Background

Many northern ecosystems are experiencing rapid changes to vegetation, permafrost, and hydrology [1,2]. Remote sensing is an effective way to detect ecological changes across large areas [3,4,5]. LandSAT Tasseled Cap (TC) greenness and wetness trends from 1985-2015 show there are concentrated areas of declining vegetation productivity and moisture across the Banks Island Migratory Bird Sanctuary. The Lesser snow goose (Chen caerulescens coeorecles) population on Banks Island has almost tripled since 1976 [6] and may be driving observed vegetation changes. However, overlapping declines in moisture may also be contributing to vegetation changes.

Objective: Explain the declines in vegetation productivity in the BIMBS1.

Hypothesis 1: Declines in vegetation productivity are related to overgrazing by the expanding lesser snow goose population.

Hypothesis 2: Declines in vegetation productivity are related to reduced surface water and soil moisture.

Methods

Landsat scenes between 1985-2015 were Tasseled Cap (TC) transformed to measure trends in: brightness (TCB), greenness (TCG), and wetness (TCW) [3]. Field sampling was conducted at 18 sites within alluvial terraces. At each site, 11 plots were established to measure vegetation, soil, and goose habitat use. Site locations were selected using Local Indicators of Spatial Association (LISA) statistics [8] (Figure 2). The 18 sites were divided into 3 classes:

- Browsing Sites: Where TCG and TCW are decreasing
- Drying Sites: Where only TCW is decreasing
- Control Sites: Where TCG and TCW have remained relatively stable

Non-metric multidimensional scaling (NMDS) and generalized linear mixed models (GLMM) [9] were used to assess differences in vegetation and goose habitat use among site types (Figure 3). All plots that landed within former pond basins were removed from these analyses.

Random forest decision trees were used to assess spatial and topographic variance in TCG trends. Variables included land cover, latitude, longitude, and metrics derived from the 10m resolution ArcticDEM. A histogram breakpoint method [5] was used to calculate sub-pixel water fractions from TCW data. Thiel-Sen linear regression was then tested for per-pixel trends in surface water between 1985-2015.

Study Area

The BIMBS1 is located on Banks Island, Northwest Territories (Figure 1). There is only one permanent settlement on Banks Island, the Inuvialuit community of Sachs Harbour.

BIMBS1 provides nesting grounds for over 95% of the western Arctic lesser snow goose population [6,7]. Topography consists of gently rolling uplands, intersected by west flowing rivers and their floodplains [7]. The area is also extensively vegetated, relative to other areas in the northern Arctic [6].

Results & Discussion

Vegetation community composition was relatively similar among site types (Figure 4), without obvious differences that could produce browning TCG signals.

Pairwise comparisons of least squares means [9] showed browning sites had significantly higher proportions of dry moss to moss cover (p < 0.05) (Figure 5), which indicates low moisture conditions. Most bryophytes are very resilient to drought conditions, but poor internal regulators of water when external conditions are unfavorable [10].

Increasing proportions of dry moss could be producing browning TCG signals (Figure 6). TCG is heavily influenced by the visible red wavelength [21]. Visible red light is reflected more by unhealthy vegetation, compared to healthy, green vegetation.

Conclusions

Observed declines in vegetation productivity are likely related to increasing proportions of dry moss in wet sedge habitat. This shift has likely been caused by a combination of snow goose grubbing and climate induced changes to hydrology. Future studies exploring the effects of goose grubbing at different moisture levels, can help to clarify the relative contributions of these processes.

TC indices have been used here to detect drying occurring in multiple terrain types on Banks Island. Widespread overlap between declines in TCW and TCG highlight the importance of using multiple remote sensing indices to measure Arctic landscape change. These or similar remote sensing techniques can be used to continue monitoring habitat changes in the BIMBS1 and other areas of the northern Arctic.

Altered habitat in the BIMBS1 could impact the snow goose population and other migratory bird species that use the area [6]. These changes are relevant to the Sachs Harbour Hunters and Trappers Committee and Canadian Wildlife Service, for appropriate management of the area.

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References