Vegetation Structure and Function

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** Also member of Vegetation Dynamics and Distribution WG*

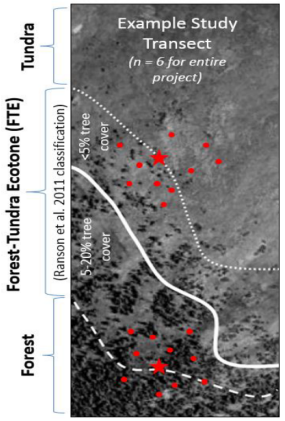
Institutional Collaborations

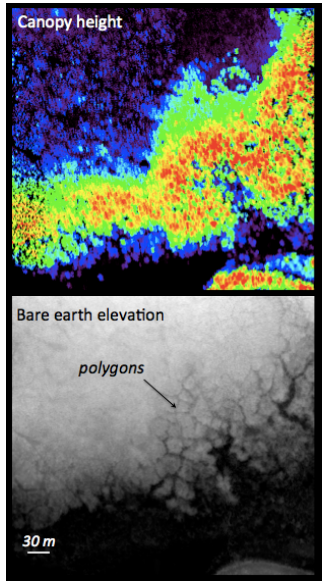
- USDA Forest Service
- US Army Corps of Engineers
- US Dept. of Defense
- US Geologic Survey
- US Fish & Wildlife Service
- US National Park Service
- US National Oceanic and Atmospheric Administration
- US National Science Foundation
- US National Geospatial Intelligence Agency
- Geologic Survey of Canada
- Canadian Forest Service
- Parks Canada
- Alaska Division of Forestry
- Alaska Division of Geological & Geophysical Surveys
- UA Geographic Information Network of Alaska
- Univ. of Alaska-Fairbanks
- Univ. of Alaska-Anchorage
- Council of Athabascan Tribal Governments
- Tanana Chiefs Conference

VEGETATION STRUCTURE & FUNCTION

are key ecosystem attributes that:

- determines ecosystem services (3.1);
- integrate the influence of historic disturbance regimes (3.2) and future disturbance risks;
- Indicative of both the presence and dynamics of permafrost (3.3);
- influence and respond to changes in hydrology (3.4);
- harbor fauna (3.5); and
- store and cycle carbon and other macronutrients (3.6).





ABoVE Questions & Objectives

Tier 2 Science Questions					
Section 3.1: How are environmental changes affecting critical **ecosystem services** - natural and cultural resources, human health, infrastructure, and climate regulation - and how are human societies responding?	Section 3.2: What processes are contributing to changes in **disturbance regimes** and what are the impacts of these changes?	Section 3.3: What processes are controlling changes in the distribution and properties of **permafrost** and what are the impacts of these changes?	Section 3.4: What are the causes and consequences of changes in the **hydrologic system**, specifically the amount, temporal distribution, and discharge of surface and subsurface water?	Section 3.5: How are **flora and fauna** responding to changes in biotic and abiotic conditions, and what are the impacts on ecosystem structure and function?	Section 3.6: How are the magnitudes, fates, and land-atmosphere exchanges of **carbon pools** responding to environmental change, and what are the **biogeochemical** mechanisms driving these changes?
Tier 2 Science Objectives: Ecosystem Dynamics					
1. Determine how interactions among vegetation, soil characteristics, hydrology, and disturbances influence surface energy exchange and **mediate permafrost vulnerability and resilience** to climate change.	2. Determine how and where interactions among **microbes, plants, and animals** exert control over ecosystem responses to climate change and disturbances.	3. Understand how **vegetation** attributes and **hydrologic** conditions interact, and respond and **feedback to disturbance.**	4. Quantify how changes in the spatial and temporal **distribution of snow impacts** ecosystem structure and function.		
5. Determine the causes of **greening and browning trends** and their **impacts** on ecosystem form and function.	6. Elucidate how climate change and disturbances interact with above- and belowground communities and processes to alter **carbon biogeochemistry**, including release to surface waters and the atmosphere.	7. Determine how the spatial and temporal dynamics in both faunal abundance and characteristics of **fish and wildlife habitat** co-vary across gradients of **climate and disturbance**.			
Tier 2 Science Objectives: Ecosystem Services					
1. Assess how future climate warming is likely to affect **infrastructure and transportation** networks.	2. Determine how changes to disturbance regimes, flora and fauna, permafrost conditions, and/or hydrology influence **human health outcomes** in the ABR.	3. Evaluate how changes to ecosystems will influence **subsistence** opportunities.	4. Analyze how changes to natural and cultural resources will impact local communities as well as influence **land management** policies and practices.	5. Determine the sources of variations in climate feedbacks from Arctic and boreal ecosystems and assess the potential for future changes to **climate regulating** services at regional to global scales.	6. Determine the degree to which changing environment and altered human activities result in synergistic or antagonistic **changes in ecosystem services.**

