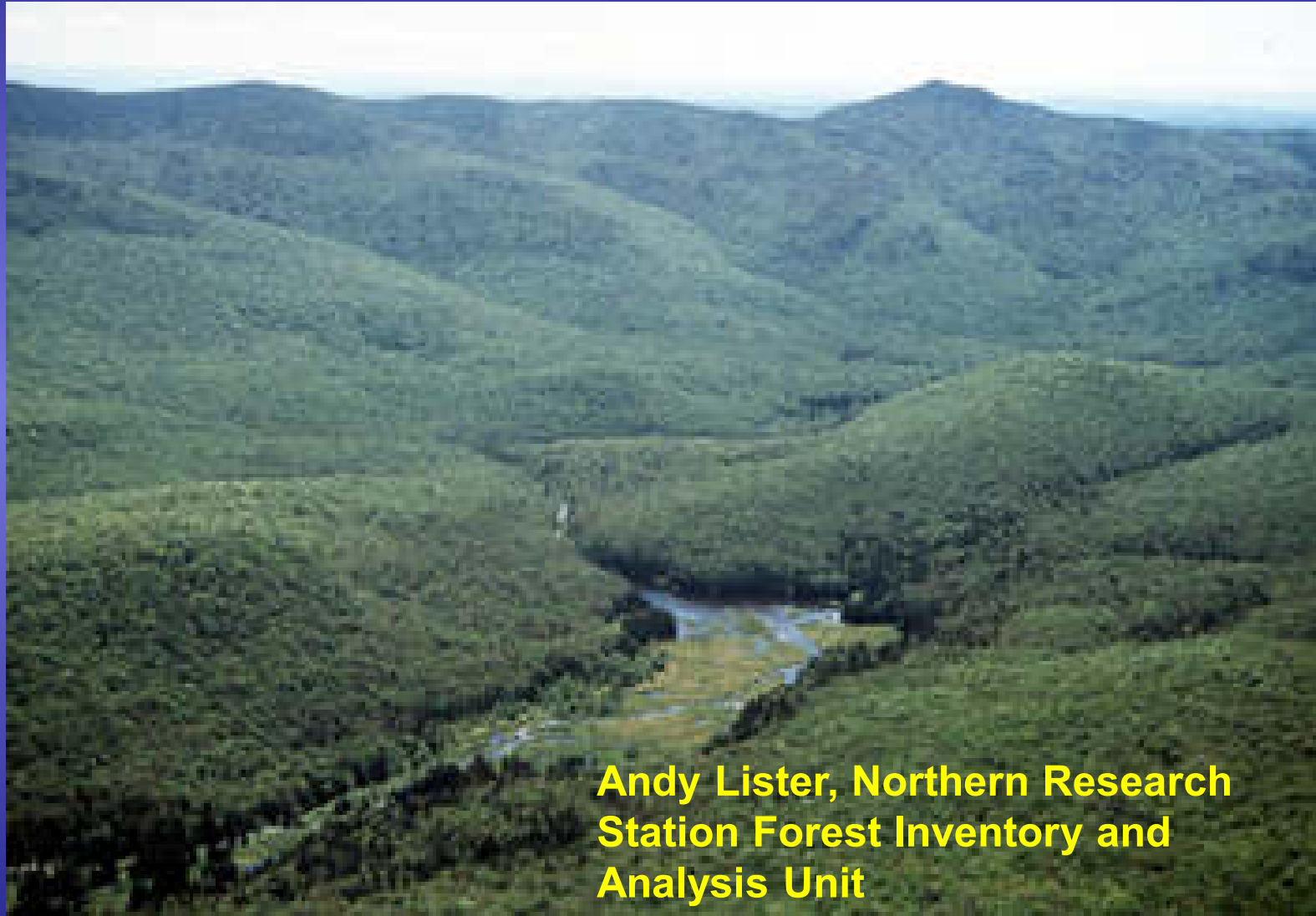# Remote Sensing Use in the USFS Forest Inventory and Analysis Program, and How NASA Can Help


Andy Lister, Northern Research Station Forest Inventory and Analysis Unit

Forest Inventory and Analysis Unit

Mission: To improve the *understanding and stewardship* of the nation's forests through *scientifically credible inventories* and analyses of the *status and trends* in forest condition, use and productivity, and by transferring timely resource information and new technology to the public.

