# ARCTIC GREENING: 25 YEARS OF TUNDRA BIOMASS CHANGE FROM IN-SITU AND REMOTELY SENSED OBSERVATIONS

Shira Ellenson, Master's Candidate, Geography, University of Montana

UM MontanaView: Final Project Report

## Problem Statement and Research Question

Satellite remote sensing adequately summarizes broad Arctic trends; however, finer resolution remote sensing data and field-based studies are needed to elucidate complex ecosystem interactions and long-term changes. This project will evaluate vegetation change over 25 years across various land cover types in Northern Alaska. This study will attempt to fill a gap in the current research by adding field measurements and fine-scale (less than 1 ha) remote sensing data that reflects tundra vegetation change rather than the use of coarse-scale remote sensing alone. This study will address: How was vegetation changed on the Alaskan North Slope over 25 years?

Objective 1) *Repeat vegetation measurements in summer 2021 to quantify vegetation change in a variety of land cover types*

Objective 2) *Quantify differences in vegetation canopy height and make digital elevation models (DEMs) of plots from 1995 aerial photos and modern UAV survey data*

Objective 3) *Make NDVI maps and assess the historic and modern correlation between field characteristics, land cover types and field biomass at these plots*

## Methods:

*Figure 1.* Color-infrared (CIR) stereo-pairs at 1:3000 resolution from August 1995 were used in photogrammetric analysis.

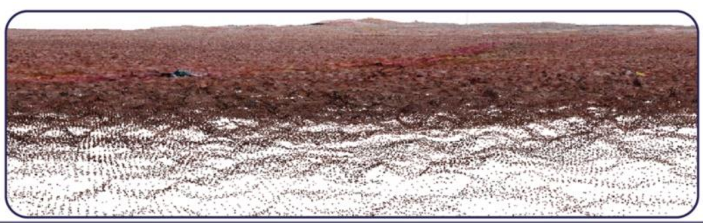


*Figure 2.* Point cloud classified into ground/non-ground points using Agisoft Metashape

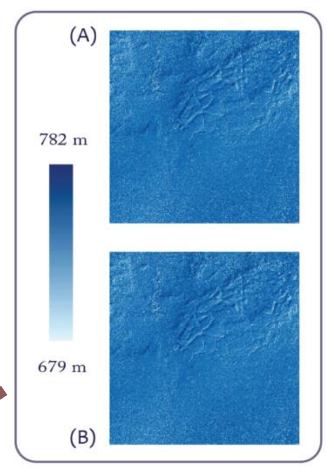



*Figure 3.* (A) Digital surface model (DSM), and (B) digital terrain model (DTM), derived from point cloud.

