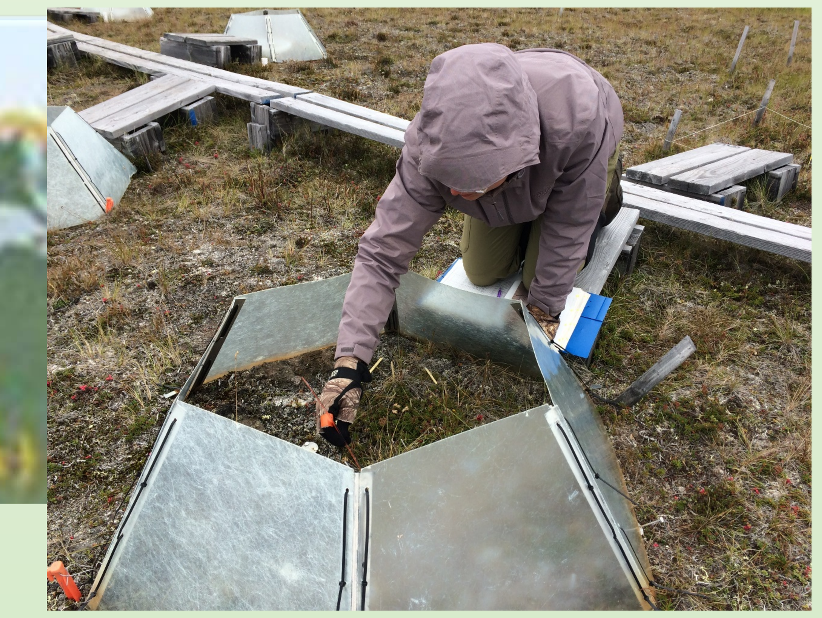
Monitoring Change in Species Density Over Time in Arctic Alaska



Kailey Keenan-Whittemore, Jacob Harris, Dr. Robert Hollister
Biology Department, Grand Valley State University