This is achieved through *annual inventories* of the nation's forest resources, *analysis* of the inventory data, and *distribution of inventory results*.
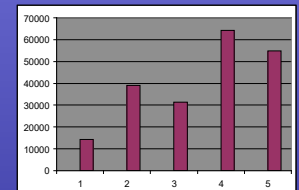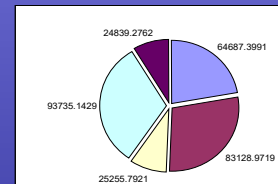
Inventory Results Table:

| County	Volume	Ownership	Species Group	Biomass	Mortality	Ingrowth	Harvest	Change
1	14371	56730.39012	Oak	79605.96412	31306.28131	80121.40539	93455.01459	42831.01747
2	38948	64555.30212	Beech	12240.13443	31492.96588	13550.57375	1317.498007	60280.63085
3	31447	37208.29333	White Pine	99570.88063	6751.389567	26529.63796	68707.08833	93447.19781
4	64131	66062.35044	Red Spruce	98333.99503	59297.8659	85473.72362	58572.41038	60775.01106
5	54821	92516.30229	Birch	47001.81348	25942.92834	6631.936019	53376.34456	30212.58686

37 meters

120 degrees

7.3m
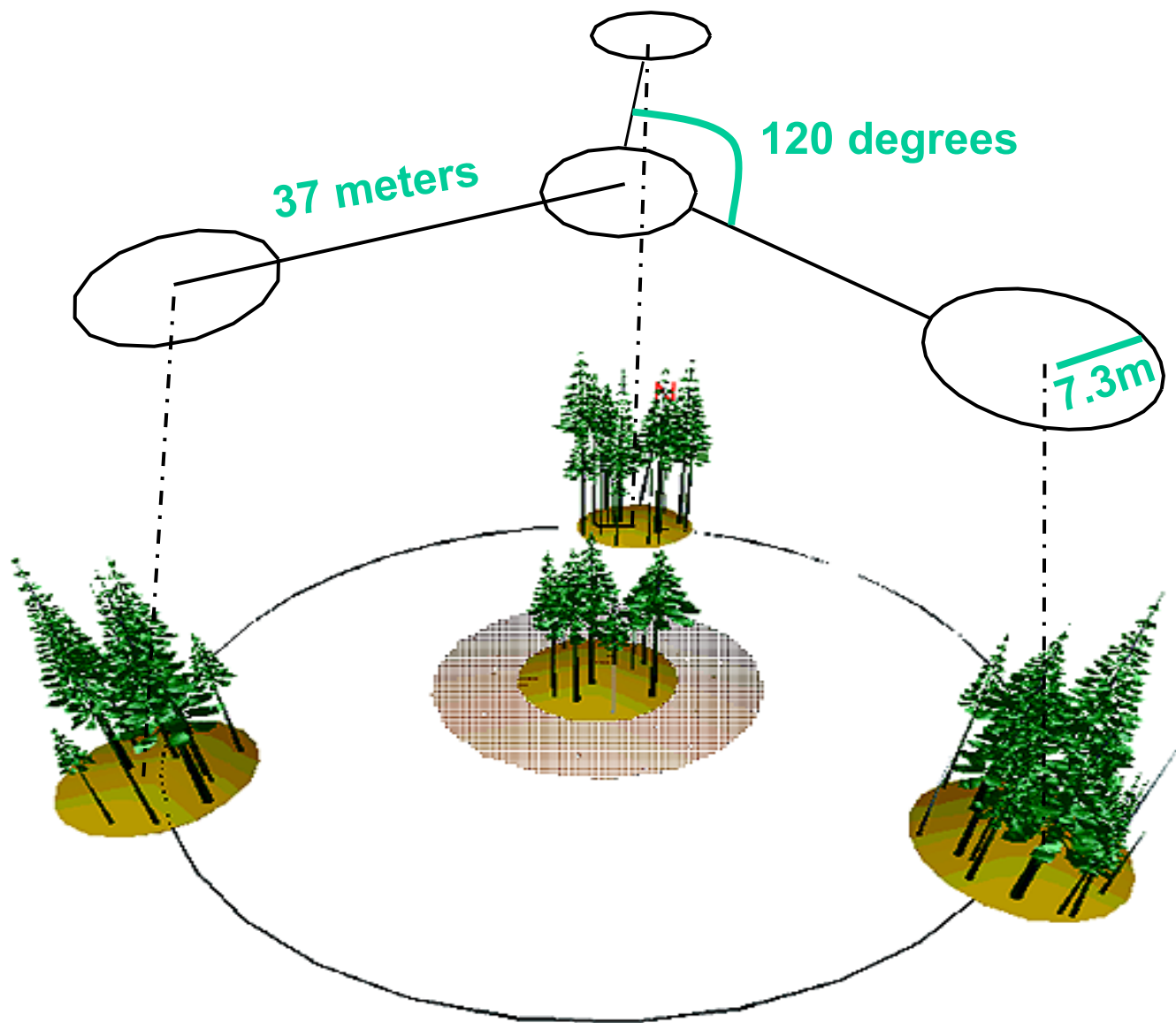
Four 0.02-ha subplots

Tree and Site Variables:
- X,Y (of plot+trees)
- Tree height
- Tree diameter
- Species
- Regeneration
- Stand age
- Forest type
- Cover and Use
- Geomorphology
- Ownership
- ....

FIA Sample Plot Distribution
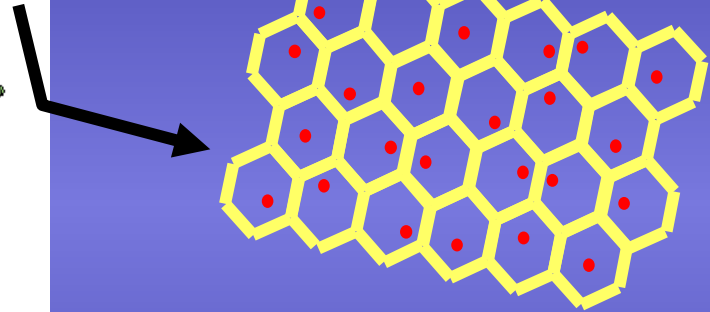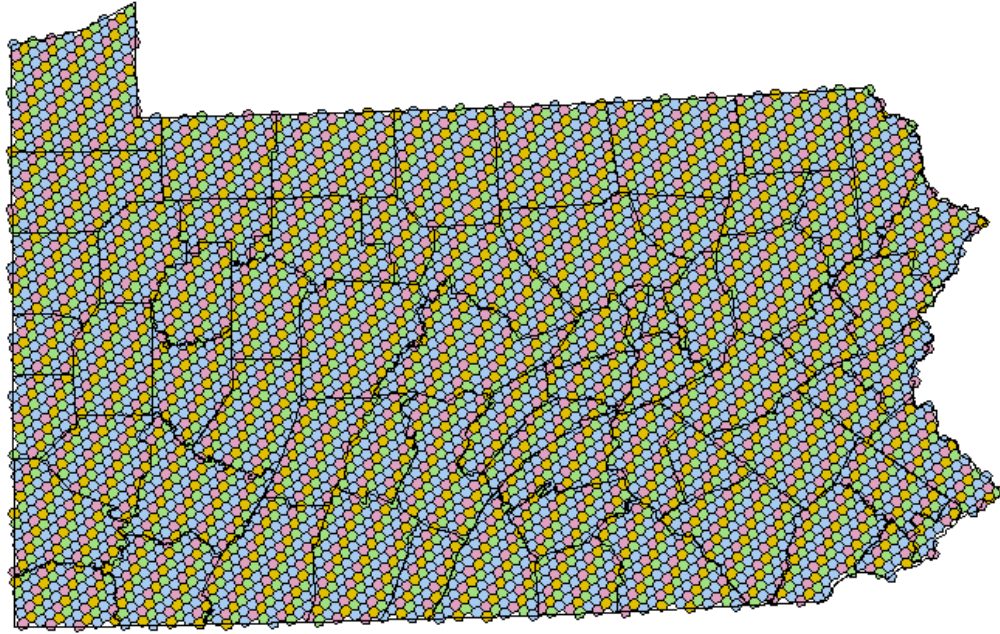
Sample Intensity = 1 sample location per hexagon (2400 ha), ~5 km average spacing

Inventory Cycle Length = 5-10 years

>300,000 plots at full implementation!!
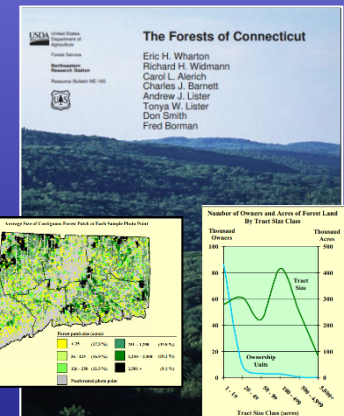
FIA production line is institutionalized…

