

An aerial photograph of a forested landscape. A river flows through the center, surrounded by dense evergreen trees. There are patches of wetlands and open areas interspersed with the forest. The lighting suggests a bright day, with shadows cast by the trees.

***Status update of the USFS-NASA partnership
leveraging remote sensing advances to
inventory forests in interior Alaska***

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Including Interior Alaska in the FIA inventory



Forest Canopy
Mapping Frame
Change



- ◆ In
- in
-
- ◆ W
- A
-
-

- ◆ Species, s
- What is the c



2017 ALASKA WOOD
ENERGY CONFERENCE

Biomass for Sustainable Communities



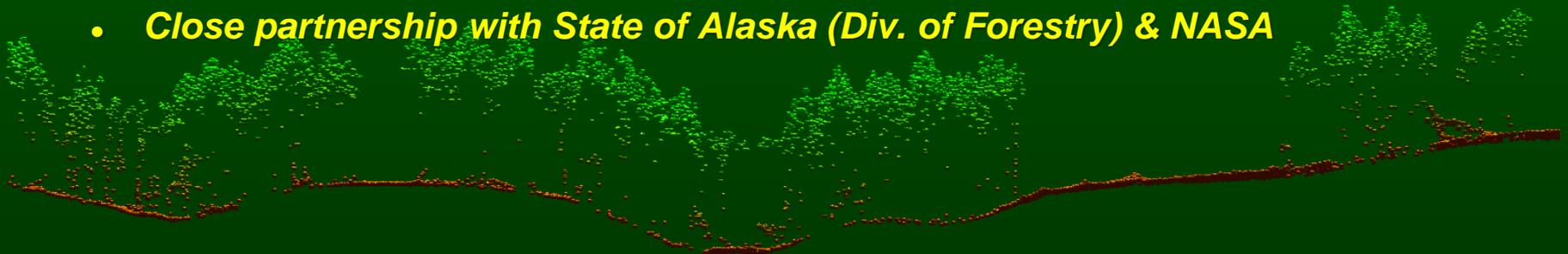
Forest Service

Northern Research Station

General Techni
Report NRS-154

Including Interior Alaska in the FIA inventory: A cost-effective way forward

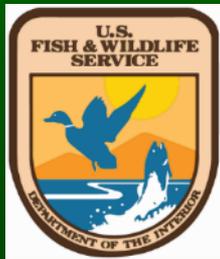
- ◆ ***Highly-complex logistics and limited transportation infrastructure makes field work difficult; therefore expensive (\$8-10K/plot)***
- ◆ ***2014 PNW-FIA & NASA pilot project (funded jointly by NASA CMS & USFS) in Tanana Valley to test a new inventory approach***
- ◆ ***Objectives of the 2014 Tanana pilot project:***
 - ***Develop the process of integrating sparse FIA field plot measurements, airborne (G-LiHT) & satellite remote sensing to support inventory goals***
 - ***Compare model-based vs. design-based estimators***
 - ***Tools to deliver remote-sensing products (maps, database, etc.)***
- ◆ ***In 2016, PNW-FIA obtained funding and began full implementation of the inventory in interior AK***
 - ***Close partnership with State of Alaska (Div. of Forestry) & NASA***



Collaborators



The Nation's Forest Census



**Interior Alaska FIA inventory
(approx. 4,642 field plots; expected
completion in 2026)**

Major roads in blue

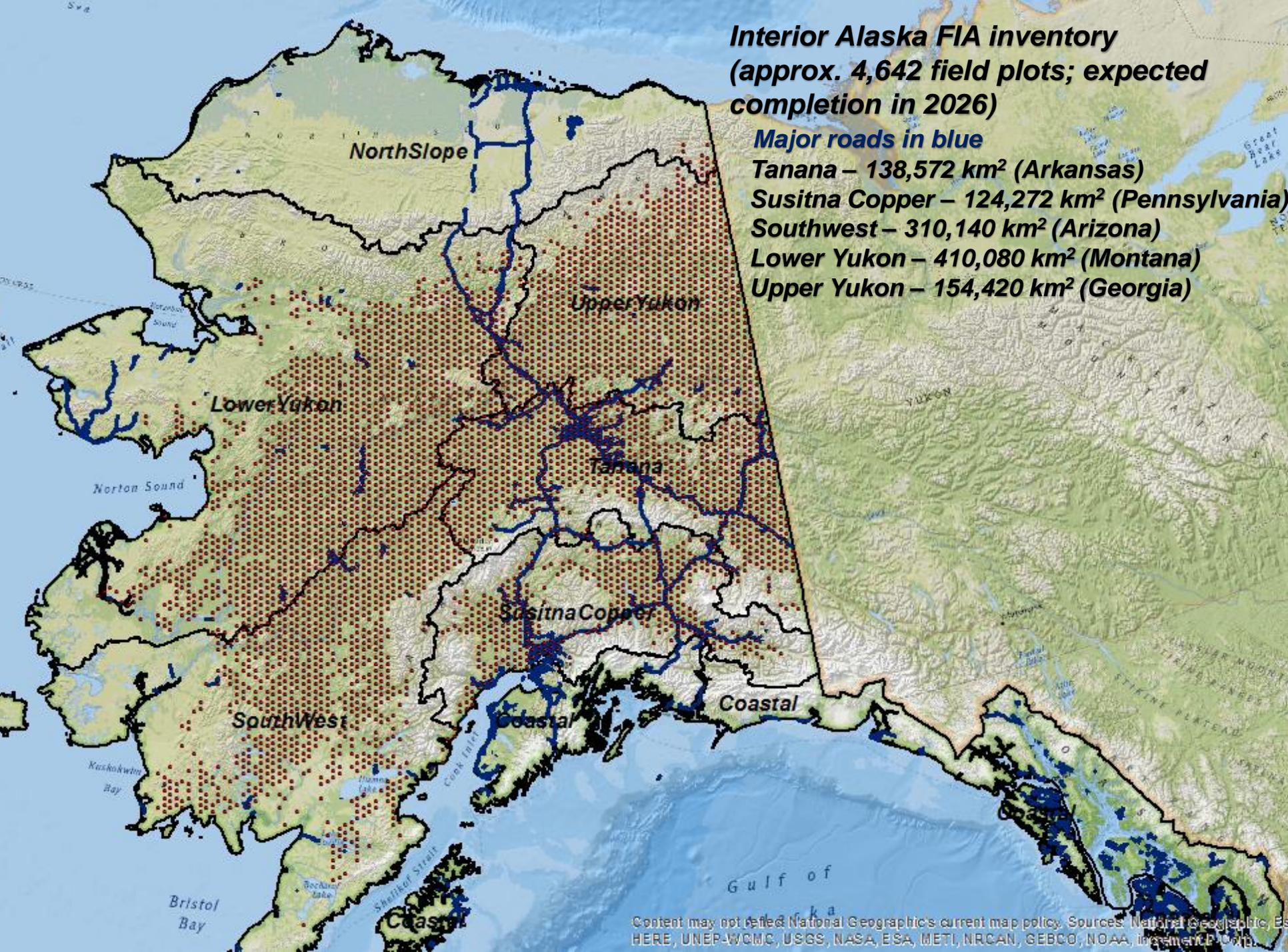
Tanana – 138,572 km² (Arkansas)

Susitna Copper – 124,272 km² (Pennsylvania)

Southwest – 310,140 km² (Arizona)

Lower Yukon – 410,080 km² (Montana)

