

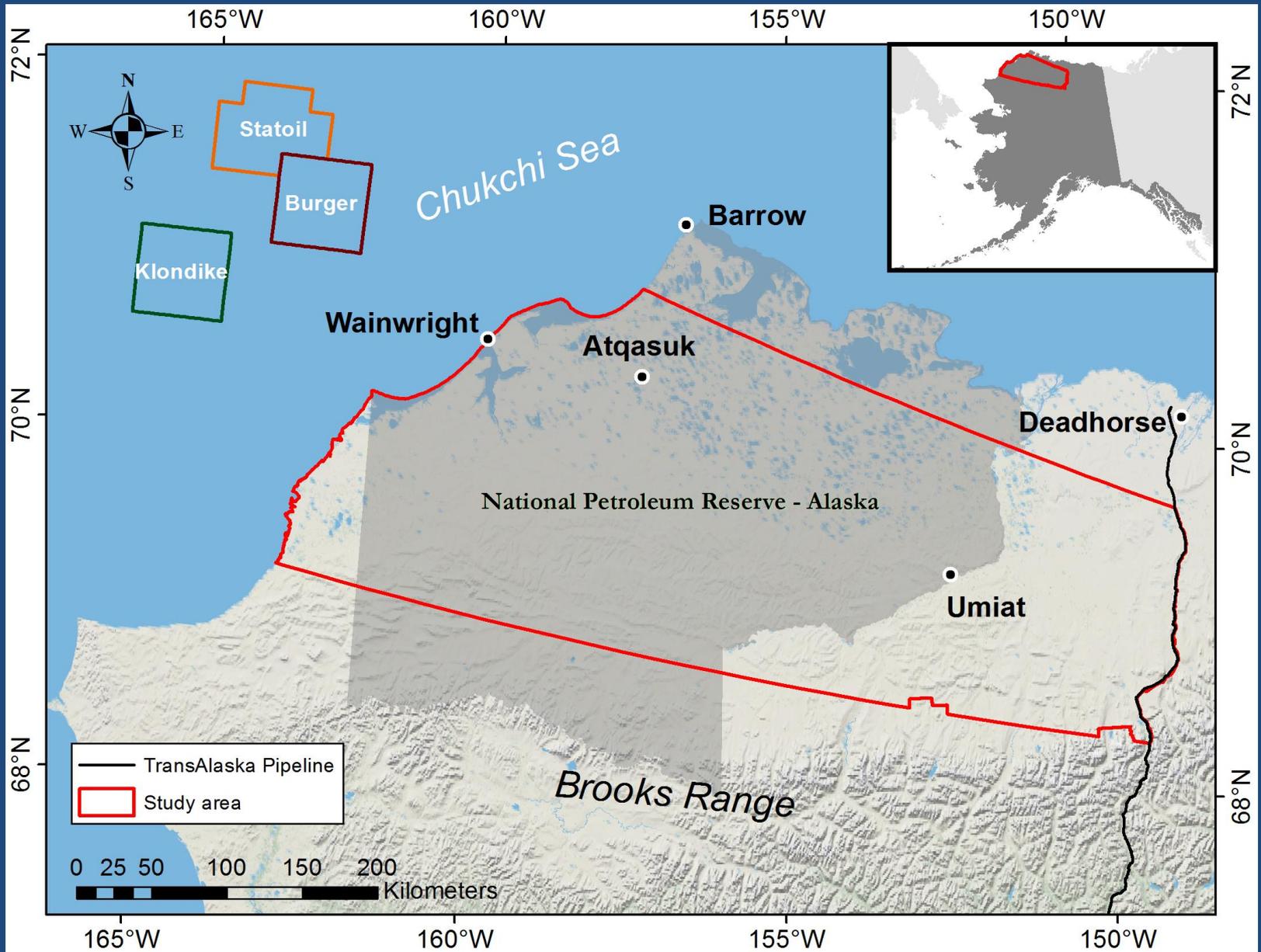
# Quantitative Interpretation of Spectral Characteristics for Habitat Characterization and Mapping on the North Slope of Alaska

Matt Macander  
ABR, Inc.—Environmental Research & Services  
Fairbanks, Alaska

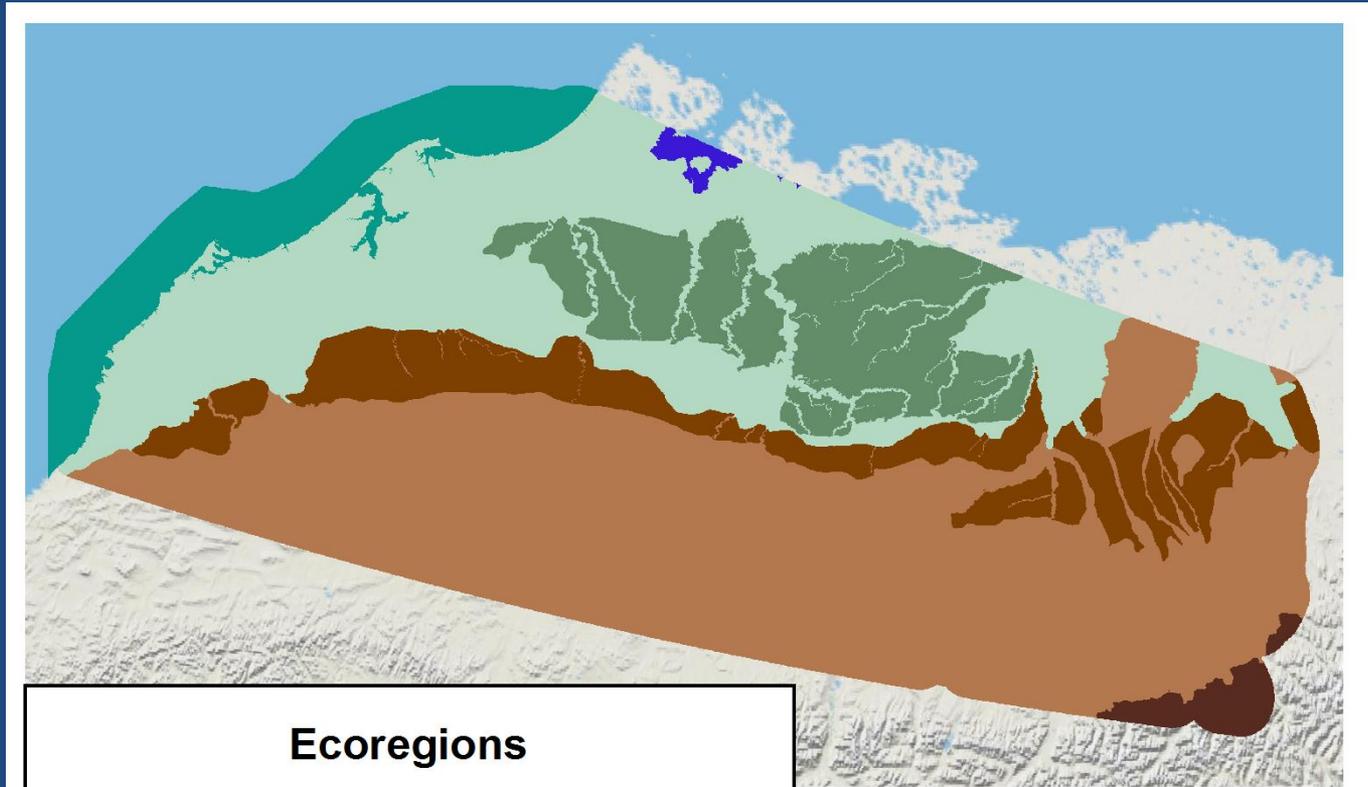
Gerald Frost, ABR, Inc.  
Martha Reynolds, UAF



# Study Area



# Study Area: Topography and Substrate

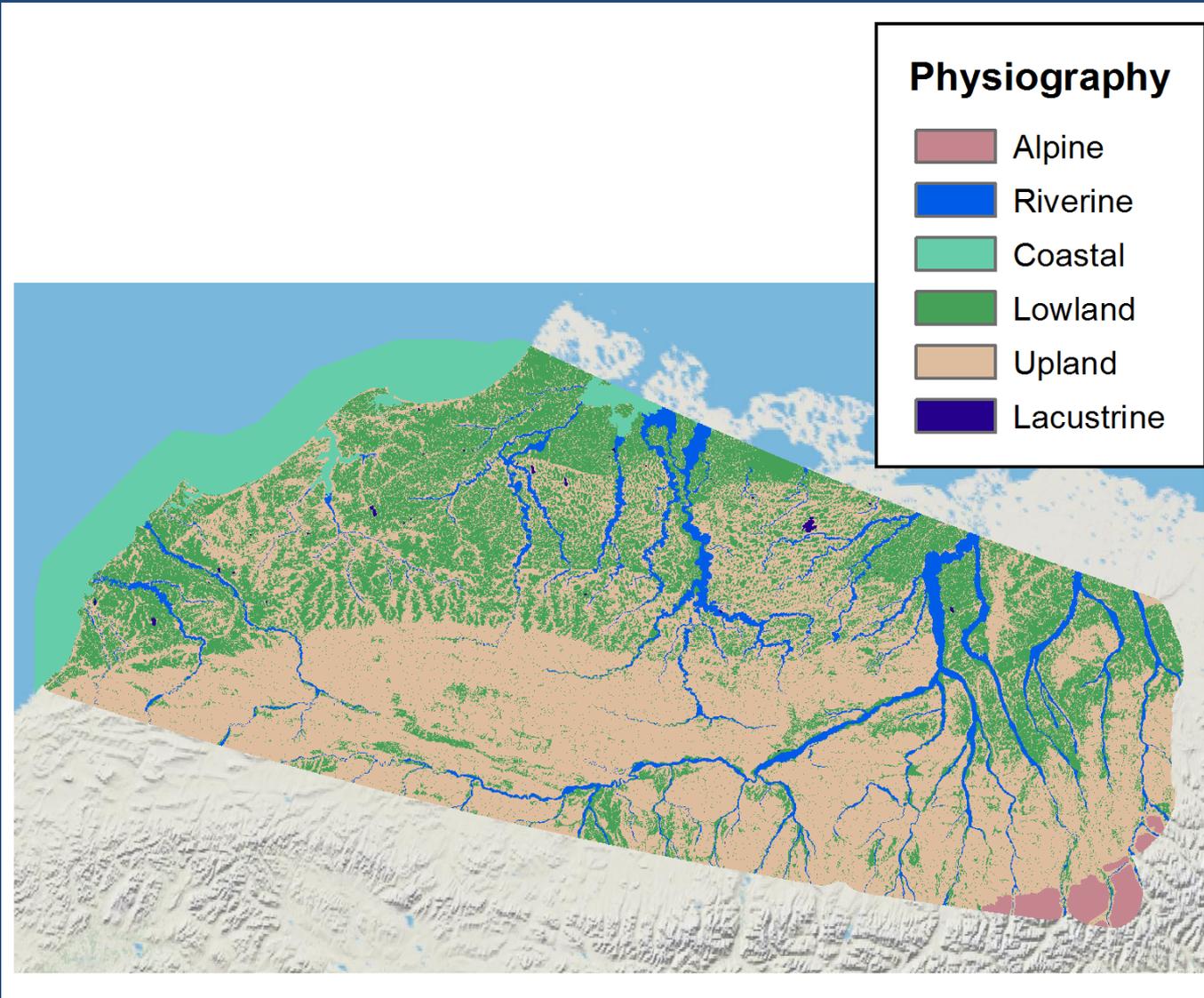


## Ecoregions

-  Northern Chukchi Coast
-  Beaufort Sea Coast
-  Beaufort Coastal Plain
-  Beaufort Coastal Plain (Sand Sheet)
-  Brooks Foothills (Yedoma Belt)
-  Brooks Foothills
-  Northern Brooks Range

Adapted from  
Jorgenson and  
Grunblatt 2013

# Study Area: Physiography



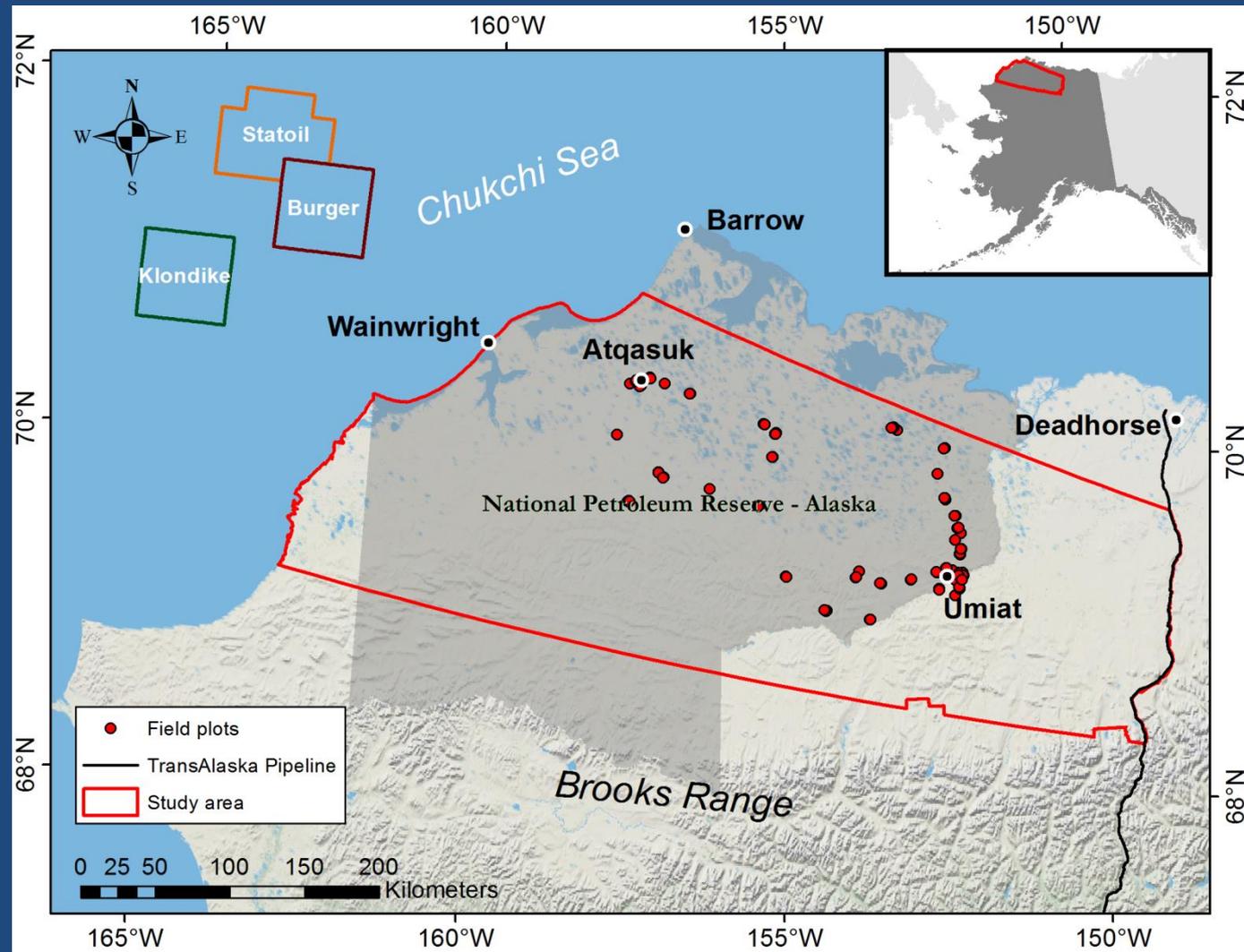
Locally dominant tectonic and geomorphic controls on landform development.

# Objectives

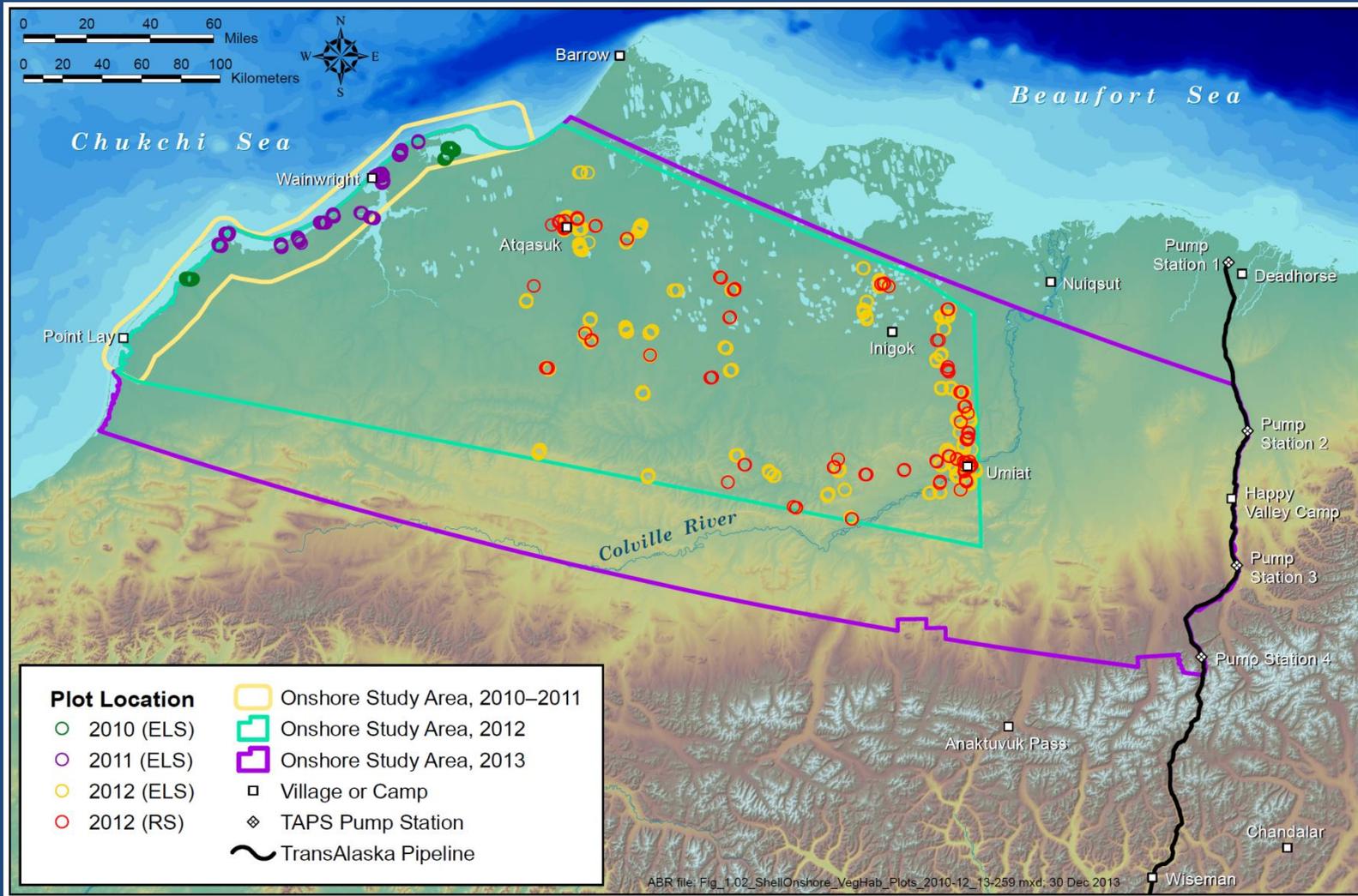
- Characterize and map wildlife habitat characteristics at multiple scales to support potential infrastructure planning.
- Compare field measurements of vegetation cover and structure to high-resolution and Landsat satellite signals.
- Calibrate and atmospherically correct commercial satellite imagery.

# Field Plot Locations: Summer 2012

- Based in Atqasuk and Umiat.
- Targeted diverse habitat types.
- Targeted similar vegetation with and without greening trends (1985–2011).