Field Work

- **Information Management**
- **Analysis**
- **Techniques Research**

Reports and other products

Field Work – Remote sensing inputs

All plots

Only plots with forest

- Prescreen plots with NAIP, only visit when p(forest) > 0
- Saves time and money

Time 1

Time 2

Image-based Change Estimation:
- Cover, use and change with PI
- Point grid, 0.4-ha area
- Mid-cycle updates
- Landscape-level view

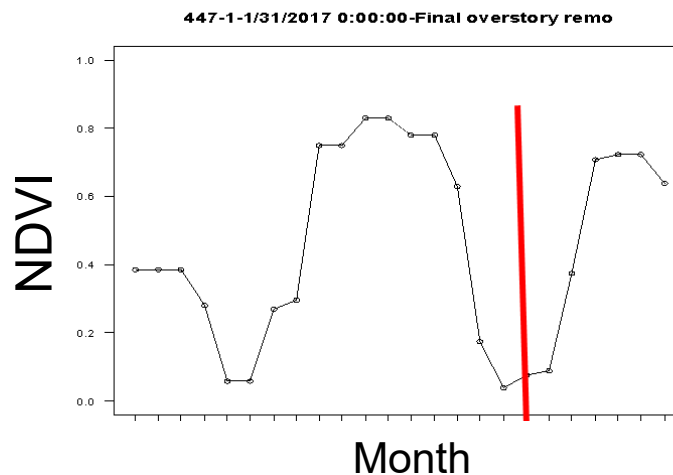# Field Work – NASA can help
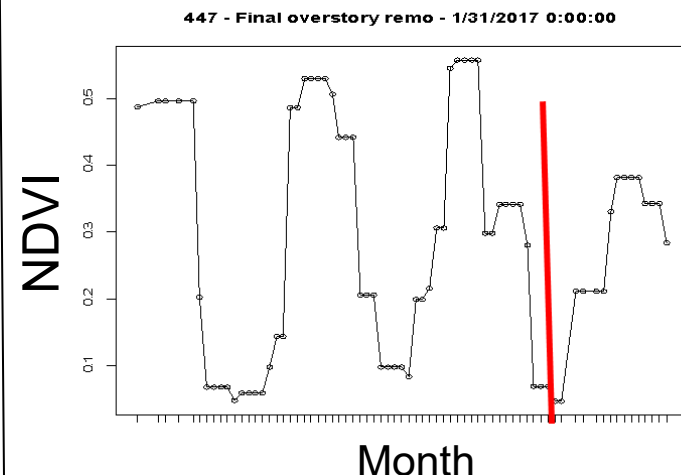
Improvements to high-res imagery, LiDAR

- automated p(tree) calculation on high-res images
- segmentation tools/algorithms/ready-made products
- 3d products for decision support
- cloud-based display and processing
- High-res time series support tools, ARD

Sentinel

447-1-1/31/2017 0:00:00-Final overstory remo

Landsat 8

447 - Final overstory remo - 1/31/2017 0:00:00

NDVI

Month

Information Management, Techniques Research and Analysis–Remote Sensing Inputs

- Model-assisted estimation (post-stratification)

- Inputs for spatial modelling

- Additional data products to add context to plot data
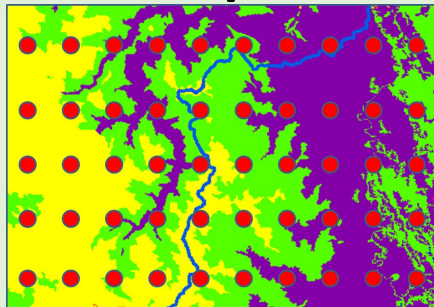
Post Stratification

Post-Stratification: Using an attribute on a map to group and weight estimates after (post) the sample on the ground is taken.