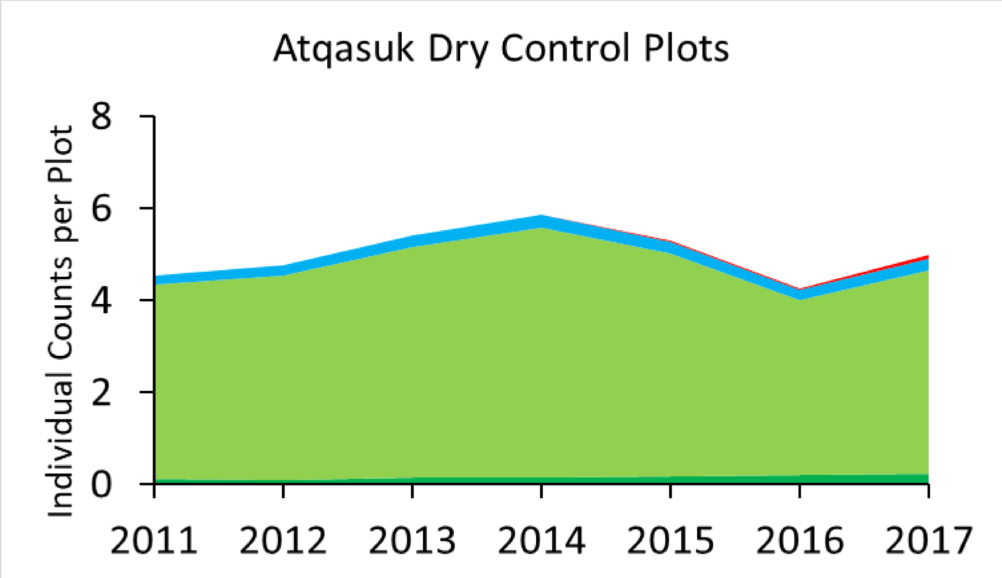
Introduction

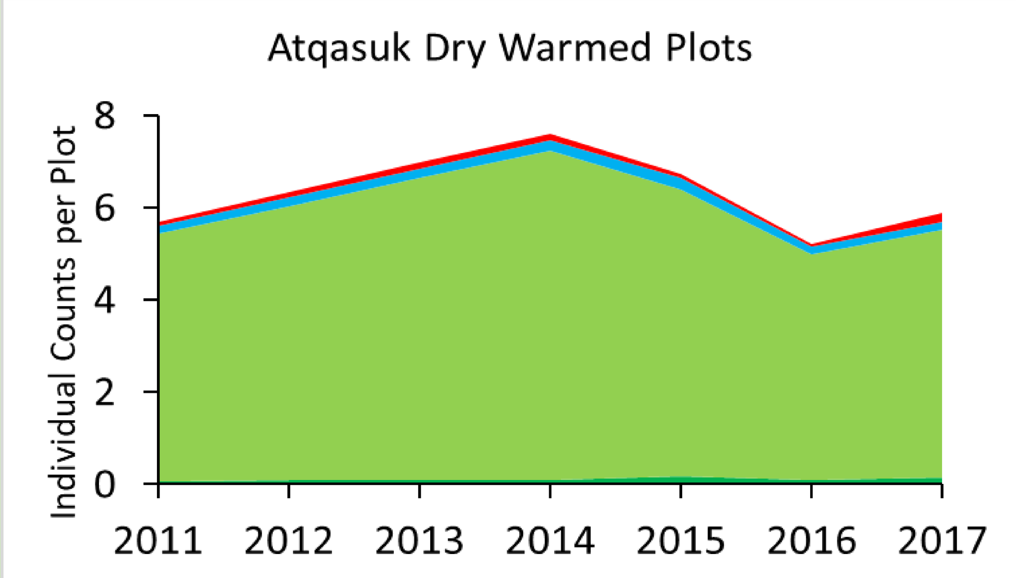
The tundra is a simple ecosystem to study because trophic interaction are fewer compared to all other ecosystems. Plant communities have adapted to low temperatures, little precipitation and a short growing season. The arctic has experienced warming since the mid-1800's but in recent decades, warming has accelerated and global climate models predict a continuous and rapid warming to take place within the next century (IPCC 2014). A network of researchers known as the International Tundra Experiment (ITEX) studies the impact of 1-3° C warming, using open-top chambers (OTC), on plant species composition and structure. Changes in species composition is crucial for understanding how increasing temperatures will influence feedback loops that may ultimately affect lower latitudes. The objective of this study was to examine the change in density of graminoids (GRAM), forbs (FORB), deciduous shrubs (DSHR) and evergreen shrubs (ESHR) at three sites in Atqasuk, Alaska.