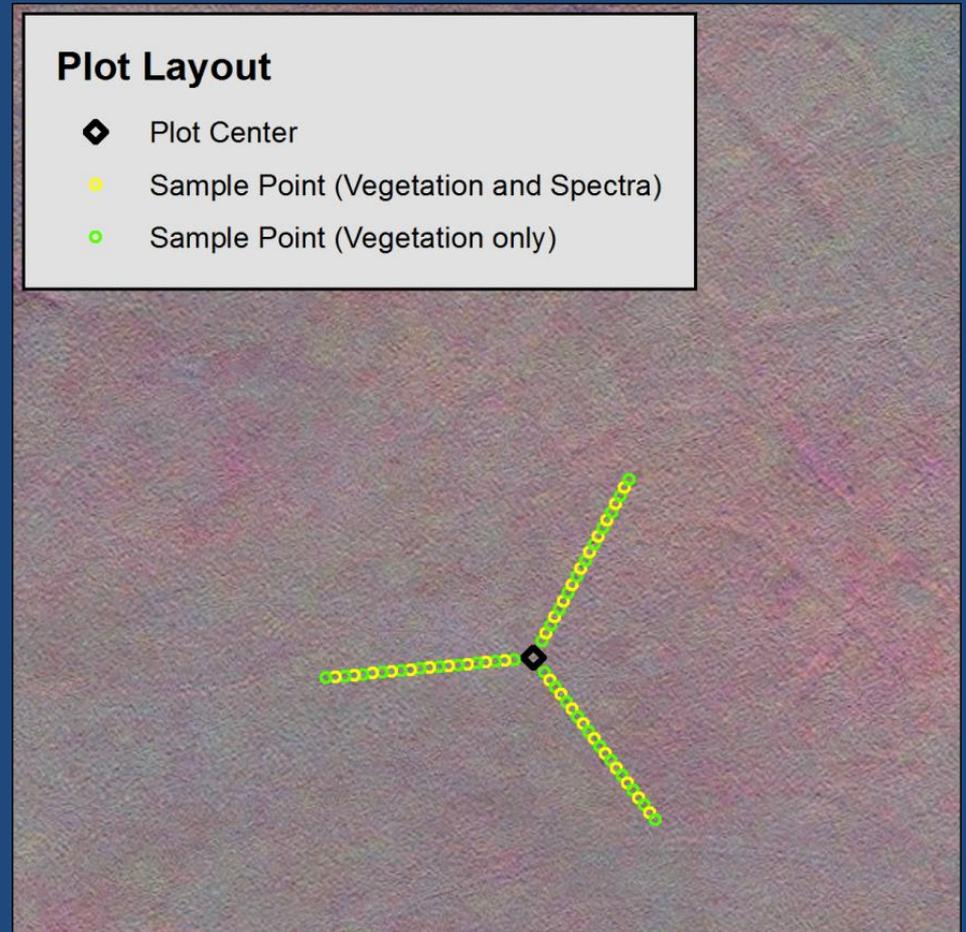


# All Plots, 2010–2012



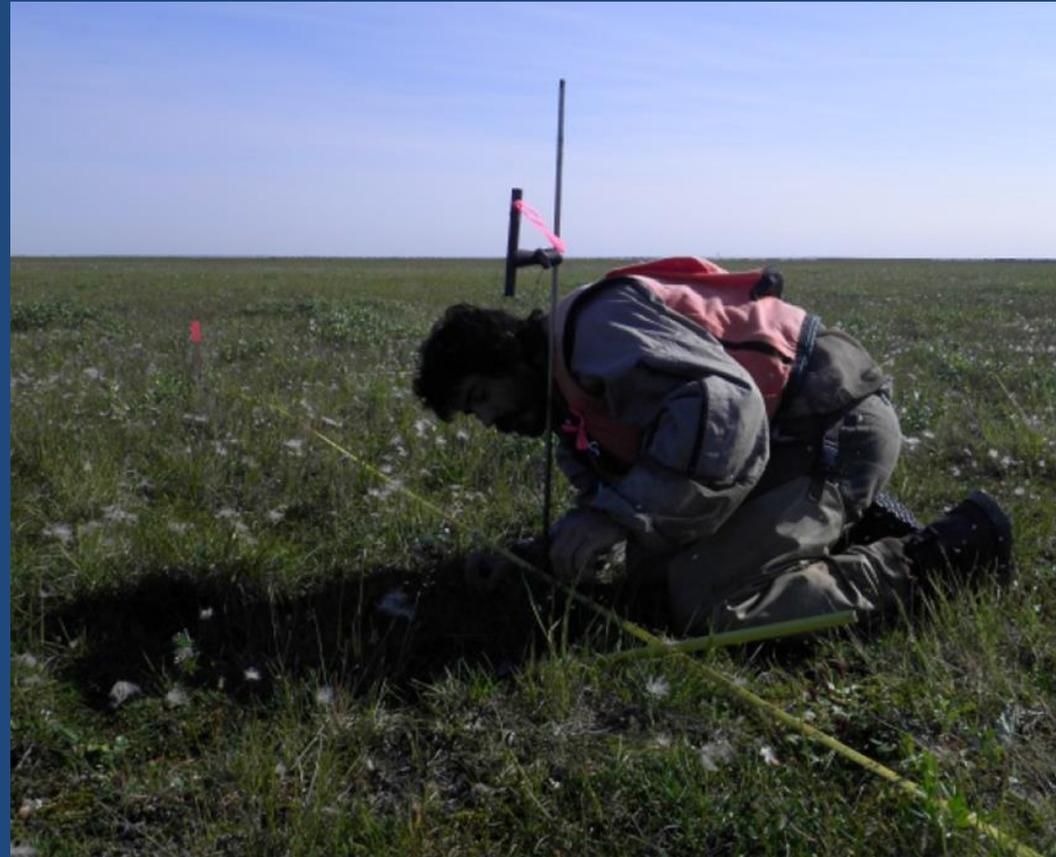
# Field Plot Layout

- 2012: Quantitative line point intercept sampling
- Plot dimensions: 3 x 50-m
- Sample points every 2.5 m



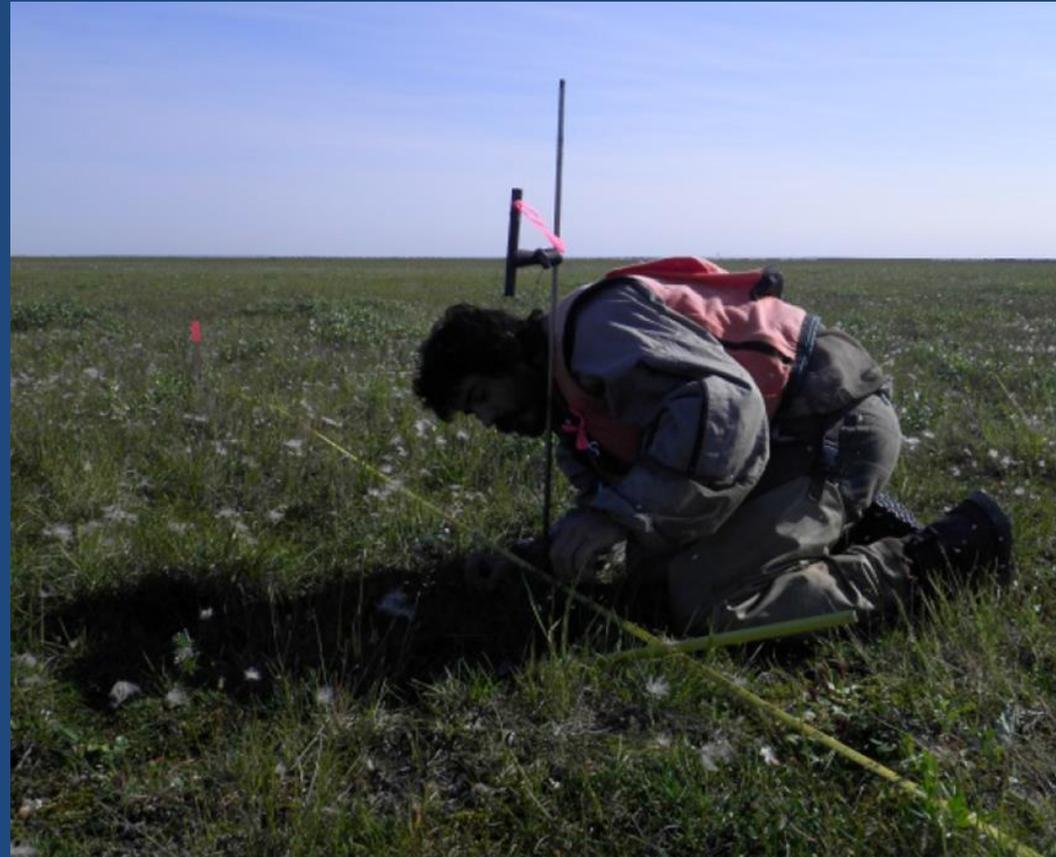
# Field Plot Methods

- All live hits recorded to species
- Up to 3 litter hits recorded
- Recorded height of woody and herbaceous plant canopy every 5 m



# Field Plot Methods

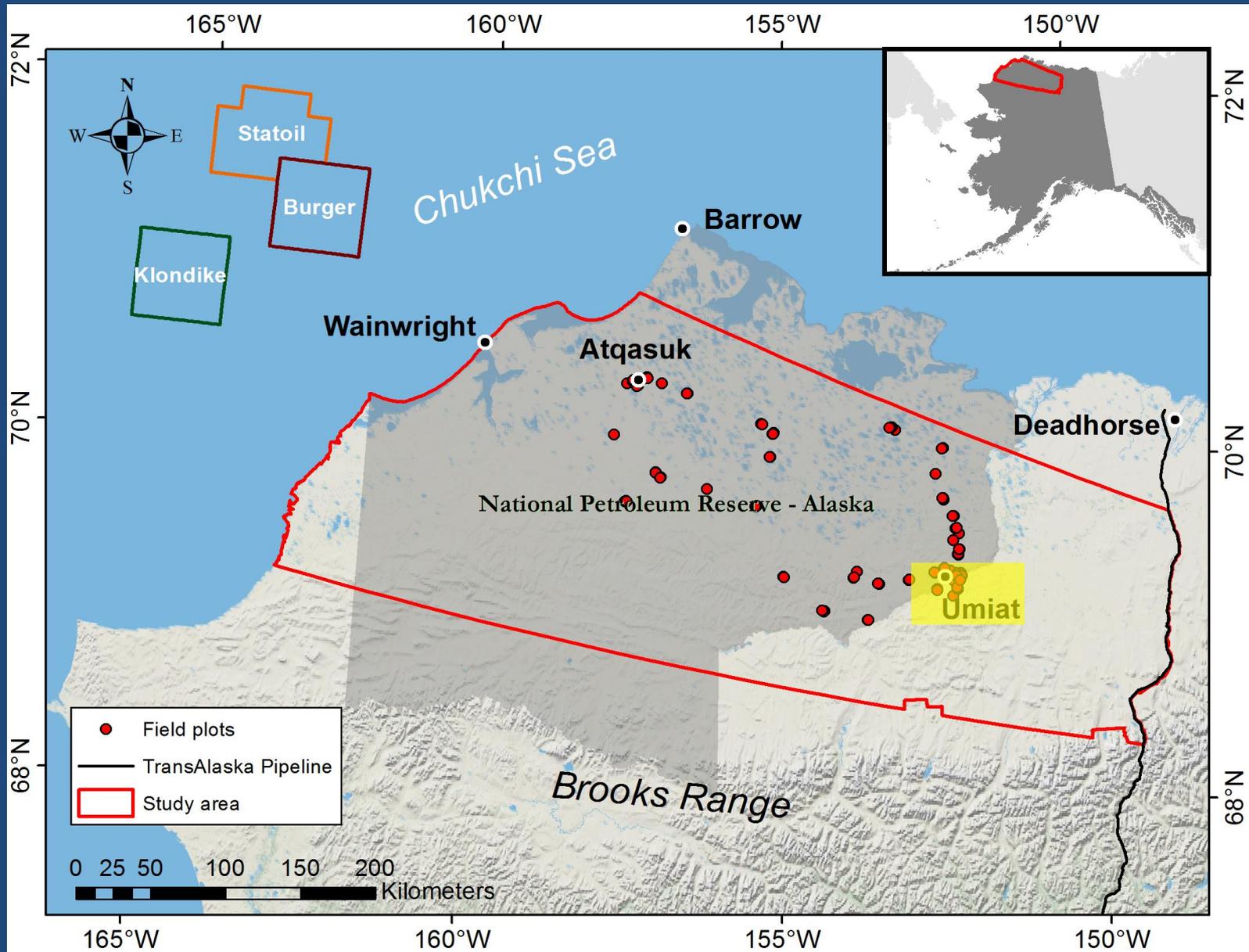
- Proxy for LAI, above ground biomass, forage quantity
- Fairly rapid and non-destructive
- Commonly used for long-term monitoring, including impacts studies

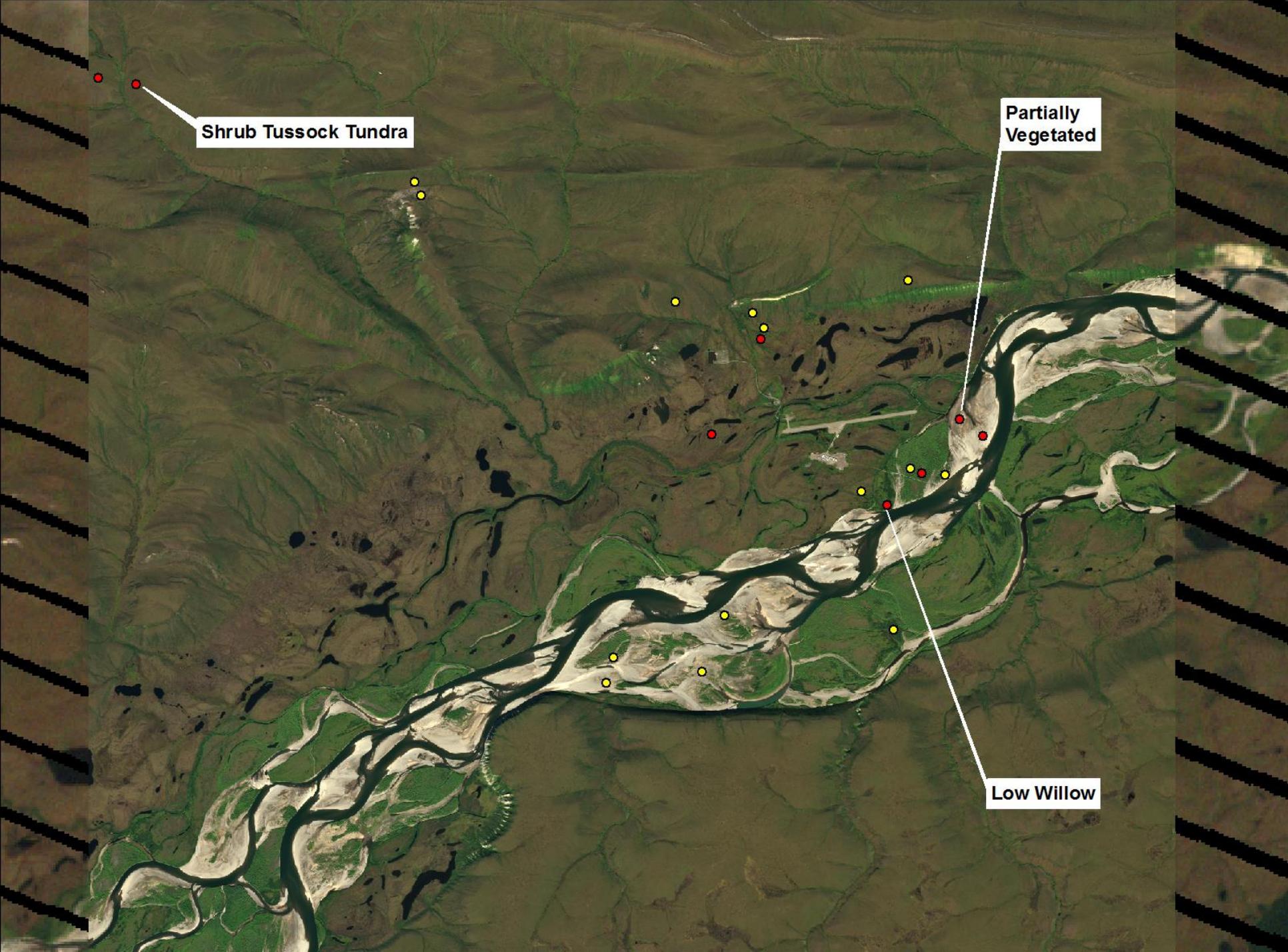


# Summarizing Point Intercept Data

- Percent cover: % of points where species or functional type occurs
- Top cover: % of points where species or functional type occurs as first hit
- Hit density: Total number of hits of a species/functional type divided by total number of points