The cross-cutting nature of ***vegetation structure and function*** highlights the interconnectedness of the ABoVE research effort and the diversity of data needs to characterize ecosystem vulnerability and resilience across a broad geographic domain.

Projects Specific Questions & Objectives (1 of 3)

What long-term (>30 years) ecosystem changes are occurring in interior AK boreal forests, and which landscapes are more susceptible or resistant to change? *(Cook, PI)*

- Characterize change in Tanana Valley, AK, using field measurements, stereo air photos and G-LiHT fine-resolution, multi-sensor airborne data (1982-2014).

What is the impact of changing shrub cover and biomass on summer albedo and the surface energy budget in Artic tundra? *(Chopping, PI)*

- Provide a 10 to 15 y assessment of shrub cover and albedo changes on the North Slope, AK.

What is the vulnerability and resilience of the forest-tundra ecotone to environmental change? *(Eitel, PI)*

- Characterize and link ecotone micro-structure with physical growth environment to assess vulnerability and resilience.

What is the link between growing season length and productivity in Artic tundra, and how is it affected by disturbance and hydrology? *(Gamon, PI)*

- Develop a new light-use efficiency (LUE) photosynthesis model based on MODIS chlorophyll and carotenoid indices to evaluate greening-browning trends and the relationship between growing season length and productivity.

Projects Specific Questions & Objectives (2 of 3)

Is the arctic–boreal biome shifting northward, causing mortality and decreased tree productivity in the south and range expansion of shrubs in the northern boreal and arctic tundra, and how will this shift affect faunal habitat? (Macander, Co-I)

- Map shrubs zones and lichens across northern AK and central Canadain northern AK; use resampled boreal forest plot data and measurements of ^{13}C to evaluate drought stress and relationships with greening and browning trends; and use individual tree models to predict boreal tree species productivity, mortality & distribution across the ABoVE domain.

Can remote sensing be used to detect methane bubbles under ice, and when combined with ground observations, be used to quantify the permafrost carbon feedback associated with thermokarst lakes? (Meyer, PI)

- Develop remote sensing methodology and algorithms needed to estimate methane emissions and vulnerability maps.

Can fine-resolution stereo imagery from commercial satellites provide suitable digital terrain and surface elevation models for ABoVE studies that require wall-to-wall ground surface elevations and tree height estimates? (Morin, PI)

- Create <1 m digital terrain model, digital surface model, and panchromatic, orthorectified mosaic of the ABoVE study domain.

Projects Specific Questions & Objectives (3 of 3)

What are the forest biomass stocks of the USFS Tanana Valley inventory unit, and can we detect changes in species composition and productivity due to climate and fire? (Morton, PI)

- Develop sampling and statistical methods for estimating forest properties and biomass using a combination of ground-based inventory plots and fine-resolution (1 m) multi-sensor airborne data (G-LiHT lidar, hyperspectral and thermal), and use the results to characterize impacts of recent fires on carbon losses and forest regrowth trajectories.

What controls warming or cooling following fires in the ABoVE domain, and how can selective fire management help mitigate fire-climate feedbacks? (Veraverbeke, Co-I)

- Quantify carbon consumption by wildfire and long-term changes to albedo.

