Using seasonal NDVI to predict plant cover in tundra ecosystems

Taylor Doorn [1], Jeremy May [2], Sergio Vargas [3], Robert Hollister [1]
[1] Grand Valley State University, [2] Marietta College / Florida International University, [3] University of Texas at El Paso, USA

Arctic Ecology Program https://www.gvsu.edu/aep

ITEX-AON Understanding Tundra Ecosystem Change

Introduction

- An increase in the size and abundance of graminoid and shrub species has led to a greening trend in the Arctic (Boelman et al. 2011; Harris et al. 2022).
- Normalized Difference Vegetation Index (NDVI) has become a popular tool in Arctic ecosystems to examine and monitor tundra health (Verbyla et al. 2008).
- We used seasonal changes in plot-level NDVI to see if we could predict plant cover based on each growth forms pattern of greening.

References

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Verbyla, D. (2008). The greening and browning of Alaska based on 1982–2003 satellite data. *Global Ecology and Biogeography*, *17*(4), 547–555. https://doi.org/10.1111/j.1466-8238.2008.00396.x

Methods

- This research takes place in Northern Alaska at two existing International Tundra Experiment (ITEX) study locations; Utqiagvik & Atqasuk (**Figure 1**).
- At each location there is a dry and wet site, that both consist of 24 control & 24 experimentally warmed square meter plots.
- To capture seasonal NDVI, a handheld Greenseeker was used on each plot multiple times a week from the beginning of June through the end of August. Plot level plant cover was assessed using the point frame method during the peak season at both locations
- Linear regressions were performed between the different growth form combinations & the difference in NDVI for their respective periods in RStudio

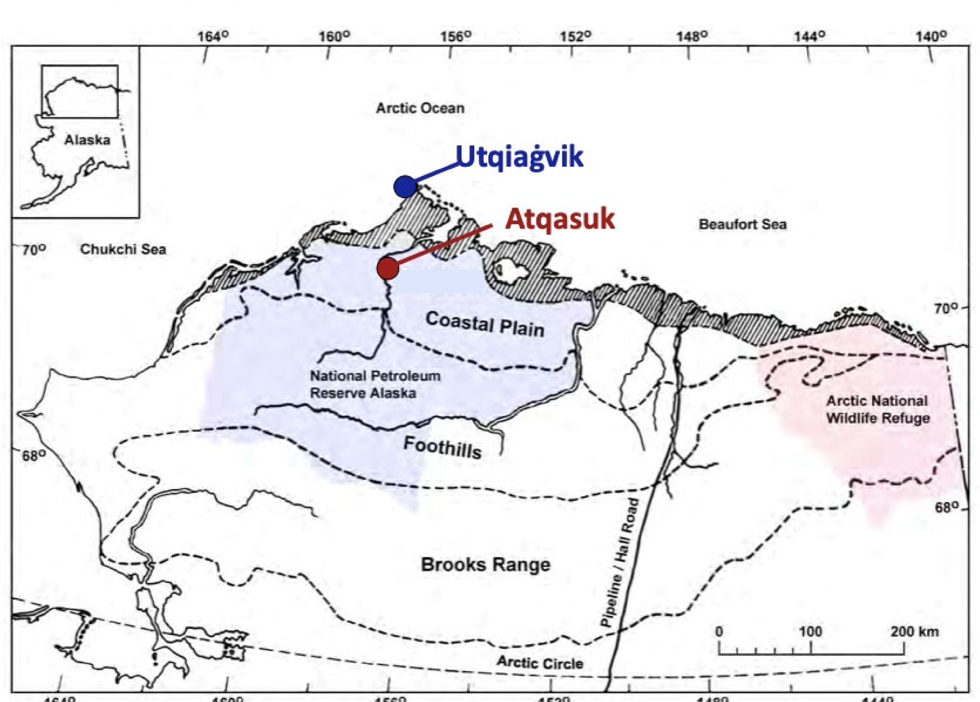

Figure 1. The research locations in Alaska.