# Field Data: Summer 2012



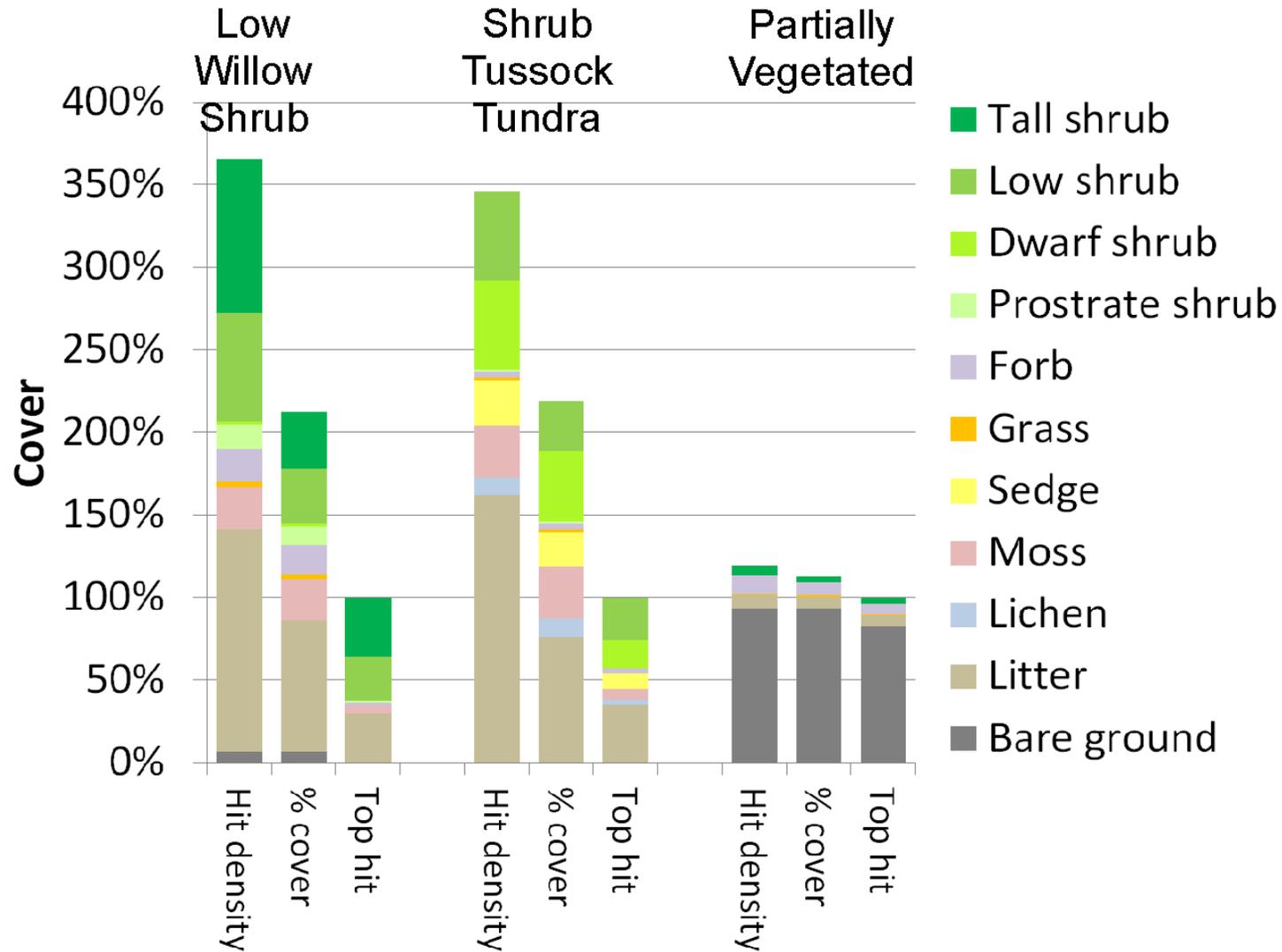


Shrub Tussock Tundra

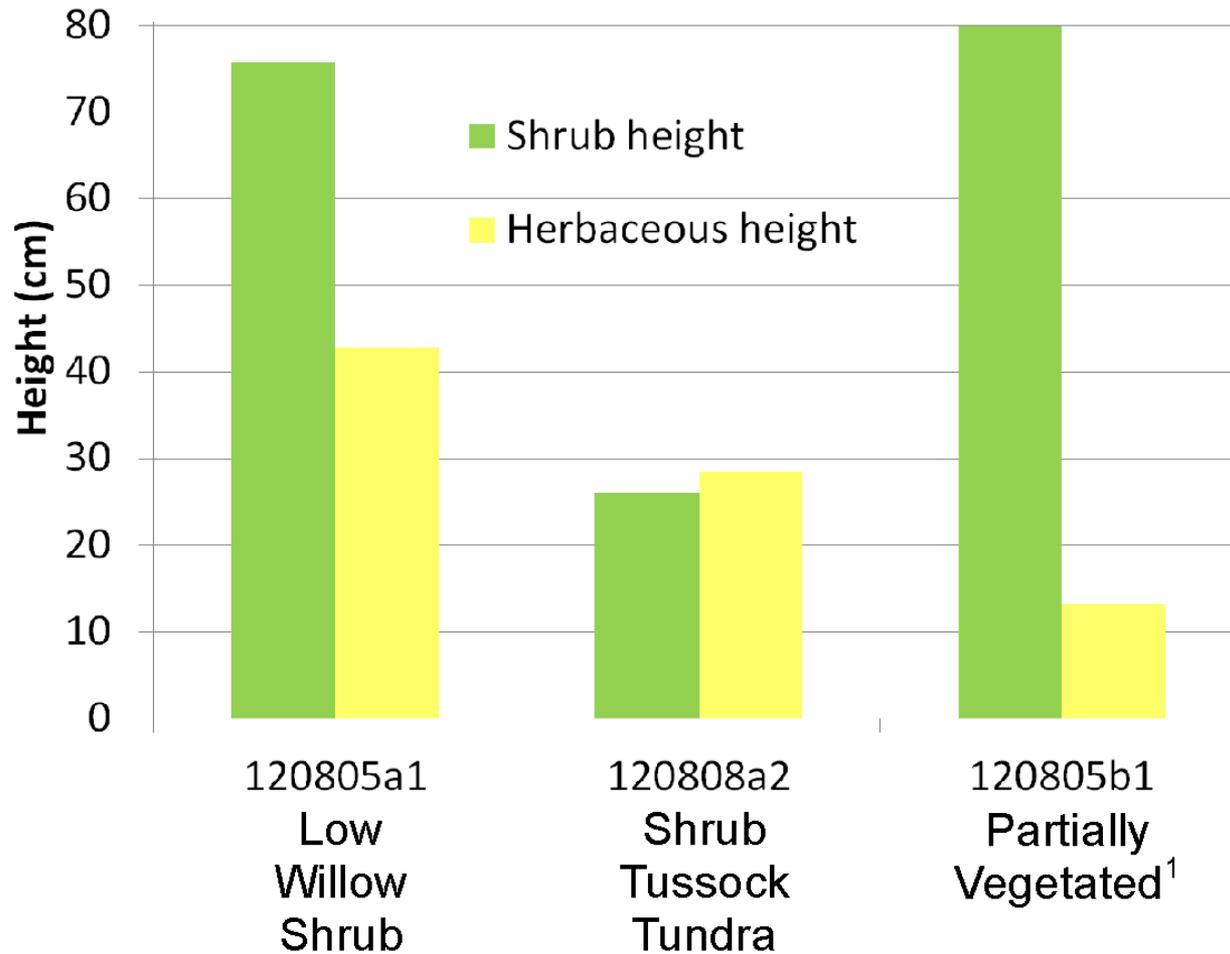
Partially Vegetated

Low Willow

# Cover Metrics



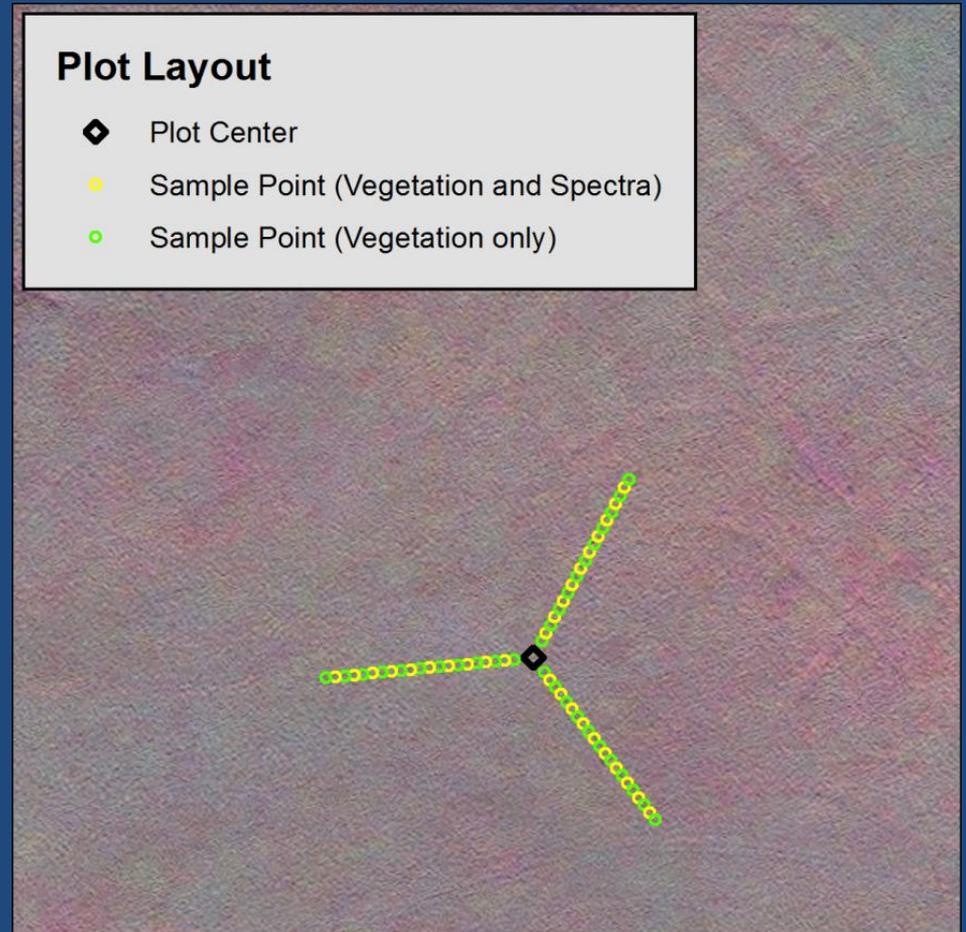
# Height Metrics



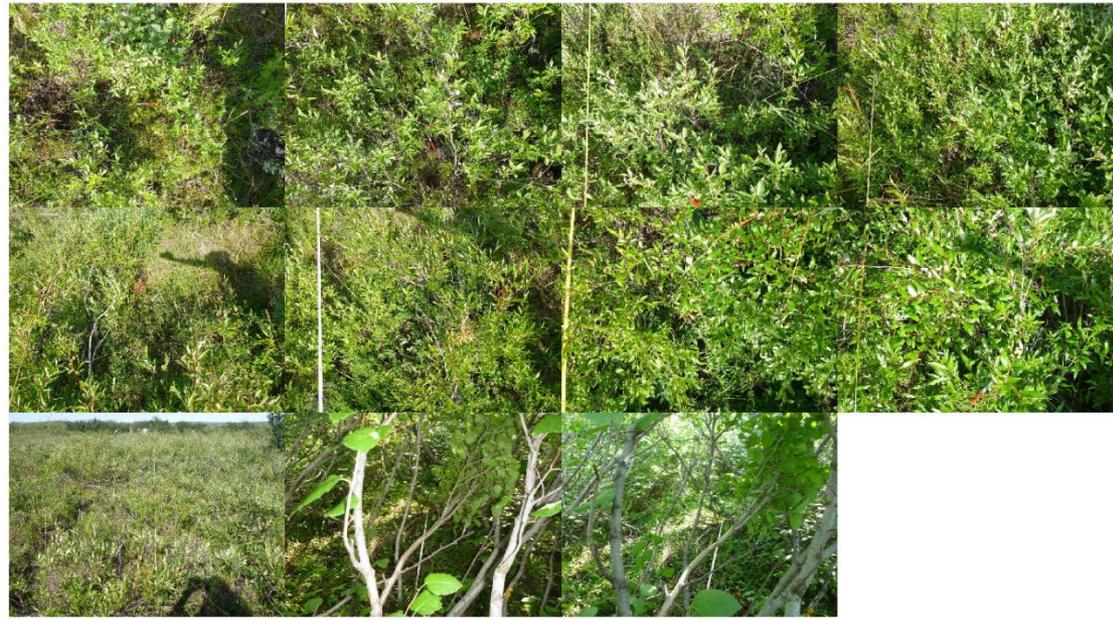
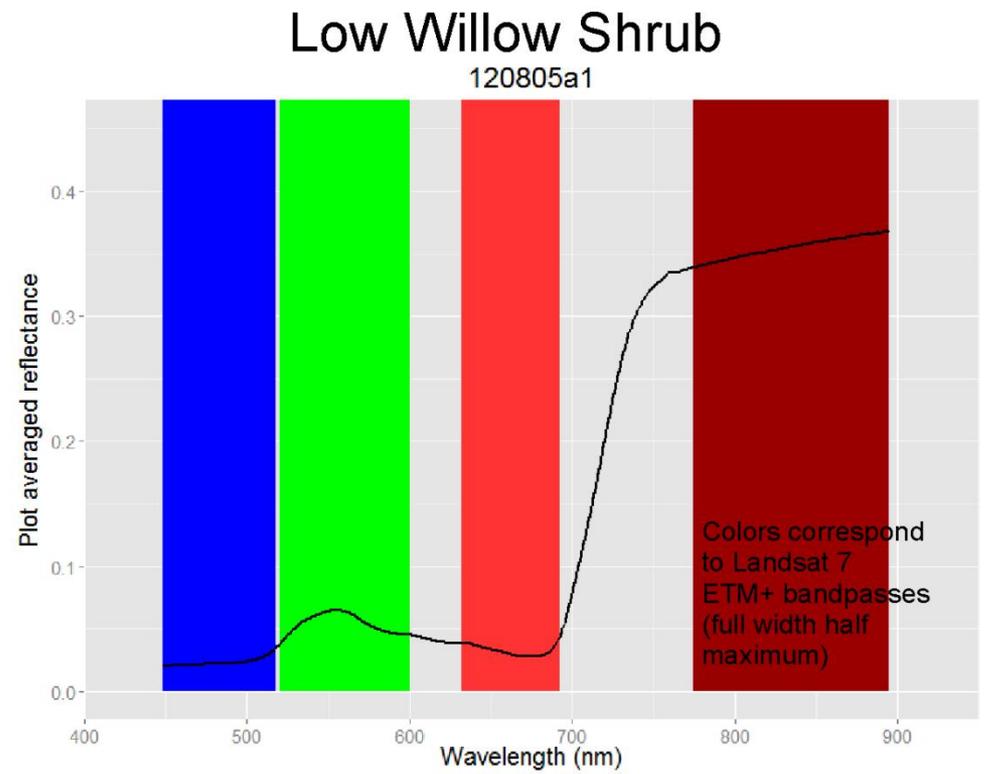
1. Height is the average height when shrub or herbaceous vegetation is present within 15 cm of the sample point. For the partially vegetated plot, shrubs were present at 15% of points and herbs were present at 52% of points.

# Field Spectra

- ASD HandHeld2 VNIR spectrometer
- With suitable lighting, spectra every 5 m
- Small and lightweight—practical for opportunistic sampling