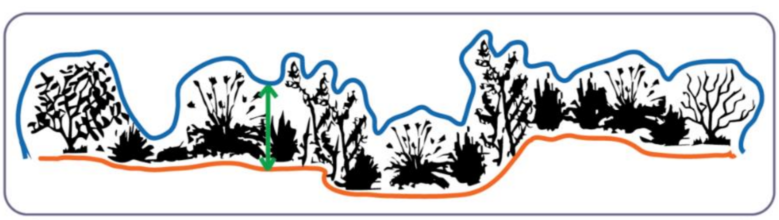
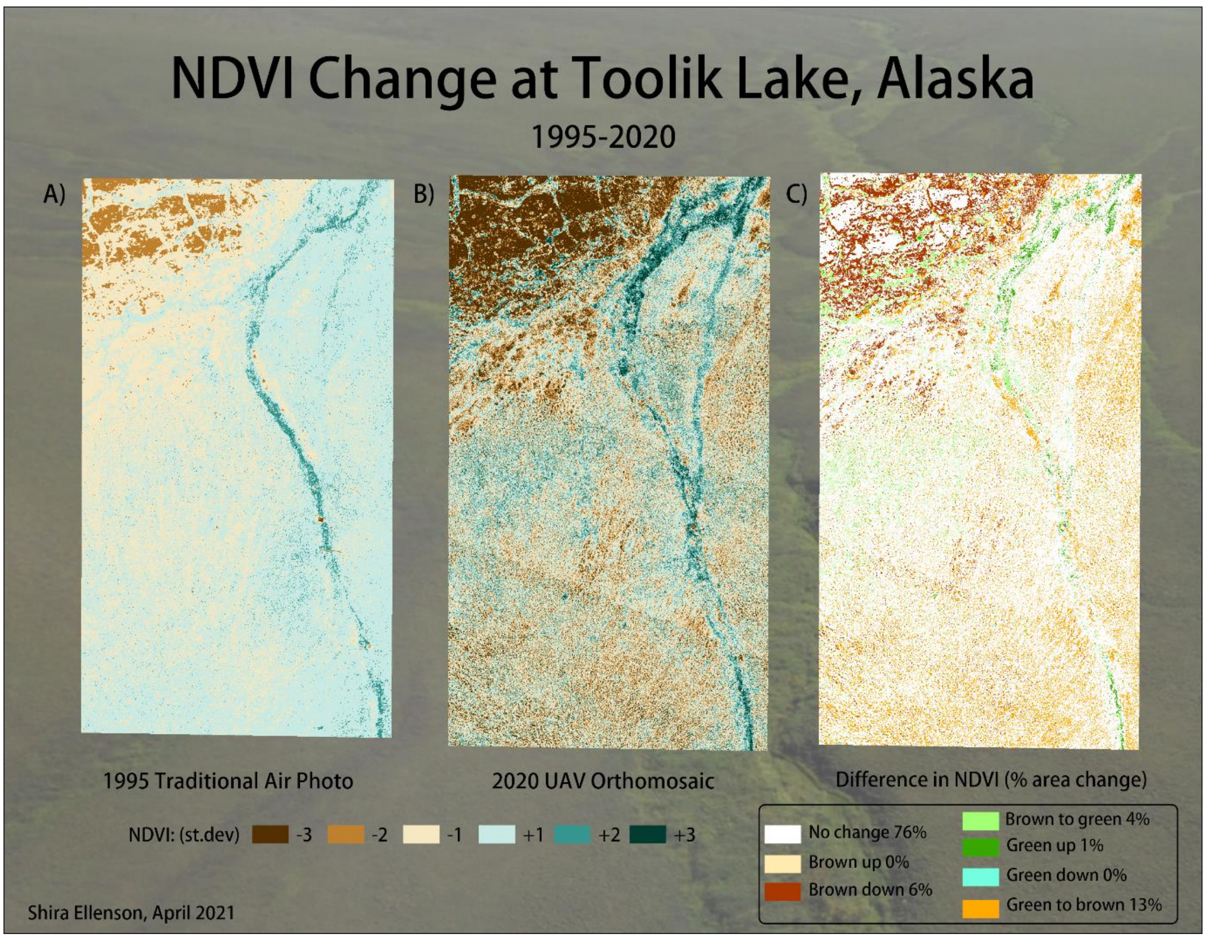


*Figure 4.* Subtracting the DSM from the DTM yields canopy height estimates (Fig 5B)

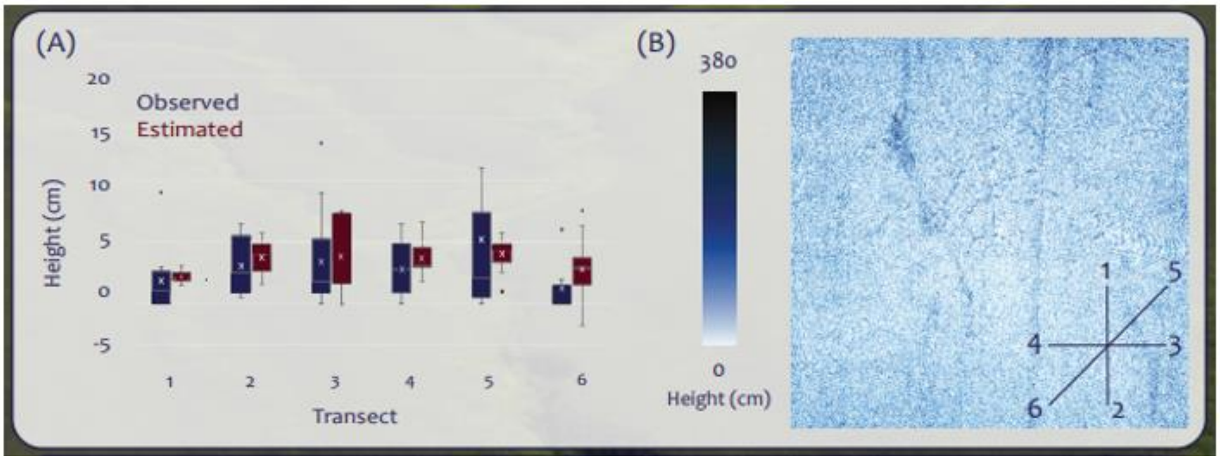
Objective 2) Agisoft Metashape was used to align historic stereopairs and develop high density point clouds of the 1-hectare plot and surroundings. The resulting point cloud was classified as ground/non-ground points and used to generate a digital surface model (DSM) and digital terrain model (DTM). Differences in the DTM and DSM yield tundra canopy height estimates. These estimates were compared to the 1995 field measurements of vegetation height, which serves as validation to the image analysis.