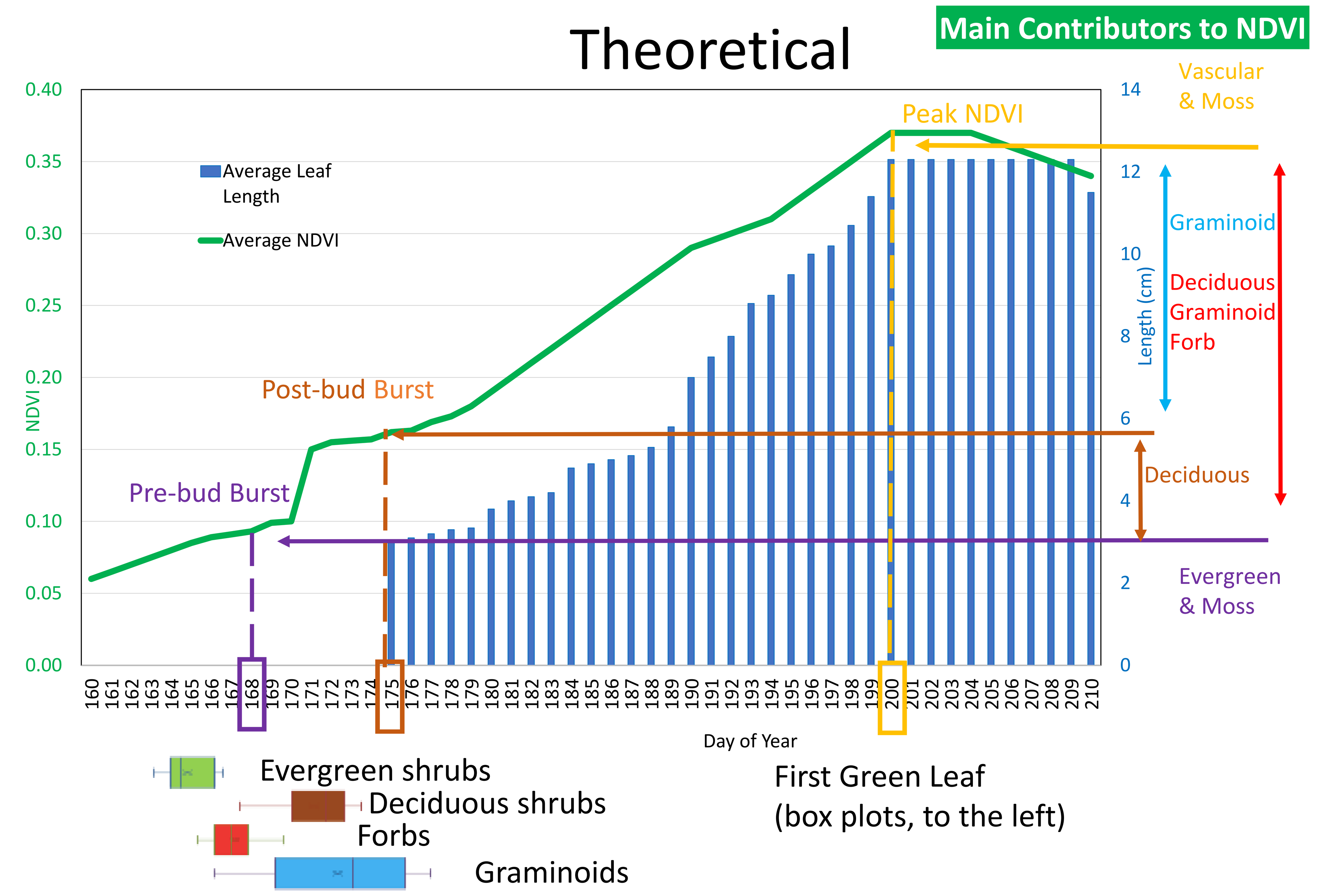

Figure 2. Theoretical association between plant phenology and plot-level NDVI over the course of the summer.

