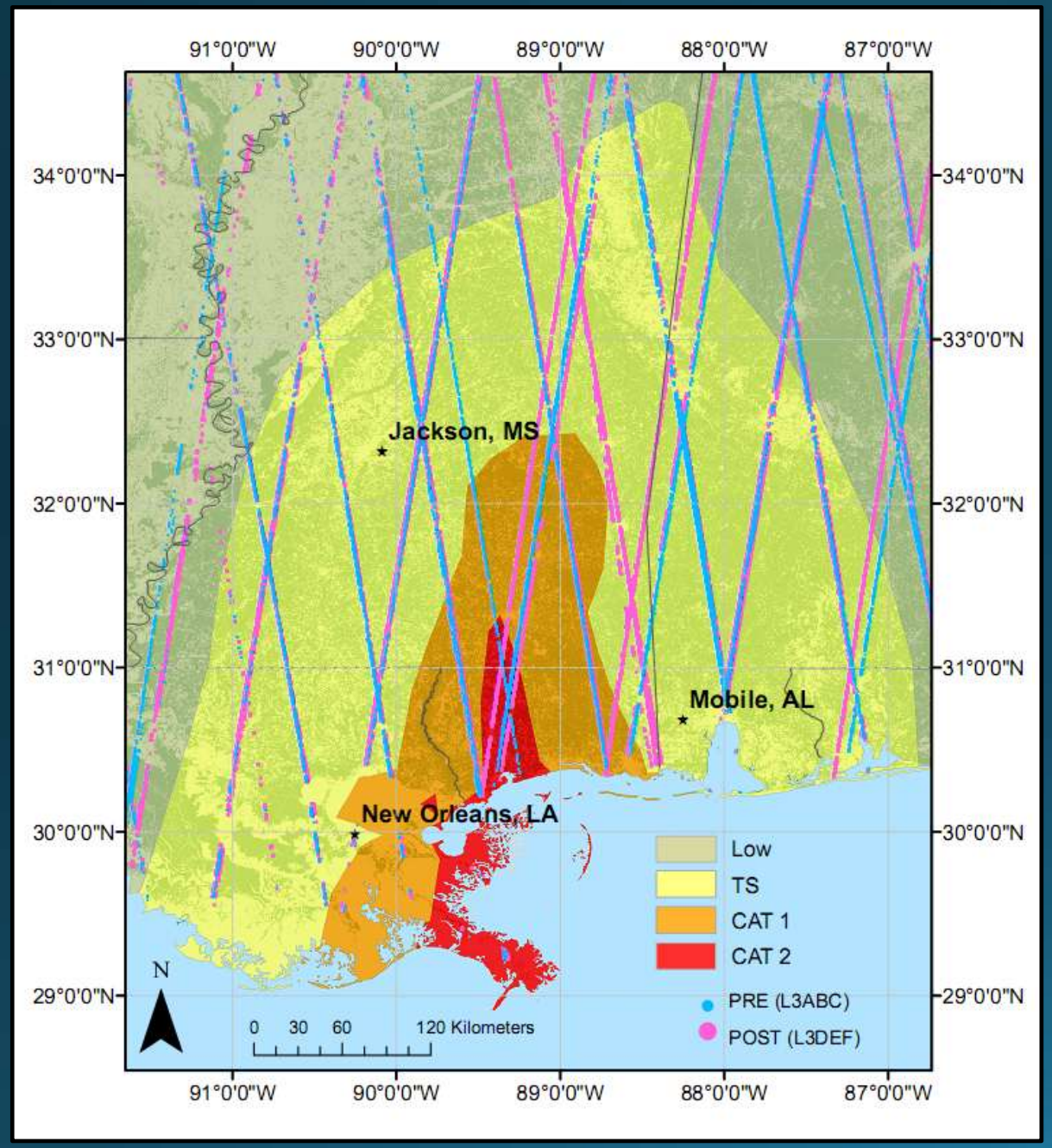
- Lidar data from 2 separate time points
  - Comparable instruments
  - Same type of lidar
  - Reprocessing may be necessary
  - Only as detailed as the coarsest scale dataset