Upper Yukon – 154,420 km² (Georgia)



Additional Measurements in Interior Alaska FIA inventory

High-accuracy GPS on
Soil sampling



woody
increments are
increase



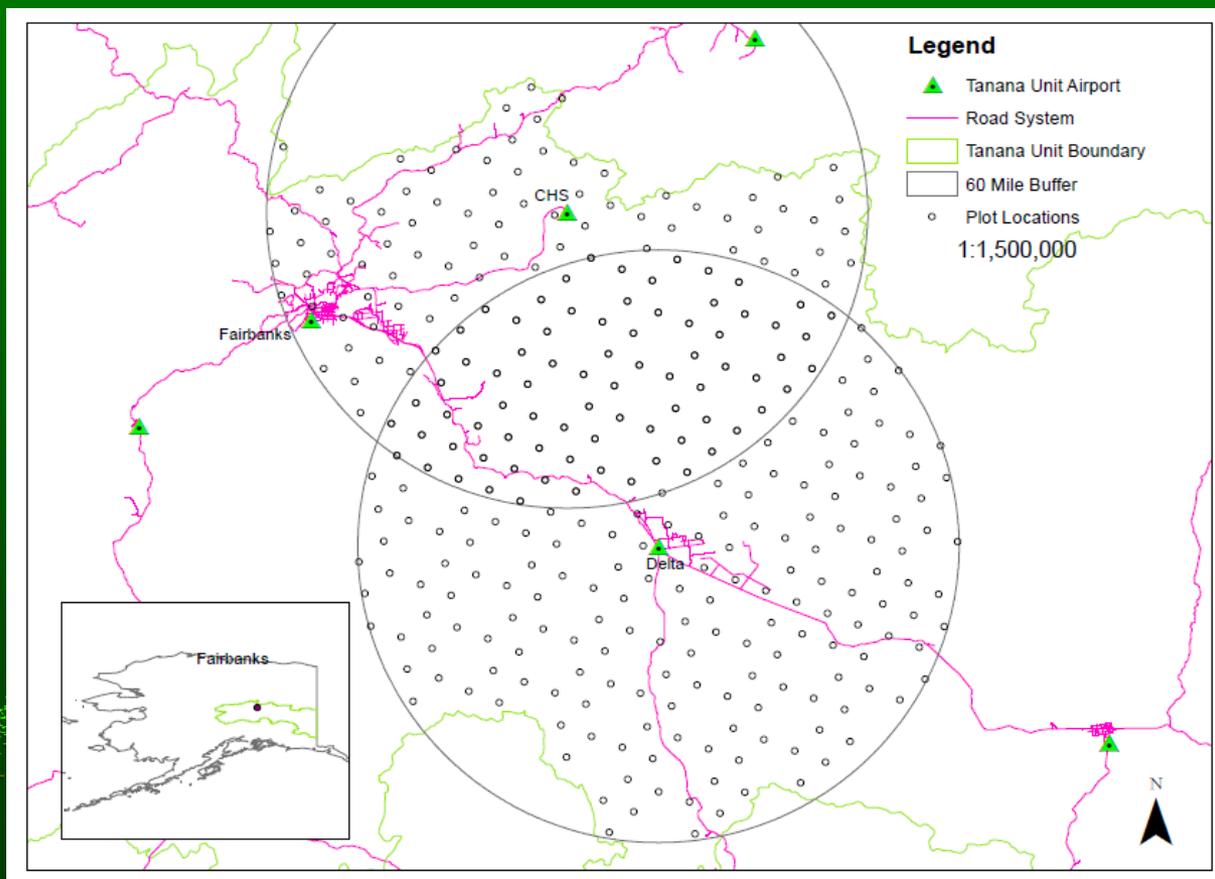
Field work 2016



- ◆ *198 plots completed*
- ◆ *No reportable injuries*
- ◆ *1 bear and 1 wolf encounter*
- ◆ *1 quicksand adventure*