- NDVI shortly after snowmelt should be driven by the amount of mosses and evergreen shrubs; however standing dead from the previous season may also inhibit greenness.
- There should be a bump in NDVI associated with bud burst that is driven by deciduous shrubs; therefore the difference in NDVI between pre and post budburst should correlate with deciduous shrubs.
- After the initial pulse in greening associated with bud burst, their should be a gradual greening driven primarily by the elongation of graminoid leaves; thus the difference between NDVI measured shortly after bud-burst and at peak season should correlate graminoids.
- The difference in NDVI at peak season from the NDVI pre-bud burst, should be driven by the combination of deciduous shrubs, graminoids and forbs (but not evergreen shrubs and moss).
- Peak NDVI should correlate with vascular plants and moss.

Results & Discussions

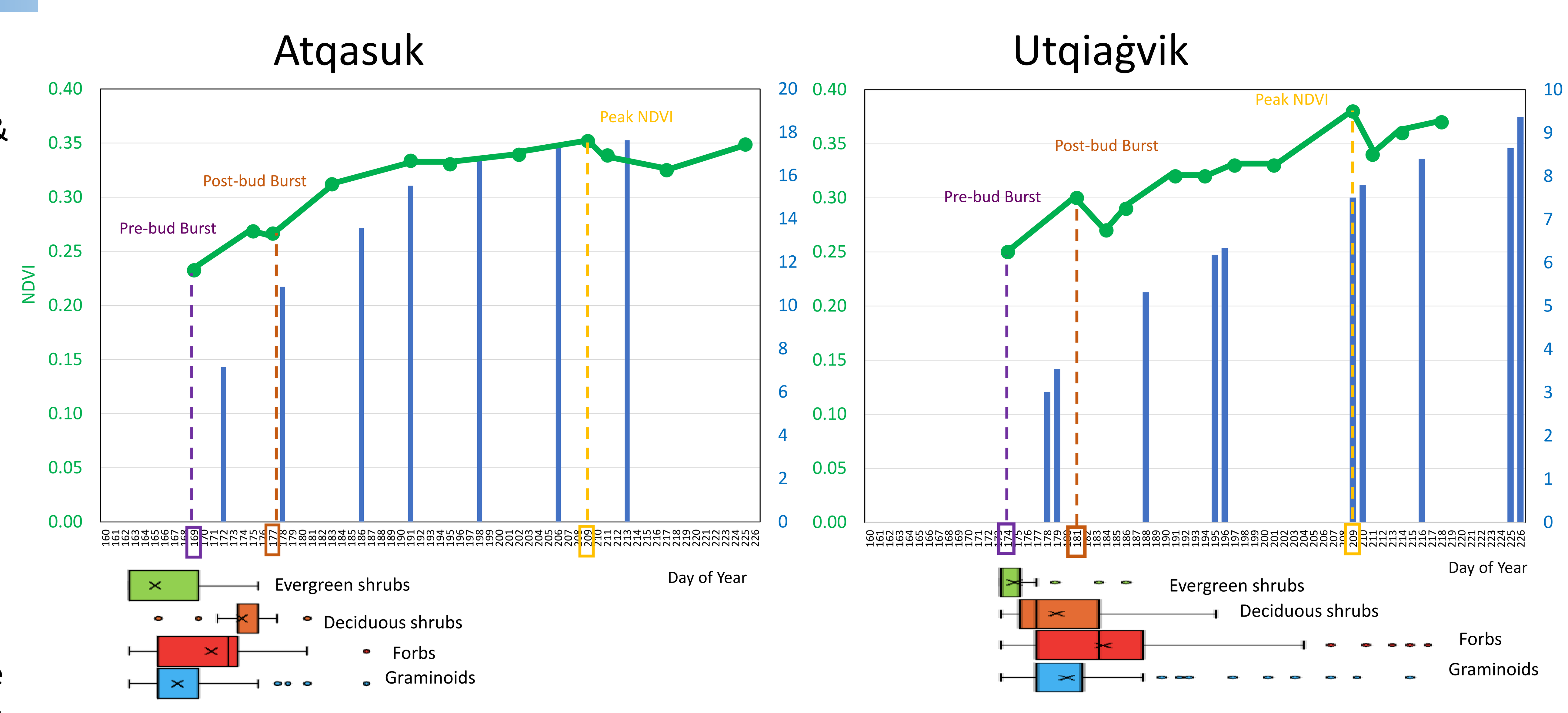

Figure 3. Average leaf length of graminoid plants paired with plot level NDVI during the 2022 field season for Atqasuk (left) and Utqiaġvik (right), AK. The timing of first green leaf of each growth form is displayed as box plots. The dates chosen for pre and post bud burst and peak NDVI are also noted. See **Figure 2** for an explanation.

	NDVI 169 (Pre Bud NDVI)	NDVI 177-169 (Post bud - Pre Bud NDVI)	NDVI 209-177 (Peak - Post Bud NDVI)	NDVI 209-169 (Peak - Pre Bud NDVI)	NDVI 209 (Peak NDVI)
Moss	(-)0.25	0.07	0.15	0.24	NS
Evergreen & Moss	0.25	NS	(-)0.17	(-)0.16	NS
Deciduous	(-)0.36	0.04	0.39	0.41	NS
Graminoid	(-)0.56	0.14	0.45	0.59	NS
Deciduous&Forb&Graminoid	(-)0.61	0.14	0.52	0.65	NS
Vascular & Moss	(-)0.43	0.15	0.40	0.55	NS
Standing Dead	(-)0.38	NS	0.26	0.26	NS
All Vascular	(-)0.30	0.11	0.34	0.45	NS

	NDVI 174 (Pre Bud NDVI)	NDVI 181-174 (Post bud - Pre Bud NDVI)	NDVI 209-181 (Peak - Post Bud NDVI)	NDVI 209-174 (Peak - Pre Bud NDVI)	NDVI 209 (Peak NDVI)
Moss	0.05	NS	0.05	NS	0.07
Evergreen & Moss	0.42	0.23	NS	0.10	0.51
Deciduous	0.28	0.23	(-)0.04	0.03	0.25
Graminoid	(-)0.30	(-)0.11	0.05	NS	(-)0.20
Deciduous&Forb&Graminoid	(-)0.18	(-)0.03	NS	NS	(-)0.09
