Seasonal Variations in NDVI, LAI, and Biomass on Four Tundra Vegetation Types at Ivotuk, Alaska

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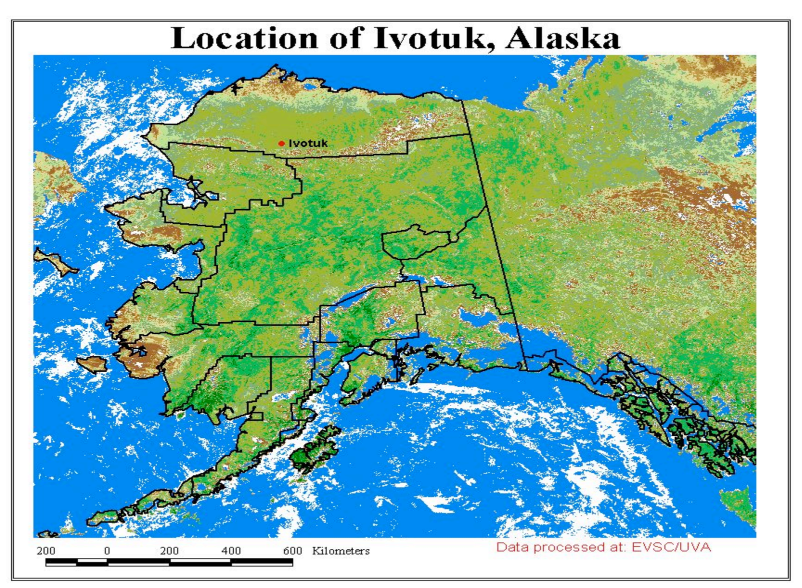
Abstract

Substrate and topography are considered factors that control local heterogeneity of tundra vegetation. Intraseasonal trends of leaf area index (LAI), normalized difference vegetation index (NDVI), and biomass were investigated for four distinct tundra vegetation types at Ivotuk, Alaska. The study site, located on the north slope of the Brooks Range (68.49 N, 155.74 W), is characterized by a growing season length of 136-150 days and a mean July maximum temperature of 12° C. LAI, NDVI, and biomass samples were collected bi-weekly from four 100 m x 100 m grids, each representing a different vegetation type, during the 1999 growing season. The vegetation types examined in this study included Moist Acidic Tundra (MAT), Moist Non-acidic Tundra (MNT), Moss Tundra (MT), and Shrub Tundra (ST). Seasonal patterns of NDVI and LAI were significantly different among the four vegetation types ($p < 0.05$). Peak values of NDVI and LAI were significantly different among all vegetation types, except between MNT and MT ($p < 0.05$). ST peak total biomass was significantly greater than peak total biomass for MAT, MNT, and MT ($p < 0.05$). NDVI was significantly related to LAI for the composite of all tundra vegetation types. Values of LAI, NDVI, and biomass obtained from this field study will be used in conjunction with satellite data for the purposes of extrapolation and examining responses to climate change.



Introduction

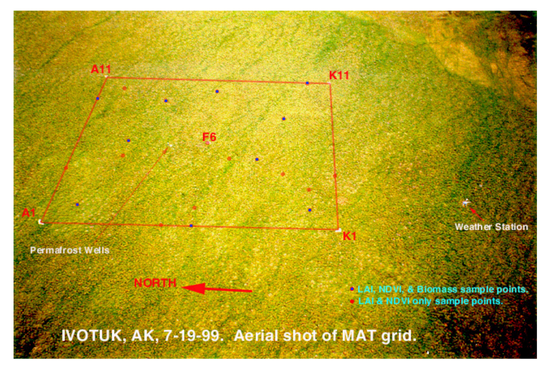
Current general circulation models predict a global warming of 1 to 3°C resulting from current rates of greenhouse gas emission increases. Additionally, general warming trends are more pronounced at high latitudes (Overpeck 1998). Potential implications of these warming trends heighten the importance of completely understanding the factors that control tundra vegetation. Climate gradients have shown to be a substantial control of regional patterns of tundra vegetation (Gilmanov 1997). Recent studies have also shown regional variations of tundra vegetation properties resulting from differences in substrate. A soil pH boundary separates two distinct tundra vegetation types, within the Kuparuk River basin in arctic Alaska north of the Brooks Mountain Range. Walker et al. (1998) found vegetation on the northern non-acidic side of the boundary differs in community structure from the vegetation found on the southern acidic side of the boundary. Additionally, ecosystem properties important with respect to climate change studies were observed to vary from moist acidic tundra to moist non-acidic tundra. Compared to moist acidic tundra, moist non-acidic tundra has greater heat flux, deeper summer thaw, and serves as a lesser carbon sink and a smaller methane source (Walker et al. 1998).