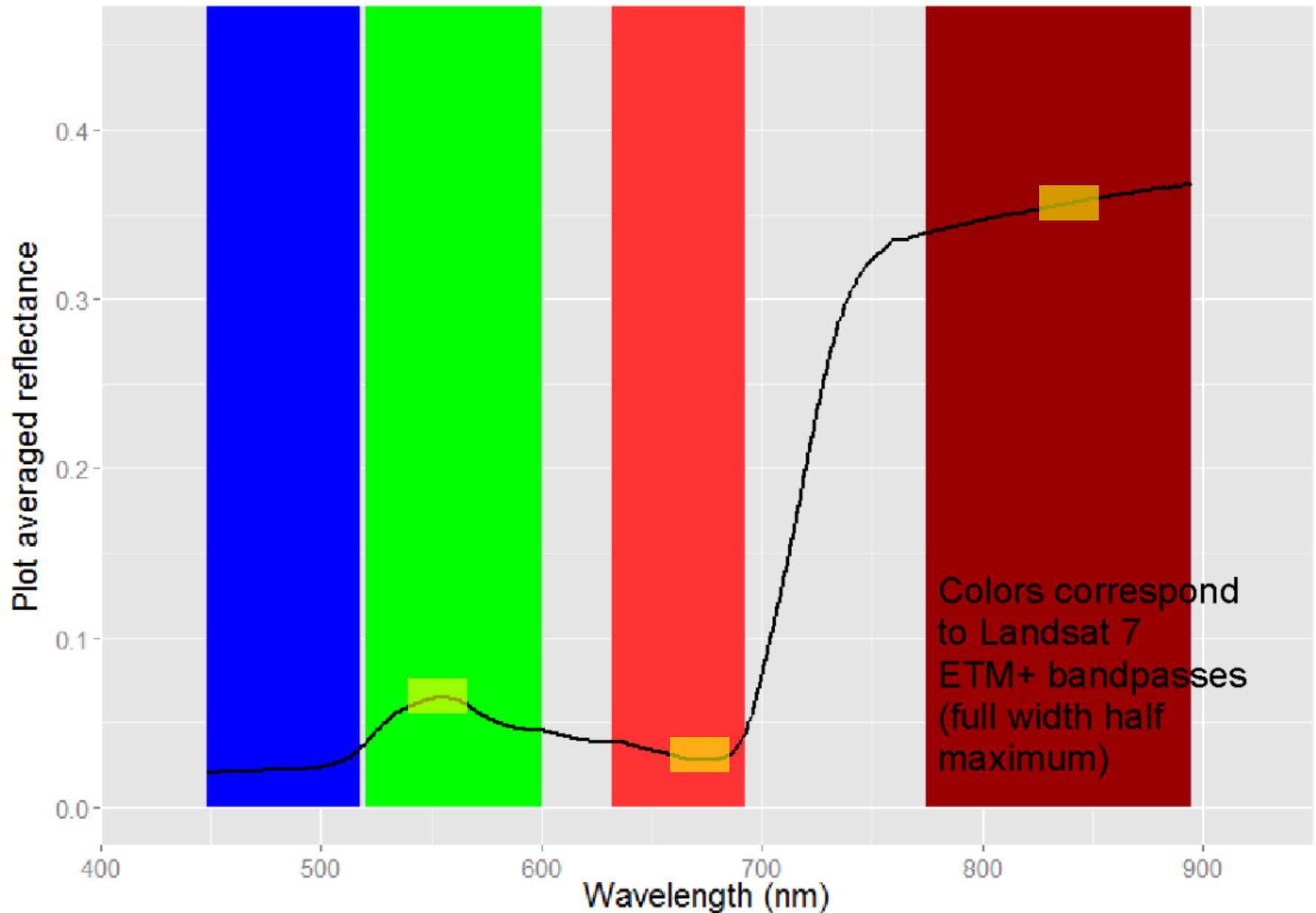


# Spectra and Ground Photos



# Low Willow Shrub

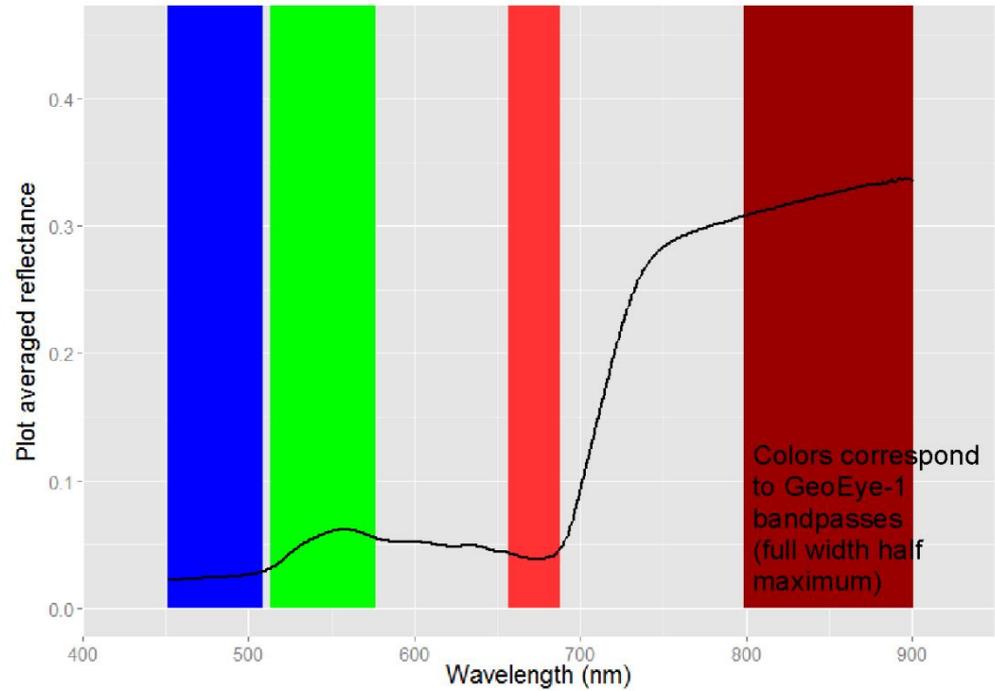
120805a1



# Spectra and Ground Photos

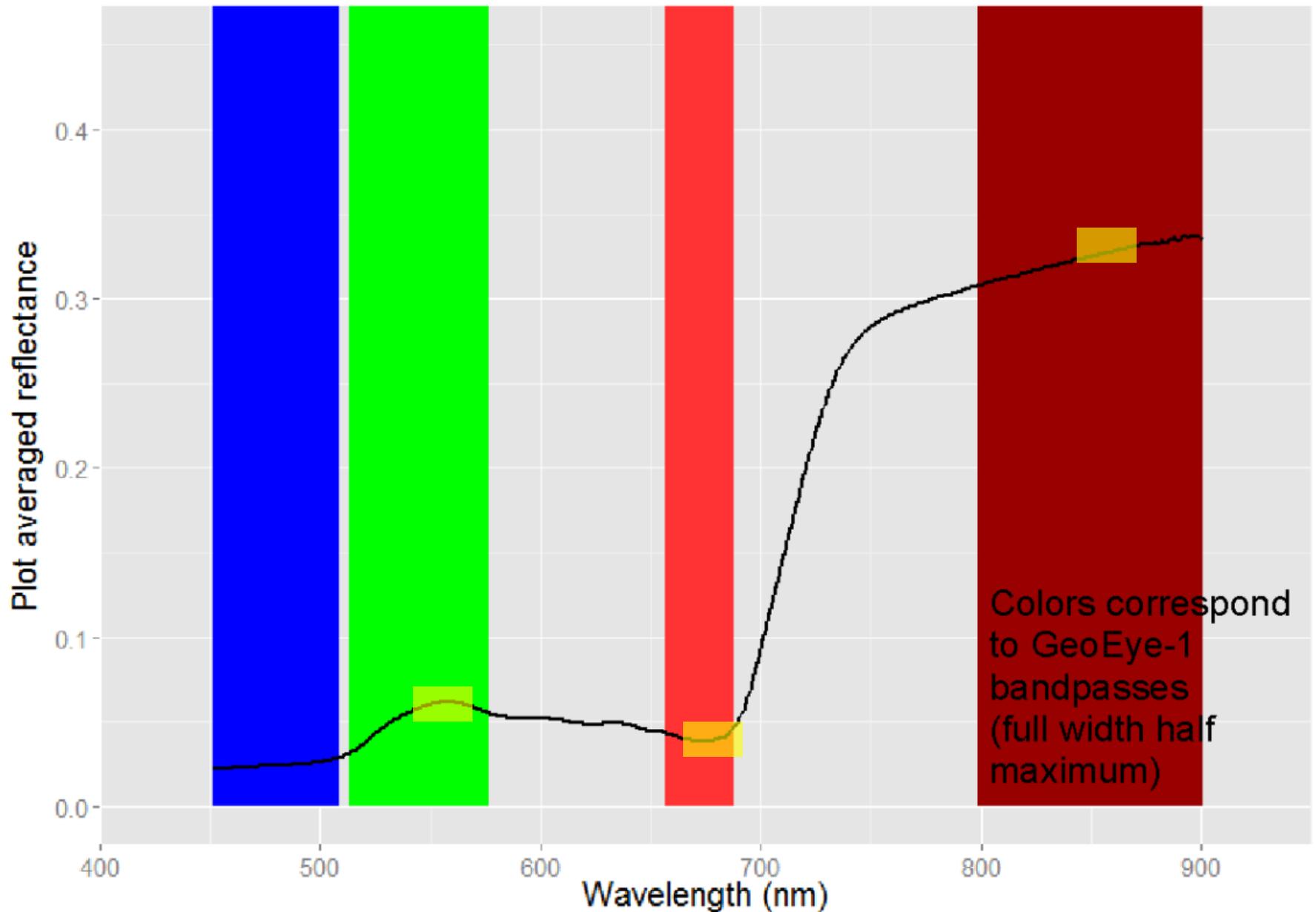
## Shrub Tussock Tundra

120808a2

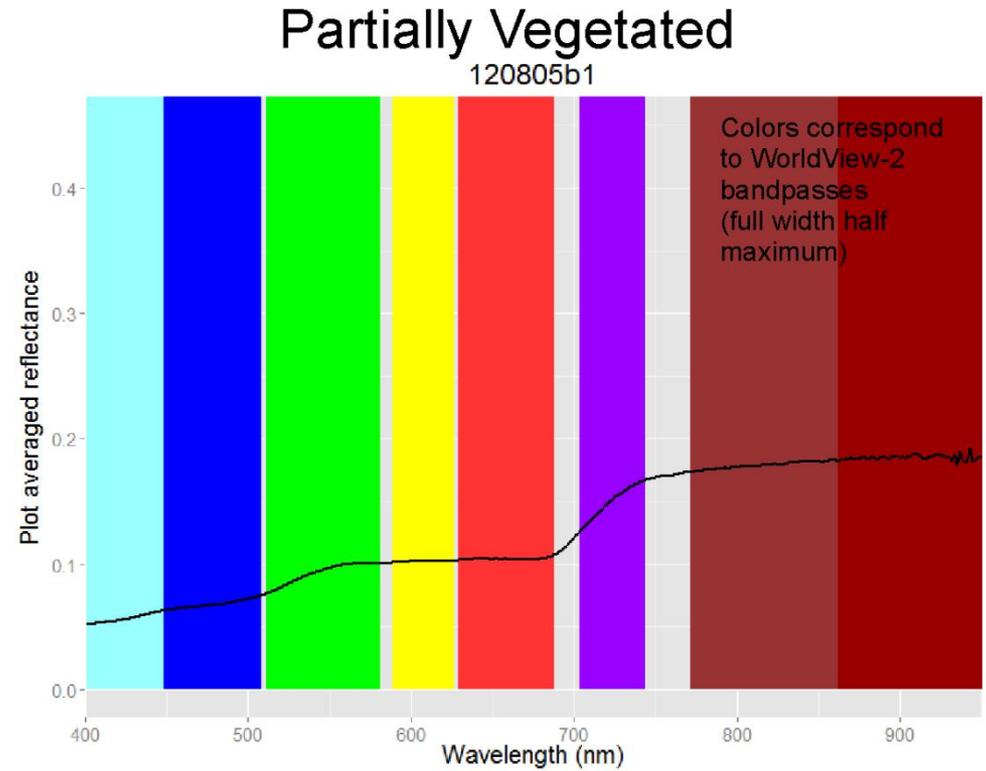


# Shrub Tussock Tundra

120808a2

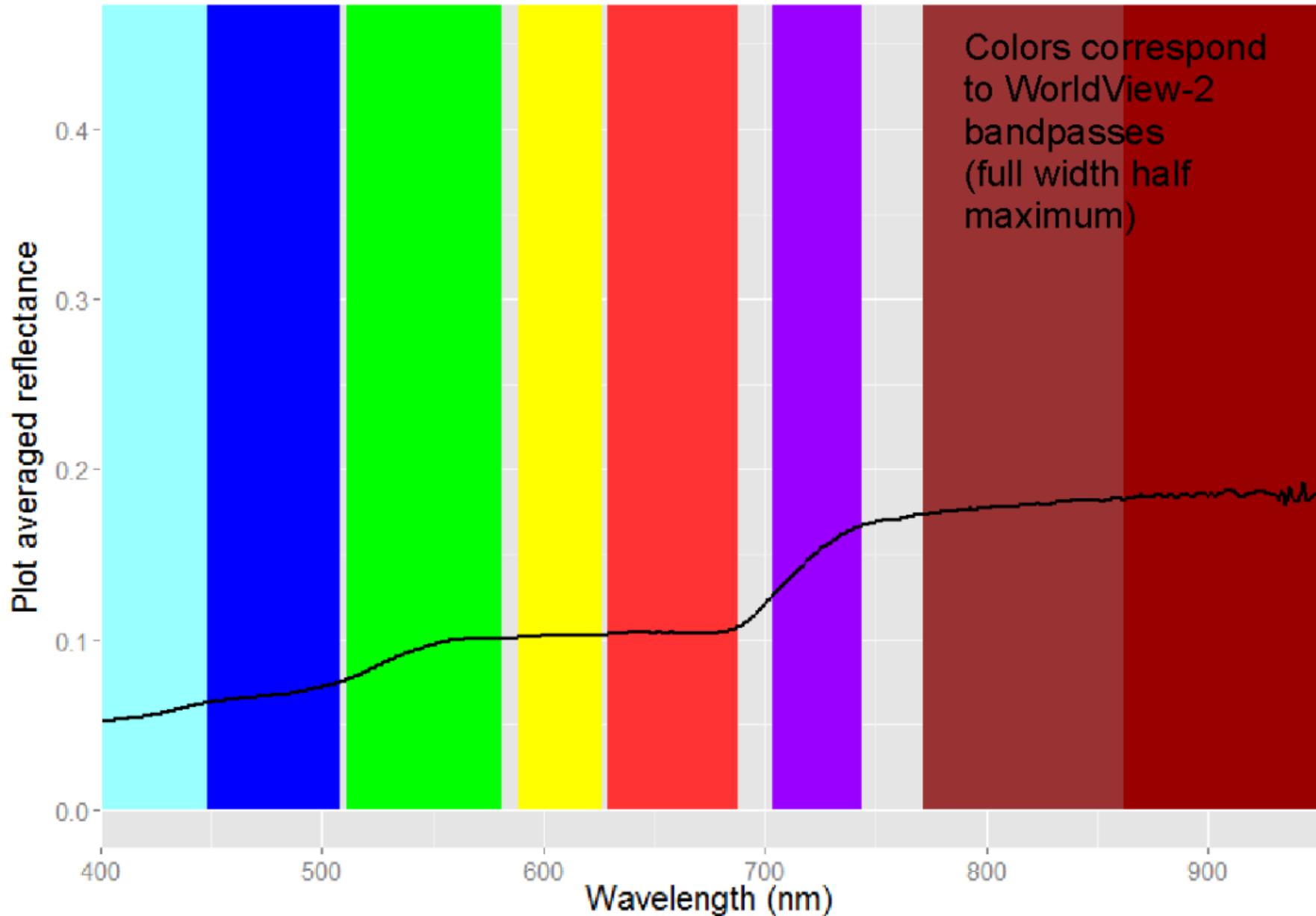


# Spectra and Ground Photos



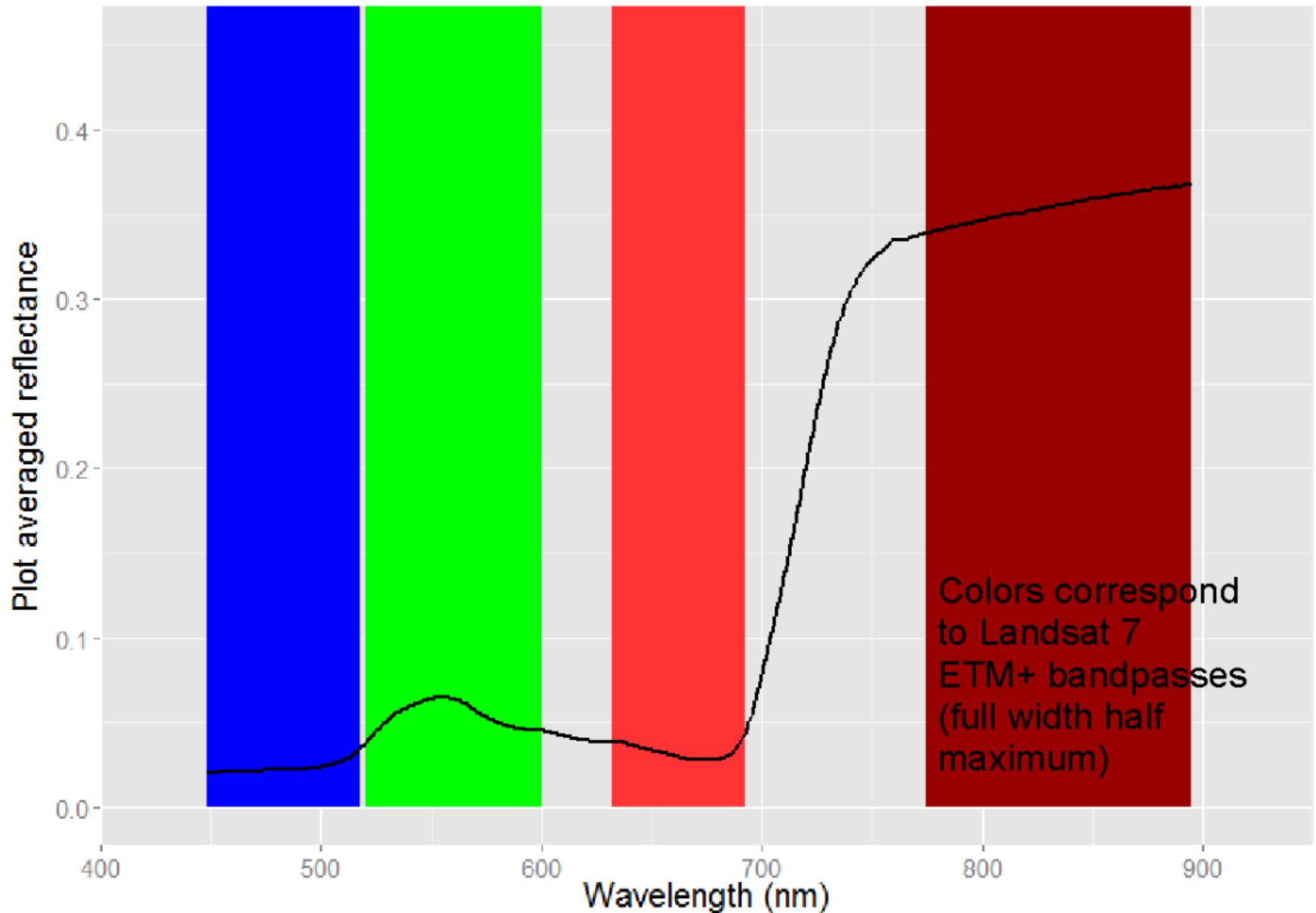
# Partially Vegetated

120805b1



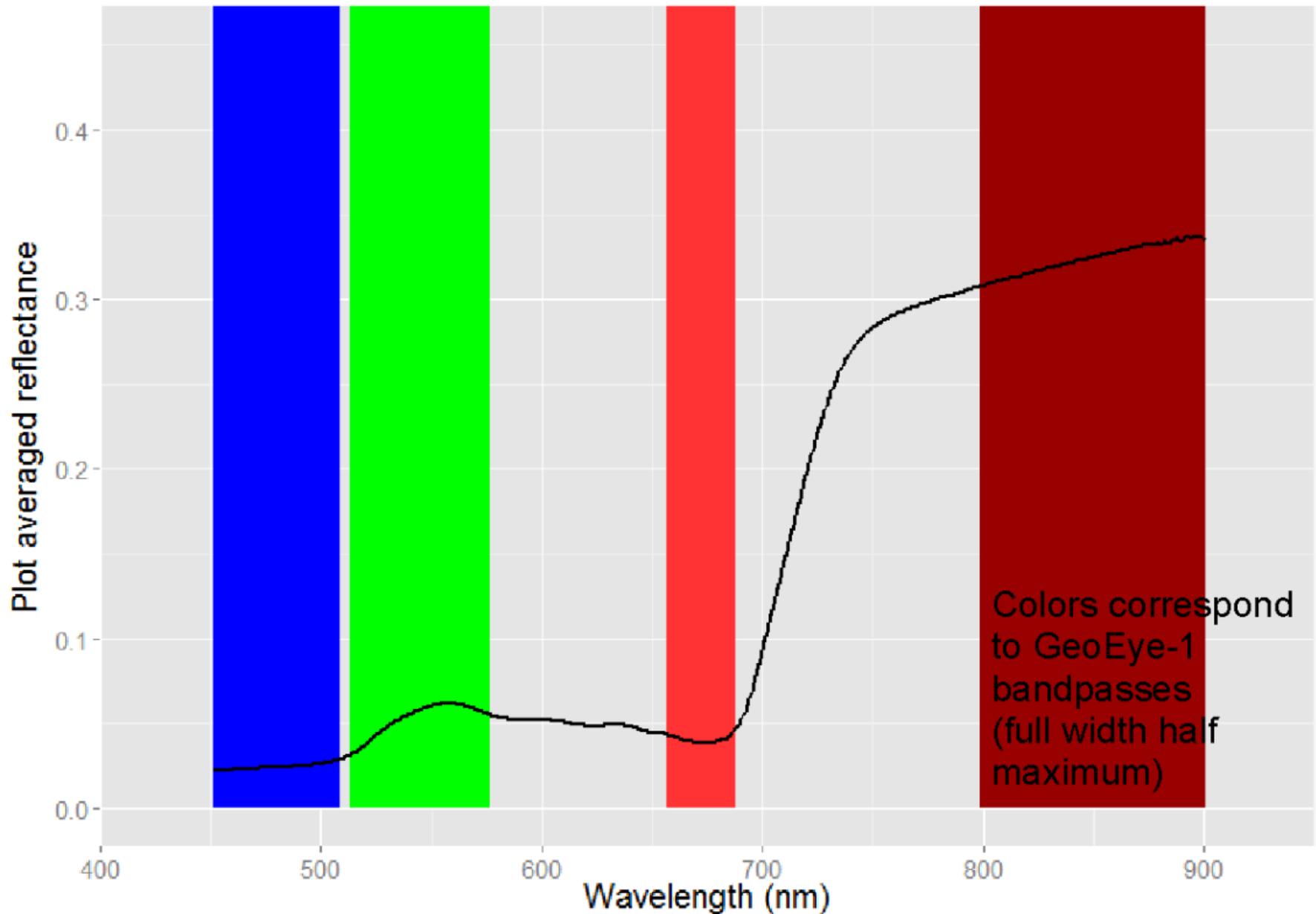
# Low Willow Shrub

120805a1

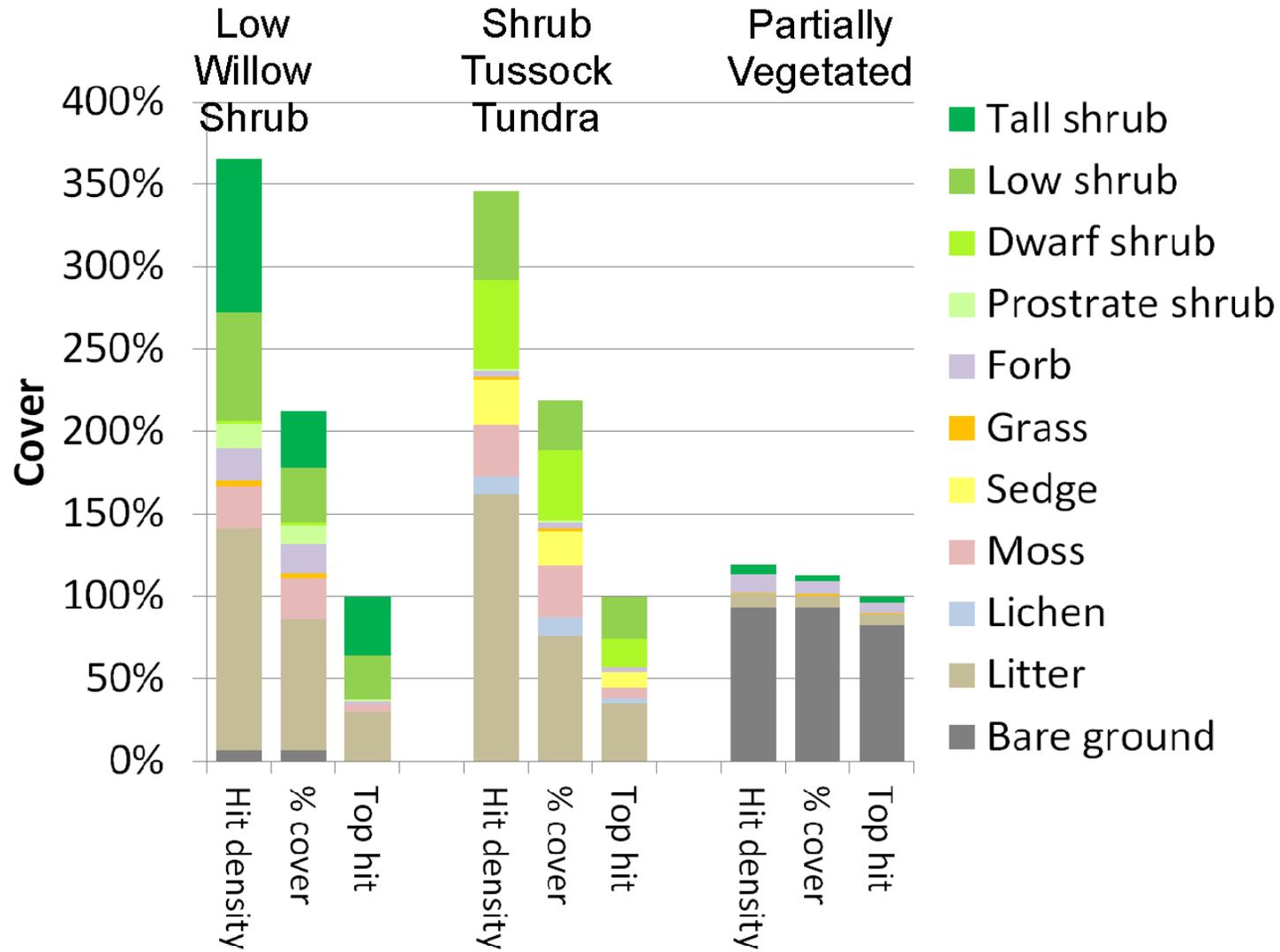


# Shrub Tussock Tundra

120808a2

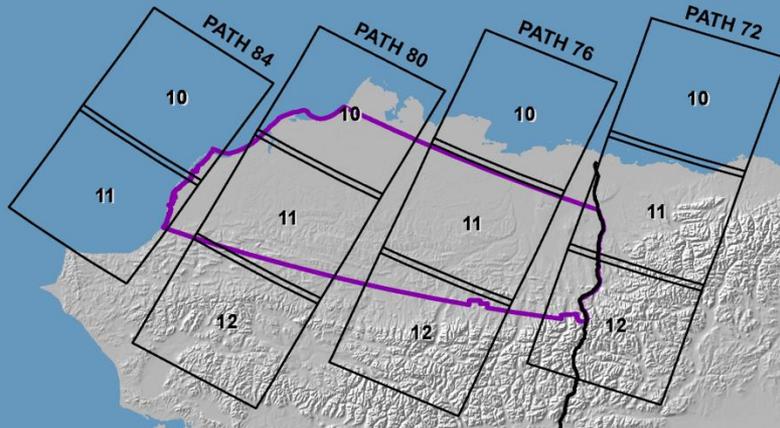


# Cover Metrics

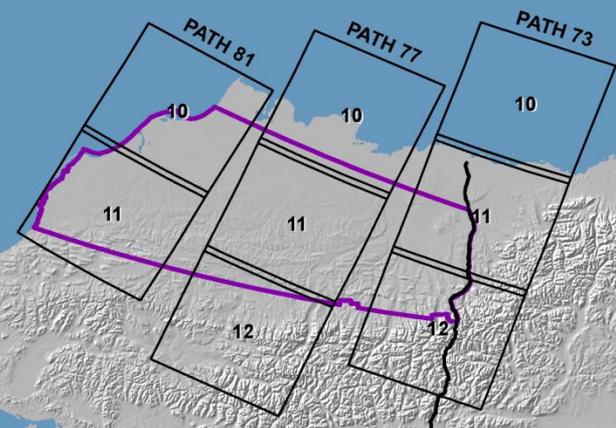


# Satellite Data: Landsat Scenes

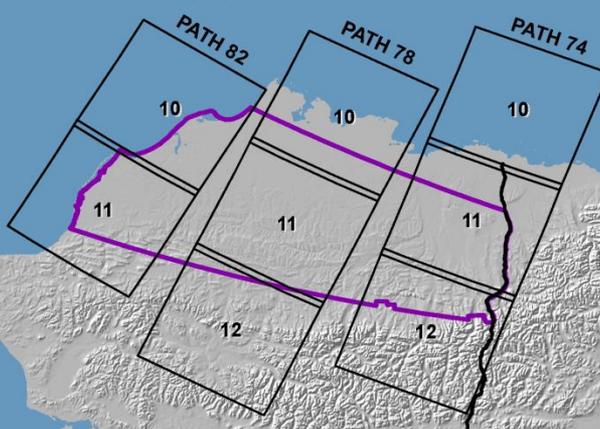
WRS2 Scene Footprints (A)



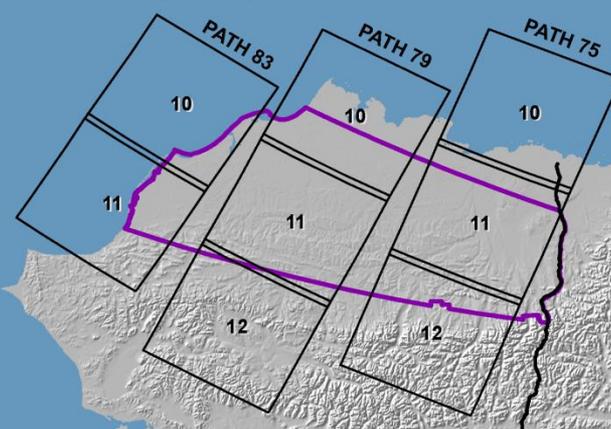
WRS2 Scene Footprints (B)



WRS2 Scene Footprints (C)



WRS2 Scene Footprints (D)



# Landsat Processing

- Atmospheric Correction: LEDAPS *Indsr* (Masek 2006)
  - Now available directly from USGS as a Climate Data Record
- Tiling to 30 km (1000 x 1000 pixel) tiles
- Cloud masking *fmask* (Zhu 2012) + extensive manual revision

# Landsat 30 km tiles





Filtering & Sorting

HHH/VV	67	6
MM/DD	0401	1031
YEARS	1972	2014
Cloud Free	20	100
Sorting	MM/DD	YYYY/MM/DD
Initials	mjm	Needs Review Reload

