Linking vegetation composition to geomorphic units in a polygonal tundra landscape: a framework for improving plant functional type representation in ecosystem models

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BACKGROUND

- Plant functional type (PFT) distribution is an important component of broad-scale carbon and nutrient cycle models, but upscaling from field measurements of community composition can be challenging, especially in heterogeneous landscapes such as Arctic tundra.
- There is a need for plant community surveys and associated functional measurements to be made within a framework which will allow the resulting data to be used effectively in carbon cycle models.

FIELD SITE AND METHODS

- 4 × polygon types (areas A-D) along a moisture gradient in a coastal tundra landscape, Barrow Environmental Observatory, Alaska
- 4 × replicate polygons (geomorphic units) within each area

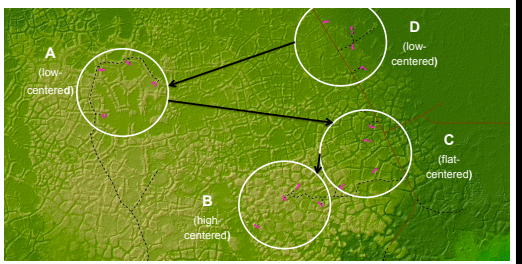
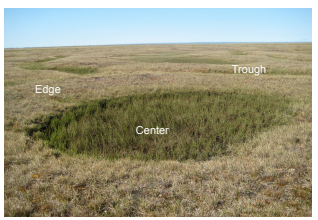


Image: Garrett Altmann (LANL), LIDAR source Craig Tweedie (UTEP). Black arrows denote gradient of decreasing average soil moisture (areas D to B), pink points show survey plot locations.

- Center, Edge and Trough sub-units in each polygon
- Plant community composition (estimated aerial coverage of vascular and non-vascular plants) determined in 1 m × 1 m plots in each sub-unit, late July, 2012
- Destructive harvests undertaken in 0.25 m x 0.25 m area adjacent to survey plot to determine leaf area index, specific leaf area, and N content by species, late July through early August, 2012
- Seasonal measurements of environmental variables



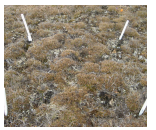
Polygon sub-units on a low-centered polygon (Area A)

Plant community survey

Environmental measurements

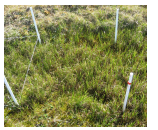
RESULTS – PLANT COMMUNITY COMPOSITION

- Indirect ordination supports use of Center, Edge, and Trough sub-divisions within polygon types to represent community variation in the landscape (Fig. 1; minimal overlap between plots from sub-units within polygon types)
- Strong relationship between community composition and soil moisture (Fig. 2)



High centers: 20+ species, frequent Luzula arctica (rush) and Vaccinium vitis-idaea (evergreen shrub), high lichen cover

Edges: 10-20 species, dominated by Eriophorum sp. (sedges) or Poa arctica (grass), mixed moss/ lichen layer



Troughs: 6-10 species, dominated by Carex aquatilis (sedge), high moss cover

Low centers (lower right Fig. 1): 5-9 species, dominated by Carex aquatilis (sedge), low moss cover

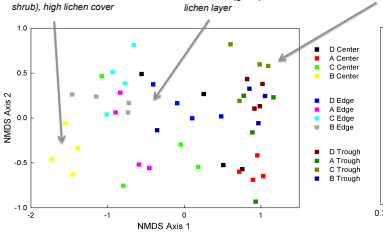


Fig. 1: NMDS community composition
(after the fact % variance explained, Axis 1 = 66%, Axis 2 = 14%)

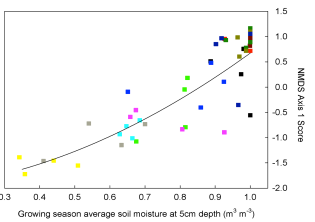


Fig. 2: Relationship between soil moisture and NMDS Axis 1 (r^2 = 0.81, P <0.01)

- 'Wet tundra graminoids' dominate vascular canopies throughout much of this landscape (Fig. 3)
- PFT diversity is higher in edges and high-centers (Fig. 3)
- Bryophytes frequently form high percentage cover and are important for distinguishing between plant communities (Figs. 1, 4)

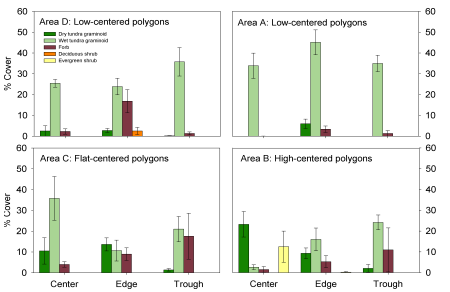


Fig. 3: Community composition by PFT (vascular plants)

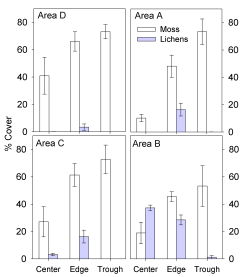


Fig. 4: Community composition by PFT (non-vascular plants)

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RESULTS – PLANT HARVESTS

- Leaf area index (LAI) is higher in trough communities, and decreases along a moisture gradient from wetter to drier areas (Fig. 5)

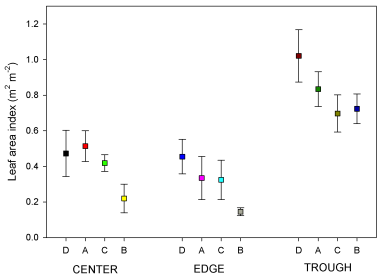

Fig. 5: Leaf area index of plant communities across polygon sub-units

- Specific leaf area follows broadly similar patterns to leaf area index (Fig. 6)

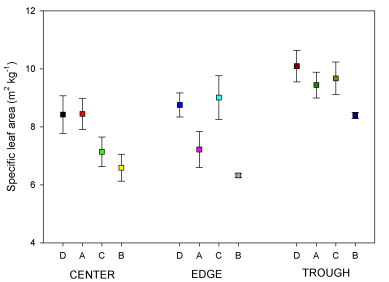

Fig. 6: Specific leaf area of plant communities across polygon sub-units

- Average leaf N content is 2.3%. Whole canopy N is tightly coupled to LAI (data not shown)

CONCLUSIONS

- Linking plant community composition and functional parameters to geomorphic units provides a basis for improving representation of tundra vegetation in models. The data shown here can be coupled with newly developed remote sensing tools for characterizing geomorphology to provide model input.
- A full analysis of community composition in relation to key drivers such as soil moisture and nutrient availability within this framework will enable better prediction of potential effects of climate change on Arctic ecosystems.