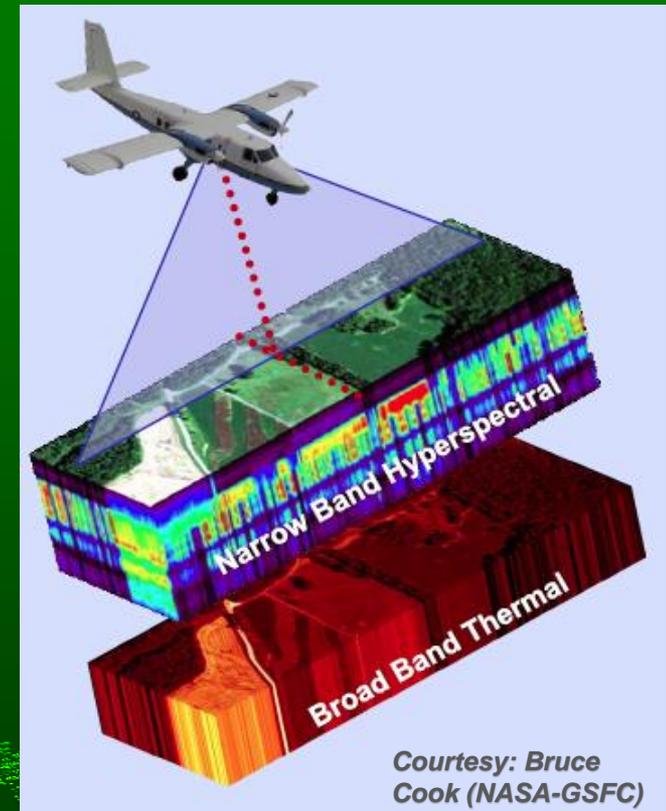
Field work 2017

~300 plots in the Tanana Unit



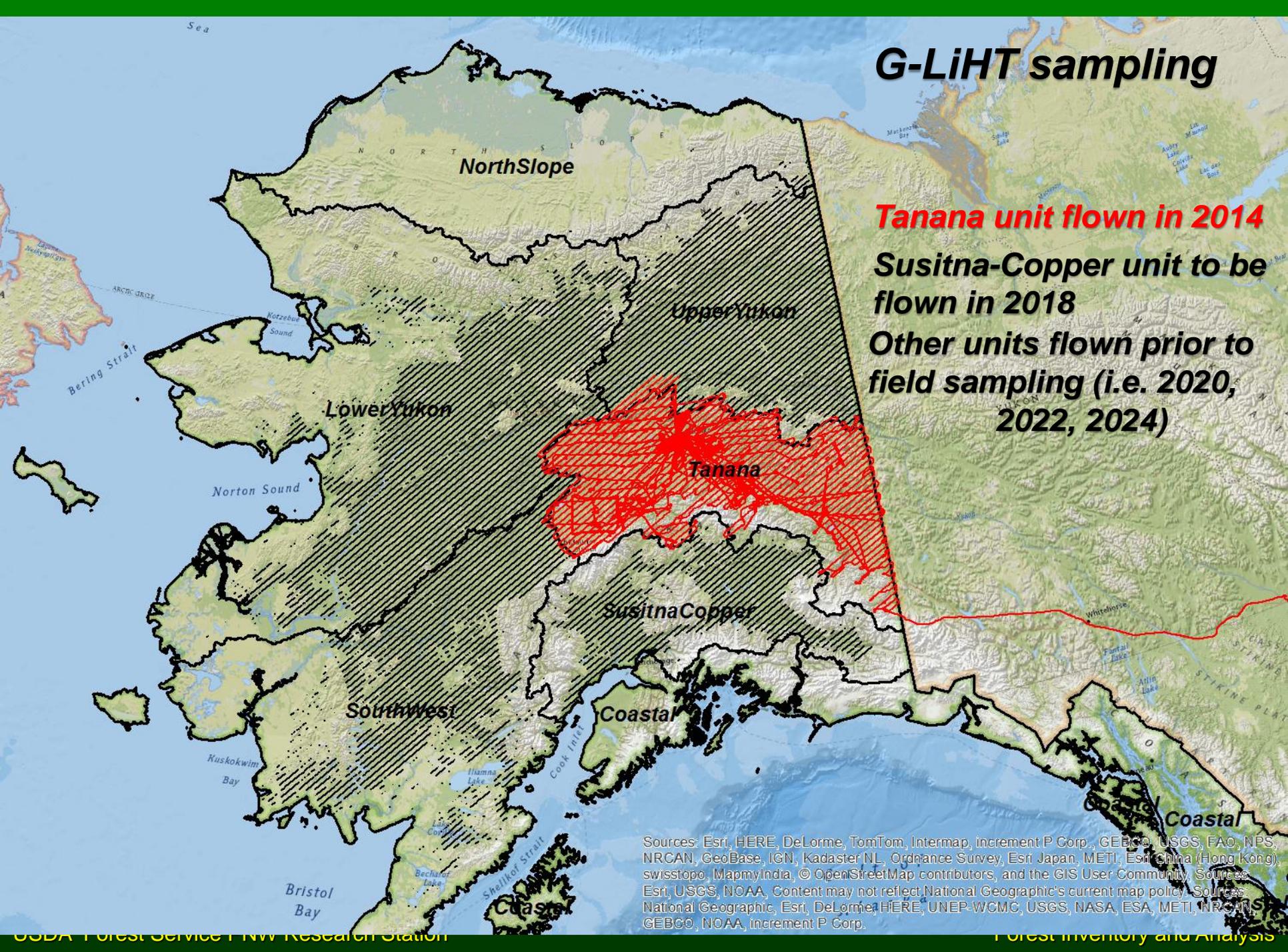
G-LiHT Remote Sensing

- ◆ Airborne G-LiHT RS collected in strip sample (9 km spacing b/n strips) over entire Tanana inventory unit (~138K sq. km) & covering every FIA plot (B. Cook, D. Morton, R. Nelson (NASA-Goddard))
- ◆ Goddard Lidar/Hyperspectral/Thermal (G-LiHT) is a state-of-the-art portable, airborne imaging system that simultaneously maps the composition, structure, and condition of vegetation using:
 1. Laser scanning – 3D structure of vegetation
 2. Imaging spectroscopy – Species composition and variations in biophysical variables
 3. Thermal measurements – Surface temperature, heat and moisture stress



G-LiHT sampling

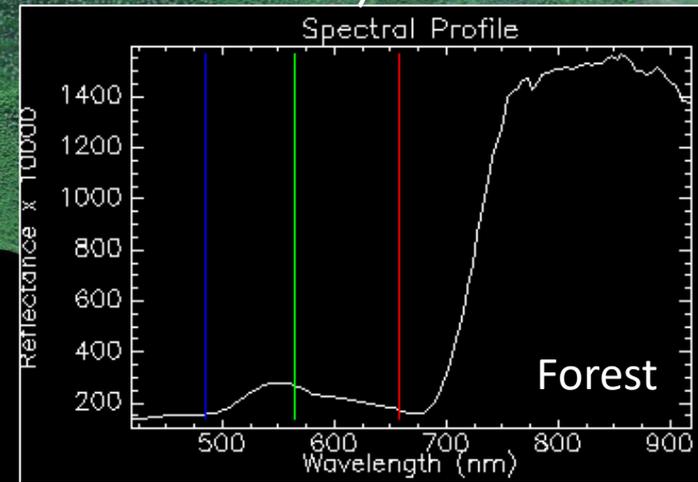
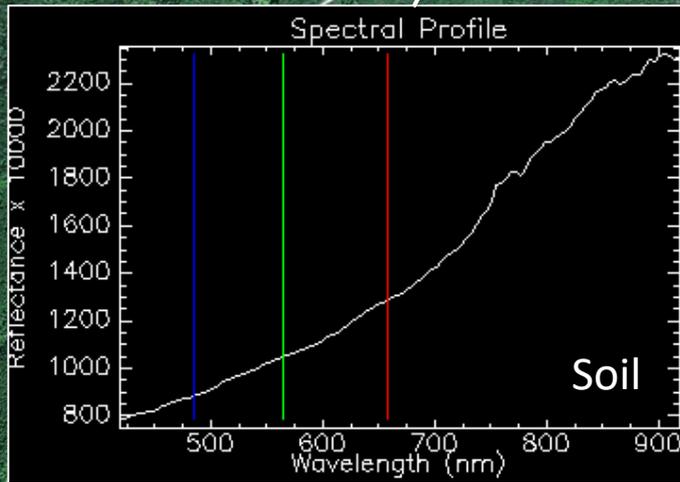
Tanana unit flown in 2014
Susitna-Copper unit to be flown in 2018
Other units flown prior to field sampling (i.e. 2020, 2022, 2024)



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community. Sources: Esri, USGS, NOAA. Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Example G-LiHT Products: Bonanza Creek