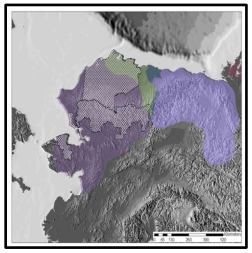
How are vegetation and snow conditions changing in alpine ecosystems, and how do these changes impact iconic northern wildlife and critical ecosystem services? (Verbyla, Co-I)

- Model the effects of snow pack properties, greening-browning trends, and shrub encroachment throughout alpine areas on Dall sheep movements, habitat selection, and population viability; and assess societal implications of altered sheep harvest.

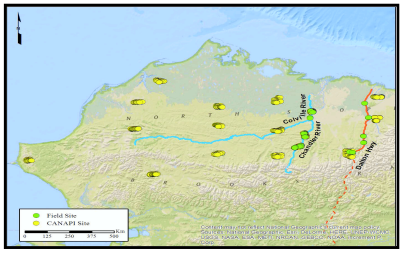
Do subtle changes in canopy stature, density, and spectral properties serve as an early warning signs or indicators of ecological change? (Vierling, PI)

- Develop remote sensing-based methods for identifying, scaling, and understanding the onset of a cascade of immediate/near-term ecological shifts associated with increased shrub height, density and leaf area in tundra ecosystems.

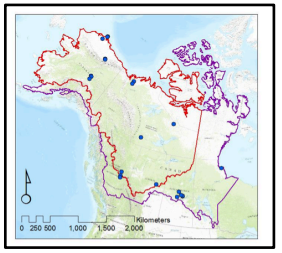
Study Regions and Field Sites



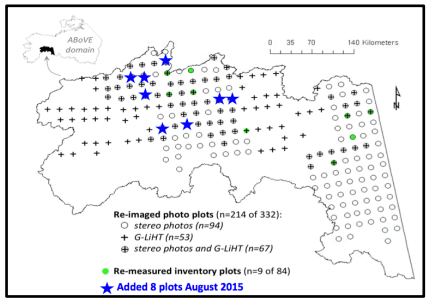
Goetz – **North Slope, AK**



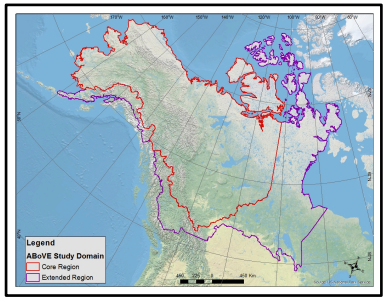
Chopping – **North Slope, AK**



Gamon – **Flux tower sites**



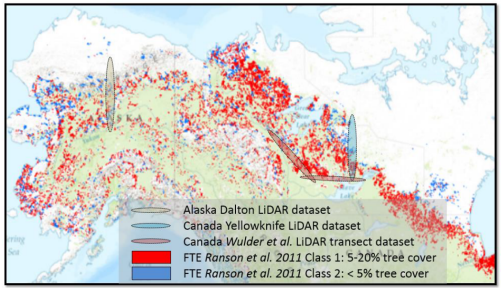
Cook; Morton - **Tanana Valley**, AK



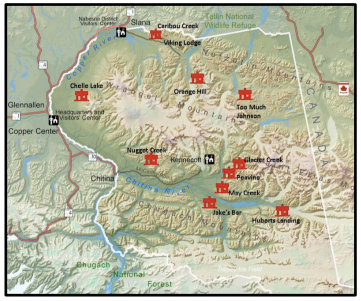
Morin – ABoVE domain (**wall-to-wall**)

Veraverbeke – **burned areas** (TBD)

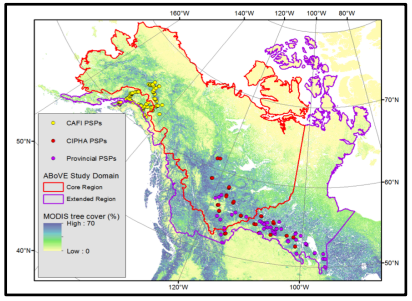
Vierling – **North Slope, AK** (TBD)