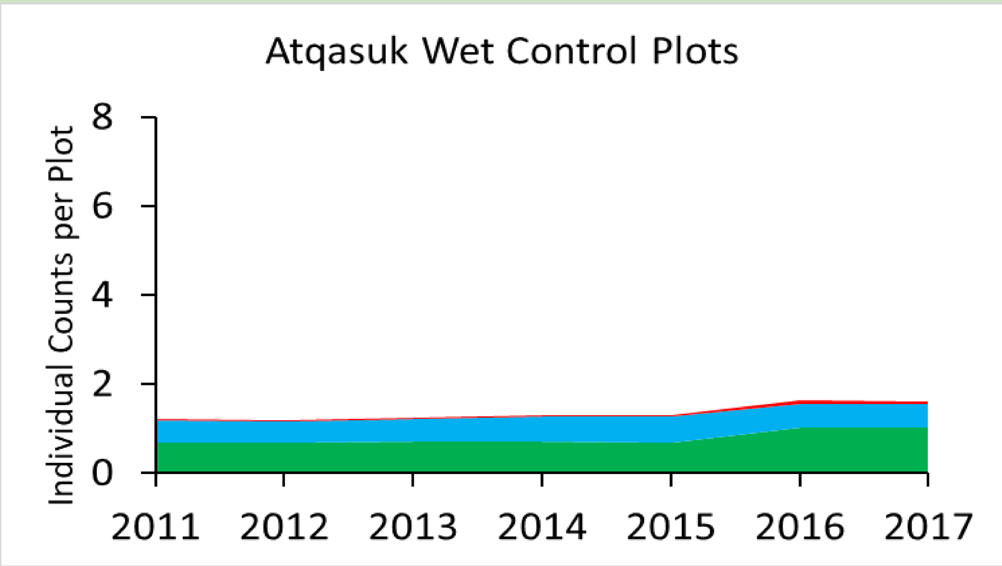
Methods

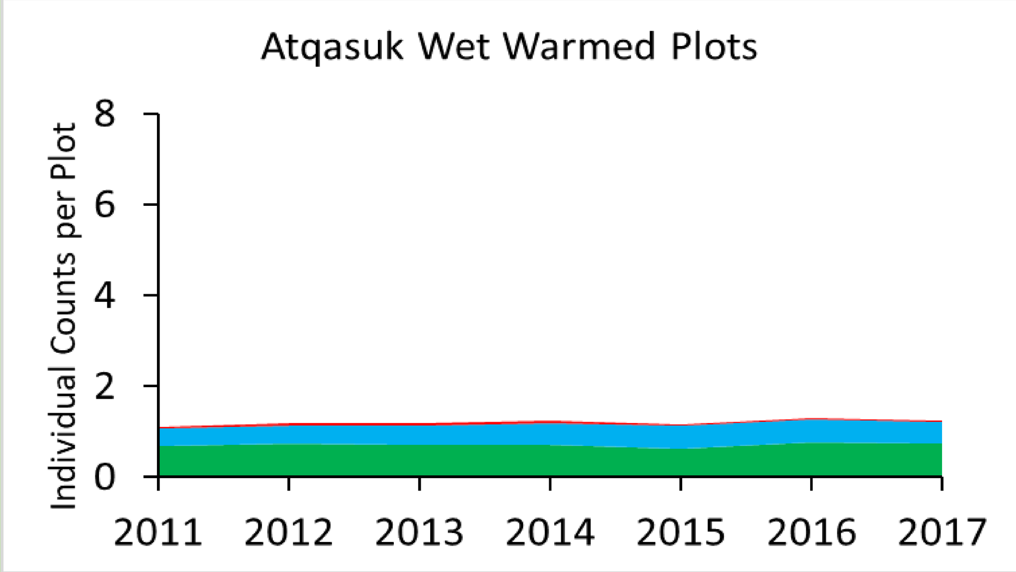
Subplots within each plot were used to measure species density. Live counts of each vascular plant species were collected from 24 experimental and 24 control plots at the Atqasuk Dry (AD) and the Atqasuk Wet (AW) sites. An additional 30 control plots located across the landscape were also sampled on the Atqasuk Grid (AG). Located within each plot, five subplots were used to monitor plant species composition. Each subplot is 10 cm^2 (**FIG 1**). The number of individuals were recorded for each plant species. For this analysis the species were grouped by the following growth forms: graminoids, forbs, evergreen shrubs and deciduous shrubs. Analysis were done by plot by averaging the values from each subplot. R Core Team statistical analysis was used to calculate one-way and two-way ANOVAs and Pearson correlations. The objective of this study is to accurately document the change in the number plants over time to provide a more accurate representation of plant communities within the ITEX plots.

FIG 1. The 10cm by 50cm sampling plot is divided into five 10 cm^2 subplots to measure species density.