300 m

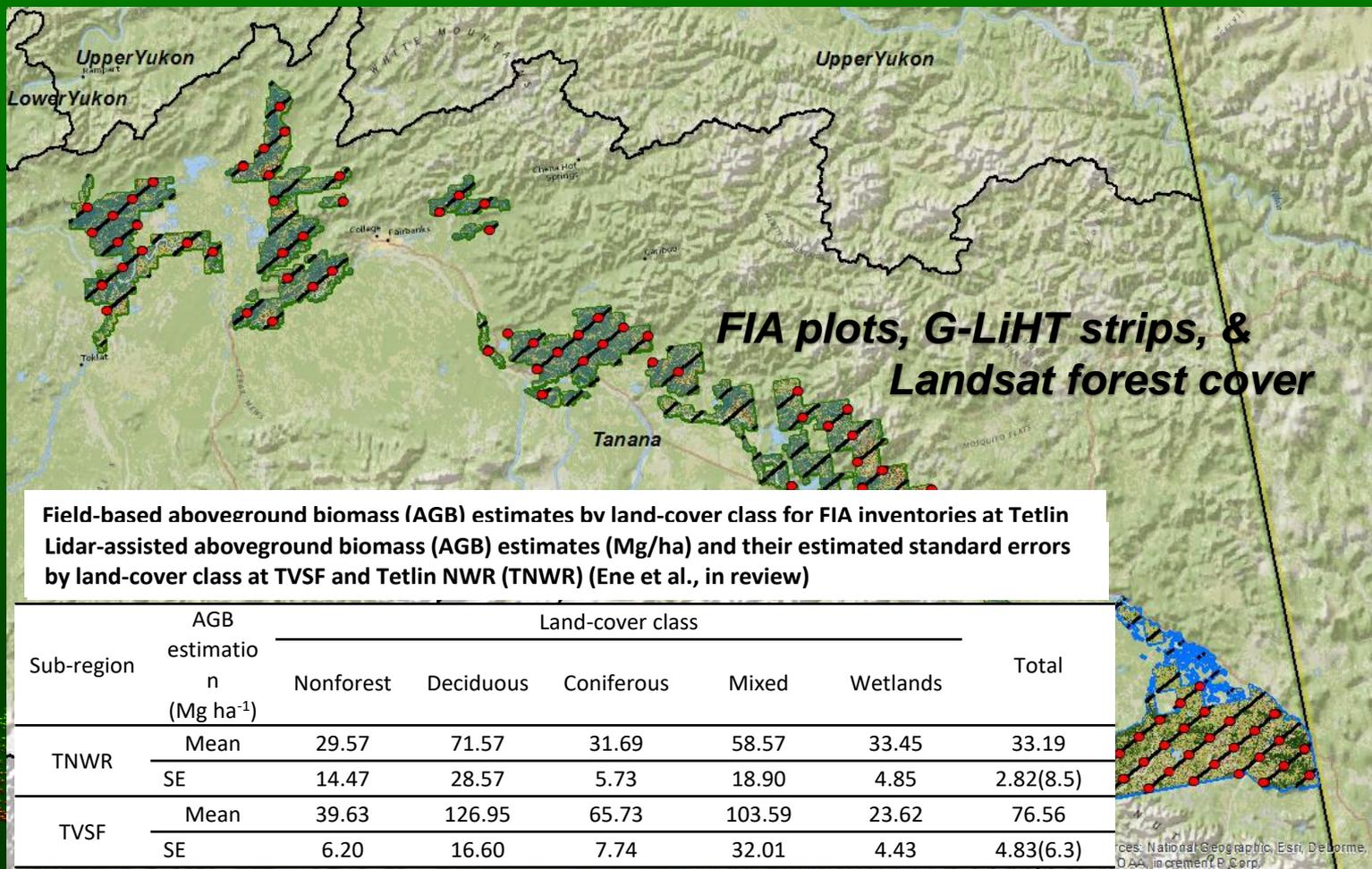


RGB At-Sensor Reflectance



G-LiHT fine-res DSLR

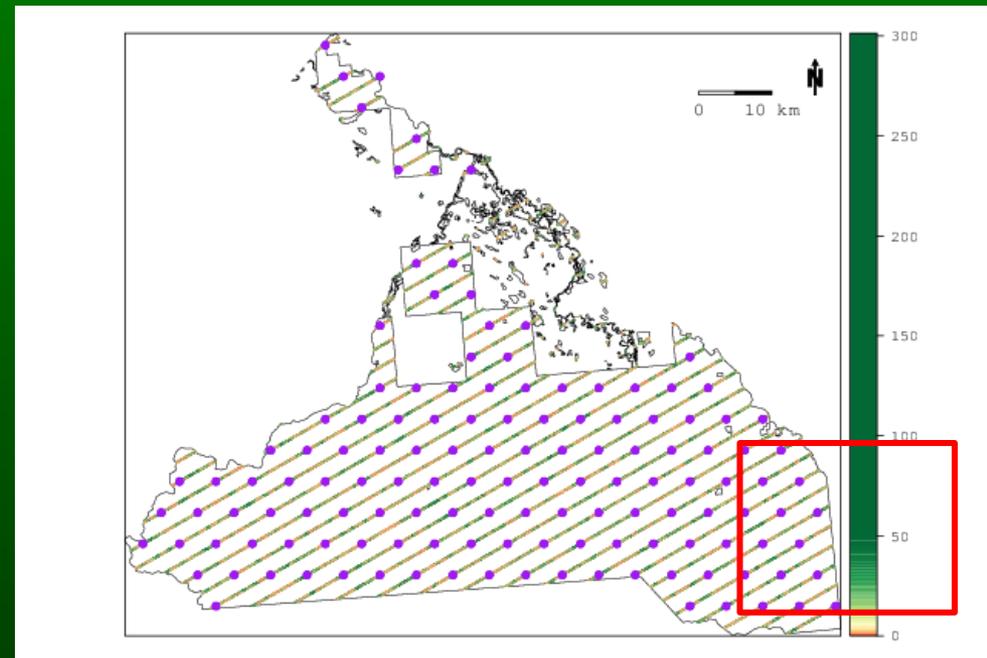
Integration of remote sensing and field data in the 2014 Tanana Pilot



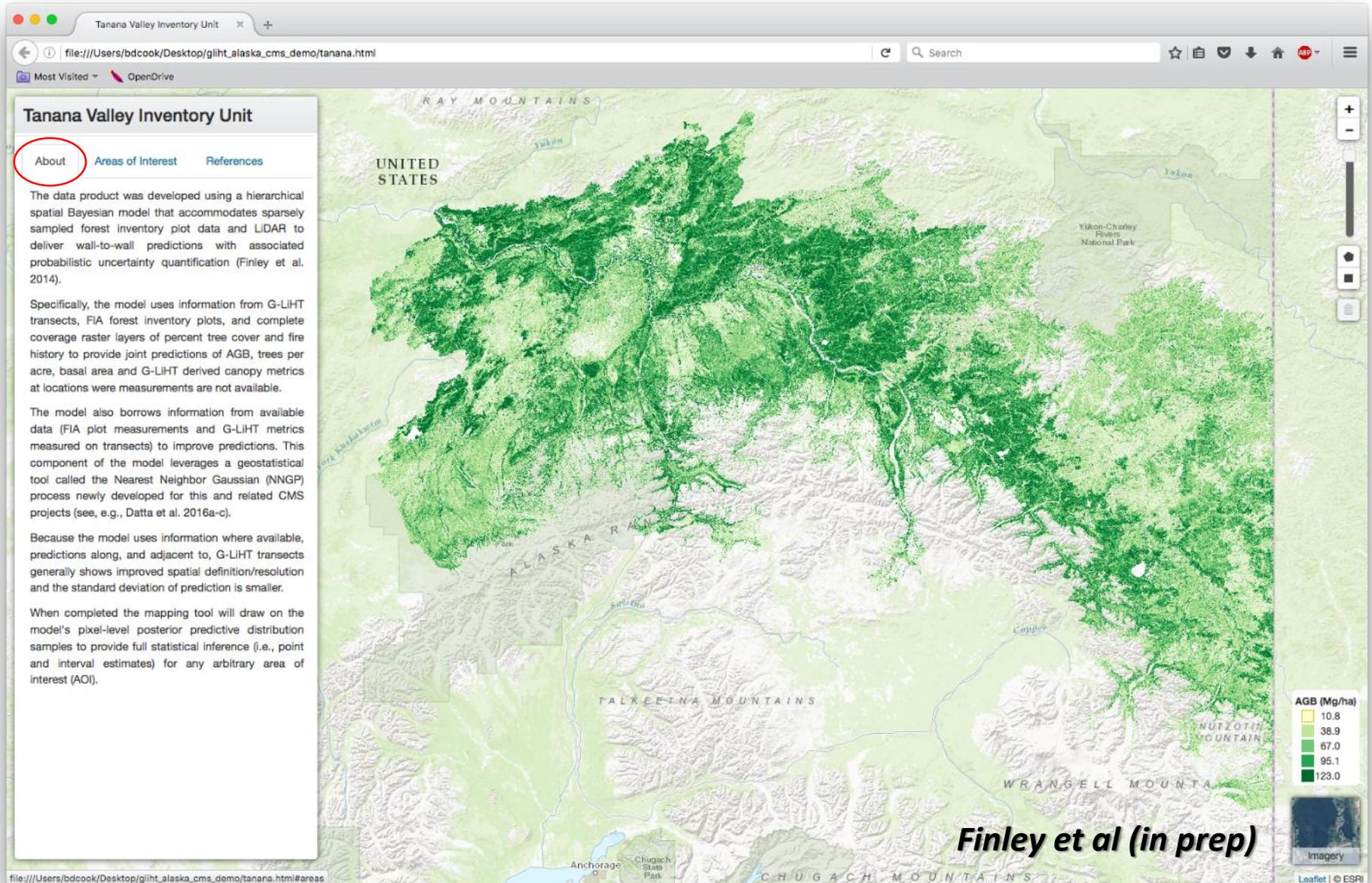
Assessment of sampling designs via simulation (Chad Babcock, Univ. of WA)