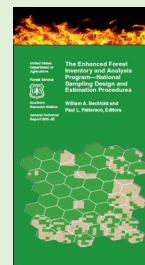> ## Goal: confidence interval with stratification smaller than CI without stratification
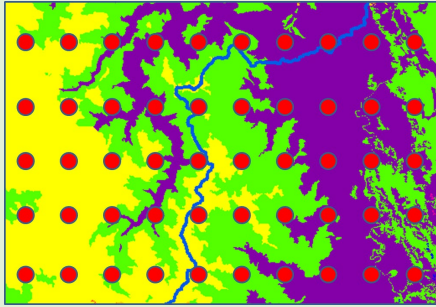
Step 1
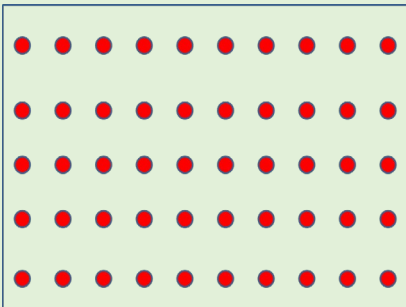
Step 2

Step 3

$$\hat{A}_d = A_T \sum_{h}^{H} W_h \overline{P_{hd}} = A_T \overline{P_d}$$

$$v(\hat{A}_d) = \frac{A_T^2}{n}\left[\sum_{h}^{H} W_h n_h v(\overline{P_{hd}}) + \sum_{h}^{H}(1-W_h)\frac{n_h}{n}v(\overline{P_{hd}}) \right]$$

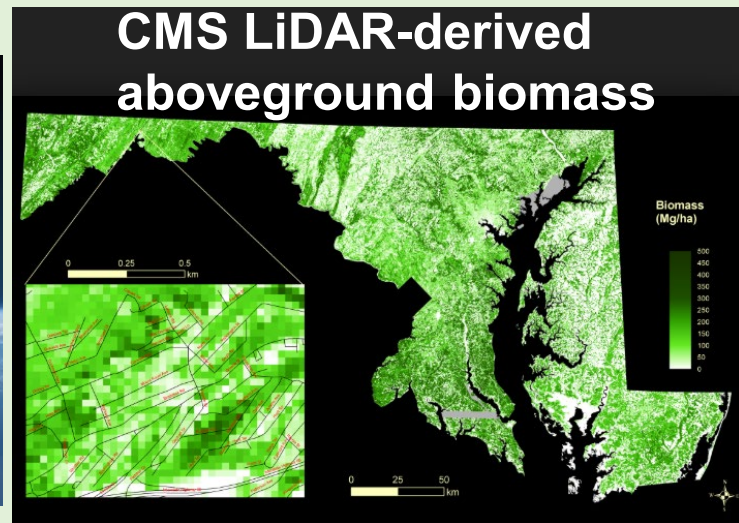http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs080/gtr_srs080.pdf
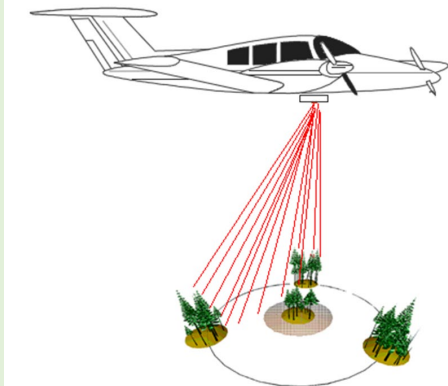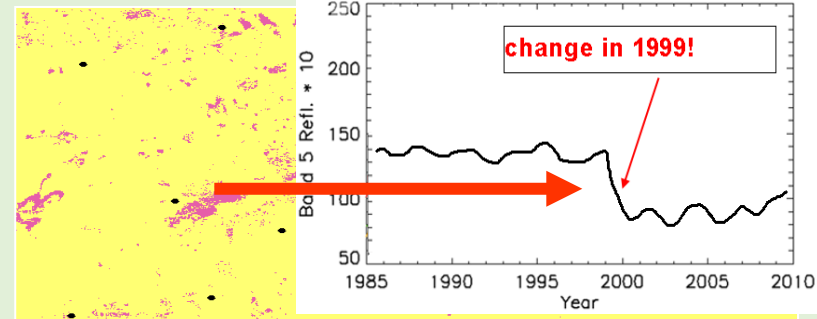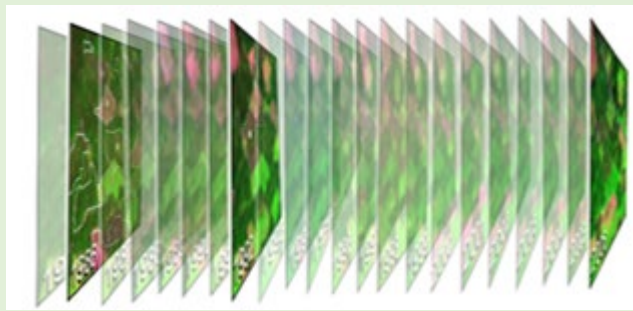
Currently:

