

Dispersal and Fire Limit Arctic Shrub Expansion

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Arctic shrub expansion has been widely reported in recent decades, with large impacts on carbon budgets, albedo, and warming rates in high latitudes. However, predicting shrub expansion across regions remains challenging because the underlying controls remain unclear. Observational studies and models typically use relationships between observed shrub presence and current environmental suitability (bioclimate and topography) to predict shrub expansion, but such approaches omit potentially important demographic processes and non-stationary response of shrubs to changing climate. Here, we investigated controls on shrub expansion as part of the NGEE Arctic project. We used long-term high-resolution satellite imagery across Alaska and western Canada to show that observed shrub expansion has not been controlled by environmental suitability during 1984—2014, but rather can only be explained by accounting for seed dispersal and fire. These findings provide the impetus for better observations of recruitment and for incorporating currently underrepresented processes of seed dispersal and fire in land models to project shrub expansion and future climate feedbacks. Integrating these dynamic processes with projected fire extent and climate, we estimate that shrubs will expand into 25% of the non-shrub tundra by 2100, in contrast to 39% predicted using a relationship with increasing suitability alone. Thus, using environmental suitability alone likely overestimates and misrepresents the spatial pattern of shrub expansion and its associated carbon sink.