Simulation provides a means to directly compare various alternative sampling designs

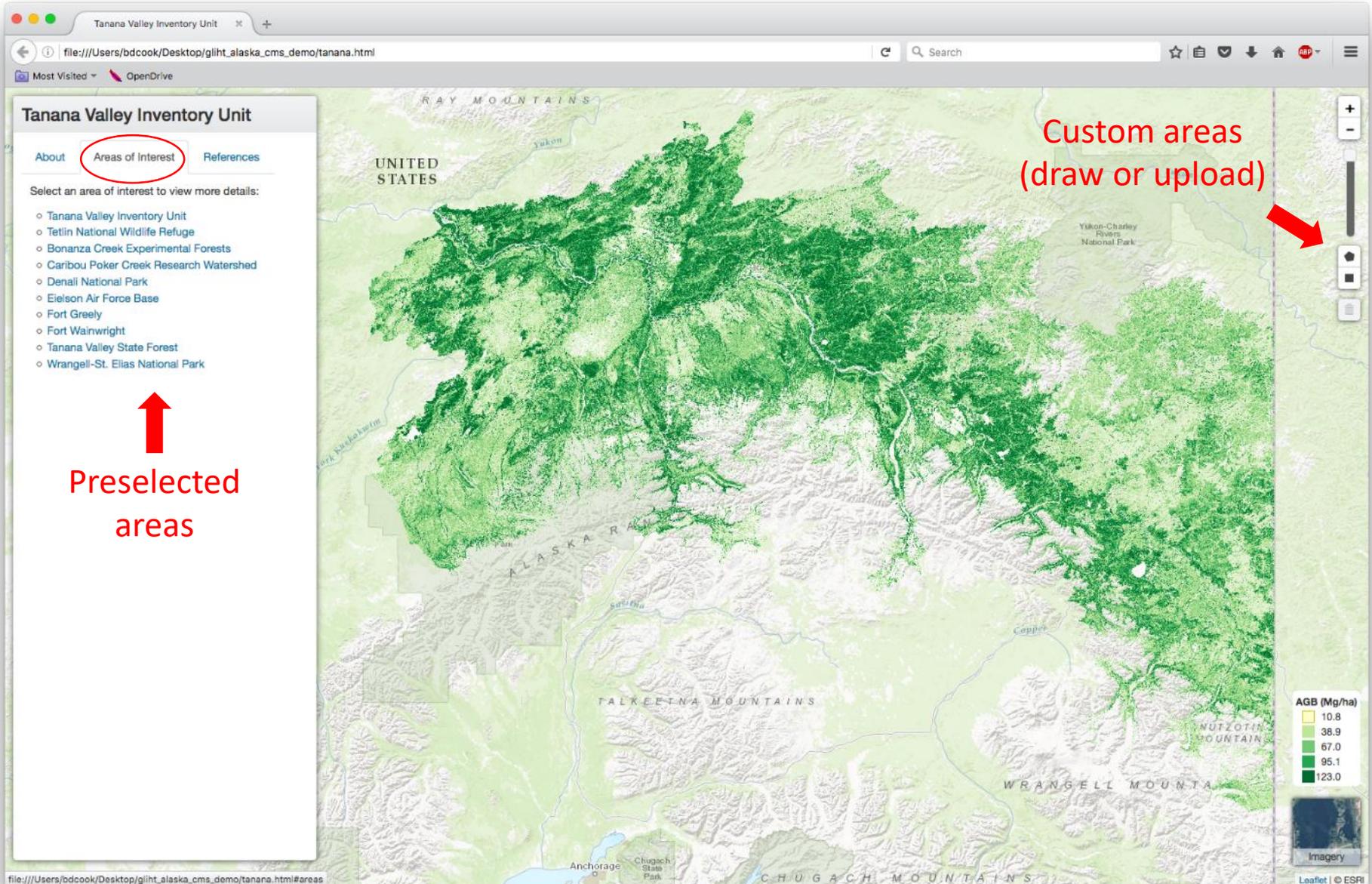
- *FIA design-based estimators using only field plot data – provide a benchmark for comparisons*
- *Model-assisted – provide design-unbiased estimators*
- *Model-based (Bayesian hierarchical spatial models) – can be used when probability sample of field plots is not available*
- *Wall-to-wall lidar vs. lidar strip sample*
- **Simulated population based on distributional characteristics of observed lidar structural metrics for Tetlin NWR**
- **Simulation used to assess variance, bias and 95% coverage probability for each approach**



