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Vegetation biomass, leaf area index, and NDVI patterns and relationships along two latitudinal transects in arctic tundra

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Analyses of vegetation properties along climatic gradients provide first order approximations as to how vegetation might respond to a temporally dynamic climate. Until recently, no systematic study of tundra vegetation had been conducted along bioclimatic transects that represent the full latitudinal extent of the arctic tundra biome. Since 1999, we have been collecting data on arctic tundra vegetation and soil properties along two such transects, the North American Arctic Transect (NAAT) and the Yamal Arctic Transect (YAT). The NAAT spans the arctic tundra from the Low Arctic of the North Slope of Alaska to the polar desert of Cape Isachsen on Ellef Ringnes Island in the Canadian Archipelago. The Yamal Arctic Transect located in northwest Siberia, Russia, presently ranges from the forest-tundra transition at Nadym to the High Arctic tundra on Belyy Ostrov off the north coast of the Yamal Peninsula. The summer warmth indices (SWI – sum of mean monthly temperatures greater than 0°C) range from approximately 40 °C months to 3 °C months from south to north. For largely zonal sites along these transects, we systematically collected leaf area index (LAI-2000 Plant Canopy Analyzer), normalized difference vegetation index (NDVI – PSII hand-held spectro-radiometer), and vegetation biomass (clip harvests). Site-averaged LAI ranges from 1.08 to 0 along the transects, yet can be highly variable at the landscape scale. Site-averaged NDVI ranges from 0.67 to 0.26 along the transects, and is less variable than LAI at the landscape scale. Total aboveground live biomass ranges from approximately 700 g m^{-2} to < 50 g m^{-2} along the NAAT, and from approximately 1100 g m^{-2} to < 400 g m^{-2} along the YAT (not including tree biomass at Nadym). LAI and NDVI are highly correlated logarithmically (r = 0.80) for the entire dataset. LAI is significantly related to total aboveground (live plus dead) vascular plant biomass, although there is some variability in the data (r = 0.63). NDVI is strongly correlated as a power function with photosynthetic biomass (r = 0.81). In general, for the same bioclimate subzone, total aboveground live biomass is substantially greater on the YAT compared to the NAAT. Some of this difference can be accounted for by the differences in measured non-vascular biomass. Since reindeer grazing on the Yamal Peninsula should reduce vegetation biomass to a greater extent than caribou grazing in North America, grazing differences are likely not responsible for biomass differences. However, different glacial and disturbance histories, soil substrates, and the resultant nutrient cycling processes could be hypothesized to yield these differences in vegetation biomass.

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