Vegetation productivity at Cape Bounty, Melville Island, NU: A high spatial resolution satellite NDVI time series analysis (2004-2016)

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Introduction

The High Arctic is undergoing environmental change due to anthropogenic climate change with further changes in temperature and precipitation regimes forecast.[1] Meanwhile, long-term records allow for a more nuanced understanding of terrestrial ecosystems' response to these changes. The remote and vast nature of the Arctic can often make long-term field measurements over large areas logistically challenging. Remote sensing change detection techniques can provide a solution. Greening trends have been observed using coarse and medium spatial resolution remote sensing products.[2,3] However, vegetation communities vary over small spatial scales and warming experiments have demonstrated that vegetation responses are not consistent across these communities.[4] In order to quantify vegetation change at these spatial scales, high spatial resolution multi-spectral imagery from 2004-2016 are paired with field measurements. With pixel sizes of less than 5 m, this allows for an investigation of change at a scale that more closely resembles the scale of changes in soil moisture and vegetation communities present on the ground. This will allow for a better understanding of the relationship between environmental change and vegetation communities.

Objectives

The objectives of this research are to:

- investigate the change in vegetation productivity (as measured by field measurements of percent vegetation cover (PVC) and the normalized difference vegetation index (NDVI)) at a High Arctic site;
- compare trends between vegetation communities (polar semi-desert, mesic heath and wet sedge); and
- contextualize results through analysis of site temperature records.

Study Site

This research was conducted at the Cape Bounty Arctic Watershed Observatory (CBAWO), Melville Island, Nunavut (Figure 1)[5]. This region has three main vegetation communities: wet sedge, mesic heath and polar semi-desert (Figure 2). These communities each have distinct moisture regimes and are dominated by different species (vascular and non-vascular).

Figure 1: Study site.

Figure 2: Vegetation communities

Methods

Field Estimations of percent vegetation cover (PVC):

- 2004: Braun-Blanquet.
- 2017: Braun-Blanquet and modified digital SLR NDVI camera.

High spatial resolution imagery (Table 1):

- Calibrated to top-of-atmosphere reflectance (TOA).
- Orthorectified a base image and co-registered other dates to the base image.
- Calculated NDVI for each date and extracted mean values for vegetation plots.

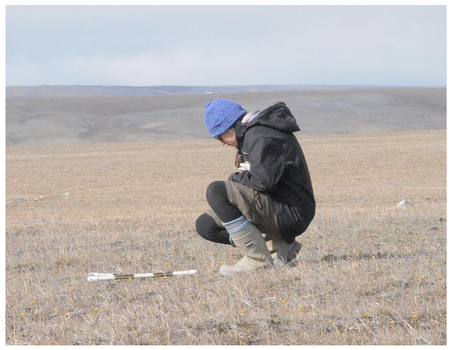

Figure 3: Braun-Blanquet Field Measurements

Preliminary Results

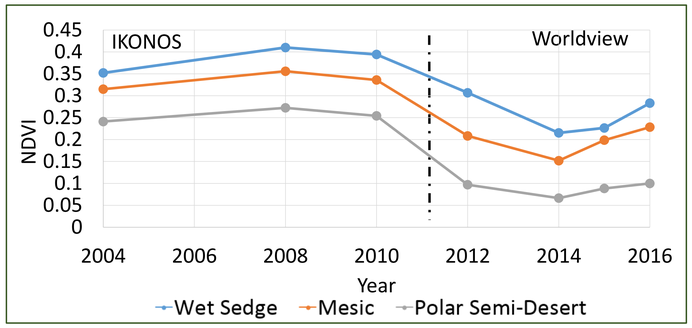

Figure 4: NDVI Change by Vegetation Community

Table 1: Growing Degree Days (GDD) by Image Capture Date

Date	Satellite	GDD (5 °C)	GDD (3 °C)
07/22/2004	IKONOS	2	8
08/02/2008	IKONOS	20	30
07/11/2010	IKONOS	12	19
07/15/2012	WorldView-2	21	32
07/10/2014	WorldView-2	3	9
08/12/2015	WorldView-2	27	36
07/28/2016	WorldView-2	22	33

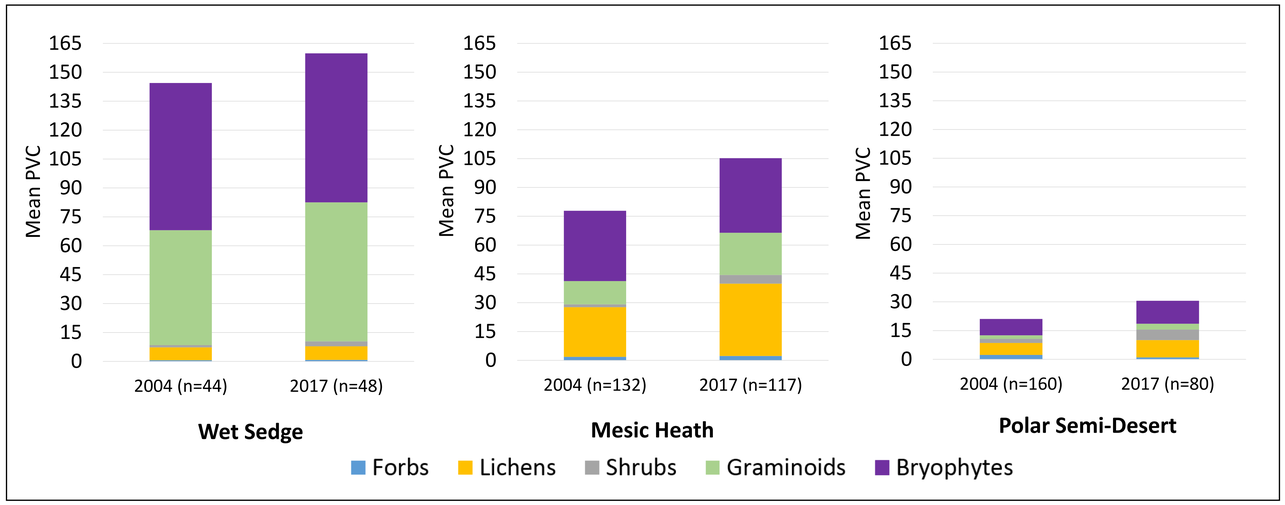

Figure 5: Mean Field PVC Estimates by Plot Functional Group

- Figure 4 shows consistent patterns between functional groups across all years. However, further normalization between sensors and growing degrees days (GDD) and growing season length (GSL) is necessary to properly interpret any potential vegetation trends.
- Preliminary analysis of field measurements (Figure 5) show an increase in percent vegetation cover across all vegetation communities.

Future Steps

- Examine relationship of observed changes to local temperature and precipitation data.
- Perform a more robust normalization technique that better accounts for different sensors and acquisition dates.
- Incorporate NDVI digital SLR camera imagery to support 2017 field measurements.

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