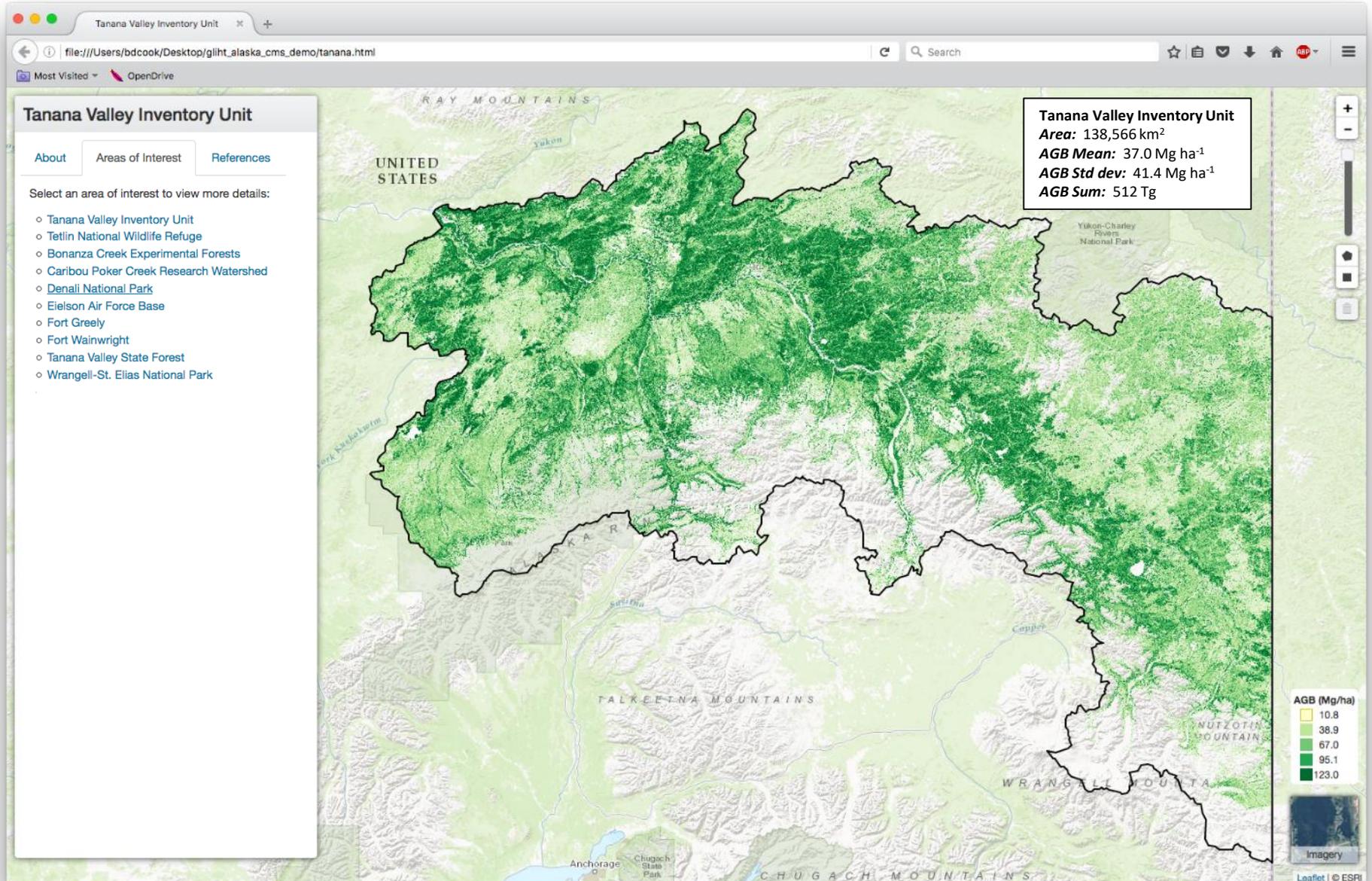
Web Map & Data User Interface



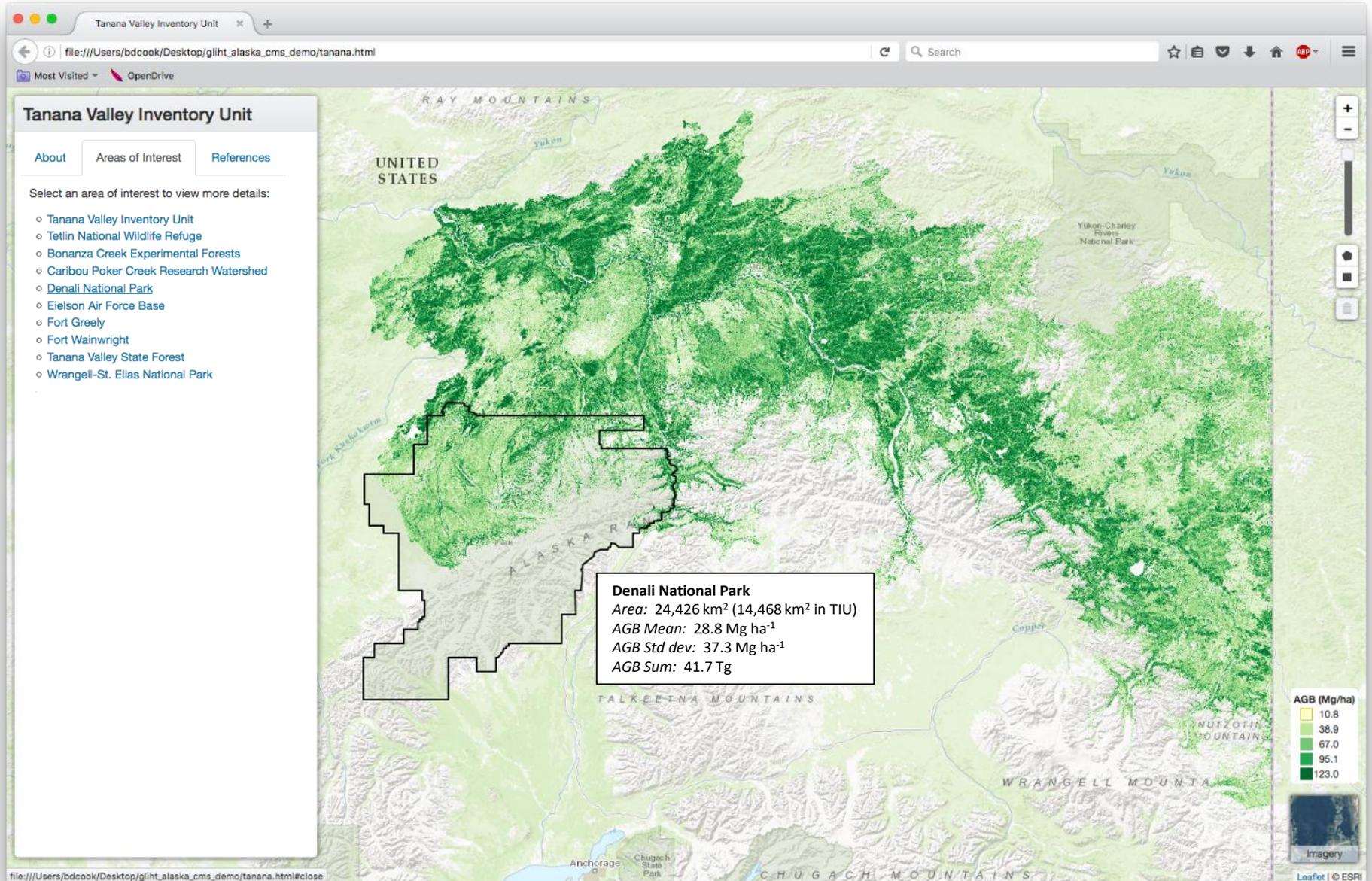
Web Map & Data User Interface



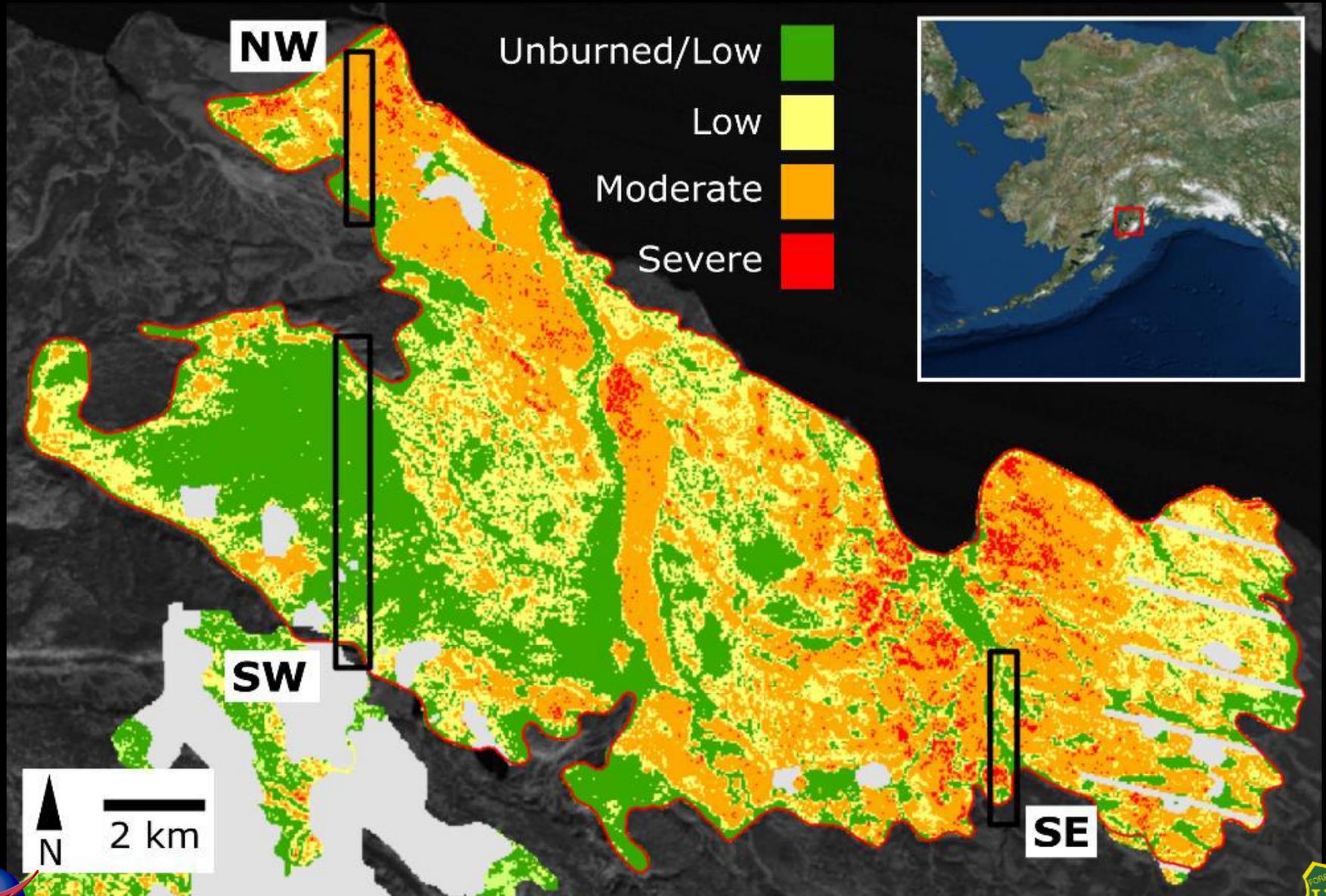
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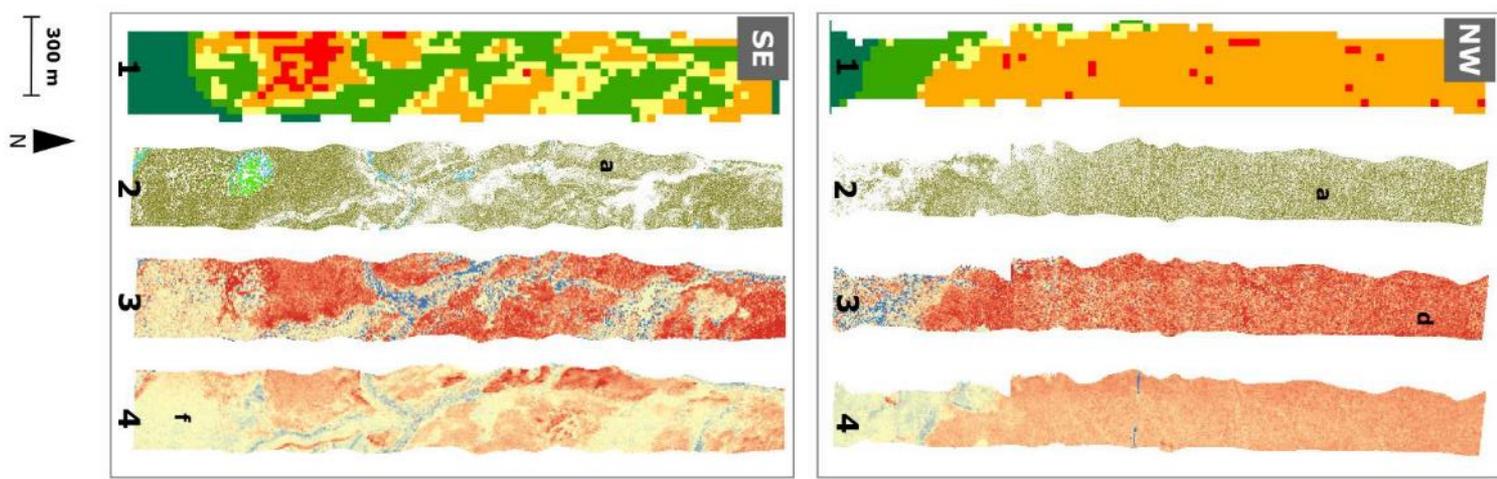