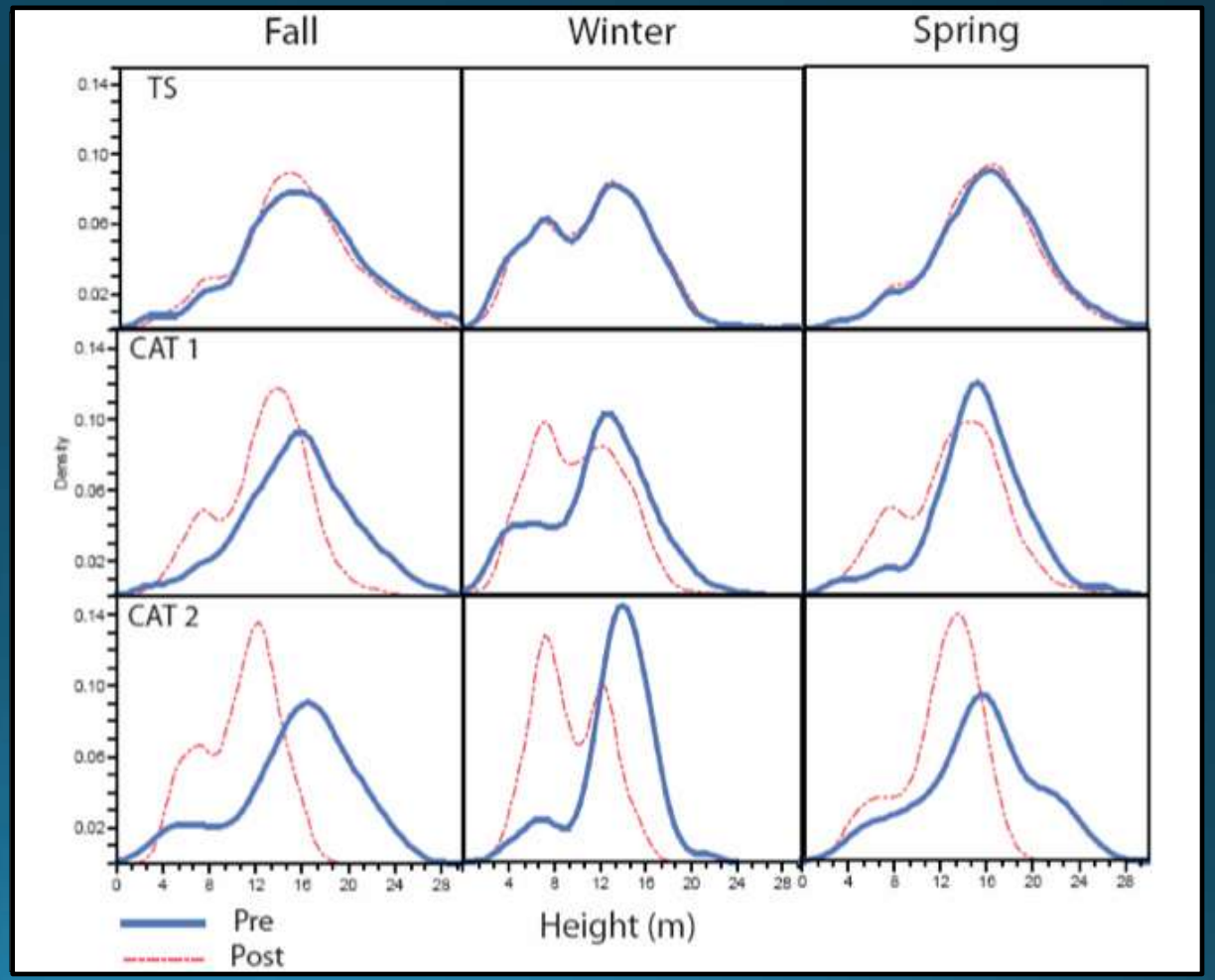
Canopy Height Change





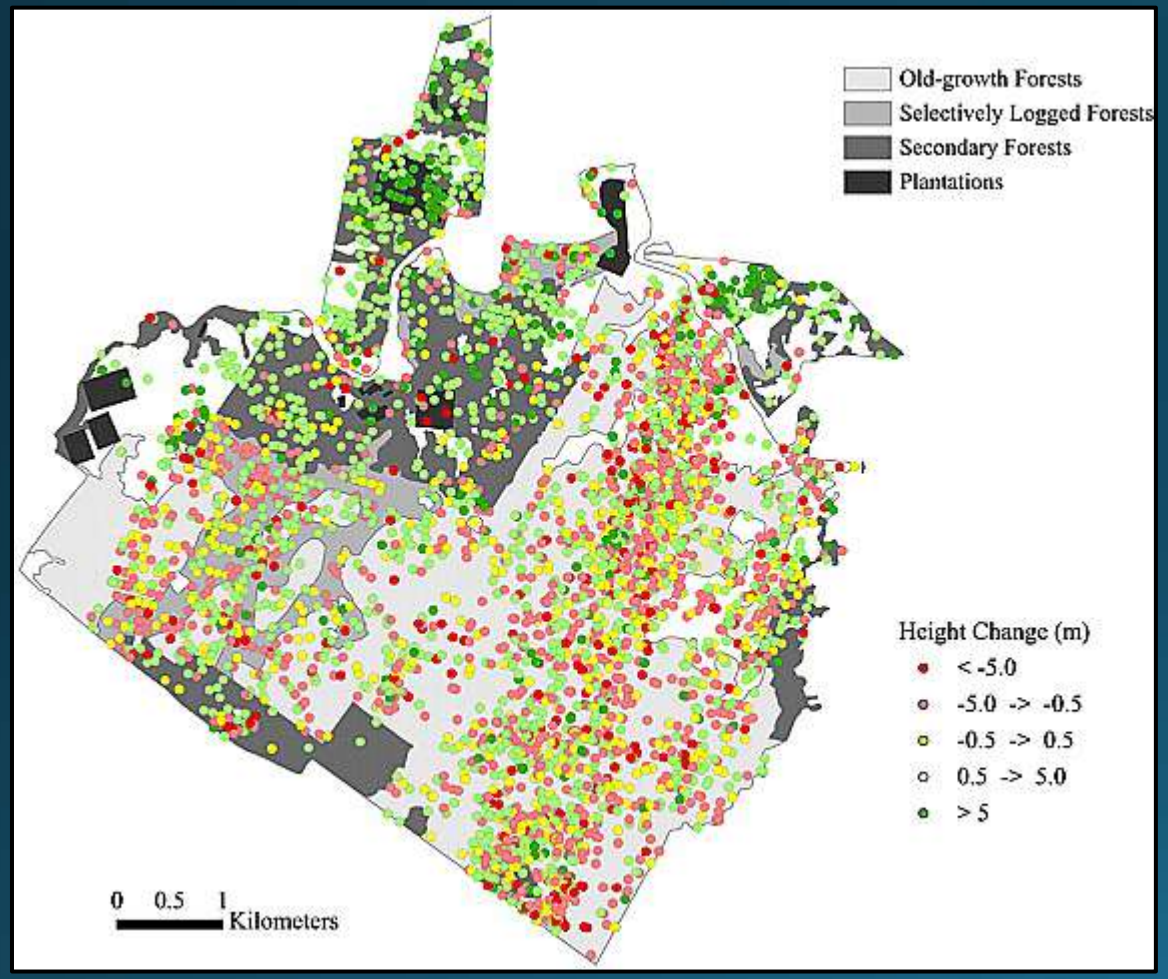
Disturbance following Hurricane Katrina



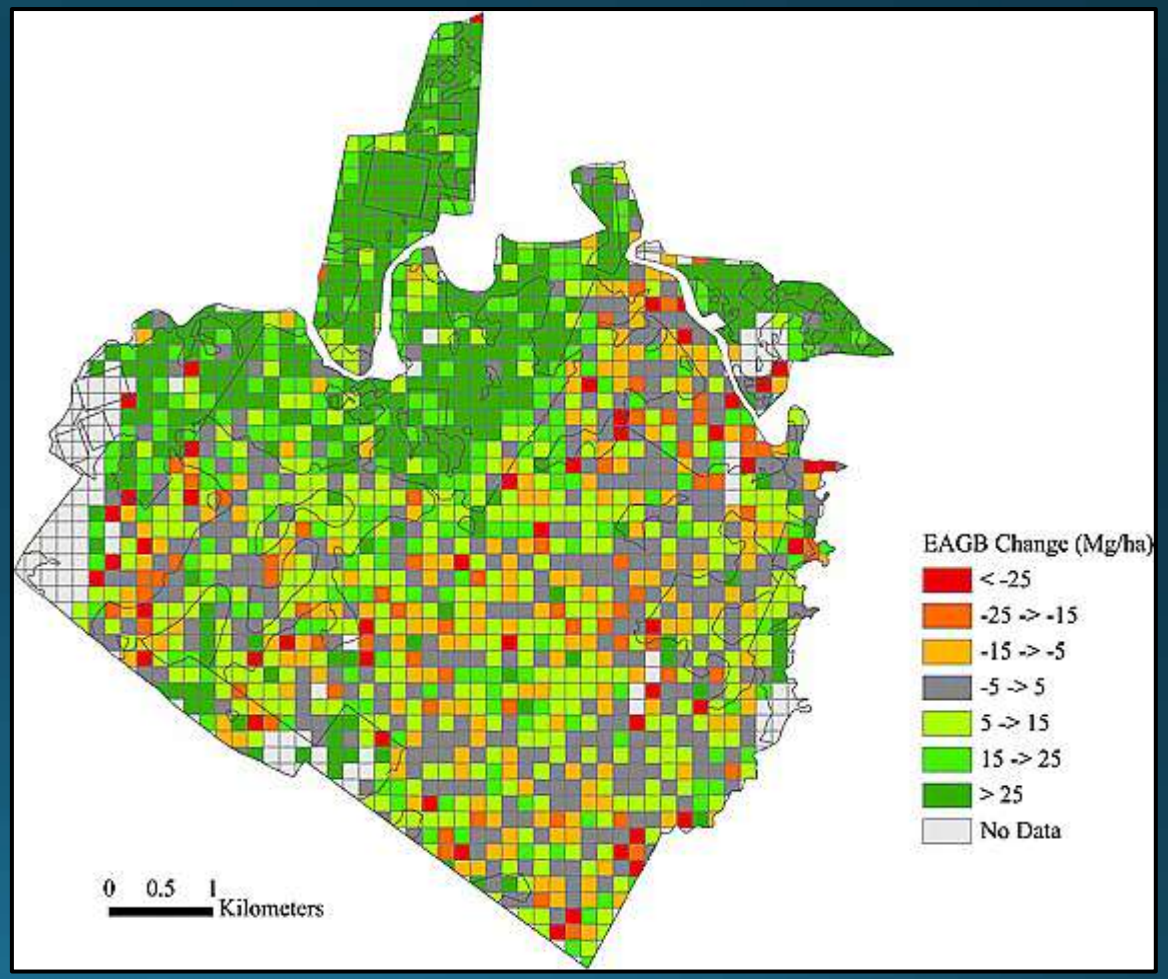


Dolan et al 2011

Estimation of tropical forest height and biomass dynamics using lidar remote sensing at La Selva, Costa Rica



Journal of Geophysical Research: Biogeosciences
Volume 115, Issue G2, G00E09, 9 APR 2010 DOI: 10.1029/2009JG000933
http://onlinelibrary.wiley.com/doi/10.1029/2009JG000933/full#jgrg530-fig-0007



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Is Lidar right for the project?