Tile Review

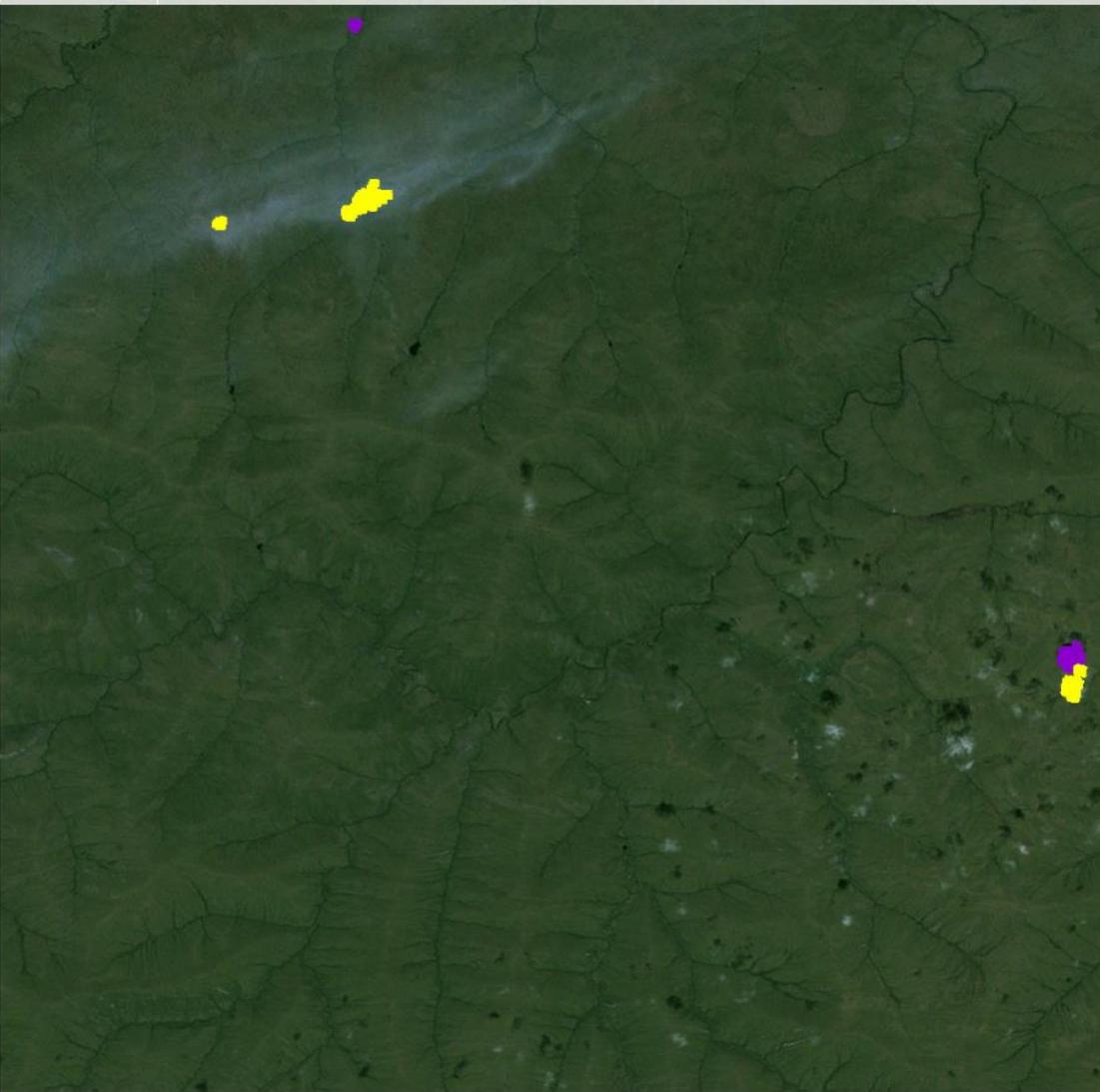
Display

Bands	321	432	543	754	Custom	custom bands
Bands (MSS)	421	321	444	Custom	mss custom bands	
Cloud Mask	none	acca	fmask	lc8qa	b2gt1800	
Masking	Polygon Cloud	Base Image	Study Area			

Inputs

Reviewer	kap	2014-07-17T14:30:24-08:00					
Data issues: (not resolved by selected mask)	Thick Clouds	Ice Clouds	Thin Clouds	Fog			
	Smoke / Haze	Cloud Shadow	Too Early	Too Late			
	Coastal Snow/Ice	Surf	No Coast				
	Bad Geolocation		Radiometric Artifacts				
	★ Landsat's Greatest Hits		Check AtCor				
	Striping Issues:	1	2	3	4	5	6
Best Cloud Mask	none	acca	fmask	lc8qa	b2gt1800		
Notes	<input type="text"/>						
Quality	1	2	3	4	5	nr	skip

Clear Submit



Filtering & Sorting

HHH/VV	67	6
MM/DD	0401	1031
YEARS	1972	2014
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Sorting	MM/DD	YYYY/MM/DD
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Tile Review

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Bands	321	432	543	754	Custom	custom bands
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	★ Landsat's Greatest Hits		Check AtCor	

Striping Issues:	1	2	3	4	5	6	7
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Best Cloud Mask:	none	acca	fmask	lc8qa	b2gt1800
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Notes

Quality	1	2	3	4	5	nr	skip
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Clear Submit



Filtering & Sorting

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MM/DD	0401	1031
YEARS	1972	2014
Cloud Free	20	100
Sorting	MM/DD	YYYY/MM/DD
Initials	mjm	Needs Review Reload

Tile Review

Display

Bands	321 432 543 754 Custom	custom bands
Bands (MSS)	421 321 444 Custom	mss custom bands
Cloud Mask	none acca fmask lc8qa b2gt1800	
Masking	Polygon Cloud Base Image Study Area	

Inputs

Reviewer: kap 2014-07-17T14:30:24-08:00

Thick Clouds	Ice Clouds	Thin Clouds	Fog
Smoke / Haze	Cloud Shadow	Too Early	Too Late
Coastal Snow/Ice	Surf	No Coast	
Bad Geolocation		Radiometric Artifacts	
★ Landsat's Greatest Hits		Check AtCor	

Striping Issues: 1 2 3 4 5 6 7

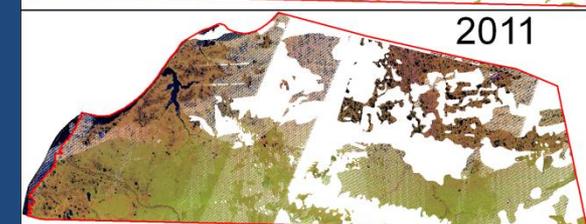
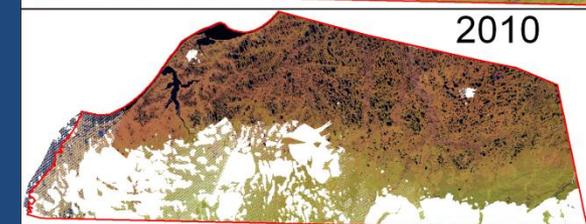
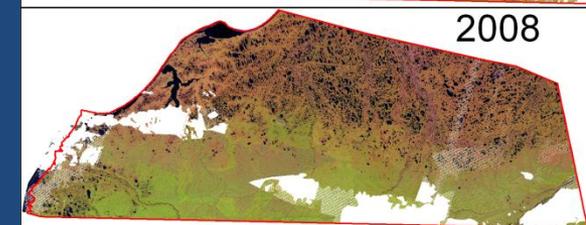
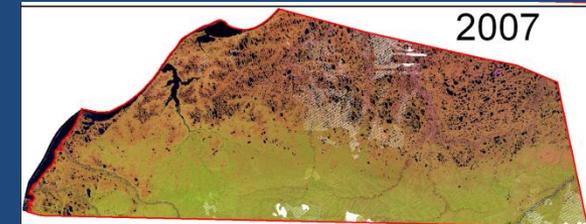
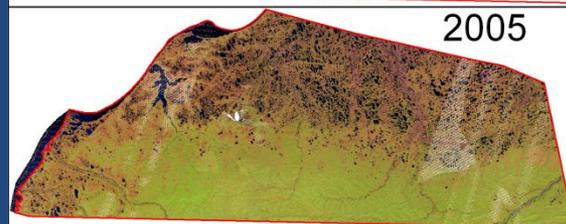
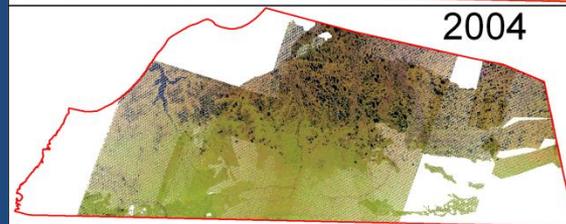
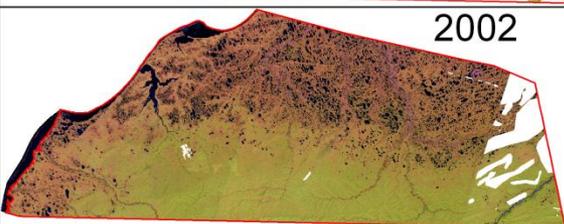
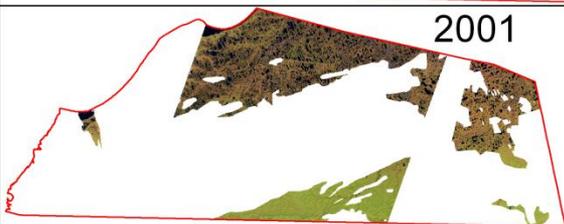
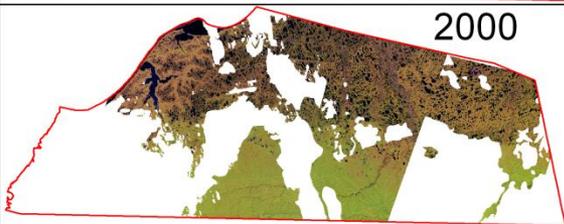
Best Cloud Mask: none acca fmask lc8qa b2gt1800

Notes:

Quality: 1 2 3 4 5 nr skip

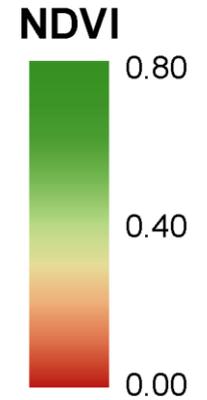
Clear Submit

# Landsat Imagery Midsummer Time-Series

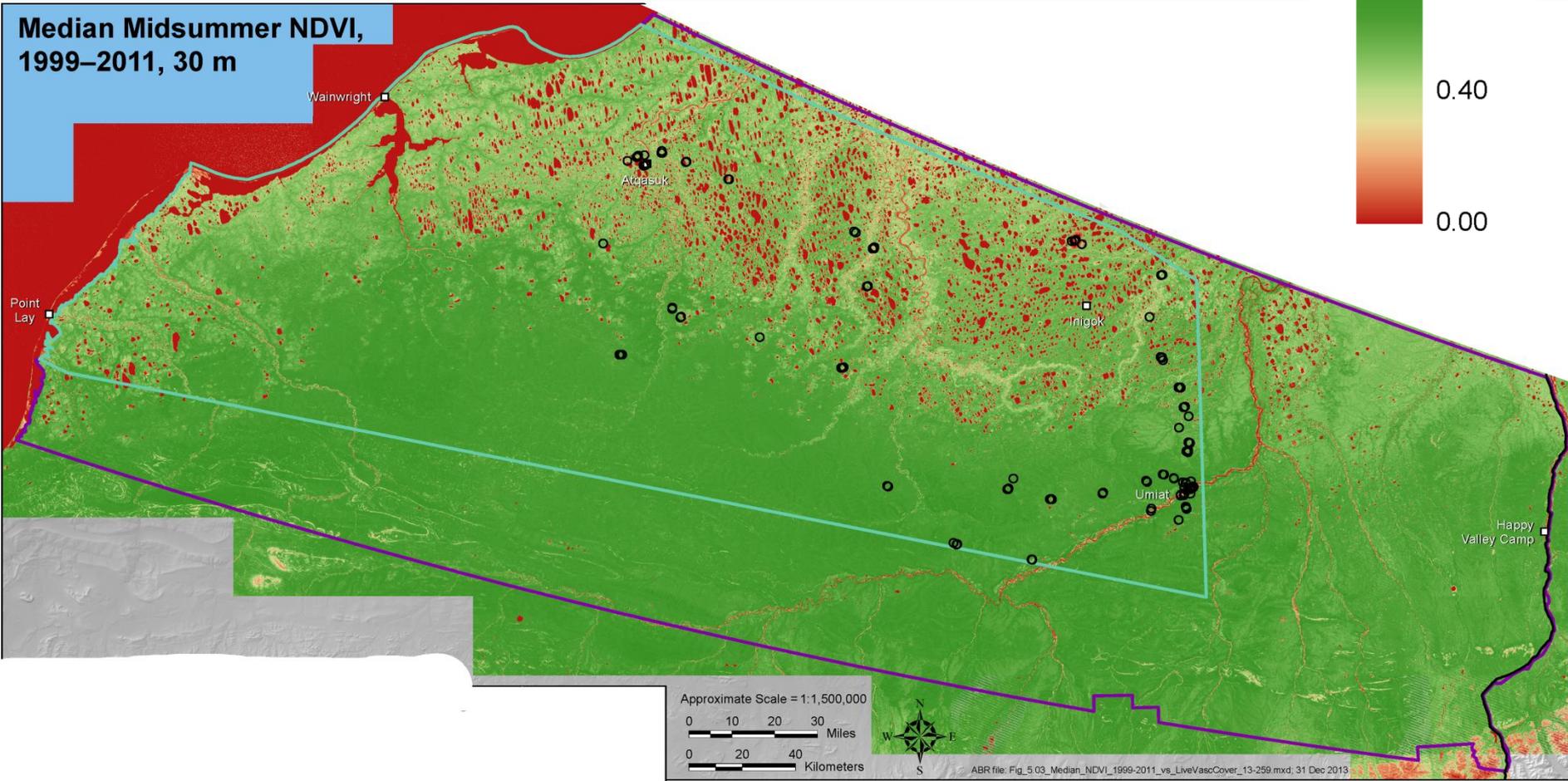


Includes data July 15–August 21  
Composited by anniversary date (closest to August 1)  
Incomplete data in each year

# Landsat Median Midsummer NDVI, 1999–2011



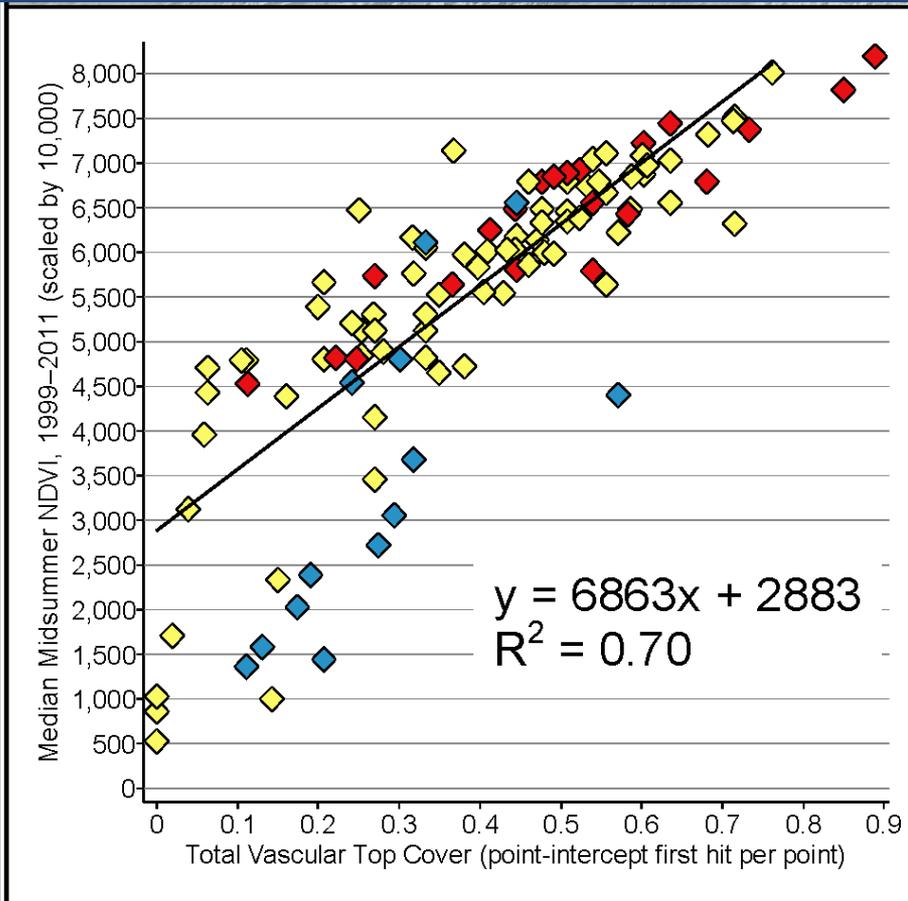
Median Midsummer NDVI,  
1999–2011, 30 m



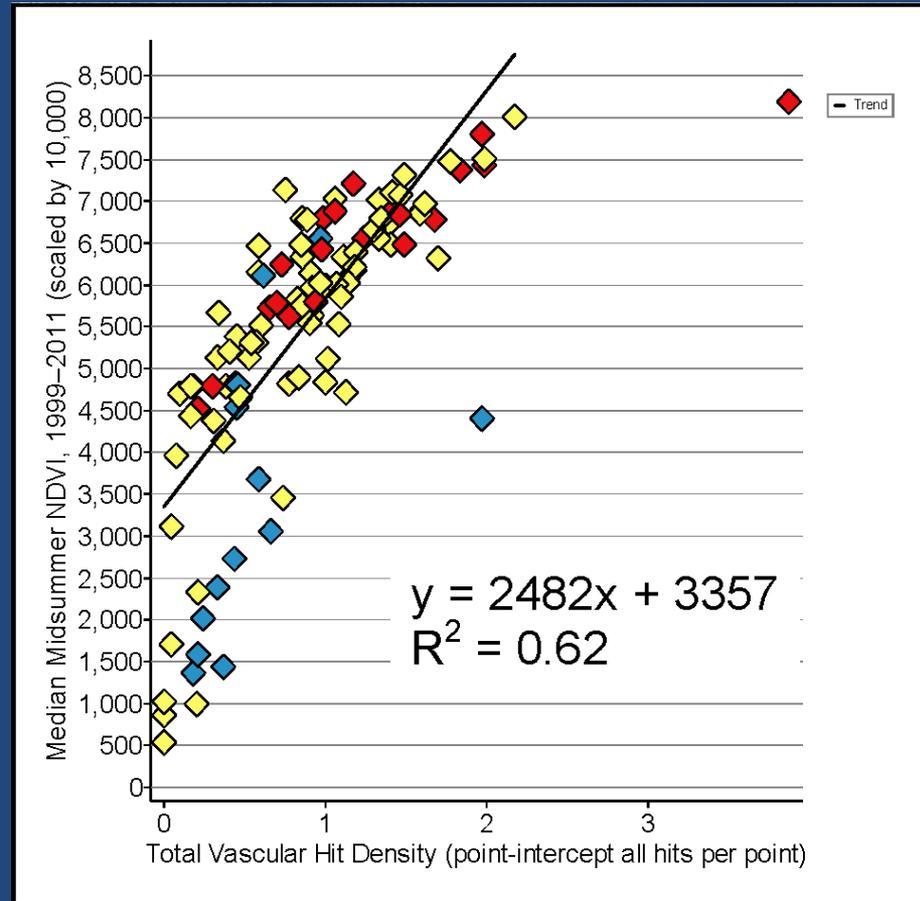
No spatial gaps or scene-edge artifacts  
No smoothing/blurring from maximum value compositing

