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Circumpolar Arctic greening: Relationships to summer sea-ice concentrations, land temperatures and disturbance regimes

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The global distribution of Arctic tundra vegetation is closely tied to the presence of summer sea ice. Models predict that the reduction of sea ice will cause large changes to summer land-surface temperatures. Warming combined with increased natural and anthropogenic disturbance are expected to greatly increase arctic tundra productivity. To examine where tundra productivity is changing most rapidly, we studied 1982-2008 trends of sea-ice concentrations, summer warmth index (SWI) and the annual Maximum Normalized Difference Vegetation Index (MaxNDVI). We summarize the results according to the tundra adjacent to 14 Arctic seas. Sea-ice concentrations have declined and summer land temperatures have increased in all parts of the Arctic coast. The overall percentage increase in Arctic MaxNDVI was +7%. The trend was much greater in North America (+11%) than in Eurasia (+4%). Large percentage increases of MaxNDVI occurred inland from Davis Straight (+20%), Baffin Bay (+18%), Canadian Archipelago (+14%), Beaufort Sea (+12%), and Laptev Sea (+8%). Declines occurred in the W. Chukchi (-6%) and E. Bering (-5%) seas. The changes in NDVI are strongly correlated to changes in summer ground temperatures. Two examples from a 900-km north-south Arctic transect in Russia and long-term observations at a High Arctic site in Canada provide insights to where the changes in productivity are occurring most rapidly. At tree line near Kharp in northwest Siberia, alder shrubs are expanding vigorously in fire-disturbed areas; seedling establishment is occurring primarily in areas with disturbed mineral soils, particularly nonsorted circles. In the Low Arctic tundra areas of the central Yamal Peninsula greening is concentrated in riparian areas and upland landslides associated with degrading massive ground ice, where low-willow shrublands replace the zonal sedge, dwarf-shrub tundra growing on nutrient-poor sands. In polar desert landscapes near the Barnes Ice Cap, Baffin Island, Canada, recent repeat photographs 46 years after the initial studies indicate that vegetation is increasing most strongly along ponds and streams. Change is less obvious and more difficult to detect in upland boulder fields. At the landscape level across the whole Arctic the most rapid changes are occurring where there are fine-grained soils, strong natural and anthropogenic disturbance regimes, and relatively high supply of water and nutrients.

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