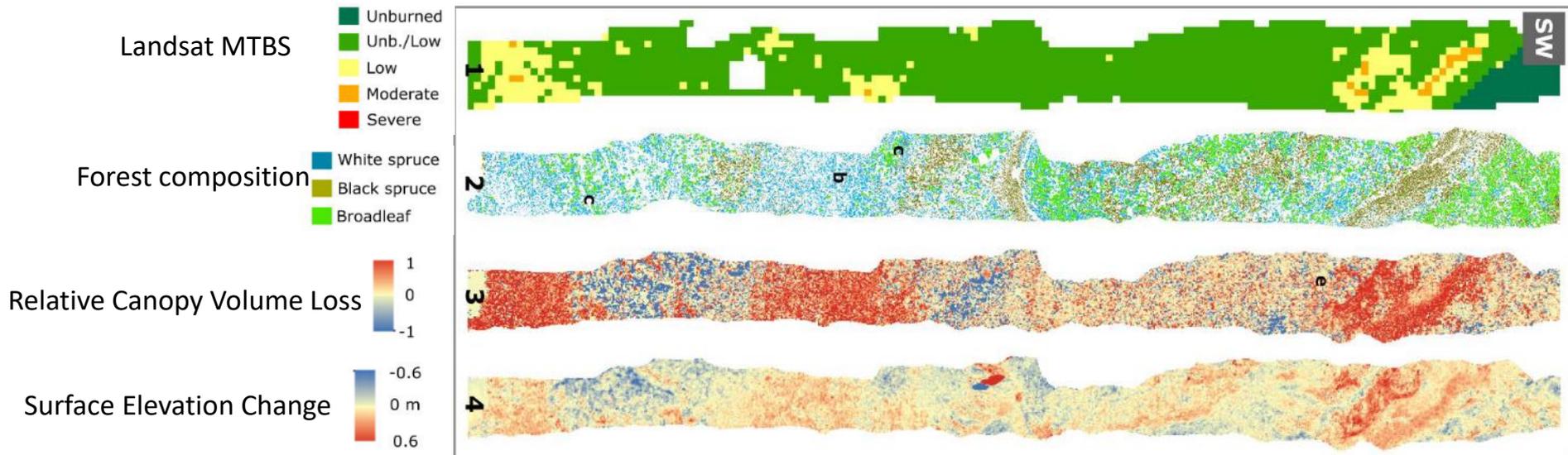
Web Map & Data User Interface



Patterns of canopy and surface layer consumption in a boreal forest fire from repeat airborne lidar



Patterns of canopy and surface layer consumption in a boreal forest fire from repeat airborne lidar (cont.)