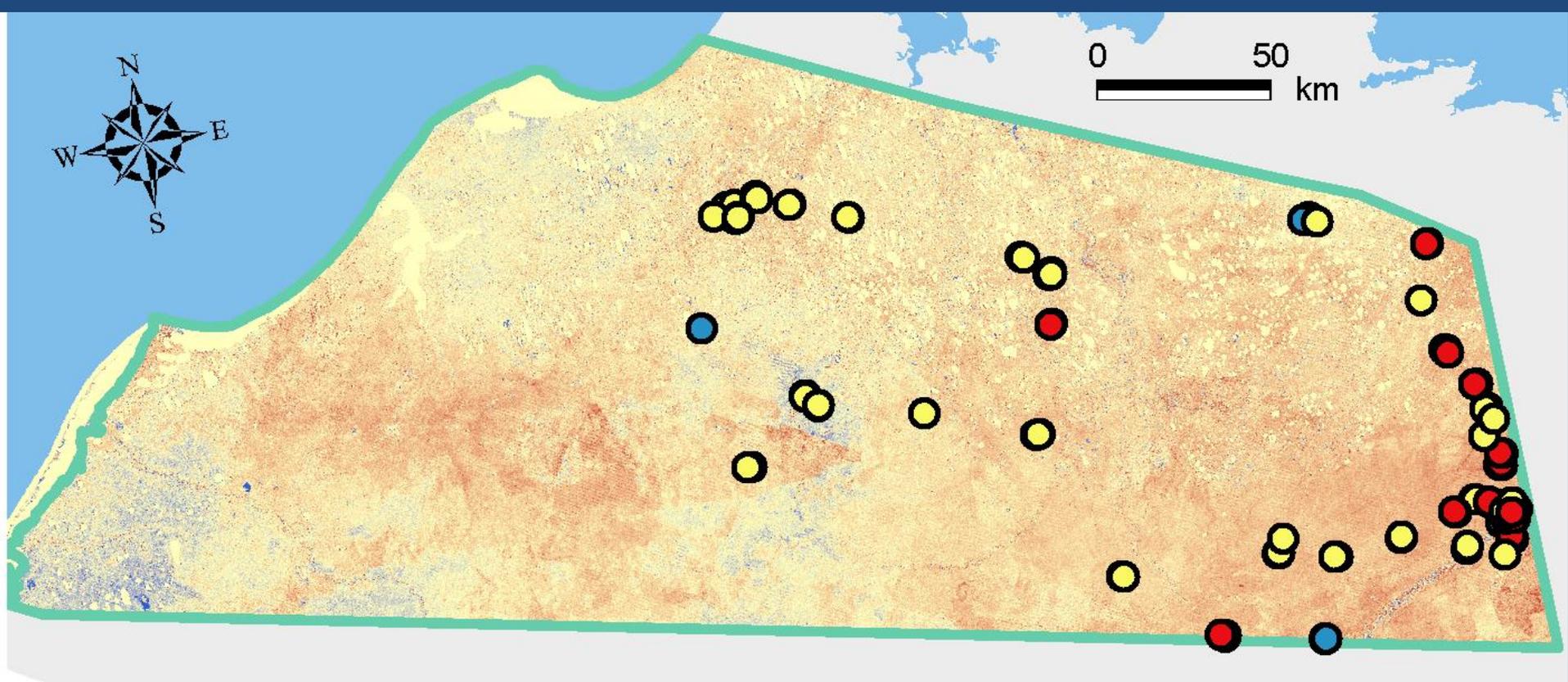
# NDVI vs. Vascular Cover Metrics

## Top Cover

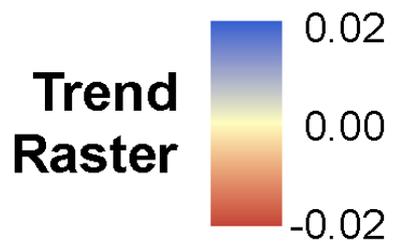


## Hit Density





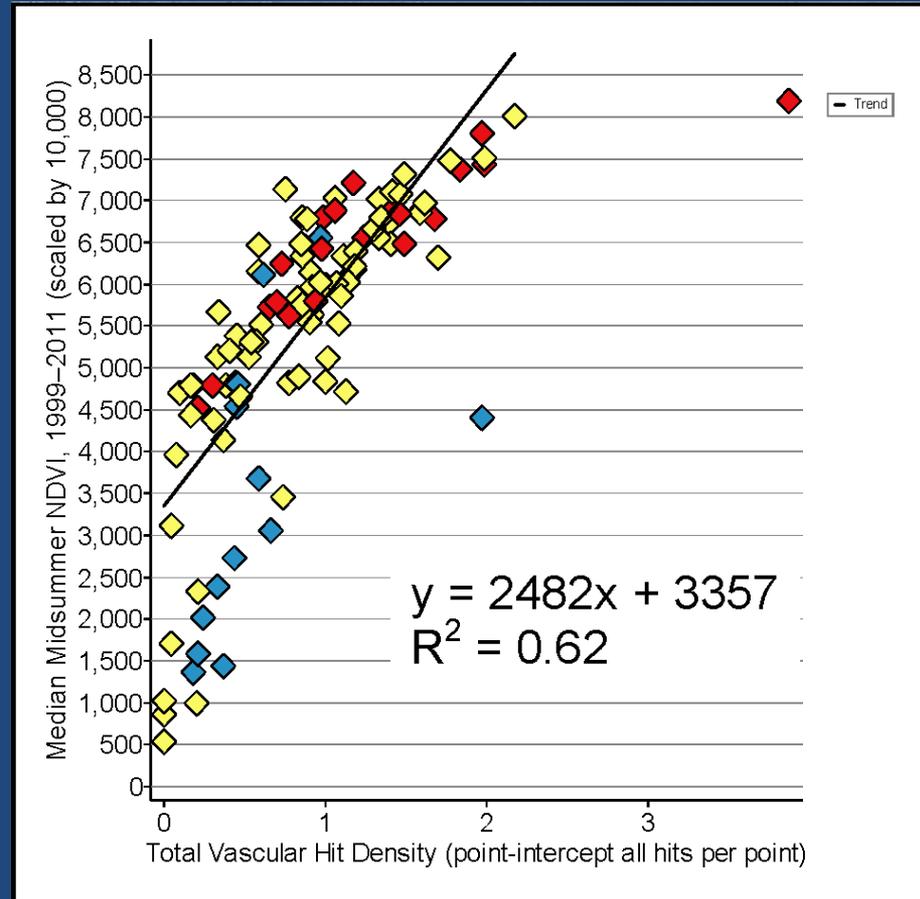
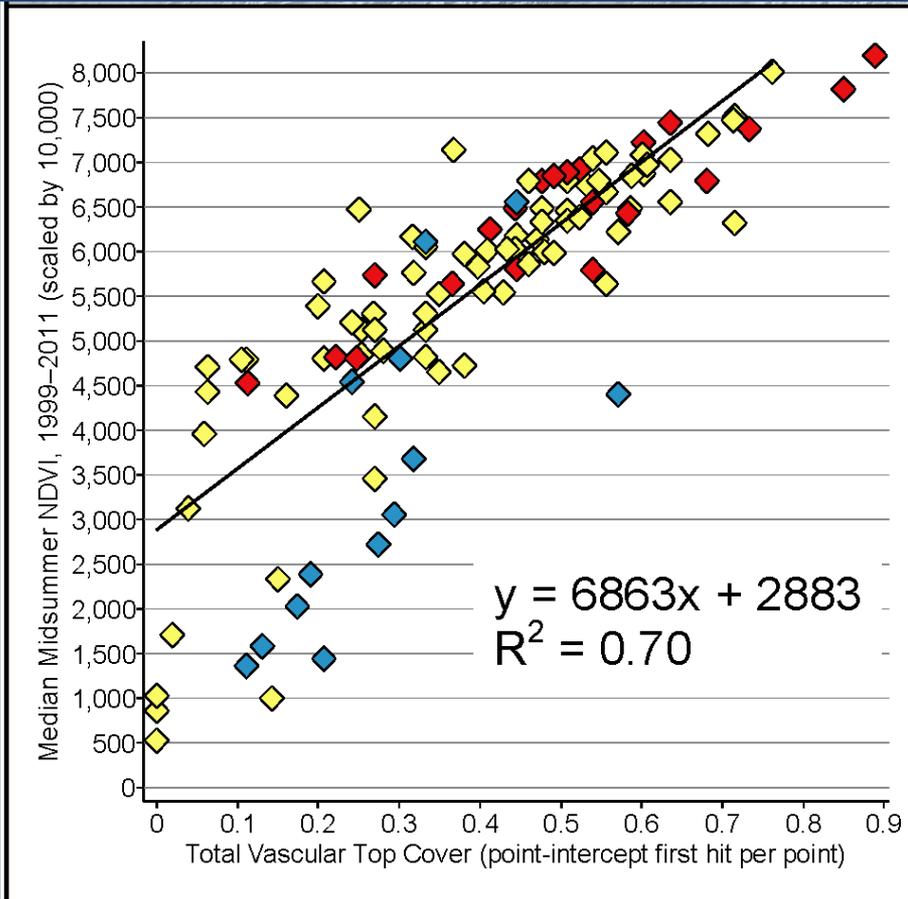
## Midsummer NDVI Trend, 1999–2011, 30 m



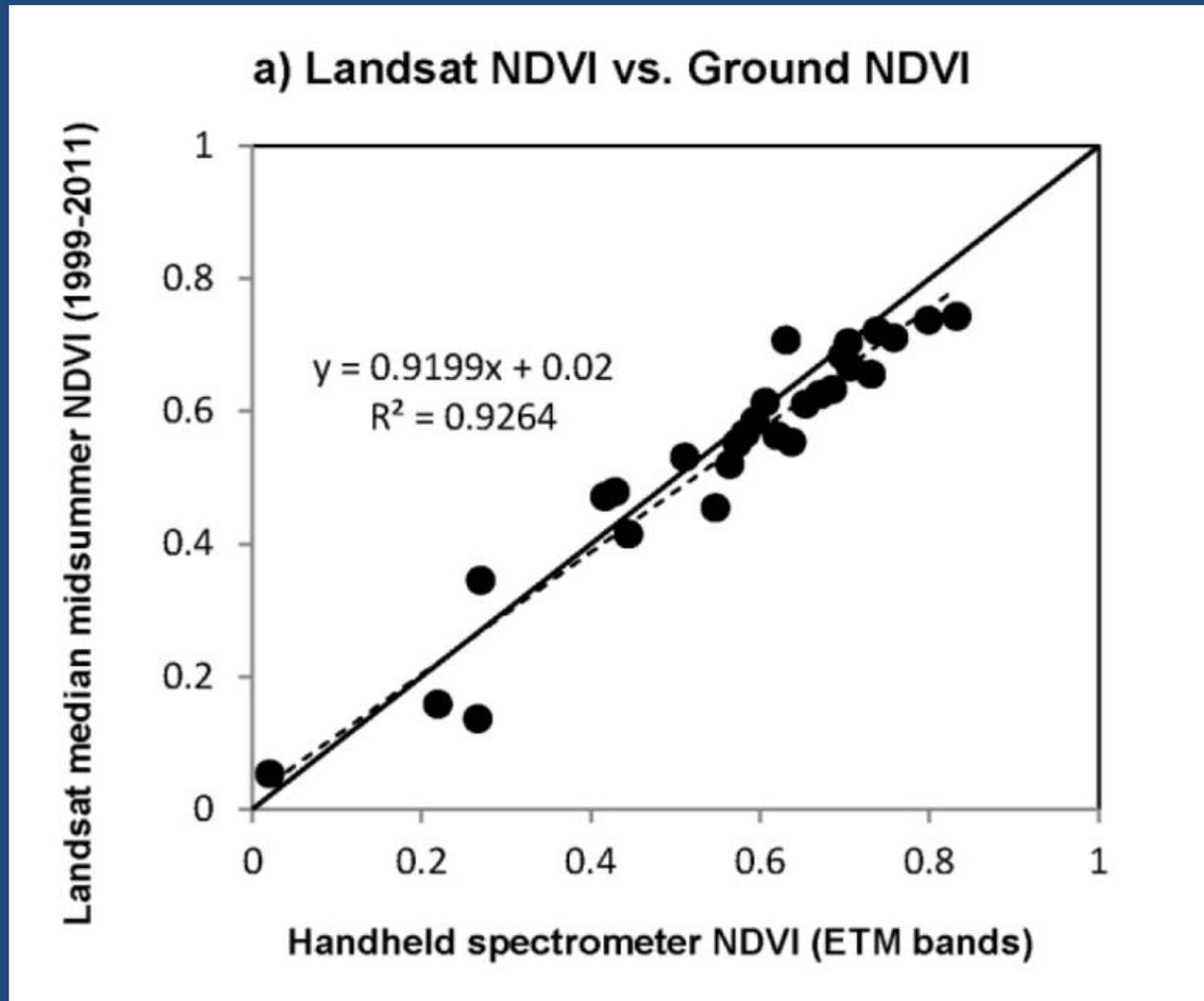
## Trend at Plots

- $< -0.0075/\text{yr}$
- $-0.0075\text{--}0.0075/\text{yr}$
- $> 0.0075/\text{yr}$

# NDVI vs. Vascular Cover Metrics



# Landsat Median Midsummer NDVI vs. Handheld Spectrometer (2012)



# Objectives

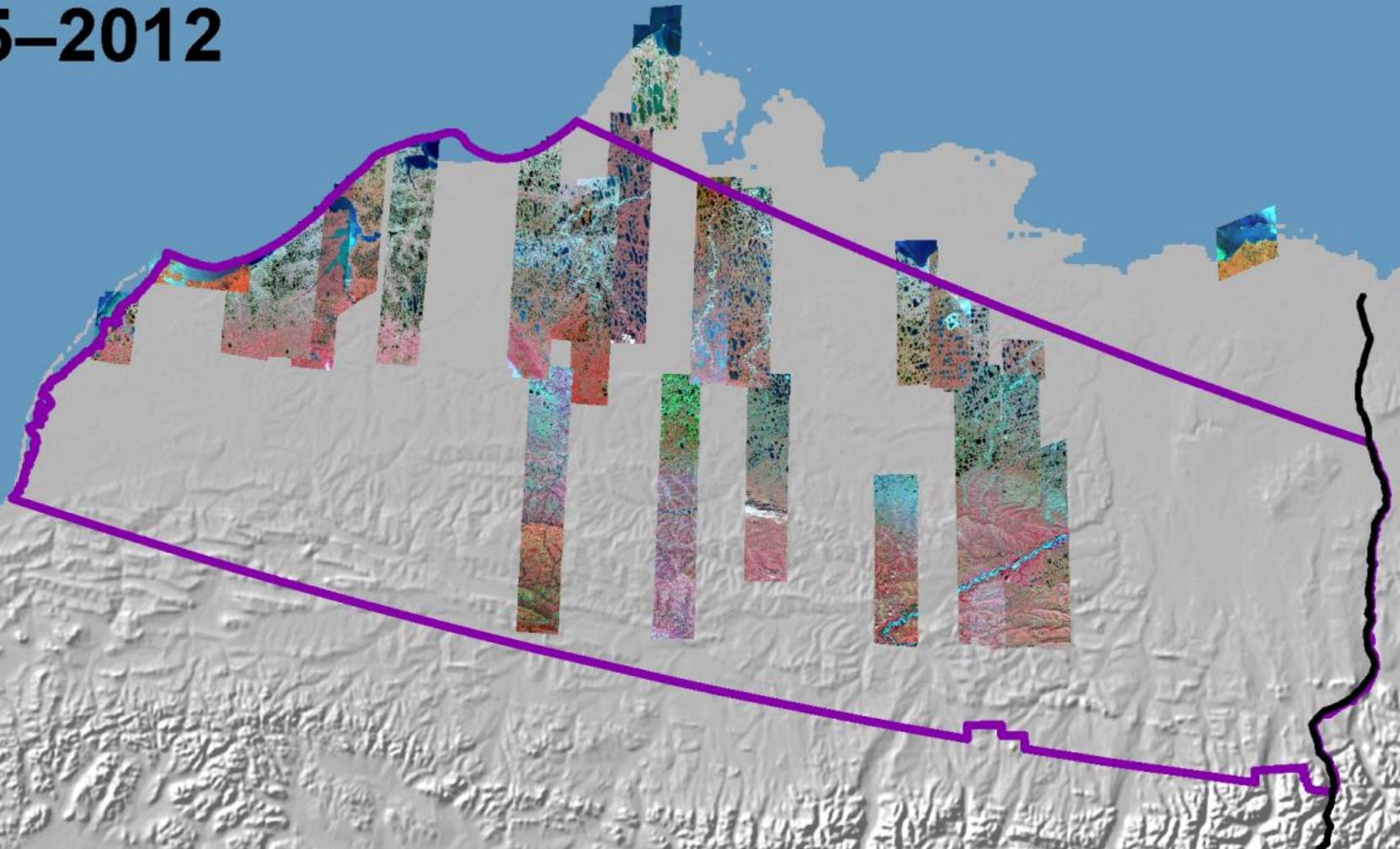
- Characterize and map wildlife habitat characteristics at multiple scales to support potential infrastructure planning
- Compare field measurements of vegetation cover and structure to high-resolution and Landsat satellite signals
- Calibrate and atmospherically correct commercial satellite imagery

# High Resolution Satellite Imagery

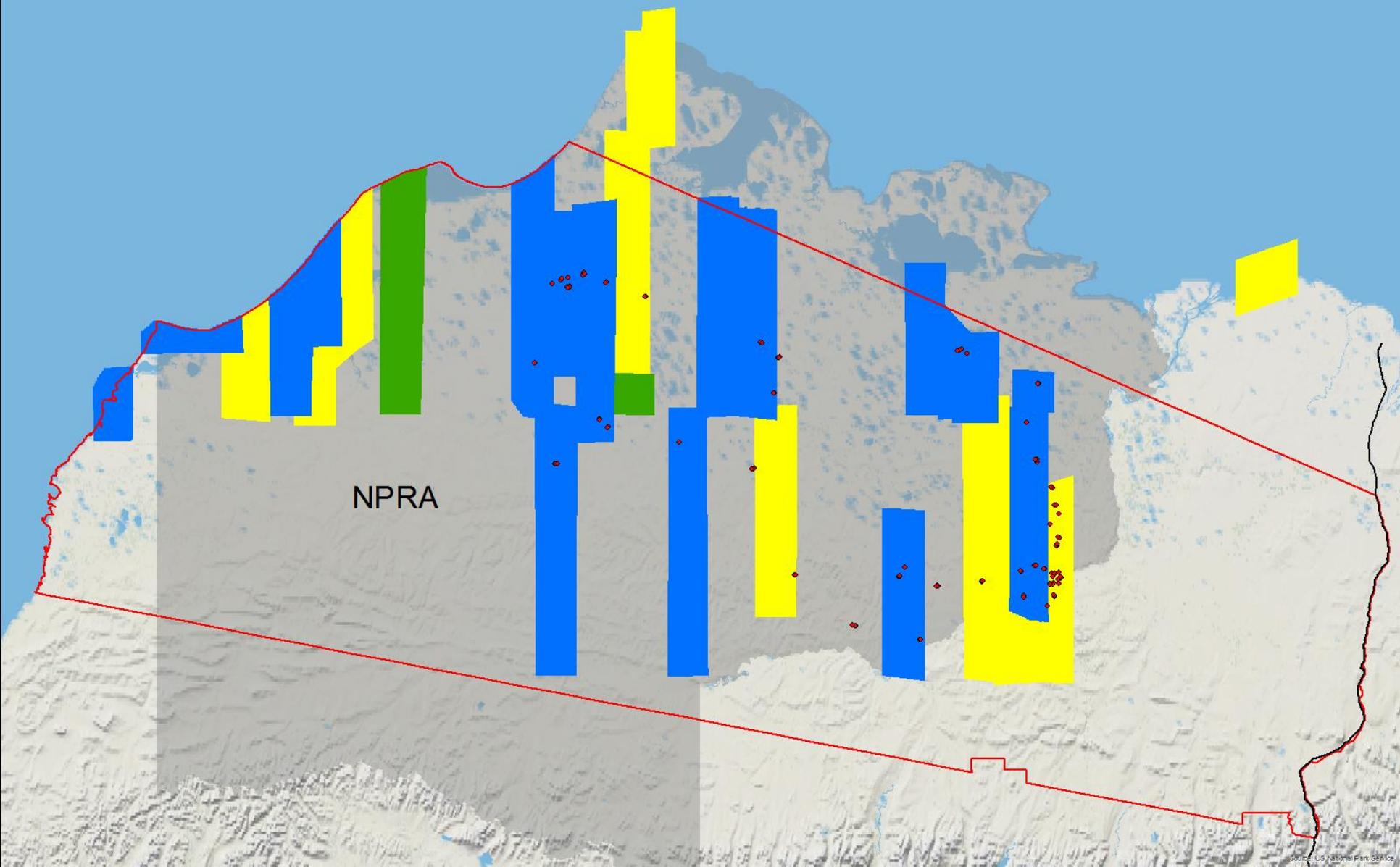
- Acquired after 2012 field work
- Targeted areas with field data
- Archive was sparse, so criteria for viewing geometry and acquisition date were flexible