Vascular & Moss	(-)0.01	NS	NS	0.06	NS
Standing Dead	(-)0.25	(-)0.13	NS	(-)0.08	(-)0.33
All Vascular	NS	0.03	NS	0.04	NS

Table 1. Adjusted R^2 from a regression between each growth form and each NDVI period at Atqasuk (left) and Utqiaġvik (right), Alaska. (-) Represents a negative relationship (that is the more of one growth form is associated with a lower NVDI).

Main points

The patterns partially matched expectations.

- The combination of evergreen shrubs and moss was correlated with pre-bud burst NDVI at both locations.
- Deciduous shrubs were correlated with the difference between NDVI from pre to post-bud burst at both locations.
- Graminoids were significantly correlated with the difference in peak and post-bud burst NDVI at both locations.
- The combination of deciduous shrubs, forbs and graminoids was correlated with the difference in peak and pre-bud burst NDVI at Atqasuk but not Utqiaġvik.
- The combination of vascular and moss species were not correlated with peak NDVI at either location. **This finding is especially noteworthy because research has shown a significant relationship at other locations, here we show the difference in seasonal NDVI is a more useful predictor of plant cover.**

While many of the relationships were technically statistically significant, other relationships were often stronger. This may be due to us not properly capturing the pre and post budburst accurately. It may also be that the patterns of NDVI change were simply not that strong at the sites during the year we measured them (2022).

We intend to use the above relationships to build a statistical model to predict plant cover based on seasonal changes in plot-level NDVI.

Acknowledgments

We thank the National Science Foundation (NSF) for providing the funding to make this research possible, UIC Science for providing logistical support of this research, the GVSU Arctic Ecology Program (AEP) , UTEP Systems Ecology Lab (SEL) & FIU members for their support in data collection and synthesis. I would also thank Justin Blough and Scott Branham for their ongoing support