- Is wall to wall coverage available/possible?
  - Holes/ data gaps in coverage (eg: HBEF and La Selva)
- Cost
- Computing power and software capability
  - Depends on the type of lidar
  - Depends on the data source (commercial vs non-commercial provider)

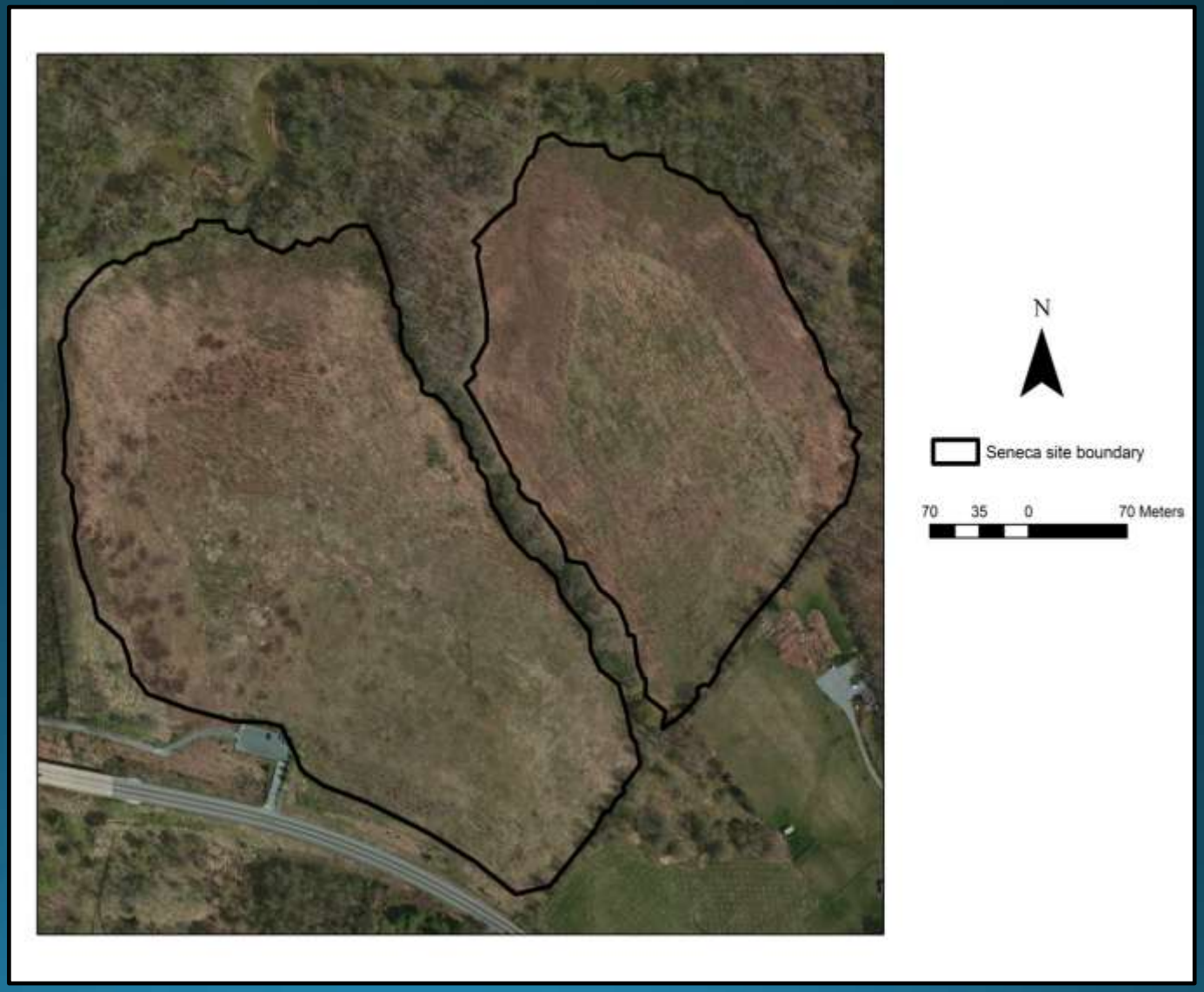
- Will some field work still be needed?
- Constantly changing/improving instruments and processing methodologies
  - Will the estimates be comparable between time-points?
- Sensor Detection Issues
  - Cloud cover
  - Ground detection
    - Steep slopes
    - Extremely thick canopy

Patapsco Valley

	Biomass (mg)
Field estimate	156.3
Lidar estimate	284.5

Seneca Creek

	Biomass (mg)
Field estimate	1215
Lidar estimate	133.7



Questions?