# High Resolution Satellite Imagery

**2005–2012**

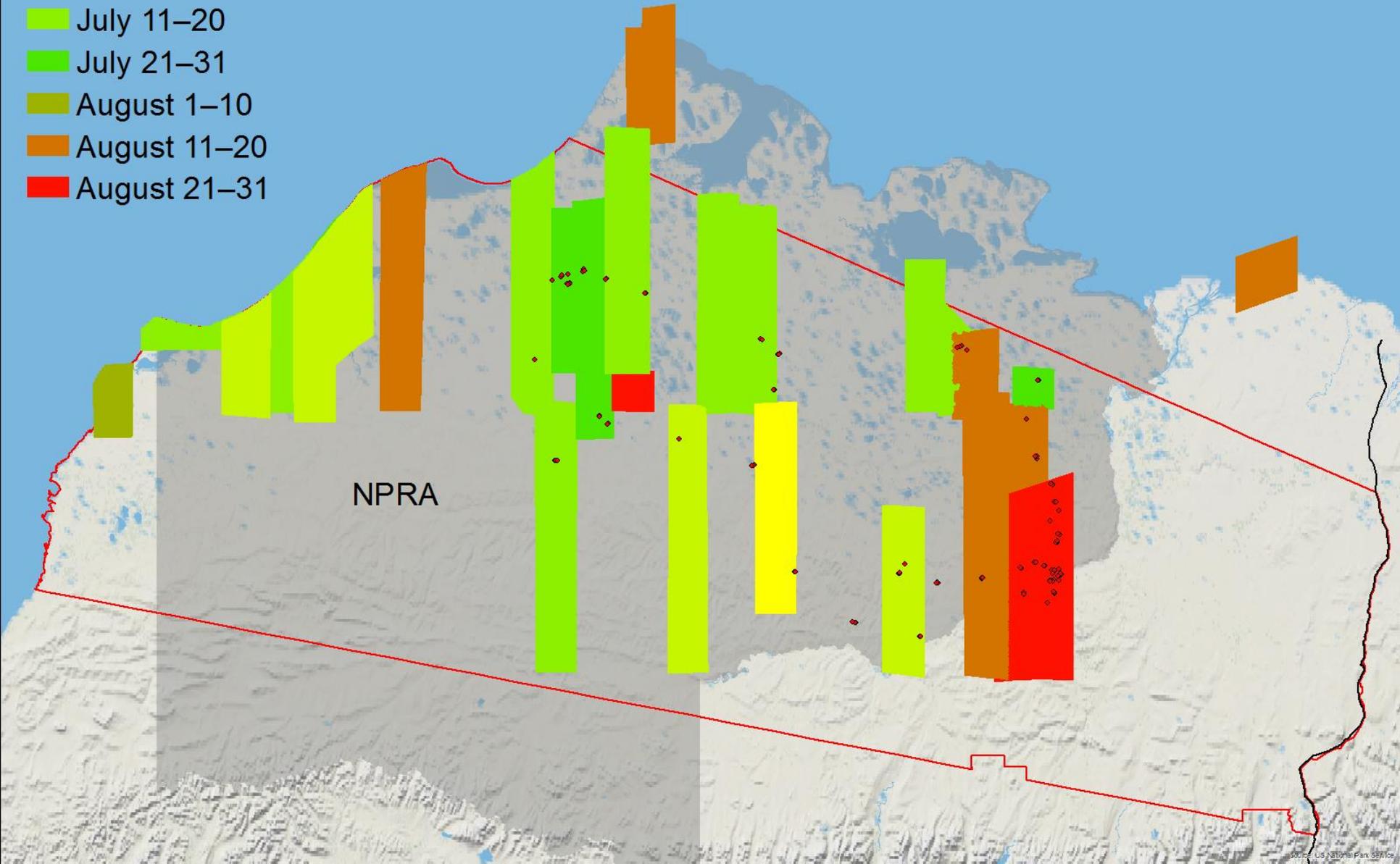


- GeoEye-1, 2009–2012
- QuickBird-2, 2002–2005
- WorldView-2, 2010–2012

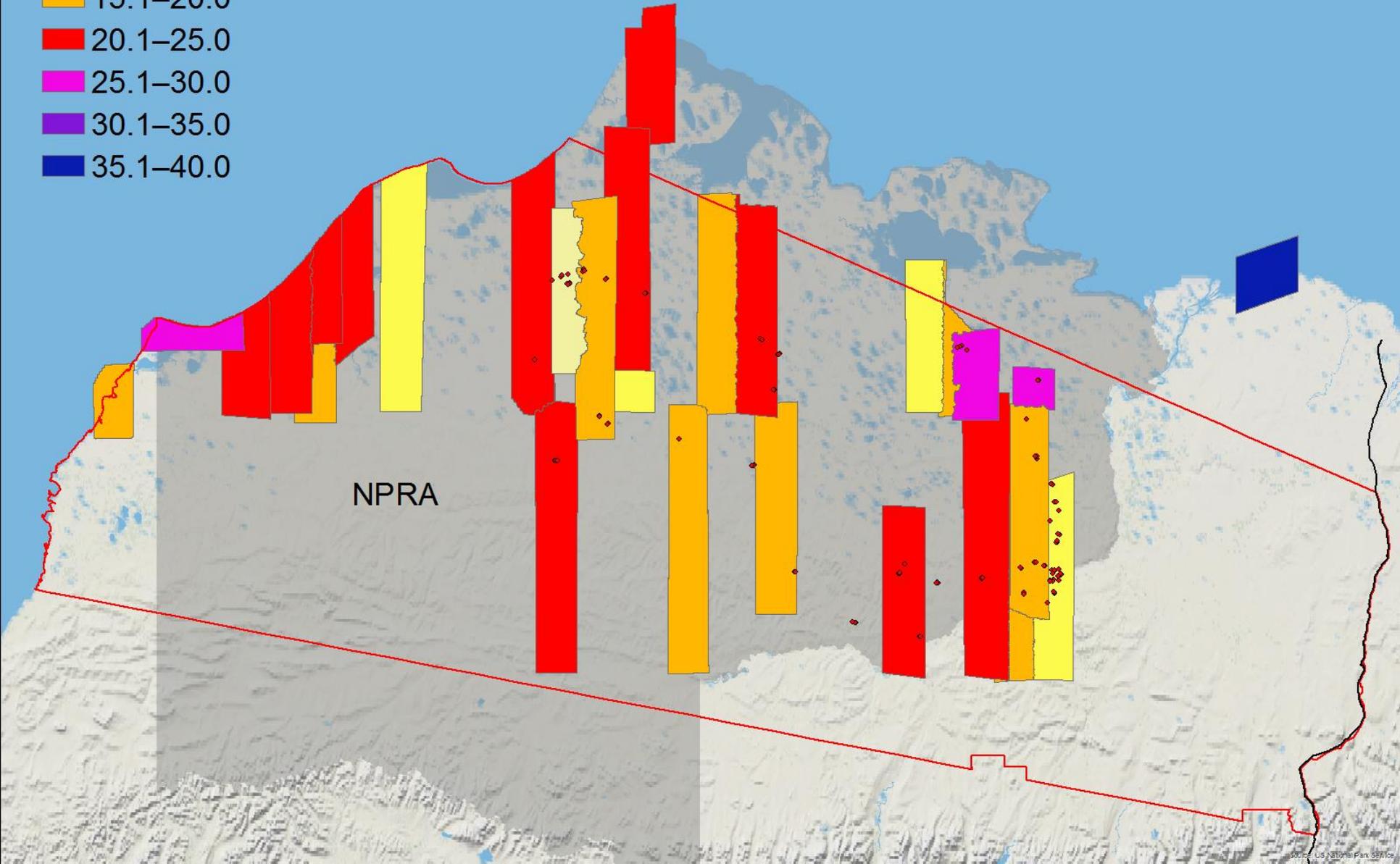
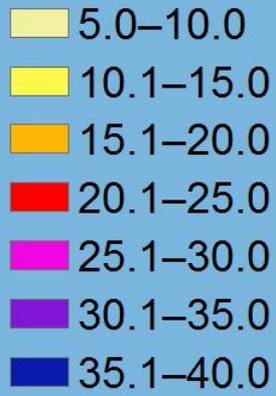


# Acquisition Day of Year

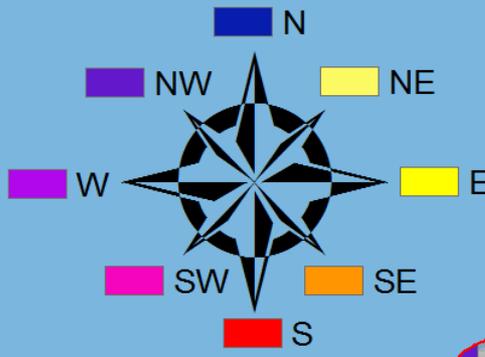
- June 20–30
- July 1–10
- July 11–20
- July 21–31
- August 1–10
- August 11–20
- August 21–31



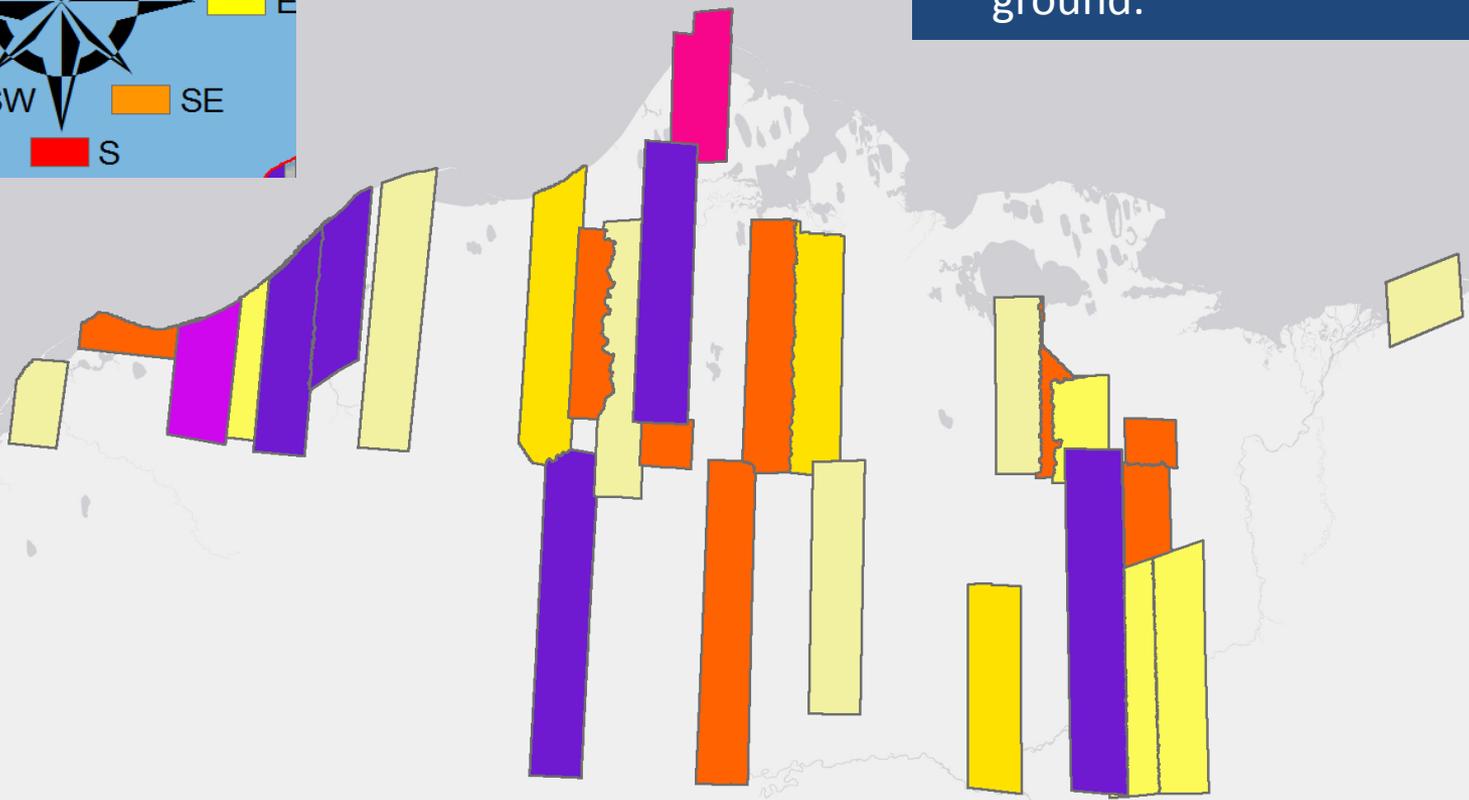
# Incidence (Off-nadir) Angle, degrees



## Collection Azimuth

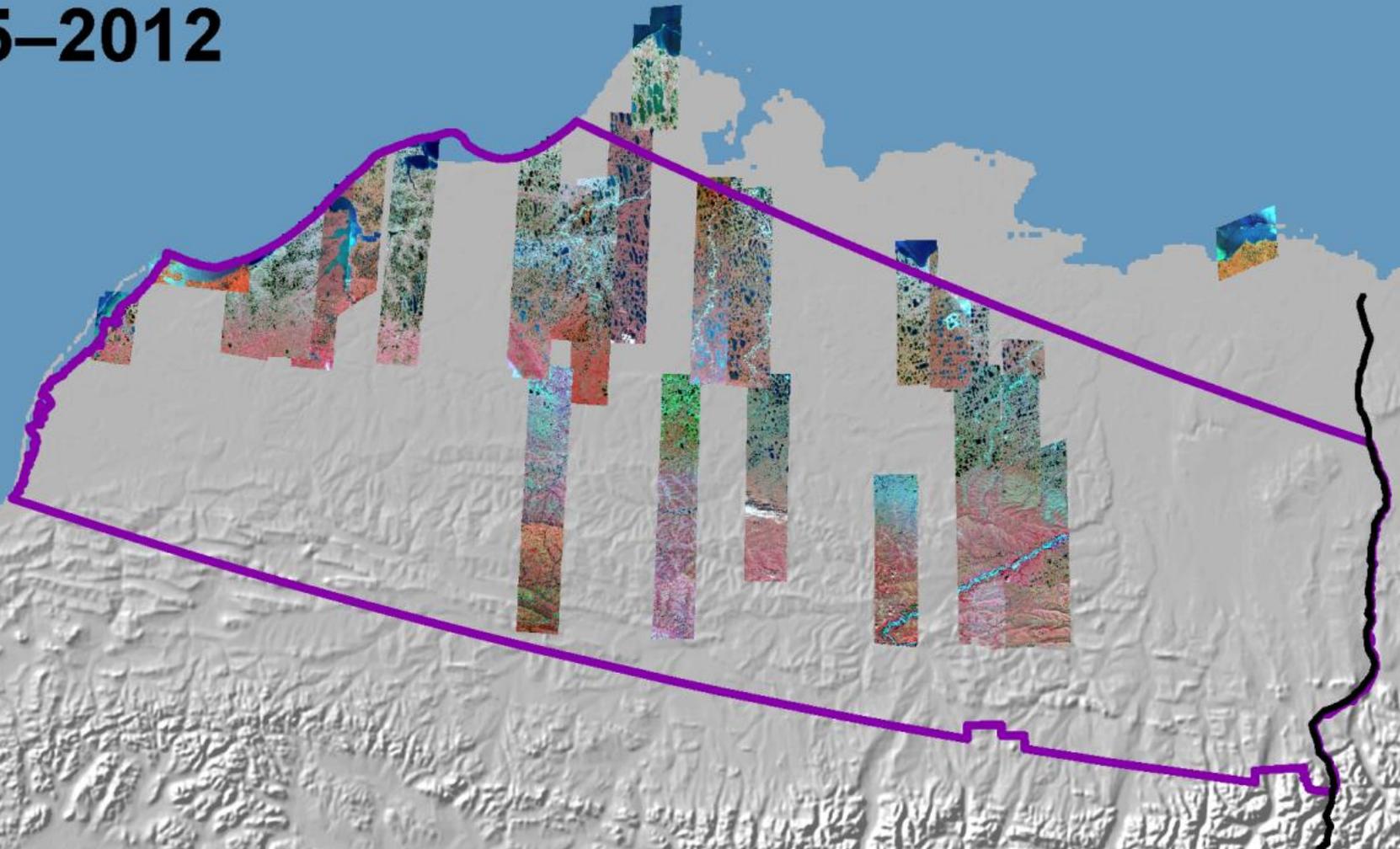


- Satellite data providers use different conventions for collection azimuth.
- Presented here as the view direction from the satellite to the ground.



# High Resolution Satellite Imagery

**2005–2012**



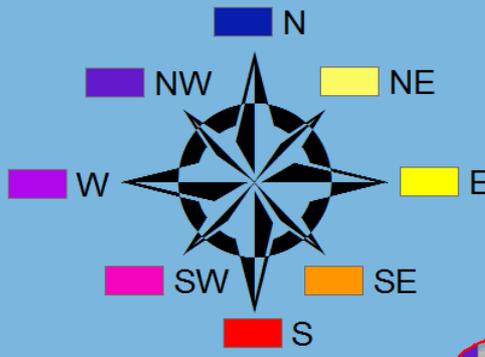
# Atmospheric Correction

- ENVI Fast Line-of-sight Atmospheric Analysis of Hypercubes (FLAASH) algorithm
  - Based on MODTRAN4
  - For multispectral imagery (no SWIR) the key required inputs are
    - Viewing geometry
    - Scene level water vapor
    - Scene level visibility
- No adjustment for Bidirectional Reflectance Distribution Function (BRDF)

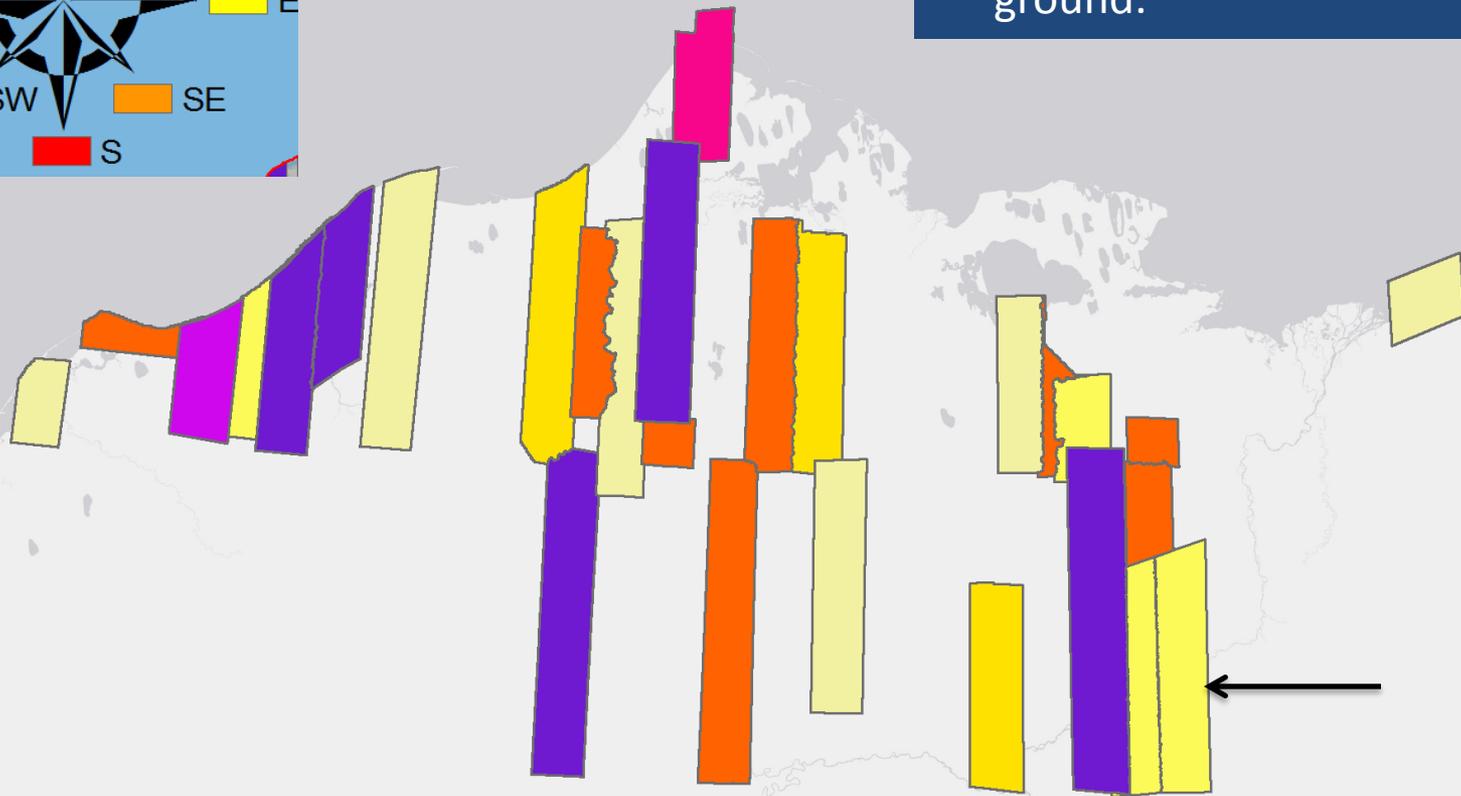
# BRDF Effects and Arctic Vegetation (Buchhorn 2013)

- Dependence on vegetation structure and surface form
- BRDF effects usually strongest in solar principal plane (east and west views have lower effect)
- Reflectance higher in backwards viewing direction (away from sun)
- Stronger in Visible vs. Near-infrared

## Collection Azimuth



- Satellite data providers use different conventions for collection azimuth.
- Presented here as the view direction from the satellite to the ground.