Substrate may also be an important factor at local scales. Examining property differences among vegetation types on a local scale will help to determine the balance of controls on vegetation dynamics from regional climate gradients, regional substrate gradients, and local heterogeneity.

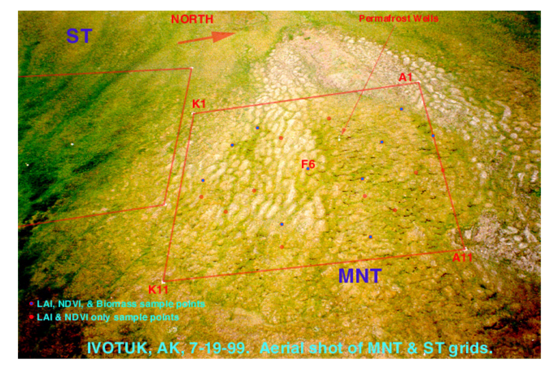
Objectives

- Examine the effects of local variations of substrate and topography on tundra vegetation properties.
- Determine if relationships between NDVI and other vegetation properties (such as LAI and biomass) exist, which will allow satellite data to be linked to field data.

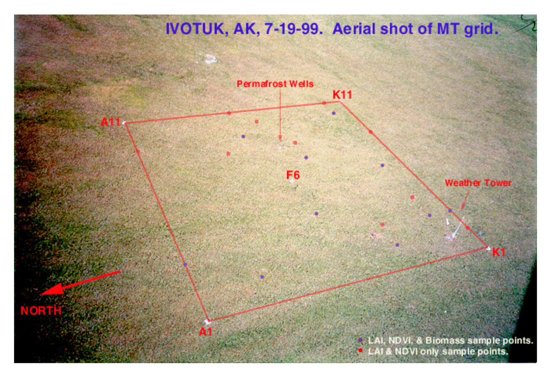
Moist Acidic Tundra



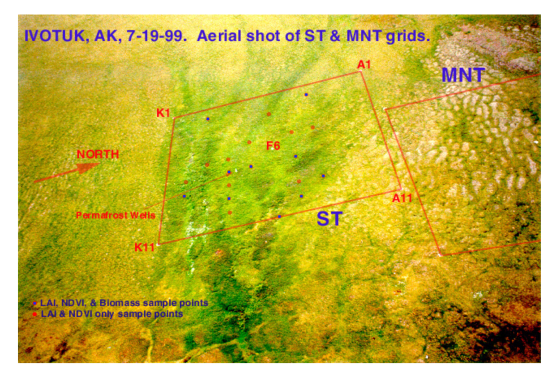
Moist Non-acidic Tundra



Moss Tundra

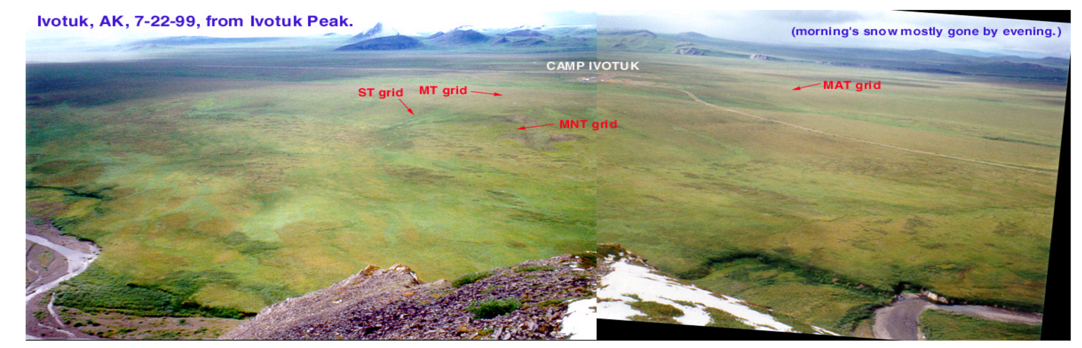


Shrub Tundra



Methods

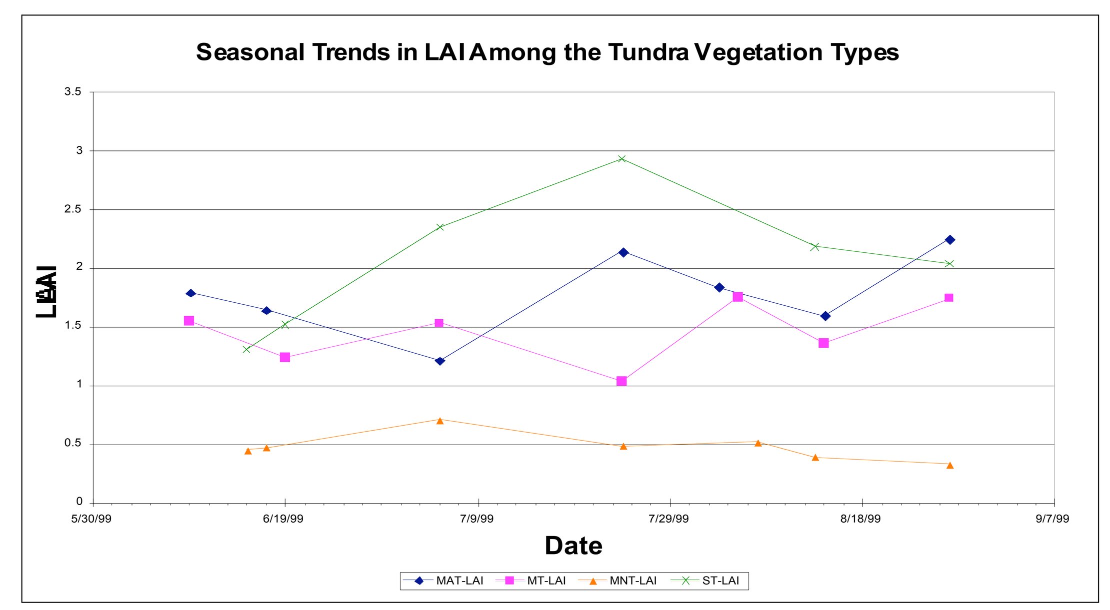
Intraseasonal trends of leaf area index (LAI) and normalized difference vegetation index (NDVI) were investigated for four distinct tundra vegetation types. Ivotuk, Alaska, located on the north slope of the Brooks Mountain Range, was chosen as the study site because four tundra vegetation types, moist acidic tundra (MAT), moist non-acidic tundra (MNT), moss tundra (MT), and shrub tundra (ST) exist with in a 2 km^2 area. LAI, NDVI, and biomass samples were collected bi-weekly from four 100 m x 100 m grids, each representing a different vegetation type, during the 1999 growing season. LAI and NDVI measurements were taken at 20 random points within each grid. LAI was measured using a Licor LAI-2000 instrument. NDVI was measured using an Analytical Spectral Devices FieldSpec spectroradiometer. Biomass was collected from 10 randomly selected 20 cm x 50 cm plots within each grid, for a total of 1 m^2 for each of the six sample dates. On the July 15^{th} sampling date, the quantity of biomass harvests was doubled for MAT and MT. Generally, vascular plants were clipped at the top of the moss surface. Mosses were clipped at the base of the green layer. Biomass samples were sorted into six main categories (bryophytes, forbs, graminoids, horsetails, lichens, and shrubs). The graminiod and shrub samples were sorted further into subcategories. Graminoid biomass was divided into live and dead material. Shrub biomass was divided into evergreen and deciduous, which was then separated into woody, herbaceous live, and herbaceous dead components. Regression analyses were performed to see if there was a significant relationship between NDVI and LAI for each tundra vegetation type and for all tundra vegetation types combined. Variations of LAI, NDVI, and biomass among the four vegetation types will be analyzed to determine the controls that local substrate and topography patterns have on vegetation.