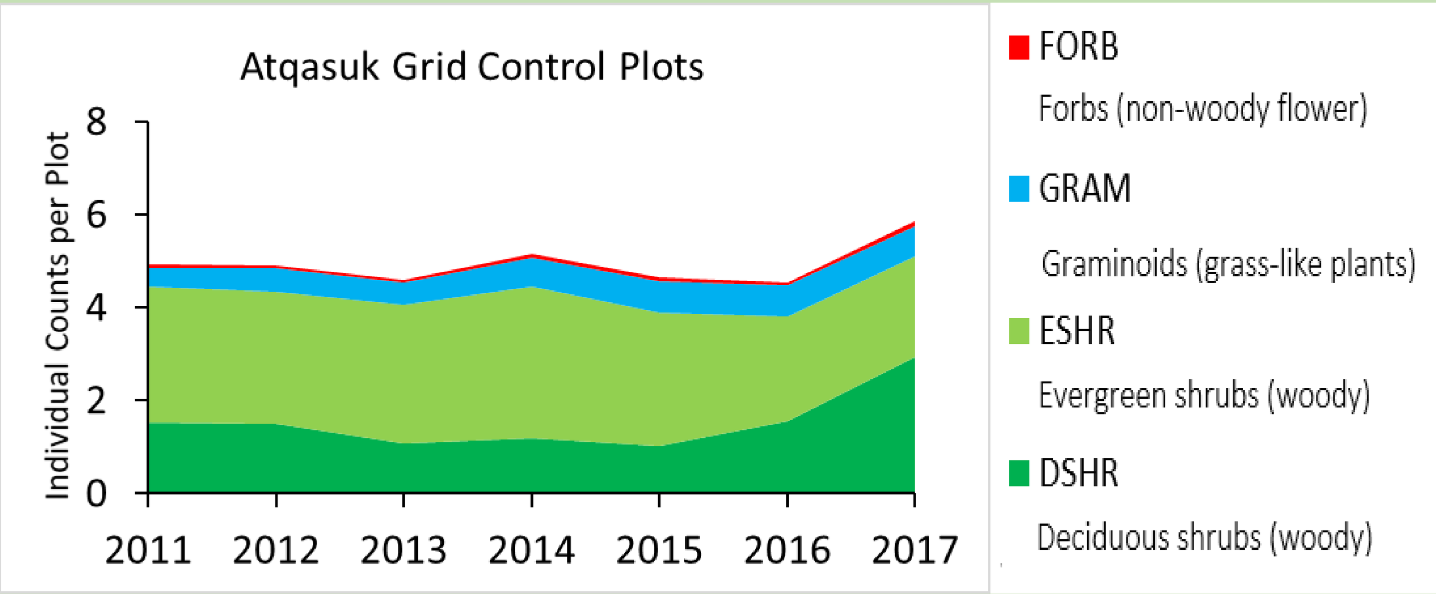


FIG 2. Change in density over time for each growth forms at the Atqasuk Dry, Wet and Grid sites. At the Atqasuk Dry and Wet sites the density of the plots in the warmed and control plots are provided separately.

Table 1. Average density per 10 cm^2 of the four growth forms measured in the three sites each year from 2011 to 2017. The three sites are the Atqasuk Dry, Wet, and Grid. At the Atqasuk Dry and Wet sites the density of the plots in the warmed and control plots are provided separately.

Atqasuk Dry Control							
Growth Form	2011	2012	2013	2014	2015	2016	2017
DSHR	0.11	0.09	0.14	0.15	0.17	0.19	0.24
ESHR	4.22	4.43	5.02	5.44	4.85	3.82	4.41
FORB	0.01	0.01	0.02	0.02	0.02	0.02	0.08
GRAM	0.01	0.01	0.02	0.02	0.02	0.02	0.08
Atqasuk Dry Warmed							
Growth Form	2011	2012	2013	2014	2015	2016	2017
DSHR	0.08	0.09	0.11	0.10	0.17	0.10	0.16
ESHR	5.36	5.94	6.55	7.13	6.24	4.89	5.36
FORB	0.10	0.12	0.13	0.15	0.10	0.07	0.18
GRAM	0.16	0.19	0.21	0.23	0.23	0.18	0.19
Atqasuk Wet Control							
Growth Form	2011	2012	2013	2014	2015	2016	2017
DSHR	0.68	0.66	0.71	0.70	0.69	1.00	1.01
ESHR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FORB	0.03	0.02	0.03	0.03	0.03	0.07	0.04
GRAM	0.49	0.49	0.49	0.55	0.57	0.56	0.55
Atqasuk Wet Warmed							
Growth Form	2011	2012	2013	2014	2015	2016	2017
DSHR	0.67	0.72	0.71	0.71	0.61	0.76	0.72
ESHR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FORB	0.02	0.04	0.03	0.04	0.04	0.02	0.04
GRAM	0.42	0.42	0.42	0.49	0.50	0.51	0.50
Atqasuk Grid Control							
Growth Form	2011	2012	2013	2014	2015	2016	2017
DSHR	1.54	1.51	1.08	1.20	1.02	1.55	2.92
ESHR	2.91	2.84	2.96	3.25	2.86	2.27	2.17
FORB	0.08	0.08	0.07	0.08	0.09	0.07	0.12
GRAM	0.41	0.49	0.49	0.61	0.69	0.67	0.65

Table 2. Results form a two-way ANOVA examining the significance of year (2011-2017), treatment (warmed versus control) and the interaction between the two on species density. The analysis was done separately for each growth form at the Atqasuk Dry and Atqasuk Wet sites. Statistically significant results are bolded.

Atqasuk Dry			
Tested Variables	Growth Form	F-value	P-Value
Year	DSHR	**31.35**	**<0.001**
Treatment	DSHR	**11.75**	**0.01**
Year:Treatment	DSHR	3.44	0.09
Year	ESHR	0.36	0.56
Treatment	ESHR	**11.91**	**0.01**
Year:Treatment	ESHR	0.09	0.77
Year	GRAM	1.72	0.22
Treatment	GRAM	**34.04**	**<0.001**
Year:Treatment	GRAM	0.24	0.64
Year	FORB	1.05	0.33
Treatment	FORB	**7.15**	**0.02**
Year:Treatment	FORB	0.02	0.89
Atqasuk Wet			
Tested Variables	Growth Form	F-value	P-Value
Year	DSHR	**8.74**	**0.01**
Treatment	DSHR	3.38	0.10
Year:Treatment	DSHR	**6.43**	**0.03**
Year	ESHR	NA	NA
Treatment	ESHR	NA	NA
Year:Treatment	ESHR	NA	NA
Year	GRAM	3.32	0.10
Treatment	GRAM	0.40	0.54
Year:Treatment	GRAM	1.77	0.21
Year	FORB	**29.09**	**<0.001**
Treatment	FORB	**29.19**	**<0.001**
Year:Treatment	FORB	0.71	0.42