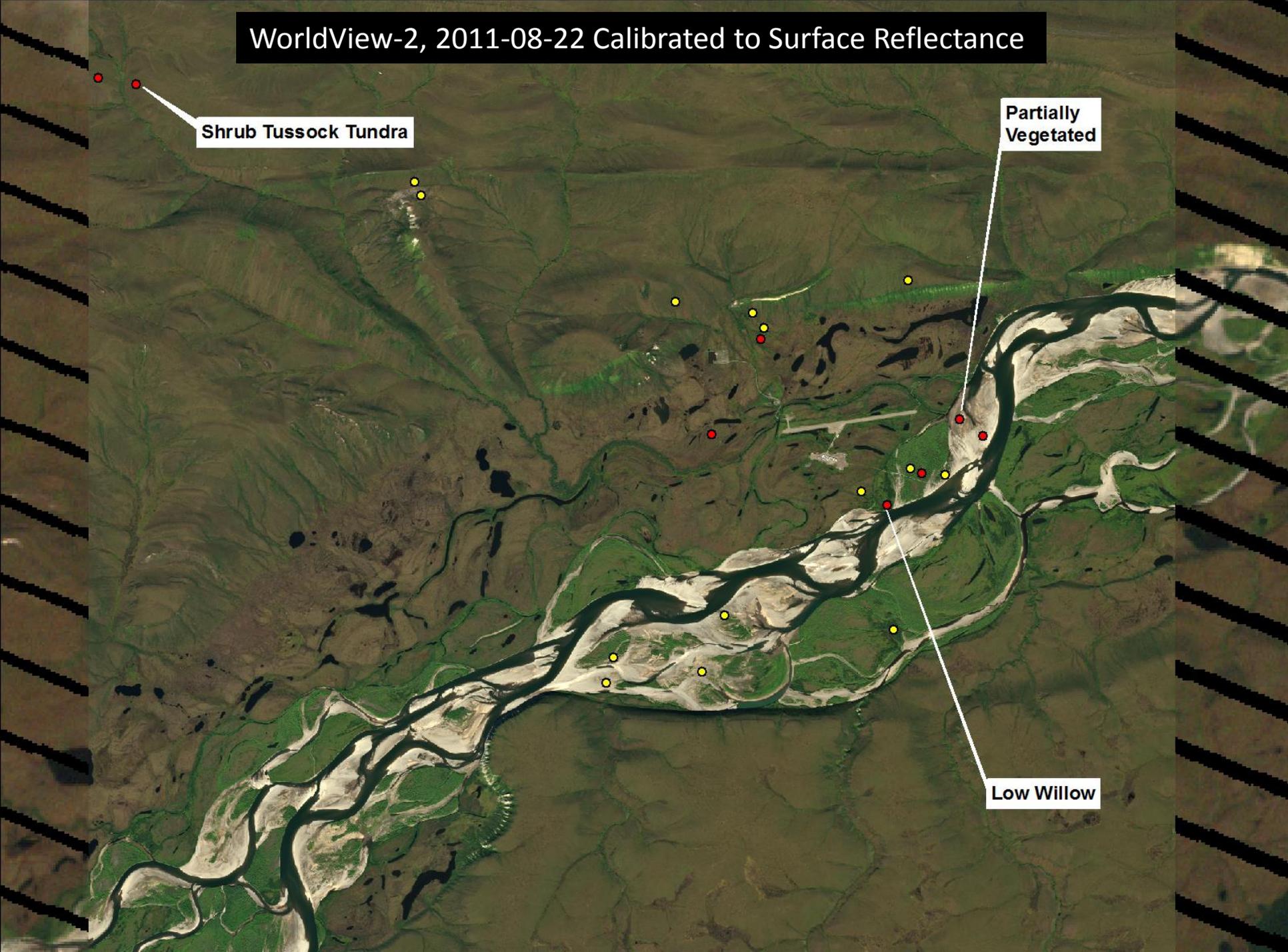


WorldView-2, 2011-08-22 Calibrated to Surface Reflectance

Shrub Tussock Tundra

Partially Vegetated

Low Willow

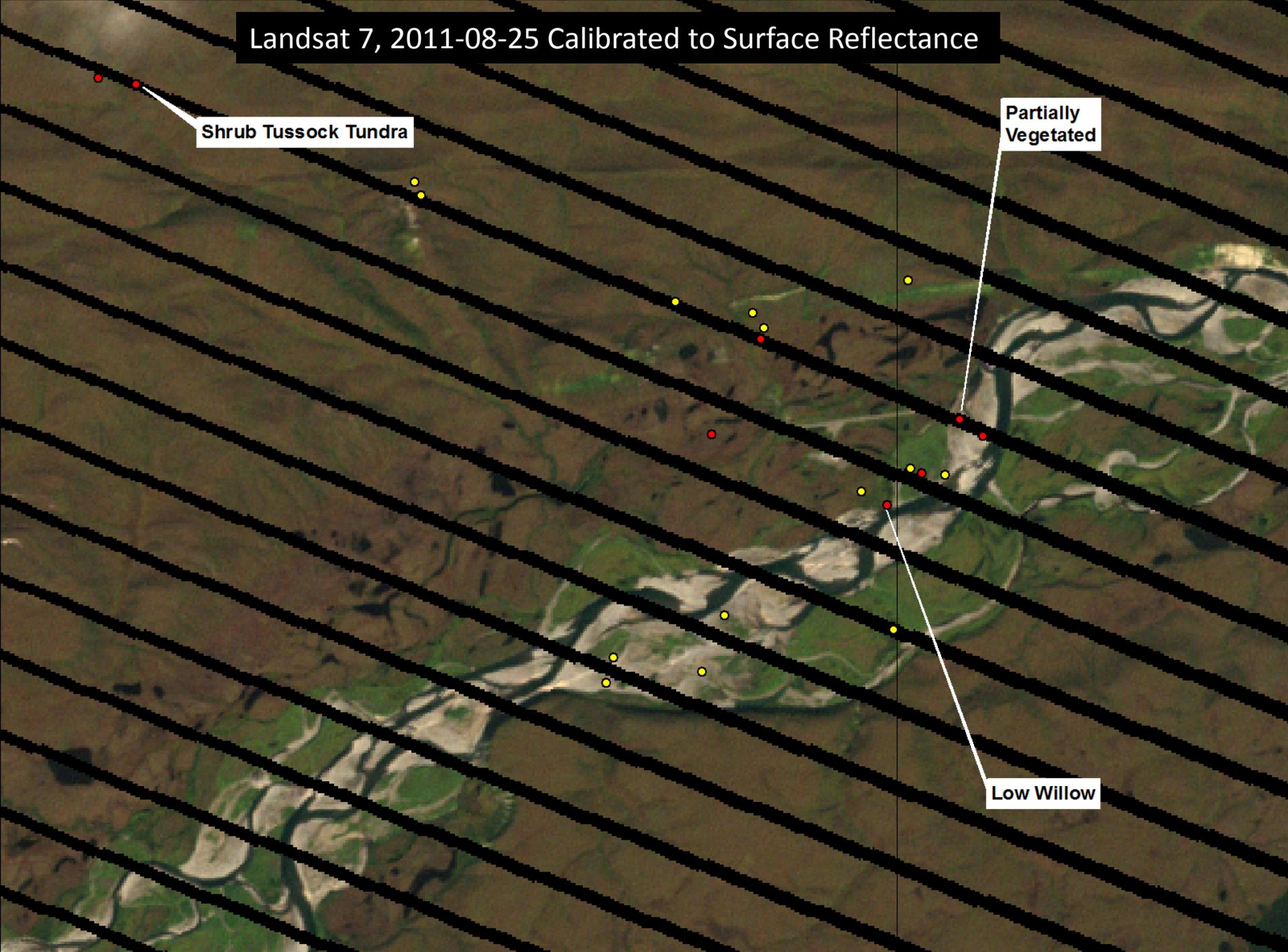


Landsat 7, 2011-08-25 Calibrated to Surface Reflectance

Shrub Tussock Tundra

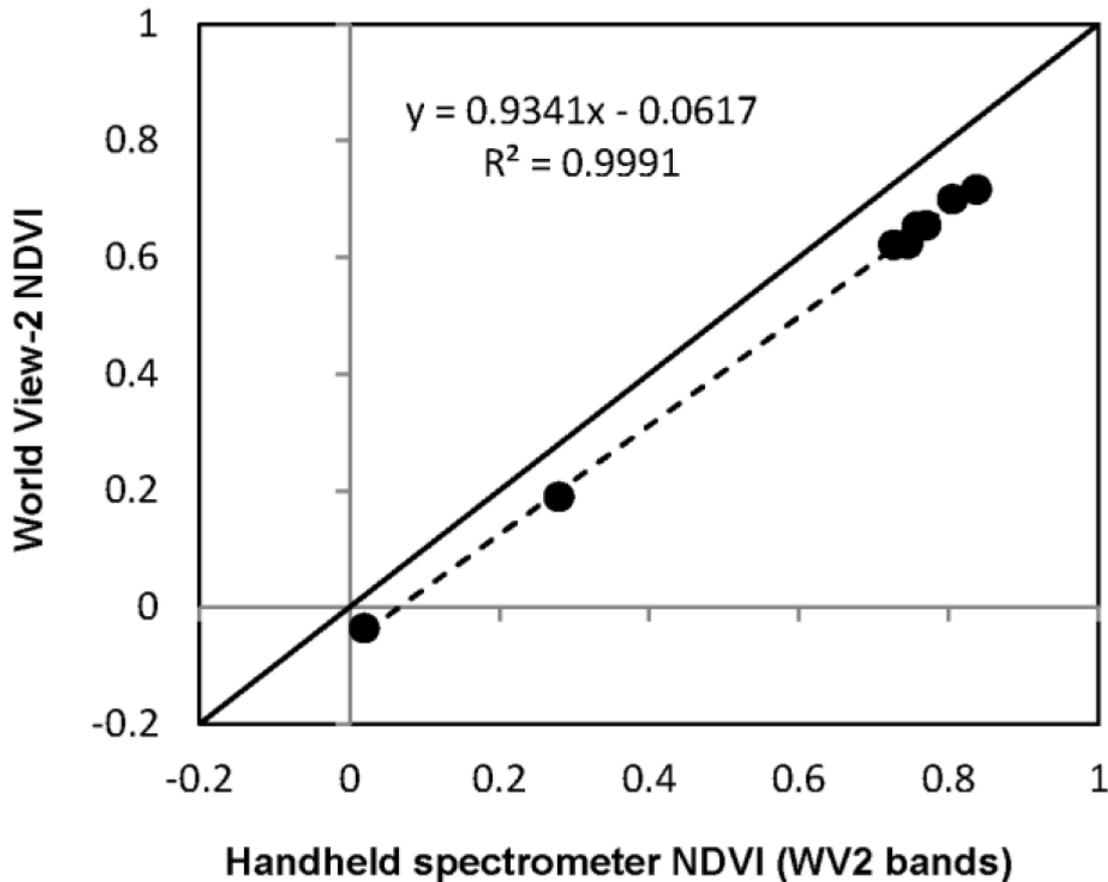
Partially Vegetated

Low Willow



# WorldView-2 NDVI (2011-08-25) vs. Handheld Spectrometer (2012-08)

b) WorldView-2 NDVI vs. Ground NDVI



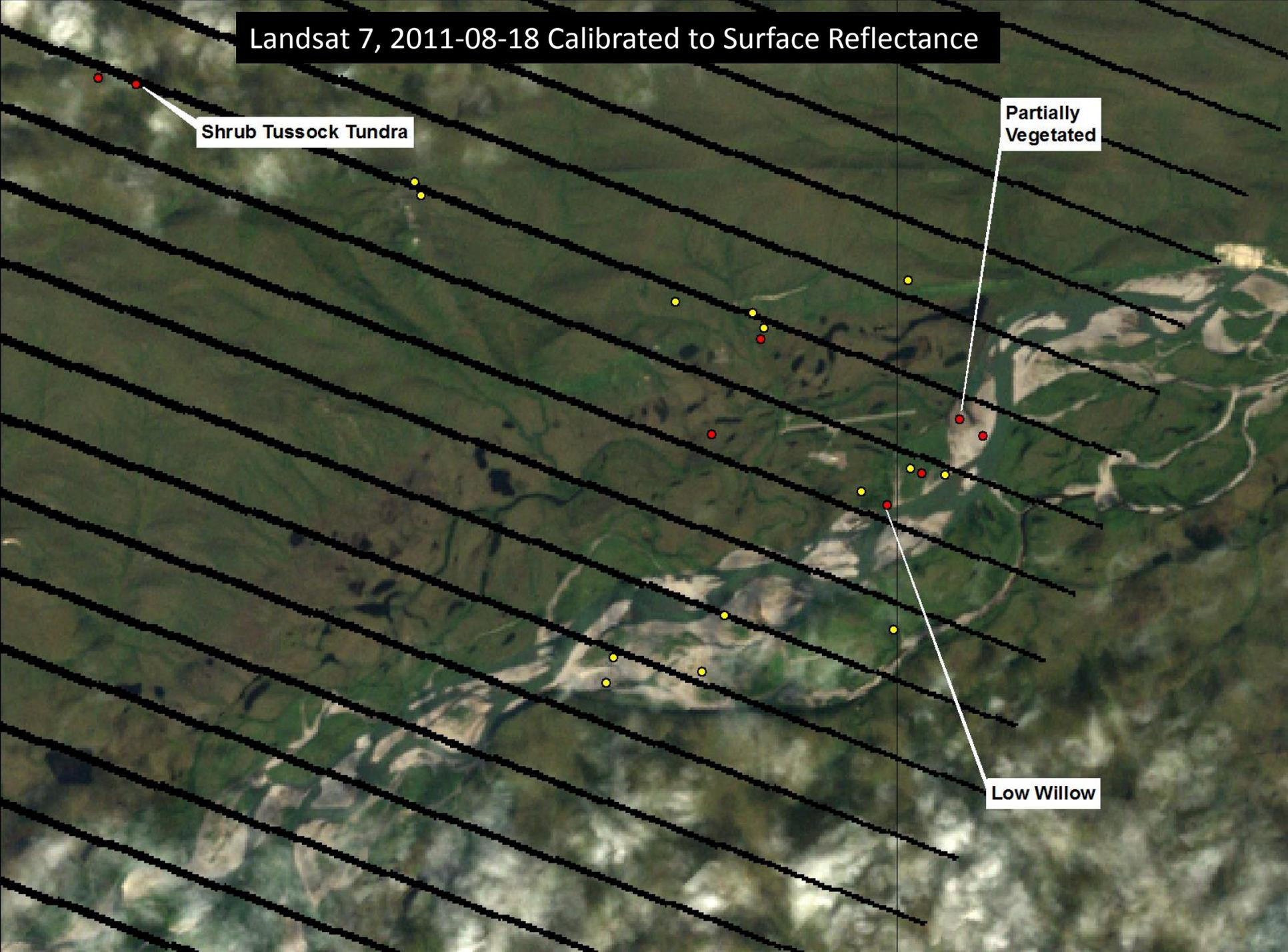
Off-nadir 14 degrees  
Collection azimuth 108

Landsat 7, 2011-08-18 Calibrated to Surface Reflectance

Shrub Tussock Tundra

Partially Vegetated

Low Willow

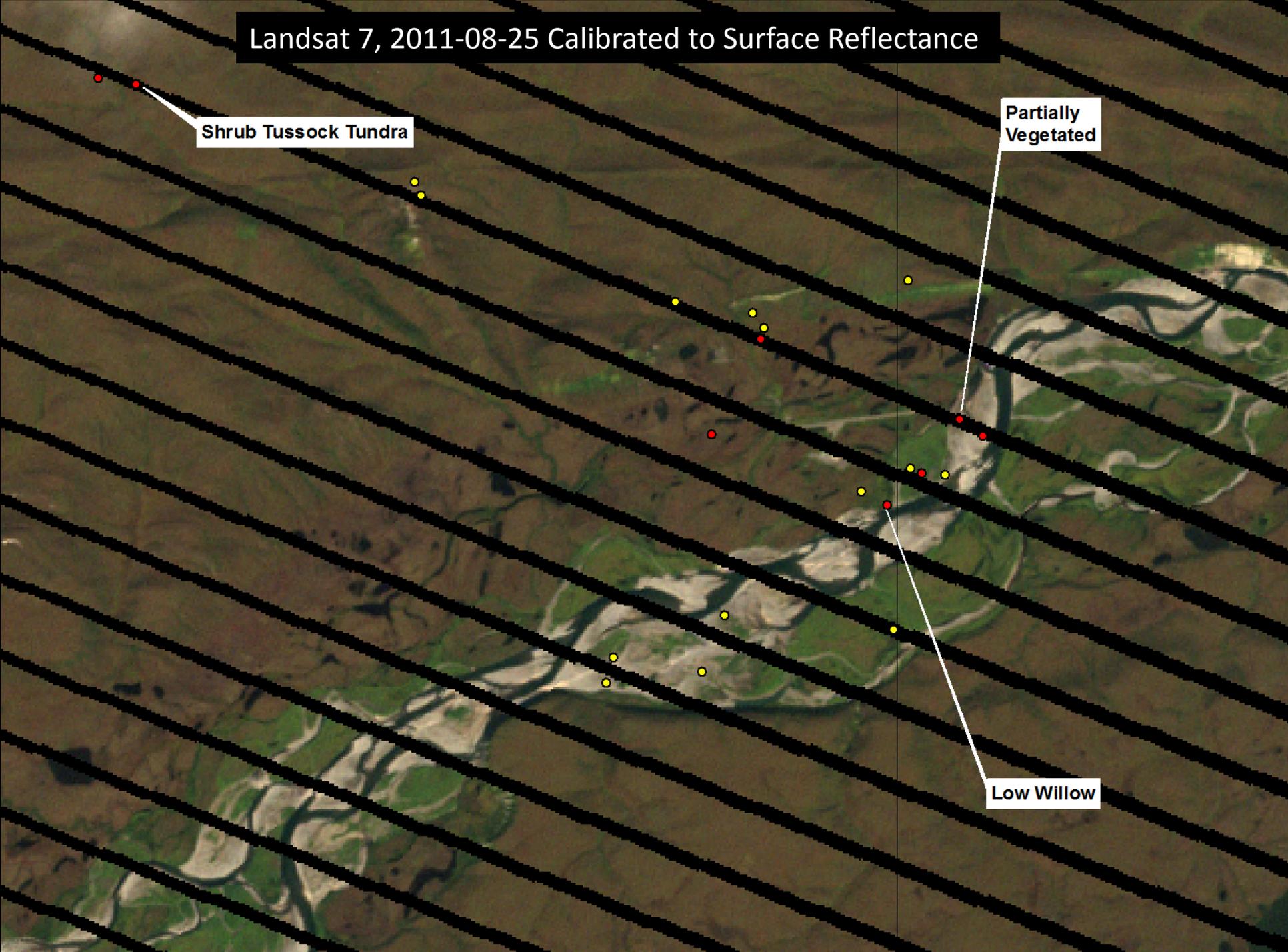


Landsat 7, 2011-08-25 Calibrated to Surface Reflectance

Shrub Tussock Tundra

Partially Vegetated

Low Willow

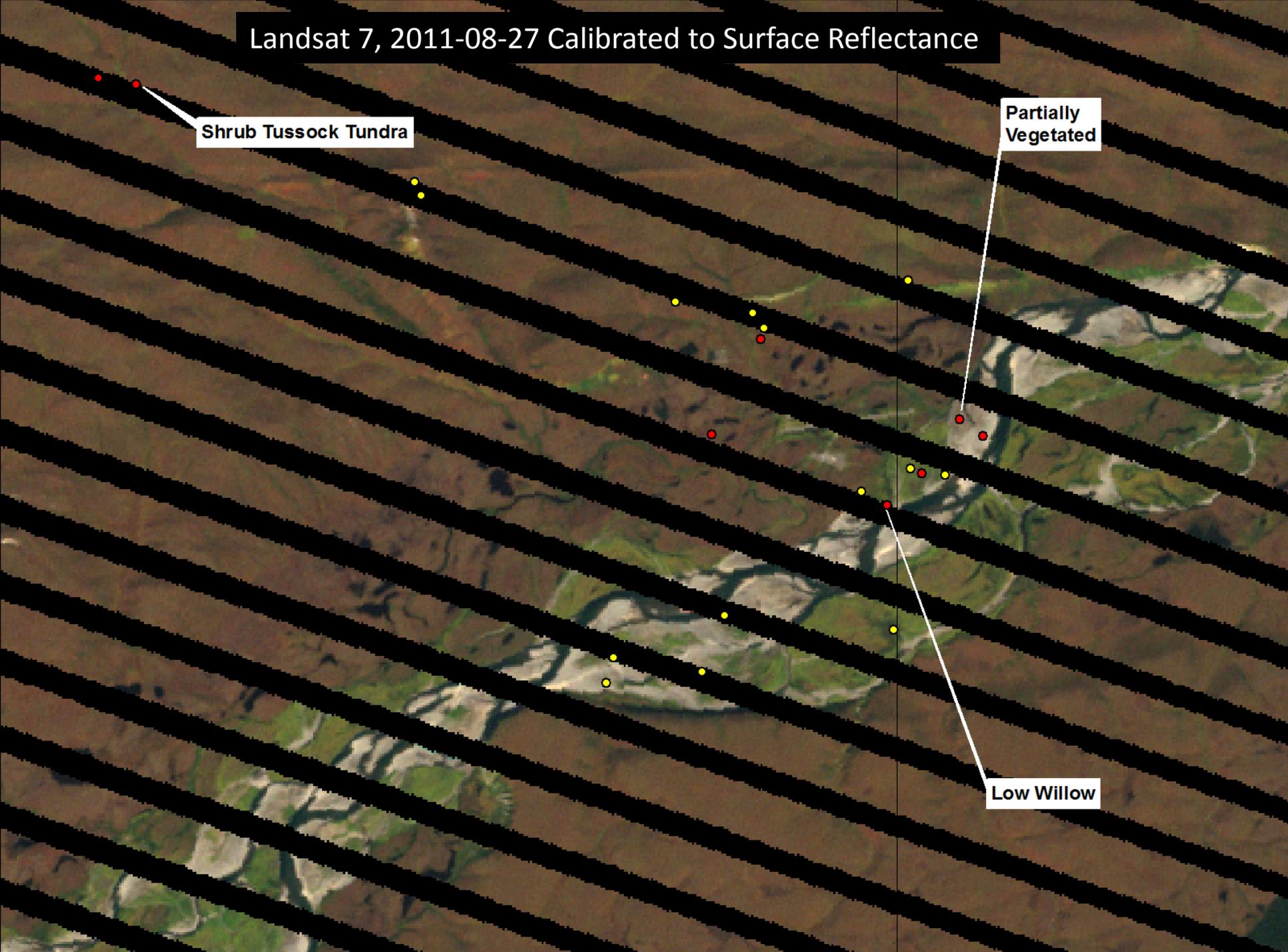


Landsat 7, 2011-08-27 Calibrated to Surface Reflectance

Shrub Tussock Tundra

Partially Vegetated

Low Willow



# Conclusions

- Results will be used to inform ongoing habitat mapping at extensive and intensive scales
- Good relationship between total vegetation cover and hit density measurements and wide-area Landsat midsummer NDVI
  - Plan to further examine response by functional type, e.g. low to tall shrubs, graminoids

# Conclusions

- Calibration and atmospheric correction of commercial high-resolution satellite imagery can be accomplished
  - If you ignore BRDF
  - With more extensive constellations more collections closer to nadir should become available
  - Plan to compare full collection of calibrated commercial imagery to Landsat and field vegetation data

Thank You



# Handheld vs. Satellite NDVI