National Land Cover Dataset Canopy Cover products (2011, 2016), discretised into strata

With NASA's partnership:
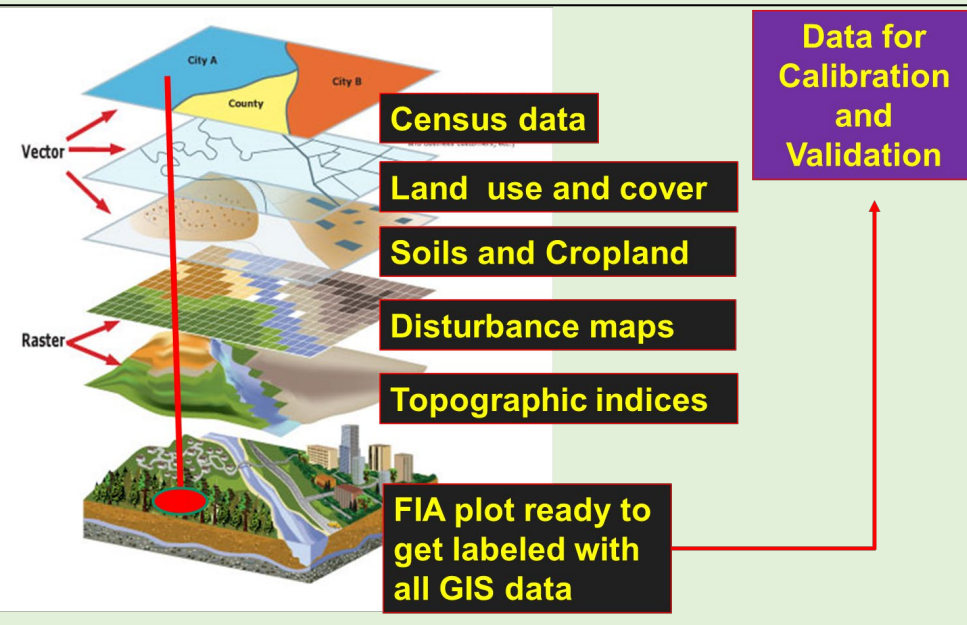
Lidar-derived tree heights

GEDI
Characterizing the Effects of Climate Change and Land Use
On ISS

CMS LiDAR-derived aboveground biomass

Biomass (Mg/ha)

Change maps for better estimation of change:

change in 1999!

Inputs for spatial modelling

$$\text{Volume} = f\left\{ \text{Imagery} , \begin{array}{c} \text{Slope,} \\ \text{Aspect,} \\ \text{Elevation} \end{array} , \begin{array}{c} \text{Soils,} \\ \text{Climate,} \\ \text{Population,} \\ \text{etc} \end{array} \right\}$$

Imagery

Slope, Aspect, Elevation

Soils, Climate, Population, etc

Vector

City A
City B
County

Census data

Land use and cover

Soils and Cropland

Raster

Disturbance maps

Topographic indices

FIA plot ready to get labeled with all GIS data

Data for Calibration and Validation

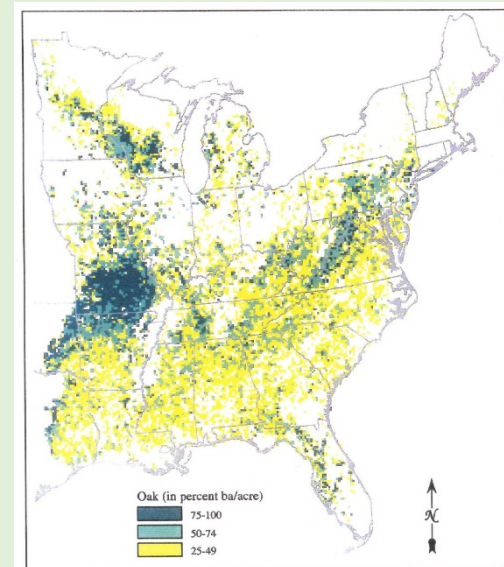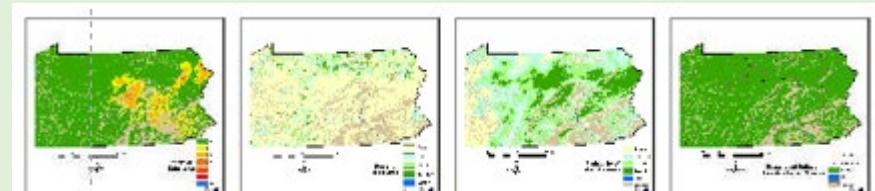## Modeled maps of FIA attributes