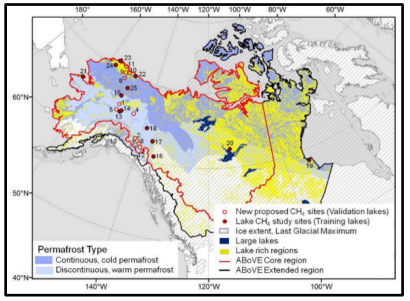
Eitel – **Forest-Tundra ecotone**



Prugh – **Wrangell Mountains, AK**



Goetz - **Boreal forest**



Meyer – **Thermokarst Lakes**

Ground Measurements

Trees

- USFS FIA/AIRIS and NPS protocols (Cook; Morton; Goetz)
- Tree species and DBH (Eitel; Goetz)
- Terrestrial Scanning Lidar (Eitel; Vierling)
- Field spectrometer measurements (Vierling)
- Continuous PRI, band dendrometers (Eitel)
- Leaf-level chlorophyll fluorescence (Eitel)
- ^{13}C in tree cores (Goetz)

Shrubs

- Location, class, species, size, height, leaf area (Chopping; Vierling)
- Phenocams (Gamon)

Mosses and lichens

- USFS FIA protocol (Morton)

Snow

- Continuous depth and water equivalent (Eitel; Prugh)
- Tansects and snow pits (Prugh)

Soils

- USFS FIA protocol (Morton)
- Continuous soil T (Eitel)
- Soil organic carbon (Meyer)

Carbon fluxes and meterorology

- AmeriFlux towers (Gamon)
- Air T (Eitel)
  - SNOTEL stations (Prugh)
  - CH_4 from thermokarst lakes (Meyer)

GPS

- ***Need plot coordinates within 1 to 2 m to match with remote sensing data!***

Spaceborne Remote Sensing

Landsat (USGS-NASA partnership)

- 30 m, 16 d revisit
- Imaging Earth's natural resources since 1972!

MODIS (NASA Earth Observing System)

- 250 to 1000 m, 1-2 day revisit
- Instrument on 2 satellites (Terra, Aqua)

Commercial fine-resolution, mono & stereo imagery

- ≤1 m resolution, no global acquisition strategy

Lidar and Radar (international)

- Lidar: ICESat (2003-2009); ICESat-2 (Oct 2017 launch)
- Radar: PALSAR, PALSAR-2; EnviSat; Radarsat-1,2; Sentinel-1

Airborne Remote Sensing

Current studies (using previously acquired data):

- ***NASA Goddard Lidar, Hyperspectral and Thermal (G-LiHT)*** (Tanana Valley, AK)
- ***Airborne Scanning Lidar*** (Dalton Highway, Yellowknife, boreal regions in Canada)
- ***Contemporary mono and stereo air photos*** from previous studies (AIRIS, Chopping)
- ***Historic air photos*** (AIRIS, AHAP, NARL, USGS)
- ***Radar*** (AirSAR, AK Statewide Digital Mapping Initiative, FMCW)

Future studies:

- **Future campaigns must consider 1) science rationale; 2) synergy with *in situ* measurements; and 3) an appropriate data collection strategy.**
- ***Fine-resolution (1 m) data is a must for spatially heterogeneous vegetation types*** (e.g., "pipe cleaner" spruce trees, shrubs, lichen & moss ground cover), tundra microtopography, and standing dead trees.

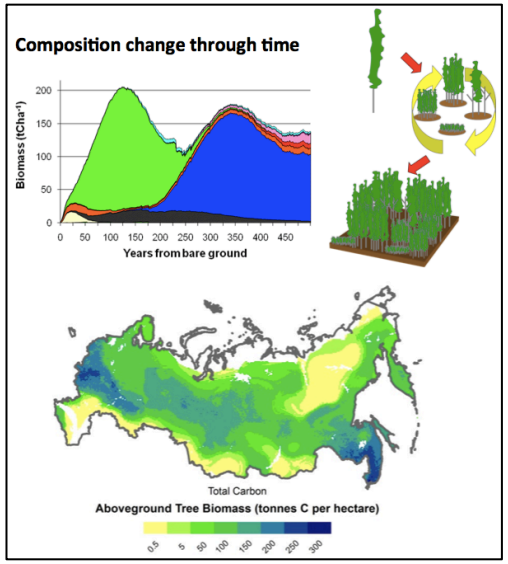
Modeling Efforts

Diagnostic Models:

- Methane release from thermokarst lakes
- LUE model of photosynthesis
- Forest biomass and other attributes
- Land cover classification

Prognostic Models:

- Univ. of Virginia Forest Model Enhanced (UVFME)
- Dall Sheep population viability and harvest models
- Radiative Transfer & Energy Budget models



Geospatial Data Products (1 of 2)

Project Lead	Product	Availability
Prugh	Dall sheep products: geo-location (1997-present), harvest, survey (both 1950s to present)	In-Progress
Prugh	Snow datasets: extent for 15-May and 1-July (500m, 2000-present); Snow transect data (Wrangells, 100m, 2016-2017), SnowModel output (Wrangells, 100m, 2000-present)	In-Progress
Prugh	Max NDVI (Dall sheep range-wide, 250m, 2000-present)	In-Progress
Prugh	Alpine shrub extent (Range-wide, 30m, 1980s and present)	In-Progress
Prugh	MicroMet output (Wrangells, 100m, 2000-present)	In-Progress
Rogers	Burned area products: Burned area (500 m, 2001-2015) and combustion in kgC m^{-2} (500m, 30 m, 250 m; 2001-2015) (for fire events in regions studied)	In-Progress
Rogers	Radiative Forcing products: GHG RF (500 m, 2001-2015); Aerosol RF (500 m, 2001-2015); Net RF (500 m, 2001-2011); RF projections during season and during event (500m, current) (for fire events in regions studied)	In-Progress
Rogers	Spring Albedo products: Increase in spring albedo (500 m, 2001-2011); Spring albedo RF (500 m, 2001-2011) (for fire events in regions studied)	In-Progress
Chopping	Shrub cover and aboveground biomass estimates for ~200 sites of 1km x 1 km, with high resolution maps (vector/raster); Albedo time series of same sites.	In-Progress
Cook-02	G-LiHT products for AIRIS plot locations, stereo photo products for AIRIS plot locations, G-LiHT products outside plot locations; Landsat and Hyperion-derived products	In-Progress
Eitel	Vegetation structure, snowpack dynamics, radiative transfer, tree physiology, and FTE vulnerability and resiliency for areas within the YK Delta	In-Progress
Morton-02	Statistical estimates of carbon stocks at stratum level (view)	In-Progress
Morton-02	Maps of carbon stocks with pixel-level carbon estimates and uncertainties (view)	In-Progress
Vierling	High resolution, validated map of songbird breeding habitat for Lapwing longspurs and Gambel's white-crowned sparrows at the Toolik Field Station, AK, and nearby field sites along Dalton Highway.	In-Progress (available Spring 2016)
Vierling	High resolution (1 m^2) map of shrub biomass for a ~13 km^2 area at the Toolik Field Station, AK and nearby field sites along Dalton Highway.	In Progress (available

Geospatial Data Products (2 of 2)

