Observed Vegetation Change in Northern Alaska Across the Landscape

GVSU Arctic Ecology Program

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The vegetation of the Arctic is expected to change as the region warms and these changes may influence global climate. This study documents vegetation change across tundra plant communities at Utqiaġvik and Atqasuk, Alaska (**FIG. 1**). At each location 30 1m² plots, distributed equally across the landscape, were sampled annually, *via* a point-frame method, from 2010 to 2017 (**FIG. 2**) in a manner similar to those described in Botting (2015). Plant specimens were identified to species and lumped into the following taxonomic groups: deciduous shrubs, evergreen shrubs, forbs, graminoids, bryophytes and lichens. The change in vegetation was compared with changes in the following abiotic factors: year, air temperature, soil temperature, degree day sums (calculated from air temperature), thaw depth, soil moisture, and precipitation.

Across years there were significant differences in plant cover (**FIG. 3**) and environmental factors (**FIG. 4**). Correlations (**FIG. 5**) between abiotic factors and plant cover provide insights into the relationships between the growth and abundance of growth forms and abiotic variables.

Overall, changes in vegetation are occurring at both Atqasuk and Utqiaġvik, many of which concur with other research findings (Elmendorf *et al.* 2012; Hollister *et al.* 2015). Yearly observations from the seven sampling periods since 2010, as well as correlation values obtained from this study suggest that some observed changes are directional over time and are due at least in part to climate influences.

Long-term monitoring is necessary to document change and understand the complexity of the many potential drivers of these observed changes. Continued monitoring is necessary for higher resolution relationships between vegetation growth forms and abiotic variables.

Documenting and understanding vegetation change is important because alterations in plant canopy cover and composition may reflect or interact with larger changes in the regional ecosystem. Processes and related systems that may be involved include the carbon cycling of the region (Rustad *et al.* 2001), regional energy balances (Chapin *et al.* 2005), and local food webs (Post and Forchhammer 2008).

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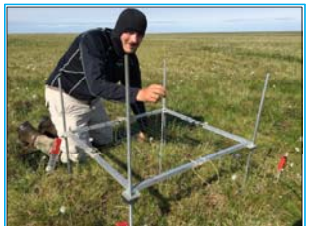
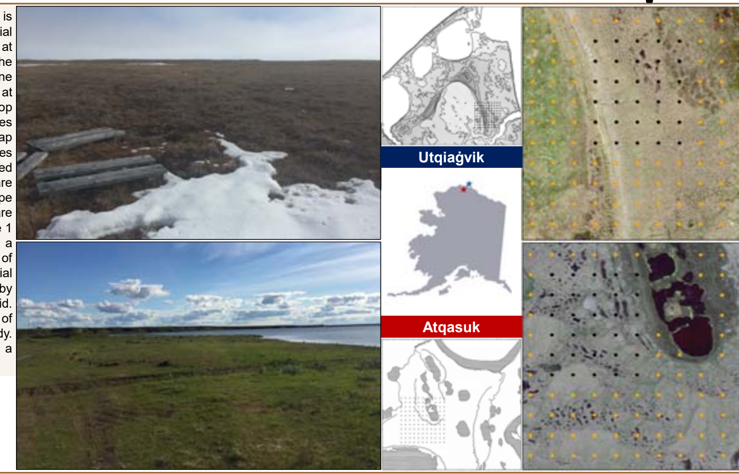


FIG. 2 Plant cover estimates were obtained *via* a point frame method. Pictured above is the frame used at typical plot in Utqiaġvik. Sampling was accomplished by placing a 100 point frame over each plot and aligning coordinates with permanently placed markers. Species were identified down to the lowest possible resolution, typically genus or species level. All plant species hits were recorded between the top of the plant canopy and the ground. All sampling was done within a two week window across years (for each plot) to minimize difference in phenological development between samplings.

FIG. 1 The overarching project is documenting change in terrestrial ecosystems at the landscape level at Utqiaġvik and Atqasuk, Alaska. The measurements collected are done collaboratively with Steve Oberbauer at FIU and Craig Tweedie at UTEP. Top images are of Utqiaġvik. Bottom images are of Atqasuk. The center image is a map of Alaska showing the location of both sites represented as a blue (Utqiaġvik) and red (Atqasuk) star. The left images are photographs showing the typical landscape of both regions. The center images are maps showing the general location of the 1 km² grid established in the 1990s as a platform to do long-term monitoring of ecosystem change. The aerial photographs on the right are overlain by dots that represent each point of the grid. The black dots represent the location of the plots that were sampled in this study. The full grid is sampled once or twice a decade.