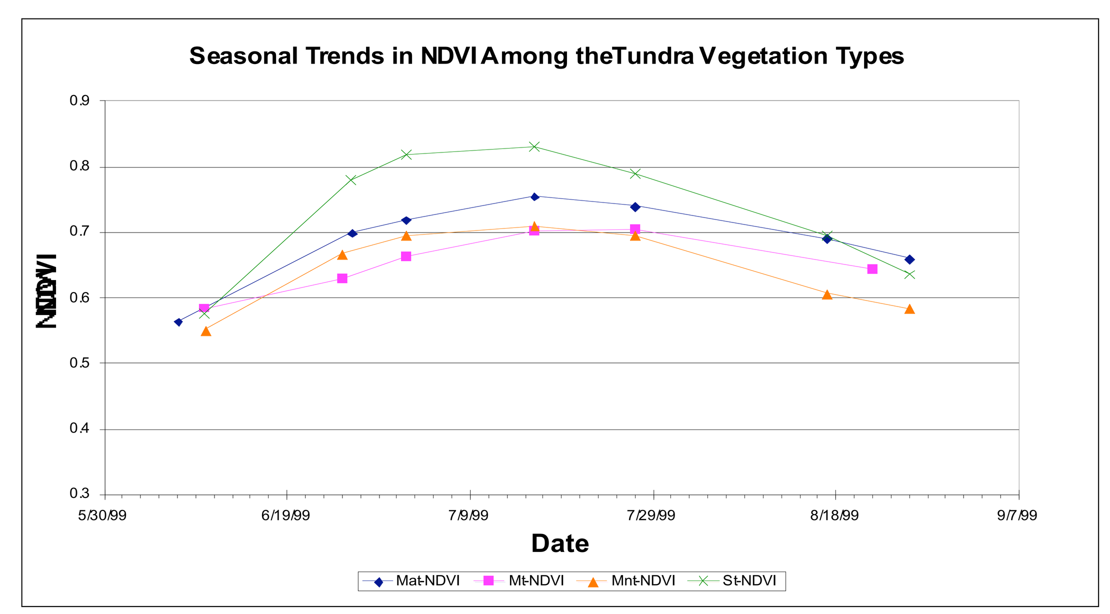


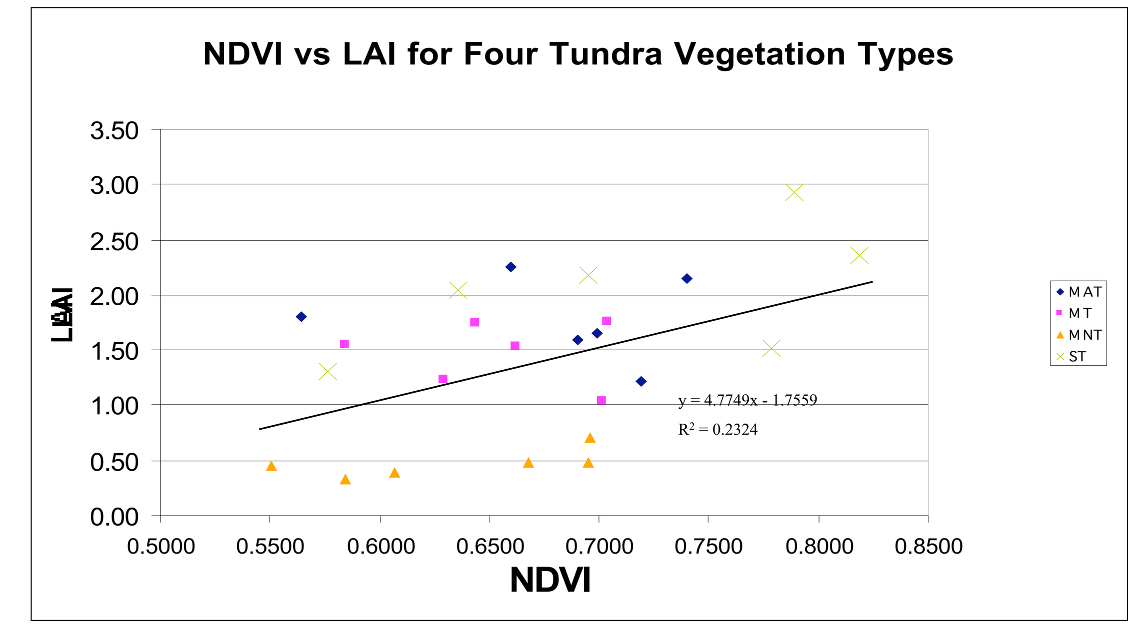
Results

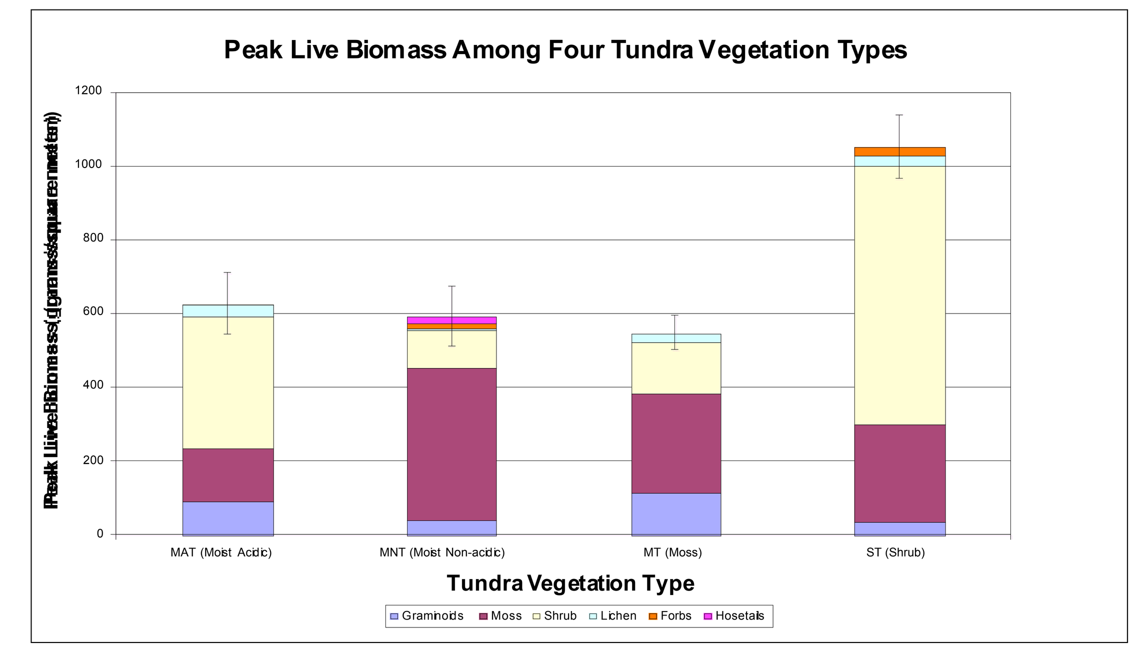
Seasonal patterns of NDVI and LAI were significantly different among the four vegetation types ($p < 0.05$). Peak values of NDVI and LAI were significantly different among all vegetation types, except between MNT and MT ($p < 0.05$). NDVI was significantly related to LAI for the composite data of all tundra vegetation types. NDVI was not significantly related to LAI for any of the individual tundra vegetation types. For moist non-acidic and shrub tundra vegetation types this is likely due to the small sample size ($n = 6$).

MT peak graminoid biomass was significantly greater than peak graminoid biomass for MNT and ST ($p < 0.05$). Peak moss biomass was not significantly different among the four vegetation types, except MNT which was significantly greater than MAT ($p < 0.05$). Peak lichen biomass was not significantly different among the four vegetation types ($p < 0.05$). ST peak shrub deciduous live biomass was significantly greater than peak shrub deciduous live biomass for MAT, MNT, and MT ($p < 0.05$). MAT peak shrub evergreen live biomass was significantly greater than peak shrub evergreen live biomass for MNT, MT, and ST ($p < 0.05$). ST peak shrub total biomass was significantly greater than peak shrub total biomass for MAT, MNT, and MT ($p < 0.05$). MAT peak shrub total biomass was significantly greater than peak shrub total biomass for MNT and MT ($p < 0.05$). ST peak total biomass was significantly greater than peak total biomass for MAT, MNT, and MT ($p < 0.05$).









Conclusions

- Seasonal patterns of NDVI and LAI were significantly different among the four vegetation types ($p < 0.05$).
- Peak values of NDVI and LAI were significantly different among all vegetation types, except between MNT and MT ($p < 0.05$).
- NDVI was significantly related to LAI for the composite data of all tundra vegetation types.
- ST peak total biomass was significantly greater than peak total biomass for MAT, MNT, and MT ($p < 0.05$).

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