		mid-2016)
Vierling	Harvest-based allometric equations relating shrub height and volume with biomass and leaf area for two common Arctic tundra shrub species, *Salix pulchra* and *Betula nana*.	Available
Vierling	Bare earth LiDAR dataset for Toolik Field Station, AK, and nearby field sites along Dalton Highway.	Available
Vierling	Four-band, 5cm resolution orthophotographs of Toolik Field Station, AK, and nearby field sites along Dalton Highway.	In progress (available mid-2017)
Goetz	Arctic vegetation maps including proportional (0-100%) shrub and lichen cover maps of North Slope for 2000 and 2010	In-Progress
Goetz	Boreal vegetation maps including 1) Probability maps of boreal tree mortality, and 2) Press and Pulse NDVI changes / trends.	In-Progress
Goetz	Boreal modeling of distribution / NPP change including: 1) species productivity & range suitability map outputs and 2) calibrate & validated maps (site inventory-like predictions including probability maps of species-specific boreal tree mortality & northern range expansion)	In-Progress
Gamon	Carbon flux & optical data from core sites	In-Progress
Gamon	Maps (MODIS, OCO-2): for vegetation type, photosynthetic productivity, season length (2000-2015, ABoVE domain-wide)	In-Progress
Meyer	Multi-temporal layers of geocoded remote sensing imagery for project region	In-Progress
Meyer	Historical hydro - multi-temporal historical lake boundaries	In-Progress
Meyer	Lake-bound CH_4 ebullition emission maps – all lakes within project region	In-Progress
Meyer	Regional SOC stock and CH_4 emission vulnerability maps – regions around selected active thermokarst margins of lakes	In-Progress
Meyer	Present-day regional-scale net lake CH_4 emission budget – project region	In-Progress
Meyer	Ebullition flux data from bubble traps – for field study lakes	In-Progress
Meyer	Bubble CH_4 content and isotopes – for field study lakes	In-Progress
Meyer	Soil carbon data – for field study lakes	In-Progress
Morin	~0.5m orthorectified panchromatic mosaic of the ABoVE study domain based on DigitalGlobe imagery (view)	In-Progress
Morin	Stereo-panchromatic and multispectral high resolution DigitalGlobe imagery of the ABoVE domain (view)	In-Progress
Morin	2-10m posting Digital Elevation Models of the ABoVE domain (view)	In-Progress

NASA Earth Science Data and Information Policy

*"**NASA promotes the full and open sharing of all data with the research and applications communities, private industry, academia, and the general public**. The greater the availability of the data, the more quickly and effectively the user communities can utilize the information to address basic Earth science questions and provide the basis for developing innovative practical applications to benefit the general public."*

http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/

E.g., Achieved Geospatial Data (Chopping)

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NACP Woody Vegetation Characteristics of 1,039 Sites across the North Slope, Alaska

Download Data

Data Set Overview

Data set	NACP Woody Vegetation Characteristics of 1,039 Sites across the North Slope, Alaska
DOI	10.3334/ORNLDAAC/1270
Release date	2015-02-10
Project	North American Carbon Program (NACP)