Atqasuk

Abiotic and Biotic Factors	DSHR	ESHR	FORB	GRAM	BRYO	LICH	SDEA	LITT
Deciduous Shrubs (DSHR)	1	**0.78**	0.54	**0.95**	0.12	-0.06	-0.25	0.50
Evergreen Shrubs (ESHR)	0.78	1	**0.76**	**0.80**	0.42	0.43	-0.01	0.40
Forbs (FORB)	0.54	0.76	1	0.59	*0.64*	*0.64*	0.11	-0.12
Graminoids (GRAM)	0.95	0.80	0.59	1	0.1	-0.06	-0.36	*0.62*
Bryophytes (BRYO)	0.12	0.42	*0.64*	0.10	1	**0.92**	-0.07	-0.31
Lichens (LICH)	-0.06	0.43	*0.64*	-0.06	0.92	1	0.24	-0.42
Standing Dead (SDEA)	0.50	0.40	-0.12	*0.62*	-0.31	-0.42	*1*	*-0.65*
Litter (LITT)	-0.25	-0.01	0.11	-0.36	-0.07	0.24	*-0.65*	1
Year (YEAR)	**0.91**	*0.67*	0.36	**0.93**	-0.07	-0.27	-0.50	**0.74**
Air Temperature (ATEM)	0.53	0.26	-0.18	0.38	-0.21	-0.29	0.04	0.32
Soil Temperature (STEM)	0.45	0.22	-0.08	0.18	0.24	0.05	-0.08	0.05
Degree Day Sums (DDSU)	0.62	0.33	-0.22	0.54	-0.23	-0.39	-0.34	*0.67*
Thaw depth (THAW)	**0.91**	**0.84**	*0.64*	**0.88**	0.05	0.01	0.02	0.40
Soil Moisture (SWVC)	0.00	-0.22	0.06	-0.02	0.17	-0.07	-0.52	-0.06
Precipitation (PREC)	0.42	0.54	*0.66*	0.35	**0.88**	*0.70*	-0.28	-0.08

Utqiaġvik

	DSHR	ESHR	FORB	GRAM	BRYO	LICH	SDEA	LITT
DSHR	1	-	**0.80**	**0.85**	0.21	0.43	-0.01	-0.71
ESHR	-	1	-	-	-	-	-	-
FORB	0.80	-	1	**0.80**	0.28	0.48	-0.09	-0.62
GRAM	0.85	-	0.80	1	-0.24	0.04	-0.32	-0.32
BRYO	0.21	-	0.28	-0.24	1	**0.92**	0.47	**-0.80**
LICH	0.43	-	0.48	0.04	0.92	1	0.15	**-0.84**
SDEA	-0.01	-	-0.09	-0.32	0.70	0.15	1	-0.45
LITT	-0.71	-	-0.62	-0.32	-0.80	-0.84	-0.45	1
YEAR	0.46	-	0.21	**0.71**	-0.62	-0.34	-0.43	0.09
ATEM	0.48	-	**0.73**	**0.81**	-0.38	-0.19	-0.27	-0.01
STEM	0.20	-	0.51	0.12	0.32	0.21	0.28	-0.23
DDSU	0.54	-	**0.75**	**0.80**	-0.33	-0.20	-0.13	-0.07
THAW	**0.73**	-	0.59	**0.77**	-0.21	-0.08	0.08	-0.31
SWVC	-0.36	-	-0.51	-0.25	-0.38	-0.36	-0.48	0.57
PREC	-0.17	-	-0.37	-0.26	0.16	0.28	-0.35	-0.02

FIG. 5 Correlation table illustrating relationships between both biotic variables (growth form) and abiotic variables (environmental factors). Values are r from Pearson correlations tests comparing the mean value of each year (n=7). Bolded values represent significant correlations at a 95% confidence level. Italicized represent significant correlations at a 90% confidence interval.

