Assessing landscape-level vegetation change via remotely-sensed hyperspectral data and traditional ground-based measurements

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Introduction

Climate change is substantially affecting the growth and productivity of Arctic vegetation (IPCC 2018). Although field studies provide evidence of cover change at ground level, advances in remote-sensing propose an alternate means to mapping, tracking and predicting change (Thorpe 2016).

The National Ecological Observatory Network (NEON) provides a continental, long-term view of vegetation change via aerial observation platform (AOP) and terrestrial observation system (TOS).

In this study, we examine the change in vegetation cover data (1995 – 2017) in Utqiaġvik, AK relative to NEON AOP hyperspectral data (2017). Ultimately, we produce a linear regression model of Utqiaġvik to predict future change in graminoid cover in northern Alaska.

Methods

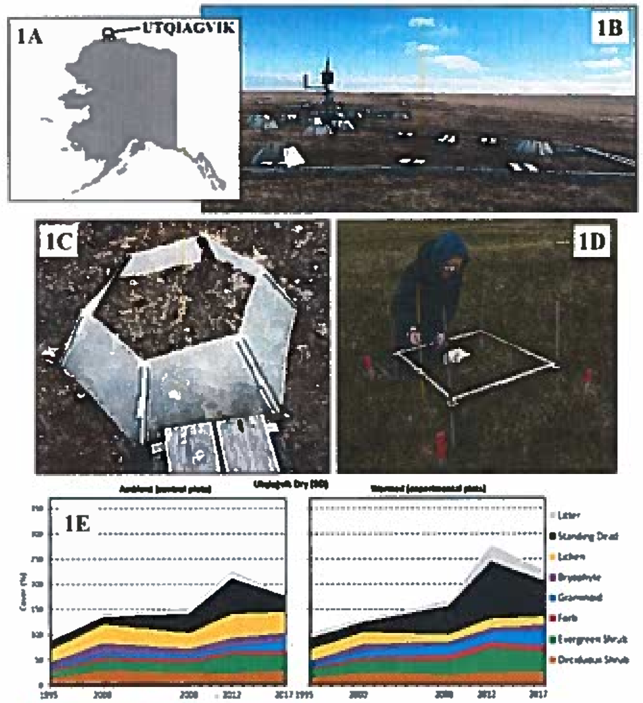
Field site was established along a dry heath ridge adjacent to a historic drained lake basin in 1995 in Utqiaġvik, AK (Fig. 1A).

Utqiaġvik dry site has 48, 1-m² plots (Fig. 1B). 24 plots are controls. 24 plots are experimentally warmed by 1°C to 3 °C via open-top chambers from June through August (Fig. 1C). Cover data were collected from 1995 – 2017 via point-intercept method (Fig. 1D, 1E).

Hyperspectral data were collected via NEON AOP in August 2017, downloaded from an open access portal, extracted via ArcGIS and normalized in R software. Statistical tests included Pearson's correlation test and stepwise linear multiple regression.

Model was selected due to correlation coefficient and AKAIKE Information Criterion. Regression model was displayed through ArcGIS.

Thorpe, A.S., Barnett, D.T., Elmendorf, S.C., et al. 2016. Introduction to the sampling designs of the National Ecological Observatory Network Terrestrial Observation System. *Ecosphere* 7(12).
IPCC. 2018. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels. In Press.



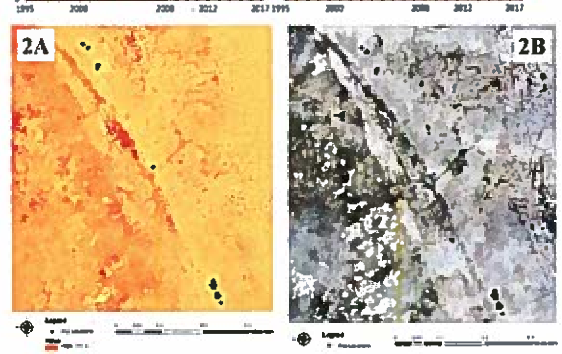


Fig. 1A: Research location at Utqiaġvik, Alaska. Fig. 1B: 32 plots are located along third boardwalk at Utqiaġvik dry site. Fig. 1C: Open-top chambers simulate warming effects at experimental plots. Fig. 1D: Point-intercept method of data collection. Fig. 1E: Change in cover over time at Utqiaġvik dry site for control and experimental plots. Fig. 2A: Regression model is mapped onto Utqiaġvik site and extrapolated to local surroundings. Areas in red are expected to increase in graminoid cover, areas in yellow are not expected to change. Fig. 2B: Less than 10% of cloud cover exhibited over 48 plots at Utqiaġvik.

Table 1. Pearson's correlation test reveals correlations between vegetation cover change and normalized hyperspectral indices: aspect, slope, fractional photosynthetically active radiation (fPAR), enhanced vegetation index (EVI), photochemical reflectance index (PRI), soil adjusted vegetation index (SAVI), moisture stress index (MSI), normalized difference infrared index (NDII), normalized difference water index (NDWI), normalized difference multi-band drought index (NDMI), and water band index (WBI). Asterisk denotes P-values < 0.05.

Taxa	Aspect	Slope	fPAR	EVI	PRI	SAVI	MSI	NDII	NDWI	NDMI	WBI
GRAM	- 0.3996*	- 0.3612*	0.0910	- 0.0158	0.0370	0.0784	- 0.4706*	0.5853*	0.4417*	0.2107	0.4469*
LICH	0.0495	- 0.0363	0.2019	0.1848	- 0.3903*	0.2158	- 0.0716	- 0.0646	- 0.0653	0.0895	- 0.1310

Results

No patterns were established between shrub, forb, lichen, bryophyte, standing dead, or litter cover and hyperspectral data.

Analysis of graminoid cover and hyperspectral data revealed significant correlations to aspect, slope and moisture indices (Table 1). Linear regression determined that the best predictors of graminoid cover change are Moisture Stress Index (MSI) and Normalized Difference Infrared Index (NDII) in experimentally warmed conditions at Utqiaġvik dry site.

The model is $\sqrt[2]{\text{Cover Change in Graminoids}} = 109.15*(\text{NDII}) + 50.06*(\text{MSI}) + (-43.06)$ with $r^2 = 0.59$, $p < 0.05$, AIC = 91.6.

Discussion

MSI quantifies water stress by assessing canopy water content. NDII quantifies soil moisture by assessing water content from different vegetation types. The model suggests that a strong relationship exists between vegetation water content, soil moisture, and graminoid cover change (Fig 2A). If moisture parameters shift, dry heath plant communities at Utqiaġvik may substantially change.

The cloud cover in Fig. 2B may generate error and restrict indices from the model, especially Normalized Difference Infrared Index (NDVI), which exhibits high sensitivity to cloud cover. Analysis of 2018 and 2019 hyperspectral data may reveal alternate, improved models.

We aim to extend analyses to the Utqiaġvik wet site, Atqasuk and Toolik Lake research sites, and explore the challenges and limitations of NEON AOP data.

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