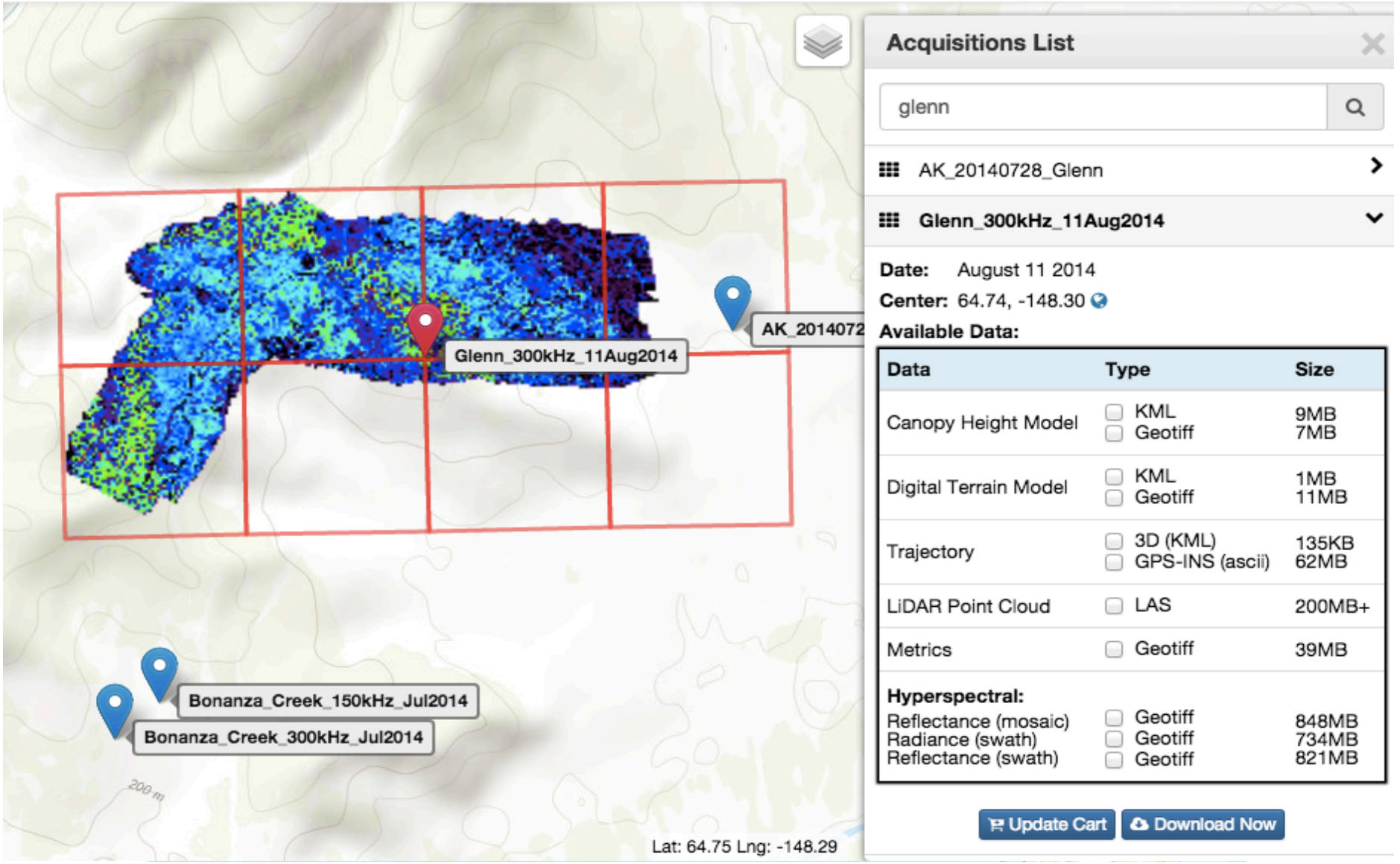
Data set bounding box.
Lat: 71.40N to 65.00N, Long: 167.00W to 145.00W

Description

This data set provides the results of (1) field measurements of woody vegetation (shrubs) at 26 diverse sites across the North Slope of Alaska during 2010 and 2011, (2) field-based statistical estimates of site shrub structural characteristics, (3) high-resolution panchromatic satellite imagery-based estimates of the field site shrub characteristics using the Canopy Analysis with Panchromatic Imagery (CANAPI) model, and (4) adjusted CANAPI estimates of shrub characteristics at 1,013 selected sites widely distributed across the North Slope. A site characterization file is included with the assigned â€œPhysiognomic vegetation classâ€, which was one of the criteria for the selection of the 1013 CANAPI sites, and with the sources of the high resolution imagery used to obtain CANAPI estimates. The CANAPI crown detection algorithm (Chopping, 2011) is also provided as a companion file. As part of a NASA-funded research project to map changes in tall shrub (taller than 0.5 m) abundance in Arctic tundra, a 3-week field campaign was carried out in 2010

