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Spatio-temporal trends in tree and tall shrub cover in the Eurasian Low Arctic: evidence from 1960s and contemporary satellite imagery and ground observations

G. V. Frost[1]; H. Epstein[1]; D. A. Walker[2]
1. Department of Environmental Sciences, University of Virginia, Charlottesville, VA, United States.
2. Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK, United States.

Patterns of tree and tall shrub occurrence form conspicuous and dynamic ecological boundaries across arctic regions. Expansion of trees and shrubs into tundra-dominated areas is one of the principal changes to arctic land cover expected with climatic warming, and there is evidence that ecological state-shifts are already occurring in ecotones of the North American Low Arctic. The ubiquity of these state-shifts across the circumpolar Low Arctic is unclear, however, because few data exist for the vast Eurasian continent. Large-scale, synchronous expansions have occurred in the past (e.g., mid-Holocene) and associated changes to land surface-atmosphere interactions could have far-reaching effects on atmospheric circulation and global climate. This study is quantifying state-level vegetation change in geographic and altitudinal tundra ecotones at ~25 sites in northern Eurasia and Alaska using comparisons of circa 1965 Corona and contemporary high-resolution satellite photography. Corona was the world's first operational satellite surveillance system and offers a readily available data source for land-surface change studies over a ~40 year temporal interval. Remote sensing and ground-based data indicate that mean annual temperatures have increased over the last ~50 years at all study sites, although the magnitude of warming varies (~1.5 - 4 °C). The degree to which patterns of vegetation change are shared among sites will indicate the ubiquity of ecological state-shifts in the Low Arctic, as well as the relative influence of large-scale forcing mechanisms (e.g., climate change) and local environmental controls (e.g., disturbance regime, geomorphology) on tree and tall shrub expansion.
Preliminary findings indicate that tall shrublands have expanded at several sites in northwestern and far eastern Siberia. Recent expansion is most apparent on floodplains, uplands, and drained lake basins. Ground data indicate that dramatic expansion of alder shrubs at a tree-line site near Kharp, northwest Siberia has occurred in areas affected by an antecedent high-intensity wildfire that removed the surface organic layer. Additionally, alder recruitment both inside and outside of the burn is concentrated on disturbed mineral soils associated with cryogenic patterned-ground features. On the southern Yamal Peninsula, Russia, comparison of 1968 Corona and 2009 aerial photographs indicate that alders have colonized retransported sands derived from barren uplands near Ozero Yaroto. Additionally, alders and willows have rapidly colonized fluvial terraces and point bars on the Tanlova River that were barren in 1968. These findings indicate that local-scale disturbance events that create mineral-dominated edaphic conditions have promoted recent shrubification and enhanced productivity in parts of the Low Arctic.

Contact Information
Gerald V. Frost, Charlottesville, Virginia, USA, 22904, click here to send an email