Table 3. Results from a one-way ANOVA examining the significance of year (2011-2017) on species density on the Atqasuk Grid. The analysis was done separately for each growth form. Statistically significant results are bolded.

Atqasuk Grid Control		
Growth Form	F-Value	P-Value
DSHR	1.630	0.258
ESHR	4.522	0.087
FORB	**22.770**	**0.005**
GRAM	2.490	0.175

Results

Species density generally changed over years for most growth forms at a site (**Table 1, FIG 2**). At the Dry site, experimental warming influenced the density of all growth forms; at the Wet site experimental warming only influenced the density of forbs (**Table 2**). Change over years was significant for deciduous shrubs at the Dry site and for deciduous shrubs, graminoids and forbs at the Wet site. There were no significant interaction between year and treatment at either the Dry or Wet site (except for deciduous shrubs at the Wet site). Change in forb density from 2011-2017 was significant across the Grid, but not for other growth forms (**Table 3**). Pearson correlations indicated that changes in deciduous shrubs corresponded with annual changes in precipitation, soil moisture (SWVC), thaw depth and year; evergreen shrubs correlated with precipitation; forbs correlated with air temperature, precipitation, soil moisture (SWVC), thawing degree days (TDD), thaw depth and year; and graminoids correlated with precipitation, soil moisture (SWVC), thaw depth and year (**Table 4**).

Discussion

Our results were collected from a variety of plant communities ranging from xeric to hydric conditions. Different plant species are found between the differing communities. Therefore, we believe our results are robust. Our method of data collection examines whether tundra plant communities are transitioning from an open to a closed canopy based on the assumption of plants either growing larger or more numerous. Here we show, in general, plants have become more numerous over time and with warming.

These results support previous research that shrubs and graminoids are increasing (Walker et al., 2006). Previous studies have not shown a significant changes in forbs. Increased species density may affect ecosystem functions by impacting the energy balance and permafrost dynamics of the Arctic (Chapin et al., 2005). Further studies are necessary to show how the change in the number of plants translates to changes in cover and biomass.

Acknowledgements

We would like to give my utmost gratitude to the National Science Foundation (NSF) for providing the funding to make this happen, UMIAQ for logistical support, and all the members from the GVSU Arctic Ecology Program (AEP) for their support in data collection, analysis and humor. In the making of this project, We are indebted to Hana Christofferson and Katlyn Betway for their hard work and support.

References

Chapin, F.S. III., Sturm, M., Serreze, M.C., et al. (2005). Role in Land-Surface Changes in Arctic Summer Warming. Science, 310(5748): 657-660.

IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyers (eds.)] IPCC, Geneva, Switzerland, 151pp.

Walker, M.D., Wahren, C.H., Hollister, R.D., et al. (2006). Plant community responses to experimental warming across the tundra biome. Proceedings of the National Academy of Sciences of (PNAS) the USA, 103(5):1342-1346

Table 4. Results form a Pearson correlation between change in abiotic variables and plant density on the Atqasuk Grid. The analysis was done separately for each growth form. Statistically significant r-value results are bolded.

Abitoic Variables	Deciduous Shrubs (DSHR)	Evergreen Shrubs (ESHR)	Forbs (FORB)	Graminoids (GRAM)
Air Temperature	-0.05	-0.44	**0.18**	-0.11
Precipitation	**-0.16**	**0.11**	**0.80**	**0.27**
Soil Temperature	-0.10	-0.21	-0.13	-0.38
Soil Water Volumetric Content (SWVC)	**0.37**	-0.35	**0.40**	**0.31**
Thawing Degree Day (TDD)	-0.16	-0.50	**0.37**	-0.13
Thaw Depth	**0.58**	-0.90	**0.55**	**0.60**
Year	**0.50**	-0.69	**0.91**	**0.58**