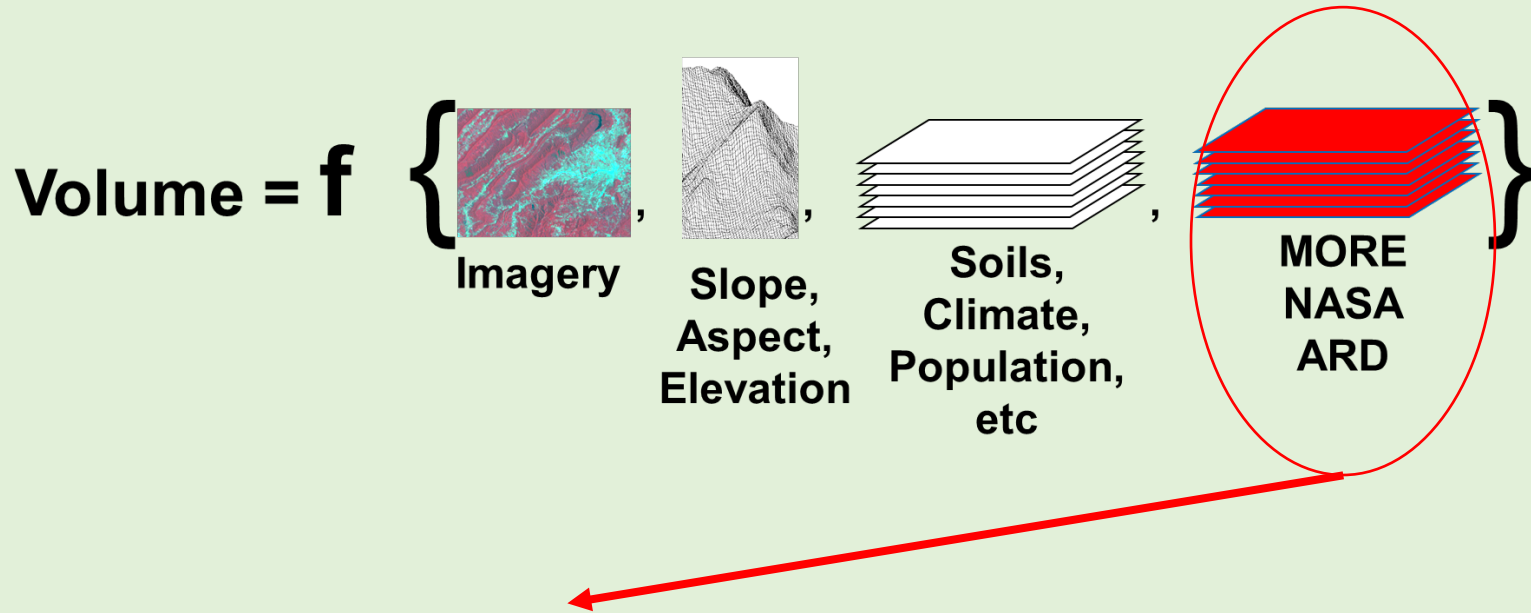Oak (in percent ba/acre)
75-100
50-74
25-49

Inputs for spatial modelling – from NASA

$$\text{Volume} = f \left\{ \text{Imagery}, \text{Slope, Aspect, Elevation}, \text{Soils, Climate, Population, etc}, \text{MORE NASA ARD} \right\}$$

- **Cloud-based ARD as raster/ArcGIS server, GEE assets**
- **Cloud-based processing tools like AppEEARS (but with full Landsat and Sentinel records)**
- **Higher resolution products/algorithms**

Additional data products to add context

The Forests of Connecticut

USDA United States Department of Agriculture
Forest Service
Northeastern Research Station
Resource Bulletin NE-160

Eric H. Wharton
Richard H. Widmann
Carol L. Alerich
Charles J. Barnett
Andrew J. Lister
Tonya W. Lister
Don Smith
Fred Borman