E.g., G-LiHT Open Access Data & User-Friendly Products

http://gliht.gsfc.nasa.gov

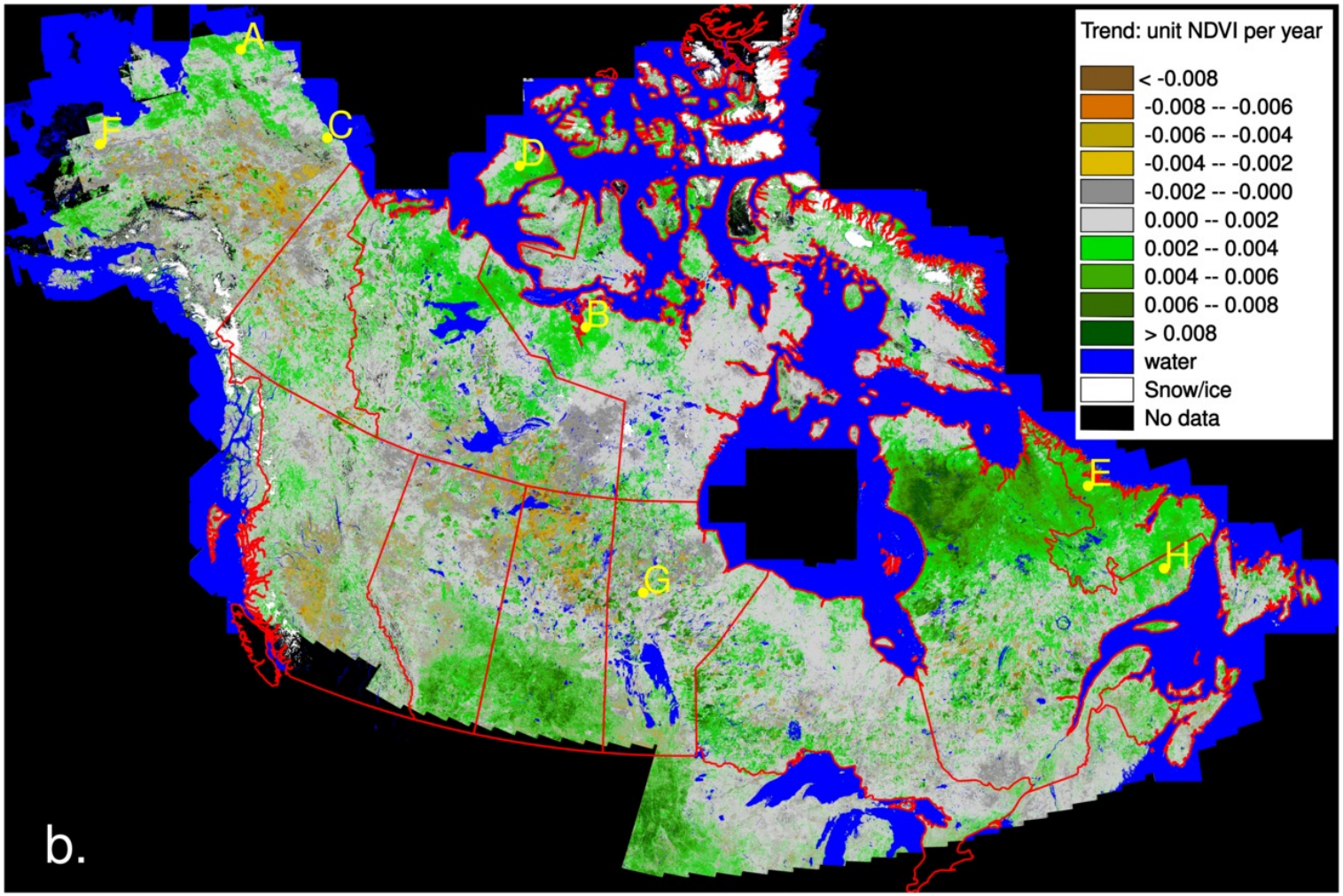


Potential Partnerships and Collaborations

- ***Local observations, community feedback and stakeholder needs are highly valued!***
- ***Educational opportunities*** exist through NASA Internships and postdocs (next gen scientists)
- ***NASA planned satellite missions*** (e.g., ICESat-2, Landsat 9, HyspIRI)
- ***Form collaborations around airborne acquisitions and targets of opportunity*** (e.g., G-LiHT data collected for Toklat River in Denali NP; research plots; wilderness areas where helicopters are not permitted)
- ***Parallel research outside AST*** (e.g., Landsat greening-browning analysis by Ju and Masek, 2016)
- ***USFS 10-year plan to inventory forests in interior Alaska*** with a combination of ground plots and airborne image data.

Landsat-derived Artic Trends

(Ju and Masek, RSE, 2016)



NASA-USFS FIA Partnership

http://www.wired.com/2014/12/alaska-laser-survey-3d-map/

WIRED

NICK STOCKTON SCIENCE 12.16.14 7:00 AM

HOW A FLYING LASER BUILT A 3-D MAP OF A MASSIVE ALASKAN FOREST