In Atqasuk there are significant positive correlations between evergreen shrub cover and deciduous shrub cover, graminoid cover and deciduous shrub cover, forbs and evergreen shrub cover, graminoids and evergreen shrub cover, and bryophyte and lichen cover. Less significant correlations exist between bryophytes and forb cover.

In Utqiaġvik there are significant positive correlations between forb cover and deciduous shrub cover, graminoid cover and deciduous shrub cover, bryophyte cover and lichen cover. Negative correlations exist between bryophyte cover and litter cover, and lichen cover and litter cover. These relationships suggest that the drivers influencing increasing cover change may affect different growth forms similarly. In the case of bryophytes and lichens in Utqiaġvik the strongly negative relationship with litter cover may suggest they are being overshadowed as the quantity of dead vascular tissue increases.

The largest directional changes were increased cover of graminoids and deciduous shrubs in Atqasuk and to a lesser degree in Utqiaġvik. Graminoid and deciduous shrub cover suggest that changes are being driven by temperature in Utqiaġvik but not in Atqasuk. Other abiotc factors driving vegetation change include the active layer (thaw) depth of soil, as seen in the strong correlations between graminoid and shrub cover in both Atqasuk and Utqiaġvik. Precipitation is important for the bryophytes present in Atqasuk, possibly because they are more sensitive to moisture constraints than vascular vegetation. In Utqiaġvik forbs correlate strongly with air temperature and graminoids, another indicator that temperature is a driver for vegetation change in this region. Other significant directional correlations include the increased cover of leaf litter in the Atqasuk region.

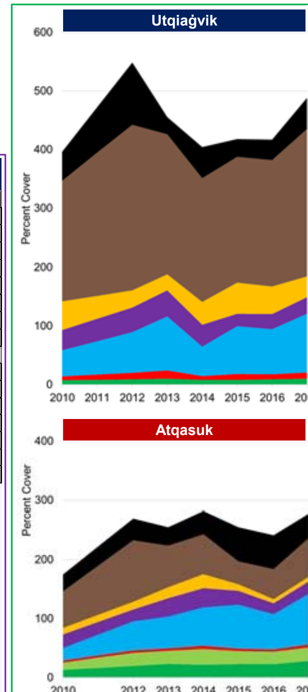


FIG. 3 Percent cover of the main growth from types through time in both Atqasuk and Utqiaġvik. Vegetation was not sampled in 2011 (the 2011 value is the average of the 2010 and 2012 value). Cover values reflect the number of live plants hits (**FIG. 2**) except for the standing dead (SDEA) and litter (LITT).

There were major difference in cover between years. Cover was higher in Utqiaġvik largely due to the increased quantities of standing dead plant material. Atqasuk has a higher abundance of shrubs and overall more live vascular plants relative to Utqiaġvik.

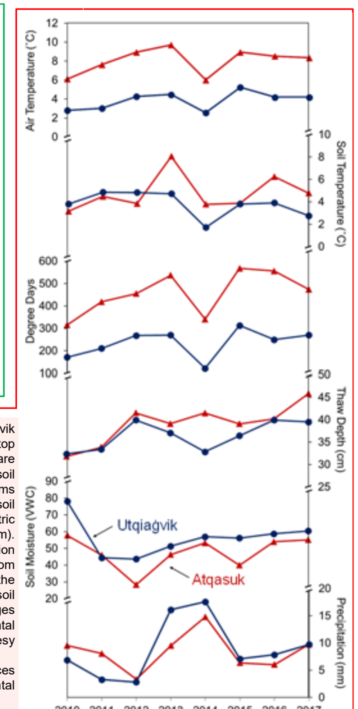


FIG. 4 Environmental factors at Utqiaġvik and Atqasuk from 2010 to 2017. From top to bottom the variables graphed are average air temperature (˚C), average soil temperature (˚C), degree day sums (temperature departures above 0), soil thaw depth (cm), soil moisture (volumetric water content), and total precipitation (mm). Air temperature and precipitation measurements were obtained from permanent weather stations within the sampling areas. Soil moisture, soil temperature, and thaw depth are averages obtained through biweekly instrumental measurements (data are provided courtesy of UTEP).

There were significant differences between years in all the environmental factors reported.