(Alonzo et al., submitted)

Summary & Future Directions

- ◆ *2014 Pilot demonstrated value of partnership between USFS & NASA to leverage advanced RS technologies to support FIA inventory goals in this region*
- ◆ *Airborne remote sensing (G-LiHT) can be used in sampling mode to estimate aboveground biomass/carbon over large, remote region*
- ◆ *Future collaborative work will improve characterization of shrub biomass (with B. Schulz (USFS-AFSL) & Roman Dial (APU); 2016 NASA CMS-funded study)*
- ◆ *Satellite radar (e.g. PALSAR L-band) will likely play a significant role in the inventory design going forward – strong correlations with biomass in boreal forests (Atwood et al., 2014)*



**G-LiHT high-res (100 MP)
camera**



More information

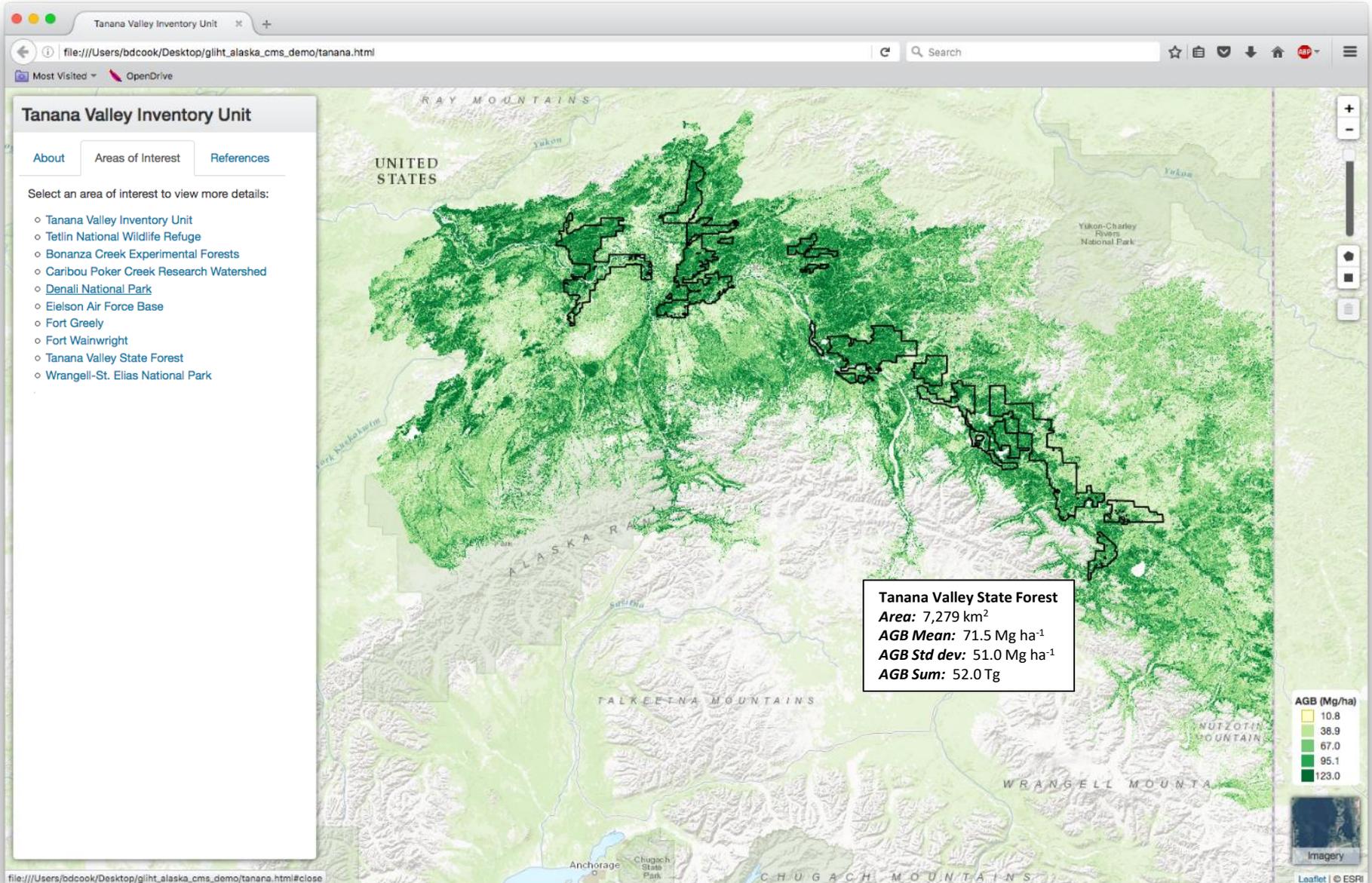
Inventorying Alaska's Forests: An Opportunity for Integrating Interagency Needs with the FIA
<http://goo.gl/WTQ6lp>

G-LiHT | Off to a Flying Start
<http://goo.gl/t0YhrY>

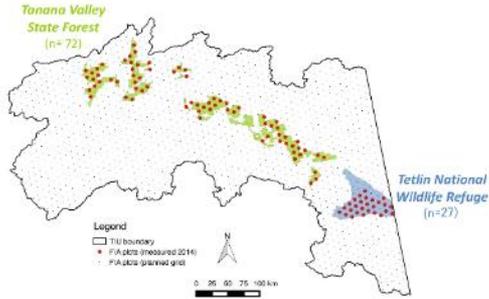
How a Flying Laser Built a 3-D Map of a Massive Alaskan Forest – Wired Magazine article
<http://www.wired.com/2014/12/alaska-laser-survey-3d-map/>



Web Map & Data User Interface



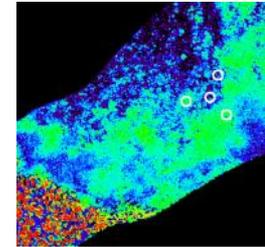
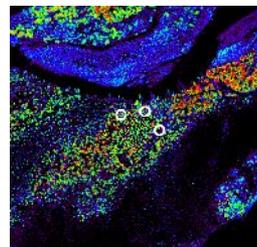
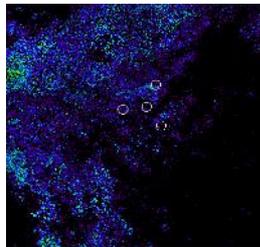
FIA Forest Type Classification Method



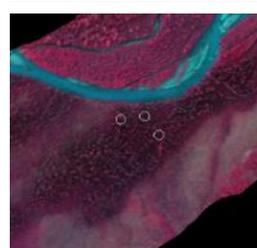
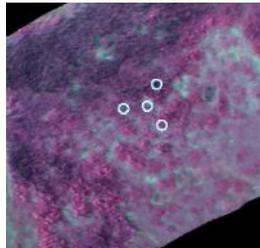
Below are examples from FIA plots in Tetlin NWR

- **Delineate individual tree objects with watershed segmentation of CHM.**
- **Compute dimensions, lidar metrics and reflectance spectra for each object (NOTE: selected G-LiHT spectral bands most similar to Landsat and Sentinel 2).**
- **Use FIA and lidar-hyperspectral data to perform supervised classification of objects >DBH height.**
- **Validate with withheld FIA plot data and TVSF stand-scale delineations.**

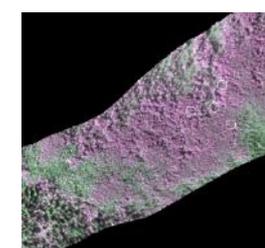
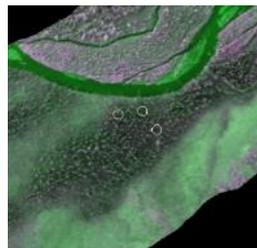
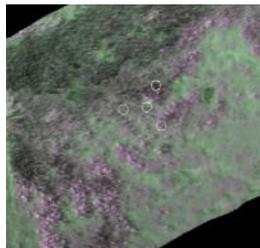
Canopy heights
(CHM)



Color Infrared
(NIR, red, green)



Red Edge bands
(783, 705, 740 nm)



Black Spruce

White Spruce

Paper Birch