NASA: Bridgeport Sea Level Rise Forecasts

FIA: How much forest will be affected? What is the nature of that forest?
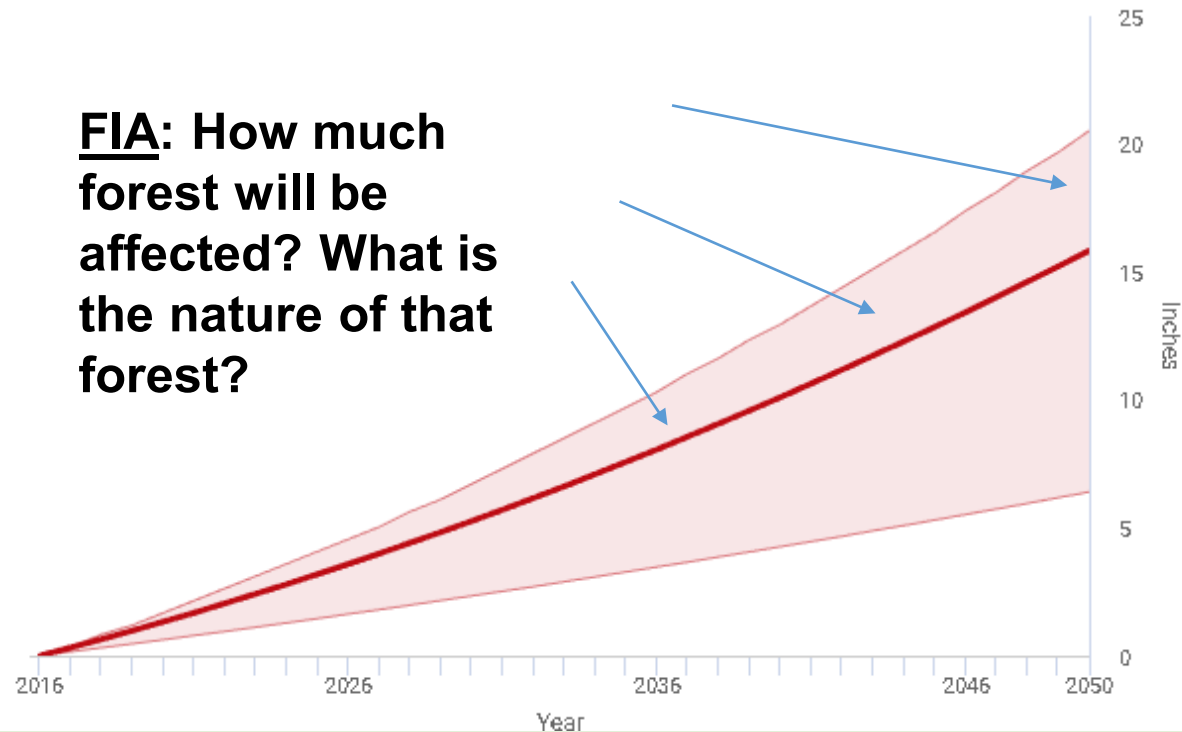
- Climate change scenario maps
- Risk models and maps
- Urbanization predictions
- Weather/Soil Moisture data

All help us put FIA results into context

Summary

1. **FIA is a well-oiled machine, for good and for bad.**

2. **Remote sensing products are used operationally, and can be improved by NASA products.**

3. **We like to do our own modelling, so ARD and cloud support and time series analysis tools are most helpful.**

4. **Together we can brainstorm what products can help us better deliver our missions.**
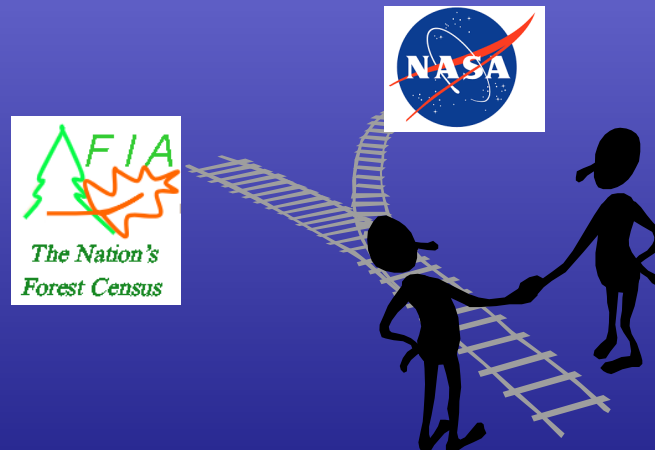
Questions?
Andy Lister
andrew.lister@usda.gov