Objective 3) This project compared historic and modern imagery to calculate NDVI change over time. Other outputs from Agisoft Metashape included orthomosaics as inputs for NDVI analysis. A modern UAS orthomosaic was obtained from the GIS office at the Toolik Field Station in August 2020 at 8 cm resolution. To normalize the data and account for differences in sensors and phenology between 1995 and 2020, the NDVI images were reclassified according to their standard deviation (SD) from mean. This grouping represented a unique greening and browning stage relative to that year.

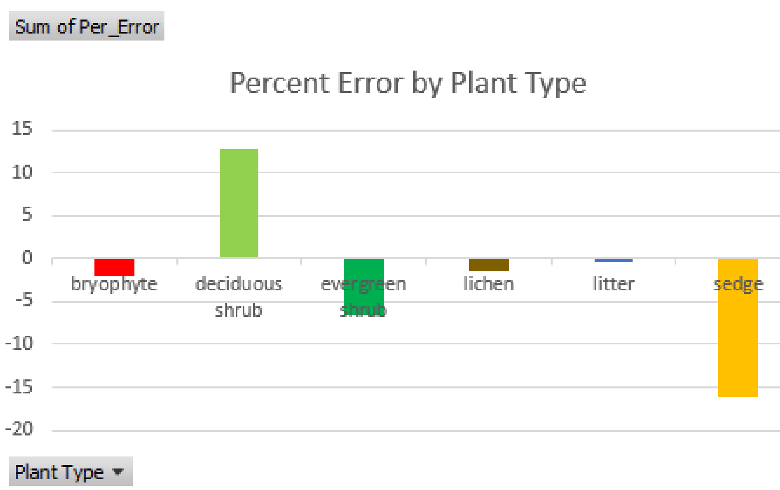
Preliminary Results:




A) NDVI for 1995 and B) NDVI for 2020 by SD relative to the mean as well as C) NDVI change from 1995 to 2020, classified based upon change between the 1995 and 2020 SD categories. Both NDVI maps reveal the highest values to be within the water track, where low shrubs are located. The lowest values are within the exposed bedrock which consists of bare ground. The difference in NDVI, C), shows 76% of the plot did not change significantly (only shifted 1 SD), 6% of the plot became browner, and 13% of the plot changed from green to brown. 4% of the plot changed from brown to green, and only 1% of the plot became greener. The water track itself reveals browning, while the edges of the water track show significant greening. The area between the exposed bedrock also reveals increases in greening.




A) Distribution of observed and estimated vegetation heights (cm) and B) estimated canopy heights (cm). Mean estimated canopy heights were within +/-3 cm from field measurements. Percent error by plant type reveals that the model is overestimating the height of deciduous shrubs and underestimating the height of sedges.




Future Studies

In August 2021, field measurements will be repeated at 8 sites across the North Slope of Alaska. The method implemented here will be repeated using 2021 field measurements and 2021 UAV survey data. These initial results suggest that responses to climate change are not likely to be uniform across a mosaic of land cover types nor driven by air temperature alone (Elmendorf et al. 2012). While satellite remote sensing is useful for summarizing Arctic trends, variation in spatial and temporal trends arise due to complex ecosystem interactions which can be missed at coarse resolution (Myers-Smith et al 2020). Smaller, plot-scale studies are necessary to better understand vegetation changes occurring on the ground.


Elmendorf, S., Henry, G., Hollister, R. *et al.* "Plot-scale evidence of tundra vegetation change and links to recent summer warming". *Nature Climate Change*, April 2012, 2, 453–457. https://doi.org/10.1038/nclimate1465

Myers-Smith, I.H., Kerby, J.T., Phoenix, G.K., *et al*. "Complexity revealed in greening of the Arctic". Nature Climate Change, January 2020, 10, 106-117. https://doi.org/10.1038/s41558-019-0688-1